EVERYDAY ELECTRONICS

MARCH 1987

INCORPORATING ELECTRONICS MONTHLY

£1·20

FREE INSIDE

16 PAGE BOOKLET

GUIDE TO PROJECT BUILDING

APEX HI FI Amplifier

DIGITAL IC TESTER

INFRA RED ALARM

***Special Feature...* AVIONICS FUTURES**

The Magazine for Electronic & Computer Projects

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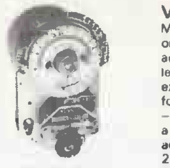
Price per pack is £1.00.* Order 12 you may choose another free. Items marked (sh) are not new but guaranteed ok.

1. 5 – 13 amp ring main junction boxes
2. 5 – 13 amp ring main spur boxes
4. 5 – surface mounting
5. 3 – electrical switches, white flush mounting
7. 4 – in flex line switches with neons
9. 2 – mains transformers with 6V 1A secondaries
10. 2 – mains transformers with 12V $\frac{1}{2}$A secondaries
11. 1 – extension speaker cabinet for $6\frac{1}{2}$" speaker
13. 12 – glass reed switches
17. 2 – ultrasonic 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 $\frac{1}{4}$ spindle your choice
28. 1 – 6 digit counter mains voltage
30. 2 – Nicad battery chargers
31. 1 – key switch with key
33. 2 – aerosol cans of ICI Dry Lubricant
34. 96 – 1 metre lengths colour-coded connecting wire
39. 1 – long and medium wave tuner kit
41. 8 – rocker switch 10 amp mains SPST
45. 1 – 24 hour time switch mains operated (s.h.)
49. 10 – neon valves – make good night lights
50. 2 – 12V DC or 24V AC, 3 CO relays
51. 1 – 12V 2 CO miniature relay very sensitive
52. 1 – 12V 4 CO miniature relay
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" × 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
77. 1 – time reminder adjustable 1-60 mins clockwork
85. 1 – mains shaded pole motor $\frac{3}{4}$" stack – $\frac{1}{4}$ 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 – $2\frac{1}{2}$ hours delay switch
103. 1 – mains power supply unit – 6V DC
104. 1 – mains power supply unit – $4\frac{1}{2}$V DC
107. 1 – 5" speaker size radio cabinet with handle
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 $1\frac{3}{4}$ 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
137. 1 – $6\frac{1}{2}$" 4 ohm 10 watt speaker
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
172. 10 – 12V 6W bulbs Philips m.e.s.
178. 3 – oblong amber indicators with lilliputs 12V
180. 6 – round amber indicators with neons 240V
181. 100 – p.v.c. grommets $\frac{3}{8}$ hole size
182. 1 – short wave tuning condenser 50 pf with $\frac{1}{4}$" spindle
184. 1 – three gang tuning condenser each section 500 pf with trimmers and good length $\frac{1}{4}$" spindle
188. 1 – plastic box sloping metal front, 16 × 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 for ovens 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 – mtres 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) $6\frac{1}{2}$" 15 ohm made for Radiomobile
241. 2 – speakers 6" × 4" 4 ohm 5 watt made for Radiomobile
243. 2 – speakers 6" × 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, $\frac{1}{2}$ meg with dp switch
249. 1 – 13A switched socket on double plate with fused spur
266. 2 – mains transformers 9V $\frac{1}{2}$A secondary
267. 1 – mains transformers 15V 1A secondary p.c.b. mounting
291. 1 ten turns 3 watt pot $\frac{1}{4}$ 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" × 3/8 × 5/16
303. 1 12 pole 3 way ceramic wave charge switch
305. 1 tubular dynamic microphone with desk rest
308. 1 T.V. turret tuner (black & white T.V.)
310. 2 oven thermostats
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 – $2\frac{1}{4}$in. 80ohm loudspeakers
454. 2 – $2\frac{1}{4}$in. 8ohm loudspeakers

FROZEN PIPES Can be avoided by winding our heating cable around them, 15 mtrs connected to mains cost only about 10p per week to run. Hundreds of other uses as it is waterproof and very flexible. Resistance 60ohms/metre. Price 28p/metre or 15m for £3.95.

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 £17.50 post £2.



Ex-Electricity Board Guaranteed 12 months

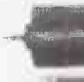
VENNER TIME SWITCH

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

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 $\frac{1}{4}$" sockets and three panel mounting fuse holders provide thyristor protection. A four pin plug and socket facilitate ease of connecting lamps. Special price is £14.95 in kit form.

12 volt MOTOR BY SMITHS



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

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

BENCH ISOLATION TRANSFORMER. Torroidal wound 400 watt but very compact. Has a separate 10V winding which can be added or subtracted to give fine voltage control. Normally £40, our price £10 plus £2 post, ref 10P9.

TANGENTIAL BLOWER HEATERS

We can supply:

1·2KW—quite definitely the smallest tangential blow heater we have ever had, measuring approx 6 × 6 × 4. This could be just the thing for a small bedroom or to fit under desk or table if you suffer from cold legs. In addition to normal heating functions if put into a simple enclosure this could be a pipe untreezer (much safer than a blow lamp) possibly even a paint stripper, hair dryer or hand dryer. Price is £5, plus £1 post, ref 5P23

2·5KW—width approx. 8" (plus motor), elements made up of two 1·2kw sections, so with switch supplied you can have 2kw, 1kw or cold blow. Over heat cut-out eleminates fire risk should fan stop or air flow be impeded. Fan blades are metal. Price £5 plus £1.50 post, ref 5P62.

3KW—width approx. 13" plus motor, element made up of 1kw and 2kw section, supplied with 4 section rocker switch, allowing 3kw, 2kw, 1kw and cold blow. Price £6.95 plus £2.00 post.

2KW D.I.Y. SPECIAL—if you want a really cheap tangential heater, this is your opportunity, made for 115v mains, to use it on 230v. Simply join elements in series, needs only simple on/off switch, as you will only have one heat level 2kw and no cold blow. Price £2 plus £1 post, ref 2P66.

VERY LOW RUNNING COST—only a 300w element. So would cost only approx. $1\frac{1}{2}$p per hour to run. Should be enough for an airing cupboard or a hot box for seed germination. Might even be enough to keep a damp corner dry. Normal construction approx. $4\frac{1}{2}$" plus motor wide. Price £5 plus £1 post, ref 5P78.

500W-115V TRANSFORMER to isolate you or yours from mains to earth shock dangers. We are able to offer these transformers at less than the price of an auto transformer. Our price for the 500w mains to 115v isolation transformer is £10 plus £5 post, ref 10P6.

RESIN CURED FILLER/BUILDER/STICKER made by the famous Holts company, suitable for repairs, not only to car bodies but also to sinks and wash basins, water tanks, drain pipes and gutters, tiles, roofs, filling holes in walls and concrete, repairing cracks in gates, window frames, etc. etc. It is weather resistant and adheres well to metals, wood, concrete and some plastics. Special bargain price 2 large tubes for £1, ref BD464.

STEPPER MOTOR. By American Phillips corporation. Step angle 7·5°. Coil resistance 27 ohms. Operating volts 10–14. Size approx. $2\frac{1}{4}$" dia by $1\frac{3}{4}$" deep on a square mounting plate. This is in fact two bi-directional motors with P.M. rotors. Applying correct pulse causes a 7·5° step angle of spindle. Number of steps through which it rotates and a speed at which it rotates is determined by the applied impulses. Properly used this provides an ideal method of speed and position control. Brand new and unused price £5, ref 5P81.

BIG GLASS FIBRE SHEETS. Virtually unbreakable, size 4' × 3' approx. Flat, approx. 1/16" thick. Intended for pcb's but ideal for roof repairs, car port, greenhouse etc. £2 each. Minimum quantity we can despatch is 10. Carriage cost £6.50 per 10. £8.50 for 15.

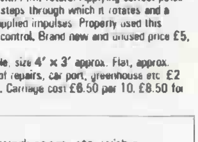
IONISER KIT

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 arrestor – ringing condenser etc) and takes B.T. plug	£3.95
Extension socket	£2.95
Dual adaptors (2 from one socket)	£3.95
Cord terminating with B.T. plug 3 metres	£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
100 mtrs 4 core telephone cable	£8.50

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



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

J & N BULL ELECTRICAL
Dept. E.E., 250 PORTLAND ROAD, HOVE, BRIGHTON, SUSSEX BN3 5QT

MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £20 add £1 service charge. Monthly account orders accepted from schools and public companies. Access & B/card orders accepted. Brighton 0273 734648. 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
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 squawk
2P15 – Interrupted Beam kit for burglar alarms, counters, etc.
2P17 – 2 rev pr minute mains driven motor, 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
2P26 – 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 – $4\frac{1}{2}$ round surface mounting 0–10A – old but working and definitely a bit of history
2P34 – Solenoid Air Valve mains operated
2P38 – 200 R.P.M. Geared Mains 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 amplifier, 3w per channel
2P55 – Mains motor, extra powerful has $1\frac{1}{2}$" stack and good length of spindle
2P62 – 1 pair Goodmans 15 ohm speakers for Unilox
2P64 – 1 five bladed fan $6\frac{1}{2}$" with mains motor
2P66 – 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. tape motor two speed and reversible
2P72 – 1 115v Muffin fan 4" × 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 $\frac{1}{2}$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
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 and switch, 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.
5P6 12V alarm bell with heavy 6" gong, suitable for outside if protected from direct rainfall. Ex GPO but in perfect order.
5P12 Equipment cooling fan – mini 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 4 pole, 25 way 50 volt coil
5P18 – motor driven water pump as fitted to many washing machines
5P20 – 2 kits, matchbox size, surveilance transmitter and FM receiver
5P23 – miniature (appr. $2\frac{1}{2}$" wide) tangential blow heater, 1·2kw
5P24 – $\frac{1}{8}$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
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/offs 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.
5P48 – telephone extension bell in black case, ex-GPO
5P51 – 200W auto transformer 230V to 115V torroidal
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. AM
5P60 – DC Muffin type fan 18 to 27V, only 3W
5P61 – drill pump mounted on frame, coupled to mains motor
5P62 – $2\frac{1}{2}$kw tangential blow heater, add £1.50 post if not collecting
5P73C high pressure mains operated gas or water valve with tube connection suitable soldering
5P74 6rpm 60W mains motor and gearbox with instant stop
5P79 30rpm 80 watt mains driven motor with gearbox
5P82 1 25rpm mains 60w motor with gearbox
5P84 1 delay time switch, adjust 0–20 seconds
7P1 1 instant heat solder gun—mains with renewable tip and job light
10P10 1 9" extractor fan 115V so supplied with adaptor

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

VOL 16 No.3 MARCH '87

EVERYDAY ELECTRONICS

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The Magazine for Electronic & Computer Projects

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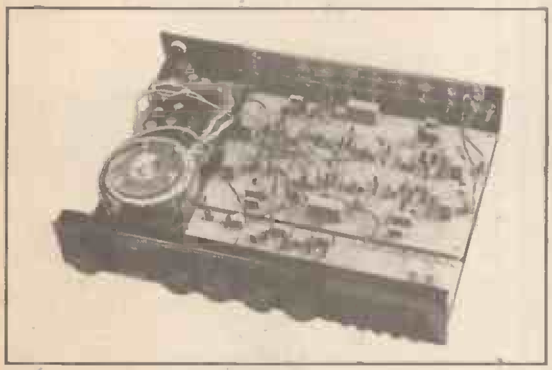
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .



Projects

Series

Features

FREE 16-Page Booklet
GUIDE TO PROJECT BUILDING **between pages 148/149**

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Our April 1987 issue will be published on Friday, 20 March 1987. See page 139 for details.

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

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NEW POWER STROBE KIT

Designed to produce a high intensity light pulse at a variable frequency of 1 to 15Hz this kit also includes circuitry to trigger the light from an external voltage source (eg. a loudspeaker) via an opto isolator. Instructions are also supplied on modifying the unit for manual triggering, as a slave flash in photographic applications or as a warning beacon in security applications. The kit includes a high quality pcb, components, connectors, 5Ws strobe tube and full assembly instructions. Supply: 240V ac. Size: 75 x 50 x 45.

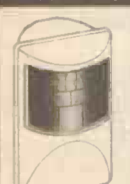
XK124 STROBOSCOPE KIT £12.50

REMOTE CONTROL SWITCH KIT

Comprises a compact 9V (PP3) powered single channel uncoded Infra-red transmitter and a mains powered receiver, this kit is ideal for switching table lamps, radios, etc. on and off remotely. Range 20ft. Max. load 500W (240V a.c. only). Size—Transmitter: 7 x 5 x 3cm (including box). Receiver: 7 x 3·5 x 3cm.

MK6 TRANSMITTER £4.95
MK7 RECEIVER £11.50

PASSIVE INFRA-RED DETECTORS



The INVADER is a Passive Infra Red Detector with 12 metre range and 110 angle of detection and a memory. Its 9–16V operation and attractive styling make it easy to install and use with virtually any control panel in a domestic alarm system. Size: 105 x 65 x 50mm.

950 136 £33.00

AUTOLITE—replaces a standard wall switch and saves energy by switching lights when movement is detected within its 4m range. Includes a dimmer and daylight sensor. 250W max.

950 137 £34.50

ELECTRONIC SIREN KIT

Produces an extremely loud piercing swept frequency tone from a 9-15V supply. Enable input for easy connection to alarm circuits. Includes 5in. Horn Speaker.

XK116 £8.65

Mini Siren
As above, but with a small speaker (instead of horn speaker) for internal use. Complete with box.

XK117 £4.70

PROPORTIONAL TEMPERATURE CONTROLLER KIT

Uses "burst fire" technique to maintain temperature to within 0·5°C. Ideal for photography, incubators wine-making, etc. Max. load 3kW (240V a.c.). Temp. range up to 90°C. Size: 7 x 4 x 2·5cms.

MK4 £7.10

NEW HIGH SECURITY LOCK KIT

Designed for use with our lock mechanism (701 150) this kit will operate from a 9V to 15V supply drawing a standby current of only 50μA. There are over 5000 possible 4-digit combinations and the sequence can be easily changed. To make things even more difficult for an unauthorised user an alarm can be sounded after 3 to 9 incorrect entries—selectable by means of a link. The alarm can sound for a few seconds to over 3 minutes during which time the keyboard is disabled preventing further entries. A latched or momentary output is available making the unit ideal for door locks, burglar alarms, car imobilisers, etc. A membrane keyboard or pushbutton switches may be used and a beep sounds when a key is depressed. Kit includes high quality PCB, all components, connectors, high power piezo buzzer and full assembly and user instructions.

XK121	LOCK KIT	£15.95
350 118	Set of Keyboard Switches	£4.00
701 150	Electric Lock Mechanism 12 volt	£16.50

TEN EXCITING PROJECTS FOR BEGINNERS

This Kit has been specially designed for the beginner and contains a SOLDERLESS BREADBOARD, COMPONENTS, and a BOOKLET with instructions to enable the absolute novice to build TEN fascinating projects including a light operated switch, intercom, burglar alarm, and electronic lock. Each project includes a circuit diagram, description of operation and an easy to follow layout diagram. A section on component identification and function is included, enabling the beginner to build the circuits with confidence.

ORDER NO XK118 £13.75

XK102 3-NOTE DOOR CHIME

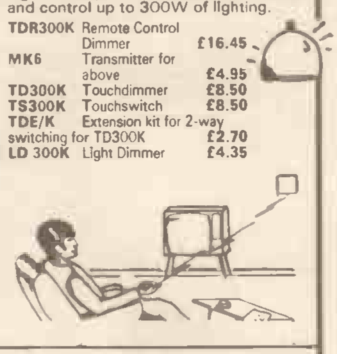
Based on the SAB0600 IC the kit is supplied with all components, including loudspeaker, printed circuit board, a predrilled box (95 x 71 x 35mm) and full instructions. Requires only a PP3 9V battery and push-switch to complete.

AN IDEAL PROJECT FOR BEGINNERS £6.00

HOME LIGHTING KITS

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

TDR300K	Remote Control Dimmer	£16.45
MK6	Transmitter for above	£4.95
TD300K	Touchdimmer	£8.50
TS300K	Touchswitch	£8.50
TDE/K	Extension kit for 2-way switching for TD300K	£2.70
LD 300K	Light Dimmer	£4.35



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Tel: 01-567 8910

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...IN ONE GREAT KIT!

The K5000 Metal Detector Kit combines the challenge of DIY Electronics assembly with the reward and excitement of discovering Britain's buried past.

THE KIT — simplified assembly techniques require little technical knowledge and no complex electronic test equipment. All stages of assembly covered in a detailed 36 page manual.

THE DETECTOR — features Analytical Discrimination & Ground Exclusion, backed by the proven pedigree of C-Scope, Europe's leading detector manufacturer.

Ask at your local Hobby/Electronics shop or contact:—

C-SCOPE C-Scope International Ltd., Dept. EE88, Wotton Road, Ashford, Kent TN23 2LN. Telephone: 0233 29181.

