

# EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY

NOVEMBER 1986

£1-10

**8  
EXTRA  
PAGES**



**New Series...**

**DIGITAL TROUBLE SHOOTING**

**with Test Gear Projects**

**REGULATED BENCH POWER SUPPLY**

**200MHz DIGITAL FREQUENCY METER**

**Special SOLDERING FEATURE**

**Newcomers Magazine for Electronic & Computer Projects**



### £1 BAKERS DOZEN PACKS

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

1. 5 - 13 amp ring main junction boxes
2. 5 - 13 amp ring main spur boxes
4. 5 - surface mounting
5. 3 - electrical switches intermediate type, will also replace 1 or 2 way switches, white flush mounting
7. 4 - in flex time switches with mains
9. 2 - mains transformers with 6V 1A secondaries
10. 2 - mains transformers with 12V 4A secondaries
11. 1 - extension speaker cabinet for 6 1/2" speaker
12. - glass reed switches
17. 2 - ultra transmitters and 2 receivers with circuit
19. 2 - light dependent resistors
25. 4 - wafer switches - 6p 2 way, 4p 3 way, 2p 6 way, 2p 5 way, 1p 12 way small one hold fixing and good length 1/2 spindle your choice
28. 1 - 6 digit counter mains voltage
30. 2 - Nicad battery chargers
31. 1 - key switch with key
32. 2 - aerosol cans of ICI Dry Lubricant
33. 1 - long and medium wave tuner kit
34. 96 - 1 metre lengths colour-coded connecting wire
39. 1 - rocker switch 10 amp mains SPST
41. 8 - 24 hour time switch mains operated
45. 10 - neon valves - make good night lights
50. 2 - 12V DC or 24V AC, 3 CD relays
51. 1 - 12V 2 CO miniature relay very sensitive
52. 1 - 12V 4 CO miniature relay
53. 2 - mains operated relays 3 x 8 amp changeover (s.h.)
54. 10 - rows of 32 gold plated IC sockets (total 320 sockets)
55. 1 - locking mechanism with 2 keys
56. 1 - miniature uniselector with circuit for electric jigsaw puzzle
60. 5 - ferrite rods 4" x 5/16" diameter aerials
61. 4 - ferrite slab aerials with L & M wave coils
63. 1 - Mullard thyristor trigger module
66. 1 - magnetic brake - stops rotation instantly
67. 1 - low pressure 3 level switch can be mouth operated
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 your choice
75. 1 - time reminder adjustable 1-20 mins clockwork
77. 1 - mains shaded pole motor 1/2" stack 1/2" shaft
89. 1 - mains motor with gear box 1 rev per 24 hours
91. 2 - mains motors with gear box 16 rpm
96. 1 - thermostat for fridge
98. 1 - motorised stud switch (s.h.)
101. 1 - 2 1/2 hours delay switch
102. 1 - mains P.S.U. 9V DC
103. 1 - mains power supply unit - 6V DC
104. 1 - mains power supply unit - 4 1/2 V DC
107. 1 - 5" speaker size radio cabinet with handle
111. 2 - musical boxes (less keys)
112. 1 - heating pad 200 watts mains
114. 1 - 1W amplifier Mullard 1172
115. 1 - wall mounting thermostat 24V
118. 1 - teak effect extension 5" speaker cabinet
120. 2 - p.c. boards with 2 amp full wave and 17 other recs
121. 4 - push push switches for table lamps etc.
122. 10 - mtrs twin screened flex white p.v.c. outer
124. 25 - clear plastic lenses 1 1/2" diameter
127. 4 - pilot bulb lamp metal clip on type
128. 10 - very fine drills for pcbs etc.
129. 4 - extra thin screw drivers for instruments
132. 2 - plastic boxes with windows, ideal for interrupted beam switch
134. 10 - model aircraft motor - require no on/off switch, just spin to start
136. 2 - car radio speakers 5" round 4 ohm made for Radiomobile
137. 1 - 6 1/2" 4 ohm 10 watt speaker and 3" tweeter
142. 10 - 4 BA spanners 1 end open, other end closed
145. 2 - 4 reed relay kits 3V coil normally open or c/o if magnets added
146. 20 - pilot bulbs 6.5V.3A Philips
154. 1 - 12V drip proof relay - ideal for car jobs
155. 3 - varicap push button tuners with knobs
169. 4 - short wave air spaced trimmers 2-30f
171. 1 - shocking coil kit with data - have fun with this
172. 10 - 12V 6W bulbs Philips m.e.s.
178. 3 - oblong amber indicators with nipples 12V
180. 6 - round amber indicators with neon 240V
181. 100 - p.v.c. grommets 1/2" hole size
182. 1 - short wave tuning condenser 50 pf with 1/2" spindle
184. 1 - three gang tuning condenser each section 500 pf with trimmers and good length 1/2" spindle
188. 1 - plastic box sloping metal front, 16 x 95mm average depth 45mm
193. 6 - 5 amp 3 pin flush sockets brown
195. 5 - B.C. lampholders brown bakelite threaded entry
196. 1 - in flex simmerstat for electric blanket soldering iron etc.
197. 2 - thermostats, spindle setting - adjustable range forovens etc.
199. 1 - mains operated solenoid with plunger 1" travel
200. 1 - 10 digit switch pad for telephones etc.
201. 8 - computer keyboard switches with knobs, pcb or vero mounting
206. 20 - mtrs 80 ohm, standard type co-ax off white
211. 1 - electric clock mains driven, always right time - not cased
216. 1 - stereo pre-amp Mullard EP9001
232. 2 - 12V solenoids, small with plunger
236. 1 - mains transformer 9V 1 amp secondary C core construction
241. 1 - car door speaker (very flat) 6 1/2" 15 ohm made for Radiomobile
241. 2 - speakers 6" x 4" 4 ohm 5 watt made for Radiomobile
243. 2 - speakers 6" x 4" 16 ohm 5 watt made for Radiomobile
244. 1 - mains motor with gear-box very small, toothed output 1 rpm
245. 4 - standard size pots, 1/2 meg with dp switch
249. 1 - 13A switched socket on double plate with fused spur for water heater
266. 2 - mains transformers 9V 1/2 A secondary split primary so ok also for 115V
267. 1 - mains transformers 15V 1A secondary p.c.b. mounting
291. 1 - ten turns 3 watt pot 1/2 spindle 100 ohm
296. 3 - car cigar lighter socket plugs
298. 2 - 15 amp round pin plugs brown bakelite
300. 1 - mains solenoid with plunger compact type
301. 10 - ceramic magnets Mullard 1" x 3/8 x 5/16
303. 1 - 12 pole 3 way ceramic wave charge switch
304. 1 - stereo amp 1 watt per channel
305. 1 - tubular dynamic microphone with desk rest
308. 1 - T.V. turret tuner (black & white T.V.)
310. 2 - oven thermostats
311. 1 - Clare Elliot sealed relay 12V
312. 1 - pressure pad switch 24 x 18 (Trigger Mat)
313. 5 - sub miniature micro switches
314. 1 - 12" 8 watt min fluorescent tube white
315. 1 - 6" 4 watt min fluorescent tube white
316. 1 - round pin kettle plug with moulded on lead
453. 2 - 2 1/2 in. 80ohm loudspeakers
454. 2 - 2 1/2 in. 80ohm loudspeakers

### MULLARD UNILEX AMPLIFIERS

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

### CAR STARTER/CHARGER KIT

Flat Battery! Don't worry you will start your car in a few minutes with this unit - 250 watt transformer 20 amp rectifiers, case and all parts with data £16.50 or without case £15.00 post paid.

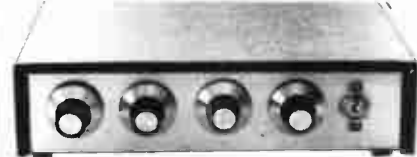


Ex-Electricity Board. Guaranteed 12 months.

### 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/off's per 24hrs. This makes an ideal controller for the immersion heater. Price of adaptor kit is £2.30.

### SOUND TO LIGHT UNIT



Complete kit of parts of 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 1/2" 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.

### 12 volt MOTOR BY SMITHS

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

### 25A ELECTRICAL PROGRAMMER

Learn in your sleep. Have radio playing and kettle boiling as you wake - switch on lights to ward off intruders - have a warm house to come home to. You can do all these and more. By a famous maker with 25 amp on/off switch. A beautiful unit at £2.50

### THIS MONTH'S SNIP

4 High quality 7-segment l.e.d. displays, high brightness, high contrast, yours for only £2 - ideal for LIGHT RIDER (Oct '86) projects. Our reference 2P121.

### MAKING SUBNEDS?

CHOKE AND STARTER for 6" 100uVa tube £2, post £1 for 1 or 50p each in quantity. TUBE HOLDERS. Canopy type spring loaded, 4 pairs for £1, 100 pairs £20, 1,000 pairs £150, post paid.

### TANGENTIAL HEATERS?

We again have very good stocks of these quiet running instant heat units. They require only a simple case, or could easily be fitted into the bottom of a kitchen unit or book case etc. At present we have stocks of 1-2kw, 2kw, 2.5kw, and 3kw. Prices are £5 each for the first 3, and £6.95 for the 3k. Add post £1.50 per heater if not collecting. CONTROL SWITCH enabling full heat, half heat or cold blow, with connection diagram, 50p for 2kw, 75p for 3kw.

### FANS & BLOWERS

Woods extractors 5" £5 + £1.25 post, 6" £6 + £1.50 post 4" x 4" Muffin equipment cooling fan 115V £2.00 10" x 3" Tangential Blower. New. Very quiet - supplied with 230 to 115V adaptor on use two in series to give low blow £2.00 + £1.50 post or £4.00 + £2.00 post for two.

### IONISER KIT

Refresh your home, office, shop, work room, etc. with a negative ION generator. Makes you feel better and work harder - a complete mains operated kit, case included. £11.95 plus £2.00 post.

### TELEPHONE BITS

Master socket (has surge arrester - 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. plus 3 metres £2.95 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

### MINI MONO AMP

on p.c.b. size 4" x 2" (app.) Fitted volume control and a box for tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amp. Brand new, perfect condition, offered at the very low price of £1.15 each, or 13 for £12.00



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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. Bulk orders: write for quote.

### £2 POUNDERS\*

- 2P2 -Wall mounting thermostat, high precision with mercury switch and thermometer
- 2P3 -Variable and reversible 8-12v psu for model control
- 2P4 -24 volt psu with separate channels for stereo made for Mullard UNILEX
- 2P6 -100W mains to 115V auto-transformer with voltage tappings
- 2P8 -Mains motor with gear box and variable speed selector. Series wound so suitable for further speed control
- 2P9 -Time and set switch. Boxed, glass fronted and with knobs. Controls up to 15 amps. Ideal to program electric heaters
- 2P10 -12 volt 5 amp mains transformer - low volt winding on separate bobbin and easy to remove to convert to lower voltages for higher currents
- 2P12 -Disk or Tape precision motor - has balanced rotor and is reversible 230v mains operated 1500 rpm
- 2P14 -Mug Stop kit - when thrown emits piercing squeak
- 2P15 -Interrupted Beam kit for burglar alarms, counters, etc.
- 2P17 -2 rev pr minute mains driven motor with gear box, ideal to operate mirror ball
- 2P18 -Liquid/gas shut off valve mains solenoid operated
- 2P19 -Disco switch-motor drives 6 or more 10 amp change over micro switches supplied ready for mains operation
- 2P20 -20 metres extension lead, 2 core - ideal most Black and Decker garden tools etc.
- 2P21 -10 watt amplifier, Mullard module reference 1173
- 2P22 -Motor driven switch 20 secs on or off after push
- 2P25 -Counter resettable mains operated 3 digit
- 2P27 -Goodmans Speaker 6 inch round 8ohm 12 watt
- 2P28 -Drill Pump - always useful couples to any make portable drill
- 2P31 -4 metres 98 way interconnecting wire easy to strip
- 2P32 -Hot Wire amp meter - 4 1/2 round surface mounting 0-10A - old but working and definitely a bit of history
- 2P34 -Solenoid Air Valve mains operated
- 2P35 -Battery charger kit comprising mains transformer, full wave rectifier and meter, suitable for charging 6v or 12v
- 2P38 -200 R.P.M. Goodmans Motor 1" stack quite powerful, definitely large enough to drive a rotating aerial or a tumbler for polishing stones etc.
- 2P43 -Small type blower or extractor fan, motor inset so very compact, 230V
- 2P46 -Our famous drill control kit complete and with prepared case.
- 2P49 -Fire Alarm break glass switch in heavy cast case
- 2P51 -Stereo Headphone amplifier, with pre-amp
- 2P55 -Mains motor, extra powerful has 1 1/2" stack and good length of spindle
- 2P62 -1 pair Goodmans 15 ohm speakers for Unilux
- 2P66 -1 1/2kw tangential heater 115v easily convertible for 230V
- 2P67 -1 12v-0-12v 2 amp mains transformer
- 2P68 -1 15v-0-15v 2 amp mains transformer
- 2P69 -1 250v-0-250v 60 mA & 86.3v 5A mains transformer + 50p post
- 2P70 -1 E.M.I. 12v 2 amp motor two speed and reversible
- 2P72 -1 115v Muffin fan 4" x 4" approx. (s.h.)
- 2P75 -1 2 hour timer, plugs into 13A socket
- 2P82 -9v-0-9v 2 amp mains transformer
- 2P84 -Modem board with press keys for telephone redialler
- 2P85 -20v-0-20v 1/2 A Mains transformer
- 2P88 -Sangamo 24 hr time switch 20 amp (s.h.)
- 2P89 -120 min. time switch with knob
- 2P90 -90 min. time switch with edgewise engraved controller
- 2P94 -Telephone handset for EE home telephone circuit
- 2P95 -13A socket on satin chrome plate
- 2P97 -mains transformer 24V 2A upright mounting
- 2P98 -20m 4 core telephone cable, white outer
- 2P99 -500 hardened pin type staples for telephone cable
- 2P101 -15V mains transformer 4A upright mounting
- 2P105 -capillary type thermostat for air temperature with c/o switch
- 2P107 -membrane keyboard, telephone type
- 2P108 -mains motor with gear box giving 110rpm
- 2P109 -5" wide black adhesive pvc tape 33m, add £1 post if not collecting

### OVER 400 GIFTS YOU CAN CHOOSE FROM

There is a total of over 400 packs in our Baker's dozen range and you become entitled to a free gift with each dozen pounds you spend on these packs.



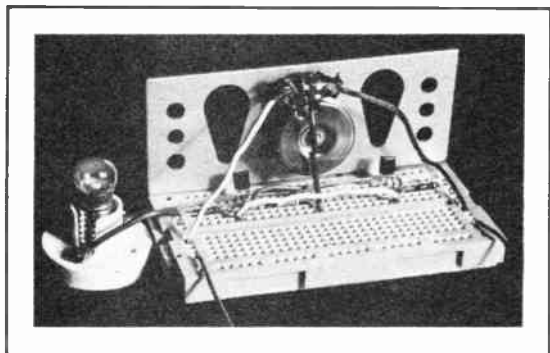
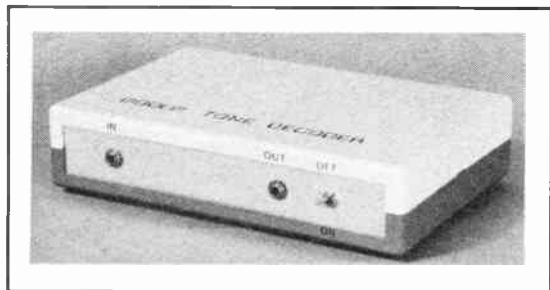
A classified list of these packs and our latest "News Letter" will be enclosed with your goods, and you will automatically receive our next news letters.

### £5 POUNDERS\*

- 5P1. 12 volt submersible pump complete with a tap which when brought over the basin switches on the pump and when pushed back switches off, an ideal caravan unit.
- 5P2. Sound to light kit complete in case suitable for up to 750 watts.
- 5P3. Silent sentinel ultra sonic transmitter and receive kit, complete.
- 5P5. 250 watt isolating transformer to make your service bench safe, has voltage adj. taps, also as it has a 115V tapping it can be used to safely operate American or other 115V equipment which is often only insulated to 115V. Please add £3 postage if you can't collect as this is a heavy item.
- 5P6. 12V alarm bell with heavy 6" gong, suitable for outside if protected from direct rainfall. Ex.GPO but In perfect order and guaranteed.
- 5P12. Equipment cooling fan - minin snail type mains operated.
- 5P13. Ping pong ball blower - or for any job that requires a powerful stream of air - ex computer. Collect or add £2 post.
- 5P15 -Uniselector 5 pole, 25 way 50 volt coil
- 5P18 -motor driven water pump as fitted to many washing machines
- 5P20 -2 kits, matchbox size, surveillance transmitter and FM receiver
- 5P23 -miniature (appr. 2 1/2" wide) tangential blow heater, 1.2kw
- 5P24 -1/2 hp motor, ex computer, 230V, mains operation 1450rpm. If not collect add £3 post
- 5P25 -special effects lighting switch. Up to 6 channels of lamps can be on or off for varying time periods
- 5P26 -Audax woofer 8" 8ohm 35 watt
- 5P27 -cartridge player 12V, has high quality stereo amplifier
- 5P28 -gear pump, mains motor driven with inlet and outlet pipe connectors
- 5P32 -large mains operated push or pull solenoid. Heavy so add £1.50 post
- 5P34 -24V 5A toroidal mains transformer
- 5P35 -modem board from telephone auto dialler, complete with keypad and all ICs
- 5P37 -24 hour time switch, 2 on/off's and clockwork reserve, ex Elec. Board loading up to 50A. Add £1 post
- 5P41 -5" extractor fan, very quiet runner (s.h.), gntd 12 mths.
- 5P45 -pack of 6 cooker clock switches
- 5P48 -telephone extension bell in black case, ex-GPO
- 5P50 -box of 20 infra red quartz glass enclosed 360W heating elements
- 5P51 -200W auto transformer 230V to 115V toroidal
- 5P52 -mains transformer 26V 10A upright mounting, add £2 post
- 5P54 -mains motor with gear box, final speed 5rpm
- 5P58 -Amstrad stereo tuner FM and LM and S. 5m
- 5P60 -DC Muffin type fan 18 to 27V, only 3W
- 5P61 -drill pump mounted on frame, coupled to mains motor
- 5P62 -2 1/2kw tangential blow heater, add £1.50 post if not collecting
- 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.

ISSN 0262-3617

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



**Readers' Discount Coupon—see page 614**

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## Projects

- 200MHz DIGITAL FREQUENCY METER** by Mark Stuart **568**  
Easy to use—easy to construct—0 to 10MHz and 10MHz to 200MHz ranges
- OPTICALLY ISOLATED SWITCH** by T. R. de Vaux Balbirnie **574**  
Mains switching in safety
- REGULATED BENCH POWER SUPPLY** by Mike Tooley BA **593**  
Separate outputs for TTL and CMOS circuits
- LIGHT TRIGGERED SWITCH** **598**  
Simple light-operated circuit—an "Exploring Electronics" project
- MODEM TONE DECODER** by R. A. Penfold **600**  
Make new friends through your micro
- CAR FLASHER WARNING** by T. R. de Vaux Balbirnie **612**  
Make sure you cancel your car indicators

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- ROBOT ROUNDUP** by Nigel Clark **577**  
A regular series that investigates the world of robotics
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Examining the different types of Read Only Memories
- DIGITAL TROUBLESHOOTING** by Mike Tooley BA **590**  
Part One: Introduction and TTL and CMOS power supplies
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*Our December 1986 issue will be published on Friday, 21 November. See page 589 for details.*

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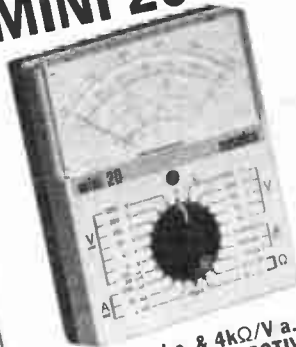
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- inductors
- ferrites
- connectors

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**28 RANGES WITH PROTECTIVE FUSE**

Accuracy: 2% d.c. and resistance, 3% a.c. (of f.s.d.)  
28 RANGES: d.c. V 100mV, 3V, 10V, 30V, 100V,  
300V, 600V; d.c. I 50μA, 600μA, 6mA, 60mA,  
600mA; a.c. V 15V, 50V, 150V, 500V, 1500V;  
a.c. I 30mA, 300mA, 3-0A; Ohms 0-2kΩ, 0-2MΩ;  
dB from -10 to +62 in 6 ranges.  
Dimensions: 105 x 130 x 40mm.

**ONLY £23.50**

## SUPER 20 A♣



**20kΩ/V d.c. & a.c.**  
**39 RANGES - INDESTRUCTIBLE**  
Electronically protected on all ranges but 10A

Accuracy: d.c. ranges 2%, 1% on ohms, 3% a.c.  
39 RANGES: d.c. V 100mV, 1-0V, 3-0V, 10V, 30V,  
100V, 300V, 1000V; d.c. I 50μA, 100μA, 300μA,  
1-0mA, 3-0mA, 10mA, 30mA, 100mA, 1-0A, 10A;  
a.c. V 10V, 30V, 100V, 300V, 1000V; a.c. I 3-0mA,  
10mA, 30mA, 100mA, 1-0A, 10A; Ohms 0-5-0kΩ,  
0-50kΩ, 0-500kΩ, 0-5-0MΩ, 0-50MΩ;  
dB from -10 to +61 in 5 ranges.  
Dimensions: 130 x 105 x 40mm.

**ONLY £33.50**

## ELECTRO TESTER A♠



**20kΩ/V a.c. and d.c.**  
**40 RANGES - with diode and fuse protection**  
plus 30A for the power men!

Accuracy: d.c. ranges and ohms 2.5% a.c. 3% of f.s.d.  
40 RANGES: d.c. V 100mV, 300mV, 1-0V, 3-0V, 10V, 30V,  
100V, 300V, 1000V; d.c. I 50μA, 100μA, 300μA, 1-0mA,  
3mA, 10mA, 30mA, 100mA, 1-0A, 6-0A, 30A;  
a.c. V 10V, 30V, 100V, 300V, 1000V;  
a.c. I 3-0mA, 10mA, 30mA, 100mA, 1-0A, 6-0A, 30A;  
Ohms: 10kΩ, 100kΩ, 1MΩ;  
dB from -10 to +61 in 5 ranges.  
Dimensions: 105 x 130 x 40mm.

**ONLY £32.00**

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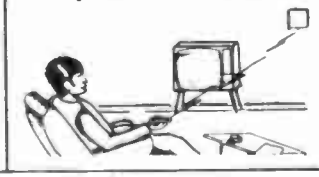
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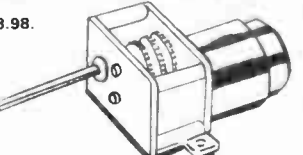


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# EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY

VOL 15 N°11

NOVEMBER '86

## SOLDERING ON

Now that winter is virtually upon us all you lucky readers can get on with building more projects in the long dark evenings (Australian readers please save this copy to read in June). To keep you all happy we have added a few extra pages to your magazine and included a special feature on soldering—just as a reminder of course. We realise that you know how to solder so the article is obviously aimed at someone else—but just take a look at your last project and compare the back of your p.c.b. with that in a piece of commercial equipment! You would be surprised how many readers' projects fail due to their inability to wield a soldering iron with sensitivity and sensibility—you don't suppose it could be someone not a million miles from you, do you? Anyway, irons don't last for ever and a modern temperature controlled instrument is a worthwhile investment.

## TROUBLE

We are also kicking off our *Digital Trouble Shooting* series in this issue. This has been designed to appeal to a very wide cross section of our readership; in fact, with the projects that form part of the series, there should be something for everyone. The introduction gives a run down of all the associated projects. This type of series is always very popular and we urge you to place an order with your newsagent or take out a subscription to ensure you get every issue.

## INDEX

As is now our normal practice, next month's issue will carry an index for the whole of 1986. The index shows exactly which articles have appeared and when and is very useful especially if you keep all your issues in an EE Binder (see the note at the foot of this page).

Each binder holds twelve issues with the page numbering running right through the bound volume. With issues stored like this they are neat, attractive and form a unique reference manual. Next time you want to find an old project or circuit, or someone decides the pile of mags is too untidy and disposes of them, just remember a binder would have prevented the problem. By the way we have just *reduced* the price of our binders, but we have had to increase the cost of back numbers due to the cost of storage and handling etc., so it makes sense to protect your issues.

## DESIGN

An interesting and possibly rewarding competition is being announced in our advertising pages this month. All you bright readers with a host of ideas should take a look at the Design Against Crime Competition.



## BACK ISSUES & BINDERS

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 now sold out of Oct. and Nov. 85 and April 86.)**

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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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All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.

## COMPONENT SUPPLIES

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

## OLD PROJECTS

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

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# 200 MHz Digital Frequency Meter



MARK STUART

**Easy to use—  
easy to  
construct—0 to  
10MHz and  
10–200MHz  
ranges**

THIS project was designed to provide a simple easy to use digital frequency meter without sacrificing accuracy or frequency range. Throughout the design particular attention was paid to keeping the cost down and the construction simple. The resulting instrument is compact and extremely convenient to use. Among its more obvious applications are checking C.B. and amateur radio transmitter frequencies, calibrating signal generators and providing accurate frequency readings when used in conjunction with a function generator when measuring audio amplifier frequency responses, etc.

The unit was designed to be powered from a small plug-in transformer but can also be powered from a 12V car battery or four HP7 cells for portable use.

## SPECIFICATION

The circuit uses eight 0.56 inch red seven segment l.e.d. displays to give a large bright clear read-out. Two frequencies ranges cover 0–10MHz and 10–200MHz. The display is automatically up-dated at one second intervals giving resolution down to 1Hz on the 10MHz range and 100Hz on the 200MHz range. Between readings the display holds the previous reading, providing a stable continuous read-out.

Accuracy of the frequency readings depends upon the internal 10MHz crystal. A standard commercial quality crystal is used, giving 0.002 per cent initial accuracy with a possible thermal drift up to 0.003 per cent per degree Celsius. If required the initial error can be trimmed out by reference to the 200kHz BBC Radio 4 carrier frequency so that very accurate measurements can be made especially if the meter is kept at or near room temperature.

Power requirements are approximately 100mA at five volts. An internal voltage regulator permits external d.c. supplies from 9V to 16V to be used as an alternative to the plug-in 9V transformer specified. When portable operation is required four standard or re-chargeable small cells can be used to give several hours of operation.

## CIRCUIT

The circuit diagram of the complete unit is shown in Fig. 1. The heart of the circuit is IC2 which provides all of the timing, counting, and display decoding functions. This remarkable i.c. provides direct drive to the entire eight digit display eliminating the need for current limiting resistors digit driving transistors and so on. There are a number of versions of this i.c. (the ICM7216), it is important that only the ICM7216D is used in this circuit—the others will not work at all.

A crystal oscillator is also built into IC2 and this is connected to the 10MHz crystal XL1 at pins 25 and 26. Resistor R7 provides d.c. bias for the oscillator and capacitors C15 and C16 provide the correct loading to suit the crystal. Where maximum accuracy is required the frequency of the crystal can be fine tuned over a small range by varying the value of C15.

To minimise the number of connections and so keep down the number of pins needed on the i.c. the display is "multiplexed". This means that each digit is lit for 12.5 per cent of the time. To do this each one of the eight digit driver lines is activated in turn by taking it from +5V down to 0V. For each digit the segment drivers are fed with the particular code to light the number required. The whole process takes place at 500Hz so that there is no perceptible flicker and all eight displays appear to be lit continuously.

The position of the decimal point in the display is selected by connecting pin 13 of IC2 to the digit drive output where the decimal point is required. In this application the decimal point is required after X7 for the 10MHz range and after X5 for the 200MHz range. Switching between the two is carried out by IC6c and IC6d which are analogue gates controlled from the range switch S2. When S2 is in the 10MHz position the +5V supply is connected to the control input of IC6c via S2b. This turns on the analogue gate and connects pin 13 of IC2 to the X7 digit drive line. The control input of IC6d is held at 0V via R2 ensuring that the X5 digit drive line is disconnected. On the 200MHz range the situation is reversed so that the X7 line is disconnected and X5 line is connected. S2b also provides gate control voltages for IC6a and IC6b which select which input stage is used to provide the signal to be counted by IC2.

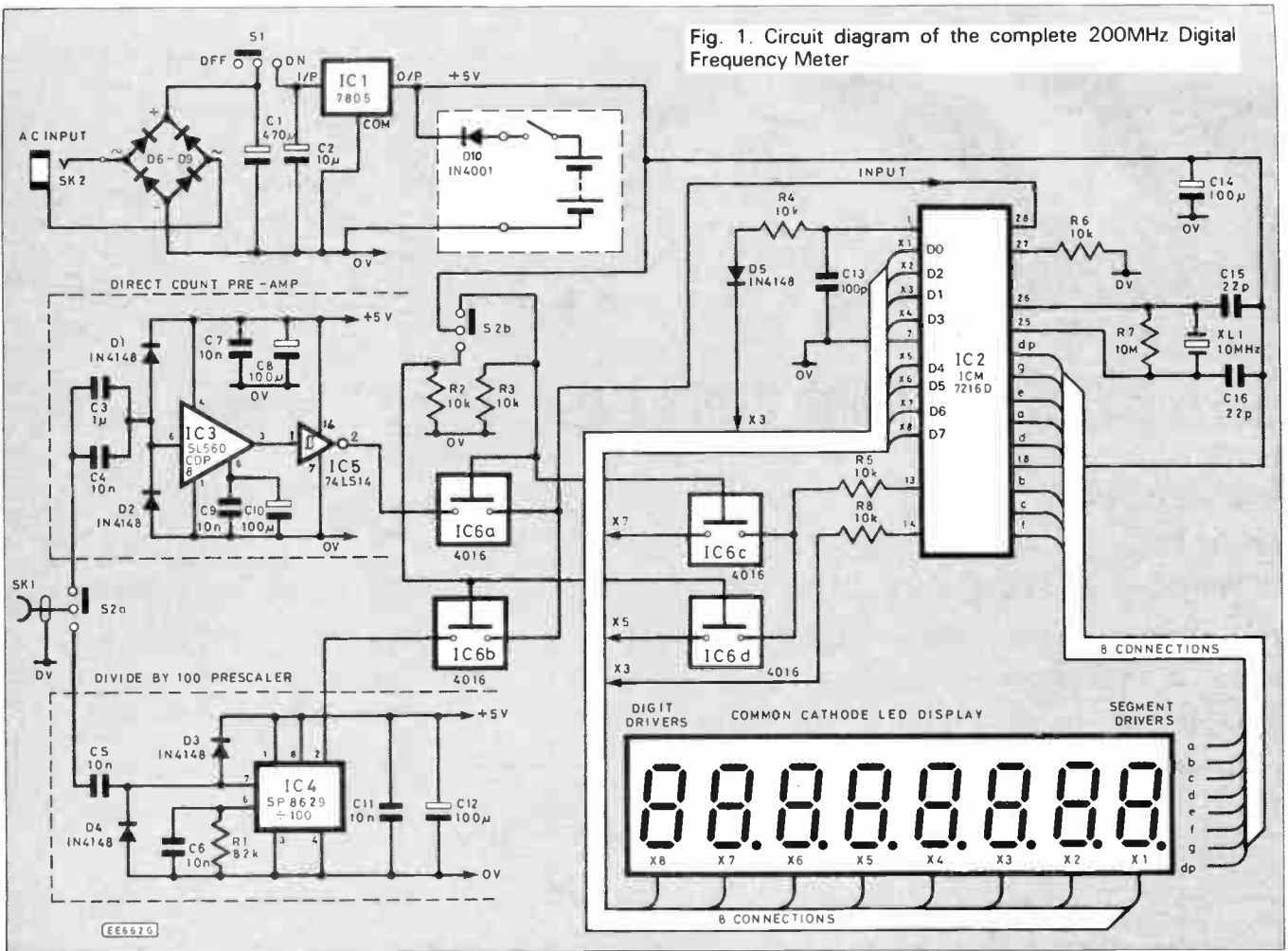
There are two other pins on IC2 which are linked to the digit select lines. Pin 1 provides various functions such as display test, and blank display, by connecting it either to the X8 or line X4. In this application pin 1 is linked to the X3 line to select "external decimal point" mode. This allows the decimal point to be positioned by linking pin 13 to the digit drive outputs as already described.

Pin 14 of IC2 is the "range" input which is used to select whether the input signal is counted for 0.01sec, 0.1sec, 1sec, or 10sec by connecting it respectively to digit drive

Front panel layout and legend for the 200MHz Digital Frequency Meter.



Fig. 1. Circuit diagram of the complete 200MHz Digital Frequency Meter



lines X1, X2, X3, or X4. The one second setting is most suitable for the present circuit as it gives a full eight digit display for 10MHz. On the 200MHz position it would be possible to gain an extra digit by selecting the ten second range, however a ten second wait between readings is too long for most practical purposes and so a common one second period is used.

### INPUT STAGES

The input circuits of the meter are completely different for the two frequency ranges. On the 10MHz range the signal is first amplified by IC3 and then squared by IC5 before being passed to IC2. IC3 contains a very high speed three transistor amplifier with a gain of 25 at frequencies up to well over 100MHz. IC5 is a schmitt trigger i.c. which is used to square up the output of IC3 so that low frequency sine waves can be counted correctly. Without IC5 the circuit would work perfectly at high frequencies but would not count low frequency sine wave inputs at all. This is because the input voltage to IC2 must change at a rate faster than 25V per micro-second to trigger the input counting circuits.

The input is coupled to IC3 by means of C3 and C4. Two capacitors are used because the larger value capacitor will not be as effective at high frequencies because of its construction. The smaller ceramic disc capacitor freely passes the high frequencies whilst not being as effective at low frequencies. Together the two capacitors are effective over the necessary wide band of frequencies.

Diodes D1 and D2 are incorporated to

## COMPONENTS

Approx. cost **£60**  
Guidance only

### Resistors

R1	82k
R2 to R6, R8	10k (6 off)
R7	10M
All 5% carbon film 1/4 W	

### Capacitors

C1	470µ axial elect. 25V
C2	10µ radial elect. 25V
C3	1µ min 100V layer type
C4 to C7, C9, C11	10n disc ceramic (6 off)
C8, C10, C12, C14	100µ min radial elect. 6-3V (4 off)
C13	100p ceramic
C15, C16	22p ceramic (2 off)

### Semiconductors

D1-D5	1N4148 (5 off)
D6-D9	50V 1A diode bridge
D10	1N4001
X1 to X8	Seven segment display 0.56 inch common cathode type HDSP 5303 (8 off)
IC1	7805 voltage regulator
IC2	ICM7216D (see text)
IC3	SL560CDP8
IC4	SP8629
IC5	74LS14
IC6	4016 CMOS

### Miscellaneous

S1, S2	d.p.d.t. miniature slide switches (2 off)
XL1	10MHz HC18U wire ended crystal
SK1	50 ohm BNC socket, bulkhead mounting type
SK2	3.5mm jack socket

Perspex for display window; p.c.b. available from the *EE PCB Service*, code EE 548; wire, screws and nuts; 9V a.c. plug in power supply (see text); two 14-pin and one 28-pin i.c. mounting sockets; case approx 160 x 95 x 60mm.

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Talk**  
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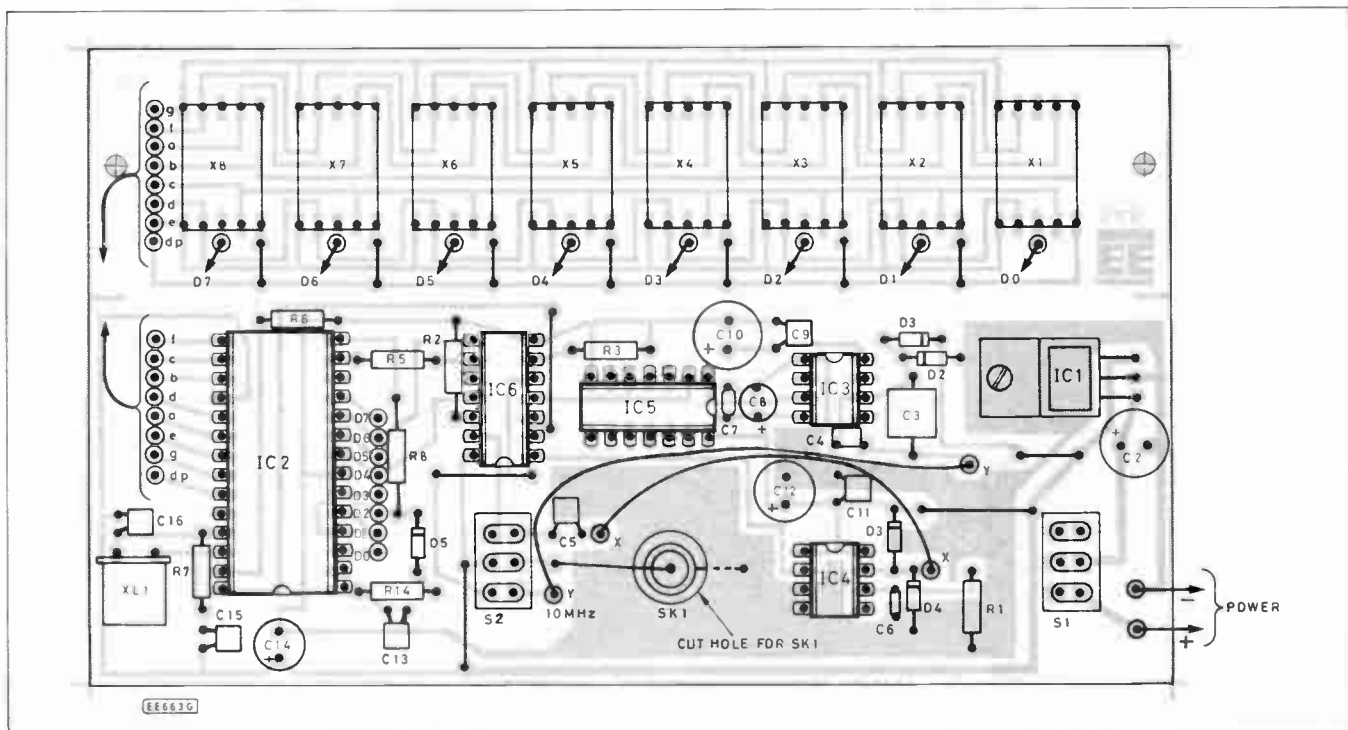


Fig. 2. Component layout on the p.c.b. This board is available from the *EE PCB Service*: code EE 548.