OSCILLOSCOPES

TEKTRONIX 2215. Dual Trace 60MHz. Delay Sweep. With Manual £475
TELEQUIPMENT D75 Dual Trace 50MHz Delay Sweep £350
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4006	0.30
4007	0.14
4008	0.30
4009	0.14
4010	0.14
4011	0.14
4012	0.14
4013	0.20
4014	0.30
4015	0.34
4016	0.18
4017	0.28
4018	0.28
4019	0.30
4020	0.30
4021	0.38
4022	0.30
4023	0.14
4024	0.24
4025	0.14
4026	1.20
4027	0.17
4028	0.25
4029	0.30
4030	0.30
4031	1.05
4034	1.36
4035	1.00
4036	3.00
4038	0.80
4040	0.42
4041	0.50
4042	0.45
4044	0.45
4045	1.00
4046	0.55
4047	0.55
4049	0.25
4050	0.20
4051	0.32
4052	0.32
4053	0.32
4054	0.52
4055	0.65
4056	0.52
4059	4.10
4060	0.60
4063	0.80
4066	0.22
4067	1.90
4068	0.14
4069	0.14
4070	0.18
4071	0.14
4072	0.18
4073	0.14
4075	0.14
4076	0.39
4077	0.28
4078	0.18
4081	0.14
4082	0.14
4085	0.25
4089	1.00
4093	0.18
4094	0.50
4095	0.85
4096	0.85
4098	0.68
4099	0.38
4502	0.62
4503	0.45
4508	0.68
4510	0.37
4511	0.45
4512	0.59
4514	0.68
4515	0.68
4516	0.38
4517	1.35
4518	0.38
4520	0.38
4522	0.80
4526	0.38
4527	0.65
4528	0.38
4529	1.35
4532	0.50
4534	3.49
4536	2.39
4538	0.45
4543	0.50
4553	2.29
4555	0.29
4556	0.40
4569	0.55
4584	0.30
4585	0.40
40101	1.20
40102	1.90
40103	1.90
40104	1.45
40105	1.85
40106	0.60
40107	0.49
40108	2.25
40109	0.75
40110	1.85

74LS TTL

74LS00	0.21
74LS01	0.21
74LS02	0.21
74LS03	0.21
74LS04	0.21
74LS05	0.21
74LS08	0.21
74LS09	0.21
74LS10	0.21
74LS11	0.21
74LS12	0.21
74LS13	0.29
74LS14	0.42
74LS15	0.21
74LS20	0.21
74LS21	0.21
74LS22	0.21
74LS24	0.45
74LS26	0.21
74LS27	0.21
74LS28	0.21
74LS30	0.21
74LS32	0.21
74LS33	0.21
74LS37	0.21
74LS38	0.21
74LS40	0.22
74LS42	0.45
74LS47	0.75
74LS48	0.75
74LS51	0.21
74LS54	0.21
74LS55	0.21
74LS73	0.28
74LS74	0.30
74LS75	0.40
74LS76	0.34
74LS78	0.34
74LS83	0.60
74LS85	0.70
74LS86	0.32
74LS90	0.45
74LS91	0.89
74LS92	0.50
74LS93	0.50
74LS95	0.69
74LS96	0.75
74LS107	0.40
74LS109	0.40
74LS112	0.40
74LS113	0.40
74LS114	0.40
74LS122	0.65
74LS123	0.80
74LS124	1.29
74LS155	0.99
74LS156	0.60
74LS157	0.50
74LS158	0.60
74LS160	0.65
74LS161	0.65
74LS162	0.66
74LS163	0.66
74LS164	0.65
74LS165	0.99
74LS166	1.80
74LS168	1.50
74LS169	0.89
74LS170	1.40
74LS174	0.89
74LS175	0.69
74LS190	0.79
74LS191	0.69
74LS192	0.80
74LS193	0.75
74LS194	0.70
74LS195	0.70
74LS196	0.80
74LS197	0.80
74LS221	0.90
74LS240	0.80
74LS241	0.80
74LS242	0.80
74LS243	0.75
74LS244	0.65
74LS245	0.89
74LS247	0.89
74LS248	0.89
74LS249	0.89
74LS251	0.69
74LS253	0.69
74LS256	0.80
74LS257	0.69
74LS258	0.55
74LS259	1.10
74LS260	0.70
74LS266	0.40
74LS273	1.00
74LS279	0.80
74LS280	1.80
74LS290	0.69
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74LS365	0.75
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CA3059	3.33
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1N4001	0.04
1N4002	0.04
1N4003	0.04
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1N4005	0.06
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BC108	0.16
BC108A	0.17
BC108B	0.18
BC108C	0.20
BC109	0.17
BC109B	0.18
BC109C	0.20
BC115	0.20
BC140	0.38
BC141	0.42
BC142	0.38
BC143	0.40
BC147	0.13
BC148	0.13
BC149	0.12
BC157	0.12
BC159	0.12
BC182	0.12
BC182L	0.12
BC183	0.12
BC183L	0.12
BC184	0.12
BC184L	0.12
BC212	0.12
BC212L	0.12
BC213	0.12
BC213L	0.12
BC214	0.12
BC214L	0.12
BC237	0.12
BC238	0.12
BC239	0.12
BC327	0.15
BC328	0.15
BC337	0.15
BC338	0.15
BC546A	0.12
BC546B	0.12
BC546C	0.12
BC547A	0.12
BC547B	0.12
BC547C	0.12
BC548A	0.12
BC548B	0.12
BC548C	0.12
BC549A	0.12
BC549B	0.12
BC549C	0.12
BC550	0.12
BC556	0.12
BC556A	0.12
BC557	0.12
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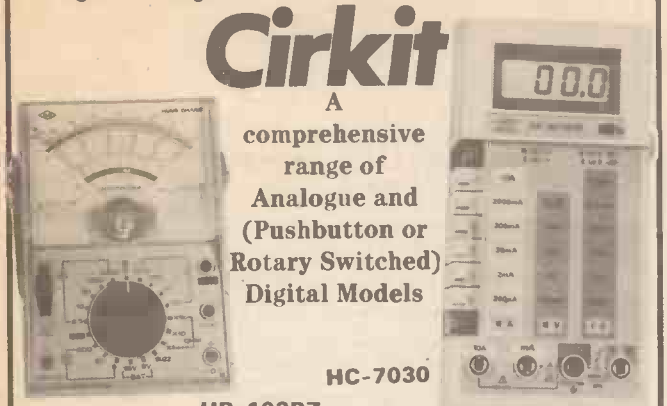

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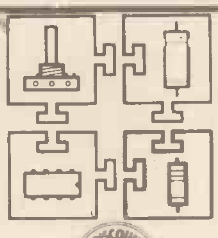

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CHIP TESTER (PE AUG 86) COMPUTER* CONTROLLED LOGIC AND CHIP ANALYSER (UP TO 24 PINS). SET 258F **£39.30**
CHORUS-FLANGER (PE JAN 84) MONO-STEREO. SUPERB DUAL-MODE MUSIC ENHANCEMENT. SET 235 **£59.99**
CYBERVOX (EE APR 85) AMAZING ROBOT TYPE VOICE UNIT, WITH RING-MODULATOR AND REVERB. SET 228 **£44.76**
DIGITAL 64K DELAY (PE JUN 85) UP TO 65 SECS DELAY, ECHO, REVERB, RE-PITCH, MULTI & REVERSE TRACK, LOOP, ETC. PLUS MICRO-INTERFACE*. 19 INCH RACK. SET 234-RK **£198.50**
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MICROSCOPE (PE DEC 85) TURNS A COMPUTER* INTO AN OSCILLOSCOPE. SET 247 **£44.50**
MICRO-TUNER (EE AUG 86) COMPUTER* CONTROLLED MUSIC TUNING AID. SET 259 **£22.50**
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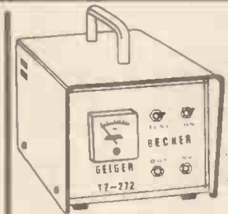
MORSE DECODER (EE JAN 87) COMPUTER* CONTROLLED MORSE CODER-DECODER, WITH VARIABLE RATE AND LEVEL CONTROLS. SET 269 **£22.16**
PHASER (PE OCT 84) EXCELLENT PHASING ENHANCED WITH MODULATED FILTERING. SET 226 **£42.36**
REVERB (EE OCT 85) MONO, WITH REVERB TO 4 SECS, ECHO TO 60MS. SET 232 **£27.35**
RING MODULATOR (PE NOV 84) FABULOUS EFFECTS GENERATION, WITH ALC AND MULTIWAVEFORM VCO. SET 231 **£45.58**
TEMPESTUOUS STORMS (PE JUN 86) RAW NATURE UNDER PANEL CONTROL! WIND & RAIN—SET 250W **£29.50** THUNDER & LIGHTNING—SET 250T **£29.50**
* COMPUTER PROGS AVAILABLE FOR BBC, C64 AND PET.
MANY MORE KITS IN CATALOGUE—OVER 70 OF THEM!

PCB SERVICE PCB'S FOR ALL PROJECTS DESIGNED BY JOHN BECKER AND PUBLISHED IN PE & EE ARE AVAILABLE SEPARATELY AS IN CATALOGUE.
CATALOGUE AND ENQUIRIES SEND 9 × 4 S.A.E. FOR FREE CATALOGUE, AND WITH ALL ENQUIRIES. (OVERSEAS SEND £1.00 OR 5 I.R.C'S).
ORDERS AND POST MAIL ORDER, CWO, CHQ, PO, ACCESS, VISA. ADD 15% VAT. ADD P&P—SET 234RK £3.50, UNIT TZ-272 £2.50, OTHERS £1.50. EACH. INSURANCE 50P PER £50. OVERSEAS P&P IN CATALOGUE.
TEXT PHOTOCOPIES—DDL £1.50, TZ-272 & 274 UNITS £1.00, OTHERS 50P EACH. SEND LARGE STAMPED ENVELOPE.
I ALSO CARE BY PROVIDING A KIT MAINTENANCE SERVICE—MY KITS ONLY.

GEIGER COUNTERS



NUCLEAR RADIATION DETECTORS

SINCE CHERNOBYL, OWNING A NUCLEAR RADIATION DETECTOR HAS TAKEN ON A NEW SIGNIFICANCE. ACCIDENTS SHOULD NOT HAPPEN—BUT THEY DO! YOU WOULD BE AMAZED AT THE GEIGER QUANTITIES SOLD SINCE CHERNOBYL. INSURANCE IS PRUDENT.

IF YOU DO NOT ALREADY OWN A GEIGER, WITH TODAY'S DEBATABLY UNCERTAIN NUCLEAR SECURITY, I BELIEVE THAT YOU SHOULD SERIOUSLY CONSIDER BUYING ONE. MINE, BELOW, HAVE BEEN DESIGNED FOR THE NON-PROFESSIONAL USER, UNSURE ABOUT THE ENVIRONMENT, BUT UNWILLING TO PAY SEVERAL HUNDRED POUNDS FOR STRICT COMMERCIAL UNITS. JOHN BECKER.

READY-BUILT & KIT FORM
TECHNOLOGICALLY FURTHER DEVELOPED VERSIONS OF THE RADIATION DETECTORS PUBLISHED IN PE & EE DURING JULY 1986, WITH PARTICULAR EMPHASIS ON LOW POWER CONSUMPTION AND FUNCTIONAL ABILITY. THEY ARE EQUALLY SUITED TO BACKGROUND AND CLOSE UP MONITORING. GEIGER TUBE ZP1310 IS SUPPLIED AS THE SENSITIVE STANDARD DETECTOR, BUT OTHERS MORE COSTLY ARE AVAILABLE.

CASE MATERIAL (EXCEPT GEIGER-MITE)—MILD STEEL COVERED IN HARD WEARING PLASTIC. WHITE PANEL, LIGHT BLUE TOP AND SIDES. BATTERY OPERATED (9V RECHARGEABLE OR DISPOSABLE). ALL UNITS HAVE SEPARATE OUTPUTS FOR MONITORING BY COMPUTER OR OTHER DIGITAL ANALYSER.

AUDIO-VISUAL GEIGER (PE)
WITH EXTENDABLE PROBE MOUNTED ON REAR OF UNIT, INTERNAL LOUDSPEAKER, METER FOR COUNTS RATE DISPLAY, COMPUTER OUTPUT, BATTERY AND AUDIO TEST SWITCH. CAN BE USED WITH HIGH IMPEDANCE (CRYSTAL) HEADPHONES. NORMAL POWER CONSUMPTION ONLY 1MA. MAY ALSO BE USED WITH EXTERNAL 9V POWER SUPPLY. CASE SIZE 197 × 108 × 90MM.

READY-BUILT UNIT = TZ-272 **£75.50**

KIT-FORM UNIT = SET 264MK2 **£59.50**

AUDIO GEIGER (EE)
WITH FIXED PROBE MOUNTED ON FRONT PANEL, INTERNAL LOUDSPEAKER, COMPUTER OUTPUT, AUDIO TEST SWITCH. MAY ALSO BE USED WITH EXTERNAL SPEAKER OR HEADPHONES FROM 8 OHMS UPWARDS. NORMAL POWER CONSUMPTION LESS THAN 4MA. CASE SIZE 150 × 83 × 67MM.

READY-BUILT UNIT = TZ-274 **£65.00**

KIT-FORM UNIT = SET 265MK2 **£49.50**

GEIGER-MITE
A POCKET-SIZED GEIGER (PLASTIC CASE 85 × 56 × 40MM) THAT USES A LIGHT EMITTING DIODE (LED) TO DISPLAY RADIATION IMPACT COUNTS. ALSO HAS AN OUTPUT SOCKET FOR MONITORING BY COMPUTER OR BY HIGH IMPEDANCE (CRYSTAL) HEADPHONES. KIT-FORM ONLY = SET 271 **£39.50**

ALL KITS INCL. PCBS, PARTS, BLACK STEEL & ALI BOXES UNLESS STATED, INSTRUCTIONS, FREE WIRE AND SOLDER. FURTHER DETAILS IN CATALOGUE.

BECKER-PHONOSONICS, DEPT EE73, 8 FINUCANE DRIVE, ORPINGTON, KENT BR5 4ED. TEL: 0689 37821

NEW THIS MONTH

Full details on Bargain List 27

CB MICROPHONE. Hand held with push to talk switch. Curly lead. 600R Dynamic £2.95

CIRCUIT TESTER. DC continuity tester. Needs 2 × AA cells. 90cm long lead has croc clip 50p

MINI DRILL. Precision geared plastic. Brass chuck takes up to 1.2mm bit. Storage in handle. 115mm long £1.69

TELEPHONE. Non-BT approved single piece. Push button with auto redial. Ivory. Wall bracket. 4m lead (half is coiled) £5.99

CRAFT KNIVES. Miniature type has 12 snap off sections. 9mm wide blade is fully retractable and can be locked in position. Supplied with spare blade. 125mm long. 50p

Heavy duty version of above—18mm wide blade, 7 sections, 150mm long. 95p

LOGIC PROBE. For TTL, CMOS etc. LED and sound indication. Pulse enlargement capability allows pulse direction down to 25nsec. Max f = 20MHz 4–16V. I/P Z:1M £9.99

STEREO TUNER. Z497 AM/FM STEREO TUNER PANEL. Complete radio chassis with push button selection for LW/MW/FM and ON/OFF. Ferrite rod for LW & MW selection, co-ax socket for FM aerial. Supplied with mains transformer and rectifier/smoothing cap, and wiring details. PCB is 333 × 90mm £12.95

1987 CATALOGUE OUT NOW

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—80pp packed with components & equipment. Bargain List, order forms & £1.50 discount vouchers all included for just £1 inc. post.

+ FREE! KIT-CAT

24 page illustrated catalogue with over 100 kits from simple amplifiers to complex EPROM programmers—also computer interface kits enabling many popular computers to be linked with the outside world. PLUS kits utilizing breadboards for beginners.

COMPONENT PACKS

Greenweld are No. 1 in component packs—No. 1 for value and No. 1 for variety! We sell thousands of packs containing millions of components every year! They all offer incredible value for money—order some now and see how much you save over buying individual parts!

Full details in catalogue.

K547 ZENER DIODES. Glass and plastic, 250mW to 5W ranging from 3V to 180V. All readily indentifiable. 100 for £4.50

K548 TANTALUM CAPACITORS. Wide range of values from 0·1 to 68µF, 3V to 50V. Includes both bead and valuable solid types. 100 for £6.50

K544 MULLARD POLYESTER CAPS. Cosmetic Imperfections, electrically OK. Wide range of values from 0·01 to 0·47µF in 100, 250 and 400V working. 200 for £4.75

K555 FUSES. Big selection of quick blow and antisurge types and sizes including 15mm, 20mm, 1" and 32mm, 60mA to 50A! 100 for £3.95

K539 LED PACK. Not only round but many shaped leds in this pack in red, yellow, green, orange and clear. Fantastic mix. 100 £5.95 250 £13.50

K517 TRANSISTOR PACK. 50 assorted full spec. marked plastic devices PNP NPN RF AF. Type numbers include BC114 117 172 182 183 198 239 251 214 255 320 BF198 255 394 2N3904 etc., etc.

Retail cost £7+ Special low price £2.75

K554 THERMISTORS. Mostly disc, rod and some valuable bead types. Identification/data sheet included. Big variety up to 40mm dia! Catalogue value over £50.00. 100 for £8.00

K540 RESISTOR PACK. Mosly ⅛, ¼ and ½W, also some 1 and 2W in carbon, film, oxide etc. All have full length leads. Tolerances from 5 to 20%. Excellent range of values. 500 £2.50 2500 £11.00

K531 PRECISION RESISTOR PACK. High quality, close tolerance R's with an extremely varied selection of values mostly ½ and ½W tolerances from 0·1% to 2%—ideal for meters, test gear etc. 250 £3 1000 £10

KEYBOARDS

TATUNG VT1400 Video Terminal Keyboard. Brand new cased unit 445 × 225 × 65/25mm 71 Alpha-numeric and function keys, + separate 14 key numeric keypad. ASCII output via curly cord and 6 way plug. Data and connection sheet supplied. Now only £17.50

CAMPUTERS LYNX keyboard 58 full travel keys. Size 334 × 112mm. Brand new. Reduced to £5.95

Z470 COMPONENT UNIT. Panel 130 × 165mm with 10 × 74 series IC's, all in sockets, R's, C's, etc. Inc. 100µF 16V Tant. Also 5A DPCO relay and 6 brass pillars 60mm long supporting a steel panel upon which is mounted a mains transformer giving 5V and 12V output; 7805KC regulator and a screened box 110 × 80 × 30mm with phono input containing 76131 stereo pre-amp IC + associated components. Various plugs and sockets. Amazing value—components must be worth over £50.

Yours for just £4.50

'NEWBRAIN' PANELS

Z494 Motherboard microprocessor panel 265 × 155mm. Complete PCB for computer. Z80, char EPROM, etc. 68 chips altogether + other associated components, plugs, skts, etc. £5.50

Z495 RAM panel. PCB 230 × 78mm with 14 × MM5290–2 (4116) (2 missing) giving 28k of memory. Also 8 LS chips. These panels have not been soldered, so chips can easily be removed if required. £5.00

'NEWBRAIN' PSU Z467

BRAND NEW Stabilized Supply in heavy duty ABS case with rubber feet. Input 220/240V ac to heavy duty transformer via suppressor filter. Regulated DC outputs: 6·5V @ 1·2A; 13·5V @ 0·3A; −12V @ 0·05A. All components readily accessible for mods etc. Chunky heatsink has 2 × TIP31A. Mains lead (fitted with 2 pin continental plug) is 2m long. 4 core output lead 1·5m long fitted with 6 pole skt on 0·1" pitch. Overall size 165 × 75 × 72 mm. £5.95 ea 10 for £40

PANELS

Z469 AL30A amp. Panel 90 × 64mm. 10W RMS O/P with 30V supply. Popular audio amp module—these are ex-equip but believed to be working. £2.50

Z475 TRIAC PANEL—240 × 165mm. 14 triacs 2N6346, TXAL116B or sim. 200V 6–8A; 16 SCR's C106A1 4A 30V; 6 × 4099 in skts; 15 suppressors; 37 ZTX450; min 12V relay; R's, C's plugs, etc. Only £4.50

FLASH UNIT

Z488 complete apart from case. Xenon tube, neon indicator, on/off switch, trigger wires. Requires 3V supply. 50 × 55 × 30mm. Brand new, with data.

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JOIN UP WITH LITESOLD

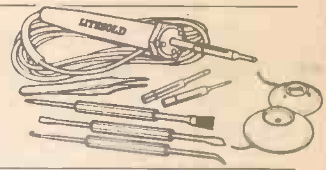
Professional Soldering Equipment at Special Mail-Order Prices.

EC50 Mains Electronic Iron. £33.16

Features spike-free, solid state proportional electronic temperature control inside the handle. Adjustable 280° to 400°C. Burn-proof 3-wire mains lead. Fitted 3.2mm Long-Life bit. 1.6, 2.4 and 4.7mm available. 240v a.c.

SK18 Soldering Kit. £16.70

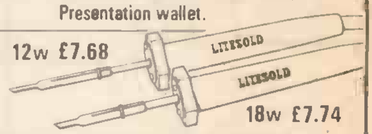
Build or repair any electronic project. LC18 240v 18w iron with 3.2, 2.4, and 1.6mm bits. Pack of 18 swg flux-cored 60/40 solder. Tweezers. 3 soldering aids. Reel of De-Solder braid. In PVC presentation wallet.



ADAMIN Miniature Iron £7.67

Possibly smallest mains iron in the world. Ideal for fine work. Slim nylon handle with finger grip. Interchangeable bits available 1.2, 1.6, 2.4, 3.4 and 4.7mm. Fitted with 2.4mm. 240v 12w (12v available). Presentation wallet.

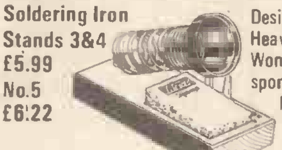
'L' Series Lightweight Irons. 12w £7.68



18w £7.74

High efficiency irons for all electronic hobby work. Non-roll handles with finger guards. Stainless steel element shafts. Screw-connected elements. Slip-on bits available from 1.6 to 4.7mm. LA12 model, 12w, 2.4mm bit. LC 18 Model, 18w, 3.2mm bit. 240v Std – 12v available. Presentation wallet.

Soldering Iron Stands 3&4 £5.99 No.5 £6.22



Designed specially for LITESOLD irons. Heavy, solid-plastic base with non-slip pads. Won't tip over, holds iron safely. With wiping sponge and location for spare (hot) bits. No 5 stand for EC50 iron No 4 stand for ADAMIN miniature Iron No 3 stand for LA12 and LC18 Irons.

Replacement Bits

For all above irons. Non-stick designs, machined from special copper alloy, with Inconel retaining rings. Two types – Chromium plated with copper face (for economy and ease of use) and Iron plated with Pre-tinned face (Long Life). State tip size, iron and type.

	Copper	L/L
EC50	–	£1.74
Adamin 12 and LA12	£1.00	£1.71
LC18	£1.12	£1.90

Yellow £1.33 Green £1.39

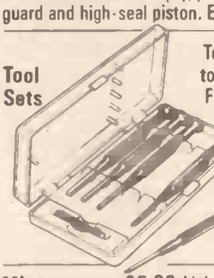
Blue £1.44 per Reel

For simple, safe and effective de-soldering of all types of joint, using a standard soldering iron. Handy colour-coded packs of 1.5 metres in 3 widths: Yellow – 1.5mm, Green – 2mm, Blue – 3mm.

De-Solder Pumps £7.28

High Quality version of increasingly popular type of tool. Precision made anodised aluminium body, plunger guard and high-seal piston. Easy thumb operation. Automatic solder ejection. Conductive PTFE nozzle – no static problems.

Tool Sets



Top quality Japanese metric hardened and tempered tools. Swivel-top chrome plated brass handles. Fitted plastic cases. 113 set – 6 miniature screwdrivers 0.9 to 3.5mm **£3.92**

227 set 5 socket spanners 3 to 5mm **£2.98**

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228 set 20 piece combination: 5 open, 5 skt spanners, 2 crosspoint, 3 hex and 3 plain drivers, scriber, handle/holder **£6.42**

Microcutters. £5.39 Light weight hardened and precision ground. Flush cutting. Screw joint, return spring, cushion-grip handles. Safety wire-retaining clip.

Soldering Aids.

Set of 3 £4.45

Scraper/Knife, Hook/Probe, Brush/Fork. 3 useful double-ended aids to soldering/desoldering/assembly. In plastic wallet.

ADAMIN Electric Stylus. £16.71

Writes like a ballpoint in Gold, Silver, Copper or 6 colours, on card, plastics, leather etc. Personalise wallets, bags, albums, books, models . . . Operates at 4.5v from its own plug/transformer – totally safe. Supplied with coloured foils.

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MAGENTA

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If you do not have the issue of E.E. which includes the project – you will need to order the instruction reprint as an extra – 70p each. Reprints available separately 70p each + p&p £1.00.

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SAE or 'phone for prices

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SPECTRUM I/O PORT less case. Feb 87 £8.99
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STEPPING MOTOR MD200 Feb 87 £16.80
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LIGHT RIDER DISCO VERSION £18.69
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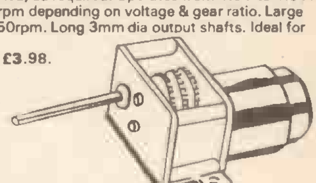

1987 CATALOGUE

Brief details of each kit, our books, & illustrations of our range of tools & components. Also stepper motor, interface kit & simple robotics. Plus circuit ideas for you to build. If you read Everyday Electronics then you need a copy of the MAGENTA catalogue.

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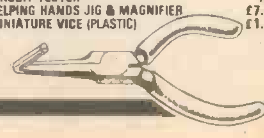

EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

The Magazine for Electronic & Computer Projects

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PROJECT BUILDING

MANY of the letters and telephone calls we receive in the EE editorial office are from readers who have built one of our projects that has failed to work. Sometimes we can help with specific problems but more often than not we have to ask readers to check their construction carefully, to make sure the correct value components have been used, that component polarities are correct and that the assembly and soldering has been carried out correctly.

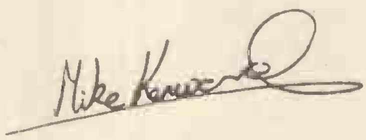
It is sad but true that some readers give up electronics because their first project fails to operate. If only they would take the trouble to practise some soldering, to learn a little about components and methods of construction, we are sure they would stay with our fascinating hobby. After all, nobody expects to be able to play golf the first time they pick up a club, or to be able to cook a beautiful meal the first time they try, so why should they be able to build electronic equipment—or even solder at the first attempt. It may seem a simple task but, like most things, it requires practice to perfect.

I well remember building models from tinned copper wire as an apprentice—great fun it was too. We had all sorts of cars, boats, planes and animals on display after a few days. Each apprentice had also made a few hundred soldered joints—many of them joining three or four wires to one point—without ever finding it boring. Try it, it's a great way to learn to solder!

KNOWLEDGE

To acquire the knowledge required to build projects, keep reading. Read our pages, read catalogues, buy some books (see our book service) or borrow some from the library. Like most other hobbies, it takes time to fully absorb the knowledge required. In short, don't expect to buy one copy of EE, purchase some components and become an expert in electronics. Our hobby is fascinating and worthwhile but to gain satisfaction from it requires patience, practice and perseverance.

Just to help you on your way, this issue and the next issue carry free booklets which have been written by a regular contributor who not only sees a number of readers' non working projects but also is mainly self taught in electronics. His experience of the problems encountered by readers has helped to formulate these two guides for project builders. We are sure the information they contain will be of value to all readers.



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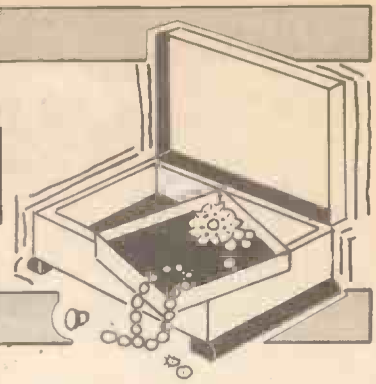
INFRA RED ALARM



MARK STUART

Multipurpose detector that uses the power of an invisible beam

THIS circuit was designed as a multipurpose movement detector able to form the basis of all sorts of burglar alarms and automatic controllers. It will work either as a single interrupted beam alarm over substantial distances, or will directly detect moving objects or persons by measuring changes in the level of reflected infra red over shorter distances. The output of the device is a set of mains-rated changeover relay contacts which operate as soon as an object is detected, and remain operated for a pre-settable time between one second and one hour.

As the relay contacts are mains voltage rated and are capable of carrying up to 6A they can be used to control a wide variety of things such as automatic garage door opening mechanisms, central heating systems, room lighting, extractor fans, alarm bells, tape-recorders, and cameras. There must be hundreds of other applications in agriculture, industry and commerce for this versatile detector.

PRINCIPLES OF OPERATION

A block diagram of the system is shown in Fig. 1. A pulsed beam of infra red radiation is produced by feeding a high efficiency l.e.d. (TX1) with 500mA pulses from a pulse generator circuit with a 1:100 mark—space ratio.

This radiation is detected by an infra red photodiode (RX1) which produces a very small pulse output which is amplified by a high gain pulse amplifier and passed to a synchronous detector circuit. The synchronous detector produces a d.c. output voltage which is proportional to the incoming pulse level and hence proportional to the level of infra red radiation received.

This level is capacitively coupled to the next stage which is a "window comparator". Provided the input level is steady or varies only slightly the output of the window comparator remains low (at logic 0). If the level increases or decreases beyond the set limits (or window) the output changes state from low to high level.

The following stage is a latch circuit which detects the low to high transition on its input and starts the timer circuit. As the timer starts it operates the relay driver and so energises the relay. The timer now operates for the set time regardless of what happens to the beam.

At the end of the set time the timer releases the relay and resets the latch circuit. The circuit then resumes its original stable state until a disturbance of the infra red beam is again detected.

The time delay is produced by a low frequency clock oscillator followed by a 12-stage binary divider. Any of these outputs can be used to provide the reset pulse so that the time delay can be pre-set to be 2, 4, 8, etc up to 2048 clock cycles. With a clock frequency of 0·5Hz this gives a maximum delay of approximately 1 hour.

CIRCUIT DESCRIPTION

The project is constructed in two separate parts. A power supply and relay unit which carries mains voltage circuits, and the detector head unit which is connected to the other unit via a three-core cable and carries only low voltage circuits.

This arrangement ensures complete safety in those applications where the detector head is to be mounted outside and exposed to weather, because the separate mains circuits can be installed indoors. It is also possible to use more than one detector head with a single power supply unit to extend the area covered.

The circuit diagram of the detector section of the Infra Red Alarm is shown in Fig. 2. IC1a is a standard Schmitt-trigger oscillator in which capacitor C2 is repeatedly charged through diode D1 and resistor R2 and discharged via R1.

As resistor R2 is 100 times smaller than R1 the capacitor charge time is 100 times less than the discharge time and so a pulse waveform with a mark-space ratio of 1 to 100 is produced at the output of IC1a (pin 3). The pulses are approximately five milliseconds apart and 50 microseconds long.

Transistor TR6 is turned on during each pulse by a base current of 10mA from IC1a through resistor R3. A minimum current gain of 50 ensures that 500mA pulses are available to drive the infra red emitting diode TX1 via series limiting resistor R4. As the pulses are very short the average supply current is only 5mA.

Decoupling capacitors C1, C8 and C11 and careful p.c.b. track routeing ensure that the high pulse currents can be handled without producing supply voltage "spikes". Poor layout and inadequate decoupling can cause severe circuit interaction problems in circuits of this type and it is recommended that the layout shown is adhered to as it is completely trouble free.

The pulse output from IC1a is also connected to the gating input (pin 5) of IC2. This forms part of the synchronous detector circuit which will be described later.

The reflected infra red beam is detected by photodiode RX1. This is a large area device with a lensed front and a built in visible light filter. This prevents pulsing light sources such as fluorescent tubes, discharge lamps, and television screens from causing interference.

Ordinary tungsten filament bulbs emit a considerable amount of infra red radiation but the thermal inertia of the filament is such that only a low level of pulsing occurs as the filament heats and cools during each half cycle of the mains. This is not generally a problem but it is advisable to keep such lamps out of the direct field of view of the photodiode.

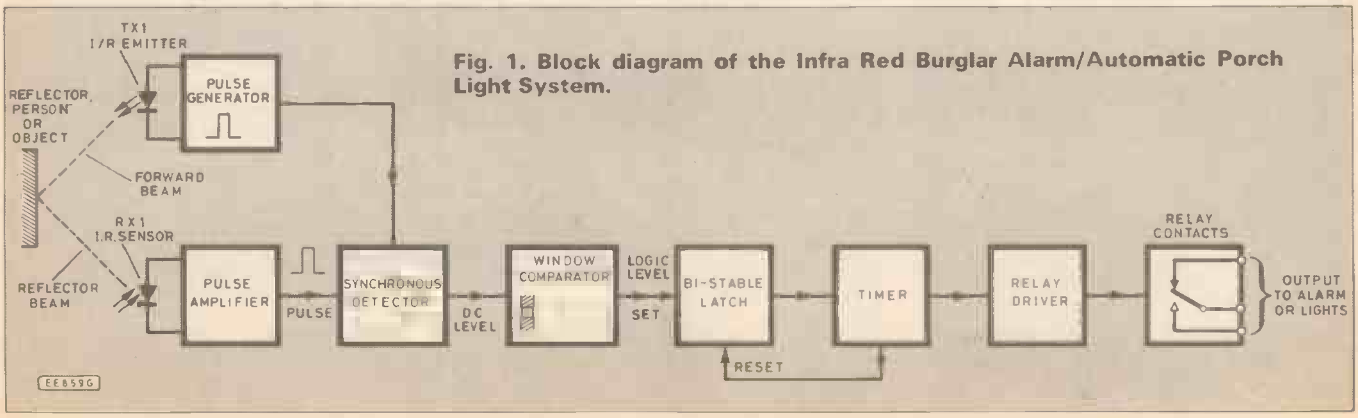


Fig. 1. Block diagram of the Infra Red Burglar Alarm/Automatic Porch Light System.

COMPONENTS

See **Shop Talk** page 135

Resistors

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R2,R3,R13, R19,R27	1k (5 off)
R4	15
R5,7	47k (2 off)
R6	2M2
R8,R11,R14, R22,R26	10k (5 off)
R9	680
R10	470k
R12,R15, R18,R25	1M (4 off)
R16,R17	470 (2 off)
R20	3k3
R21	220k

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Capacitors

C1	100µ radial 16V
C2,C14	470n polyester (small 100V type) C280
C3,C8	10µ radial 16V
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C6	220n polyester 100V
C7	0·47µ tantalum 35V
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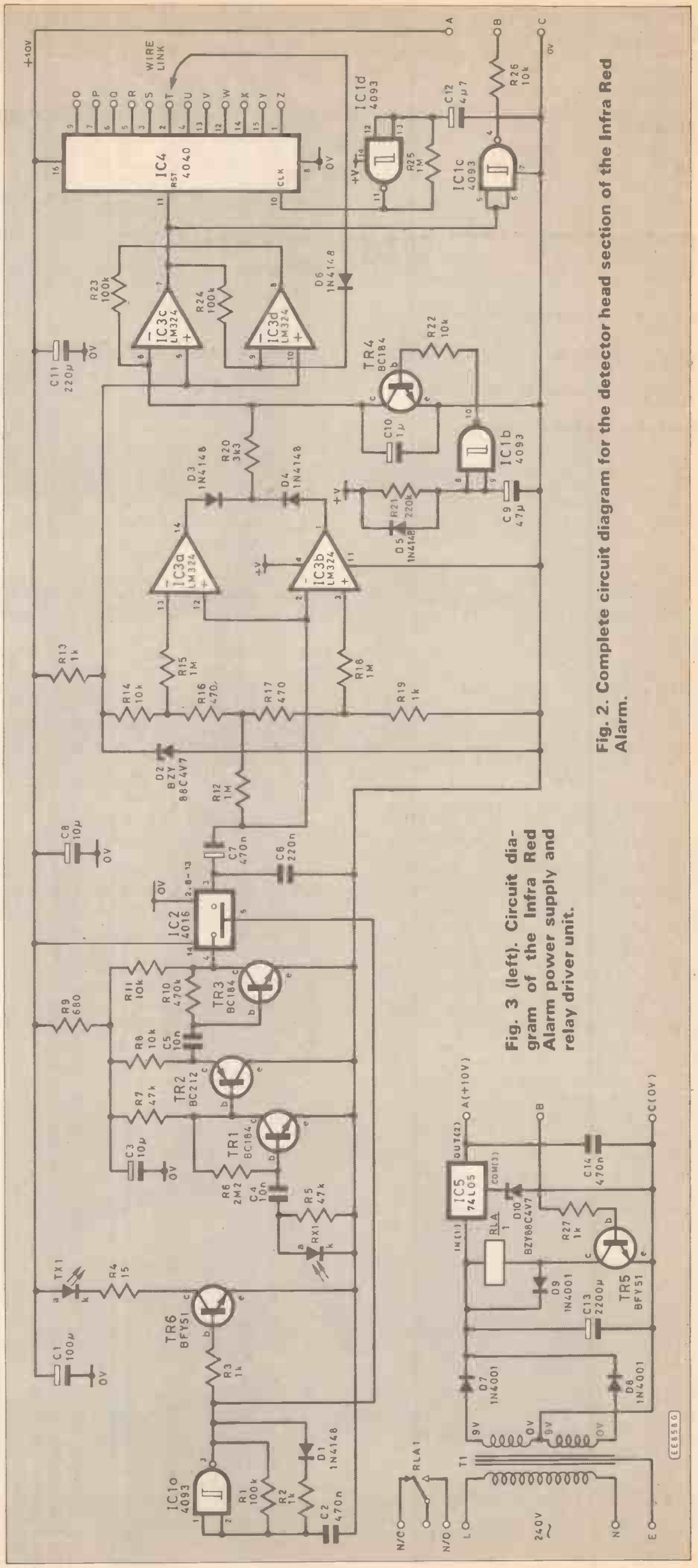


Fig. 2. Complete circuit diagram for the detector head section of the Infra Red Alarm.