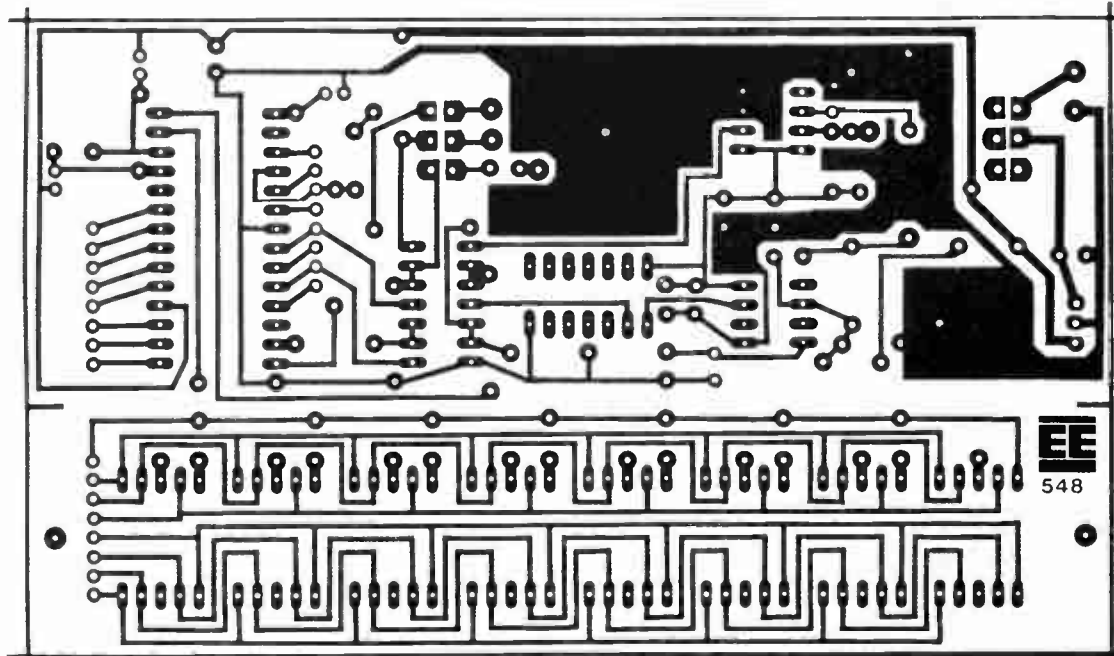


Fig. 3. Track pattern for the p.c.b. (full size).

protect the input circuits from excessive input voltages, and capacitors C7, C8, C9 and C10 provide decoupling of the power supply and the input stages of IC3. Two capacitors are again used in each case to cover the wide frequency range.

On the 200MHz range a prescaler i.c. is used to divide the incoming frequency by 100 so that it is reduced to a value that can be handled comfortably by IC2 which has an upper frequency limit of 10MHz. The necessary adjustment to the display so that it reads correctly is achieved by moving the decimal point from X7 to X5.

As well as the divider circuit, IC4 also contains a pre-amplifier and so no further signal amplification is required. Only a single input coupling capacitor is required on this channel as frequencies below 10MHz are of no interest. Diodes D3 and D4 are fitted to protect the circuit from excessive input signals. The input to IC4 is a

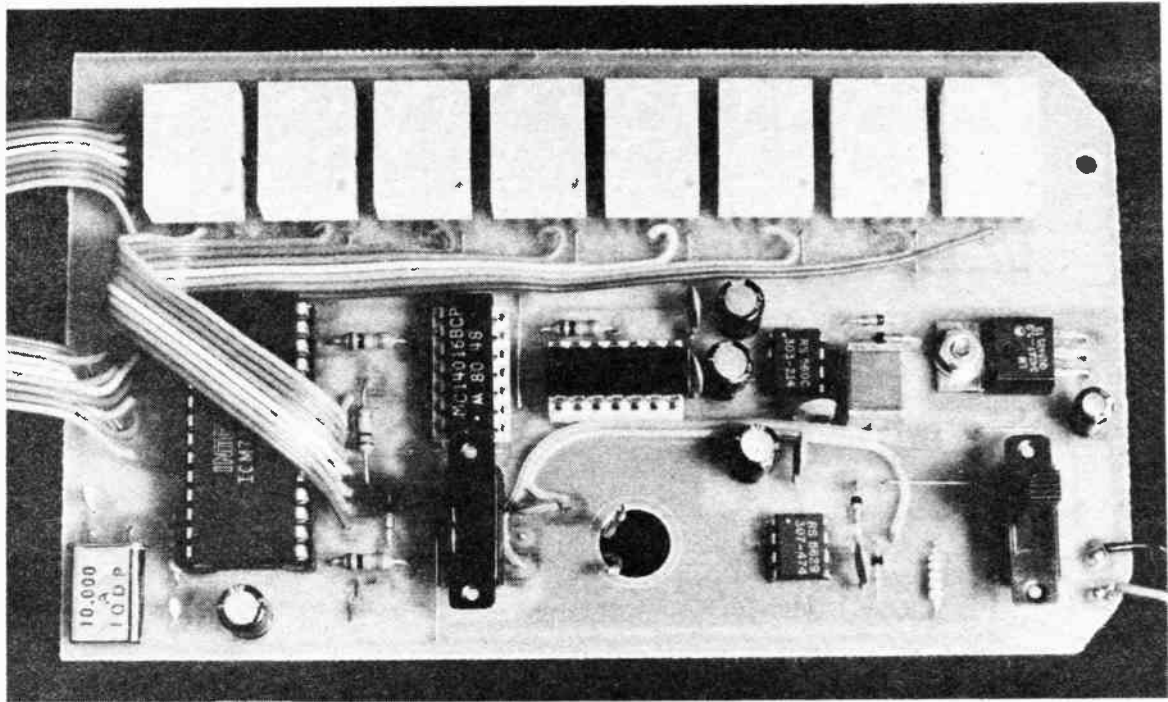
differential amplifier circuit which like an op-amp i.c. has inverting and a non-inverting terminals. Pin 6 of the i.c. which is the inverting input is decoupled by C6 and given a small offset bias by means of R1. This introduces a small signal cut off effect which prevents circuit noise from causing spurious counting. The selection of R1 is a compromise between sensitivity and false triggering. Reducing its value will decrease the sensitivity if random counting is found to be a problem.

The power supply section of the circuit is completely straightforward. An i.c. voltage regulator provides five volts output for any input from 9V to 16V. For mains operation a simple plug-in 9V a.c. transformer followed by a diode bridge and smoothing capacitor is used. When portable operation is required a small battery holder containing four 1.5V HP7 cells can be used and will give several hours of operation.

## CONSTRUCTION

The circuit is built on a single printed circuit board. Fig. 2 shows the component layout and Fig. 3 the track pattern. As parts of the circuit are operating at very high frequencies it is **essential that the layout shown is used**. Even simple changes to the input stages could result in instability and oscillation which would make the instrument completely unusable. The final layout shown is completely stable and reliable and there should be no difficulty at all in producing a sound stable instrument.

To simplify board layout and to save space the displays have been wired to IC2 using short lengths of ribbon cable. The cable should be connected to the board directly by stripping and twisting approximately 5mm of each wire, passing it through the board, and soldering on the track side. This method is simpler and neater than



using wiring pins which are only really necessary when the wires are going to be disconnected and reconnected several times.

The display layout has been done so that if required the display section of the board can be cut off and mounted at an angle or remotely if required to allow various types of case to be used.

In the prototype the board is kept in one piece and mounted to the front panel by means of the two switches S1 and S2. The input socket SK1 is mounted directly on the front panel and fitted with two short lengths of tinned wire which are soldered directly to the printed circuit board tracks after the board is fitted in position.

ICs 3 and 4 should be fitted directly to the board to avoid introducing the extra capacitance of sockets. The other i.c.s can be fitted in standard low profile sockets. The crystal XL1 should have its leads bent carefully at 90 deg and be fixed to the board with a small piece of double sided adhesive tape. Take care not to stress the glass seal when bending the leads as this can severely reduce the reliability and stability of the crystal. The displays are fitted directly to the board as sockets are not readily available and soldercon pins are very difficult to use properly. Make sure the displays are mounted the right way up by means of the manufacturer's type number which is printed on the top of each digit.

Switches S1 and S2 have tags which are too big to mount directly on the board. The switches should first be fitted with short lengths of tinned wire which can then pass easily into the board and be soldered in position. Make sure when doing this that the switches are fitted squarely and as close to the board as possible.

The voltage regulator IC1 is fitted with its tab flat against the board. As this is a 1A device it is not necessary to provide any heatsinking unless continuous operation from more than 12 volts d.c. is anticipated in which case a small strip of aluminium should suffice.

To keep the mechanical assembly of the counter as simple as possible the front panel is made in two parts. The top part is the display window made from a piece of

transparent red perspex 3mm thick. The bottom part is made from the case front panel simply by cutting a strip from the top edge. The two panels are joined in the middle by means of a thin film of adhesive where the perspex panel overlaps the metal panel. The edge of the perspex can be "tidied up" if required by fixing a thin strip of black plastic tape on the front surface.

Power is provided by a plug-in power supply delivering 9V a.c. This is connected to the counter via a 3.5mm jack plug and socket. A small diode bridge mounted on the socket and smoothing capacitor (C1) provide the necessary 9V d.c. which feeds the 5V regulator on the board (Fig. 4). A 12V car battery can also be used as an external power supply. It can be connected via the diode bridge and smoothing capacitor as these will have no effect on the d.c. supply.

If an internal battery supply is required this is connected to the 0V and +5V rails via diode D7 which will prevent the battery from being damaged if an external supply is accidentally connected. A separate on-off switch can be fitted or alternatively the unused section of the on-off switch is available. Fig. 5 shows the mechanical construction of the unit and p.c.b. mounting.

## TESTING

Once the circuit board has been completed it should be very carefully inspected for dry joints, solder bridges and reversed components. When everything looks correct, connect the power and check that the

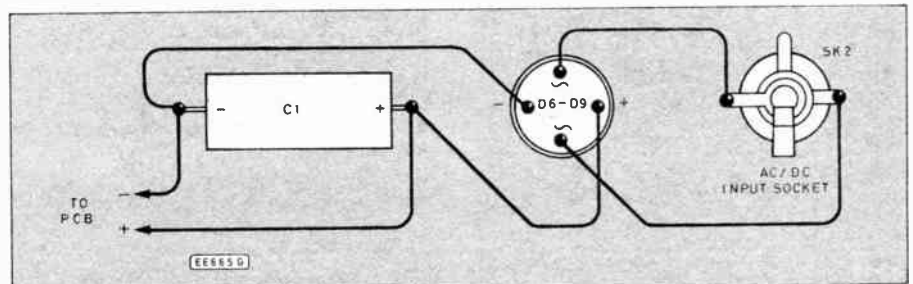
displays to the right of the decimal point show zeros. Check that operating S2 moves the decimal point from X7 to X5. If a multimeter is available the current taken by the circuit can be measured. A figure of around 100mA is correct.

If all these checks are correct the only thing that remains is to connect an input signal and check that the display gives stable accurate readings from known frequencies. The initial accuracy of the instrument is determined by the counter crystal XL1. For most purposes this will be adequate without trimming, however if desired it is possible to vary the crystal frequency slightly by altering the value of C15. This should be done whilst a known frequency standard is connected to the counter input. If required C15 can be replaced with a small high quality 33 picofarad trimmer capacitor and the frequency set up exactly.

## USE

Use of the frequency meter is quite straightforward. Provided there is a sufficiently high input signal level the display should give stable readings from a variety of sources. When low level, low frequency sine wave inputs are used the display may vary from reading to reading due to circuit noise on the input. This effect is due to the very wide bandwidth of the amplifier which is necessary to enable 10MHz readings to be made. It is a normal characteristic of digital frequency meters and is overcome by either increasing the input signal amplitude or by using a square wave of the same frequency.

Fig. 4. Wiring of the components for the 9V a.c. power supply.



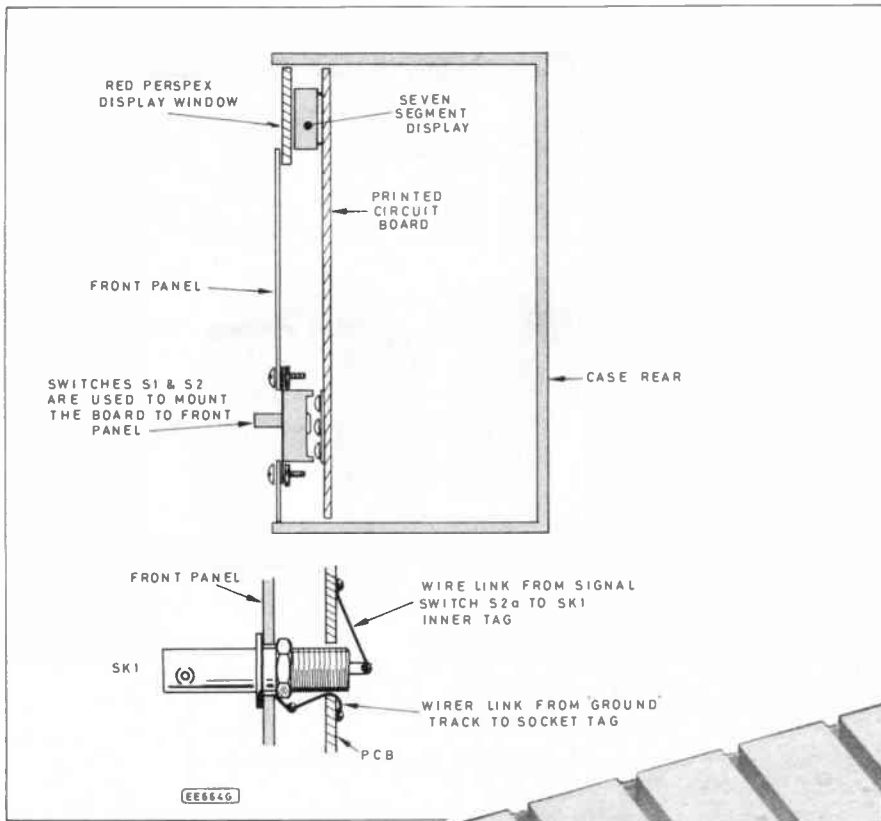
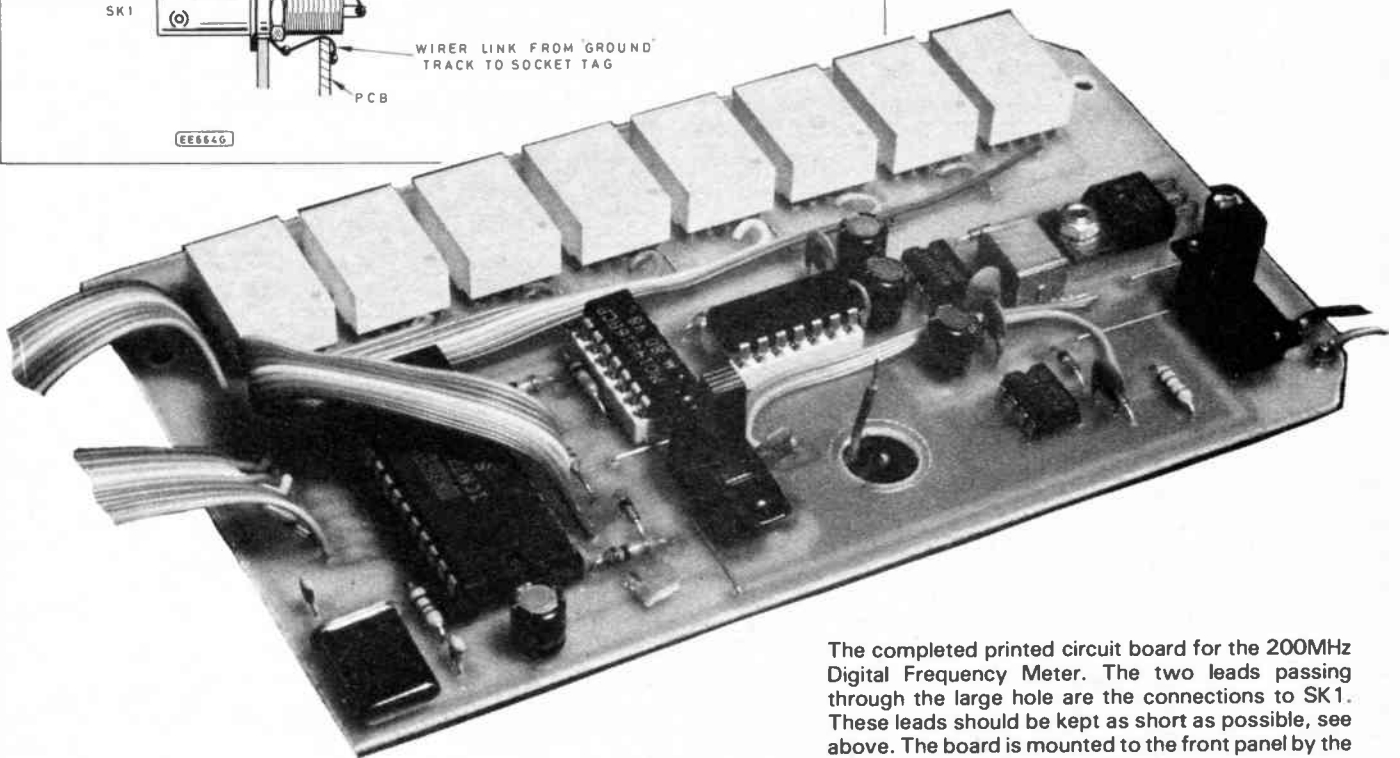


Fig. 5. Switches S1 and S2 are used to mount the p.c.b. to the case. Note that spacers may be required between these switches and the front panel. In this format it is simply necessary to trim the top section off the front panel of the case and replace it with a piece of red tinted perspex to form a display window. Also shown are the connections to SK1; these should be kept as short as possible and soldered to the p.c.b. once it is mounted.



The completed printed circuit board for the 200MHz Digital Frequency Meter. The two leads passing through the large hole are the connections to SK1. These leads should be kept as short as possible, see above. The board is mounted to the front panel by the switch mounting tabs.

Most signal generators (such as the *Function Generator* published in EE Feb '86) have a constant amplitude square-wave output which can be connected to the digital frequency meter whilst the other sine wave or triangular wave outputs are used as inputs to the circuit being tested. A typical arrangement for plotting the frequency response of an amplifier is shown in Fig. 6.

To check the operating frequency of C.B. and amateur radio transmitters it is necessary only to connect a short length of wire to the input socket and be within about 10 metres of the transmitter antenna. Note that the digital frequency meter should never be connected directly to transmitters of any type as the input would be badly overloaded by the large signal. The upper frequency limit of the circuit is determined by the prescaler i.c. which is guaranteed to be 150MHz and typically exceeds 200MHz. □

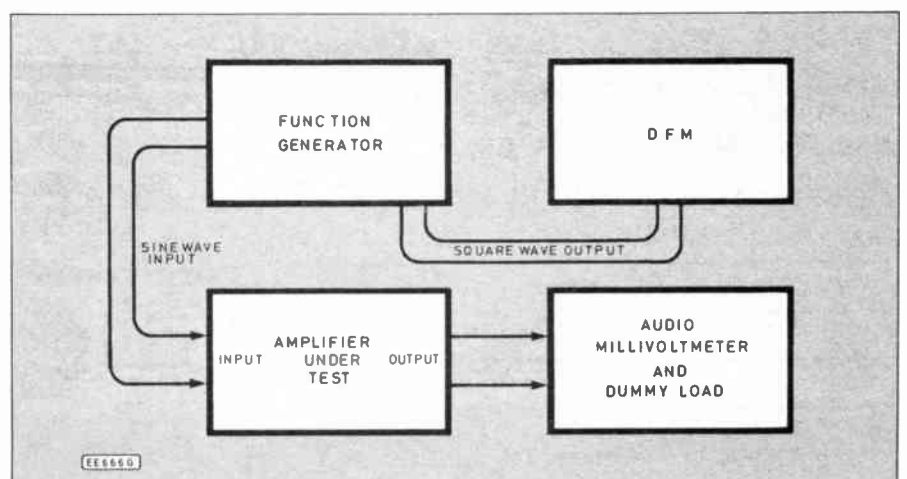


Fig. 6. A typical arrangement for checking amplifier frequency response.

# REWARD

# £500

## FOR YOUR DESIGN AGAINST CRIME

If you've ever asked yourself what the general public can do about the rising crime rate, here's one answer. Have a go at this competition sponsored by the British Security Industry Association – you could well be handsomely rewarded in the process.

All you have to do is submit your own design or idea for an anti-crime product. It can be something to deter a burglary. Or to prevent an assault. Or to protect a car from being broken into. Or to stop a computer fraud being committed. It can be virtually anything, but it must be original.

A further encouraging thought: our prize could just be the start of the financial rewards possible if the winning idea takes off. In this case, advice would be available in developing products with real potential.

Your entry can be detailed with drawings or it can be just a simple description. So if you haven't yet received an entry form send back this Freepost coupon now. It's the most acceptable way of making crime pay.

*\*An important note to those in full-time education or the security industry.*

The B.S.I.A. are running special categories of 'Design Against Crime' awards and competitions for you too. Don't miss the entry form/leaflet that will give you full details of what you can win.

Competition closes 30th January 1987.

FOR YOUR ENTRY FORM, POST THIS COUPON TO:

**'Design Against Crime' Competition**  
**FREEPOST, 107-109 High Street,**  
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Please send me ..... entry forms.

NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_  
\_\_\_\_\_  
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Entry category: **General Public**

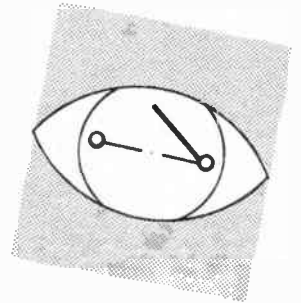
(Tick as appropriate) **School/Colleges**



**DESIGN**  
**AGAINST**  
**CRIME**  
**COMPETITION**

A red pencil is positioned vertically, pointing downwards, and is superimposed over the word 'CRIME' in the 'DESIGN AGAINST CRIME' logo.

# OPTICALLY ISOLATED SWITCH



T.R. de Vaux Balbirnie

## Switch on in safety even in damp conditions

PEOPLE are understandably wary of installing mains switches in damp places for, unless safety procedures are strictly observed, the effects can be dangerous. This *optically-isolated* system overcomes the problem since no electrical connections exist between the switch itself and the mains. Any light-duty switch may be used, connected with cheap twin wire; some readers might use the circuit simply to avoid the high cost of mains switches and long pieces of cable. One application is to operate a porch light from a point outside the house—to prevent unauthorised use, a key operated switch could be used.

The Optically-Isolated Switch may be used with lights or other non-inductive appliances up to 300W rating on 240V mains. The entire system, apart from the switch and connecting wires, is housed in a wall-mounted plastic case with a socket to connect the remote switch and a flying lead for plugging into a nearby mains outlet. A

mains on-off switch with neon indicator and a fuse are provided. Internal "AA" size batteries provide power for the switch section of the circuit and these will give long service in normal use. For very long duty periods, it is better to use nickel-cadmium batteries kept charged as required. With the light on, the circuit draws a few milliamps from the batteries. When off, consumption is virtually nil.

Constructing this circuit demands special care over mains connections. In cases of doubt, the assistance of a qualified electrician must be sought.

### CIRCUIT

The entire circuit for the Optically-Isolated Switch is shown in Fig. 1. The dotted line indicates the division between battery and mains sections. S1 allows current to flow from the battery, through R1 and R2 to the base of TR1 in the Darlington arrangement, TR1/TR2. Both transistors turn on and allow current to flow in the l.e.d. contained in IC1 via pins one and two. Resistor R4 and VR1 limit the operating current. IC1 is a six-pin integrated circuit containing a triac as well as the l.e.d. just mentioned. With the l.e.d. on, the triac triggers and operates the mains section of the circuit.

The l.e.d. often requires much less current to operate the triac than the data specifies so VR1 provides an adjustment to minimise this and conserve the battery. With the triac section of IC1 on, a conducting path is established between pins four

## COMPONENTS

See  
**Shop  
Talk**

### Resistors

R1,R2	1M (2 off)	page 588
R3	2M2	
R4	150	
R5	150 2W (or 3 off 470 0.5W wired in parallel)	

All  $\frac{1}{4}$ W except where stated

### Potentiometer

VR1	1k miniature preset: vertical mounting
-----	---

### Capacitor

C1	10n ceramic
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### Semiconductors

IC1	MOC3020 optically- isolated triac
CSR1	C206D 3A triac
TR1,TR2	BC184L npn silicon (2 off)

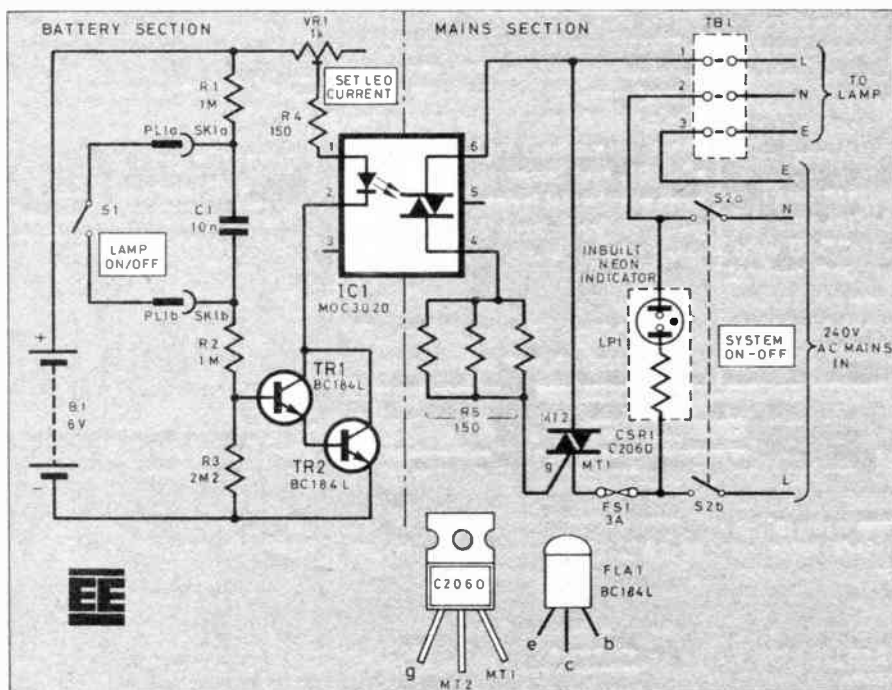
### Miscellaneous

S1	small single-pole switch (or 2 off 2- way switches—see text)
S2	d.p.s.t. mains rocker switch with neon indicator
B1	"AA" size batteries (4 off)
FS1	3A fuse and 20mm panel-mounting fuseholder
TB1	3A terminal block

Battery holder for above with PP3 connector; 6-pin d.i.l. socket (or 8-pin socket if 6-pin not available); TO66 mounting kit for CSR1; thin sheet aluminium for triac panel size 32 x 60mm; plastic box size 150 x 80 x 50mm external (2005 box); fixings; connecting wire; cable clamps etc.

Approx. cost  
Guidance only **£8.50**

Fig. 1. Complete circuit diagram of the Optically Isolated Switch.





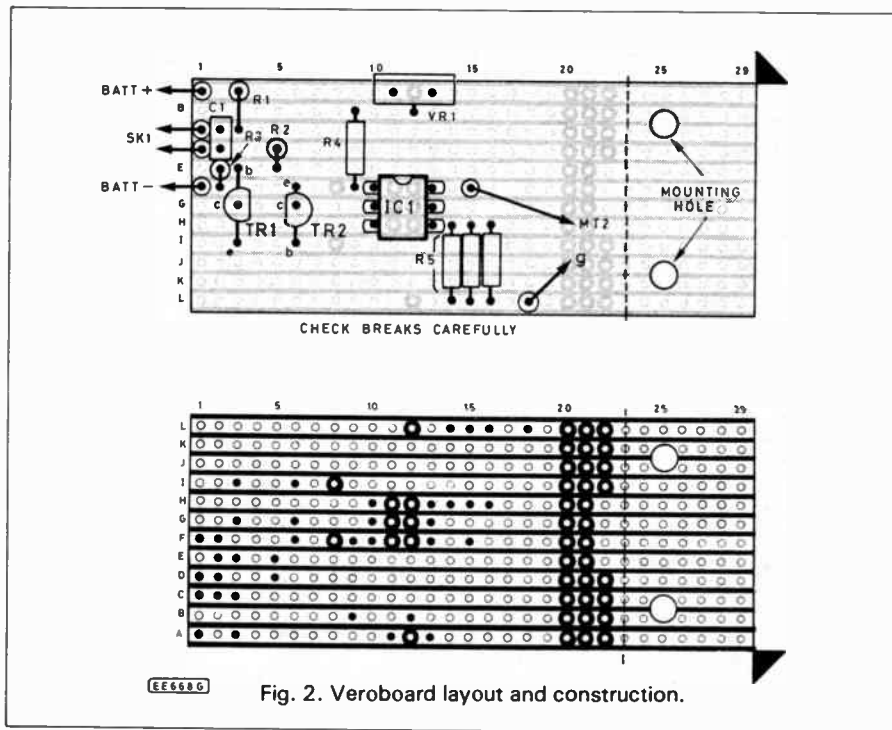


Fig. 2. Veroboard layout and construction.

and six. Although the internal triac is capable of carrying mains current, this is not sufficient for a suitable lamp so for this purpose a separate triac, CSR1, of greater current rating is used. Triggering is achieved through R5. With S1 off, the i.e.d. no longer maintains the triacs so they both switch off next time the a.c. cycle falls to zero. Since this never takes longer than 1/100th second, the effect appears to be instantaneous. The reason for the darlington pair, TR1 and TR2, is to allow a very high input resistance ( $R1 + R2$ ) giving even greater isolation between the switch and the rest of the circuit.

Fuse FS1 protects the circuit from overload. It may occasionally blow when a lamp fails, so the fuseholder has been made

accessible from outside the case. Adjustment to VR1 is made through a hole drilled in the case lid so all testing and operation is carried out with the case closed—an important safety point.

### CONSTRUCTION

Refer to Fig. 2 and construct the circuit panel using a piece of 0.1 inch matrix stripboard size 12 strips  $\times$  29 holes. Make the breaks as indicated: **Safety depends on the copper strips being completely broken**—check carefully. Drill the two holes used for mounting the triac panel, mount the i.c. socket (it may not be possible to buy one with six pins so buy an eight pin socket and file it down). Follow with all on-board

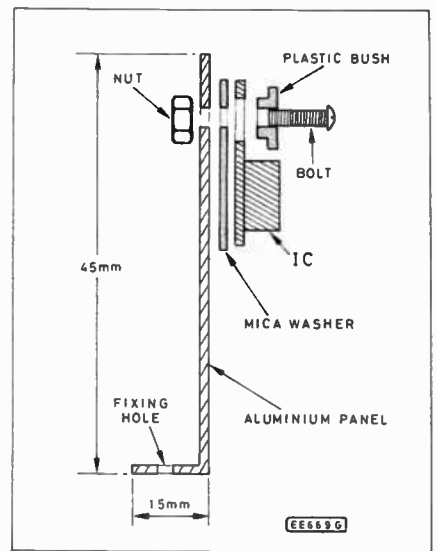


Fig. 3. Details for mounting the triac.

components. Resistor R5 requires an adequate power rating and either three 470 ohm resistors as specified connected in parallel may be used or, alternatively, a single 150 ohm 2W component. Solder light-duty stranded connecting wires to strips C and D. Extend the battery connector leads as necessary and connect these to strips A and F. Refer to Fig. 3 and make the triac panel from thin sheet aluminium size 32  $\times$  60mm. Attach the triac using a single fixing and a mounting kit. This prevents the panel becoming "live". Attach the triac panel to the circuit panel using the holes drilled for the purpose. Make the gate and MT2 connection using mains-rated wire.

Prepare the case by making holes for FS1, S1, SK1, TB1 mounting and for mains input and lamp wires. With the circuit panel in position, measure the position of VR1 and drill a hole of 5mm diameter in the lid of the case to correspond. Check that a

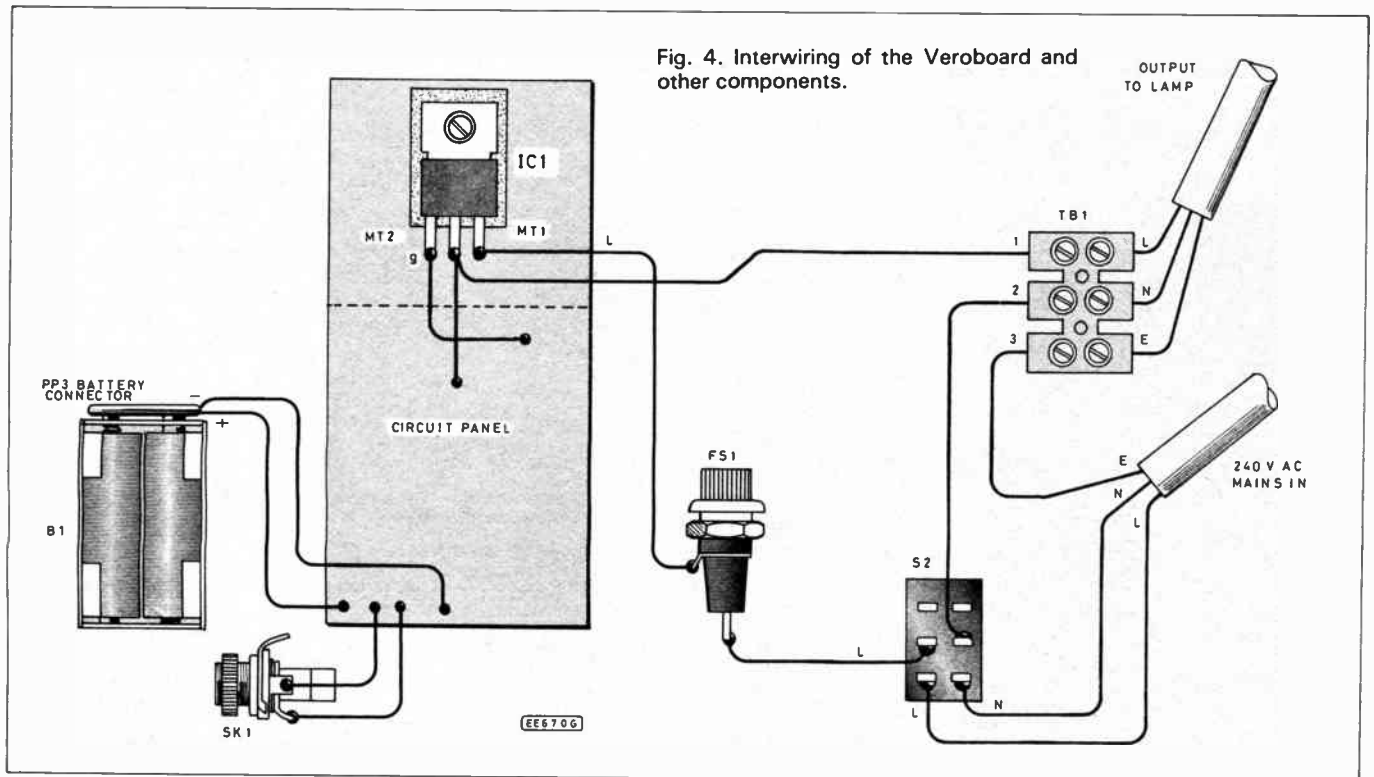


Fig. 4. Interwiring of the Veroboard and other components.

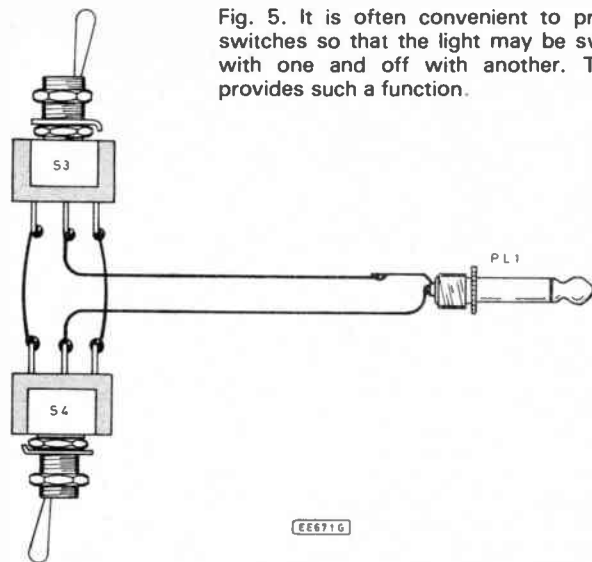


Fig. 5. It is often convenient to provide two switches so that the light may be switched on with one and off with another. This circuit provides such a function.

small screwdriver can be used through the hole for adjustment. Leave the sliding contact of VR1 fully clockwise. Refer to Fig. 4 and complete the internal wiring using 3A mains-rated wire for all S2, FS1 and TB1 connections. Note that TB1/3 is only needed if the light has an earth connection. Fit the mains leads with strain relief clamps inside the case. Place a 3A fuse in the fuseholder and connect the batteries. If possible, fit used batteries for testing and adjustment purposes since this will ensure correct operation as the new ones age. Cut two pieces of thick cardboard to secure the battery holder as shown in the photograph.