Fig. 3 (left). Circuit diagram of the Infra Red Alarm power supply and relay driver unit.

PULSE AMPLIFIER

The output from the photodiode is a low level pulse waveform which is coupled via capacitor C4 to the three-stage pulse amplifier made up from transistor TR1, TR2 and TR3. Transistors TR1 and TR3 are standard common emitter amplifier stages with bias and negative feedback via resistors R6 and R10 respectively.

Each stage provides a substantial voltage gain. Transistor TR2 is an emitter-follower stage which has a high impedance input and low impedance output but no voltage gain. Its function is to match the output of TR1 to the input of TR3 and so optimize the gain of each.

The power supply to the sensitive pulse amplifier stages is decoupled by resistor R9 and capacitor C3 to ensure a very clean supply rail. At the collector of TR3 the output waveform is in the form of positive pulses. The amplitude of which is proportional to the strength of the received beam.

To detect changes in the received beam level it is first necessary to convert the pulse level into a steady voltage which represents the received pulse level. There are a number of ways of doing this. The simplest way is to use a diode to rectify the pulses and charge a smoothing capacitor.

This method would work but has the drawback that the voltage output will only fall slowly even if the beam level falls quickly. This is because the smoothing capacitor (*C*) charges via the diode (*D*) but discharges via a parallel resistor (*R*).

Using a lower value resistor for *R* improves the speed at which the voltage can fall but as the voltage also falls further between pulses the result is a large amount of ripple in the output and a lower average signal level.

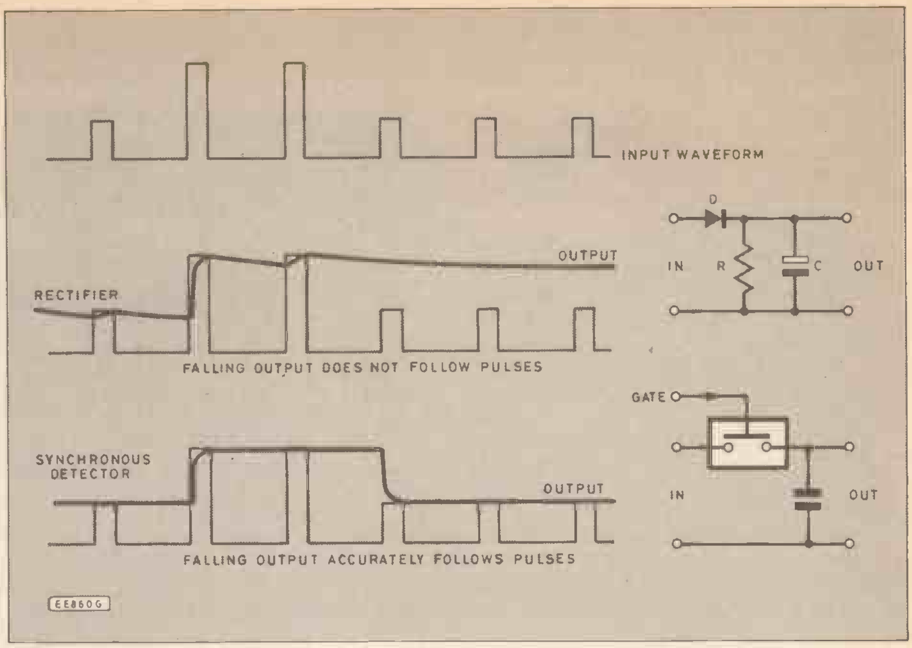


Fig. 4. The comparison of the two types of detection circuits, rectifier and synchronous, with idealised waveforms.

SYNCHRONOUS DETECTOR

The synchronous detector circuit overcomes all of these problems by using a switch in place of the diode. The switch is closed during each pulse and the capacitor charges almost instantly to the peak pulse voltage. As the switch is bi-directional the capacitor can also discharge instantly to a new lower peak pulse level as the signal level drops. In between pulses the switch is open circuit and so the capacitor level remains constant and there is no output ripple at all.

The comparison of the two types of detection with idealised circuit waveforms is shown in Fig. 4. The synchronous detector is so called because the switch must operate in synchronism with the pulse waveform. In this circuit the switch is part of a 4016 CMOS bi-directional switch i.c. and is turned on and off by a "gating" pulse derived from IC1a. As IC1a is the oscillator that drives the infra red emitter circuit the gating pulses are automatically in synchronism with the received pulses.

The output of the synchronous detector is a steady d.c. voltage across capacitor C6. Any fluctuation in this voltage is a result of the infra red beam being disturbed and is passed, via coupling capacitor C7, to the inputs of IC3a and IC3b. IC3a and IC3b are standard op-amp i.c.s which amplify the difference in voltage between their two inputs. As their gain is very high only a few millivolts difference between the inputs is sufficient to make the output "swing" from 0V to the positive supply voltage.

The inputs of the op-amps that are not connected to the signal are connected to constant voltage bias points on the resistive potential divider chain consisting of resistors R14, R16, R17 and R19. This divider chain is fed from a 4·7V stabilised supply provided by resistor R13 and Zener diode D2.

WINDOW COMPARATOR

The voltages on pin 13 of IC3a and pin 3 of IC3b are 800mV and 400mV respectively. At the junction of resistors R16 and R17 the voltage is 600mV and this is used to provide the d.c. bias via R12 for the other inputs of IC3a and IC3b.

These d.c. conditions are such that the non-inverting (+) input of IC3b is at 400mV which is 200mV lower than the 600mV at its inverting input. This means that the output of IC3b will be held at or very close to 0V.

The d.c. conditions of IC3a are also such that the non-inverting input is 200mV lower than its inverting input as these are at 600mV and 800mV respectively. The output of IC3a is therefore also close to 0V.

Fluctuations in the voltage across capacitor C6 are passed via C7 and are added to the 600mV d.c. bias. Provided the fluctuations are less than 200mV in either direction nothing happens. Once this level is exceeded however pin 12 of IC3a may rise above 800mV or pin 2 of IC3b may fall below 400mV.

In each case the effect is to reverse the polarity of the voltage between the inverting and non-inverting inputs of the amplifiers so that the non-inverting input is at a higher voltage than the inverting input. The result of this is that the output swings positive from 0V up to almost the full positive supply voltage.

This type of circuit is known as a "Window Comparator". The "window" is the gap between 400mV and 800mV within which the input signal may be, without changing the state of the output. If the input signal falls outside the "window" below 400mV or above 800mV the output changes state.

Diodes D3 and D4 are connected to couple a positive output voltage from either of the outputs of IC3a and IC3b through resistor R20 to the bi-stable latch circuit made up from IC3c and IC3d. These are a pair of cross-coupled amplifiers which work in a similar way to cross-coupled logic gates.

The non-inverting inputs of both amplifiers are connected to 4·7V at the junction of resistors R13, R14 and diode D2. The inverting outputs are cross-coupled via resistors R23 and R24. The circuit can rest in two stable states with either the output of IC3c high (positive) or output of IC3d high.

Normally the circuit resets with the output of IC3c held high. This holds the Reset pin of IC4 high which sets all the outputs low. When the beam is disturbed a positive output signal from the "window" comparator passes to pin 6 of IC3c. This forces the output of IC3c to change from high to low.

Pin 9 of IC3d is pulled low via R24 forcing its output to change from low to high. Feedback through resistor R23 now completes the latching operation of the circuit by holding pin 6 of IC3c high even after the original positive signal from the window comparator is removed.

BINARY COUNTER

The circuit is now stable in this state until pin 9 of IC3d is pulled high via diode D6. This happens when the selected output of the binary counter IC4 changes state. The speed at which this happens is determined by the low frequency clock oscillator consisting of IC1d, R25 and C12. This is a standard Schmitt trigger oscillator (similar to IC1a) producing an output of approximately 0·5Hz.

There are twelve stages in IC4 which change state in a binary sequence after 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048 clock cycles respectively. These are lettered O–Z in ascending order.

Whichever of these pins is used its voltage level changes from low to high after the appropriate number of clock cycles. When this happens, pin 9 of IC3d is pulled high via D6 and the bi-stable latch circuit returns to its original state with IC3c output held high and IC4 reset so that all its outputs are forced low.

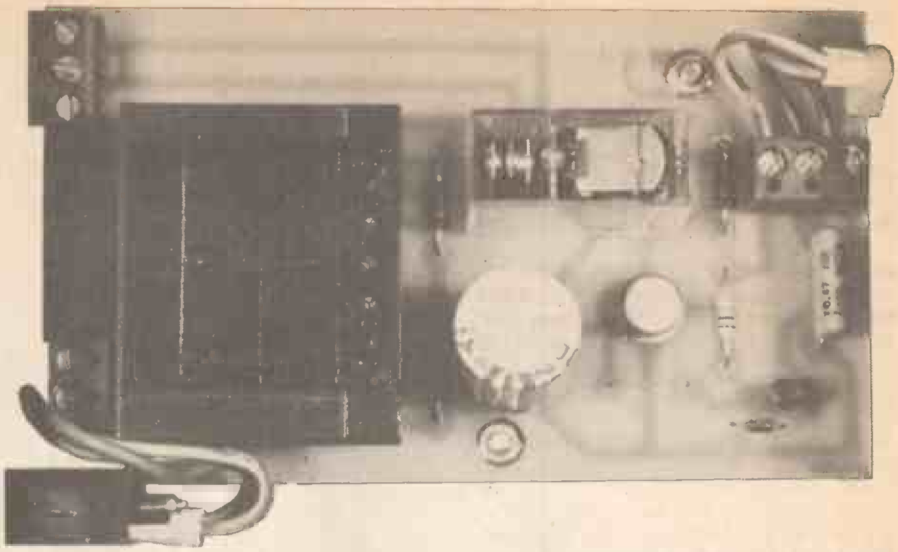
Drive to the ouput relay is provided by IC1c which inverts the level from IC3c so that terminal B is pulled positive for the full time period whenever the circuit is triggered.

The remaining components of the detection circuit are to ensure that the circuit does not trigger when first switched on. Transistor TR4 is turned on by IC1b for approximately 10 seconds after switch-on, whilst capacitor C9 charges from zero up to approximately half of the supply voltage. This effectively short-circuits capacitor C10 and sets the bi-stable circuit in the correct state.

After 10 seconds the voltage across C9 exceeds half of the supply voltage and the output of IC1d falls from high to low, TR4 is turned off, and these components play no further part.

POWER SUPPLY

The power supply and relay driver circuit is shown in Fig. 3. A small centre tapped mains transformer T1 provides approximately 12V via rectifier diodes D7 and D8 across smoothing capacitor C13. A 5V regulator IC5 is used along with a 4·7V Zener diode to give a regulated 10V supply for the detector circuit. Connections to the detector are via a three-core lead linking the three points A, B, and C.



The relay RLA is driven from terminal B on the sensor head via transistor TR5 which provides the necessary current gain. A set of changeover mains rated 6A contacts on the relay are terminated by a three-way terminal block on the circuit board.

These contacts can be wired directly to mains lighting or motor control circuits or may be fitted into a burglar alarm loop systems etc.

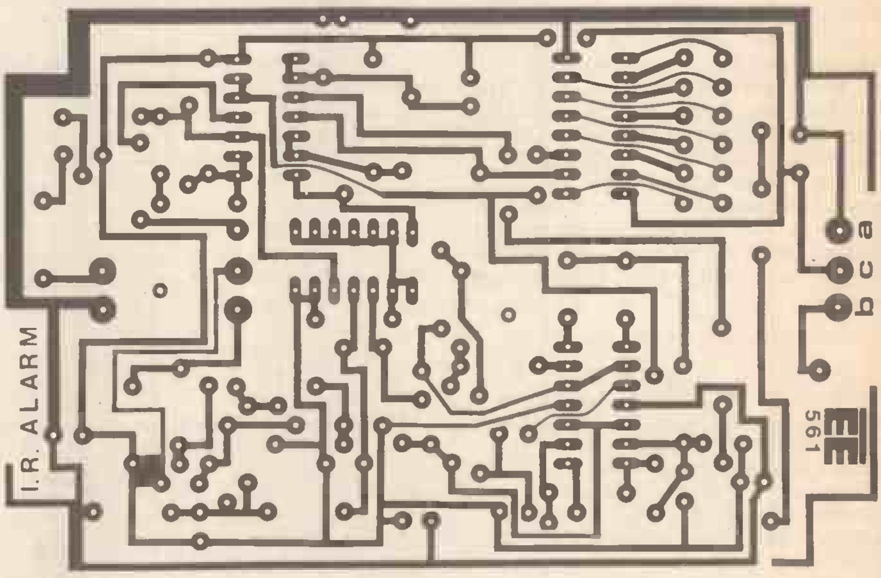


Fig. 5. Full size printed circuit master pattern for the Infra Red Alarm—Detection Head.

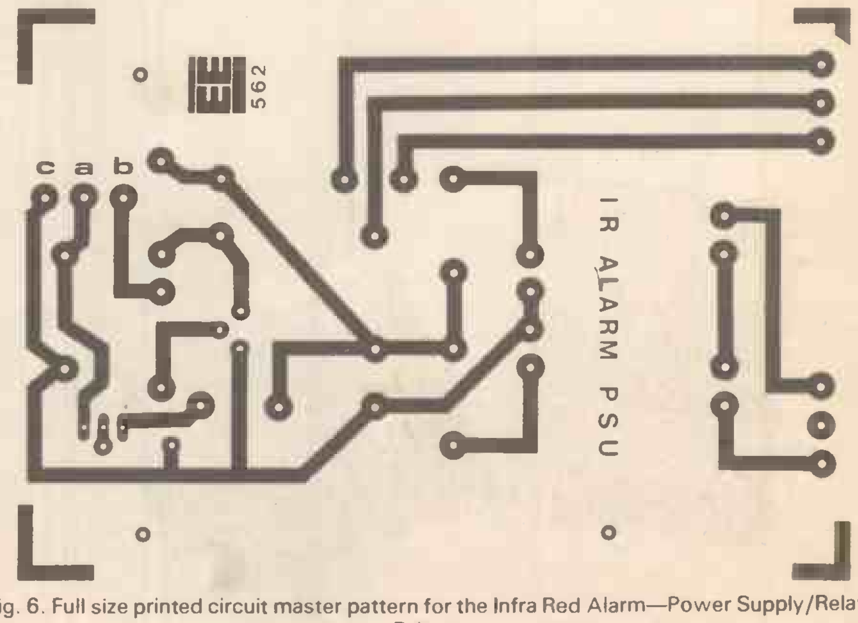


Fig. 6. Full size printed circuit master pattern for the Infra Red Alarm—Power Supply/Relay Driver.

The above boards are available from the EE PCB Service, code EE561/2.

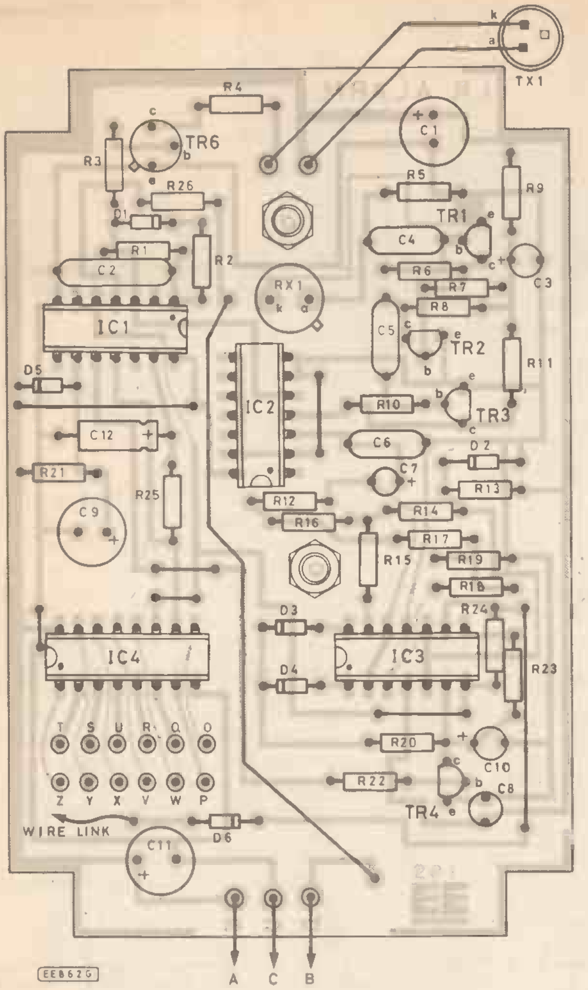


Fig. 7. Printed circuit board component layout for the detector circuit.

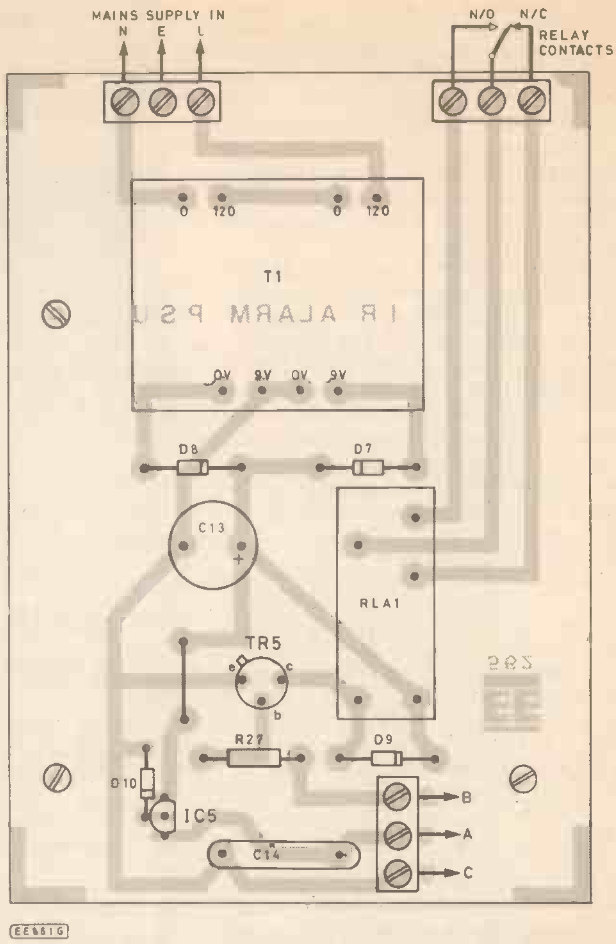


Fig. 8. Printed circuit board component layout for the p.s.u. and relay driver.

CONSTRUCTION

The detector circuit and the power supply are built on separate printed circuit boards. These boards are available from the EE PCB Service: code EE560 and EE561. Full size foil patterns and component layouts for the boards are shown in Figs. 5, 7 and Figs. 6, 8. Except for the infra red emitter TX1 all of the components are board mounted.

Begin construction by referring to Fig. 7 and assembling the detector head. After inspecting the printed circuit board drill out the two fixing holes to 3mm and if necessary cut the corner notches. The board can then be used as a template to drill the holes for the fixing screws in the case.

The prototype board was mounted on the case lid with the corners notched for the case and mounting screws and pillars. Alternative arrangement may be used if desired. It is possible to mount the emitter at some distance from the board by the use of screened cable. With simple lenses, up to 50 metres' separation is possible.

Fit the short wire links, resistors, and the diodes to the board first, followed by i.c. sockets, transistors and capacitors. Check carefully that diode, transistor, and capacitor polarities and types are correctly identified and fitted. The photodiode should be fitted flush with the board and of course the right way round as indicated by the small tab.

The long wire link from terminal B to the hole near resistor R2 should be made using solid core insulated wire. A further link from near capacitor C11 to one of the timer output pins should be made with similar wire and it is recommended that this is set to the *Q* position at first so that testing does not take too long.

Two holes are required in the case, one for the emitter and the other for a window for the detector. In the prototype an 8mm diameter hole was drilled exactly opposite the detector and a thin clear plastic window was glued to the inside. The emitter has a lens and bezel which enables it to be mounted in the panel about 20 millimetres away from the detector window and connected to the board using a twisted pair of multi strand wire. Ensure that the polarity of the emitter is correct; the anode (a) is the short lead.

The power supply board should be assembled next. First inspect the board and drill out the two 3mm mounting holes. As with the detector head use the board as a template to drill the bottom of the power supply case with mounting holes. (See Figs. 6, 8.)

Fit all the components, small ones first, and take care to correctly identify their type and polarity. Most mains transformers are varnish impregnated and their tags are frequently covered with the stuff. It not only smokes and smells when soldering but also makes it difficult to make good connections. A careful scrape of each transformer pin before assembly will eliminate these problems and save time in the long run.

Once the board is complete it should be assembled into a suitable case and fitted with a mains lead via a proper mains cable retaining clamp or bush. The specified case has internal p.c.b. guide slots which can be removed with a sharp wood chisel if they are in the way. Fitting the lids and the interconnecting cable is all that remains of construction and should be completed after testing.

TESTING

The mains power supply unit should be tested first. Fit three wires to the output terminals A, B and C and bring these out of the case through a suitable grommet.

Fit the case lid and connect up the mains supply. If all is well it should be possible to make the relay click in and out by connecting terminals A and B, and there should be a voltage between 9·5V and 10·5V between terminals A and C. If not, switch off, remove the mains plug, inspect the board again and correct any faults.

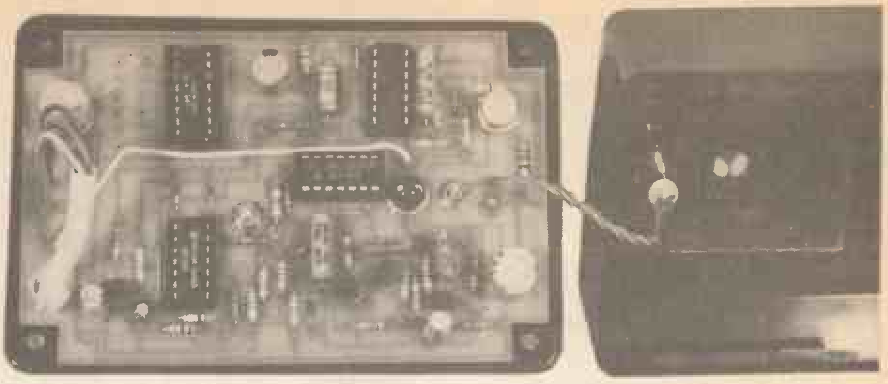
It may be necessary to check voltage whilst the mains is on. If so, keep the board fastened in the box, use a multimeter with well insulated probes and **keep clear of the mains end of the board**. Voltage readings can be taken across the various component leads on top of the board.

Once the power supply is working correctly, switch off, connect the three wires to the detector head, and insert the four i.c.s. Switch on again and check that the relay is not operating and that the supply voltage is still correct.

By moving a hand between or in front of the emitter and sensor it should be possible to operate the relay. Once the relay is operated move away and wait for 10 seconds or so for the relay to release. If this happens—well done—everything is working OK. If not, check and double check.

It is possible to check for correct voltages around IC3 and IC4, IC1b and IC1c and to check that IC1d pin 11 is pulsing up and down about every two seconds by using a simple multimeter on the 10V d.c. range. Check also for 4·7V across Zener diode D2 and approximately 9V across C3. The collector of TR6 should read almost +10V and the collector of TR3 +1·5V to 2V measured with respect to 0V (terminal C).

It is hard to go much further without more sophisticated equipment but bear in mind that 99 per cent of circuit problems are due to connections, soldering, and incorrectly fitted components. Faulty components and correctly wired circuits that don't work are rare so check your work very carefully.



The completed detector board mounted on the case lid.

APPLICATIONS

As mentioned earlier there are endless ways in which this circuit can be used. The infra red emitter can be removed from the detector head case and mounted opposite to form a broken-beam type alarm. Considerable range should be achieved in this way which could be extended even further by the use of cheap plastic lenses carefully positioned.

Various forms of reflector can be used if the standard arrangement is used with the emitter and detector side by side. Reflective tapes, discs and adhesive pads are fairly easy to obtain from motor cycle or car accessory shops.

If the detector head is to be used outside it should be protected from direct sunlight and rain and sealed with a strip of adhesive tape around the join between the case and the lid. As mentioned earlier, more detector heads can be used with a single power supply and relay unit by wiring them in parallel to terminals A, B and C.

The time delay is set by making the appropriate link to IC4. Intermediate times if required can be obtained by altering the values of resistor R25 and capacitor C12. If the unit is to be used as a burglar alarm sensor then a short time delay should be selected.

With the emitter and sensor mounted side by side the circuit works extremely well as a proximity detector just by measuring the increased amount of infra red reflected from the object or person. This mode of operation is extremely effective for porch light operation and as an indoor intruder detector. □

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. . . Timers and Frequency Counters . . .

IN PREVIOUS articles in this series we have considered several aspects of the BBC computer's user port, but one facet that has been ignored so far is the timer/counter capability. In fact, port B of the 6522 device which is used to provide the user port has two 16-bit timer/counters, and these can be used in more than one way. They are primarily intended to count the system clock pulses, and provide interrupts to the microprocessor at regular intervals to act as the basis of a simple timer function.

There is another mode of operation, and one which is perhaps of more use from the point of view of the add-on enthusiast, where the counters are used to count clock pulses and effectively give a divider action so that an output signal at some subdivision of the clock frequency can be provided. The output signal is at normal logic levels, and is proably of more use in logic checking applications than for audio testing, but with little or no additional hardware the BBC computers can act as a useful signal source.

A third mode of operation enables pulses applied to the appropriate pin of the user port to be counted, and this permits the computer to be used in simple frequency counter type applications.

Counting On It

To make full use of some aspects of the counter/timers it is necessary to resort to assembly language routines in order to get the software to function fast enough. However, this is not necessary in the mode where the counters are used to divide the clock signal to provide an output signal, and we will concentrate on this facility initially.

The six main registers associated with the counter/timers are at addresses from &FE64 to &FE69, which is where the counter registers themselves are located. There are three other registers associated with the timer/counters, and the most important of these is the auxiliary control register at &FE6B which is used to set the desired mode of operation.

As the counters can generate interrupts they also interact with the interrupt flag register and the interrupt enable register at addresses &FE6D and &FE6E respectively, but interrupts is not a subject we will pursue further at present. Note though, that the interrupt flag register can be used to detect when a count has been completed, and it is not solely for use with interrupt driven software.

Details of the function of each of the six main counter/timer addresses are given below:-

?&FE64	TIMER 1 COUNTER LOW BYTE
?&FE65	TIMER 1 COUNTER HIGH BYTE
?&FE66	TIMER 1 LATCH LOW BYTE
?&FE67	TIMER 1 LATCH HIGH BYTE
?&FE68	TIMER 2 COUNTER LOW BYTE
?&FE69	TIMER 2 COUNTER HIGH BYTE

The timer/counters are both 16-bit binary down counters, and this gives a problem in that the BBC computer only has a 8-bit data bus. The counters are therefore divided into two 8-bit types for loading and reading purposes, the low byte having bits 0 to 7, and the high byte containing bits 8 to 15. Of course, the range of the counter (in decimal) is 65535 to 0.

Timer/counter 1 is the most simple of the two counters in that it can only be fed from the system clock and not from external pulse signals. Although the BBC computer has a 2MHz clock frequency, this is divided by two to give a 1MHz clock to the input/output devices, including the 6522 VIA that provides the user port.

Timer 1 therefore counts down in microseconds, and can consequently be used for accurate timing as well as simple counting applications. Because Timer 1 is always fed with the clock signal it counts down continuously, and if you try reading either of the counters at addresses &FE64 or &FE65 you should get a different answer each time.

Loading

The counter addresses are used for reading the timer, and they can be used for writing values to the timer, but the latches are often used for writing values to the counter. This may seem like an unnecessary complication, but the idea is to ensure that both halves of the counter are loaded simultaneously. Loading the counters separately would result in one byte having commenced the down count by the time the other one was loaded, which in some applications could compromise accuracy.

A sixteen bit load can be achieved by writing the low byte to the appropriate latch at address &FE66, and then writing the high byte to the appropriate counter at &FE65. The low byte is stored in the latch until the high byte is written to the counter, when both bytes are loaded simultaneously.

From this description the high byte latch might seem to be superfluous, as it is never seems to be needed for loading or for reading purposes. In fact, it is required in the "free running" mode of the counter.

So far we have only considered it as a straightforward down counter where it operates in the "one shot" mode, with a number being loaded into the counter and a flag being set or an interrupt being generated when it reaches zero. In the free running mode the counter is automatically reloaded from the latches after the count has reached zero, and the down count then commences again. In this way the counter can be made to set a flag or generate an interrupt at a regular and preset interval.

Counted Out

A very useful feature of Timer 1 is its ability to provide an output signal on line PB7 of the user port. The original design intention was probably to permit the device to be used as a baud rate generator for a serial interface chip, but as line PB7 is available on the user port this capability opens up a host of possibilities for the hardware add-on enthusiast.

In the one shot mode the output goes low when the counter is loaded (or when ?&FE65 is loaded to be precise), and high again when a count of zero is reached. In other words, it acts rather like a programmable monostable multivibrator having a negative output pulse.

The free running mode is perhaps of greater interest, and in this mode we effectively have the arrangement shown in the block diagram of Fig. 1. The 1MHz clock signal is fed to the input of the counter which operates as a divide by 'N' type, where 'N' is any integer from 1 to 65535 (obviously both a divide by 0 and an output period of 0 are nonsensical and the counter would not be loaded with zero in practice).

The output changes state each time the count reaches zero, and the effect is much the same as if the output of the counter was fed to a divide by two flip/flop circuit. This is a point which has to be borne in mind when selecting the counter value for the required output frequency, as the actual output frequency is half the figure obtained by dividing the 1MHz clock frequency by the division rate through the counter.

A point to keep in mind when using the timers and latches is that the current value in a counter can only be read at one of the counter addresses; reading one of the latches simply returns the last value written to that address.

Setting The Mode

As mentioned previously, the counters are controlled by the auxiliary control register at ?&FE6B, or to be more precise, they are controlled by three bits of this regiser. It is essential to set up this register for the desired function before writing values to the counter/latch registers and attempting to use the counters if the desired result is to be obtained. In this article we are only concerned with Timer 1, and so the only two bits of the auxiliary control register that we need to consider are bits 6 and 7.

Bit 6 is used to select either the one shot or the free running mode, and to select these functions it is set to 0 and 1 respectively. In terms of decimal numbers written to the register this works out as 0 to select the one shot mode or 64 to obtain the free running mode.

Fig. 1. The effective arangement when timer 1 is used to generate a squarewave output on PB7.

Bit 7 is used to enable or disable output on PB7, and it is set to 1 (128 in decimal) in order to enable output on PB7. To try out Timer 1 as a programmable squarewave generator a value of 192 (i.e. bits 6 and 7 both set high) must be written to address &FE6B, or for the monostable mode a value of 128 is needed (i.e. bit 6 set low and bit 7 set high).

This simple program is useful as an initial test of Timer 1, and it simply sets it up as a squarewave generator and then lets you try out various counter values.

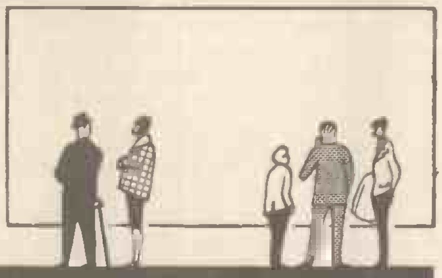
```
10 REM TIMER 1 TEST PROG
20 ?&FE6B = 192
30 INPUT "LOW BYTE" L
40 ?&FE66 = L
50 INPUT "HIGH BYTE" H
60 ?&FE65 = H
70 GOTO 30
```

The values must be between 0 and 255, and the low byte provides fine adjustment while the high byte gives coarse frequency control. The larger the number the greater the division rate, and the lower the frequency. With any frequency synthesiser of this type, quite precise control is possible at the low frequency end of the range, while the output frequency changes in large steps towards the high frequency end of range. The overall division rate varies from 2 to 131070 in increments of 2, which with a 1MHz clock represents a frequency range of 500kHz to about 7·6Hz.

The high byte is written to the counter at ?&FE65 rather than to the latch at ?&FE67 as this seems to be necessary in order to initiate the counting and output action. Thereafter the values can be written to either the counter registers or the latches, as values sent to the counters seem to be fed to the latches as well. For write operations ?&FE67 would appear to be unnecessary, but if you wish to read the value in the high byte latch this can only be read from this address as ?&FE65 will return the current value in the counter.

Next month: We continue looking at the operation and applications of the timers, including a detailed description of Timer 2.

SHOP TALK



BY DAVID BARRINGTON

For our southern readers, it is encouraging news to see a new components shop in Hove, Sussex, offering a comprehensive range of electronic components at competitive prices. Although it is early days, this promising young business looks set fair to provide a useful source of components either direct sale to customers at the shop or through their new "mail order" service.

SCS Components is open six full days a week and they claim that they are able to offer kits for most of the projects published in EE. They are also stockists of Velleman kits.

For those readers looking for someone to undertake the task of troubleshooting their "shell shocked" home micro, SCS run a busy computer repair workshop. For more information contact SCS Components by phone on 0273 770191.

East of Watford

With the increasing upward spiral of the Japanese Yen against the pound and other world currencies, the "economical experts" have been predicting heavy price increases in all electrical and electronic goods throughout 1987. It is claimed that particular sectors that will feel the "crunch" are likely to be the audio/video field and the computer peripheral market.

However, some good news for BBC Micro owners, thanks to a £1M plus shopping spree in the Far East by Watford Electronics MD, Nazir Jessa, customers wanting disc drives and other peripherals for the Beeb micro should find prices fairly stable for the early part of the year.

Realising the likely unsettling impact on trade that a continuing pricing adjustment would have on customers, Jessa headed for Japan. There he was able to negotiate a deal which will ensure that there will be no significant price rise in the months ahead.

Commenting on the trip Nazir said, *"I was in a position to order in sufficient quantity to ensure a good price. But more important, I was able to persuade them to fix the price in Sterling."*

Another outcome of the trip was the signing of an agreement to the exclusive rights to a number of peripherals which will carry the company's name. The first product is to be a dot matrix printer.

Power Plug

Ideal for housing battery eliminator components, West Hyde Developments have introduced a plastic enclosure incorporating a three-pin 13A plug which meets BS1363 safety requirements.

The live and neutral pins are part sleeved to prevent accidental contact should the "case" be partially withdrawn from the socket. A separate internal moulding forms a mounting plate for transformers and other components. For nearest stockist contact: West Hyde Developments, 9–10 Park Street Industrial Estate, Aylesbury, Bucks, HP20 1ET.

CONSTRUCTIONAL PROJECTS

EE Apex Hi Fi Amplifier

If readers are to obain the very high performance expected from the *EE Apex Hi Fi Amplifier* then we strongly advise constructors to adhere to the components specified.

A complete kit of parts, including printed circuit boards, for the "standard" or "enhanced" version may be purchased from **Audiokits Precision Components.** Also, separate individual circuit stage kits, to enable the constructor to spread the costs over several months, are available.