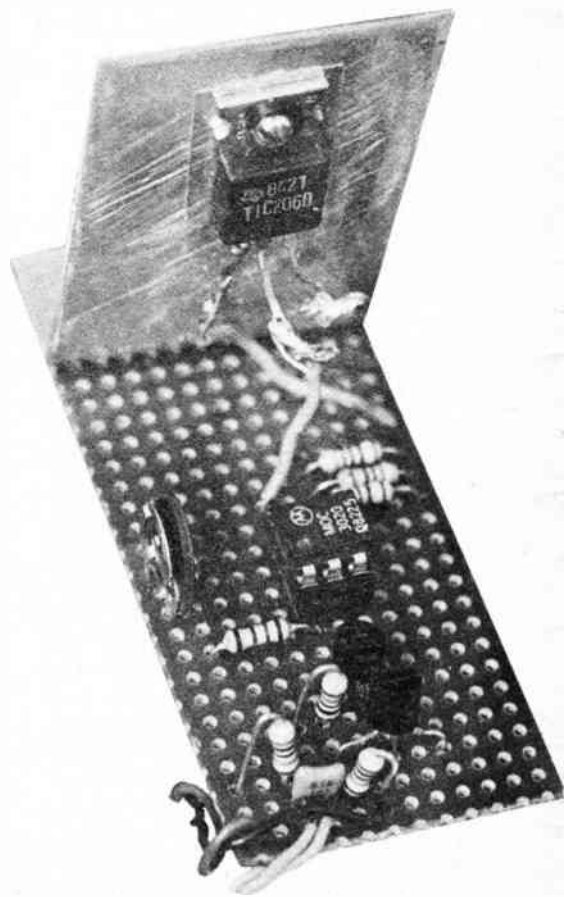
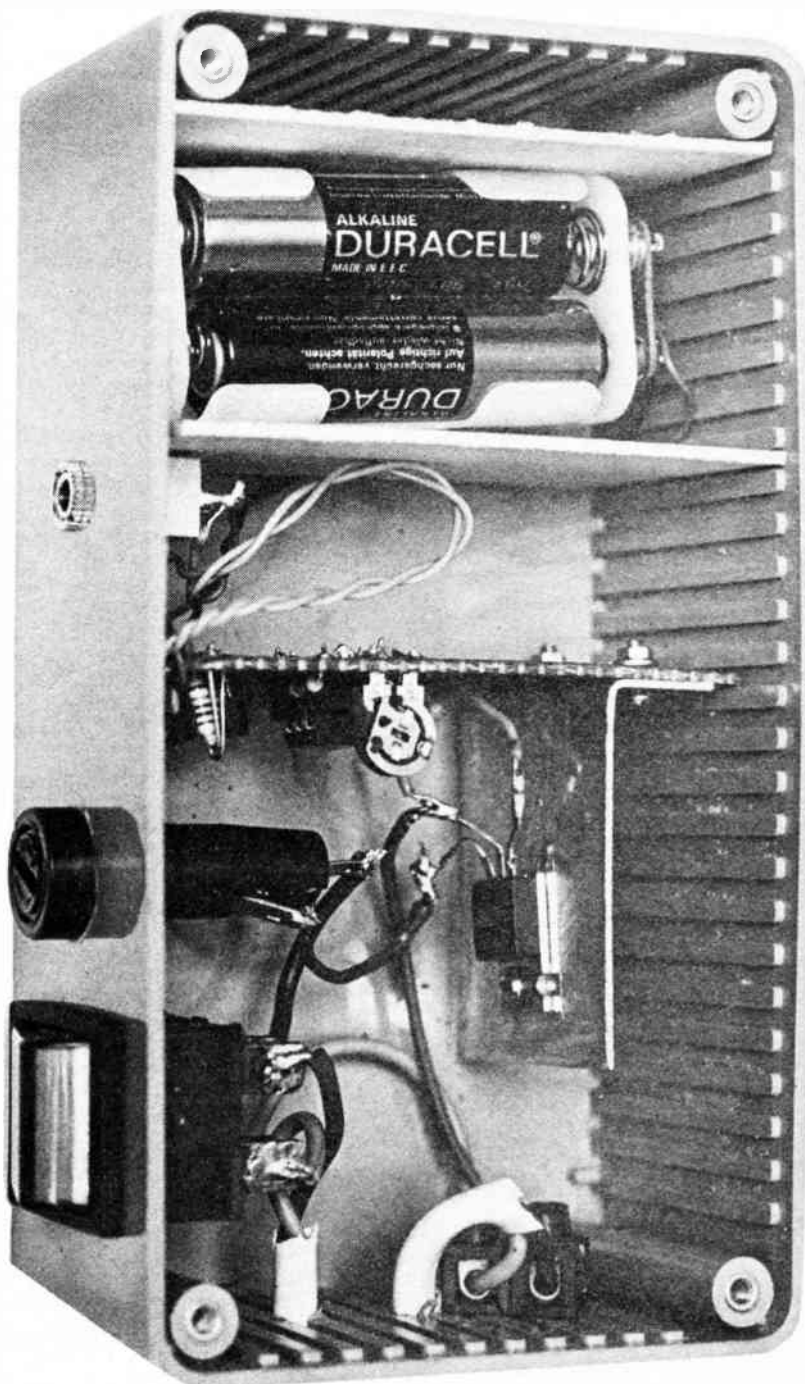
## INSTALLATION AND ADJUSTMENT

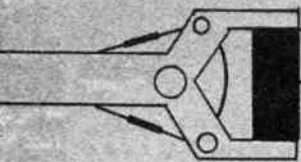
Due to exposed mains connections, all operation must be carried out with the lid of the case on. **Unplug from the mains before changing batteries.** Secure the main unit to the wall in a dry place. Connect S1 with light-duty twin wire. Plug the unit into the mains and test the system. The lamp may flash briefly as S2 is switched on—this is of no consequence. Adjust VR1 anti-clockwise to give minimum l.e.d. current for reliable operation. If it works with the sliding contact fully anti-clockwise so much the better.

Switches situated outdoors should be protected from rain to prevent corrosion and early failure. Also, any water entering and "bridging" the contacts will short-circuit them and actuate the light. If the lamp flickers or operates at reduced brightness this is a sign to replace the batteries.

## TWO-WAY SWITCH

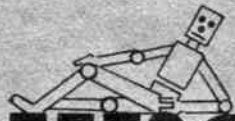
A circuit to enable the light to be switched on with one switch and off with the other is shown in Fig. 5. Both switches are single-pole two-way types. □





# Robot Roundup

NIGEL CLARK



## MECCANO

With kit makers like Lego and Fischer having moved into the technology market some time ago it was inevitable that another of the famous names should eventually follow. Meccano, which for many of today's adults was their introduction to things technical, has introduced a range of technology kits catering for a wide variety of abilities.

At the top end of the range are the Enthusiast Sets the largest of which contains more than 600 parts and detailed instructions for making 92 working models for about £50. At the other end there are the Junior Sets with the simplest containing 25 parts for making three models for about £3. In between there are the Standard Sets, in all there are 17 sets with all pieces being compatible.

Unlike Lego and Fischer there are no specific robotic models, like the Buggy and Fischer's arms, for which instructions are given. The existing sets have instructions for items like tipper trucks, cranes and car ferries.

However they provide the basic mechanics which can be adapted for robotics and there are a series of what are called Mechanisms Sets which contain motors and gearing and the option of the model being given instructions through a control unit. For those who prefer simpler control Meccano still supplies a clockwork motor.

Meccano is one of the new items being distributed by Commotion of Enfield, Middlesex. The company distributes a wide range of robotic equipment particularly for schools and it has recently opened a technology centre displaying arms such as the Beasty and Alfred and mobiles including Trekker and Zero II.

The company says that the centre allows users to get hands-on experience and

staff can give help with any queries. It is open seven days a week and anyone wanting to go should contact the company to arrange a visit.

## NEW YEAR

The end of the teacher's dispute and the beginning of a new school year sees a number of companies with new hope after suffering a lot of problems during the year. A pick-up in orders is already being seen following a period of very low sales. One company in particular, Valiant Technology, is hoping that it will not suffer the same financial problems of its predecessor, Valiant Design, which went into receivership last year. Valiant Technology was formed to take over the manufacture and marketing of the Valiant Turtle, the only turtle which was designed to look like one.

The new company has the backing of some of its suppliers and is said to be on target for sales so far with most of the machines going to education. The company added however that it had set modest targets to begin with.

The original company first got into financial difficulties following the 1984 Christmas which was the year when home computer firms had problems resulting from over-estimating the market. Valiant's position was then aggravated by the beginning of the teacher's dispute in 1985. Now the new company is on course and selling the infra-red controlled turtle for about £300.

At the time of its closure the old company was developing what it called Microworlds which were software and documentation packages to go with the turtle to help in the learning of a variety of subjects. That work has been continued but only the first section on geometry is available. The company says that it has 15 sections being worked on but added that

there was a lot of work involved in making sure they were correct and tested sufficiently.

IGR, maker of Zero II is also hoping for a further increase in orders. At one stage during the year orders had almost dried up but recently IGR has seen fresh interest. And it is making a growing number of presentations to possible customers and looking for exports, an area where other robot companies have found useful sales.

The company is also looking at a long-term project in China. Two Zeros have been in Peking for some time for assessment and it is possible they will be taking part in a proposed pilot scheme involving different aspects of the teaching of new technology in Chinese schools, which is expected to begin next April.

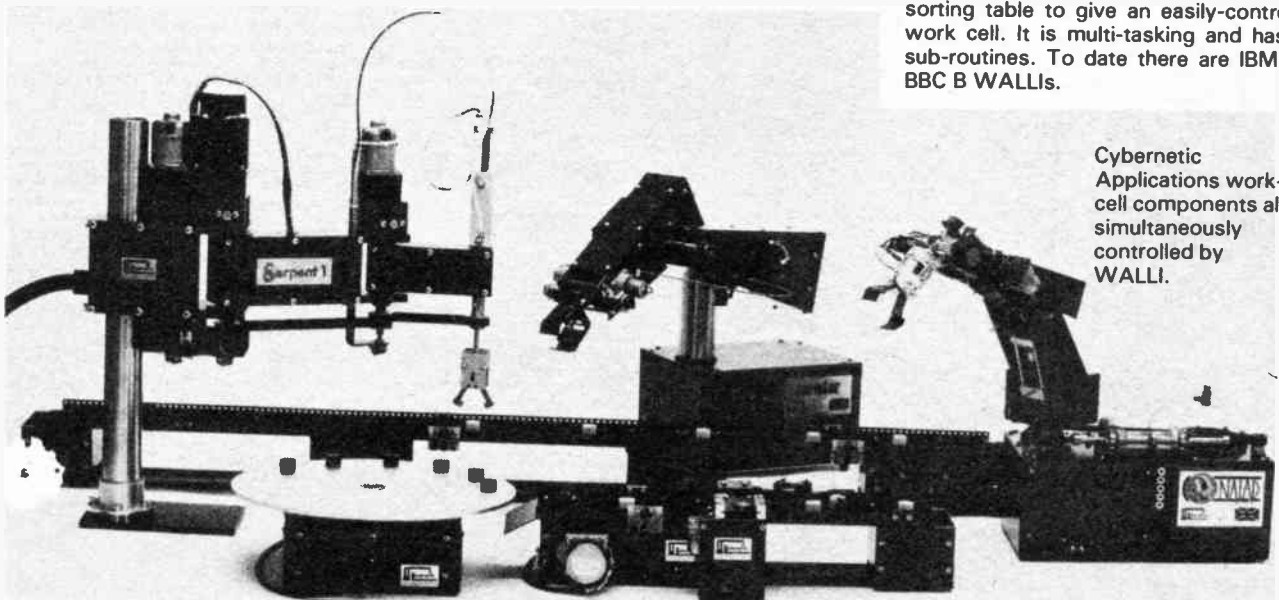
It is unlikely, however, that IGR will see any quick return for their efforts. Chinese officials usually take a long time before making a decision and each area has to make up its own mind before reporting to a central committee which will then act on the advice.

The company said that one thing in its favour was that construction could be done partly in China because of the way Zero had been designed.

## WALLI

Ever wanted to own a WALLI? It is now possible when one of Cybernetic Applications machines is bought. It stands for Work-cell Amalgamated Logical Linguistic Instructions which is a tortuous way of achieving an amusing acronym and means that the company has developed a software package which allows a group of up to four arms and four sensors to be controlled centrally.

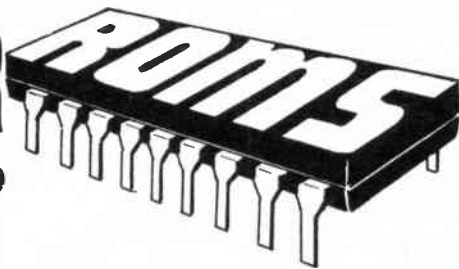
Any of the company's machines, Mentor, Neptune, Naiad and Serpent, can be linked with its conveyor, width gauge and sorting table to give an easily-controlled work cell. It is multi-tasking and has 10 sub-routines. To date there are IBM and BBC B WALLIs.



Cybernetic Applications work-cell components all simultaneously controlled by WALLI.

# SEMICONDUCTOR

JOE PRITCHARD



IN THIS article, I want to examine the different types of Read Only Memory (ROM) that are around today. The proliferation of microprocessor technology has caused this market to expand rapidly in recent years, and I hope in this article will give you an idea of the way in which these ROMs, as they are usually called, can be used.

## WHAT IS A ROM?

A ROM is simply an electronic device that can store sequences of binary digits—"1"s or "0"s, or bits—that can be read back as required, and that does not lose the information when power is removed. A ROM is thus a *non volatile* memory device. A given sequence of bits in a ROM can be accessed by their *address* within the ROM. A ROM may have between as few as 16 and as many as several thousand different addresses in it, and the selection of a given address is done by putting a pattern of electrical signals, usually 0V and 5V, representing 0's and 1's respectively, onto a set of inputs to the ROM called the *address lines*. When this is done, the collection of bits held at that address will be output from the ROM on a series of lines called the *data lines*.

Fig. 1 shows a representation of a simple ROM containing six different addresses, each address containing a

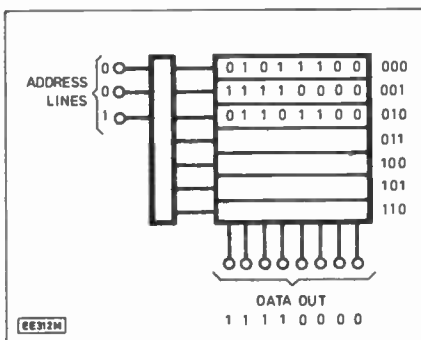


Fig. 1. Representation of a simple ROM.

word which is made up of eight bits. This is called, in ROM jargon, a six by eight bit ROM. Whatever word is output from the ROM onto the data lines depends upon the address that has been set up on the address lines. An eight bit word, which is the commonest word length at the moment, is called a *byte*. The electrical means by which bits are stored in ROMs depends upon the manufacturing method used to build the ROM, but must obviously be such that when the power is removed from the ROM the bit patterns are retained.

A microprocessor doesn't really care what type of ROM it is connected to, as long as the ROM can supply the particular information that the CPU (central processing unit) requires. The only

problem that arises is where a particular ROM isn't fast enough for a processor, but this only comes into play in fast systems. Let's now look at the different classes of ROM that are available. Fig. 2 shows a ROM "family tree". One thing that is obvious from it is that many of our ROMs should probably be more correctly christened Read Mostly Memories!

## MASK PROGRAMMABLE ROMS

You could have already used a mask programmable ROM and been unaware of it; in a pocket calculator, home computer or certain logic chips that you might have used in a constructional project, such as the 7447 segment decoder. The user gets no choice of what is in the ROM; it depends totally on what the manufacturer wants. The structure of the ROM is based on MOSFET technology and a typical "cell" in such a ROM, capable of holding a "1" or a "0", is shown in Fig. 3. During manufacture, a *mask* is used to specify which transistors in the array have a thick oxide film between the gate of TR1 and the other electrodes and which have a thin oxide layer. A thin layer will, when the cell is selected by the decoded address line, allow the f.e.t. to turn on, giving a 0V or logic "0" as output. A thick layer won't allow the transistor to turn on and so a 5V output, or logic "1", will be obtained. TR2 is built on the chip so as to provide a load "resistor" for TR1.

Applications for this type of chip are confined to situations in which large

Fig. 2. A ROM family tree.

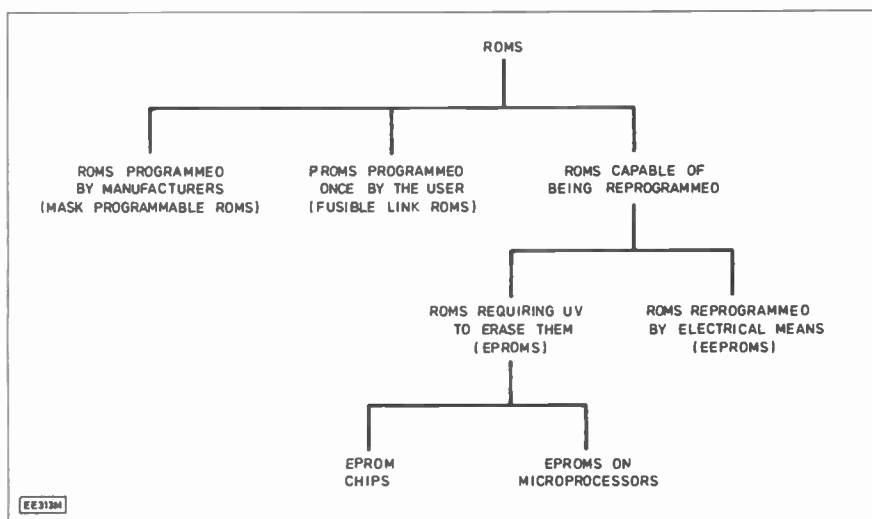
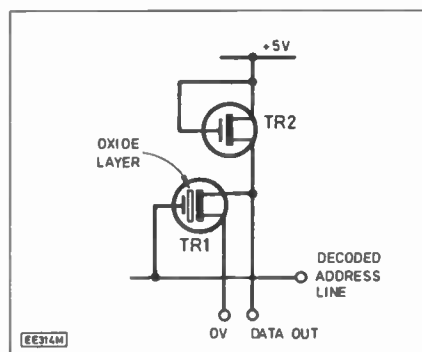


Fig. 3. A typical ROM MOSFET "cell".



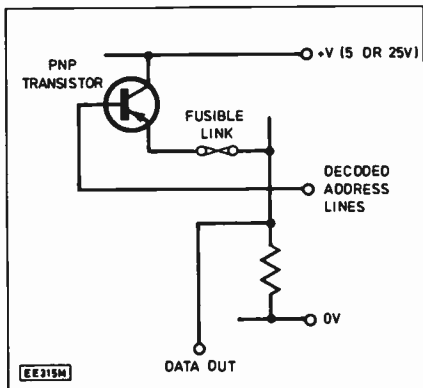


Fig. 4. A storage cell in a typical fusible link ROM.

numbers of identical ROMs are required, so as to justify the expense of designing a mask. Examples include the RO-3-2513 character generator ROM, used in some VDU terminals to provide data for the displaying of different characters, and the "Sinclair BASIC" ROM in every ZX Spectrum. This method of fabrication, due to the mask, is not feasible for amateur involvement; there are very few electronics hobbyists who will require 30,000 identical ROM chips! The advantages of such a ROM are obvious; in volume, their production is simple and cheap. However, an error in the program often has to be lived with, as we can see in the "bugs" present in the ROMs of various home computers; it's too expensive to correct them!

## FUSIBLE LINK PROMs

Fusible link PROMs are all manufactured identically, and are sold "blank" so that the user can put his own information into them. They can only be programmed once, if programming is incorrect the ROM is wasted. A storage cell within a typical fusible link ROM is shown in Fig. 4. It is based on bipolar technology and the active elements are bipolar transistors. This type of ROM is different from the others we'll see in that current, rather than voltage, is instrumental in storing information on the ROM.

Programming involves "blowing" the fusible link, which is commonly made of some alloy such as titanium/tungsten. This is deposited on the silicon substrate, and programming is done one bit at a time. Thus to program a single byte in a fusible link ROM will take eight separate operations. The actual operation of programming is dependant upon the ROM concerned, but effectively consists of selecting the address, and then switching on the transistors in that byte so that a current large enough to burn out the links passes. Usually a blown link will return a logic 0 when read, and an intact link will return a logic 1.

A typical device is the 74S288, which is a 32 by eight bit ROM, but

here a "1" is returned for a blown link and a "0" for an intact link. These devices are user programmable, but have a disturbing habit. After a few years, a diffusion process can cause the blown link to start acting as if it were intact, or at least still partially intact. This can cause corruption of the data, and is usually indicative that the programming wasn't quite right. Also, fusible link ROMs are tedious to program, being programmed one bit at a time, and have the disadvantage for amateur use of being "once only" devices. These problems have been at least partially removed by the Erasable Programmable Read Only Memory, or EPROM.

## EPROMs

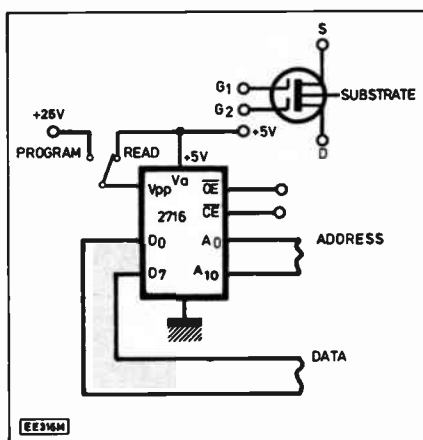
EPROMs are again based on field effect transistors rather than bipolar transistors, they can be reprogrammed after being erased with ultra violet light.

The storage cell of an EPROM is an insulated gate f.e.t., and the process of programming is one of injecting electrons in to the area of insulating substrate between the gates of the f.e.t. and the drain and source. This is done by applying a programming voltage of around 25 volts between the source or drain and the substrate. This causes changes in the electrical characteristic of a cell which has had the charge injected. As the substrate is a reasonable insulator, the electrical charge is retained for a considerable period of time, usually a minimum of around ten years, assuming it is not erased.

Typical EPROMs are the 2716, a 2048 by eight bit ROM, the 2732, which is a 4096 by eight bit ROM and the 2764 which is a 8192 by eight bit ROM. Programming is carried out in a similar fashion for each chip. Fig. 5 shows a typical programming arrangement. Programming of EPROMs proceeds one byte at a time, rather than the one bit at a time of the fusible link devices. A typical procedure for the 2716 is:

- i  $\overline{OE}$ , the output enable, is set to 5V

Fig. 5. Typical programming arrangement for an EPROM.



- ii PGM is set to +25V
- iii The address of interest is set up on the address lines of the EPROM
- iv The data for that address is set up on the data lines
- v  $\overline{CE}$ , is taken to 5V for about 50ms and then back to 0V
- vi Take PGM to 5V, OE to 0V, and the data can be verified

This process is repeated for each byte in the ROM. The programming pulse must not exceed 55ms, as otherwise localised heating can damage the EPROM. If the verification process reports that a byte has not been programmed properly, then, after a delay, further programming pulses can be applied until the data is correct.

Erasing EPROMs is easy; stick them under a suitable UV lamp for about 15-20 minutes. The exact time, however, depends upon the frequency of the UV and its power. The UV falls on the IGFETs through the quartz window in the chip and causes the charge to leak away. The optimum wavelength is about 2500 Å, although if an EPROM is exposed to sunlight, whose UV component has a wavelength of about 3000-4000 Å, it can be erased in a few weeks! This is why EPROMs often have black adhesive tape over the window.

The integrity of data stored in EPROMs can also be reduced by exposing the chip to "harder" radiation, such as X-Rays. This is, however, not a common problem! Over "cooking" EPROMs, by leaving them in an eraser for too long, can cause damage to the device. In fact, each erasure takes a little off the life of the chip, and so the number of times an EPROM can be reprogrammed is finite.

EPROMs have found wide use in prototyping of microprocessor based systems, where they can be programmed and altered until the software is debugged. Unfortunately, the process of testing often seems to be left to the user, as in the case of the very early BBC microcomputers where some of the operating systems were in EPROM. Once debugged, the EPROM can be used to produce a mask programmed ROM if the production run warrants it.

A recent development has been the one chip microcomputer, a single device containing EPROM, input/output facilities and RAM (random access memory) as well as a microprocessor chip. These devices, a typical one being the 68705, are intended to be used as "intelligent controllers" in various items.

Until about five years ago, the EPROM was the main means by which prototype systems could be produced by the hobbyist. Although reasonably priced, the additional hardware of an erasure unit and the necessity of pulling the chip out of the system to reprogram it could be a little tedious. Life is now easier for developers who

can use the EEPROM, or Electrically Erasable PROM.

## EEPROMs

EEPROMs can be reprogrammed like an EPROM but have the advantage that no UV is required for erasure. It is all done electrically, thus allowing the designer to put together a prototype system in which the ROM can be reprogrammed without it being removed.

Typical members are the 2804 and 2816, which are pin compatible with and have the same capacity as the 2704 and 2716 EPROMs (Fig. 6).

Early versions need a programming voltage, though, just like EPROM's. But later devices, such as the recent versions produced by Xicor, work on 5V and 0V only—very useful indeed! However, here we'll concentrate on the older version of the 2816 EEPROM. Reading such a device is easy; PGM is set to 5V, OE and CE are set to 0V and the address is set up on the address lines of the device. The data at that address is then available on the data lines. Writing data to an EEPROM is a two stage affair; erasure and writing. The difference here, though, is that erasure is electrical and it is possible

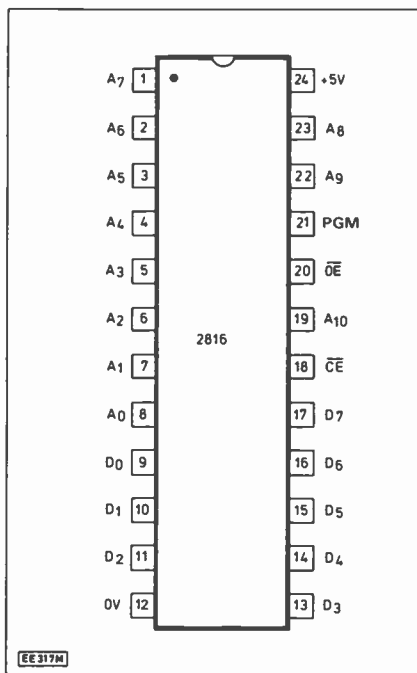


Fig. 6. Pin connections of the 2816 EEPROM.

to erase only particular bytes of the EEPROM. This is a great advantage over the EPROM. The erased state of the 2816 is all "1's". To erase the

whole 2K of the chip, the following procedure is carried out.

- i Data lines are set to "1"
- ii  $\overline{CE}$  is set to 0V
- iii  $\overline{OE}$  is set to 12V
- v PGM is pulsed for 10mS with 21V

The whole erasure process thus takes about 10mS.

A single byte can be erased by:

- i Data lines are set to "1"
- ii  $\overline{CE}$  is set to 0V
- iii  $\overline{OE}$  is set to 5V
- iv The address lines hold the address of interest
- v PGM is pulsed for 10mS with 21V

A byte can be written to the EEPROM by repeating the above steps but this time with the data lines holding the byte to be written to the EEPROM. Data retention on the 2816 EEPROM, assuming it is not erased or altered, is a minimum of about 10 years. This type of ROM will thus probably replace the EPROM, offering as it does all of the advantages of that device but with none of the disadvantages, especially with the new "single voltage" devices.

I hope that this survey has been useful, and has helped shine light on the many different types of ROM that are available today. □

# LETTERS

## Back to Basics

Sir—I have just returned home from my holiday to find the July issue of *EVERYDAY ELECTRONICS* waiting for me.

I could not believe my eyes when on page 373 I read Mr. David Lloyd's letter headed *Back To The Beginning*. I have wanted to write just a letter myself for months, and I agree with everything he has written. Having taken the magazine since issue No. 1, I have for a long time been put off by the number of music sound effects and computer projects that you have been publishing. Also many of your projects are now still above the capability of many of us amateurs and hobbyists.

Why can't we have some of the more simple type projects and more useful ones.

I have been waiting for months for a simple timer project to stop my burglar alarm bell ringing after say 15 minutes—a sort of 555 i.c. project. Also a fun project like a simple 3-figure random number selector and such other items.

Good for Mr. Lloyd's letter. I do hope you can soon come back to more basic stuff.

P. M. Price,  
Doncaster.

## Welcome Additions

Sir—I have read with interest some of the letters of your other readers. Personally I

find the magazine excellent, and I particularly welcome the addition of projects for the BBC and the Spectrum. Obviously, there will be some projects or articles that don't appeal to everyone, but to generalise by saying "beginners are not interested in . . . !" as some do is a little bit silly.

What I find much more worrying, is people's fear of "a little bit of maths." None of the maths you are likely to introduce is going to be difficult and the only time there will be a problem is if a printing error gives the wrong answer. It must be quite despairing to pop the numbers into a formula only to find your answer disagrees with the author.

Also what does happen in some of your basic articles, is that diagrams get the wrong label (for example *Electronics Monthly*, May, 1985, page 4, Diodes, Figs. 5 and 8). This sort of error must be very disconcerting to a beginner. Fortunately there are not too many of these, but they do occur.

One of your best series, has been the one on transducers. What a pity it has finished.

Talking of series, what might be useful would be a series on circuit design. Perhaps, some simple problems posed one month followed by some possible solutions the next. You could then show how a 741 or BC109 might do the job and then how another approach uses a more modern device.

Finally, I know some people love their old 741's and so forth, but how else are we to find out about new and better devices if they are not included in projects.

Well, there you are, keep up the good work, it's the best value for money around by far.

A. N. Marshall,  
Pen Y Fai,  
Bridgend.

## More Consideration

Sir—I first wrote to you soon after April '83 when you added "Computer Projects" to your title. I was interested to read in recent issues further letters expressing similar sentiments.

I personally enjoy laying out circuits on stripboard. To do this I use an exercise book ruled in 7mm squares and hopefully make all the mistakes before beginning construction.

I read in the September '86 issue the *Car Timer* project which included both printed circuit board and stripboard layouts. I think many readers would like to see these alternatives for the more simple circuits.

I have also noted readers pleas for more detail of the design considerations which lead up to the articles, for example, what are the writers conclusions of the best way to achieve his objective.

I would, and I think other readers would also, like one project written up right from the authors first thoughts. Why did he reject other possibilities? Why did he choose a particular i.c. etc.?

Such articles would not only achieve what the present ones do but would also teach us, your readers, to think better when trying to design for ourselves. Please consider, say, four such articles a year.

I have started to design a card dealing machine for bridge and whist to assist handicapped people, and I do feel that some of your authors could come up with projects which would be of great help to people handicapped by arthritis for example.

I would be pleased to hear from anyone locally who is interested in electronics other than computers. I am in the phone book.

Fred G. R. Rice (aged 74 years)  
Sidmouth, Devon.

# SOLDERING

ROBERT PENFOLD

## Choosing & making the right connection

**B**EFORE you can start electronics construction you must have the right tools available, and although some of these are general types that will already be present in many households, many are not. It would certainly be very easy to spend a great deal of money setting up a workshop equipped with a vast array of tools and test equipment, but it is possible to make a reasonable start with just a few fairly inexpensive tools.

Apart from the most fundamental tools, it is probably best to buy things as you need them so that a lot of expense on tools you will never need is avoided. You should build a few battery powered projects to start with, and with these it is often possible to build up and test the electronics without having to house the projects.

This makes it possible to try your hand at electronics construction without having to invest large sums of money in tools. The projects can always be finished off properly at a later date when you have become "hooked" and are prepared to invest more money in the hobby.

### ESSENTIAL TOOL

The one tool you will NOT be able to do without is a *soldering iron*, and there are quite a number to choose from. Electronics is no longer a matter of soldering large components to solder tags, and is much more concerned with miniature components on complex printed circuit boards with minute copper pads.

The traditional electrician's soldering iron having a rating of about 65 watts and large bit of about 7 millimetres in diameter is therefore completely unsuitable for current requirements. On the other hand, most projects require some point to point

style wiring, and the iron must be powerful enough to handle this.

Probably the best compromise is an iron with a rating of about 17W to 25W with a bit diameter of about 2.3mm to 3mm. It is important not to have a bit diameter any larger than this as you would find it difficult to build up printed circuit boards without leaving short circuits all over it due to solder blobs and trails.

Another problem is that of desoldering one component while connecting another. There are some quite expensive temperature controlled soldering irons available, and these make soldering easier by enabling the bit temperature to be adjusted for optimum results with whatever solder you are using. They also provide extended bit life by ensuring that the iron does not operate at an excessive temperature.

The cost of these tools is fairly high to make them an "essential" proposition for most hobbyists though. Beware of the cheaper thermostatically controlled types—the one I have works fine on small joints, but "freezes" when applied to medium or large size joints. The same can happen with very low power non-controlled types.

### MAKING A STAND

In use the soldering iron must have some sort of stand in which it can be fitted or rested during pauses when you are not actually soldering, and the usual ready made type consists of a solid base section with a metal tubular section (often spring-like in construction) into which the barrel and bit of the iron are fitted.

Ideally a soldering iron stand should provide more than just a safe temporary resting place for the iron, and it should also act as a heatsink to prevent overheating.

The iron will generate sufficient heat to enable it to be used for almost continuous and rapid soldering, but this results in too much heat being generated when it is not in use.

The metal part of the soldering iron stand taps off some the heat from the iron and helps to keep its temperatures down to a good working level. This is not essential though, and most irons still have good bit element life if used with a stand that does not provide any heatsinking.

Ready made soldering iron stands are not particularly expensive, but it is also not difficult to construct your own stand if you wish, or it might be possible to improvise something. However, for obvious reasons you should ensure that the stand is stable and reliable.

Most soldering irons have a "U" shaped clip which can be used with a bar type stand of the type illustrated in Fig. 1. These are not difficult to build, but the base section should be a fairly large and heavy piece of wood or metal so as to give the whole unit good stability. Construction can be modified to suit whatever materials are to hand or readily available, and the bar on which the iron rests could be a length of studding fixed each end with a bracket and a pair of nuts.

### SOLDER

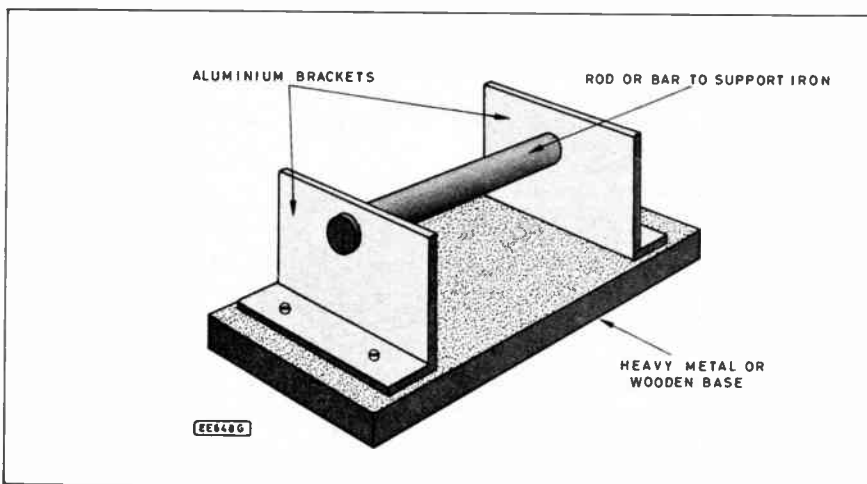
In order to produce good soldered joints you will need not just solder, but the right kind of solder. Many electronic component suppliers stock electrical solder and it is also available from many DIY and electrical shops in local high streets.

The solder should be a 60 per cent tin and 40 per cent lead type (*not the other way round*) with a multicore flux. Solder which has 60 per cent lead content tends to be difficult to use as it solidifies relatively slowly, making it much more difficult to prevent cracking of the solder due to any slight movement of the wire as the solder sets.

The flux is important as it helps the solder to flow over the joint, making it physically and electrically sound. Ideally the flux should be a non-corrosive type so that it does not attack the bit and greatly reduce its operating life.

Solder is only generally available in two thicknesses; 18 s.w.g. and the thinner 22 s.w.g. type. For modern electronic construction the thinner gauge is generally much easier to use. With the thicker gauge it is all too easy to use too much solder and produce solder bridges all over the board. Solder is relatively expensive these days and a worthwhile saving can be obtained by buying a large (1/2kg) reel. This also helps to avoid the frustration of running

Fig. 1. Suggested design for a simple soldering iron stand.



## IN USE

Be careful to set up the soldering iron where no one is going to kick or otherwise disturb the mains lead. Avoid the classic mistake of getting the mains lead into contact with the bit, which could result in the iron burning through the insulation and blowing the fuse. This is more easily done than you might think, and not for nothing do most irons these days come supplied with a burn resistant mains lead. They also come with coiled "flexi-leads" which help to cut down on the tugging effect of long mains leads during prolonged soldering operations.

When you first switch on the iron it is quite normal for it to produce a certain amount of smoke as dust and grease burns off the element and the bit. As soon as the bit starts to reach a suitable temperature it should be tinned with solder (i.e. just apply a little solder to the end of the bit so that the end becomes nicely covered with solder).

If this is not done almost at once it may be found that the end of the bit soon starts to become blackened and that when the solder is applied it simply runs straight off the bit. This would be useless for soldering purposes and the only solution would be to switch off the iron, let it cool down, and then clean off the bit using fine emery paper. It would then be a matter of starting again and applying the solder as soon as the bit was hot enough to melt it.

Many soldering iron stands are fitted with sponges that can be used to wipe the end of the bit clean when it becomes encrusted in excess flux and oxidised solder. The sponges must be kept reasonably moist or the heat of the bit will simply melt them.

With modern solders bits do not seem to get dirty very fast, and frequent cleaning is unlikely to be necessary. I find that occasional gentle scraping of the hot bit with the blade of a screwdriver is usually sufficient to keep the bit in good working order. If you try soldering with a bit that is well and truly polluted the result is almost certain to be short circuits due to blobs of excess solder and "dry" joints.

## STRIPPERS

About the only other essential tools for good soldering are wire strippers and cutters. Separate tools are to be preferred, but there are plenty of combination cutters/strippers available and these are mostly very good, even some of the cheaper types. Scissors are virtually useless as wire cutters as they would almost certainly wear out very rapidly, and can not be manoeuvred into restricted places easily.

Trying to use a modelling knife or scissors for wire stripping is very bad practice and definitely *not* to be recommended. The problem here is that there is a tendency to damage the wire, and even cutting into the wire very slightly makes it prone to break at that point. Proper wire strippers overcome this by having two semicircular cutting blades which are adjusted so that they provide an aperture when fully closed that is marginally larger than the wire thickness. This makes it almost impossible to nick the wire, but the sleeving is cut through sufficiently to enable it to be stripped away without difficulty.

The basic requirement of a soldered joint is to provide an electrically conductive path with a secondary consideration being the mechanical strength of the joint.

Before soldering it is essential that the surfaces to be soldered are clean and free from any dirt or grease. If solder is to be applied to any heat-sensitive components then a suitably sized heat-shunt should be used. These are normally in the form of specially designed tweezers, although many people prefer to use a small pair of pliers.

The most important part of the soldering iron is the "tip" or "bit". This is the part of the iron which stores the heat ready for passing onto the joint. The size of the bit and the power rating of the iron will determine the amount of heat that is supplied by the iron to the work and also the rate at which the work can be carried out.

Before commencing soldering especially with a new bit, it should be tinned. This is done by plugging in the iron and when the bit is hot, melting solder on the bit so that it flows evenly over it.

Excess solder on the bit may be wiped off on a piece of damp sponge fitted somewhere on the bench or iron stand. You will need this frequently during soldering to periodically wipe away any flux and solder that accumulates.

There is but one way to learn to solder properly, and that is to practise, *and practise*. Get yourself a piece of stripboard and a reel of 22 s.w.g. tinned copper wire, and, of course, a soldering iron. Snip off several lengths of wire of about 30mm each and bend them as shown in Fig. 2, to be inserted as random links around the piece of stripboard. Now commence soldering the links to the copper track.

Apply the iron to the joint so that its flat surface (a beginner's iron should have one) forms a triangle between copper track and the perpendicular component lead. It is essential that the soldering iron bit imparts heat to both the track and the lead simultaneously.

The moment contact is made gently push some 22 s.w.g. multicore solder into the flat surface of the bit, encouraging molten solder to fill the "triangle" and flow on around the whole joint. If you are doing it right, the whole process should take about two seconds. Just keep practising on those links until you're happy. Only fresh solder will leave behind a shiny joint, especially if it is applied with smart, positive actions.

Snip off the excess leads to make it easier to approach other joints. Using side-cutters (illustrated) cut off just flush with the edge of the solder. Do not snip the solder itself, and be sure the joint has solidified first before disturbing it.

A good joint will be seen to be smooth, shiny and globular in shape. If the rules below are not obeyed, a dry joint is the likely outcome. The main cause for such a joint will be due to 2 and 7. A dry joint may appear mechanically sound (many are not) but no electrical contact is made and the circuitry will not function satisfactorily—if at all. A dry joint has a dull ragged appearance.

You will encounter many different kinds of connection between components and hardware but whatever type of joint is being made the same basic rules of solder-

ing must be observed in order to obtain a good joint.

- 1—The iron should be tinned.
- 2—Both surfaces to be bonded must be perfectly clean and free from grease.
- 3—The surfaces to be joined together must be in good contact.
- 4—The bit must be used to simultaneously heat both surfaces.
- 5—The solder should be melted around the contact area, and not on the iron, and allowed to flow.
- 6—Remove the solder followed by the iron.
- 7—Do not disturb the joint while the solder is solidifying naturally.

## CIRCUIT BOARDS

Soldering component leads to stripboards or printed circuit boards (p.c.b.s) is fairly straightforward. Trim the lead so that only about 3mm protrudes beyond the copper track. The leads pass through small holes surrounded by copper (tinned copper in the case of a p.c.b.). Bending the lead slightly to make contact with the copper plate is sufficient. Alternatively, the lead may be bent at 90 degrees onto the copper to increase the contact area and at the same time make a semi-mechanical joint, see Fig. 2.