For a complete listing and prices write to: **Audiokits Precision Components, Dept EE, 6 Mill Close, Borrowash, Derby DE7 3GU.**

Computer Buffer/Interface

The 20-way IDC cable and socket used in the *Computer Buffer/Interface* are fairly common items now and should be stocked by most good component suppliers.

The series buffer/driver i.c.s. are currently held by Omega, Omni, Cirkit, SCS Components and TK Electronics.

Exploring Electronics

The TIL78 phototransistor specified in the *Exploring Electronics* projects this month could prove troublesome to locate. This device is currently stocked by Omega, Cricklewood and Magenta Electronics.

All other components for the two projects are readily available "off-the-shelf" items.

Infra Red Alarm

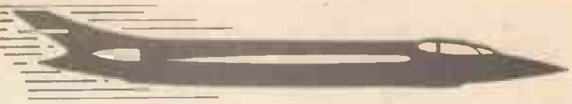
Most of the parts required for the *Infra Red Alarm* appear to be standard components and should be available from most of our advertisers. However, the infra red emitter and sensor may prove difficult to locate. The high efficiency infra red l.e.d., type CQW13R, and the sensor photodiode, type MIR1OL, used in the prototype model were purchased from Magenta Electronics.

The relay used is from the Omron p.c.b. range and the coil is rated at 12V d.c., with 10A 250V a.c. contacts. This relay was also purchased from the above firm although other types may be used provided they have similar characteristics. The printed circuit boards are obtainable through the *EE PCB Service*—see page 172.

A complete kit (£33.95), including a set of printed circuit boards, is available from **Magenta Electronics, Dept EE, 135 Hunter Street, Burton-on-Trent, Staffs DE14 2ST**. Add £1 for p&p per order.

Looking through the components list for the *Digital I.C. Tester*—this month's *Digital Troubleshooting* project—we cannot foresee any component buying problems.

AVIONICS FUTURES



IAN GRAHAM

Fly-by-wire planes with propellers are the transport of the future

It is not an exaggeration to say that electronics is revolutionising aviation. Of course, most of the leading edge research is devoted to military aircraft, but civil aircraft, too, are experiencing rapid advancements.

As you board your aircraft in ten years time, will it be a sleek supersonic dart? Probably not. It's more likely to be a subsonic aircraft with propellers (yes, propellers!) and a remarkable new control system. Within ten years, aircraft will begin to lose the familiar control column that has been a feature of the flight deck since the first planes took to the air at the beginning of the century. The control column, or "joystick", is designed and built the way it is, because the pilot needs the extra leverage of the column height to help him physically pull the plane's control surfaces (rudder, tail-plane, etc.) into position. The column is linked to the control surfaces by a network of cables, pulleys and other mechanical and hydraulic linkages. But that arrangement will certainly change dramatically as a result of implementing a system called "fly-by-wire" that has already been used by military plane-makers for the past decade.

FLY-BY-WIRE

To survive in the air, modern fighters have to be very nimble indeed. Very stable aircraft, aircraft that will return to straight, level flight if the pilot takes his hands off the controls, tend to be very sluggish to manoeuvre, because they're always trying to return to their stable attitude. Aircraft designed for aerobatic displays achieve increased manoeuvrability by having a degree of in-built instability. The less stable they are, the more quickly and easily they respond to the controls, because they're not continually trying to return to stable flight.

Fighter aircraft use this reduction of stability for increased agility. But there comes a point where the plane can be made so unstable that a human pilot cannot possibly fly it. But a computer *can*. A computer can monitor the plane's attitude perhaps 50 times a second and apply tiny adjustments to maintain good trim. The computer sits between the pilot and his plane. The pilot moves the controls, but all he is doing is signalling the computer what he wants the plane to do. It is the *computer* that decides how best to do what the pilot wants. Planes like British Aerospace's EAP (Experimental Aircraft Programme) and the French Dassault-Breguet Rafale, forerunners of the next generation of European fighters, could not fly without this "*fly-by-wire*" technology.

SAFETY

Compared to modern fighter aircraft, civil airliners are aerodynamically very stable indeed. Some designers plan to incorporate fly-by-wire into the next generation of civil airliners for a different reason. At the last Farnborough Air Show, Airbus Industrie demonstrated an A300 Airbus with a difference. In a very impressive demonstration of the capabilities of fly-by-wire, the pilot flew the A300 along the runway very low, very slow and with its nose pitched up. It was dangerously close to the point where it would stall and fall out of the sky. An aircraft of that size would normally need several hundred feet of space underneath it to recover from a stall. If this aircraft had stalled, it would certainly have had a close (and expensive) encounter with the runway. But whether the pilot had inadvertently allowed his plane to reach the beginning of a stall or deliberately decided to fly it into the ground, the plane would not have done so!

A300 Airbus fly-by-wire demonstrator shown during its flying display at Farnborough.

This plane was equipped with fly-by-wire. Its computer could sense conditions like an imminent stall, ground proximity or wind shear (potentially lethal wind conditions near the ground that can cut the lift from an aircraft as it comes in to land). If the computer system detected a dangerous situation, it could take over control of the aircraft and fly it out to safety.

As if to drive this point home, the pilot flew the plane slowly along the runway and then pulled the stick back. Any normal aircraft would have stalled, but the computer system automatically brought up the engine power and modified the nose-up attitude so that the plane could climb away from the ground *safely*. Fly-by-wire promises to make a positive contribution to air safety.

FAILURE

Of course, its advantages are all lost if the system fails or if all channels of the system suffer from an identical fault. The designers have naturally given all the systems back-ups. For example, there are at least four power generation systems, driven from a number of different power plants. If one fails, another trips in automatically.

Primary systems and their back-ups are not only run by different computer programs, but the hardware in the primary systems and their back-ups is also different. Different companies supply different computers, using different microprocessors to guarantee that the same fault cannot possibly exist in more than one channel of the system. Cables are run along different routes, so that minor physical damage to the aircraft should not knock out any more than one channel.

But what if all the electronics *do* fail? Just as computers occasionally issue gas bills for millions of pounds or signal the Pentagon that the Third World War is imminent, aircraft systems aren't perfect and never will be. If the Airbus loses all electrical power from its control system, an emergency mechanical system can be engaged, giving the crew just enough control to fly the plane.

As the crew is normally only sending electrical signals to a computer system, the control column can be dispensed with altogether and be replaced by a tiny hand controller resembling a computer games joystick.

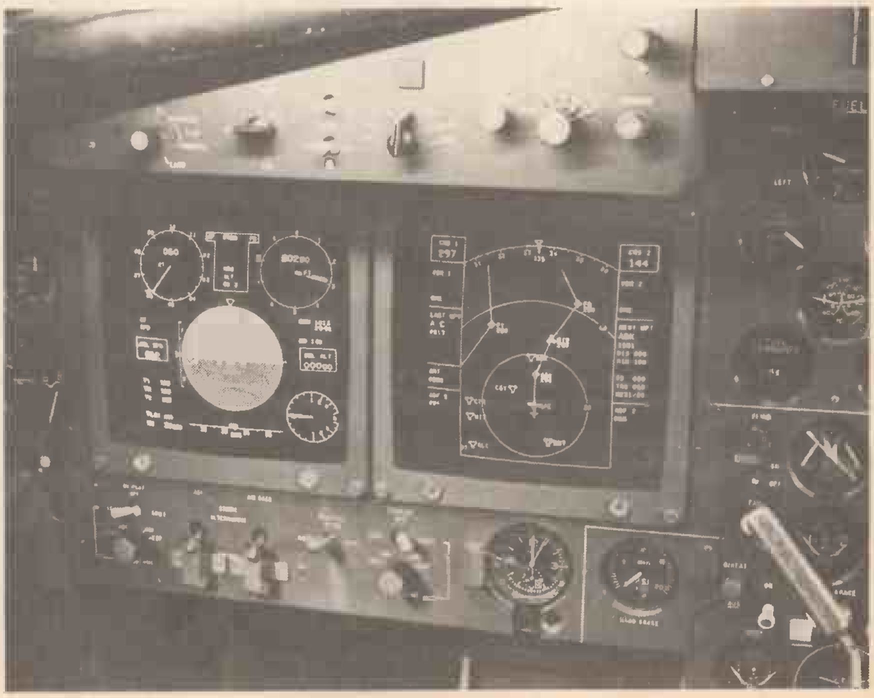
Of course, the move away from "needle and dial" instruments to multi-purpose cathode ray tubes (television screens) linked to computerised flight management systems has already begun and the Airbus was also "instrumental" (awful pun) in implementing *this* leap in technology. The trend now, with the computerisation of more and more systems on the aircraft, is to gradually integrate these individual systems into one super-system.

British Aerospace EAP technology demonstrator aircraft.

FUEL-EFFICIENT

As aircraft become increasingly computerised "space-age" machines, why should propellers be making a come-back? They're old hat, aren't they? They disappeared from large passenger aircraft in the 1960s when suitable jet engines were developed. Twenty years ago, fuel was a fraction of today's prices and so it made sense to move away from noisy propellers to quieter (inside the passenger cabin) and faster jet power. Now, though, fuel economy is a critical factor in airline economics and designers are looking again at the more fuel-efficient propeller. The new high speed designs have curious curling swept-back blades. The first experimental "prop-fan" engines (also called UnDucted Fans or UDF) have been run up to speed on test beds and in flying trials and appear to be capable of the same order of power outputs as current jet engines.

New materials and improved control of the propeller blades by a technique called synchrophasing all help to reduce the propeller's noise problem. Inside the cabin, wall panels may be vibrated like flat loudspeakers out of phase with the engine vibrations in order to "cancel" them out and dra-



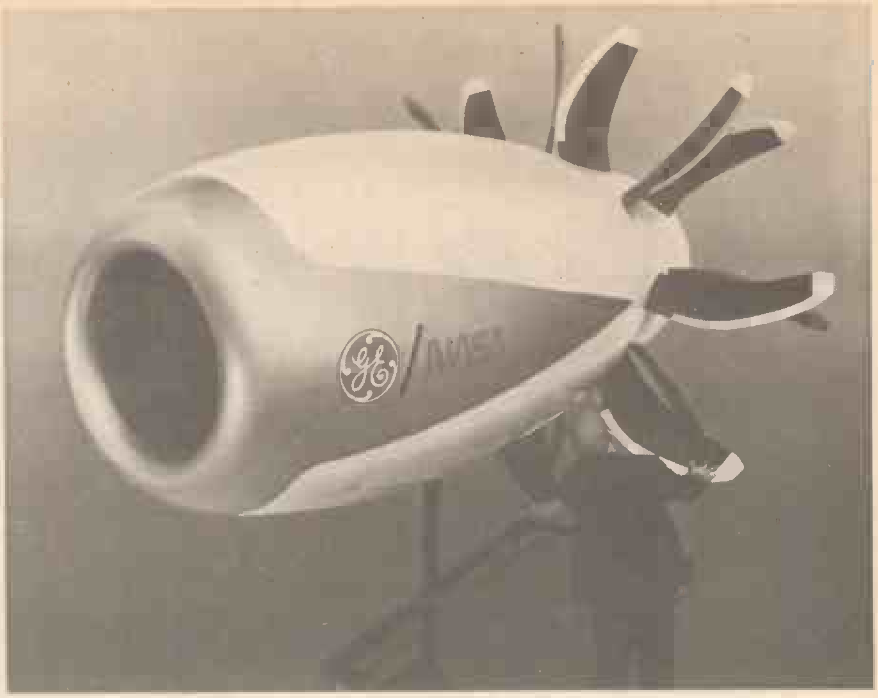
Computer-generated images on cathode ray tubes provide air crew with a much more flexible way of monitoring the condition of their aircraft.

matically reduce the noise and vibration levels experienced by passengers. The technique is also known as active anti-sound.

1990s

Boeing has already enlisted the support of several Japanese aerospace companies to build a new aircraft, code-named the 7J7, which will be powered by prop-fans. The 7J7 is expected to fly in 1991 and to enter service in the world's airways in 1992. McDonnel-Douglas has also unveilled plans to build a prop-fan-powered aircraft. Code-name the MD-91X. All the major engine and aircraft manufacturers are involved in the development of prop-fan engines and the aircraft that will carry them, so propellers are certain to reappear in the 1990s.

So, the plane that whisks you off for your holidays in the 1990s will probably have exotic curling, swept-back propellers, have a "Buck Rogers" flight deck bristling with computer screens and hand controllers, be eerily quiet inside the cabin as the engine noise is "cancelled out" and it will actually be flown by a computer system "managed" and supervised by the aircrews. □



This engine, developed in America by General Electric and NASA, or something very like it, will become much more familiar to air travellers in the 1990s. The Prop-fan or UnDucted Fan (UDF), as it is known, promises greater fuel efficiency than today's jet engines. Photo: General Electric.

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- 2 operating modes full alarm anti tamper and panic facility
- Screw connections for ease of installation
- Separate relay contacts for external loads
- Test loop facility

500W Quartz Halogen Floodlight FL 500
only £14.95 + VAT
Whilst intended for security lighting applications, this unit is suitable for lighting patios, pathways and gardens etc. Supplied complete with 500W lamp, priced only £14.95 + VAT. Protective grill, £1.95 + VAT

Lighting Controller DP 3570
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This versatile module provides timed switching of loads up to 3A for pre-set times between 10 secs and 5 mins, the timed period being triggered by the opening or closing of an external loop or switch. The built in 12V 250mA power supply is available for operating external sensors. Priced only £13.95 + VAT. Suitable plastic enclosure £2.85 + VAT.

HW 1250 – Enclosure & fixings for CA 1250
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This attractive case is designed to house the control unit CA 1250, together with the appropriate LED indicators and key switch. Supplied with the necessary mounting pillars and punched front panel, the unit is given a professional appearance by an adhesive silk screened label. Size 200 × 180 × 700mm.

Infra-red System IR 1470
only £25.61 + VAT
Consisting of separate transmitter and receiver both of which are housed in attractive moulded cases the system provides an invisible modulated beam over distances of up to 50ft operating a relay when the beam is broken. Intended for use in security systems, but also ideal for photographic and measurement applications. Size 80 × 50 × 35mm

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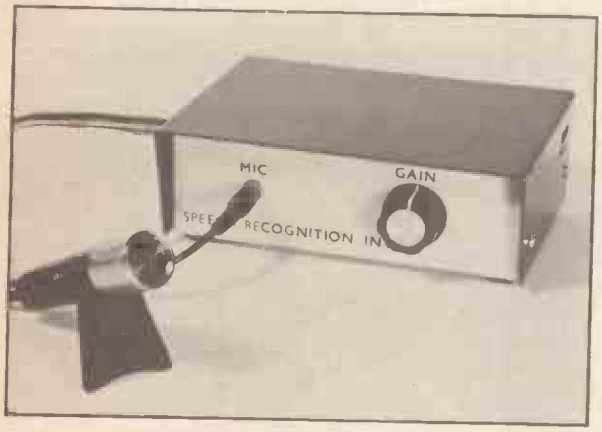
APRIL FEATURES...

FREE 16 PAGE BOOKLET

If p.c.b.s are just a jumbled mass of connections to you, if you have no idea of component layout, producing artwork or etching the board then cry no more, our booklet will solve your problems! There is also a siren effects unit to build—police cars, star wars, machine guns etc.

Guide to...
PRINTED CIRCUIT BOARDS
Design · Layout · Construction



Experimental Speech Recognition Unit

While speech recognition is a complicated process, it is possible for your computer to recognise your speech—or, at least, some words—with the aid of a little electronics. Our experimental unit will provide insight into the recognition processes and hours of enjoyment.

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Do you have ornamental light fittings with lots of small bulbs, expensive silvered bulbs or maybe you use a projector or spot lights? If you do, no doubt you curse each time a bulb blows. Curse no more, build our bulb life extender, sit back and see the light!

CURRENT TRACER

A simple project that can prove invaluable for testing equipment. If you build projects then this little tester will help sort out the ones that don't work first time. It's next month's *Digital Trouble Shooting* project.

EVERYDAY ELECTRONICS

OUR APRIL ISSUE IS ON SALE FRIDAY, MAR 20

exploring electronics

OWEN BISHOP

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

Part 9 Light-triggered circuits

THE FIRST circuit described this month is a Slave Flash Unit. This fires a photographic flash-bulb when it senses the flash from the bulb on the camera.

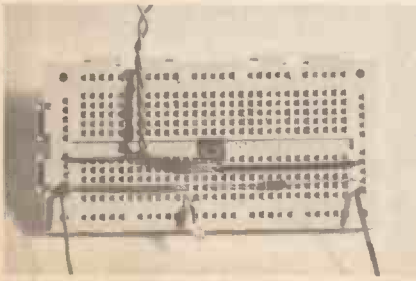
If you use this unit for indoor photography, you can fire one or more extra flash-bulbs and so arrange for lighting effects that are much more interesting than the rather flat lighting obtained from a single bulb mounted on the camera. A similar circuit is described for robot or model railway control and like purposes.

SLAVE FLASH UNIT

The circuit diagram for a simple Slave Flash Unit is shown in Fig. 9.1. The circuit shows the flash-bulb as a filament lamp, LP1, for this is what it is. The filament is a thin one which burns away immediately a current is passed through the lamp. In doing this it ignites the foil in the lamp and the brilliant flash is emitted.

The flash-bulb is fired by turning on TR2 which is a power transistor capable of carrying the large current required. The other transistor in the circuit, TR1, is a phototransistor.

This type of phototransistor has no wire to its base. Instead of supplying it with a base current, we shine a light on it and this causes additional electrons to be set free from the atoms of the base material. These additional electrons have the same effect as a base current.



Shining light on the phototransistor turns it on. When it is turned on, current passes through resistor R1. The effect of this is that a p.d. is generated across R1 and the voltage at point A rises. A base current then flows to TR2 turning it on and setting off the flash-bulb.

The reasons for using a phototransistor in this circuit instead of using an LDR (light dependant resistor) is that the phototransistor responds to changes in light levels much more quickly than an LDR does. This feature is essential for a slave flash unit.