Place the bit so that it makes contact with both lead and track and apply solder to the joint (not the iron) so that solder flows evenly. Remove solder followed by iron.

Stripboard is usually protected by a thin coat of lacquer to prevent tarnishing. However, if the copper is tarnished rub with fine emery cloth before soldering.

Most component lead-outs and tags are nowadays solder tinned during manufacture or plated with a non-tarnishing metal. However, tinned leads do become "dirty" and it is wise to clean them with emery paper before soldering if this is the case.

If too much tinning is removed, retinning is advised for easier soldering. This is done by heating the lead with the bit and applying solder to the lead (not the bit) so that solder flows evenly over its surface.

A much stronger joint can be made by making a mechanical joint prior to soldering.

## STRANDED WIRE

Soldering p.v.c. covered stranded wire to a component tag, pin or circuit board for example can often be a problem for the beginner.

Strip off about 8mm of insulation and using thumb and index finger twist all the strands together. Place a tinned bit at the extreme to heat up the wire and then melt the solder onto the wire.

The solidified solder produces a solid core which is suitable for a number of different types of connection. It may be formed into a hook when connecting to a tag on a potentiometer, switch or another solid lead such as that from an l.e.d. It is also ideal for connecting to a screw terminal block in a straight or U-shaped form.

When it is to be soldered to a circuit board it can now be treated in a similar fashion to a component lead. However, when soldering a lead to a solder tag it has been found easier not to tin the wires, but to thread the strands through the eyelet, loop and twist tightly before soldering.



# ART of SOLDERING

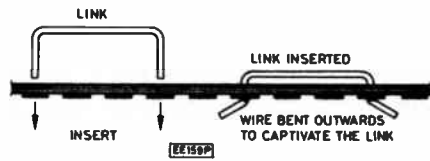


Fig. 2. Forming and inserting a series of "practise" links. The wires can be single-strand tinned copper wire, with or without sleeving, or even multi-strand plastic covered wire. Try not to burn the plastic insulation covering the wire.

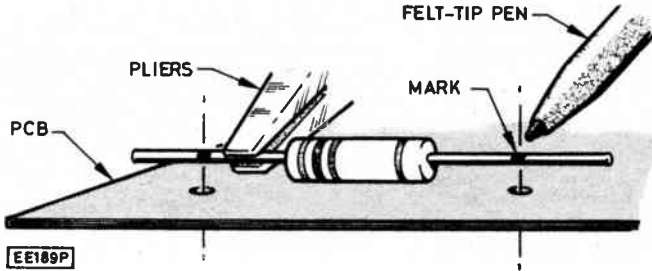
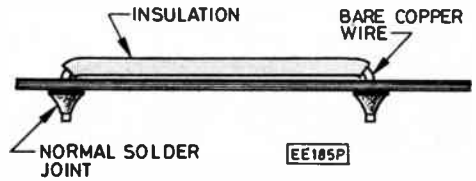


Fig. 3. Marking the hole spacing distance on the component so that it can be fitted on the circuit board.

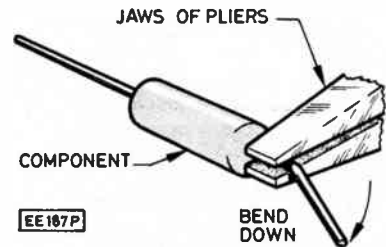


Fig. 4. Using a pair of pliers to bend the component leads at the required hole spacing points.

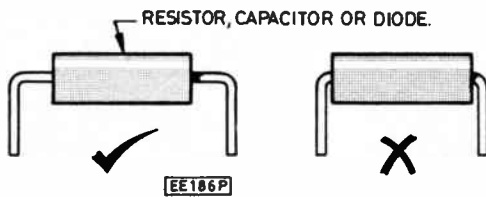


Fig. 5. The component leads must NOT be bent too close to the body of the component. This can cause fracturing of the lead where it enters the body of the component and is hard to detect.

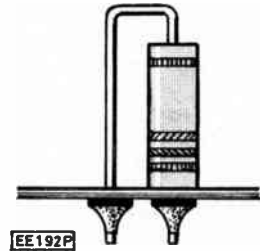


Fig. 6. Sometimes components are mounted on-end to save space, although it is not good practice to mount axial lead devices this way.

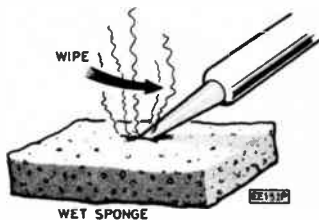


Fig. 7. Cleaning the soldering iron bit prior to tinning. A moist sponge is ideal for this operation.

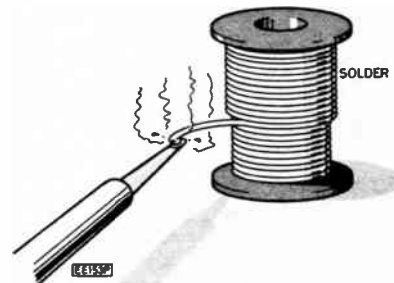


Fig. 8. Tinning the iron tip with solder to encourage heat transfer from the bit to the workpiece.

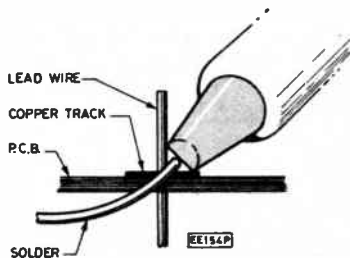


Fig. 9. To make a good joint, apply the iron to the copper track and component lead simultaneously and feed the solder to the joint at the same time.



Fig. 10. Identifying the correct amount of solder to apply is a matter of common sense and, of course, practise.

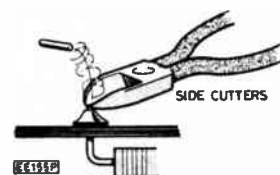
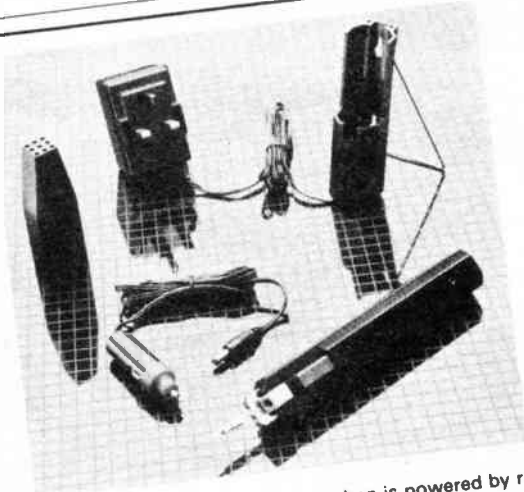


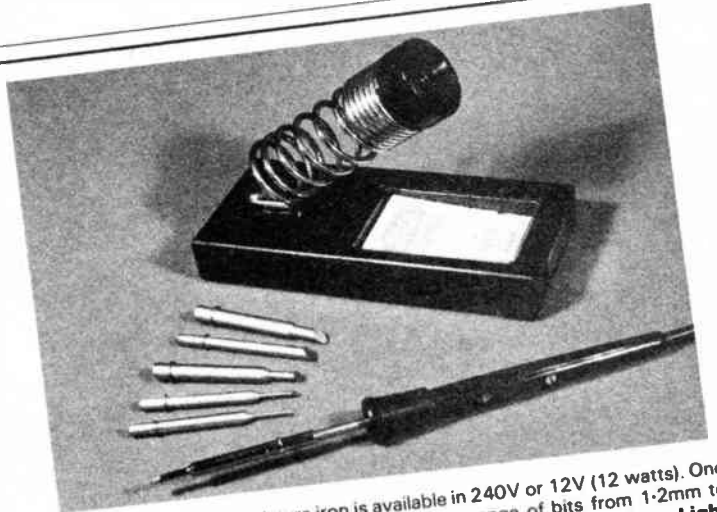
Fig. 11. Using side-cutters to snip off excess lead. Do not snip the solder and be sure to let the solder cool first.

# SHOPPING AROUND

A SMALL SELECTION OF WHAT'S AVAILABLE ON THE MARKET



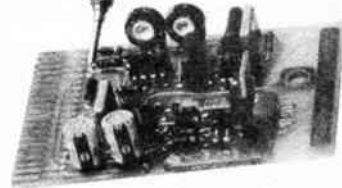
The **Burgess M890** cordless soldering iron is powered by rechargeable NiCad batteries and comes complete with charger, cigar lighter adaptor, tip protector and clip-on stand. The 12W iron is claimed to be able to solder 250 joints on full charge. Price £21.95 (inc. VAT, p&p) from **J.E.M. Marketing**, 180 Princes Avenue, Palmers Green, London N13 6HL. ☎ 01-889 1415.



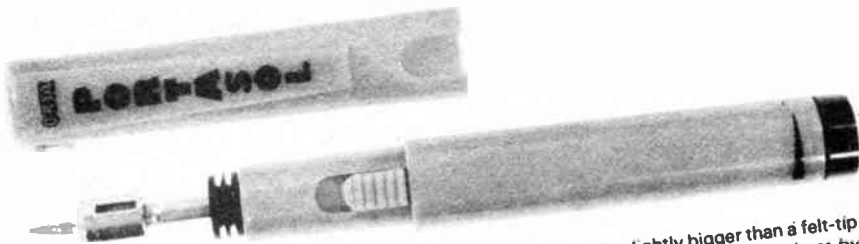
**Adamin Model 12** miniature iron is available in 240V or 12V (12 watts). One of the smallest irons in the world and takes a range of bits from 1.2mm to 4.7mm. Price (iron) £7.08, (spring stand) £5.66 (inc. p & p) from **Light Soldering Developments Ltd.**, Spencer Place, 97/99 Gloucester Road, Croydon, Surrey CR0 2DN. ☎ 01-689 0574.



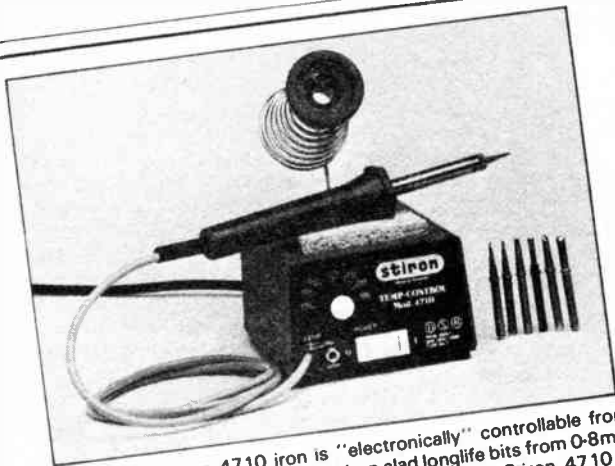
**Litesold SK18** Soldering Kit includes the LS18 18 watt iron along with a selection of bits, 18 s.w.g. fluxed solder, tweezers, three other aids and desolder braid. All in p.v.c. wallet. Price £16.36 (inc. p & p), from **Light Soldering Developments Ltd.**, Spencer Place, 97/99 Gloucester Road, Croydon, Surrey CR0 2DN. ☎ 01-689 0574.



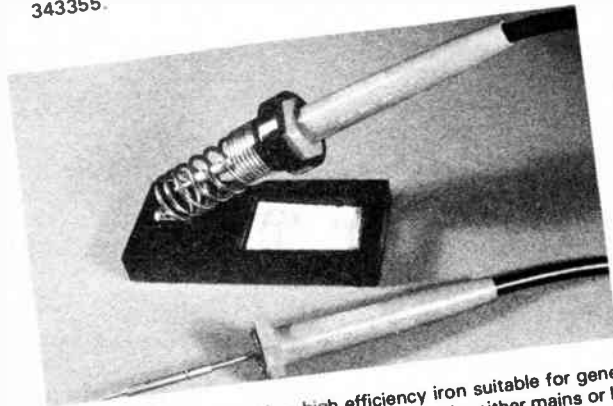
The **Weller WM12D** weighs just 7 ounces and is the smallest iron in their range. It is rated at 12 watts and develops a tip temperature of 425 degrees centigrade. There is a choice of three tips which can be easily interchanged. The WM12D which is priced at £6.32 is also available in kit form together with two spare tips, a pair of tweezers and a supply of resin cored solder. Supplier details from **Cooper Tools Limited**, Sedling Road, Wear, Washington, Tyne & Wear. ☎ 091 416 6062.



The new portable butane powered soldering iron from **Oryx** is only slightly bigger than a felt-tip pen. There is no flame during use, the chemical energy of the gas is converted into heat by means of a catalytic converter in the bit. The iron delivers the equivalent of 60 watts with the tip temperature being variable between 250 and 450 degrees centigrade. The iron will run for 60 minutes on its gas supply. The **Oryx Portasol** is available from **J.E.M. Marketing and Marco Trading**, The Maltings, High Street, Wem, Shropshire. ☎ 0939 32763.



The 100W Stiron 4710 iron is "electronically" controllable from 100 to 400°C and comes with 14 iron clad longlife bits from 0.8mm to 5mm, in chisel and screwdriver profiles. The Stiron 4710 is priced at £88.12 (inc. VAT, p&p) from **Tele-Production Tools**, Stiron House, Electric Avenue, Westcliff-on-Sea, Essex. ☎ 0702 343355.

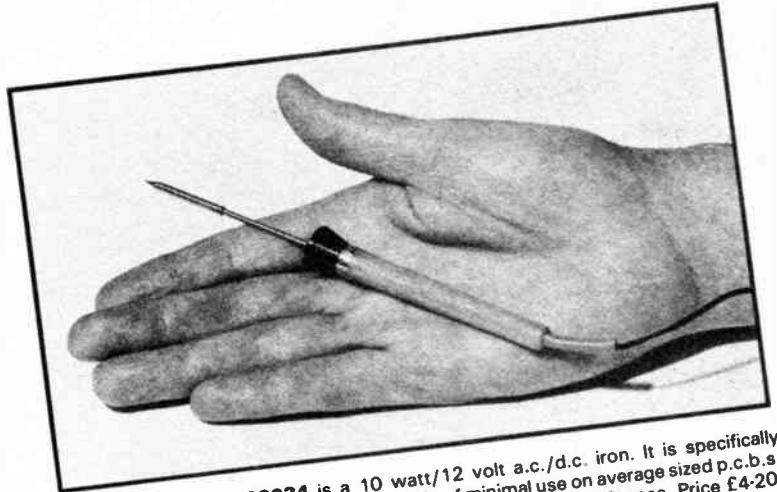
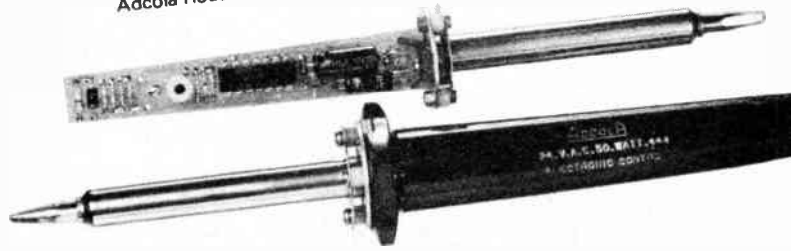


The **LC18** from Litesold is a high efficiency iron suitable for general electronic assembly and servicing work. It can be either mains or low voltage powered and takes a wide range of bits. The **LA12** is similar to the LC18 but is rated at 12 watts and is mainly intended for smaller work. The LA12 is priced at £7.06 and the LC18 is priced at £7.12 (inc. p & p). **Light Soldering Developments Ltd.**, Spencer Place, 97/99 Gloucester Road, Croydon, Surrey CRO 2DN. ☎ 01-689 0574.

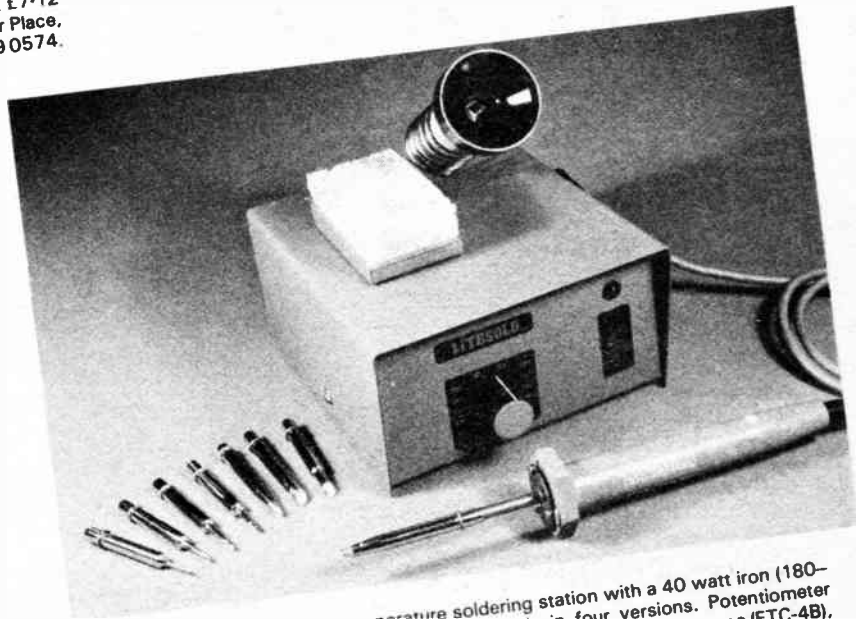


The Antex **TCSU1** soldering station has an anti-static earth connection to protect MOS devices. The temperature can be pre-set anywhere between 65 and 430 degrees centigrade. Three iron-coated bits are also supplied with each station. Priced at £90.22 (inc. p & p). **Antex (Electronics) Ltd.**, Mayflower House, Plymouth, Devon. ☎ 0752 667377.

The **Adcola 444** has its control circuit housed in the handle. It operates from a 24V supply and the 50 watt element can be controlled from 220 to 420 degrees centigrade. The temperature is factory set at 360 degrees and can be adjusted through the handle. The 444 is priced at £27.48 (compatible power supply £32.39) and is available from **Adcola Products Ltd.**, Adcola House, Gauden Road, London. ☎ 01-622 0291.



The tiny **Maxicraft 90034** is a 10 watt/12 volt a.c./d.c. iron. It is specifically designed for fine circuit work, and is capable of minimal use on average sized p.c.b.s. The fine bit enables the user to delve into the most delicate of areas. Price £4.20. Replacement bits 70p each. A 12 volt transformer is also available for £2.75 (p & p 80p per order). From **Croydon Discount Electronics**, 38 Lower Addiscombe Road, Croydon, Surrey. CRO 6AA ☎ 01-688 2950.



The **ETC-4A** is a variable temperature soldering station with a 40 watt iron (180-400°C). The mains supplied station is available in four versions. Potentiometer control (ETC-4A), with digital display (ETC-4C). Tamper-proof setting type (ETC-4B), with digital display (ETC 4D). This unit offers close temperature control and a fast heat-up/recovery time. The ETC-4A illustrated is priced at £70.50 (inc. p & p). From **Light Soldering Developments Ltd.**, Spencer Place, 97/99 Gloucester Road, Croydon, Surrey CRO 2DN. ☎ 01-689 0574.

## SHOPPING AROUND

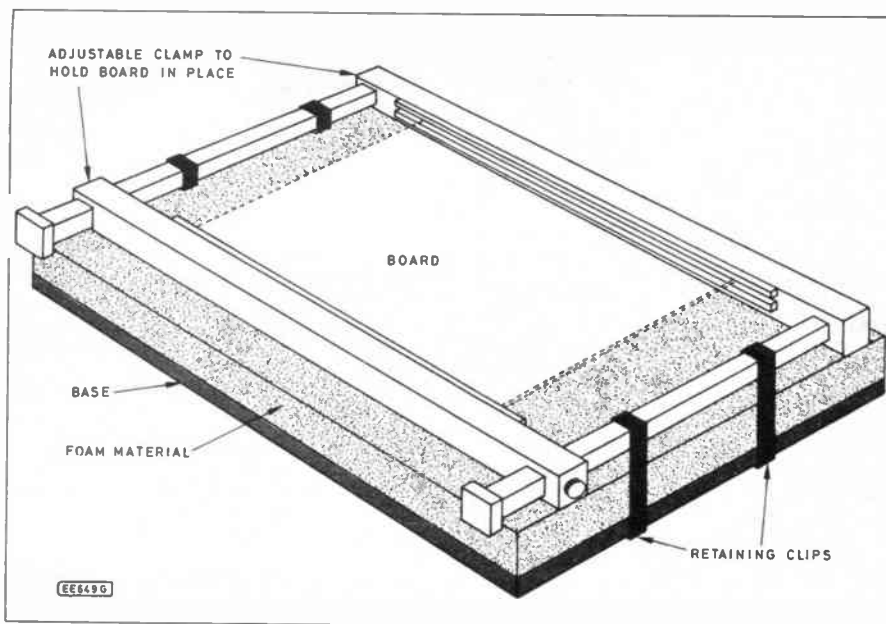


Fig. 12. Basic arrangement for a circuit board soldering jig.

## USEFUL AIDS

Moving on to items that are useful but not essential, devices which hold circuit boards while work is carried out on them are becoming quite popular, and these often include a magnifying glass which assists with the construction of intricate boards. I prefer circuit board assembly jigs which are admittedly much more expensive, and are more difficult to obtain as well. They consist basically of a base section which contains a large sheet of fairly thick foam material, and above this there is an adjustable frame which can be used to press the board down into the foam and clamp it in place (as in Fig. 2).

The idea of a p.c.b. jig is to first have the board the right way up and to mount all the components on the board. Then the board is carefully fitted into the jig with the component side facing downwards, taking care not to let any of the components fall out. The foam material holds all the components in place while their leadout wires are trimmed down and soldered in place.

The beauty of this system is that it leaves both hands free when soldering, so that one hand can hold the solder while the other is used to hold the iron. This enables a large number of soldered joints to be completed easily and reliably.

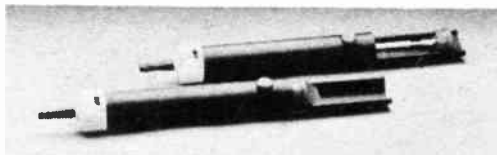
In practice a few components might protrude too far above the board to enable them to fit into the jig, or they might prevent other components from being held in place properly. However, any large components can be left off the board initially, and then fitted one by one once the other components have been fitted.

Although a good printed circuit jig is not cheap to buy ready-made, this is another example where it would probably be possible to home construct one.

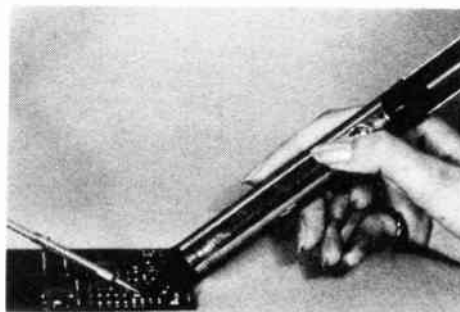
Antistatic work mats and similar pieces of equipment are now becoming readily available, and are obviously very useful when dealing with static sensitive devices such as CMOS integrated circuits. These work mats are made of some form of conductive material which is earthed so that it is rendered static-free. Unfortunately, antistatic aids tend to be quite expensive and are mainly aimed at professional users.



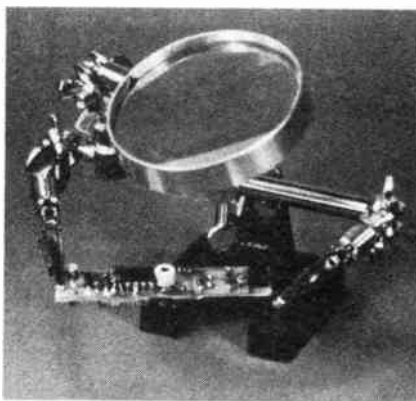
Bradewick desolder braid from Light Soldering Developments comes in reels and costs £1.04 inclusive.



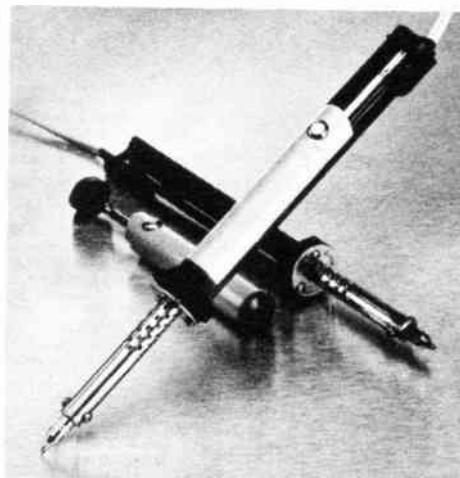
Typical examples of desolder pumps marketed by OK Industries.



The Light Soldering desolder "pump" in action.



This helpful gadget, mounted on a solid cast base, consists of a support bar fitted with two crocodile clips and a 5 diopetre magnifying glass. The support bar, clips and lens are all mounted on adjustable balljoints for adjusting and soldering etc, giving a clear magnified view of the workpiece. 'Helping Hands' (T402) is priced at £9.99 (inc. VAT, P&P), it is available from **Electrovalue Ltd.**, St Judes Road, Englefield Green, Egham, Surrey, TW20 0HB. ☎ 0784 33603.



**SA-6** desoldering iron is a powerful lightweight tool combining heating and suction. The suction chamber is easily removed for cleaning. Available 115 or 230V. Price £15.40 from **OK Industries UK Ltd.**, Dutton Lane, Eastleigh, Hants SO5 4AA. ☎ 0703 619841.

## DESOLDERING

There will always be occasions when the need arises to remove a faulty component from a board or to correct a wiring error. The job of desoldering can be very tricky, particularly when confronted with an i.c., and, like soldering, needs plenty of practice to master.

There are two common methods of achieving desoldering painlessly and both are very efficient. The two methods are vacuum suction and capillary action, both necessitate the melting of the solder around the joint.

As the name implies, the molten solder around the joint or i.c. pin is drawn away by the action of a suction tool. Shaped like a miniature bicycle pump, with a pointed nozzle, the internal piston is spring-loaded and when released shoots back drawing the molten solder through the nozzle into the barrel.

Probably the cheapest method of desoldering components is by the use of a "solder wick" or desoldering braid. The wick is simply immersed in the molten solder which is then drawn up the wick leaving the joint free from solder. □

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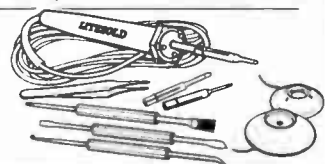


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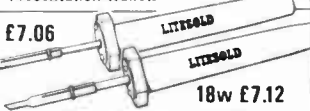
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Adamin 12 and		
LA12	91p	£1.62
LC18		£1.01 £1.79

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# SHOP TALK



BY DAVID BARRINGTON

## £500 Reward

Today you can pick up any newspaper or listen to almost any newscast and you will read or hear of some kind of robbery or vicious assault on a member of the public. The outcry is nearly always the same, "something must be done about this country's escalating crime." But very little seems to be done or it is left to just a dedicated few, our police force, to try and control this cancer in our society.

Well, now is your chance to really help, and possibly gain some financial reward in the process. The **British Security Industry Association** have set up a competition, entitled Design Against Crime, with a £500 reward for the winning entry (see page 573). Also, advice will be available for possible development of any submissions which are considered to have commercial potential.

If you are already involved in the security industry you have not been forgotten. The BSIA is running a special category for those already in the "crime prevention" field.

Open to any individual, University, College, and school groups, all you have to do is submit your own design or idea for an anti-crime product. It can be something to deter a burglary; prevent an assault; protect a car from being broken into or even stop a computer fraud being committed. It can be virtually anything that is your *own original idea*.

Submissions can be detailed drawings and copy, just like an EE constructional article, or a simple outline description. Of course, the more detail you can give the better the chances of success.

We have published many designs from authors that could be contenders, including ultrasonics, infra red, loop systems and code locks, so it is now up to *YOU*. The challenge is there, so what about it **BK Electronics, Riscomp** and **TK Electronics**?—Good Luck.

## Alarm Monitor

A new product that would possibly do very well in the "commercial" category of the BSIA competition is the latest security control panel from **Riscomp**. The CA1382 control panel has been simplified to allow it to be set-up and "armed" by most members of the family without considerable tuition.

The inclusion of an automatic "system testing" procedure, which is carried out each time the unit is switched on, is one of the main reasons for the simplified operation. Such a feature, it is claimed, reduces the likelihood of false alarms.

Working on a loop principle, the CA1382 will cater for most types of security installations ranging from the sophisti-

cated to the simple two or three magnet contact type. The complete alarm system is activated by a single key-operated on/off switch.

A built-in exit and entrance buzzer provides audible warning of the unit's operation, whilst the alarm memory allows it to be set up without annoyance to neighbours. The inclusion of the provision for



sounding the alarm by means of a "personal attack" switch, even though the unit may be switched off, is a good idea.

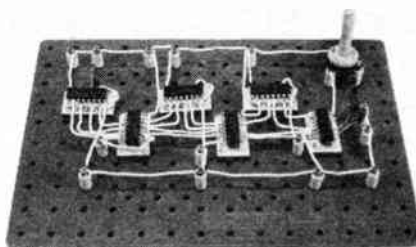
The CA1382 Control Unit is housed in a steel case and is available either built and tested (£44.95, plus VAT) or in self-assembly form (£39.95, plus VAT). Both versions are accompanied by an installation data sheet.

Full details of the complete range of Riscomp security modules may be obtained from: **Riscomp Ltd., Dept EE, 51 Poppy Road, Princes Risborough, Bucks HP17 9DB.**

## Circuit Board

Now that the "Exploring Electronics" series has progressed to using stripboard, any system that enables the constructor to lay out his project to conform to the circuit diagram and allow him to test it prior to transferring to stripboard is always welcome. Just such a prototyping system is manufactured by **Camboard** and marketed by **Hogg Laboratory Supplies**.

The Camboard CM-Series of prototyping boards are claimed to enable the user to construct circuits in a layout identical to



a theoretical diagram without the need for any soldering. It is also possible to mimic printed circuit board layouts.

Unlike other breadboards, the contacts are solid metal studs on stand-off pegs and can take up to ten 1mm diameter connecting wires. Controls and switches can be mounted directly without the need for a separate bracket.

The boards measure 180mm x 129mm, have an alphanumeric grid, for easy component location, and are available with up to six i.c. holders which can be placed anywhere on the board. Supply lines are made by simply connecting the battery or PSU to selected connecting "posts".

Prices for the board range from about £4.25, without i.c. holders, up to £7.95, including six i.c. holders. For further information write to: **Hogg Laboratory Supplies, Dept EE, Sloane St, Birmingham BR1 1BR. Tel: 021-233 1972.**

## Regulated Bench Power Supply

The *Regulated Bench Power Supply* is the first project in our new nine-part "Digital Trouble Shooting" series.

We cannot foresee any component problems with this month's project. However, no doubt some of our advertisers will be making up kits for this important new series and readers are advised to keep an eye on advertisers' announcements.

## 200MHz Digital Frequency Meter

If readers wish to obtain the best possible performance from the *200MHz Digital Frequency Meter* then we advise that only top quality components be used.

There are a number of versions of the frequency counter IC2 on the market, but it is important that only the ICM7216D version be used; other types will *not* work. The 10MHz crystal, XL1, should be available from most advertisers.

A complete kit of parts, including the printed circuit board (£60.98 inclusive) is available from **Magenta Electronics Ltd., Dept EE, 135 Hunter Street, Burton-on-Trent, Staffs, DE14 2ST.** This includes a separate plug-in 9V a.c. PSU.

## Optically Isolated Switch

The only item that could cause sourcing problems when commencing the *Optically Isolated Switch* is the MOC3020 triac. This is listed by Rapid, Maplin, Greenwell and TK Electronics.

Triac and transistor mounting kits are now quite common items and stocked by most of our advertisers. If you experience any problems locating the 2W resistor, R5, it is quite in order to use one of a higher rating but do *not* use one of a lower rating.

## Car Flasher Warning

The relay used in the prototype *Car Flasher Warning* project was purchased from the Maplin Micro Miniature range. Provided the ratings are identical, other relays should work and be quite suitable for this application.

## Modem Tone Decoder

The phase locked loop, type 4046, used in the *Modem Tone Decoder* should be available from most component advertisers. If any readers do have difficulty, it is currently stocked by CPL Electronics, Marco and Rapid.

The only source we have been able to locate for the telephone pick-up coil is CPL and Maplin. A full kit for the decoder is available from CPL Electronics.

# DECEMBER FEATURES...

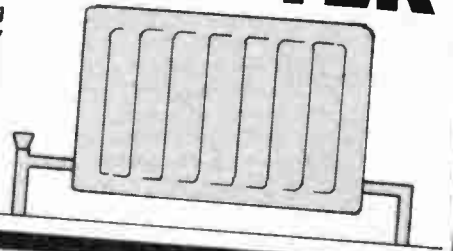
## TO GO WITH PART TWO OF *DIGITAL Trouble Shooting*

The second item of test gear associated with our new Digital Trouble Shooting series is a Logic Probe. Designed to have a specification equal to commercially available products the probe will be an invaluable item of test gear for hobbyists and professionals.

LOGIC PROBE

## DUAL THERMOMETER

The original idea behind this twin reading thermometer was for a device to permit easy balancing of radiators in a central heating system. However, the unit is not restricted to this application; it could be used in photographic applications, in heat experiments in schools, or it could easily monitor indoor and outdoor temperatures. The temperature range covered is 2 to 100 degrees Centigrade.



## BBC 16K SIDEWAYS RAM

There are many different sideways RAM boards on offer to the BBC micro user nowadays. However, these tend to be a little expensive if all you require is 16K of RAM to develop sideways ROM software ready for transferring to EPROM. This design plugs directly into one of the spare ROM sockets inside of the BBC computer and allows up to 16K of software to be developed in RAM before "blowing" it into an EPROM.

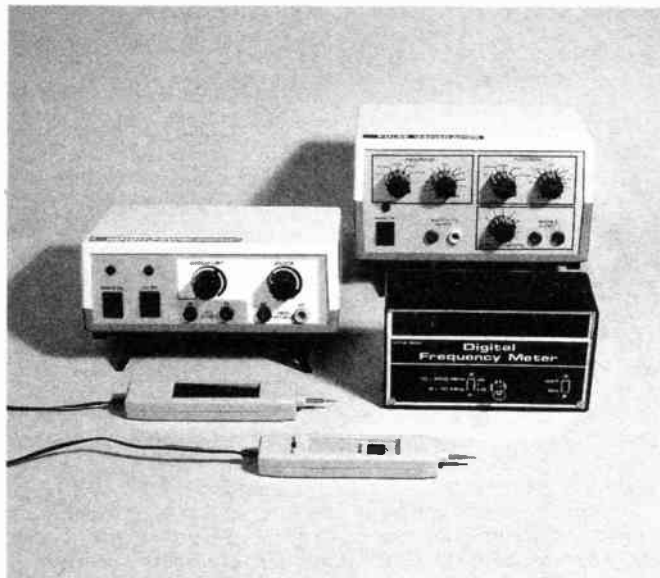
EVERYDAY  
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DECEMBER ISSUE ON SALE FRIDAY, NOVEMBER 21

# DIGITAL Trouble Shooting Part One

MIKE TOOLEY BA

*Welcome to our new nine part series on Digital Troubleshooting which aims to provide readers with a practically biased introduction to the diagnosis of faults within digital equipment. The series should also be of interest to anyone wishing to update their knowledge of modern digital devices and circuitry.*



## PROJECTS

IN ORDER to illustrate the practical applications of digital test gear, each part of our series has an accompanying Digital Test Gear Project. These have been carefully chosen to complement the text for each particular part of the series and, whilst construction has been kept as simple as possible, readers can be assured that standards of performance have not been compromised. Indeed, the specification of each instrument matches that of commercially available test gear—the only pre-requisite for successful testing and calibration being that of having access to a reasonably accurate multi-range meter (either digital or analogue type).

To assist constructors, a standard range of cases and matrix board sizes has been used. These items are reasonably priced and stocked by several of the advertisers in *Everyday Electronics*. In order to achieve a “professional” finish, readers should follow the front panel labelling shown in the photographs.

In this first part of the series we shall be introducing some basic concepts of digital circuits and, in particular, the use of integrated circuit logic elements (gates) which constitute the basic building blocks of all modern digital systems. We shall begin by outlining the basic tools and test equipment required for successful digital troubleshooting.

## TOOLS AND TEST EQUIPMENT

Fortunately, relatively few basic tools are considered essential in order to effect cures for the majority of faults which appear in digital circuitry. A set of small hand tools (long nosed pliers, side cutters, cross point and flat bladed screwdrivers of various sizes) will be a good starting point. Furthermore, it is well worth purchasing good quality hand tools at the outset since, with reasonable care, these can be expected to last a lifetime.

A good quality, preferably low voltage temperature controlled, soldering iron, with a selection of bits, should also be an initial purchase. If a temperature controlled iron is considered prohibitively expensive, then a good quality mains operated iron rated at between 15W and 25W should suffice for most applications. Readers should check that spare bits, elements, and accessories are available for any iron that they purchase—some of the cheaper irons fail badly on this point!

A desoldering pump is also a worthwhile purchase. Such an item need only be a manually operated suction type and need not cost more than £5, or so. This item will, however, prove to be invaluable for desoldering multi-pin i.c. devices on both single- and double-sided p.c.b.s. It is not necessary to purchase complex chip desoldering equipment since a desoldering pump can, with a little practice, be an extremely versatile tool.

As regards test equipment, the only *ESSENTIAL* item is a good quality analogue or digital multimeter. This should provide d.c. and a.c. voltage and current ranges together with resistance ranges.

The choice of analogue or digital types is very much a question of personal preference and either type should suffice for basic fault finding. Additional ranges which permit continuity testing, diode and transistor measurements etc are useful, but not essential. In any event, readers are advised to “shop around”.

Our Digital Test Gear Projects will describe a range of other recommended items of test gear. It is not, however, necessary to have access to all of these items at the outset; they can simply be added as, and when, required. The following items of test gear will be described:

**Regulated Bench Power Supply—**

**Logic Probe— Logic Pulser— Pulse Generator—**

**I.C. Tester— Current Tracer— Logic Tracer—**

**Break-out Box— Counter/Frequency Meter**

## INTEGRATED CIRCUITS

All modern digital systems rely on the use of integrated circuits in which hundreds or thousands of components are fabricated on a single chip of silicon. A relative measure of the number of individual semiconductor devices within the chip is given by referring to its “scale of integration”. The following terminology is commonly applied:

Scale of integration	Abbreviation	Number of logic gates*
Small	SSI	1 to 10
Medium	MSI	10 to 100
Large	LSI	100 to 1000
Very large	VLSI	1000 to 10000
Super large	SLSI	10000 to 100000

\*or circuitry of equivalent complexity.

## ENCAPSULATION

The most common package used to encapsulate an integrated circuit, and that with which most readers will already be familiar, is the plastic dual-in-line (DIL) type. These are available with a differing number of pins depending upon the complexity of the integrated circuit in question and, in particular, the need to provide external connections to the device.

Conventional logic gates, for example, are often supplied in 14-pin or 16-pin DIL packages whilst microprocessors (and their more complex support devices) often require 40-pins or more. Some common DIL package outlines together with pin numbering are shown in Fig. 1.1.



It should be noted that these are TOP views of the device, i.e. they show how the device appears when viewed from the component side of the p.c.b. NOT from the underside. This is, perhaps, an obvious point but it is one which nevertheless causes much confusion!

In each case, the pins of the i.c. are numbered sequentially (starting at the indentation) moving in an anti-clockwise direction. Thus, in the case of a 14-pin DIL package viewed from the top, pins 1 and 14 appear respectively on the left and right hand side of the indentation.

## IDENTIFICATION

When delving into an unfamiliar piece of equipment, one of the most common problems is that of identifying the integrated circuit devices. To aid (or sometimes to confuse!) us in this task, manufacturers provide some coding on the upper surface of each chip. Such a coding generally includes the type number of the chip (including some form of generic coding), the manufacturer's name (usually in the form of prefix letters), and the classification of the device (in the form of a prefix, infix, or suffix).

In many cases the coding is further extended to indicate such things as encapsulation, date of manufacture, and any special characteristics of the device. Unfortunately, all of this potentially useful information often leads to some considerable confusion due to inconsistencies in marking from one manufacturer to the next!

## LOGIC ELEMENTS

Logic elements are invariably supplied in integrated circuit form; freeing the equipment designer from the need to construct circuits with individual discrete components such as transistors, diodes, and resistors. The secret, of course, is that, with modern integrated circuit technology, it is possible to fabricate a large number of equivalent discrete components on a tiny slice of silicon. Not only is the resulting arrangement more compact than its discrete component equivalent but it is also considerably cheaper and very much more reliable.

At this stage we should, perhaps, make one further point for the benefit of the newcomer. It is not necessary to have a detailed understanding of the internal circuitry of an integrated circuit in order to be able to make effective use of it. Rather, we have to be aware of some basic ground rules concerning the supply voltage rails, and input and output requirements. Furthermore, with digital circuitry we are primarily concerned with the logical function of logic elements rather than their precise electrical characteristics.

The most common range of conventional TTL logic devices is known as the "74" series. These devices are, not surprisingly, distinguished by the prefix number 74 in their coding. Thus devices coded with the numbers 7400, 7408, 7432 and 74121 are all members of this family which is often referred to as "Standard TTL". Low Power Schottky variants of these devices are distinguished by an LS infix. The coding would then be 74LS00, 74LS08, 74LS32 and 74LS121.

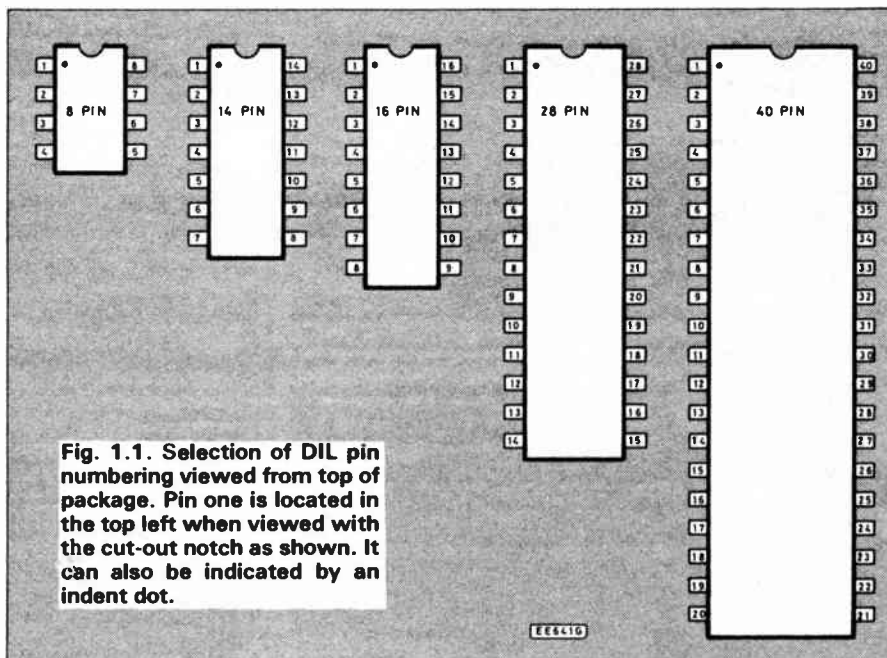


Fig. 1.1. Selection of DIL pin numbering viewed from top of package. Pin one is located in the top left when viewed with the cut-out notch as shown. It can also be indicated by an indent dot.

Other common infix coding for TTL devices is as follows:

Infix Letters	Meaning
C	CMOS version of a corresponding TTL device
F	"Fast"—a high speed version of the device
H	High speed version
S	Schottky (a name resulting from the input circuit configuration)
HC	High speed CMOS version (with CMOS compatible inputs)
HCT	High speed CMOS version (with TTL compatible inputs)

Popular CMOS devices form part of the "4000" series and are coded with an initial prefix of 4. Thus 4001, 4174, 4501 and 4574 are all CMOS devices. CMOS devices are sometimes also given a suffix letter; A to denote the "original" (now obsolete) unbuffered series, and B to denote the improved (buffered) series. A UB suffix denotes an unbuffered B-series device.

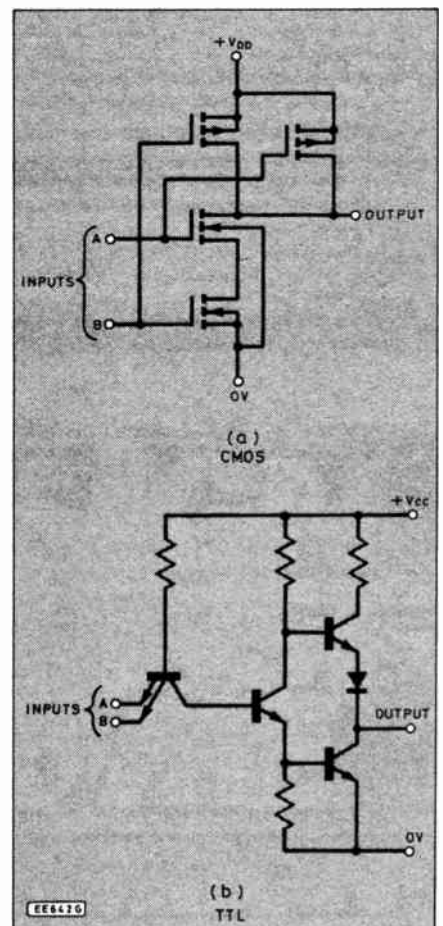
## POWER SUPPLIES

Most TTL and CMOS logic systems are designed to operate from a single supply voltage rail of nominally +5V. With TTL devices, it is important for this voltage to be very closely regulated. Typical TTL i.c. specifications call for regulation of better than  $\pm 5$  per cent (i.e. the supply voltage should not fall outside the range 4.75V to 5.25V).

In fairness, most TTL devices will operate happily outside this range; 4V to 5.5V being not untypical. At least one manufacturer uses a simple 4.5V supply derived from three 1.5V series-connected dry batteries as the power source for his TTL operated digital circuitry. A common fault with this equipment is, not surprisingly, nothing more than a flat battery!

Whilst on the subject of reduced supply voltages, whereas the logical function of a gate is the same when operated from a 4V supply as it is when operated from 5V, the switching characteristics are considerably different. The "propagation delay" (in effect, the time taken for a logical change to pass through the logic gate) increases considerably as the supply voltage falls. Whilst this may not be important in many applications it does explain why such

Fig. 1.2. Representative circuit of CMOS and TTL two-input AND gates.



circuits as counters and frequency dividers cease to operate to their full specification when operated from reduced supply voltages.

Having dealt with reduced supply voltages we should now make some mention of the upper limit for TTL devices. This "absolute maximum" voltage is +7V. If the supply voltage ever exceeds this value any TTL devices connected to the supply rail are liable to "self destruct" very quickly!

CMOS logic devices are fortunately very much more tolerant of their supply voltage than their TTL counterparts. Most CMOS devices will operate from a supply rails of anything between +3V and +15V. This, coupled with a minimal requirement for supply current (a CMOS gate typically requires a supply current of only a few microamps in the quiescent state) makes them eminently suited to battery powered equipment. Indeed, there is little need for any form of supply regulation in most portable CMOS based equipment: the equipment will often continue to operate until the battery voltage falls below 3V!

Like their TTL counterparts, CMOS devices offer inferior switching speeds when operated on reduced supply voltages and, whilst it is common practice to operate CMOS devices from a +5V rail, switching speeds can typically be doubled by operating them from +9V, +12V or +15V rails.

TTL devices require considerably more supply current than their CMOS equivalents. A typical TTL logic gate requires a supply current of around 8mA; approximately 1000 times that of its CMOS counterpart when operating at a typical switching speed of 10kHz.

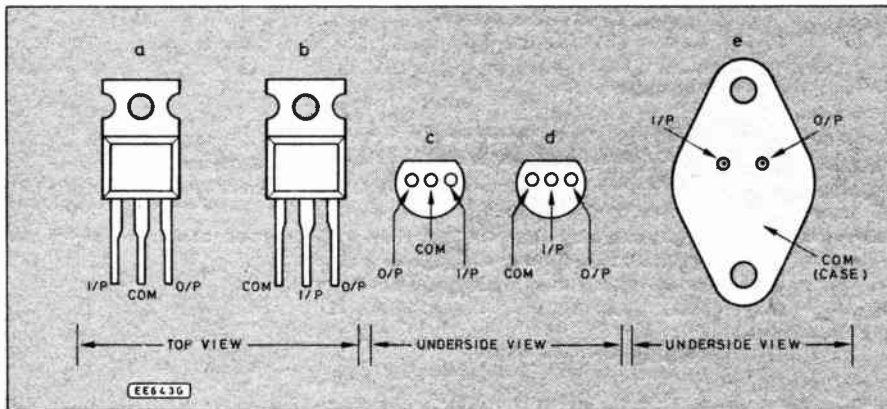


Fig. 1.3 (left). Typical encapsulation used for monolithic three-terminal voltage regulators.

## REGULATORS

Most CMOS and TTL supplies employ simple monolithic three-terminal i.e. voltage regulators. These handy devices are ideally suited to the job of maintaining a closely regulated supply rail and furthermore they also provide such facilities as internal current limiting and thermal shut-down. Some typical regulator encapsulations are shown in Fig. 1.3.

The following regulators are in common usage:

Coding	Output voltage	Max. output current	Encapsulation
7805	+5V	1A	a
7905	-5V	1A	b
7809	+9V	1A	a
7909	-9V	1A	b
7812	+12V	1A	a
7912	-12V	1A	b
7815	+15V	1A	a
7915	-15V	1A	b
78L05	+5V	100mA	c
79L05	-5V	100mA	d
78L12	+12V	100mA	c
79L12	-12V	100mA	d
78L15	+15V	100mA	c
79L15	-15V	100mA	d
78S05	+5V	2A	a
78S12	+12V	2A	a
78H05	+5V	5A	e
78H12	+12V	5A	e

## TYPICAL POWER SUPPLY

A typical TTL/CMOS power supply having a single +5V regulated output is shown in Fig. 1.4. A step-down transformer, T1, provides a source of low voltage a.c. for the encapsulated bridge

rectifier, D1-D4. The secondary voltage of the mains transformer is usually around 9V and, after rectification this results in an unregulated d.c. voltage of approximately 12V which is developed across the reservoir capacitor, C1.

The output of the regulator, at nominally +5V, is fed to the supply rail and decoupled by C4. Two extra capacitors, C2 and C3, of somewhat smaller value (invariably non-electrolytic types) are usually also fitted in close proximity to the regulator terminals. These provide effective decoupling at high frequencies and are instrumental in counteracting any high frequency instability which may otherwise arise from the stray reactances associated with the regulator wiring.

## SAFETY

Before we outline the steps required for fault finding on a typical power supply used in conjunction with digital equipment, it is vitally important that readers are made fully aware of the potential hazards associated with this type of equipment.

Whereas most digital circuits operate from low voltage supplies and can thus be handled quite safely, *the high a.c. voltages present in mains power units represent a potentially lethal shock hazard. The following general rules should ALWAYS be followed when handling such equipment:*

1. Switch off the mains supply AND remove the mains power connector whenever ANY of the following tasks are being performed:
  - (a) dismantling the equipment
  - (b) inspecting fuses
  - (c) disconnecting or connecting internal modules
  - (d) desoldering or soldering components
  - (e) carrying out continuity tests on switches, transformer windings, bridge rectifiers, etc

2. When measuring a.c. and d.c. voltages present within the power unit take the following precautions:

- (a) avoid direct contact with incoming mains wiring
- (b) check that the equipment is properly earthed
- (c) use insulated test prods
- (d) select appropriate meter ranges BEFORE attempting to take any measurements
- (e) if in any doubt about what you are doing, switch off at the mains, disconnect the mains connector and THINK!

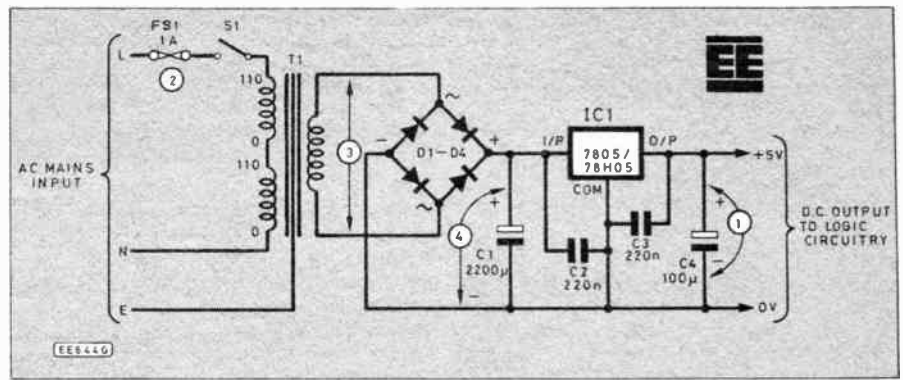
## POWER SUPPLY FAULT FINDING

Fault finding on the typical power supply shown in Fig. 1.4 is fortunately extremely straightforward since there is a limited number of "stock faults" (such as regulator failure, transformer failure etc) which can occur in such a simple piece of equipment.

To assist readers, four test/check points have been identified. Readers should note that, as with many items of equipment, the most rapid method of fault diagnosis is not necessarily that of following voltages or signals from one end to the other. The following sequence of checks and measurements is recommended:

1. Check, preferably using a digital multimeter, that the output voltage at test point ① is in the range 4.75V to 5.25V. If it is outside this range, then proceed to stage ② otherwise assume that the power supply is operating correctly.
2. Disconnect the +5V line in order to isolate the power supply from the rest of the circuitry and repeat the previous measurement. If the voltage at test point ① is now in the range 4.75V to 5.25V, then suspect a fault in the main circuitry which is causing the regulator to "current limit". (Such a fault will often be nothing more than a failed chip. This will be running extremely hot and should easily be located with nothing more than the time honoured "finger tip" test!)

Fig. 1.4. Typical power supply circuit diagram for powering digital logic circuitry. The numbers within the circles are suggested circuit "test" points.



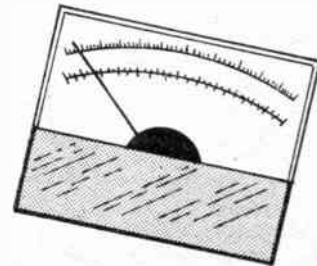
If the voltage at test point ① is outside the range 4.75V to 5.25V, then check the mains fuse at point ②. If the mains fuse has ruptured replace it with a fuse of identical rating and then repeat step ①. If the fuse immediately fails again use an ohmmeter to check bridge rectifier (D1-D4), C1, and IC1 for short circuits.

3. If the mains fuse is intact, use the multimeter on the a.c. voltage ranges to check the secondary voltage of T1 at test point ③. If this is not in the range 7V to 12V a.c. then disconnect the mains supply and check the on/off switch and mains transformer primary for continuity (a failure of the secondary winding is extremely unlikely).
4. If the secondary voltage is correct, check the d.c. voltage appearing across C1. If this is unusually low, or is zero, check bridge rectifier using an ohmmeter. Each individual diode of the

bridge may be tested in turn. These should each exhibit a low resistance in one direction and a very high resistance in the other. If the d.c. voltage appearing across capacitor C1 is in the range 9V to 14V, replace IC1 with a known good device and then repeat step ①.

Next Month: we shall be dealing with Symbols, Logic Diagrams and Logic Gates. Our next *Digital Test Gear Project* is a Versatile Logic Probe which can be used for logic state tracing in both CMOS and TTL circuits.

# REGULATED BENCH PSU



**MIKE TOOLEY BA**

OUR FIRST Digital Test Gear Project deals with the construction of Regulated Bench Power Supply. This unit has been designed specifically for use with digital circuitry and has separate outputs for CMOS and TTL circuits.

The CMOS output is variable from 3V to 15V (the normal range associated with CMOS devices) whilst the separately switched TTL output is fixed at 5V. Both outputs are closely regulated, have an extremely low output resistance, and are virtually completely free from hum and noise.

In order to protect both itself and the circuit to which it is connected, an essential requirement of any power supply is that it includes some form of current limiting. In order to satisfy this need, the CMOS output



## SPECIFICATIONS

CMOS OUTPUT	
Adjustable Voltage Range:	3V to 15V
Adjustable Current Limit:	10mA to 2A
Output Resistance:	less than 0.05 ohm (measured at 10V 1A output)
Output Noise Voltage:	less than 0.5mV (10Hz to 100kHz)
Regulation:	better than 1 per cent (at rated output)

TTL OUTPUT	
Fixed Output Voltage:	5V ± 4 per cent
Max. Rated Current:	1A
Short Circuit Current:	750mA
Output Resistance:	less than 0.05 ohm (measured at 500mA output)
Output Noise Voltage:	less than 0.05mV (10Hz to 100kHz)
Regulation:	better than 0.5 per cent (at rated output)

provides current limiting which is fully adjustable from 10mA to 2A. The TTL output, on the other hand, incorporates foldback current limiting which reduces the short circuit current to approximately 750mA. In common with our other Digital Test Gear Projects, the power supply uses low-cost readily available components and is based on a standard case and stripboard.

## COMPONENTS

### Resistors

R1	1k	0.25W
R2	1k	0.25W
R3	220	0.25W
All 1/4 W carbon film		

### Potentiometers

VR1	10k lin. wirewound
VR2	50 lin. wirewound

### Capacitors

C1	4700µ axial lead elec. 25V
C2	220n polyester
C3	100n polyester
C4	47µ axial lead elec. 25V
C5	220n polyester
C6	100n polyester
C7	47µ axial lead elec. 25V

### Semiconductors

D1-D4	In-line bridge rectifier rated at 200V 1.6A (e.g. SKB2/02L5A)
D5	Red LED (fitted with bezel)
D6	Green LED (fitted with bezel)
IC1	L200
IC2	7805

### Miscellaneous

T1	Mains transformer rated at 20VA or 24VA and having a 240V primary (or 2 x 120V primaries connected in series) and a 12V secondary (or 2 x 6V secondaries connected in series). The secondary (or secondaries) should be rated at 1.6A or 2A
FS1	20mm 1A quick-blow fuse and panel mounting fuseholder
S1	DPST or DPDT min. rocker switch rated for 240V a.c. operation
S2	SPST or SPDT min. rocker switch
SK1 to SK4	4mm sockets (2 black, 1 red, 1 yellow)
Heatsink, TO220 extruded heatsink rated at 6.8 deg.C/W or better; Case, Verobox measuring 205 x 140 x 75mm approx. (optional tilt-leg assembly); Veroboard, 0.1in. matrix measuring 95 x 63mm; Single-sided 1mm terminal pins (14 required); Insulated spacers or mounting pillars (2 required); Mounting nuts and bolts (6 required).	

Approx. cost  
Guidance only **£25**

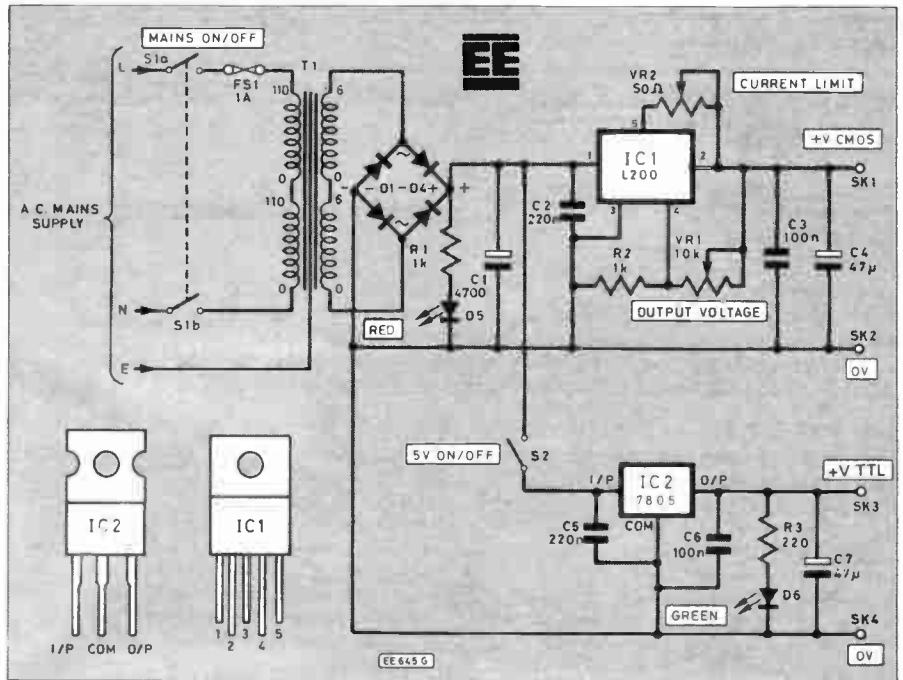


Fig. 1. Complete circuit diagram for the EE Regulated Bench Power Supply Unit.

## CIRCUIT DESCRIPTION

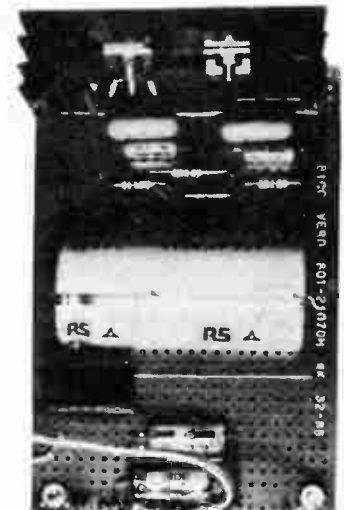
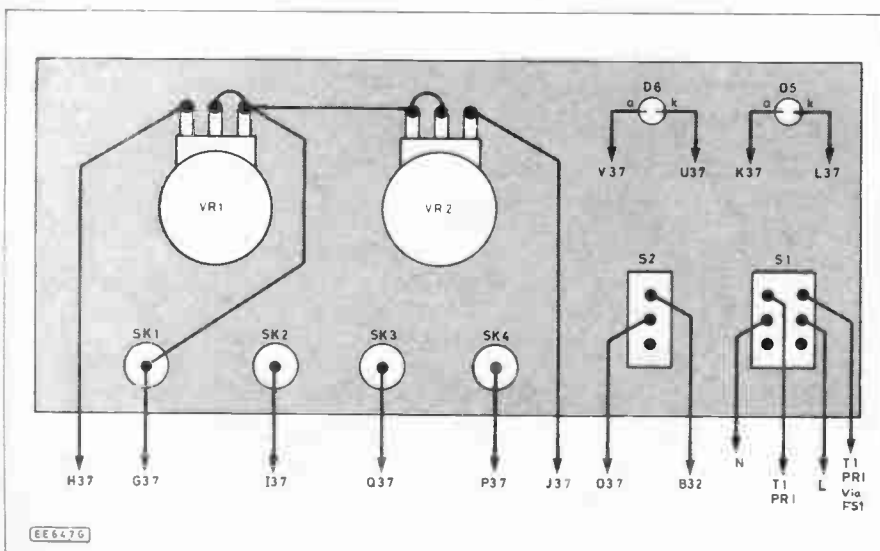
The complete circuit diagram for the EE Regulated Bench Power Supply is shown in Fig. 1. The mains transformer, T1, provides low-voltage a.c. input to the encapsulated bridge rectifier, D1-D4.

The d.c. output of the bridge rectifier (approximately 17V) is developed across the reservoir capacitor, C1. An LED, D5, together with current limiting resistor, R1, is used to indicate the presence of d.c. at this point and hence also serves as a simple "mains indicator".

The unregulated direct voltage developed across capacitor C1 is applied to the inputs of IC1, the adjustable regulator, and via switch S2 to IC2, the three-terminal fixed 5V regulator. The output of IC1 is made adjustable by means of potentiometer VR1, whilst adjustable current limiting is provided by VR2.

A separate LED, D6, is used to indicate the presence of the 5V (TTL) output. High frequency stability is ensured by means of capacitors C2, C3, C5 and C6 whilst capacitors C4 and C7 provide additional decoupling of the CMOS and TTL outputs respectively.

Fig. 3. Interwiring details for the front panel mounted components.



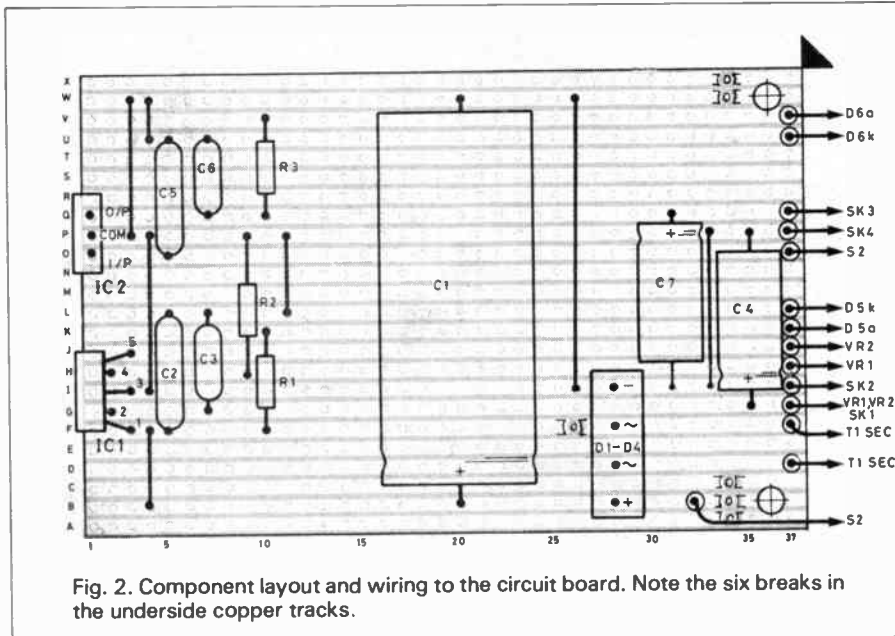
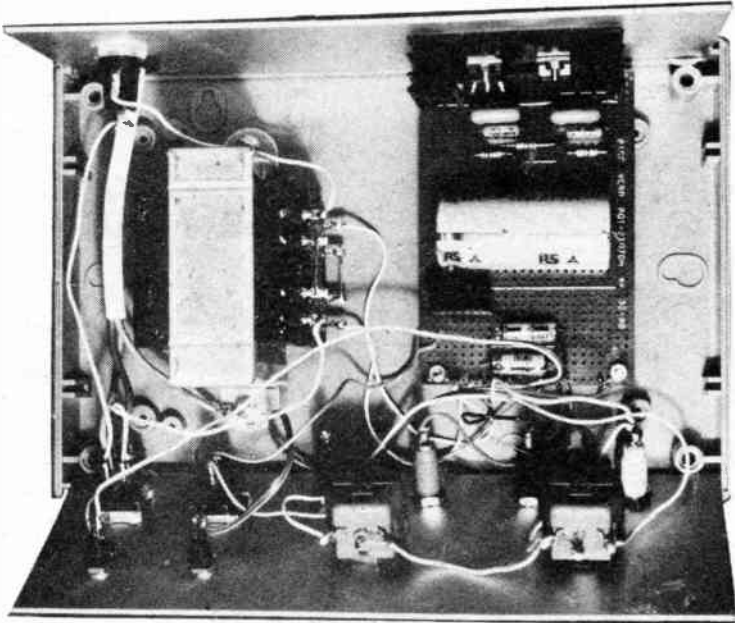


Fig. 2. Component layout and wiring to the circuit board. Note the six breaks in the underside copper tracks.



**CONSTRUCTION**

With the exception of the mains transformer, fuseholder, and front-panel controls, all components are mounted on a standard size matrix board comprising 24

strips of 37 holes. The component layout is shown in Fig. 2.

Readers should note that six track breaks are required and these should be made using a spot face cutter. If such a tool is

unavailable, a sharp drill bit of appropriate size may be used.

The following sequences of component assembly is recommended; links, capacitors, resistors, bridge rectifier, terminal pins, and integrated circuits. These latter devices are mounted so that their heatsink tabs are aligned in a common vertical plane to facilitate mounting on a common heatsink bolted to the inside of the rear metal panel of the case.

Before mounting the circuit board in its final position, however, constructors are advised to carefully check that components, links, and track breaks have been correctly placed. Furthermore, it is also worth checking that the polarised components (including electrolytic capacitors and bridge rectifier) have been correctly orientated.

Constructors should also examine the underside of the Veroboard for dry joints, solder splashes, and bridges between tracks. It should go without saying that a few minutes spent checking the board at this stage can save many hours of agony later on!

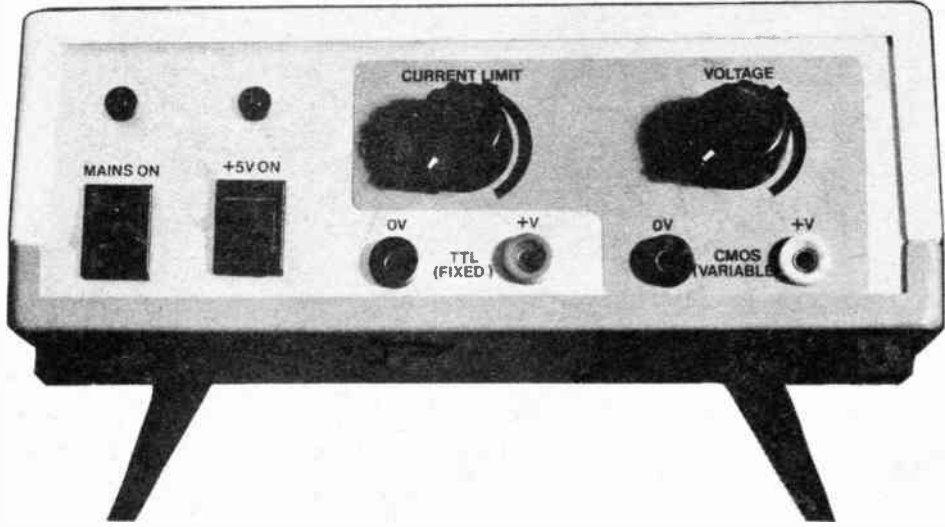
When the board has been thoroughly checked, it should be mounted horizontally in the base of the case. Two short insulated stand-off pillars should be used to support the front edge of the board whilst the rear edge of the board is supported by the heatsink assembly.

**INTERWIRING**

Controls, switches, indicators, and output connectors should be mounted on the rear of the front panel according to Fig. 3 and photograph. A separate overlay may be made and fixed to the front panel using an appropriate adhesive. Links to the front panel mounted components should be made using short lengths of insulated wire, following the wiring diagram shown in Fig. 3.

When complete, constructors should carefully check the internal wiring—taking particular care to check the fuseholder, mains transformer, and mains switch. The mains supply should now be connected and a multimeter (switched to the d.c. voltage ranges) should be used to check that the voltage developed across capacitor C1 is in the range 15V to 18V.

Having confirmed that this voltage is correct, the meter should first be transferred to the TTL and then to the CMOS output. Where a fault is suspected, constructors should follow the "Power Supply Fault Finding" procedure described earlier! □



Next Month: A Versatile Logic Probe which can be used for logic state tracing in both CMOS and TTL circuits.

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# exploring electronics

OWEN BISHOP

## PART 5 Triggered circuits

**T**HIS month we look at some circuits that are triggered into action by a relatively small change of voltage at some part of the circuit. The essential point about a circuit that is triggered (as opposed to one that is merely switched on or off) is that reversing the condition which triggered the action does not cause the action to cease.

One of the classical triggering circuits is the Schmitt Trigger, which we shall now investigate.

### SCHMITT TRIGGER CIRCUIT

First set up the circuit of Fig. 5.1 on the demonstration "breadboard". In this circuit you can vary the voltage at the base of TR1 from 0V to 6V by simply adjusting VR1.

Start with the wiper of VR1 nearest to the 0V end (fully anticlockwise). Now turn the knob slowly clockwise and watch what happens to the lamp LP1.

At first it is not lit, because the base voltage is too low and the base current is too small. As VR1 is turned the lamp starts to come on and brightens gradually. After a little more turning it is fully lit and further turning does not make it any brighter. The transistor is termed to be *saturated*.

If you reverse the direction of turning just as the lamp begins to come on, it immediately goes out again. The change in voltage simply turns the lamp on or off, acting in a similar way to an ordinary switch.

Now set up the circuit of Fig. 5.3 in which there is an extra transistor between VR1 and TR1. This is one form of the type of circuit generally referred to as a Schmitt Trigger.

Start with VR1 fully anticlockwise, as before. In this position the lamp is on. Since TR2 is off, its collector voltage is high and current flows through resistor R3 to the base of TR1, turning it on. This switches the lamp LP1 on, too.

Turn the potentiometer VR1 slowly, as before. At a certain point the lamp LP1 goes out suddenly, even though it

was previously glowing at full brightness.

This circuit has a much more definite "on-off" switching action than the one in Fig. 5.1. This is the first distinguishing feature of the Schmitt Trigger.

As soon as the lamp goes out, stop

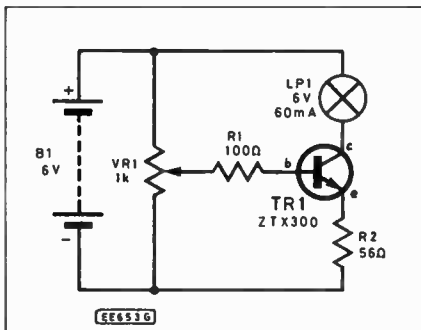
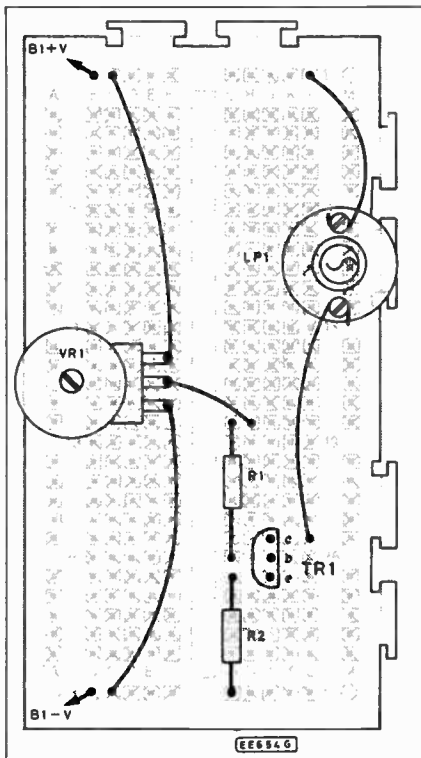


Fig. 5.1. Circuit demonstrating simple switching action of a single transistor.

Fig. 5.2. (below). Breadboard layout for the demonstration circuit of Fig. 5.1.



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.

turning VR1. Now slowly turn it back again. The lamp does not immediately light again. You have to turn the knob an appreciable distance before the

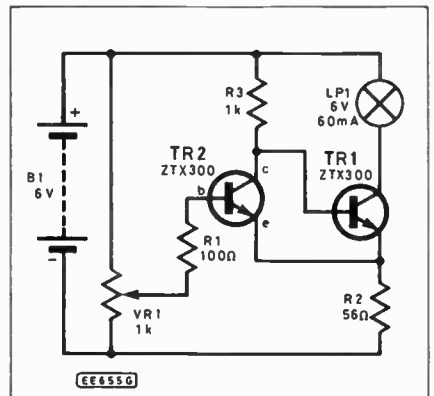
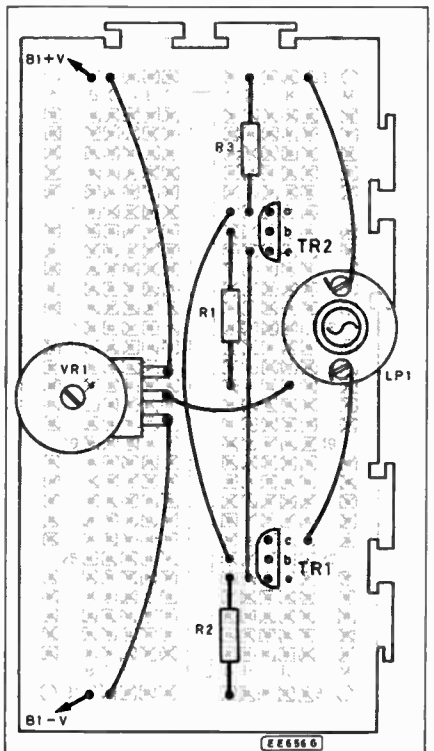
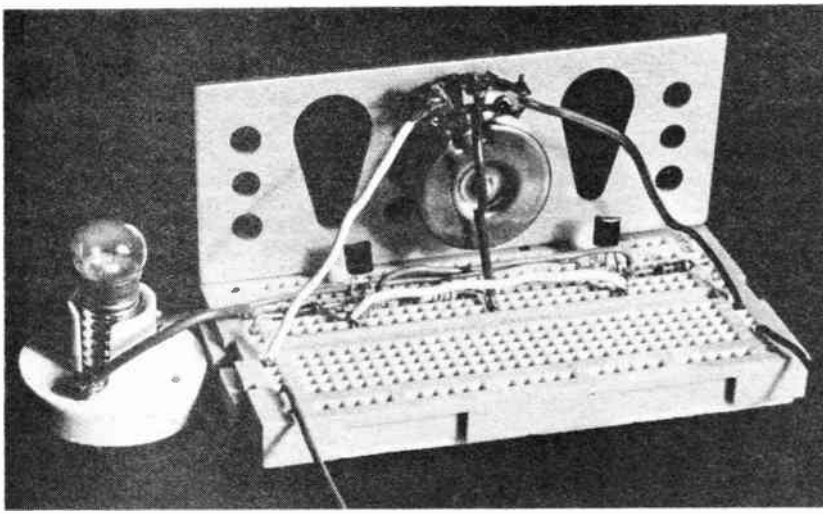


Fig. 5.3. Circuit with Schmitt trigger action.

Fig. 5.4. (below). Breadboard layout for demonstrating Schmitt trigger action of Fig. 5.3.





lamp lights. Once turned off, the lamp stays off until the control has been reversed by a fairly large amount.

This is the second important feature of the Schmitt trigger circuit. Note also

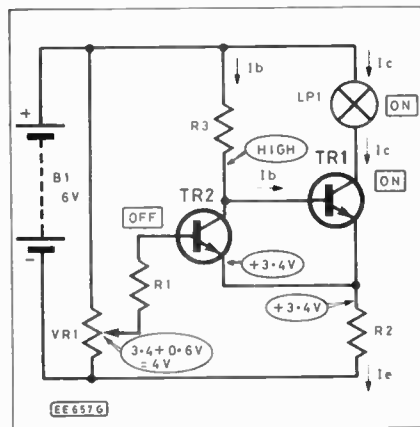


Fig. 5.5. Circuit depicting the action of the Schmitt trigger during lamp switch-on.

that, when the lamp comes on again, it is at full brightness.