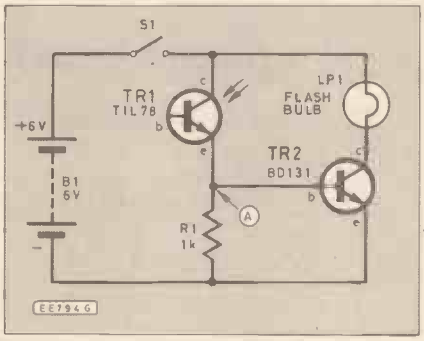


Fig. 9.1. Circuit diagram for the simple Slave Flash Unit.

Fig. 9.2 (right). Breadboard demonstration layout for the Slave Flash.

From the moment the shutter release of the camera is pressed the following sequence occurs: the mechanisms in the camera open the shutter; then they fire the camera flash; TR1 senses the light from the flash; TR1 is turned on, TR2 is turned on; the Slave Flash is fired.

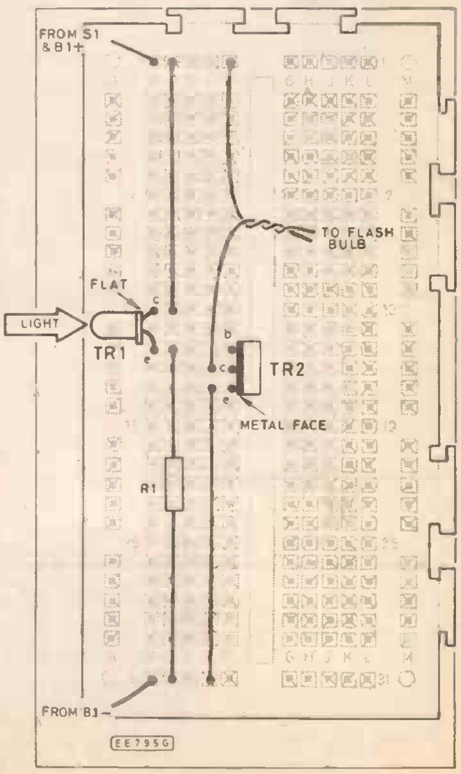
All this must happen in less that 1/30 second if the Slave Flash is to be completely burned out before the shutter of the camera closes. Thus the rapid action of the phototransistor is essential to reliable exposure.

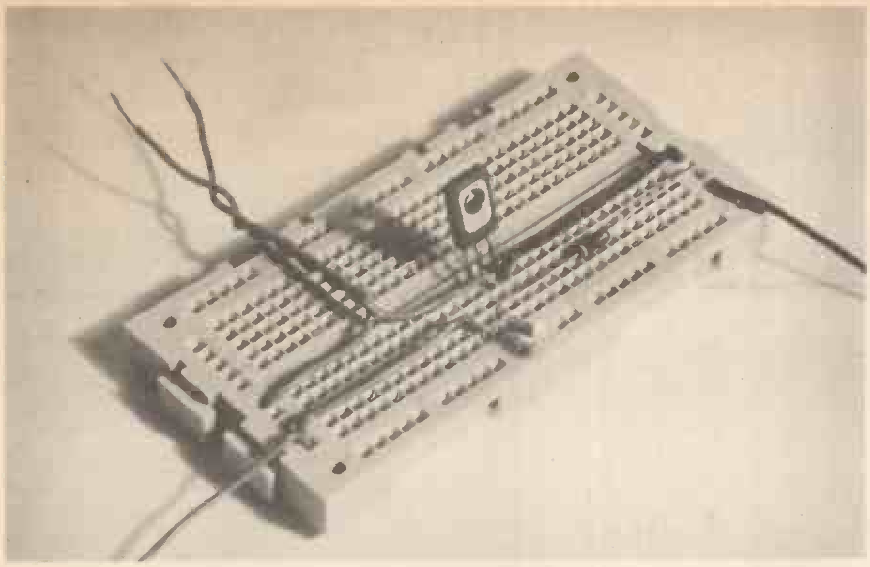
CONSTRUCTION

The demonstration breadboard layout for the Slave Flash Unit is shown in Fig.9.2. Wiring up the circuit presents little trouble, but care must be taken not to fire the flash unintentionally.

The circuit may be tested by first wiring an ordinary 6V 0·6A lamp in a lampholder in place of the flash bulb, LP1. Expose the phototransistor to bright light, for example a 100W lamp a metre away, and the low voltage lamp should light.

Note that this unit can be fired by bright room lighting. Avoid directing bright lamps at the phototransistor when you are setting up the circuit ready for taking a photograph. Keep the switch S1 turned off until you are ready to take the photograph. To avoid the risk of accidentally burning your fingers, make sure that the switch is off at all times when you are connecting a flash-bulb into the circuit.





COMPONENTS

SLAVE FLASH

Resistor
R1 1k carbon, 0·25W 5% carbon

Semiconductors
TR1 TIL78 phototransistor
TR2 BD131 medium power *npn* transistor

Miscellaneous
S1 on/off switch; flashbulbs; breadboard; connecting wire and 6V battery.

MODEL RAILWAY CONTROLLER

Resistors
R1,R3 1k
R2 1k5
All 0·25W, 5% carbon

See Shop Talk page 135

Semiconductors
TR1 TIL78 phototransistor
TR2 ZTX300 *npn* transistor
TR3 BD131 *npn* medium power transistor
D1 1N4148 silicon diode

Miscellaneous
B1 6V battery box with cells, or 6–12V d.c. power supply unit
LP1 6V 60mA lamp (optional)
RLA1 6V relay with single make or break contact
Connecting wire; on/off switch; breadboard.

Approx. cost Guidance only £5 each

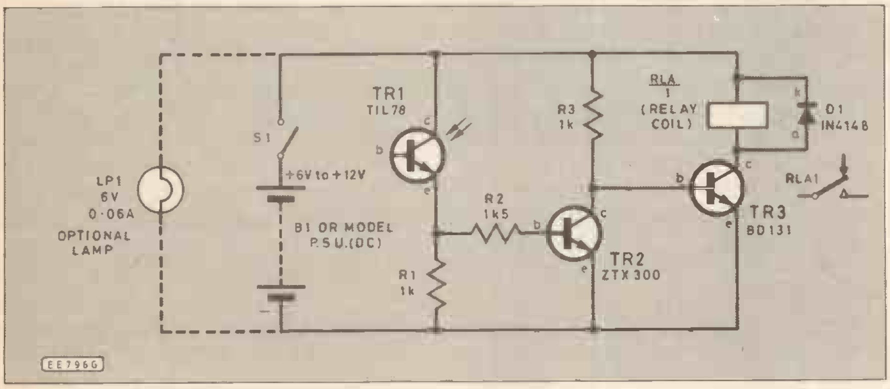


Fig. 9.3. Circuit diagram for a basic Model Railway Controller.

The circuit should be set up so that the flash-bulb lights the appropriate part of the scene. If possible, the phototransistor should be placed so it can receive light direct from the camera flash, though this is not essential.

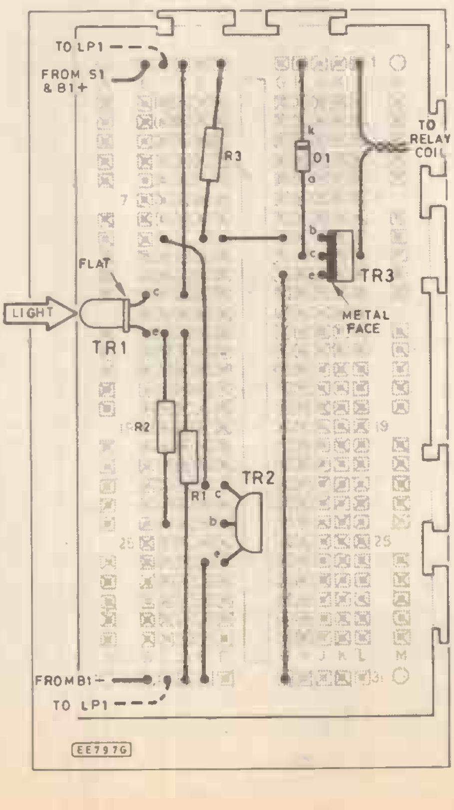
The unit will operate on receiving flash-light reflected from light-coloured walls, or the ceiling. If you have several such units, it is possible to trigger them all from a single camera-flash and to take pictures of scenes and large interiors that would be quite impossible with a single flash-bulb.

An alternative is to connect a relay coil in place of the flash bulb. The contacts of the coil are connected across the "shoe" contacts of an electronic flash-gun. When the circuit is triggered the relay contacts close and fire the flash-gun.

MODEL RAILWAY CONTROLLER

The circuit diagram for a Model Railway Controller is shown in Fig. 9.3. This circuit uses a phototransistor to sense the approach of a model train and to set the points to allow it to pass. It can also be adapted to switch on a lamp or a low voltage motor whenever a light beam is broken. It could have a similar application in robot control.

Fig. 9.4 (below). Demonstration component layout for Fig. 9.3.



HOW IT WORKS

For a description of the action of a phototransistor, see the Slave Flash section. When a train breaks the light beam, as it approaches the junction along line *P* (Fig. 9.5), TR1 is turned off. The voltage at its emitter falls to zero, turning TR2 off. The voltage at the emitter of TR2 therefore goes high providing base current to TR3, turning it on.

Transistor TR3 is a power transistor with the magnetic coil of the railway points in its collector circuit. The coil is energised, pulling the points across so as to allow the train to proceed to *Q*.

The diode, D1, is an important part of this circuit. As the circuit goes back to its original state and TR3 is turned off, the magnetic field in the coil is suddenly removed. The effect of this is to generate a high voltage in the coil —perhaps a hundred or more volts. This is in the reverse direction to the voltage of the circuit, and could destroy the transistor. The current produced by this voltage is safely conducted by D1, so protecting the transistor.

CONSTRUCTION

The demonstration breadboard layout for a simple Model Railway Controller circuit is shown in Fig. 9.4. Make sure that the diode D1 is connected the correct way round, or it will not protect the circuit. Note that this circuit can be run from the model railway power supply, provided this operates between 6V and 12V d.c.

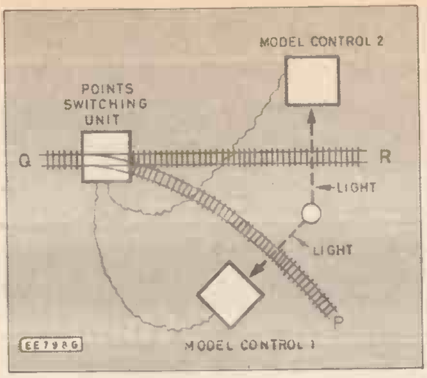


Fig. 9.5. Using two control units for automatic points switching.

In the diagram, Fig. 9.5, a small lamp is shown producing a beam across the track. This is not essential—a room light or window in a suitable position can be used instead. Fig. 9.5 also shows a detector on track *R*. This can be made to change the points over in the opposite direction, so that a train approaching along track *R* can pass over the junction.

A train approaching from *Q* will be routed along track *P* or *R*, depending upon which one was used last. With several sensors and sets of points it is possible to devise more elaborate systems of automatic points switching. □

Next Month: Timer circuits, including a simple Metronome project based on the 555 Timer i.c.

EE

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Readers—you can obtain a 5% discount on goods from the advertisers listed using coupons cut from EE, provided you follow the rules below:

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Robot Roundup

NIGEL CLARK

STRATEGY

People's expectations about the abilities of robots have caused a recent entrant into the market to rethink its strategy. Spectravideo launched a low-cost arm in the autumn intending to sell it through retail outlets. However, despite advertising the arm's capabilities no retailers have come forward willing to sell it.

A spokesman for the company said the arm was thought to be too cheap for the serious market and was perceived as a toy. But it was too expensive for the toy market.

It is a common problem among the lower-cost machines. People do not believe that any robot which has a low price can do anything useful whereas, at the same time, they think that because many items of new technology have come down sharply in price during the last few years that high technology toys should be cheaper and capable of more complex activities.

It always will be a problem until people can be educated in the real responsibilities and limitations of robots, or until the technology makes some advances to reduce the limitations.

The main problem is in the area of artificial intelligence. There are plenty of sensors which can tell a machine about its environment and plenty of actions they can take in response. The difficulty occurs when requiring the machine to react reasonably quickly so that it can do something simple such as make its way across a room without having previous knowledge of the room's geography.

Spectravideo will not, however, be removing the arm from the market. It has found that it can sell it to schools and will be concentrating on education. Interfaces exist for the MSX and Commodore ranges and others are being developed.

The articulated arm is a 4-axis model with three clip-on end effectors, a forceps gripper, shovel and magnet. It is intended as a computer peripheral but can stand alone being powered by four batteries. It can be controlled by two joysticks.

The arm is made of plastic and powered by d.c. motors without feedback and, claim the makers, it is strong enough to lift something like the weight of a coffee cup. The price, excluding the joysticks, is in the region of £50.

POLAR

Feedback Instruments has developed a new high-level language for its IVAX Scara arm, called IVAX-Polar. The makers say that the language features the general purpose capabilities of Basic combined with commands for robot movements and input/output. There are also specialised robot move files and a built-in post-processor for downloading commands for stand alone operation.

The language has been created to work with the Apple II series and is said to be a fully-integrated version of Applesoft. Programs can accept input from and give output to I/O devices for the Apple II series.

As with other robot control languages it allows the usual creation, storage and editing of move sequences. The sequences can be inputted from the keyboard by specifying points within the IVAX's working envelope or from the teach pendant with which it is supplied. The language is supplied on floppy disc and comes with two demonstration programs to illustrate its use.

IVAX

The IVAX has four axes plus a gripper, with three rotational axes, shoulder, elbow and wrist, moving up and down a central pillar. Each rotational axis moves through 270 degrees with the vertical axis having a range of 40mm.

Power is provided by d.c. servos with feedback by optical encoders. It comes with its own work cell, including a parts distributor and conveyors. The arm communicates with other parts of the cell through its 16 inputs and 16 outputs.

The price of about £3,000 puts it in the higher education bracket and the makers say that it is capable of light industrial use.

Feedback also makes the PW800 robotic system for an up market price of about £7,000. Originally named the Pedro when early prototypes were seen at the last Automan in 1985, the full system has only recently become available. The name was changed in the process because of the possibility of causing offence in North America.

The system contains a Scara arm and a workcell.

The arm has two rotational axes, a wrist, vertical movement on a pillar and a gripper. All the axes are driven by d.c. motors with feedback except for the wrist which has a stepper. It has a load capacity of 2kg and a claimed repeatability of about 0·25mm.

It comes with a control unit and information can be entered via a teach pendant or microcomputer. Software is available for IBM PC and Apricots. Move sequences can be developed off-line or by leadthrough using the pendant.

The gripper has interchangeable jaws. The workcell contains all the usual pieces such as conveyors, hoppers, workpieces and an integrated circuit handling kit. Feedback says that it can perform realistic tasks such as the insertion of i.c.s into a standard p.c.b.

The documentation contains a robotics tutorial text, a manual of hardware and software exercises and a maintenance manual.

The modestly priced "Quick-Shot" robot arm from Spectravideo

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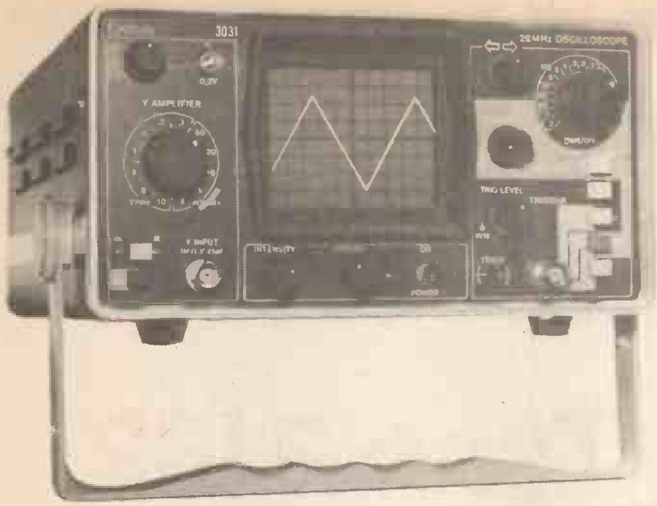

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- ★ 10 × 8 division display
- ★ Component tester
- ★ Probe test output
- ★ Measures 125H × 240W × 317D (mm), weight 6kg (approx)