## HOW IT WORKS

A better understanding of the circuit action of Fig. 5.3 can be gathered by studying Fig. 5.5 and Fig. 5.6.

With transistor TR1 fully on and the lamp LP1 shining brightly, Fig. 5.5, a current of about 60mA flows through

LP1, TR1 and R2. The p.d. across resistor R2 is  $V = IR = 0.06 \times 56 = 3.36V$  (approx. 3.4V).

Potentiometer VR1 is turned to increase the voltage at the base of TR2.

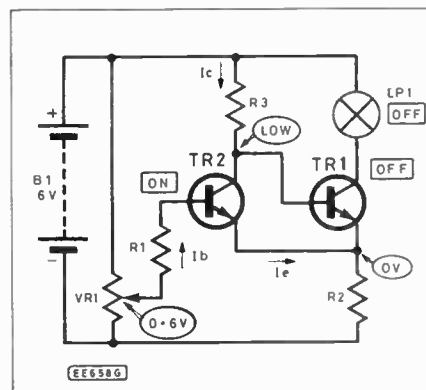
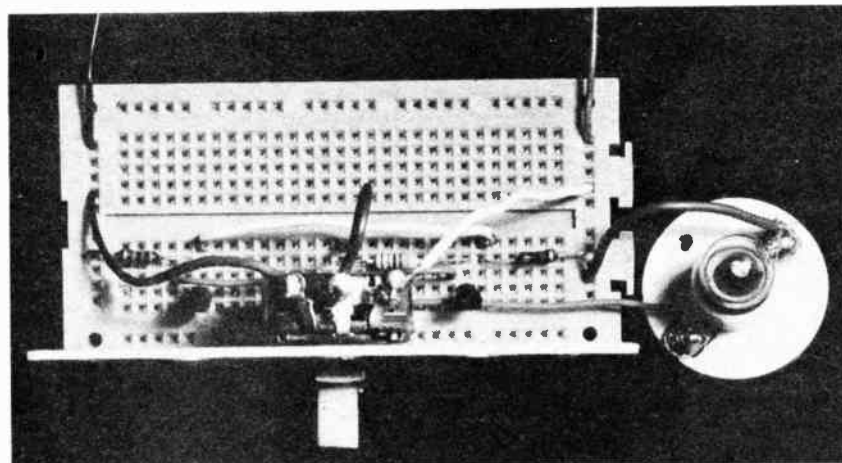


Fig. 5.6. Circuit showing the condition of the Schmitt trigger during lamp switch-off.

TR2 does not begin to turn on until its base is 0.6V higher than its emitter (which is at 3.4V, the same as the "upper" end of resistor R2). So TR2 remains off until the voltage at VR1 exceeds 4V (3.4V + 0.6V).

As soon as TR2 begins to turn on, the voltage at its collector falls, see Fig. 5.6. TR1 receives less base current and begins to turn off. The current through LP1, TR1 and R2 is reduced.



## Resistors

- R1 100
- R2 56
- R3,R5 1k (2 off)
- All  $\frac{1}{4}W \pm 5\%$  carbon

## Potentiometers

- VR1 1k carbon track, lin.
- VR2 10k carbon track, lin.

## Semiconductors

- TR1-TR3 ZTX300 npn transistor (3 off)

## Miscellaneous

- R4 ORP12 (or similar) cadmium sulphide light-dependent resistor

0.1in matrix stripboard, 10 strips x 24 holes; knob for VR1 or VR2; LP1 filament lamp 6V, 0.06A; holder for lamp; 6V audible warning device or 6V relay (optional); 1mm terminal pins (5 off); connecting wire.

Approx. cost  
Guidance only

£5

Reduction of current through resistor R2 reduces the p.d. across it. The voltage at its upper end begins to fall. Consequently, without turning VR1 any further, the p.d. between the base and emitter of TR2 is greatly increased. This turns it "hard" on, turning TR1 hard off, extinguishing the lamp. This type of circuit has a sharp "snap" action, giving a quick response for a small change of voltage at VR1.

As we start to turn VR1 to switch the lamp on again, there is no current through resistor R2, so its "upper" end is at 0V (Fig. 5.6). There is 4V p.d. between the base and emitter of TR2, so it is firmly on. Reducing the voltage slightly at VR1 has no effect.

In order to turn TR2 off, we have to turn VR1 until the voltage at its wiper is only 0.6V. As soon as this point is reached, TR2 starts turning off, the voltage at its collector rises, TR1 starts turning on, current starts to flow through LP1, TR1 and R2 and a p.d. appears across R2. The voltage at the "upper" end of R2 rises, making the p.d. between the base and emitter of TR2 much less than 0.6V. TR2 snaps off, TR1 snaps on and the lamp comes on.

Thus this circuit has a "snap" action for turning the lamp on and off. It also has a differential between the voltage required at VR1 for turning the lamp off (4V) and voltage required for turning it on (0.6V).

Turn over for Light Triggered Switch

## LIGHT TRIGGERED SWITCH

A circuit diagram for a simple Light Triggered Switch is shown in Fig. 5.7. A stripboard layout is shown in Fig. 5.8, with an additional transistor to drive an audible warning device (see Fig. 5.9).

This circuit switches on a lamp whenever it detects a fall in the level of illumination. It could turn on a small lamp when it begins to get dark each evening.

It can also be used to detect when a beam of light has been broken, for example when a person walks between a source of light and the sensor of the circuit. The lamp can be placed at a distance from the rest of the circuit, so a remote warning can be given.

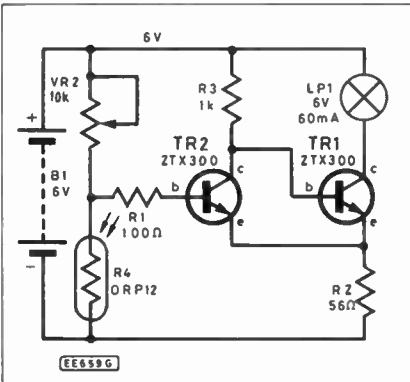


Fig. 5.7. Circuit modification to Fig. 5.3. to give a simple Light Triggered Switch.

The light switch Fig. 5.7 is a Schmitt trigger circuit using a pair of resistors to control the current to the base of TR2. One resistor R4 is a light-dependent resistor (LDR). It has high resistance in the dark, and its resistance decreases as the level of light falling on it is increased. The other resistor VR1 is used for setting the level at which the circuit triggers.

## CONSTRUCTION

The Light Triggered Switch circuit may be constructed using a piece of 0.1in. matrix stripboard having 10 strips  $\times$  24 holes. You can, of course, build the circuit on the breadboard.

The component layout for the stripboard is shown in Fig. 5.8. No special construction techniques are used, except care should be exercised when soldering the transistors in position. (See this month's *Soldering* feature).

Apart from ensuring the transistors are inserted with their leads in the correct order, be sure to make the break in the underside copper strip at point D16. Also, remember to insert the wire link. Use solder pins to anchor the lead-off wires to the board.

No problems should be experienced in setting the circuit up and getting it to work. When it is switched on, turn VR1 until the lamp lights; then turn it slowly until it just goes out.

If you now place your hand over the

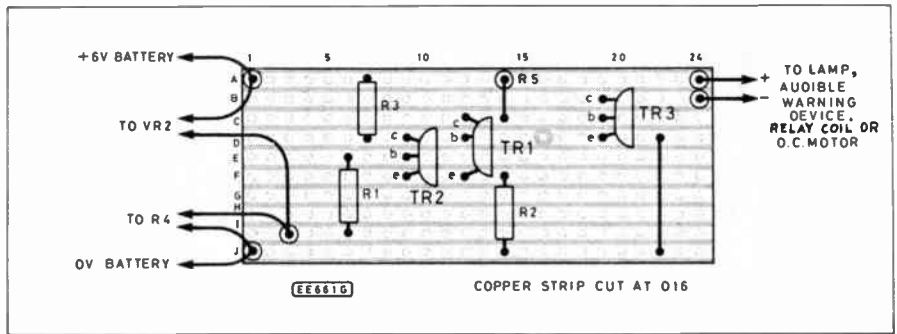
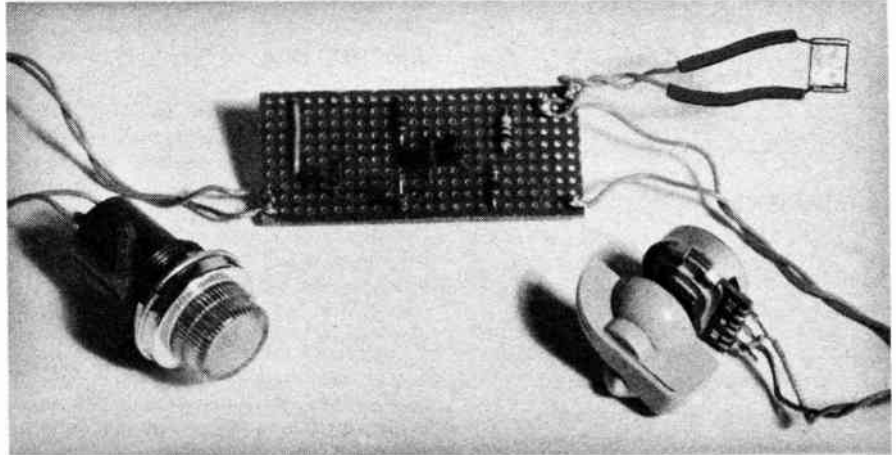


Fig. 5.8. Stripboard component layout for the Light Triggered Switch.



The completed light-operated switch. The battery leads are not shown.

LDR to shade it, the lamp should come on again. It should go out when you take your hand away.

It can switch on a lamp at dusk, for example, and turn it off the next morning. The advantage is that, having switched a lamp on at dusk, it will not switch it off again should the sky temporarily clear and light intensity increase for a while.

You can use the circuit in another way. Turn VR1 until the lamp lights, then until it just goes out. Now turn VR1 back a little way, but not far enough to switch the lamp on again. You should be able to find a setting of VR1 in which the lamp comes on when the LDR is shaded, and then stays on, even when you take your hand away. It could be used to detect when an intruder breaks a light beam. Once triggered the lamp remains on after the beam is restored by the person moving out of the beam.

## MORE POWER

The Schmitt trigger circuit must have a resistor (R2) between the emitter of TR1 and the 0V line. This cuts down the amount of current that can flow through the lamp, so it does not shine at its full brightness.

To make it shine really brightly we use the Schmitt circuit to switch a third transistor, Fig. 5.9. The third transistor TR3 switches the lamp fully on.

A small audible warning device could be wired in place of the lamp LP1. Or you could substitute a small relay to operate a mains powered lamp, bell or motor.

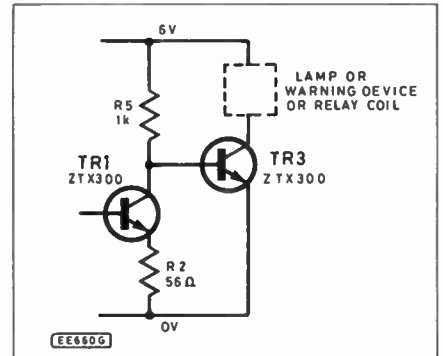


Fig. 5.9. Modification of Fig. 5.3. to allow switching of a larger current. For even greater currents use a power transistor in place of TR3.

Next month: Transistor as an amplifier plus simple intercom and radio receiver with amplifier.

### You Will Need

#### Resistors

R1	3M3	R3	39k	R5	330
R2	820k	R4	10k		
All $\frac{1}{2}$ W $\pm$ 5% carbon					

#### Capacitors

C1	100n polyester
C2	47 $\mu$ elec. 10V
C3	220 $\mu$ elec. 10V
C4	10n polyester (if diode radio is to be connected)

#### Transistors

TR1, TR2, TR3 ZTX300 npn (3 off)


#### Miscellaneous

Breadboard or 0.1in matrix stripboard, 24 strips  $\times$  37 holes; crystal microphone or mic. inset; 8 ohm loudspeaker (crystal earpiece preferred for radio version); 1mm terminal pins (6 off); connecting wire, including several metres twin speaker lead for intercom version.



# DOWN TO EARTH

BY GEORGE HYLTON



## LOOP AERIALS

Loop aerials of the ferrite rod type are now almost universal for medium and long wave reception. Why aren't they used for short waves?

They are, occasionally. But a short-wave ferrite rod aerial is very insensitive compared with the conventional pull-out telescopic whip.

## OPPOSING VOLTAGES

The reason lies in the way a loop aerial works. Forget about the ferrite rod for the time being and think about the winding on it. This is just a little coil of wire. To see how it works, we'll simplify it by using a single turn, see Fig. 1.

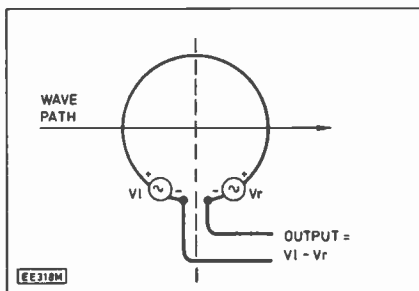


Fig. 1. Loop aerial basics.

If a radio wave passes across the loop from left to right it strikes first the left hand part, inducing a voltage  $V_1$ , then the right hand part, inducing voltage  $V_r$ . These voltages oppose one another. They try to drive currents round the loop in opposite directions. The consequence is that current flows only if the voltages are unequal.

In general the voltages are indeed unequal, because at any instant the two halves of the loop see slightly different parts of the passing wave. If the peak of the wave just reaches the left hand part then the right hand part is seeing something less than the peak. So  $V_r$  is less than  $V_1$  and current can flow.

But not much current. If the wavelength is long compared with the diameter of the loop (as it always is) the two halves see almost the same phase of the passing wave and the two voltages are almost equal. Consequently very little voltage difference is available to provide an output.

In a practical ferrite aerial for medium and long waves this inherent inefficiency is

improved in three ways. First, the number of turns is increased. This multiplies the voltage. Secondly, the ferrite rod is inserted into the coil. This concentrates the magnetic field and improves signal pickup, by an amount which depends on the length of the rod and which is often 5 to 10 times. Thirdly, the coil is tuned by a capacitor to the signal frequency. This improves matters by a factor which is the quality factor or  $Q$  of the coil. It can be 100 at medium frequencies.

All these improvements combine to provide adequate sensitivity on medium and long waves where signals come from relatively close transmitters so that field strengths are high.

## SHORT WAVE LOOPS

It's a different story on short waves. Here the transmission you are tuned to may have come a very long distance.

Even if the transmitter has high power the signal is likely to be weak by the time it reaches you. For this reason, even though the efficiency of a loop aerial improves as the wavelength gets shorter it is still not good enough.

What can be done? The obvious way to improve pickup is to use a bigger loop. If the left hand side is further from the right, Fig. 2, then the two sides see bits of the passing wave whose amplitude difference is greater. Hence more voltage difference and more output.

In practice, long thin loops like Fig. 2 are not the best shape. The reason is that although the two vertical sides (which are the bits that respond to the passing wave, if it is vertically polarised) are well separated they are also relatively short. For good pickup they should be long.

typical short-wave frequency of 10MHz, an untuned loop would have to be several metres in diameter to pick up as much voltage as the average whip. A few short-wave receivers with built-in loop aerials have been made, but the loop is not popular and, as receivers get smaller, is likely to be even less so.

This is a pity, because, despite their inefficiency, loops have some attractive properties. One is that they tend to be less susceptible than whips to interference from vacuum cleaners, fans and so on. Another is that they are directional. In theory a loop is quite blind when turned to face an incoming signal. This is the property that is used in direction-finding receivers; to the home user it means that a loop can be used to reduce interference from a too-powerful local station.

## EXTERNAL LOOPS

If you are prepared to make a separate tuned loop to use with a short-wave receiver you can get quite useful results. On short waves only a small tuning inductance is needed and a single turn of thick wire is sufficient.

A circular loop of one metre diameter has an inductance of about 4 microhenries. For other diameters inductance is roughly proportional to the relative area.

The ends of the one-turn loop are connected to a tuning capacitor of the usual MW/LW type (a few hundred picofarads). The most convenient way of coupling the loop to the receiver is to wind a secondary loop of about two turns of any sort of insulated wire round the cabinet (longest way round).

If the receiver has aerial and earth terminals the bared ends are connected to

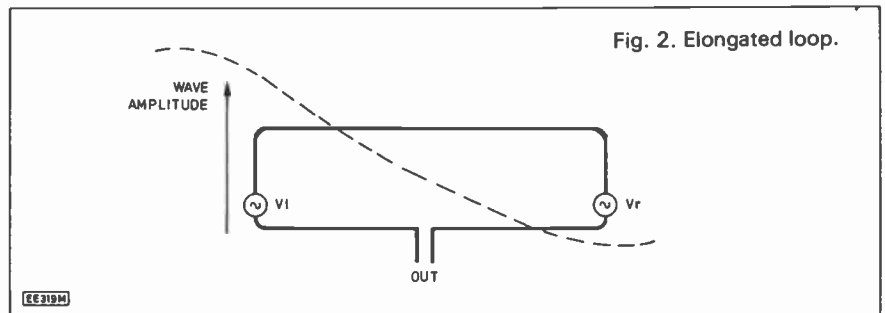


Fig. 2. Elongated loop.

The upshot of all this is that, given a length of wire to make a loop the most efficient strategy is to bend it into a shape which embraces the biggest possible area. The optimum shape is a circle, but a square is nearly as good and is often easier to make.

## OPEN WIRE LOOPS

It's hardly practicable to fill a large-area loop with ferrite, so one cannot now obtain any field-concentration. Even so, quite a modestly dimensioned open wire loop can be much better than a ferrite rod.

The diameter of the coil round a rod might be 20mm. An open loop can easily have a diameter of 200mm. Ten times the diameter means a hundred times the area, and it's the area that counts. So even if the ferrite rod in the small loop gives a tenfold improvement the open loop is still ten times better.

It seems that an open loop might be quite a good thing for short-wave reception. Unfortunately, it's still poor compared with a telescopic whip. At the

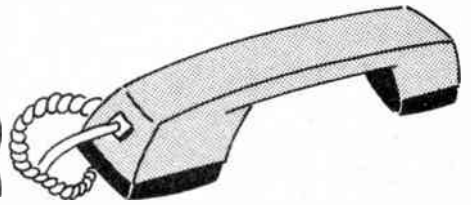
these. If not, connect one end to one side of the battery and the other end indirectly to the whip aerial by wrapping the wire round the whip a few turns without removing the insulation.

Tune the receiver to a weak station. Place it inside the loop. Tune the loop to get an increase in volume. The tuning of the loop holds good for nearby frequencies.

Occasionally a station will disappear when the loop is tuned. This is because the station was breaking through on the "image" or "second channel" frequency which differs from the correct frequency by twice the i.f. of the receiver. The loop, by providing enhanced selectivity at the signal frequency, reduces this sort of breakthrough.

A large, multi-turn loop can be used on medium or long waves to improve fringe-area reception. In this case there is no need of a coupling loop: the built-in ferrite rod aerial does the job. Usually the cabinet must be set at right angles to the face of the loop for maximum coupling.

# MODEM TONE DECODER



R.A. PENFOLD

## The "DEM" part of a modem. Needs no approval from BT!

MODEMS must now rank as one of the most popular of computer add-ons, and they can certainly increase the usefulness of a computer quite substantially. They provide a means of accessing large data bases and bulletin boards, as well as permitting users to swap programs or other data via the telephone system.

It was the need of a data link via the telephone lines that led to the development of this project. All that is needed to provide such a link is a couple of 300 baud CCITT standard modems, but if simplex operation is all that is required (i.e. data will only be sent in one direction) this is a rather expensive solution. For simplex operation a BT approved modem should be used at the sending end of the system, but a simple tone decoder is all that is needed at the receiving end.

This article describes a suitable tone decoder for 300 baud CCITT standard signals. It is inexpensive to build, and although powered from a single nine volt battery it provides full RS232C output levels, and is capable of driving any RS232C or RS423 serial input.

It extracts the signal from the telephone via a pick-up coil; the unit does not connect directly to the telephone system. Apart from making the unit quick and easy to install this has the advantage of eliminating any problems with gaining BT approval. As there is no direct connection to the tele-

phone lines and the unit does not transmit a signal into the system, no approval is needed and it can be used quite legally.

## TONE DECODING

Serial signals are not suitable for direct connection to the telephone lines as the signal voltages involved are incompatible, and there would almost certainly be problems with any noise on the lines causing corrupted data anyway. The signals must therefore be encoded into audio tones which can be sent down the telephone lines just like ordinary voice signals, and then decoded back to ordinary serial signals again at the receiving equipment.

All tone encoder/decoder systems of this type operate with a simple two-tone arrangement where the two logic levels are represented by different frequencies. This is really just the most basic of frequency modulation/demodulation systems, and the word "modem" is a contraction of modulator/demodulator. This unit could presumably be accurately referred to as a "dem".

The CCITT 300 baud system is capable of full duplex operation (simultaneous data exchange in both directions), and four tones are consequently involved, with each modem transmitting on a different pair of frequencies. Obviously the two modems must be set to the opposite operating modes so that they do in fact transmit on different frequencies, and the two modes are called "originate" and "answer".

As these names suggest, the originate mode is used by the originator of a call, while the answer mode is used when a call is answered. With the 300 baud CCITT system the transmit frequencies are 980 and 1180 in the originate mode, and 1650 plus

1850 in the answer mode. This decoder circuit can be adjusted for reception of either set of frequencies.

## DECODER OPERATION

The block diagram of Fig. 1 helps to explain the way in which the decoder functions.

A telephone pick-up coil consists of little more than a coil of wire and a rubber sucker which enables it to be fixed to the telephone. The pick-up acts as the secondary winding of a transformer in conjunction with an inductive component in the telephone base, or with some telephones better results might be obtained with the coil on the earpiece.

The pick-up coil does not produce a very high output level, and devices of this type are in fact designed to have output characteristics similar to a low impedance dynamic microphone. This means a typical output level of something under 1mV r.m.s., but from a low source impedance.

The first stage of the unit is an amplifier which boosts the signal voltage by about one hundred times. The boosted signal is fed to lowpass and highpass active filters which restrict the bandwidth of the system and help to avoid problems with noise corrupting data.

Modems often use very high quality bandpass filters, but this is only necessary where two way communications is involved and there would otherwise be a risk of the unit's output signal interfering with reception of the incoming signals. In this case the main purpose of the filtering is to reduce any mains "hum" received by the pick-up coil. The next stage is another amplifier having a voltage gain of around one

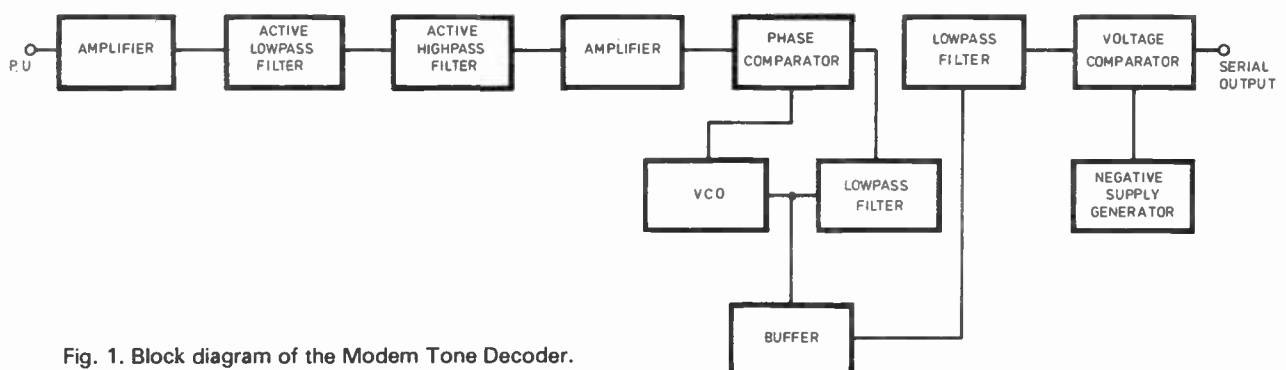


Fig. 1. Block diagram of the Modem Tone Decoder.

EE302M

hundred times, and this boosts the signal to a level which is adequate to drive the tone decoder reliably.

The tone decoder is based on a phase locked loop which is comprised of the phase comparator, lowpass filter, and VCO (voltage controlled oscillator) stages. The purpose of the phase locked loop is to lock the VCO onto precisely the same frequency as the input signal.

The phase comparator and lowpass filter produce an output voltage which depends on the relative phase and frequency of the input signal and the output of the VCO. With the VCO lagging in frequency or in phase the output voltage is relatively high, and with the VCO leading in frequency or in phase the output voltage is comparatively low.

The operating frequency of the VCO is proportional to the control voltage from the lowpass filter, and we therefore have a simple negative feedback arrangement. If the VCO's frequency is too low, the control voltage goes higher, giving a higher frequency and compensating for the error. Similarly, if the VCO's output frequency is too high, the control voltage drops, giving a reduction in frequency which corrects the error.

It is not the signal from the VCO that is required in this application, but the output from the lowpass filter. As the input signal switches between the two tones, the output voltage of the filter shifts up and down. The signal here is inadequate to directly drive a serial input, but some simple signal conditioning is all that is required in order to give a standard serial output signal.

The first of these stages is a buffer amplifier which ensures that there is no significant loading on the lowpass filter. This is followed by a second lowpass filter which reduces any ripple on the signal to an insignificant level. Finally, a voltage comparator compares the demodulated signal with a reference voltage. The comparator simply provides a high output level if the demodulated signal is at a higher voltage than the reference, or a low output level if it is not.

In practice the circuit is adjusted so that the demodulated signal switches either side of the reference potential, thus producing the required output signal. This system of a phase locked loop plus signal conditioning might seem to be an excessively complex way of doing things, but in practice this method gives excellent results with good noise immunity.

Serial signals as used in the RS232C and RS423 systems are not at the usual 0 and 5V logic levels. Instead, typical signal levels of +12V and -12V are used, and the minimum requirement is +3V and -3V. Suitable output levels could be obtained by using two 9V batteries as a power source, but in the final design a single 9V battery is used, together with a simple circuit to derive a negative supply from this.

## CIRCUIT OPERATION

The full circuit diagram of the Modem Tone Decoder is shown in Fig. 2. Transistor TR1 acts as the input amplifier, and this is a standard high gain common emitter circuit. TR2 and TR3 operate as emitter follower buffer stages in the lowpass and highpass filters respectively. These circuits are both third order (18dB per octave) types, and their respective cut-off frequencies are approximately 600Hz and 2kHz.

The second amplifier is another common

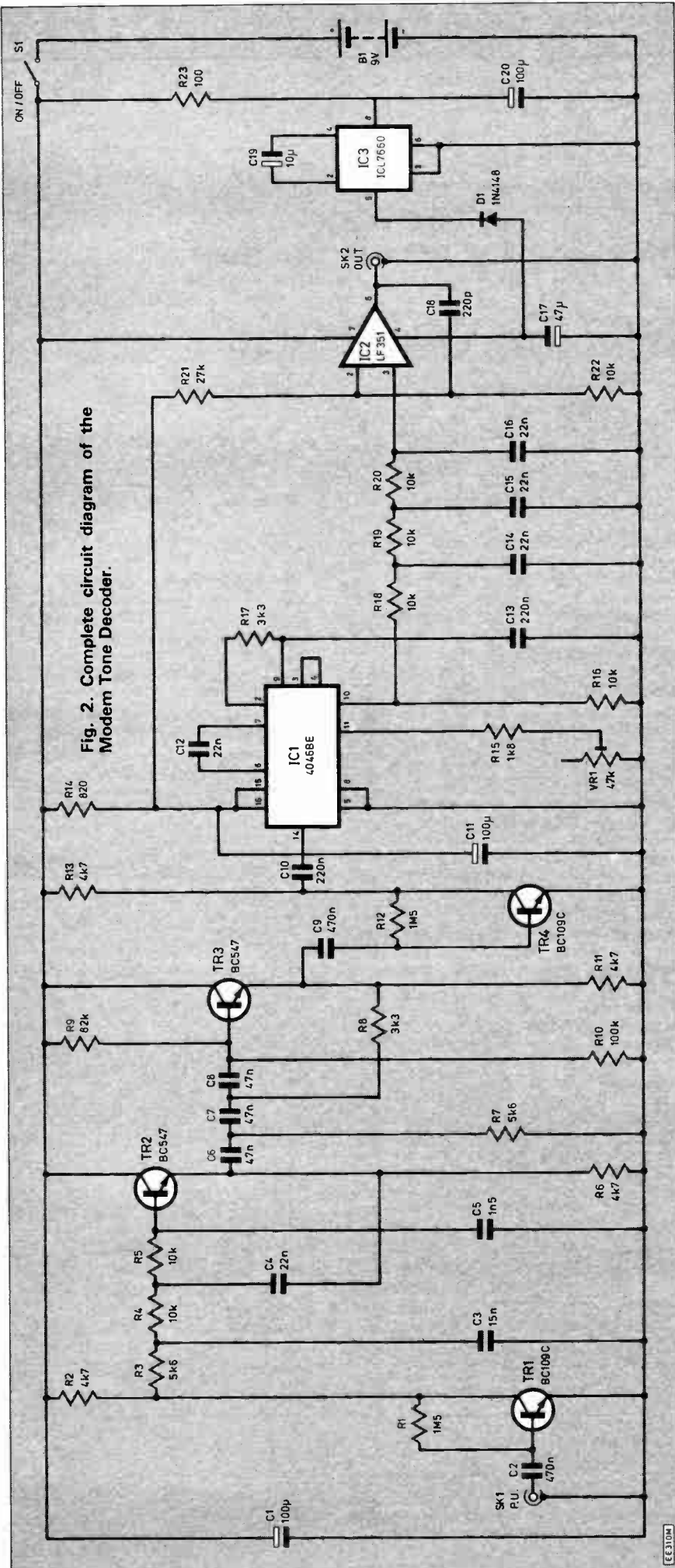


Fig. 2. Complete circuit diagram of the Modem Tone Decoder.

See  
**Shop  
Talk**  
page 588

**Resistors**

R1,12	1M5 (2 off)
R2,R6,R11,R13	4k7 (4 off)
R3,R7	5k6 (2 off)
R4,R5,R16,R18, R19,R20,R22	10k (7 off)
R8,R17	3k3 (2 off)
R9	82k
R10	100k
R14	820
R15	1k8
R21	27k
R23	100

All 1/4W 5% carbon film

**Potentiometer**

VR1	47k sub-min horizontal preset
-----	-------------------------------------

**Capacitors**

C1,C11,C20	100µ radial elec. 10V (3 off)
C2,C9	470n polyester layer (2 off)
C3	15n polyester layer
C4,C12,C14, C15,C16	22n polyester layer (5 off)
C5	1n5 polyester layer
C6,C7,C8	47n polyester layer (3 off)
C10,C13	220n polyester layer (2 off)
C17	47µ radial elec. 16V
C18	220p ceramic plate
C19	10µ radial elec. 25V

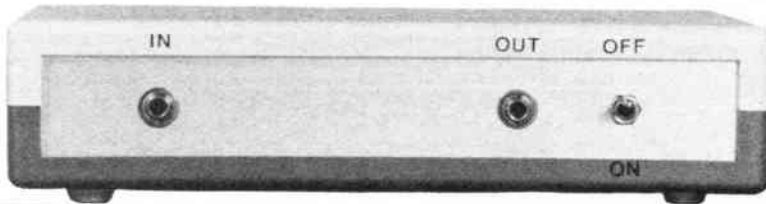
**Semiconductors**

D1	1N4148
TR1,TR4	BC109C high gain silicon npn (2 off)
TR2,TR3	BC547 high gain silicon npn (2 off)
IC1	4046BE CMOS phase locked loop
IC2	LF351 bifet op amp
IC3	ICL7660 negative supply generator

**Miscellaneous**

S1	Miniature s.p.s.t. toggle switch
B1	6 x HP7 cells in plastic holder
SK1,SK2	3.5mm jack sockets (2 off)

Printed circuit board, available from the *EE PCB Service*—code EE547; case about 180mm x 120mm x 39mm; telephone pick-up coil; battery connector; 16-pin d.i.l. i.c. holder; 8-pin d.i.l. i.c. holder (2 off); Veropins, wire, etc.



emitter type, and it is based on TR4. IC1 is a CMOS 4046BE phase locked loop. Capacitor C10 couples the output of TR4 to the input of IC1 and, as an input level of only about 200mV peak-to-peak is required, the unit has more than adequate overall sensitivity.

Capacitor C12, resistor R15, and potentiometer VR1 are the timing components in the VCO, and VR1 is adjusted to give a properly decoded output. In order to avoid the need for frequent retrimming of VR1 the phase locked loop circuit should be fed with a stabilised supply, and a stabilised 5.2V supply is provided by load resistor R14 and an internal Zener diode of IC1.

Resistor R17 and capacitor C13 are the loop lowpass filter. The buffer stage is an internal source follower of IC1, but this requires a discrete load resistor (R16).

The additional lowpass filtering is provided by a passive three stage circuit comprised of C14 to C16 and R18 to R20. IC2 is an operational amplifier which operates here as the voltage comparator.

The non-inverting input is fed with the demodulated and filtered signal while resistors R21 and R22 provide a reference voltage to the inverting input. This potential divider circuit is fed from the stabilised 5.2V rail so that the reference voltage is stabilised. This is again essential if the need for frequent readjustment of VR1 is to be avoided.

The negative supply for IC2 is generated by IC3, which is a type designed specifically as a negative supply generator. It consists basically of an oscillator driving an electronic switch. The switch repeatedly

charges capacitor C19 across the positive supply rail, and then (with the appropriate polarity) discharges it into the negative supply. C17 smoothes the negative supply, which is at a potential of around -6V to 7V.

**CONSTRUCTION**

The circuit for the Modem Tone Decoder is built on a single p.c.b. This board is available from the *EE PCB Service*, code EE547.

Only switch S1, the battery, and the two sockets are not fitted on to the printed circuit board. Fig. 3 shows the component layout and other details of the board.

While the board is not especially difficult to construct there are, nevertheless, a few points that should be borne in mind. Firstly, IC1 and IC3 are both MOS devices, and

accordingly they should be fitted in i.c. sockets and the other standard antistatic handling precautions should be taken.

The component layout is quite compact and it is essential to use suitable capacitors if they are to fit into the available space. The electrolytic types are radial lead (printed circuit mounting) components, and capacitor C18 is a ceramic plate type.

All other capacitors are carbonate or miniature polyester layer capacitors having 7.5 millimetre lead spacing. With this type of capacitor it is important to have the correct lead spacing since bending the leads inwards or outwards often results in one of them breaking off. At this stage only pins are fitted to the board at the points where connections to B1, S1, SK1, and SK2 are to be made.

A Verocase having approximate outside



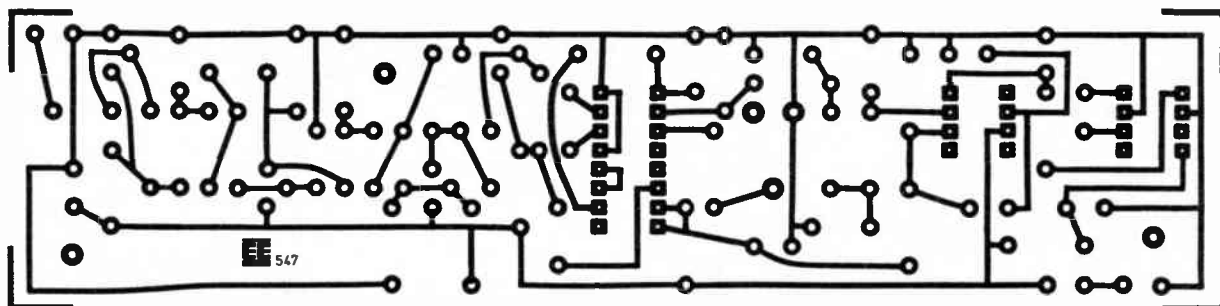
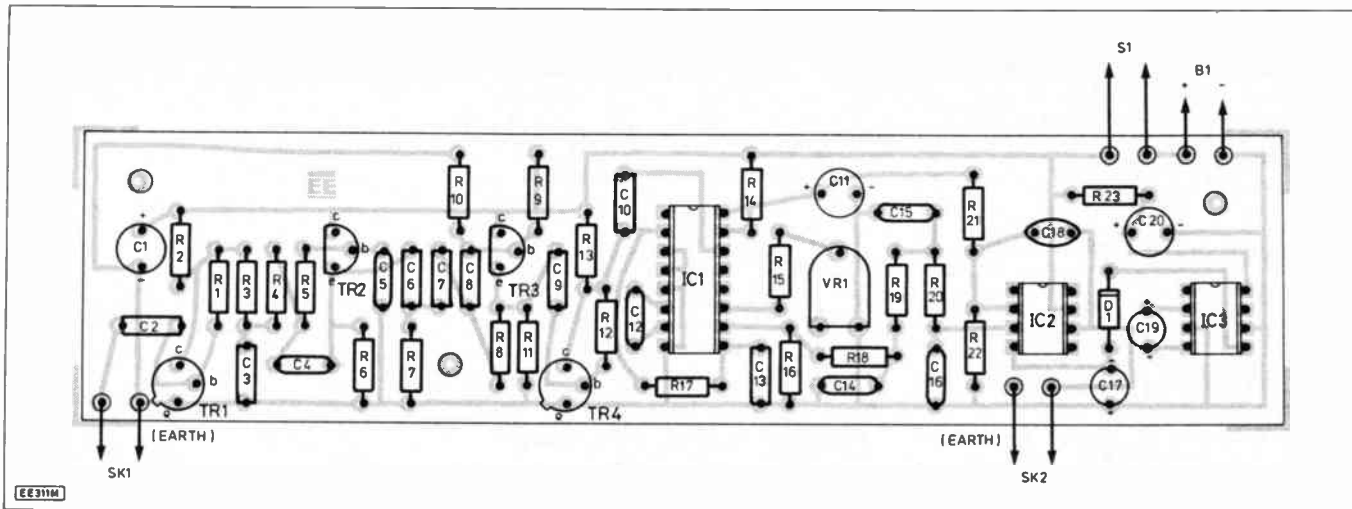
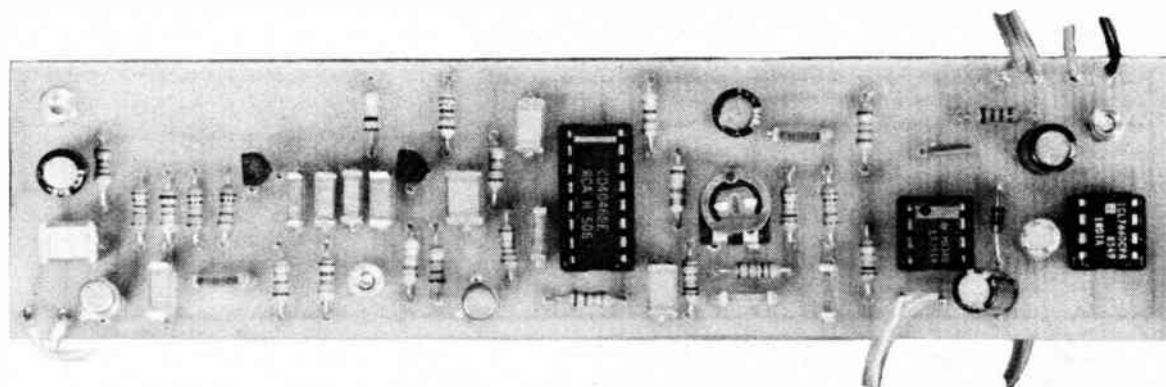


Fig. 3. Printed circuit board (full size) layout and wiring. This board is available from the *EE PCB Service*: code EE547.



dimensions of 180mm by 120mm by 39mm will comfortably accommodate all the components including the battery, and gives a neat appearance to the finished unit. However, any case of around this size should suffice. The two sockets and the on/off switch are mounted on the front panel, and the completed printed circuit board is bolted to the base panel using 6BA or M3 fixings.

Mount the board well forward so that there is sufficient space for the battery at the rear of the unit. The battery clip and the six remaining interconnections are then added to complete the unit.

The current consumption of the unit is approximately 10mA. This could be provided by a small battery such as a PP3, but more economic operation will probably be provided using a higher capacity battery. The prototype is powered by six HP7 size cells fitted in a plastic holder. The latter has a standard PP3 style connector.

### ADJUSTMENT AND USE

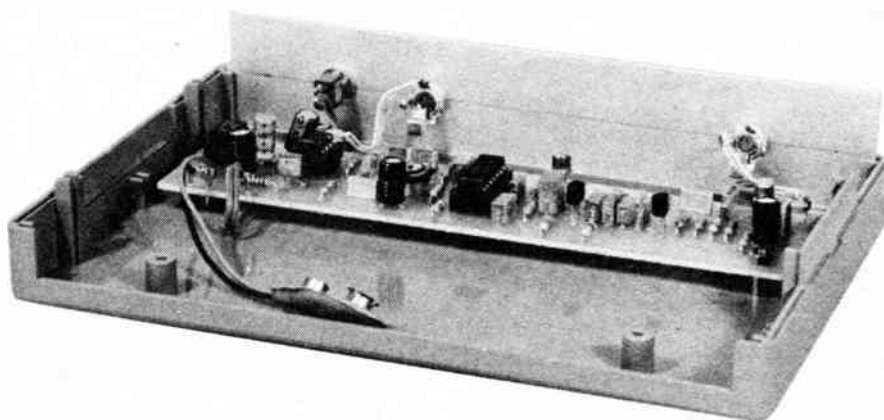
Before the unit can be set up ready for use it is necessary to have the telephone providing a suitable test signal. In order to achieve

this it is first necessary to make telephone contact with whoever is going to be supplying data, and their modem must be switched on line and fed with data.

For testing purposes it is advisable to have the system simply transmitting the same word plus a carriage return over and over again. For example, I set up a BBC computer to repeatedly send the word "TEST". Something simple such as this

makes it easy to determine whether or not data is being received correctly. It has to be emphasised here that the unit is only suitable for decoding 300 baud CCITT signals, and it is unlikely to function at all with other tone standards.

The first task is to find a suitable position for the pick-up coil, and this is something that varies depending on the particular type of telephone in use. With a standard BT



type 706 telephone there seems to be optimum pick-up with the coil positioned roughly centrally on the right hand side of the telephone base.

With a Trimphone the maximum pick-up seems to be with the coil at the rear of the telephone base, towards the left hand side. A BT push-button telephone seems to give good pick-up with the coil placed just below the keypad.

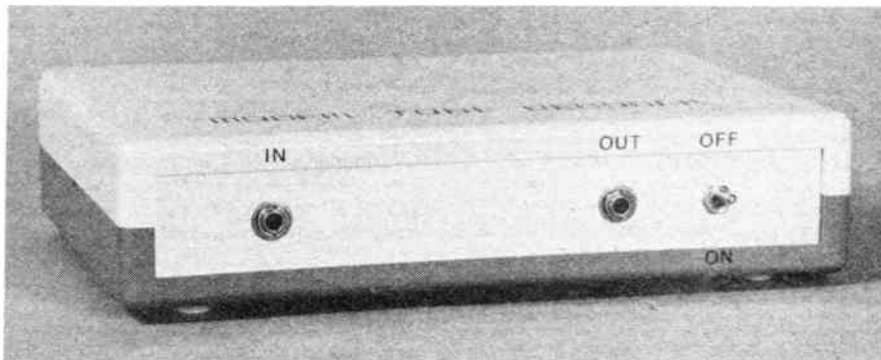
The best way to find the optimum setting is to temporarily connect a crystal earphone between the collector of TR4 and the negative supply rail. You can then hear how well or otherwise the signal is being picked up, and a little experimentation should soon locate a suitable position for the coil.

Some telephones may not give much output, and of those I have checked only a BT type 746 failed to give good results. In such cases the alternative of acoustic coupling could be used, with a high impedance loudspeaker or a low impedance dynamic microphone being used to pick up the sounds from the earpiece. A few experiments with the prototype suggests that it is not difficult to obtain good results with this

method of coupling. In the vast majority of cases a pick-up coil can be used though, and this method is preferable as it is easier to implement and is free from problems with vibrations and ambient sounds.

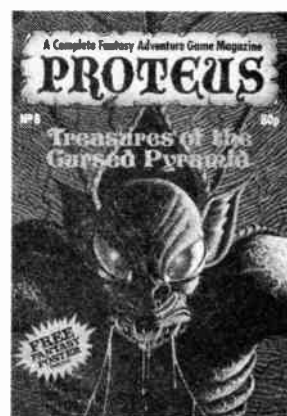
The output of the unit should be fed to "ground" and "data in" of the computer at the receiving end of the system. Note that no handshaking is implemented with modems, and that the receiving computer must

be able to keep up with the computer sending the data. As 300 baud represents a maximum of only about 30 characters per second most computers can cope without any difficulty. The receiving computer should be set up to print any received characters on-screen, and it is then just a matter of adjusting VRI to find a setting that results in error-free data being printed on the screen. □



## WATCH OUT FOR

# PROTEUS



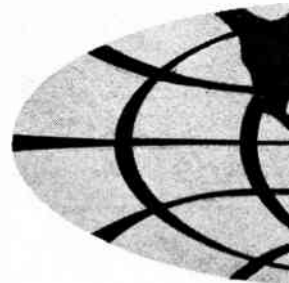
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# REPORTING AMATEUR RADIO

TONY SMITH G4FAI



## 5N CALLING

The Nigerian Amateur Radio Society is celebrating its Silver Jubilee this year. To commemorate the occasion, and to encourage more contacts with Nigerian stations, the Society is issuing a special award certificate to amateurs working into Nigeria during Jubilee year.

The Society also wants to tell the rest of the world what it has achieved during the last 25 years, and the following information about amateur radio in Nigeria has been kindly provided by Kunle B. Ajayi, 5NØBA, Secretary-General of the Nigerian ARS.

There are at present 185 licensed radio amateurs operating in Nigeria. To obtain an amateur licence, an applicant must pass the Amateur Radio Examination which, as in Britain, includes technical knowledge, operating procedures, law and regulations applying to the amateur service, and a Morse test of 12 w.p.m. The Society undertakes both the training for, and the conduct of, the examination which is held twice a year, in May and November.

NARS members keep in touch with each other through a Sunday morning two-hour net, on 40 metres, when stations call in from all over Nigeria. The Society has two repeaters for the 2m band, one in Lagos, to the south, and the other in Kano to the north, of the country. It has its own national magazine, "QRZ-5N", containing useful information originating from both within Nigeria and from around the world.

I found information in the October 1985, edition, relating to the international scene, of a kind rarely found in UK amateur magazines. Reading it, I realised how necessary it is for a country with a relatively small number of licensed stations to look to the international scene for contacts, and for encouragement in its amateur activities. Compare this to Britain, for example, where, if you don't want to, you need never work a station outside your national boundaries.

## BEGINNERS' BOOKLET

NARS has issued a very good "Introduction To Amateur radio" booklet. This covers just about everything an aspiring amateur is likely to ask, ranging from details of the Society itself to the training programme and syllabus for the amateur examination.

Nigeria is a relatively new nation, created in 1960, and the booklet includes a paper on the problems facing the government of such a country in terms of communications. It stresses that the creation of an effective amateur radio service can be an effective tool in creating enough technically trained citizens to maintain domestic and international communications circuits.

In countries subject to natural disasters, it can also provide valuable back-up communications for the emergency services, and the NARS Emergency Communication

Corps has been specially created for this purpose.

Every year, during October, the anniversary of the creation of the Federal Republic, Nigerian stations add the number of the year of celebration to their call-signs. This year is the 26th year, and during October all stations will have used the prefix 5N26, offering amateurs in other countries the opportunity of gaining yet another special award.

Amateur radio is obviously alive and well in Nigeria. Unfortunately, sunspot conditions at the present time prevent too frequent contacts between Britain and 5N-land. When they do improve, G-stations will find a group of enthusiastic outward looking operators, only too pleased to make contact with them and to tell them at first hand something of the achievements of their national society in its first 25 years.

## SPECIAL EVENT STATIONS

I sometimes mention demonstration stations set up by radio clubs, etc, at public events such as county shows, fetes, carnivals, and the like. I may have given the impression that it is just a question of taking a transceiver and antenna along to the site on the day and going on the air, but there's a lot more to it than that!

The operators of such stations can use their own call-signs, or that of their club. But if they want to commemorate the event the station is associated with, they must apply to the RSGB, acting on behalf of the DTI, for a special call-sign which can incorporate the initial letters of the event.

Prefixes allocated are GBØ, 1, 2, 4, 6, & 8. Thus, GB2RIP is currently celebrating the 1100th anniversary of the granting of a Charter to the city of Ripon, by King Alfred the Great. GB8CG operated at the Commonwealth Games, GB2YFT was at the Yeovil Festival of Transport, and GB2TVF celebrated the 22nd annual Towersey Village Festival.

## RULES

Operation of special event GB stations is subject to special rules and/or concessions. For example, simultaneous operation on several bands is permitted, using the same call-sign, allowing a multi-station demonstration to be mounted.

Under the control of the operator, members of the public may speak into the microphone to send simple greetings to other stations in the UK and in some other countries, including the USA, Canada, and the Falklands. The station, with its special call, is authorised to operate, at the site specified, during a period not normally exceeding 28 days, although there are exceptions, for example when an anniversary year is celebrated.

After obtaining the agreement of the organisers that an amateur station is an appropriate activity to link in with the

public event concerned; confirming that a suitable site, or accommodation, is available for the station and its antenna(s); and having got the special licence and call-sign; there are still a number of things to be done to ensure the success of the operation.

Suitable transmitting and receiving equipment, plus antennas for the bands to be used, need to be organised, and it is desirable to have spares as well in case anything goes wrong on the day. Suitable power supplies are needed, whether from generators, batteries, or mains. Safety measures must be carefully considered, and implemented, in terms of both operators and the general public.

Appropriate insurance must be taken out. Special policies are available for this, covering the organisers against a variety of risks, ranging from antenna masts falling down on nearby cars, to equipment blowing up, and food poisoning among the operators!

The station itself must be organised to ensure a constant supply of competent operators and assistants throughout the event. Accommodation, whether in tents, motor vehicles, or permanent buildings, has to be furnished with tables and chairs. Even stationery has to be supplied, eg, paper, pens, QSL cards, station log books, and instructions notices for the operators and, after the event, several hundred QSL cards have to be sent off.

## INFORMATION

The best stations also make proper arrangements to welcome visitors. There is usually an information desk, linked with explanatory notices and displays, and visitors are encouraged to ask questions from easily identified information stewards.

Catering is not overlooked, and often wives (XYL's) and girlfriends (YL's) provide much appreciated support, with supplies of tea, coffee, and even full meals, while the station is on the air.

The operation of these stations is usually advertised widely in advance, in amateur magazines and over the RSGB radio news bulletins. As a result, other stations are on the lookout for them anxious to obtain their QSL cards, which are often specially printed for the occasion, and a good number of contacts are made.

Next time you come across a special event station operating, you will know something of what has had to be done to get it on the air. Have a good look at everything going on, and don't hesitate to ask questions if you are not sure about anything. The purpose of a demonstration station is to show the public what amateur radio is, and what it can do, providing a good opportunity to attract prospective newcomers to the hobby.

If you have the slightest interest in amateur radio, take advantage of this chance to find out more. It could be the beginning of a new way of life!

## ... getting to grips with Handshaking ... I/O and the Tube ...

THE two handshake lines on the user port of the BBC micro can be a little confusing to those who are unfamiliar with parallel computer port techniques, and they are far less straightforward in use than are the eight data lines. The first point to bear in mind when using the handshake lines is that CB1 can only operate as an input and has no output mode at all, whereas CB2 can operate as an input or an output and it does in fact have more than one output mode.

Probably what causes most confusion for newcomers to the user port lines is the fact that when operating as inputs the handshake lines are edge sensitive types. In other words the static input level is irrelevant, and is something which can not be read. It is a transition from the low state to the high one (or vice versa, depending on the operating mode) which activates one of these inputs. The general scheme of things is to have a number of bits in a register of the 6522 VIA which are used to set the CB1 and CB2 to the required operating modes, and then to have two bits of another register which operate as "flags", and which are set to 1 when there is an active transition on their respective lines.

This system may seem rather over-complicated, and a bit pointless, but edge activated inputs do have advantages in certain applications, and particularly where handshaking is involved. The main purpose of these lines is to control the flow of data into or out of the port, and this often requires some means of regulating the flow of data so that the sending device does not output data at a faster rate than the receiving device can process it.

### Strobe Pulse

A typical arrangement would be to have a strobe output on the sending equipment which would briefly pulse low each time a new byte of data was placed onto the data lines. This would indicate to the receiving device that fresh data was available, and if necessary the strobe pulse could be used to latch the data into a data register. The receiving equipment would process the received byte of data, and would set a handshake output low to indicate that it was busy and not ready for further data to be sent. A handshake input on the receiving equipment would monitor this output and provide a hold-off until it was set high again by the receiving equipment. A new byte of data would then be placed on the data lines, a strobe pulse would be sent on the appropriate handshake output, and so on until all the data had been transferred. This is the type of handshaking used by parallel printer interfaces, and many other types of parallel come to that.

*If you have any comments or ideas for inclusion in the Beeb Micro pages, please send them to: Everyday Electronics, 6 Church St, Wimborne, Dorset BH21 1JH.*

The main point of using an edge triggered input is that even if the handshake signal it receives is a strobe pulse lasting perhaps less than a microsecond, the pulse should not be missed. This could easily occur with the alternative of using an ordinary input with periodic testing of its state by a software routine. With an edge sensitive input the pulse would be detected and the appropriate flag would be set. The flag would remain set even after the strobe pulse had finished, and it would always be set when read by the software routine, whenever that might be. The method of resetting the flag varies from one device to another, and there is sometimes more than one way of doing this, but generally it is either reset by a write operation to the flag concerned, or the flag may be automatically reset when a certain register is read (not necessarily the register containing the flag).

Edge sensitive inputs often have the capability of generating interrupts, and this is certainly the case with the two user port handshake inputs. This is something which few applications really require, but it is useful to have this facility available and the BBC computers can be set up to handle user generated interrupts. This is a topic to which we will return in a later article.

### CB2 Output

CB2 in its output modes probably represents the easiest introduction to the user port handshake lines. The handshake lines are controlled by the peripheral control register at address &FE6C, and the operating mode of CB2 is governed by three bits of this register (bits 5 to 7). There are four output modes, and the binary and decimal numbers for each of these are shown below:

Operating Mode	Binary	Decimal
High to low handshake output	100	128
High to low pulse output	101	160
Constant low output	110	192
Constant high output	111	224

In the "constant high" and "constant low" modes CB2 operates as an ordinary latching output which is set to the required state by writing the appropriate value to &FE6C. In the pulse output mode it provides a very brief negative pulse each time data is written to the user port, and this is a very useful mode as it can be used to automatically provide a strobe pulse when data is sent to the port.

In the "handshake output" mode CB2 goes low each time data is sent to the user port, but it differs from the pulse mode in that it stays in the low state. It can be reset to the high state by an active transition on CB1. This is again a useful output mode which can provide semi-automatic handshaking.

If you would like to try out CB2 as an output, try these two commands:—

```
?&FE6C = 192
?&FE6C = 224
```

The first of these should set CB2 low, and the second should set it high. A multimeter or logic probe can be used to check this. You could also try these two lines:—

```
?&FE6C = 160
?&FE60 = 0
```

First CB2 is set to the pulse output mode, and then data is written to the user port to produce an output pulse. The pulse is only in the region of 1µs, but a logic probe should be able to detect it.

### Inputs

When acting as an input CB2 is again controlled by bits 5 to 7 of the peripheral control register, and it has four input modes, as detailed below:

Operating Mode	Binary	Decimal
High to low handshake input	000	0
High to low independent input	001	32
Low to high handshake input	010	640
Low to high independent input	011	96

There are basically just two operating modes ("handshake" and "independent"), but with both of these the 6522 VIA can be set up so that the CB2 flag is set on either a low to high transition or a high to low type, as required. The CB2 flag is bit 3 of the Interrupt Flag Register at address &FE6D (the CB1 flag is bit 4 of this register incidentally). The handshake and independent modes differ in the way in which the flag can be reset. With the handshake mode it can be reset by reading from or writing to the user port, as well as by writing 1 to the relevant bit of the interrupt flag register (i.e. ?&FE6D = 8 to reset the CB2 flag, or ?&FE6D = 16 to reset the CB1 flag). Only writing 1 to the flag will reset it if an independent mode is selected.

CB1 is a very simple handshake line in that it has no output mode and only two input modes. It consequently only requires one bit of the peripheral control register for mode selection purposes, and this is bit 4. Details of the two modes and the numbers required to select them are provided below:

Operating Mode	Binary	Decimal
High to low handshake input	0	0
Low to high handshake input	1	16



You might like to try this simple program which tests CB1 as a high to low handshake input and CB2 as a pulse mode output.

```

10 ?&FE6C = 160
20 ?&FE60 = 0
30 PRINT ?&FE6D AND 16
40 ?&FE6D = 16
50 PRINT ?&FE6D AND 16
60 FOR D = 1 TO 1000:NEXT
70 GOTO 20

```

At the first line CB1 and CB2 are set to the required operating modes, and the two values needed are 0 and 160 which obviously gives a total value of 160 to be written to address &FE6C. Line 20 sends a value to the user port which results in the pulse on CB2 being generated, and if CB1 and CB2 are connected the CB1 flag will be set. The next line reads the flag, and returns a value of 16 if it is set, or 0 if it is not. The flag is reset at line 40, and then read again at line 50 to check to that it has been reset. After a delay the program is looped back to line 50 again.

If you try running the program it will simply print pairs of "0"s down the screen. However, if you try connecting CB1 to CB2 the program should print "16" followed by "0" on each loop, showing that the CB1 flag is being activated and reset properly.

There is more to the user port than the eight data lines and the basic ways of using the handshake lines, but for most purposes these are the only features of the port that are required. It is certainly worthwhile spending some time experimenting with the user port and familiarising yourself with the fundamentals of its operation and use.

### I/O and the Tube

The BBC micro uses a 6502 processor (or derivatives), and this processor, unlike the Z80, does not have input or output instructions. Instead, I/O devices appear in the

64K of the microprocessor's memory map. Input and output is therefore a simple matter of writing to and reading from these addresses.

Simple, that is, until the Tube comes into consideration. When the Tube is used, the BBC micro becomes a two-processor machine, with the two microprocessors working in parallel, each with its own memory map (see Fig. 1). In this configuration, the second processor executes the programs. These programs are stored in the second processor's memory, and use this memory for data storage. The second processor becomes responsible for all input and output, including keyboard, screen, printer, RS432, analogue port, user port, and anything else. The devices associated with these I/O facilities therefore appear in the first (I/O) processor's memory map.

This means that, from a program running on the second processor, you cannot simply use the "?" indirection operator—the BEEB equivalent of PEEK and POKE—to access, for example, the user port, as these operators will access memory locations in the second processor's memory. Instead, you have to use OSBYTE calls to read to and write from the memory mapped I/O areas.

Of course, we should all have done this when using single-processor machines, but the fact that the original user guides omitted certain vital information, like in which register the OSBYTE calls returned the value input, meant that many of us took the lazy way. Now second processors are becoming more common, many of us will have some rewriting to do!

In fact, the \*FX calls are associated with the OSBYTE calls, and for writing to these areas \*FX calls can be used.

The memory-mapped I/O is arranged in three areas, called FRED, SHEILA, and JIM. Each of these areas is one page (256 bytes) in size. FRED starts at &FC00. JIM at &FD00, and SHEILA at &FE00. There is

a separate \*FX call for each area., \*FX147 for FRED, \*FX149 for JIM, and \*FX151 for SHEILA. These calls require two further parameters. The first is the offset within the page for the device (or device register) to be written to, and the second is the value to be written.

As an example, here is how to write the value 15 (decimal) to the data direction register of the user port. The user port 6522 uses addresses from &FE60 to &FE6F, and the data direction register B is at &FE62. The offset is therefore &62, but the \*FX call cannot take HEX values, so this must be given in decimal form, 98. Therefore you would use \*FX 151,98,15.

From assembly language, the number of the OSBYTE calls is loaded in the accumulator, the offset in the X register, and the value to be written in the Y register. In assembly language, the above example becomes

```

LDA #&98
LDX #&62
LDY #&15
JSR OSBYTE

```

You should, of course, have set the value of the variable OSBYTE to &FFF4 at the head of the program.

Reading is slightly more complicated as a value has to be returned. From BASIC, this is best done by using the USR function. When this function is used, the microprocessors A, X, and Y registers are set to the values in the least significant bytes of the resident integer variables A%, X%, and Y% respectively. On return, an integer number is produced from the P, Y, X, and A registers (MSB to LSB), and this is assigned to a BASIC variable.

As with writing, the accumulator is set to the OSBYTE call number, and X is set to the offset. Y is used to return the value read. Again, each area has its own OSBYTE call to read, 146 for FRED, 148 for JIM, and 150 for SHEILA.

Here is how to read from the user port. The output register B of the 6522 VIA is at &FE60. The offset is therefore &60 or 96 decimal. The following is a short BASIC routine to read from this address. It is in the form of a function.

```

1000 DEF FNread_port
1010 A%=&96:REM osbyte call number
1020 X%=&60:REM offset
1030 R=USR(&FFF4)
1040 R=R AND &FF0000:REM mask to
      extract Y
1050 R=R DIV 65535:REM to get byte value
1060 =R

```

This returns the value read in the BASIC variable R.

In assembly language this is, perhaps, simpler.

```

LDA #&96
LDX #&60
JSR OSBYTE
STY reading

```

This stores the value read in the memory location labelled "reading". (These assembly language versions are, of course, for the 6502 or 65C102 second processors, or for the unadorned BBC micro.)

As you can see, it's quite easy when you know how!

In the next article it is back to some circuits when we look at digital to analogue and high speed analogue to digital converters for the BBC machines.

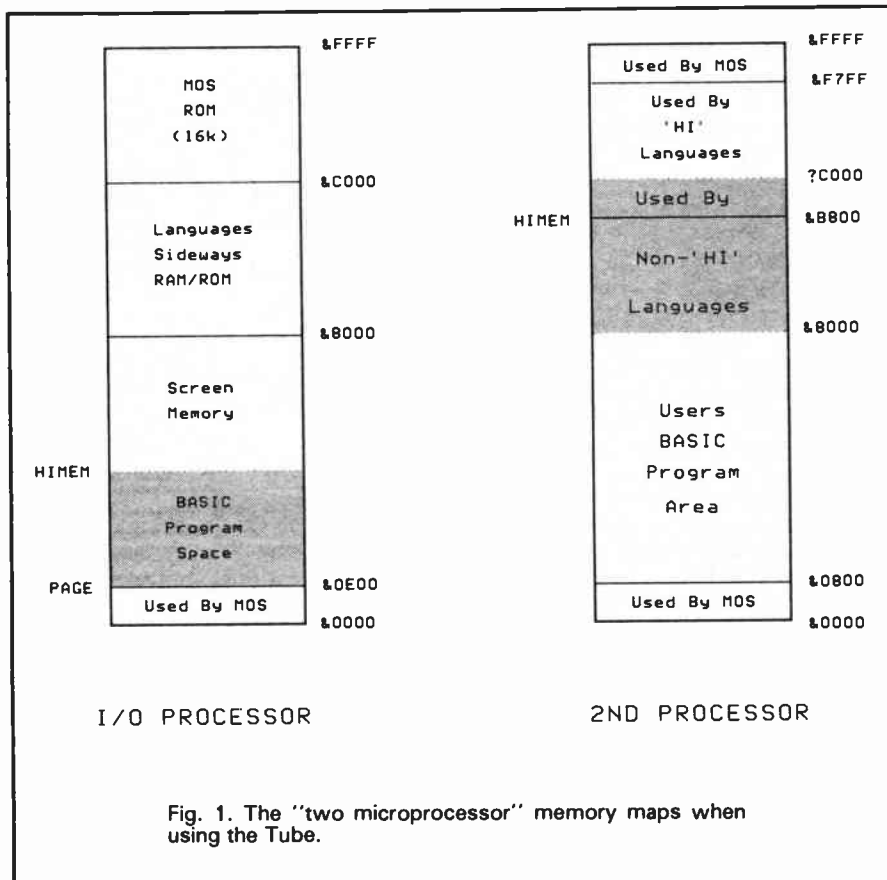
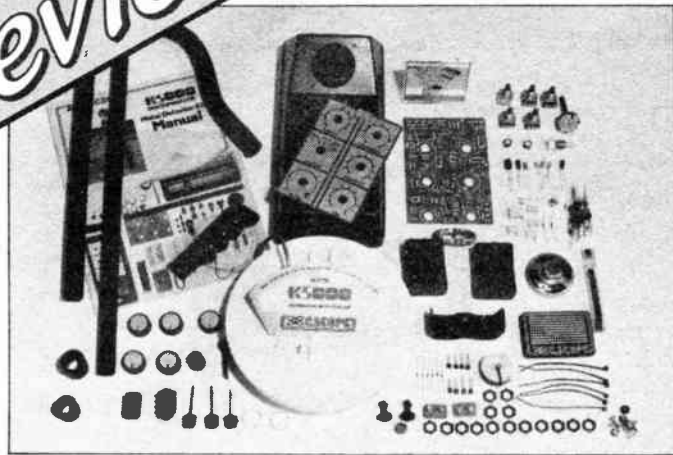


Fig. 1. The "two microprocessor" memory maps when using the Tube.

Review...



# C-SCOPE K5000 METAL DETECTOR KIT

R.A. PENFOLD

If you were to compare a recent issue of EE with an electronics magazine of about 20 years ago, one of the most striking differences would be the nature of the advertisements. Around 20 years ago a substantial proportion of the advertisements were for kits (mostly radios of one kind or another), whereas today there are very few kits on offer. We have to distinguish here between a kit of parts for a published design, and a true kit which has everything down to the last nut and bolt including a specially made case and perhaps other custom parts as well. Also, things like the holes in the case are generally ready-prepared on a true kit, so that building the unit is really a matter of assembling the parts with little or no cutting or drilling being required.

There are many possible reasons for the reduction in the number of the electronics kit, but probably the main one was the poor quality of many of the products on offer. In an attempt to keep costs down they were often largely put together from cheap surplus components, and this led directly to problems with reliability and performance, assuming you could get everything to fit together in the first place. Badly produced and often ambiguous instruction sheets did not help matters either.

Although the preponderance of kits available in the sixties is something that we will probably never see again, kits have been making something of a come-back over recent years and there are probably a great deal more available than you think. Like many other markets though, things have moved steadily up-market over the years, and most of the kits currently available are quite expensive, but when made up give a quality of performance and finish that is genuinely comparable to ready made equivalents, and with some saving in cost. There has also been a tendency for the types of thing on offer to be of a more specialised

nature so that they are not in competition with mass produced ready made units of far-eastern origins, where it is difficult to compete on price.

The subject of this review is the C-Scope K5000 metal detector kit which is quite definitely in the specialised field and at £119.99 it could not be described as cheap. C-Scope immodestly but probably quite justifiably claim to be "Europe's leading manufacturer of metal detectors for the treasure hunting hobbyist", and they will probably be well known to many readers. As one would therefore expect, the K5000 is not a simple type, but is a high quality unit with good sensitivity and refinements such as ground exclusion and the ability to discriminate to some extent between various types of metal. This can help to reduce the amount of time taken up digging for worthless bits of iron, aluminium foil, ring-pulls, etc.

## WHAT YOU GET

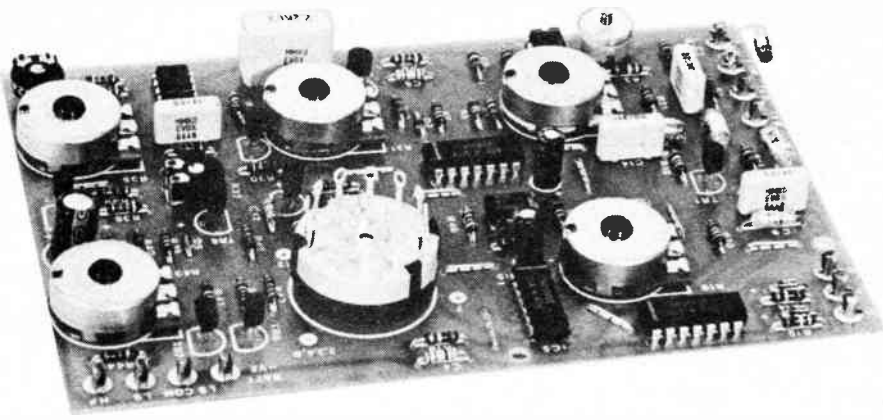
The pedigree of the K5000 kit is not in question, but what do you get for the money? A large box with the usual expanded polystyrene insert, in which are bags of resistors, i.c.s, etc. (about 100 electronic components), plus various mechanical parts including the very neat plastic cased search coil. The components are all new with no sign of any surplus items, and all seem to be of good quality.

You get all the parts needed including ample amounts of solder and connecting wire, but only the battery holders and not the batteries themselves are included. It is quite normal for equipment to be sold less-batteries as this avoids the possibility of the batteries running flat and perhaps leaking if there is a long gap between the manufacture of the kit and the customer commencing construction. It does mean though that there is one additional expense to take into account, and with some twelve HP7 size cells

being required, a set of batteries costs in the region of £3.00. Nicad rechargeable cells probably represent a better alternative in the long term, but a full set of these plus a charger would normally cost over £20.00.

Probably the most important item in any kit is the instruction booklet, and the one supplied with K5000 is a 36 page A4 size booklet with good quality paper, printing and illustrations. A couple of errors have been clearly corrected, and an addenda sheet also points out any differences there might be between the component descriptions in the booklet and the parts actually supplied.





## PUTTING IT TOGETHER

A metal detector of this sophistication is not a particularly simple piece of electronics, and things are complicated by the slightly less than straightforward mechanical side of construction that is inevitably involved with the assembly of a metal detector. For a beginner at electronics to stand a chance of successfully building such a unit it is essential for the instructions to be clear, and for everything in the kit to be just right.

The first step is to check that all the parts are present and correct, and the only problem I experienced here was the base section of the stem. This was eventually found well and truly wedged in the middle section and had to be hammered free, but neither part sustained any significant damage. The instruction book provides clear illustrations and descriptions of the components, both electronic and mechanical, including colour codes for the resistors. Even someone who has never seen an electronic component before should not have any difficulty in identifying everything. The introduction also gives details of what you will need to undertake construction of the unit, apart from the batteries this is just a few basic tools (soldering iron, wire cutters, screwdriver, etc.).

The second section covers the basics of soldering, and then the third section gives blow by blow details of how to assemble the kit, starting with the printed circuit board. The board itself is a good quality screen printed type with solder resist mask to reduce the risk of accidental short circuits. In general the components are evenly spread out over the board so that apart from the i.c. pins the connection points are not unduly crowded, and the board is not difficult to construct. All the components fitted onto the board without difficulty, including the six rotary controls. I was a little surprised that no integrated circuit holders were supplied with the kit, especially considering that most of the integrated circuits are static sensitive types. However, I soldered them direct to the board and none seemed to sustain any damage. The board is single-sided and

a number of link wires are required. These are made from trimmings of resistor leads (which is my normal way of doing things anyway), but the generally quite short leads of the resistors makes this task a little fiddly.

Construction of the board is about as easy as it could be, the instructions show the position of every component on the board. Mechanical assembly is covered in section four of the instruction booklet, and although this is perhaps a little more sketchy than the previous section, it is still fairly detailed and easy to follow. Everything fits together properly, and the only slightly awkward job is fitting a toggle switch into the handle, and I managed to nip myself with the pliers when doing this. The length of the stem is adjustable, and this enables the unit to be used comfortably by someone of any height within reason. The whole thing locks together reliably and is mechanically quite strong.

Little in the way of hard wiring is required as most of the controls are mounted on the board, but detailed instructions on this aspect of construction are provided, and there is little scope for errors here. Cable ties are provided so that everything can be kept neat and tidy.

I suppose it says a lot for the quality of the kit that the most difficult task was the fitting of the control knobs. All but one of these are fitted with 1.5

millimetre allen screws, and I was at the point of giving up and fitting a set of control knobs from the spares box when I found an allen key that would just about do the job. Control knobs with ordinary grub screws would surely be a much better choice for a kit.

## SETTING UP

The simple setting up procedure is described in section six of the instruction booklet, and there are just two preset resistors and a trimmer to adjust. These are to eliminate any drift with changes in the setting of the sensitivity control, to permit alignment of the meter and audio indication circuit, and to bring the ground exclusion facility in-range. The latter is the most difficult, but it should take no more than a few minutes to get everything set up provided the unit is working properly.

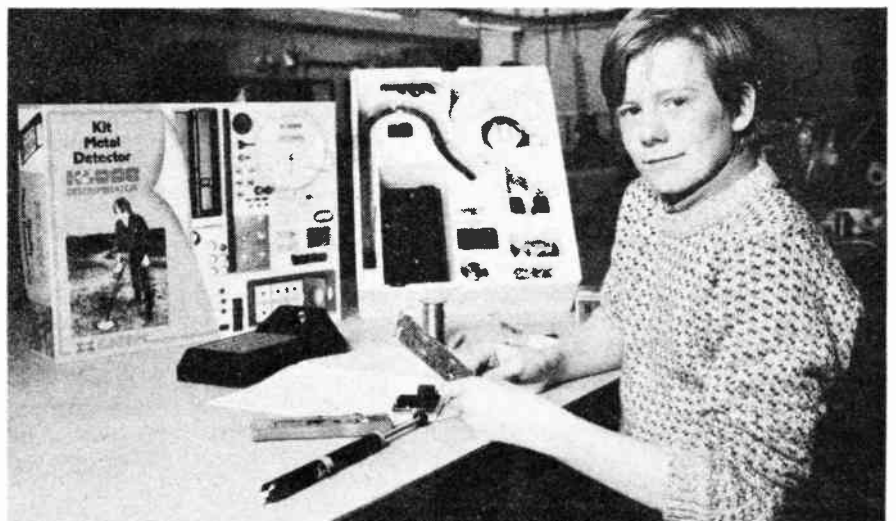
If the unit fails to work there is a useful trouble shooting section. If all else fails C-Scope will service the unit at reasonable cost.

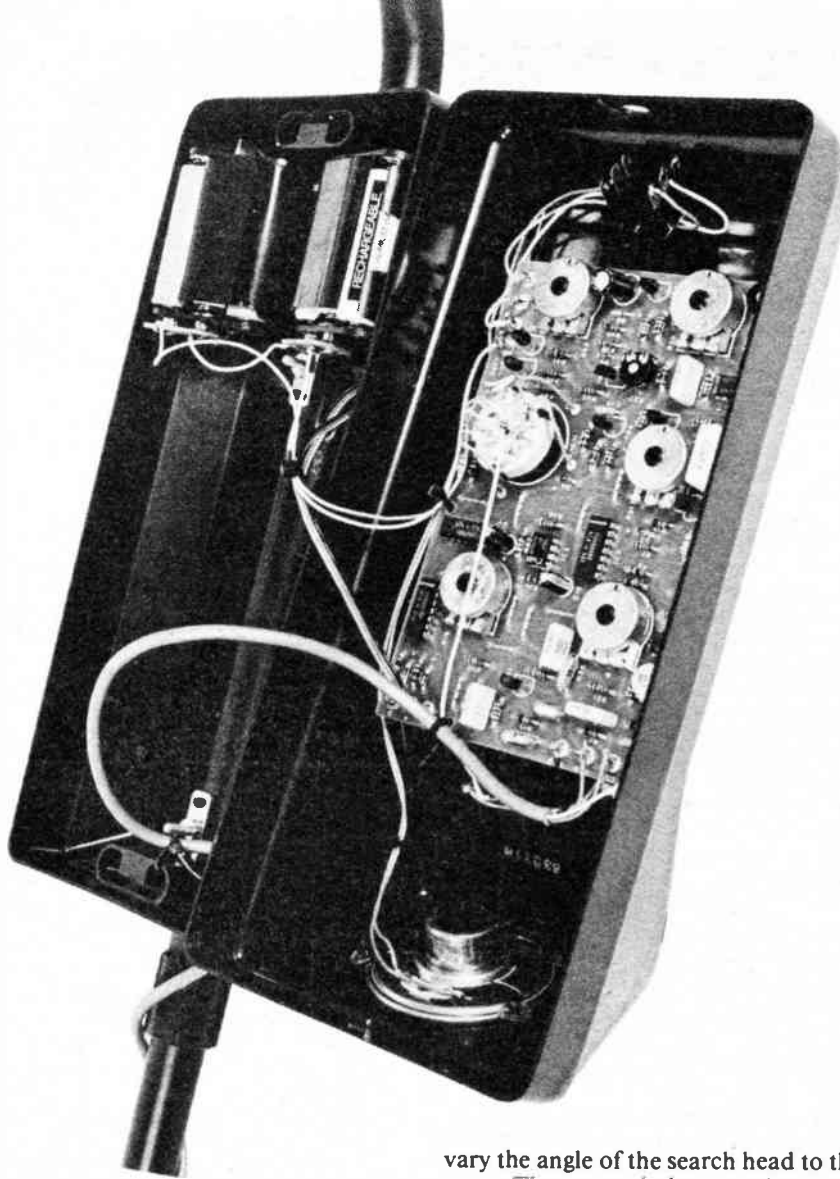
In the final section of the instruction book details of how to operate the unit are provided, together with helpful notes on where to search, a code of conduct, treasure hunting and the law, and a glossary of terms.

## IN USE

The finished detector worked first time (it had to happen one day!), and once set up it worked very well. An experienced constructor could finish the unit in a day, but it is probably better to spread things over two days (as I did) rather than rush at construction, and even an inexperienced constructor could probably have the detector up and running in a weekend.

A large meter (which doubles as a battery state indicator) provides a visual indication of detection, and in the discriminate mode the direction of deflection gives some indication as to the type of metal that has been detected. There is insufficient space for a detailed description of the use of this mode here, but it operates in conjunc-





tion with the discrimination control and can be extremely helpful under certain operating conditions.

The ground exclusion seems to work very well, and there is an automatic version of this facility as well. Basically what this does is to automatically tune the unit to zero regardless of what is picked up by the search head, but readjustment takes a second or two. The ground is therefore tuned out, but provided the search head is kept moving an indication will be obtained as it is scanned over any metal object. This is useful for roughly locating an object on difficult ground with the normal mode then being used to pin-point the object.

In addition to the meter indication there is an audio tone which increases in volume when an object is detected. This is generally easier to get on with than the change in pitch produced by simple BFO (beat frequency oscillator) designs. The K5000 is the more sophisticated IB (induction balance) type incidentally.

The unit is well balanced and comfortable to use. As explained previously, the stem is telescopic and can be varied substantially in length, and another refinement is the ability to

vary the angle of the search head to the stem. The meter is large and easy to read, and at maximum volume the audio tone is loud and clear. There is a headphone socket which enables the unit to function with stereo or mono headphones having a 6.35 millimetre jack, and this is useful when operating the unit where it might otherwise cause annoyance to others or where a very noisy environment would make the tone from the loudspeaker difficult to use.

In operation the unit is easy to use, aided by its several refinements, and sensitivity is very good. Very large objects can be detected at a range of around one metre, and even small objects such as coins and rings can be detected at depths of down to about 150 millimetres, with the exact depth depending on such factors as the difficulty of the terrain, the exact size of the object, and the ability of the searcher. Although a range of around 150 millimetres for small objects may not sound very impressive, with simpler types of detector the maximum range is generally only a fraction of this even under ideal conditions, and under adverse conditions small objects are all but undetectable. In fact the K5000 can sometimes be too sensitive making it a little difficult to use, but there is a

sensitivity control which can be backed off slightly when necessary.

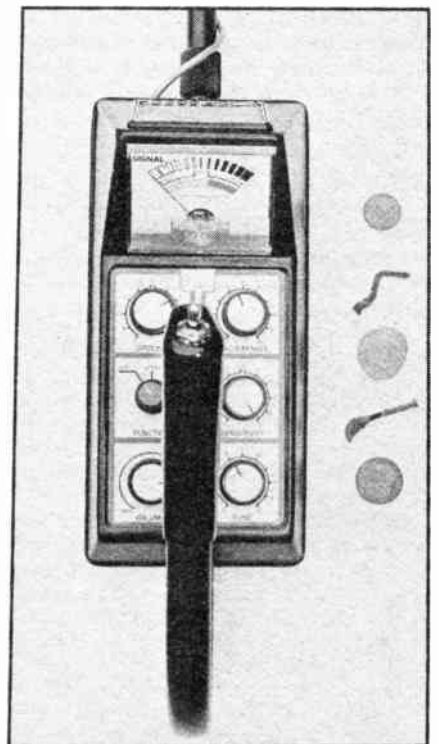
"Writer finds treasure while reviewing metal detector" would make a great newspaper headline, but unless your idea of treasure is a few rusty nails, miscellaneous bits of iron, and a couple of (not particularly valuable) coins, I failed to locate any treasure with the unit. On the other hand, what was there I located easily, and the detector can do no more than that. It is up to the user to find the right area to search.

## CONCLUSION

Having built many kits over a period of 20 years or so, the K5000 certainly ranks as the best I have yet come across. The instructions are clear and concise, all the parts are present and fit properly, and the finished unit looks good and performs well. All the vices I have come to expect from kits are absent from this one. The only real drawback is the price, and building a comparable design from scratch would certainly be very much cheaper. On the other hand, the difficulties associated with a project of this type are such that it would not be feasible for most people to build from scratch, and a comparison with ready made detectors would be more realistic. The K5000 then represents much better value for money, and becomes a very worthwhile proposition.

I enjoyed building and using this kit and it can certainly be strongly recommended for anyone from a beginner to the most experienced of constructors. □

The "treasure" found by the author with the completed kit which worked first time.



# FOR YOUR ENTERTAINMENT

BY BARRY FOX

## Making a Noise

Ray Dolby, inventor of the various Dolby noise reduction systems, was in London recently to launch something new.

In the last 20 years Dolby Labs has sold over 90,000 noise reduction units for music recording and broadcast studios and licensed electronics companies round the world to make 150 million domestic stereo tape recorders which incorporate his consumer systems. The new system, SR, is for professional use only.

SR stands for Spectral Recording. It's not, insists Ray Dolby, a noise reduction system. It's a new system of recording signals on analogue tape, using existing professional studio recorders. The only modification is a circuit board which plugs into the equipment rack instead of the conventional Dolby A noise reduction boards.

"We quite deliberately don't quote noise reduction figures in dB for SR" explains Ray Dolby.

"Yes, but how much does it give" persisted one engineer.

"Enough" was all Ray Dolby would say.

It certainly is enough. The SR system cuts tape noise so drastically that an analogue recorder running at 15 inches per second matches the specification of a digital recorder. The difference is that whereas a digital recorder can make signals sound "mucky" when they are at a very low, quiet level, Dolby SR sounds clean right down into the noise floor.

## No Difference

The big question is whether speech or music recorded with SR encoding, and then replayed with SR decoding, sounds any different after the processing. Ray Dolby and his engineers have been touring the world giving recording engineers the chance to try for themselves. In London, at the Master Rock Studios in Kilburn, British engineers had the chance to compare any sound they liked through an AB comparator.

Signal chain A routed sound from the studio direct by line to the control room monitor speakers; chain B routed the same sound onto tape with SR. The recording was then immediately replayed from the same tape with SR decoding and fed to the same monitors.

A stream of engineers tried switching between the sound from compact disc records, live piano in the studio, low level and high level sound effects, in fact anything they could think of. Consensus of opinion seems to be that the system works. You really can't hear the difference. I certainly couldn't.

Conventional Dolby noise reduction works by exaggerating low level, high frequency sounds in music at the recording stage so that they stand proud of unwanted background noise, like hiss, introduced by the tape recorder. When the recording is played back, there is mirror-image reduction of the exaggerated frequencies. This reduces unwanted hiss noise, while returning the music to its original state

## Flexible Sounds

Although the system works well, its action is limited in practice to not much more than halving the subjective sound of noise. The new SR system works in similar fashion but is much more powerful.

Normally, very powerful noise reduction can be heard "working". As the wanted signal changes, it "pumps" the background noise. SR avoids this effect because it is very flexible in the way it treats the signal it is handling.

In the case of SR, it continually monitors the signal being recorded and varies the way it is processed. The frequency range is divided into two halves, above and below 800Hz.

A series of different threshold detectors work above and below this frequency divide, to sense the strength of signal in these bands. This creates the equivalent of five different processing bands. Each band has a variable filter which modifies the signal.

There are so many variables that the complete SR circuit has a virtually infinite range of electronic characteristics. It constantly adapts itself to the sound being recorded, for example, if in a generally loud piece of music a quiet violin is likely to be lost in background noise, SR singles out the endangered frequencies and amplifies just them. On playback exactly the same frequencies are singled out and reduced in level.

Inventor Ray Dolby has been working on SR for 6 years and the first units are now going into studios. Ray Dolby says he built on technology developed for his three existing noise reduction systems, professional A type and domestic B and C.

"I knew something had to be done to improve analogue recording. But I kept putting off the idea of starting work", he recalls. Dolby knew it would be a long haul. And it was. He spent 3 years on weeding out ideas that would not work. It then took two years to develop a working system and one more year to get into production. The boards are being made in San Francisco and London.

Dolby describes SR as "tracking the signal as closely as possible. But don't expect it to sound good" he warns. "There is nothing to hear except the signal you want to record. The system doesn't have a sound of its own. That would be the last thing we wanted". And, judging by the demonstrations given recently in London, he's right.

"We've upset a few people in the digital business" admits Ray Dolby with a wry smile. "We didn't set out trying to attack digital technology—it has just been our company philosophy to try and do things as well as possible".

## Fashion Industry

The recording industry is a fashion business, like the rag trade. Pop stars and famous producers want to use the most modern equipment.

Digital is "in". Studios must buy digital

multi-track recorders (24-track or 32-track) if they are to stay in the race.

The results are good but the price is high—around £100,000 for the recorder alone. To convert a studio to full digital operation can cost £0.3 million.

Dolby SR is absurdly cheap in comparison. The plug-in boards or cards cost £500 each in Britain, and \$750 in America.

A studio needs to buy one card for each channel on the recorder. So an existing 24-track analogue recorder can be upgraded to SR for just £12,000, which is around a tenth the cost of buying a digital replacement.

## Right Corrections

If you've ever tried to connect two computers together with an RS-232 lead, or a modem to a computer, or a computer to a serial printer, you will know what a nightmare it can be to get a lead with the right connections. The crazy computer industry can't even agree on how to connect the wires of a standard plug.

For around £25 you can buy what looks like a neat solution. It's the "serial master cable" from Connexions. This is an RS-232 cable, with a bank of d.i.p. switches on the plugs at each end. Setting the d.i.p. switches correctly, makes the lead perform almost every imaginable function. But be warned; the instruction leaflet is far from clear. Worse still, the first version was wrong. If you have bought one of these leads and still can't get it to work, you may have been led astray by vital misprints in the section which tells how the d.i.p. switches should be set to give a crossover connection, i.e. to connect the output of one piece of equipment to the input of the other.

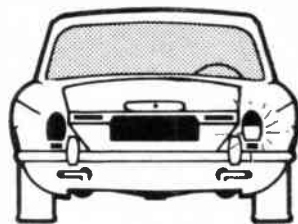
The Connexions leaflet originally said that switch 1 should be off, switch 2 on, switch 3 off and switch 4 on. This is wrong on two settings. The revised leaflet is correct. Switch 1 should be off, switch 2 on, switch 3 on and switch 4 off. Those two little errors make all the difference in the world.

There is an interesting parallel here with the audio industry. Five-pin DIN leads provide a useful way of connecting an amplifier to a tape recorder. But if you connect two tape recorders together, you need a crossover connection where the output of one goes to the input of the other. Accessory shops sell crossover leads but as often as not the salesmen don't know what they are selling. If you are trying to connect two tape recorders together so that one records the output from the other, and are having no success, there is a good chance you are using a straight-through lead instead of the crossover lead you should be using.

**EE BOOK SERVICE**

**See Page 618**

# CAR FLASHER WARNING



T.R.de Vaux Balbirnie

## Make sure you cancel every time with this warning

ALTHOUGH most cars have self-cancelling direction indicators, these are rarely found to be completely foolproof especially when making small turns. It is therefore easy to leave them operating after the manoeuvre has been made. This presents a hazard to other road users which is made even worse if towing a trailer or caravan. The clicking of the flasher unit and the dashboard warning light are not entirely successful in preventing unintentional operation—the sound is often too quiet to be heard above engine and traffic noise while the warning light is too dim to attract attention in bright conditions.

This add-on unit (which is only suitable for negative-earth cars) gives an additional warning in the form of a loud bleeping sound. This does not begin as soon as the indicators are operated but waits for a preset time to elapse, allowing time for

normal cancellation to take place. In the prototype unit this delay was adjusted to one minute approximately.

In use, a plastic box with terminal block and audible warning device mounted on top is placed in some out-of-the-way place such as behind the car dashboard. Connections are made to the direction indicator and battery supply circuits. Current is only drawn while the ignition is on and the loading effect on the existing flasher unit is negligible.

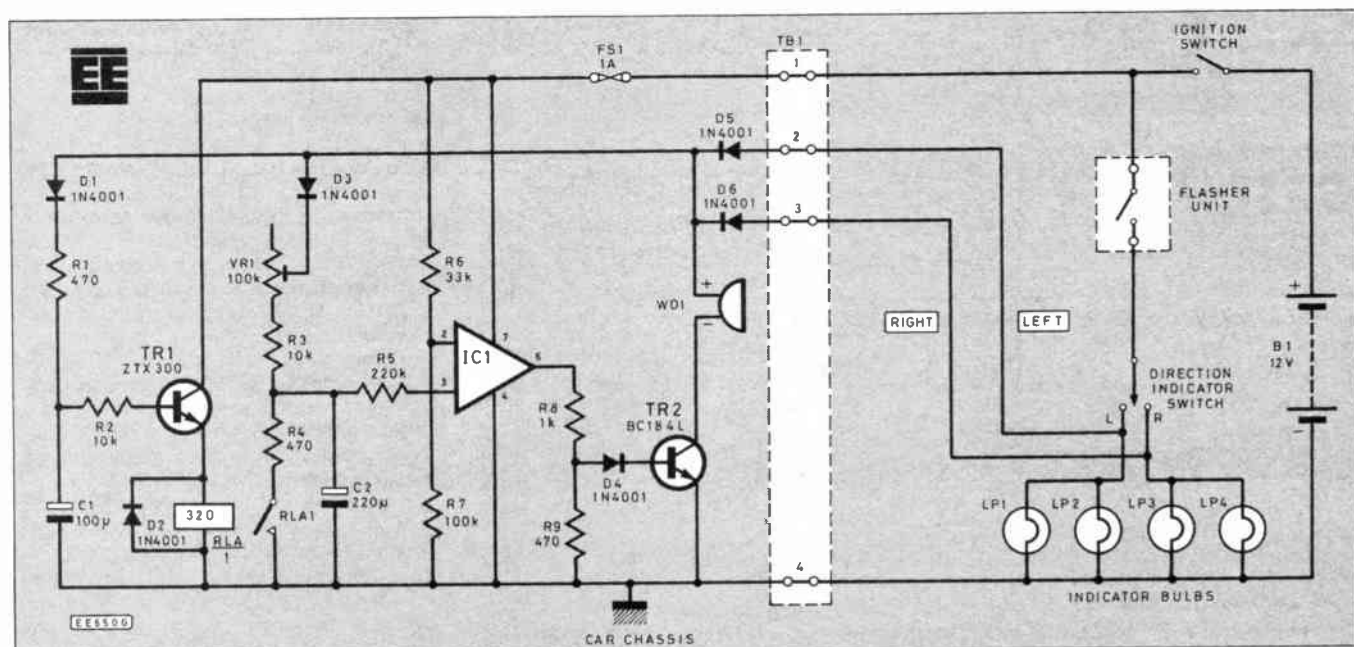
### CIRCUIT DESCRIPTION

The circuit for the Car Flasher Warning is shown in Fig. 1. With the ignition switched on, current flows through fuse FS1 to operational amplifier IC1. The inverting input (pin two) is maintained at a nominal 9V by the potential divider R6/R7 and this is used as a reference. Meanwhile, the non-inverting input (pin three) receives whatever voltage exists across C2—this is initially zero since it is bypassed by RLA “make” contacts, RLA1 and R4. Since the inverting input voltage exceeds the non-inverting one, the op-amp is off with the output (pin six) low; TR2 and the audible warning device WD1, then remain off. With either a left or a right turn being signalled, current

pulses flow through either D5 or D6 as appropriate, hence through D1 and R1 to charge C1. This produces a rising voltage at TR1 base, this exceeds the 0.7V turn-on voltage almost instantly so TR1 turns on and with it the relay, RLA. RLA1 contacts open allowing C2 to charge by current flowing through D3, VR1 and R3. This results in a rising voltage at IC1 pin three. When this exceeds the reference voltage at pin two, the op-amp switches on, this results in the output (pin six) going high (supply positive voltage). The time taken for this to happen depends on the adjustment of VR1 and is nominally one minute.

The on state of IC1 operates TR2 and hence WD1. Since this component is connected to the pulsed supply from the car flasher unit, the bleeping sound is given in sympathy with the flashing indicators. This bleeping continues until the indicators are switched off, whereupon C1 discharges through R2 and TR1 and RLA switches off. With the component values specified this takes approximately ten seconds. RLA1 contacts then re-make and discharge C2 through R4 ready for a further cycle. Resistor R4 limits the discharge current flowing through the relay contacts which could otherwise damage them. Diode D2 bypasses the high-voltage pulse which appears across the relay coil as it switches off.

Fig. 1. Circuit of the Car Flasher Warning.



# COMPONENTS

## Resistors

- R1,R4,R9 470 (3 off)
  - R2,R3 10k (2 off)
  - R5 220k
  - R6 33k
  - R7 100k
  - R8 1k
- All  $\frac{1}{3}$ W  $\pm 5\%$

See  
**Shop  
Talk**

page 588

## Potentiometer

- VR1 100k miniature horizontal preset

## Capacitors

- C1 100 $\mu$  elect. 16V
- C2 220 $\mu$  elect. 16V

## Semiconductors

- D1 to D6 1N4001 (6 off)
- TR1 ZTX300 npn silicon
- TR2 BC184L npn silicon

## Miscellaneous

- WD1 12V solid-state buzzer
- FS1 20mm chassis fuse-holder with 1A fuse.
- RLA Sub-miniature relay with 12V 320 ohm coil and normally-closed or changeover contacts.
- TB1 3A terminal block—4 sections required. Plastic box size 100 x 50 x 25mm external; 8-pin d.i.l. socket; fixings, stranded connecting wire, light duty auto wire, connectors.

Approx. cost  
Guidance only

**£7.25**

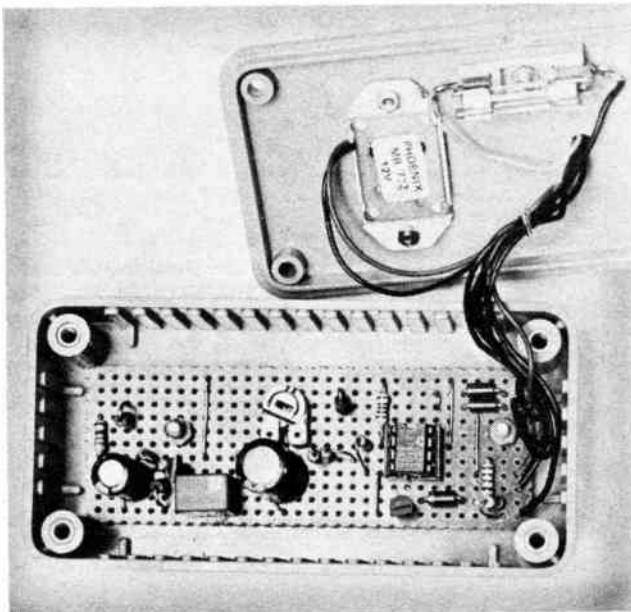
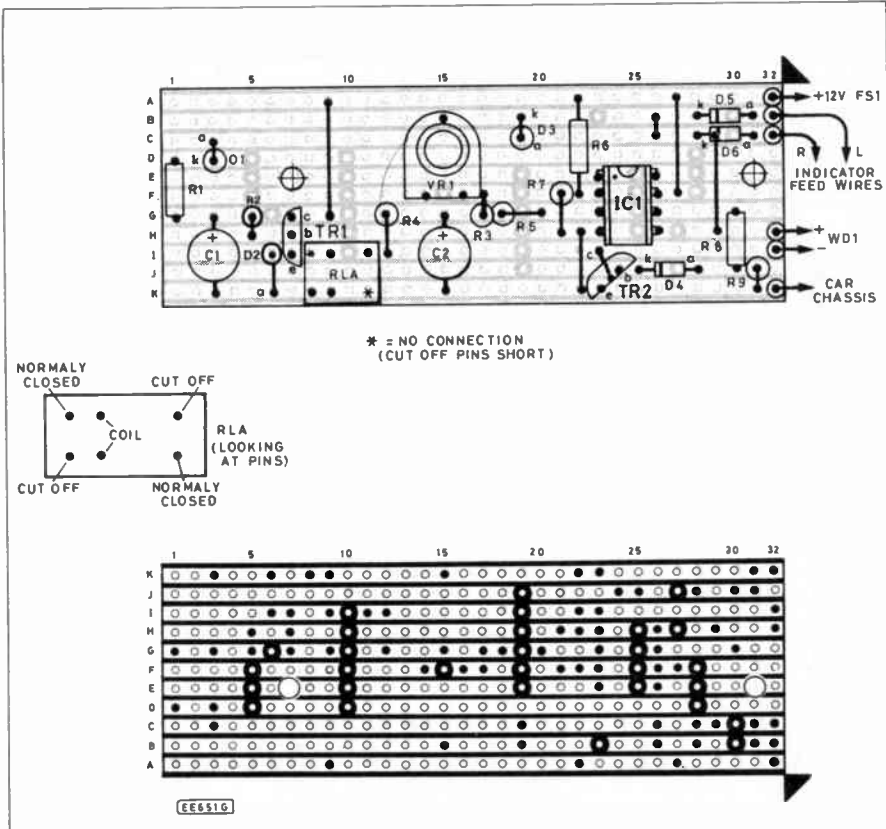
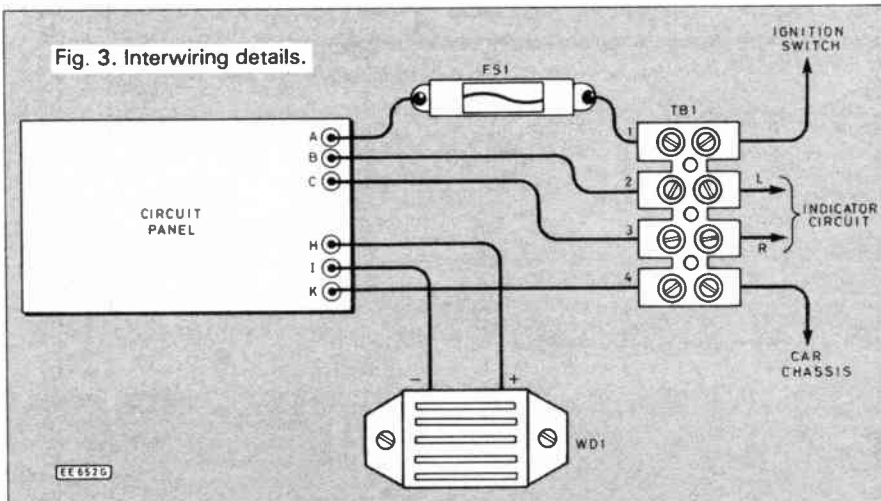


Fig. 3. Interwiring details.



## CONSTRUCTION

Construction is based on a main circuit panel consisting of a piece of 0.1 inch matrix stripboard size 11 strips x 32 holes. Fig. 2 shows the details. Begin by making all copper strip breaks and drilling the two fixing holes as indicated. It is essential to check that the breaks are complete. Solder the inter-strip link wires and follow with the on-board components. Before mounting the relay, break off the two unused pins close to the body so that no connection will be made with them. Note that the diodes and capacitors must be connected the correct way round. Complete the panel by soldering 15cm pieces of light-duty stranded connecting wire to strips A, B, C and K. Leave VR1 adjusted to approximately mid-track position.

Refer to Fig. 3 and prepare the case by making holes for WD1, FS1, terminal block TB1 and circuit panel mounting. Drill a 4mm diameter hole near the terminal block position for the wires passing through from the circuit panel.

Mount the remaining components and complete the internal wiring. Shorten any wires from the circuit panel as necessary to keep them tidy. Note how WD1 was mounted in the prototype (see photograph). This is neater than direct surface mounting. Place the fuse in its holder and attach the lid of

the case, checking carefully that the fuse holder remains clear of other internal components.

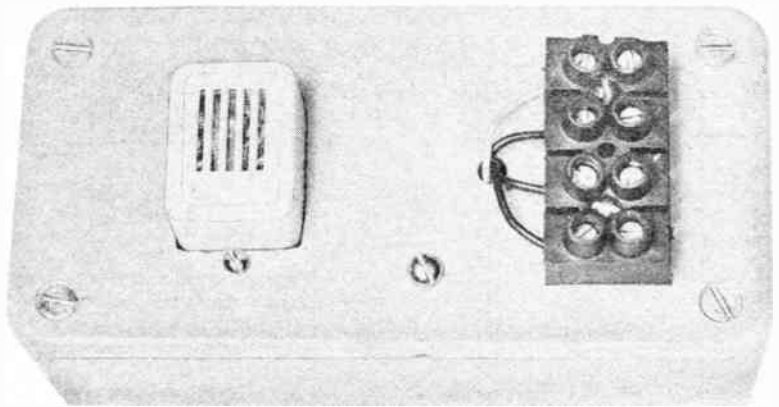
## TESTING

Locate the feed wires for left and right direction indicator circuits on their way to the bulbs. Make connections to these using pieces of light-duty auto type wire. Connectors should be used which do not involve cutting the wires. Make the connections to TB1/2 and TB1/3 on the terminal block. Find a fuse which is "live" only while the ignition is switched on. Make a connection to this on the outlet side of the fuse and connect to TB1/1. Connect TB1/4 to the car chassis at a nearby earth point.

Switch on the indicators (either direction) and wait approximately one minute for the circuit to operate. WD1 will not start "sharply" but will attain maximum loudness after a few beats—this is due to the

very slow rising of the voltage at IC1 Pin 3. Check for correct operation with the engine running and when the opposite indicators are used. If the timing needs to be altered, adjust VR1—anticlockwise rotation will increase it. When the engine is running, WD1

may emit a "warbling" sound due to voltage fluctuations from the generator, this is of no consequence. The "sharpness" of the pulses emitted by WD1 also depends to some extent, on the model of car to which the device is fitted. □



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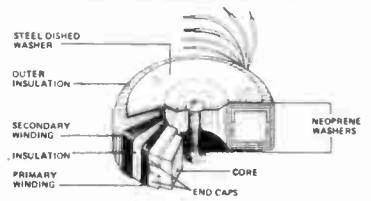
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	03013	15-15	0.50
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	03015	22-22	0.34
	03016	25-25	0.30
<b>30VA</b> Regulation 16% Size A B C 70 35 37 0.45 Kgs Mounting bolt M5 x 50	13010	6-6	2.50
	13011	9-9	1.66
	13012	12-12	1.25
	13013	15-15	1.00
	13014	18-18	0.83
	13015	22-22	0.68
	13016	25-25	0.60
<b>50VA</b> Regulation 13% Size A B C 80 40 43 0.9 Kgs Mounting bolt M5 x 50	23010	6-6	4.16
	23011	9-9	2.77
	23012	12-12	2.08
	23013	15-15	1.66
	23014	18-18	1.38
	23015	22-22	1.13
	23016	25-25	1.00
<b>80VA</b> Regulation 12% Size A B C 95 40 43 1.0 Kgs Mounting bolt M5 x 50	33010	6-6	5.66
	33011	9-9	4.44
	33012	12-12	3.33
	33013	15-15	2.66
	33014	18-18	2.22
	33015	22-22	1.81
	33016	25-25	1.60
<b>120VA</b> Regulation 11% Size A B C 95 45 50 1.2 Kgs Mounting bolt M5 x 50	43010	6-6	10.00
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	43012	12-12	5.00
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	43015	22-22	2.72
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<b>160VA</b> Regulation 8% Size A B C 110 45 50 1.8 Kgs Mounting bolt M5 x 50	53010	9-9	8.89
	53012	12-12	6.66
	53013	15-15	5.33
	53014	18-18	4.44
	53015	22-22	3.63
	53016	25-25	3.20
	53017	30-30	2.66
<b>225VA</b> Regulation 7% Size A B C 110 50 55 2.2 Kgs Mounting bolt M5 x 60	63010	12-12	9.38
	63013	15-15	7.50
	63014	18-18	6.25
	63015	22-22	5.11
	63016	25-25	4.50
	63017	30-30	3.75
	63018	35-35	3.21
<b>300VA</b> Regulation 6% Size A B C 110 57 62 2.6 Kgs Mounting bolt M5 x 60	73010	15-15	10.00
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	73026	40-40	3.75
<b>500VA</b> Regulation 5% Size A B C 135 60 65 4.0 Kgs Mounting bolt M8 x 70	83016	25-25	10.00
	83017	30-30	8.33
	83018	35-35	7.14
	83026	40-40	6.25
	83025	45-45	5.55
	83033	50-50	5.00
	83042	55-55	4.54
<b>625VA</b> Regulation 4% Size A B C 140 70 75 5.0 Kgs Mounting bolt M8 x 90	93017	30-30	10.41
	93018	35-35	8.92
	93026	40-40	7.81
	93025	45-45	6.94
	93033	50-50	6.25
	93042	55-55	5.68
	93028	110	5.68
<b>800VA</b> Regulation 4% Size A B C 140 70 75 5.0 Kgs Mounting bolt M8 x 90	93029	220	2.84
	93030	240	2.60

TYPE	SERIES NO.	SEC. VOLTS	R.M.S. CURRENT
<b>160VA</b> Regulation 8% Size A B C 110 45 50 1.8 Kgs Mounting bolt M5 x 50	53011	9-9	8.89
	53012	12-12	6.66
	53013	15-15	5.33
	53014	18-18	4.44
	53015	22-22	3.63
	53016	25-25	3.20
	53017	30-30	2.66
<b>225VA</b> Regulation 7% Size A B C 110 50 55 2.2 Kgs Mounting bolt M5 x 60	63010	12-12	9.38
	63013	15-15	7.50
	63014	18-18	6.25
	63015	22-22	5.11
	63016	25-25	4.50
	63017	30-30	3.75
	63018	35-35	3.21
<b>300VA</b> Regulation 6% Size A B C 110 57 62 2.6 Kgs Mounting bolt M5 x 60	73013	15-15	10.00
	73014	18-18	8.33
	73015	22-22	6.82
	73016	25-25	6.00
	73017	30-30	5.00
	73018	35-35	4.28
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<b>500VA</b> Regulation 5% Size A B C 135 60 65 4.0 Kgs Mounting bolt M8 x 70	83016	25-25	10.00
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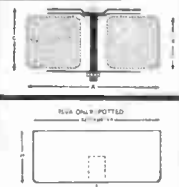
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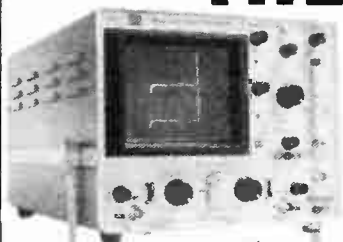
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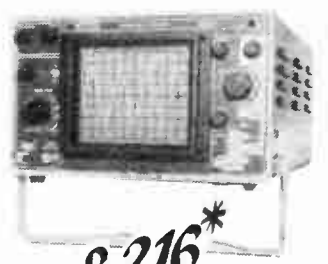
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*a regular  
feature for  
the Spectrum  
Owner...*

by Mike Tooley BA

## Plan your own escape from the limitations of the Spectrum

**T**HIS month we shall be dealing with the construction, testing and use of the "escape" interface described last month. We start, however, by taking a look at another enhanced BASIC interpreter for the Spectrum in the shape of MEGA BASIC.

### MEGA BASIC

MEGA BASIC was written by Mike Leaman and is published by *Your Sinclair*. The program is approximately 20K in length and takes around two minutes to load. RAMTOP is lowered to 44999 (leaving the user with approximately 20K to play with).

The manual supplied with MEGA BASIC consists of 29 pages of A6 format and, whilst not over-generous, it is just about adequate. It is a pity that the manual is not of the same standard as that supplied with BETA BASIC but, in fairness, it does cover the salient points (leaving the user plenty of scope for further experimentation).

When loaded, the Spectrum takes on a markedly different appearance. Indeed, with a new set of yellow characters upon a black screen complete with a blank square non-blinking cursor, one could even be forgiven for thinking that the Spectrum had been transformed into some other machine (a BBC or Amstrad perhaps?). There is, however, no need to panic—all of this is being produced by your "old faithful" Spectrum! The trick is simply that Mike Leaman has provided you with two additional character fonts which emulate the BBC Microcomputer/Acorn Electron and Amstrad CPC-464. Both are very clearly readable and do make for a nice change! Furthermore, you can switch between these two new fonts and the standard ZX font (which we all know and love!) using a simple command. This is a feature which never fails to impress...

Character size is also programmable with MEGA BASIC's four modes. The smallest

of these permits the use of a 64 column display (just about the maximum allowable with a domestic colour TV) whilst the largest is equivalent to double height/double width on the standard Spectrum. This latter mode uses a 16 pixel square character cell and permits the use of "stipples".

Unlike ZX-BASIC and BETA BASIC, MEGA BASIC allows input over the whole screen; one is not merely constrained to using the bottom few lines of the screen! Another nice feature is that the bottom line of the display is used to provide a status message which replaces the cursor mode (L, C, E and G) used in ZX-BASIC. Thus one is presented with meaningful reminders of the status of the keyboard such as "CAPS OFF EXTENDED" or "CAPS OFF GRAPHICS".

### Editing

Program editing in MEGA BASIC follows the format adopted on the BBC Microcomputer with a second (blinking) cursor being steered around the screen. In use, I found this a little confusing as the keys used to move the "copy" cursor are not those used for normal cursor movement. Another important difference is that, during RUN-time, the SPACE key becomes a CONTROL key and, when used with various other keys, it provides some extremely useful control functions. CONTROL-F, for example, halts program execution and produces a system monitor "front-panel". This valuable de-bugging aid uses MEGA BASIC's "window three" and displays the contents of the CPU registers in hex with the exception of the flag register which is displayed in binary.

The "front panel" also displays the contents of a block of memory (with the current location shown in inverse strip). Various monitor commands can be executed from the "front panel" including block moves, setting and restoring breakpoints, loading memory with data, stepping the address pointer (memory location) forwards or backwards, and calling a machine code routine at a given address.

Like BETA BASIC, MEGA BASIC includes several new control structures including procedures (using @ and END-PROC followed by the procedure's name to indicate the start and end respectively) and REPEAT-UNTIL loops. MEGA BASIC also provides up to ten user-defined windows in which attributes may be changed at will.

A unique feature of MEGA BASIC is the ability to "multi-task" a BASIC program. This simple form of multi-tasking alternately executes successive lines from two parts of a program. It would, for example, be possible to print a table of data on the screen whilst, at the same time, the Spectrum is controlling some external hardware!

For all you arcade games addicts, MEGA BASIC provides sprite handling facilities (a separate Sprite Generator program is included in the package) and incorporates an interrupt driven sound generator which is capable of producing some interesting noises by manipulating data stored in a "sound buffer".

MEGA BASIC is an extremely versatile enhancement to ZX-BASIC and can be very highly recommended and, whilst my own personal preference is for BETA BASIC, MEGA BASIC is the cheapest package of the two and may be preferred by many as being more suited to applications which

involve sprites, graphics, and sound. MEGA BASIC is available from Your Sinclair at 14 Rathbone Place, London, W1P 1DE.

### Constructing the Escape Interface

The escape interface is assembled on a piece of Veroboard measuring approximately 80mm x 100mm. As with previous projects, the precise dimensions of the board are unimportant provided that it has a minimum of 28 tracks aligned in the vertical plane sufficient to allow the mounting of a 28-ways double-sided edge connector. This connector should be fitted to the lower edge of the board and will require five holes across the full width of the stripboard so that the board stands vertically when the connector is mated with the Spectrum.

Before soldering any of the components (including i.c. sockets) it is important to allow some clearance for the rear "overhang" of the case. For the Spectrum this gap should correspond to eight rows of holes (20mm approx.) whilst for the Spectrum Plus the gap should be increased to 12 rows of holes (30mm approx.).

Component layout is generally uncritical though considerable economies can be made by carefully planning the layout in advance of mounting the components and i.c. sockets. Readers are advised to carry out this exercise on paper first (using, if desired, the layout sheet provided with our "On Spec Update"). Great care must be taken to ensure that all unwanted tracks are cut (including, in particular, those which link the upper and lower sides of the 28-way connector). A purpose designed "spot-face" cutter is ideal for this purpose or, if such a tool is not obtainable, a small sharp drill bit may be used.

Links on the underside of the board should make use of appropriate lengths of miniature insulated wire (of the type normally used for wire wrapping). Readers requiring further information on the connector should refer to March 1985 *On Spec* or send for the "Update".

When the stripboard wiring has been completed, the integrated circuits should be inserted into their respective sockets (taking care to ensure correct orientation of each device) and the entire board should be very carefully checked before attempting to connect it to the Spectrum. Note that the Spectrum should always be disconnected from its supply before either connecting or disconnecting any interface module. If all is well, when power is re-applied, the normal copyright message should appear. If not, disconnect the power, remove the interface and check again!

### Testing the Escape Interface

The Escape Interface may be easily tested by simply PEEKing the offending memory location (6D hex or 109 decimal). Without the interface connected a command of the form:

**PRINT PEEK 109**

will return a value of 40 whilst, with a functional interface, this value should be changed to 32. Readers having access to a disassembler may, alternatively, prefer to disassemble the code from the start of the ROM NMI routine at 66 hex (102 decimal) and check that JR Z has been converted into JR NZ at address 6DH.

Now press the ESCAPE button. If nothing happens don't panic—we have not yet placed our NMI routine in memory nor have we initialised the NMI address system variable with the start of our routine! Before we do, however, we shall need a little BASIC test program so key in the following:

```
10 PRINT "x"
20 BEEP 0.1,0.1
30 GO TO 10
```

Now RUN the test program to fill the left-hand column of the screen with x's. Having established that the program does what is expected (i.e. gives the Spectrum something to do!) press BREAK and then key in the following POKES:

```
POKE 23728,232
POKE 23729,253
POKE 65000,251
POKE 65001,195
POKE 65002,162
POKE 65003,18
```

The first two pokes place address 65000 into the NMI address system variable (low order byte first) and provides the machine with the address to jump to when a non-maskable interrupt occurs. The remaining four pokes constitute our own very simple NMI routine. This enables interrupts and jumps to the ROM routine starting at address 12A2 hex. This is the beginning of the main execution loop responsible for invoking and controlling the Spectrum's BASIC editor.

The time has come to return to our simple BASIC test program! Press ENTER and RUN it again but, this time, when the left-hand column of the screen is half-full and the machine is BEEPing away merrily, press the ESCAPE key and see what happens. If you are returned to BASIC, with the program listing on-screen ready for editing, you can be confident that the interface is operating correctly. You now have an infallible

mechanism for BREAKing into a running program!

Having demonstrated that all is well with a simple BASIC test program (one which you could have easily broken into using the BREAK key) it is time to try to escape from an endless machine code loop. Enter the following POKES (there is no need to NEW the BASIC program which should still be intact in memory):

```
POKE 32768,195
POKE 32769,0
POKE 32770,128
```

A command of the form:

**RANDOMIZE USR 32768**

will enter the loop and apparently lock up your Spectrum forever. Now just press ESCAPE to regain control—clever eh! With a little thought, readers should be able to develop NMI service routines to meet their own particular needs (not merely returning to the BASIC editor as shown in our example). The necessary data can either be POKEd from within a BASIC program or be loaded from a separate machine code module. If you come up with something useful in this respect please drop me a line so that I can include it in a future *On Spec* or in our 'Update'.

### Next Month

Next month we shall be taking a look at LASER BASIC and describing a versatile 8-channel analogue to digital converter for use with the Spectrum. In the meantime, if you have any comments or suggestions or would just like a copy of our "Update", please drop me a line at the following address and enclose a large A4 size (30cm x 23cm approx.) stamped addressed envelope:

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

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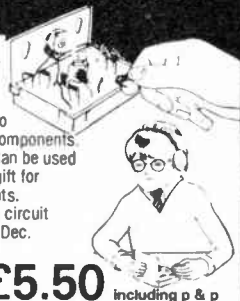
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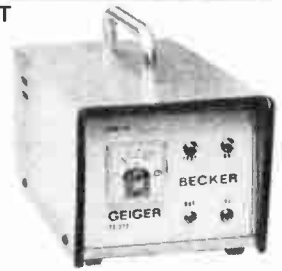
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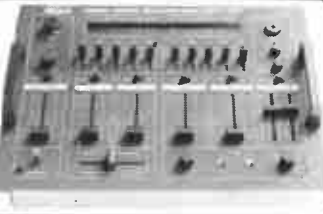
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