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Single Trace 20MHz
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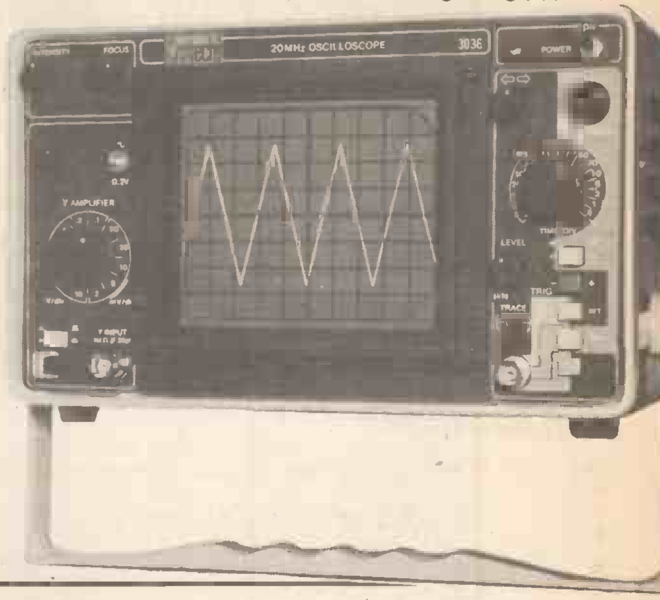
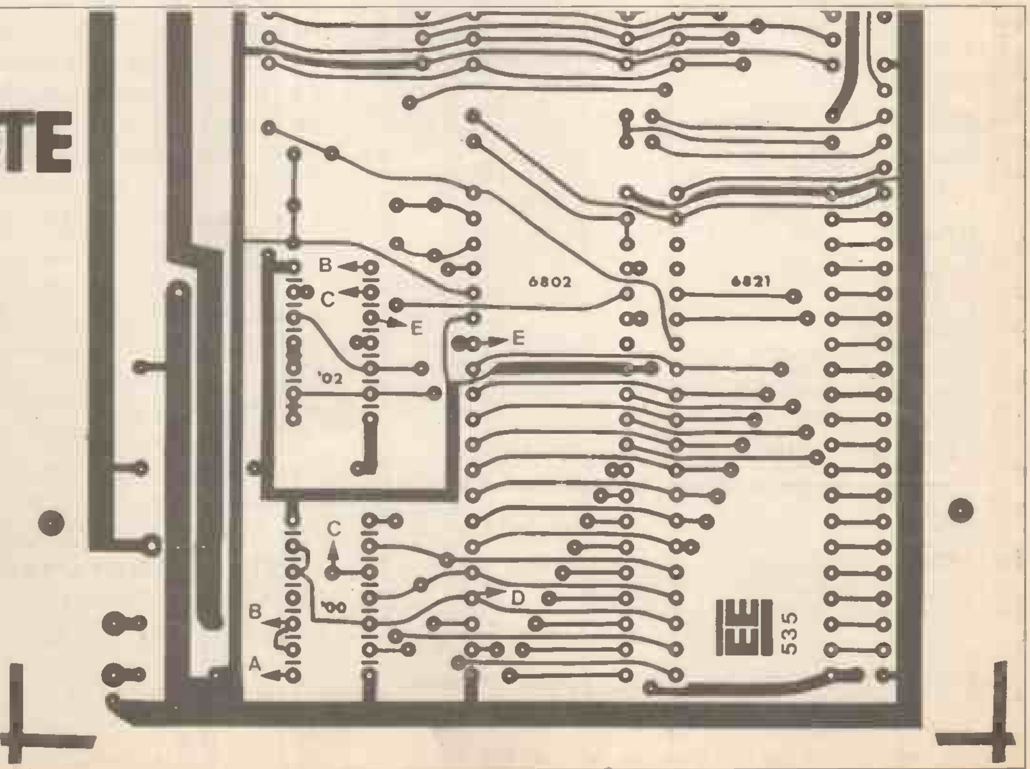


- ★ 2mV/division to 10V/division (12 steps) calibrated sensitivity (±3%)
- ★ DC–20MHz bandwidth (–3dB). Rise time 18ns
- ★ X–Y operation
- ★ 130mm cathode ray tube
- ★ 40ns/division to 0·2s/division (18 steps) timebase (±5%)
- ★ Manual/automatic triggering
- ★ Triggering to 25MHz
- ★ 10 × 8 division display
- ★ Component tester
- ★ Calibrator output
- ★ Measures 160H × 265W × 317D (mm); weight 6kg (approx)

PLEASE TAKE NOTE

PRINTER BUFFER *(Feb 1987)*
Unfortunately we cut too much out of the *Simple Printer Buffer* modified p.c.b. shown in the February '87 issue. The lower half of the p.c.b. is shown again here.

MINI ACTIVE SPEAKER *(Dec 1986)*
The Electromail p.c.b. order code for the *Mini Active Speaker* amplifier boards should be 434-576 and the Electromail data should be used when constructing these boards. The Veroboard was shown incorrectly—components C4, C5 and R6 should go to strip L and not K and R5 and C1 should go to strip K and not L. We apologise for the problems with this design.



EE APEX HI FI AMPLIFIER PART 1

GRAHAM NULTY

Based on the very latest research this amplifier is capable of the very best sound quality. The component quality of the standard kit is higher than most manufactured units costing up to three times as much.

IF YOU really enjoy your music, this is the amplifier for you. It has been designed with just one end in view—to enable you to build for yourself a really good hi fi amplifier at a fraction of the cost of buying it. The design is based on the very latest research into circuits and components, but the explanations given will be simple and easy to understand.

One of the problems of building electronic equipment is in obtaining decent cases to house it. Plain aluminium boxes maybe fine for test instruments in your workshop, but your hi fi system is usually prominently displayed in your lounge. Even if you are skilled at metalwork and artwork, it is difficult (or very expensive) to finish your amplifier case so that it does not look "homemade" alongside your cassette deck and C.D. player. For this reason the Apex kit is available with a couple of specially designed cases that you will be proud to display in your home.

There must be many people who would like to build their own amplifier, but who are discouraged by the lack of professionally finished cases to house it. The cases for the Apex have been professionally manufactured and finished to a standard higher than would be used for manufactured amplifiers.

SOUND QUALITY

The really important feature of an amplifier is sound quality. If you are building your own amplifier you want to be reassured that its sound quality is as good as the units you can afford to buy. When you buy a ready built amplifier you can listen to the sound of different amplifiers in a system in a shop (most good hi fi specialists will also let you try an amplifier in your home) in order to make your choice. If you are building your own amplifier, you cannot usually hear a sample before you start to build it, but you can always change the sound by changing different components and you can almost invariably improve the sound by changing to better (usually more expensive) components.

You cannot predict how an amplifier will sound without actually hearing it, but you can make valued judgements from observation of features. Many amplifiers have detailed published specifications of their performance. Whilst the rated power output figures give you some guide as to how loud the amplifier will go, published measurements of steady state distortion are useless. If one amplifier has lower distortion figures this is no guide that it will sound better. In fact it is quite possible that the second amplifier with higher measured "distortion" figures sounds better because its designer has improved the sound by listening in such a way that measured distortion has risen.

But you can make reasonable predictions on the sound quality of an amplifier from other features. The size of the power supply, the quality of passive components, switches and connectors all affect the sound quality of an amplifier in a greater way than most people would imagine. Many hi fi enthusiasts are learning that simply by replacing critical components or wiring in their amplifier or speakers with a similar component of much higher quality of manufacture, that sound quality is audibly improved, often quite considerably.

The excellence of the sound quality of the Apex is guaranteed by the use of large power supplies (much larger than that needed to power the circuits and drive the loud speakers) and very high quality components. For the benefit of readers who want to build their amplifiers to sound even better than the standard hi fi, I have made space on the p.c.b. for capacitors of the highest quality which are quite large in size and I have specified on the components list even higher grade (and sometimes quite expensive) parts which further improve the sound quality. **But the component quality of the standard kit is much higher than most manufactured preamps and power amps at up to three times the cost.**

PASSIVE COMPONENTS

You may find it hard to believe that passive components can have a significant (i.e. a very large) affect on the sound quality. However, if we look at almost any amplifier circuit (except some single stage f.e.t.s) we see that the gain can be fairly accurately defined by the ratio of resistors (Fig. 1a and 1b). When we look at the detailed specification of a resistor we notice a figure for the temperature coefficient. Table 1 shows typical figures for different types of resistors.

When we pass an audio signal through a resistor the amount of heat generated will vary with the signal level. If we increase the signal level, the heat generated will cause the temperature of the resistor to rise. After the signal has ceased the temperature of the resistor will slowly return to its equilibrium position. But during the time that the resistor was at the higher temperature, its resistance had changed.

In an amplifier where the gain is defined by a pair of resistors, the effect of the change in temperature in the resistors is to modulate the output. Because the temperature of the resistor at any time is dependent on the amount of energy previously generated but not dissipated, rather than the actual signal level, this modulation is a form of distortion which is audible.

TABLE 1
Temperature coefficient of Resistors

Type	Temp. coeff.
Carbon	1000 ppm/°C.
Metal Oxide	250 ppm/°C.
Metal Film	50–100 ppm/°C.
Precision Metal Film	15–50 ppm/°C.
Bulk Foil	1–8 ppm/°C.

TABLE 2
Dielectric loss of Capacitors

Dielectric	Power Factor
Aluminium Electrolyte	0·1–0·2
Tantalum Electrolyte	0·06–0·1
Polyester	0·01
Polycarbonate	0·003
Polypropylene	0·001
Polystyrene	0·0003–0·0005

When we investigate the sound quality of resistors used in an amplifier, we find amazingly large differences. Metal film resistors generally sound better than metal oxide or carbon resistors. The price of close tolerance metal film resistors is so low (typically 5p each) that there can be no justification at all for using carbon resistors in any audio circuits. Precision metal film resistors such as the Holco range which are very popular with audio enthusiasts cost up to 10 times the price of mass produced metal film resistors, but when applied to the critical parts of an amplifier significantly improve the sound quality.

One experience which really amazed me was the affect of changing the cartridge loading resistors for a magnetic cartridge from a metal oxide to a Holco H8. The effect was as if the tracking ability of the cartridge had been significantly improved on a difficult track. I can't explain it to convince myself—yet. But this is one of many strange effects which influence the final sound.

But the Holco resistors are not the last word in sound quality. Bulk foil resistors can be made with temperature coefficients as low as 1ppm/degree C by controlling two opposing physical phenomena to cancel each other's affect on the resistance. By these properties and special techniques to minimise capacitance and inductance, the sound quality gained from using bulk foil resistors in critical positions takes a big step forward.

Much has been written about the effect of capacitors on an amplifier's sound quality. To cut a long story short, the more natural accurate sound can be enjoyed by using capacitors with the lower dielectric loss. Table 2 shows some typical figures for different types of capacitor. As a general rule changing a capacitor to a lower loss type results in quite worthwhile improvements in sound quality.

Other properties of capacitors which are likely to affect its sound quality are mechanical and electrical resonance and dielectric absorption, Dielectric absorption is the ability of a capacitor to retain its charge after it has been discharged. It's measured by the amount the voltage at its terminals rises after being disconnected from the resistor into which it has been discharging.

TRANSISTORS

Research which I have carried out on transistors shows that different types of transistors actually sound different in the same part of the circuit. Listening tests I have conducted have shown that high power transistors, despite poor gain and high frequency measurements, actually sound better than small signal transistors. The reason for this is that as the level of the audio signal varies any transistor handling that signal is subject to instantaneous changes in power dissipation at the junction.

Transistors with low thermal resistance around the junction (i.e. they can get rid of the heat quicker) experience much smaller temperature changes at the semi-conductor junction. It can be easily shown from manufacturers' published performance curves of transistors that the gain will vary with temperature. Changes in gain will give rise to audible distortion so the transistor which experiences the lowest variation in junction temperature as the level varies, will give the best sound. This distortion is best described as temperature generated distortion.

POWER SUPPLY

In past years audio designers have applied most of their efforts towards reducing harmonic "distortion" and more recently avoiding slew induced distortion. But unless an amplifier has a ridiculously poor slew rate (and many popular i.c. op. amps are in this category), these matters have comparatively little relevance to sound quality.

However good the power supply of an amplifier, it will sound better if the power supply ripple rejection of the circuit is improved. One of the most effective ways to improve power supply ripple rejection is by cascode circuitry.

Cascode circuitry was first developed in the days of valve amplifiers as a means of extending the high frequency response of a circuit. But its principles apply equally well to transistor circuits and I shall explain it in transistor terms.

Any transistor will exhibit the properties of a capacitor between its terminals and this applies in the case of the transistor in Fig. 2. If a high frequency signal is applied to its base, the signal will be amplified and at 180

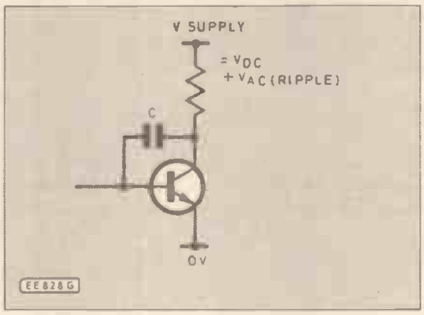
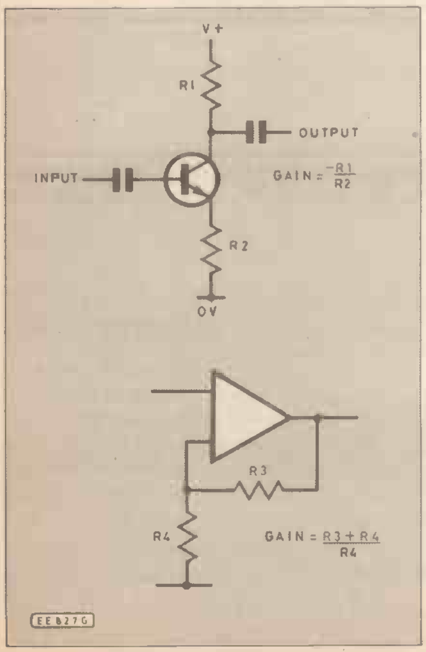


Fig. 2. Base to collector capacitance of a transistor.

Fig. 1a and 1b. The gain of an amplifier can be defined by the ratio of two resistors.



Photograph of the Apex pre-amplifier and power amplifier.

degrees out of phase at the collector. The higher the frequency the more the amount of the amplified signal will be fed back to the base via the "collector to base" capacitance.

We can reduce the effect of the capacitance between the transistor's leads quite significantly by holding the collector at a near constant voltage. The circuit of Fig. 3

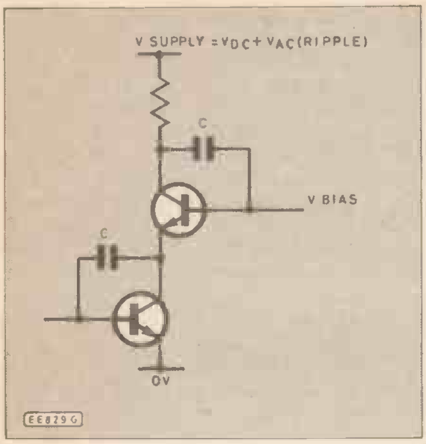


Fig. 3. Cascode configuration.

shows two transistors on a cascode configuration. The base of the cascode transistor is held at a fixed d.c. potential above ground by its bias voltage V_{bias}. So long as this transistor conducts, its emitter voltage will stay constant at around 0·6V below V_{bias}. The amplified a.c. voltage is now at the collector of the cascode transistor. Capacitance between the leads of this transistor will have little effect as the base voltage is kept constant by the circuitry which produces V_{bias}.

The main amplifying transistor will still have the same capacitance between collector and base, but because its collector voltage is kept almost constant, the current feedback to the base is greatly reduced and the high frequency response of the circuit is greatly extended. This property of cascode circuitry was used extensively in the past in valve circuits and is used these days in video recorder amplifiers and v.h.f. radio receiver r.f. mixer/oscillators with bipolar and field effect transistors.

The cascode circuit also has the effect of isolating the transistor which amplifies the signal, from ripple on the power supply. If we look again at Fig. 2 the supply voltage will contain the d.c. voltage ($V_{d.c.}$) required to power the circuit and a.c. voltage fluctuations ($V_{a.c.}$).

$V_{a.c.}$ contains two components:

a) 100Hz continuous ripple from the rectifiers.

b) Audio frequency voltages caused as a direct result of current drawn from the supply as an audio frequency signal is being amplified. Such voltages are quite large at the output stage of a power amplifier where peak currents may reach several amps.

In the circuit of Fig. 2, almost all of the ripple voltage $V_{a.c.}$ is present at the collector of the transistor. In Fig. 3, the supply has the same ripple voltage $V_{a.c.}$. The bias voltage to the cascode transistor will contain the d.c. voltage $V_{(bias)\,d.c.}$ + ripple $V_{(bias)\,a.c.}$. If that bias voltage is obtained from the resistor diode network of Fig. 4, the ripple voltage is greatly reduced and

$$V_{(bias)\,a.c.} = \text{(typically) } 1/30\ V_{a.c.}$$

COMPONENTS

Tone and input switching board

	Standard kit	Improved version
Resistors		
R32,38,39,132,138,139	10k 1% metal film (6 off)	10k Holco H8
R33,34,35,42,133,134, 135,142	47k 1% metal film (8 off)	47k5 Holco H8
R36,44,136,144	4k7 1% metal film (4 off)	4k75 Holco H8
R37,40,41,43,137,140, 141,143	1k 1% metal film (8 off)	1k Holco H8
R45,145	330k 1% metal film (2 off)	332k Holco H8
R30,31,130,131	2k2 1% metal film (4 off)	2k21 Holco H8
R60,61	33k carbon (2 off)	
VR1	100k MN balance	
VR2	50k log dual	
VR3	100k linear dual	
VR4	10k linear dual	
Capacitors		
C12,112	470n polyester	470nF polypropylene
C13,113	100p polystyrene	
C15,16,115,116	10n 5% polyester	8nF 1½% LCR EXFS/RP
C17,18,117,118	47n 5% polyester	56n 1½% LCR EXFS/RP
C20,120	220n polyester	220n polypropylene
C21,121	220n polyester	220n polycarbonate
C27,37	4μ7 elect. 35V	
C28	220μ elect. 16V	
Semiconductors		
TR16,18,30,116,118	BC184C (5 off)	
TR17,19,117,119	BC184C (4 off)	BD243C
D17,18,29,30,31, 129,130	1N4148 (7 off)	
Miscellaneous		
S1,2,3,4	2 pole C/O (4 off)	2P C/O ITT FOX N
S5,6	4 pole C/O (2 off)	4P C/O ITT FOX N

24 p.c.b. pins 1mm dia. double sided; 6 black knobs for push button switches.

Power supplies and assembly hardware

	Standard kit	Improved version
Resistors		
R62,64,66,68,162,164, 166,168	201 Holco H8 (8 off)	
R63,65,67,69,163, 165,167,169	3k32 Holco H8	
R70	4k7 carbon	
R71	VDR 26j	VDR 61j
Capacitors		
C29,30,31,32,129,130, 131,132	10μ elect. 40V (8 off)	
C33,34,35,36,133,134, 135,136	1000μ elect. 35V (8 off)	
Semiconductors		
D19,20,21,22,23,24, 25,26,27,28,119,120, 121,122,123,124,125, 126,127,128	1N4002 (20 off)	
IC4,5,6,7,104,105, 106,107	LM317T (8 off)	

Miscellaneous

T1 Toroidal transformer 0–18, 0–18 secondaries 120VA

Mains fuseholder; 2·5A quick blow fuse; 2 pole mains switch rotary; 5 knobs 6mm internal dia.; 14 6BA × ⅜" threaded spacers; 6BA nuts, bolts, washers and solder tags.

See Shop Talk page 135

Disc and output amps

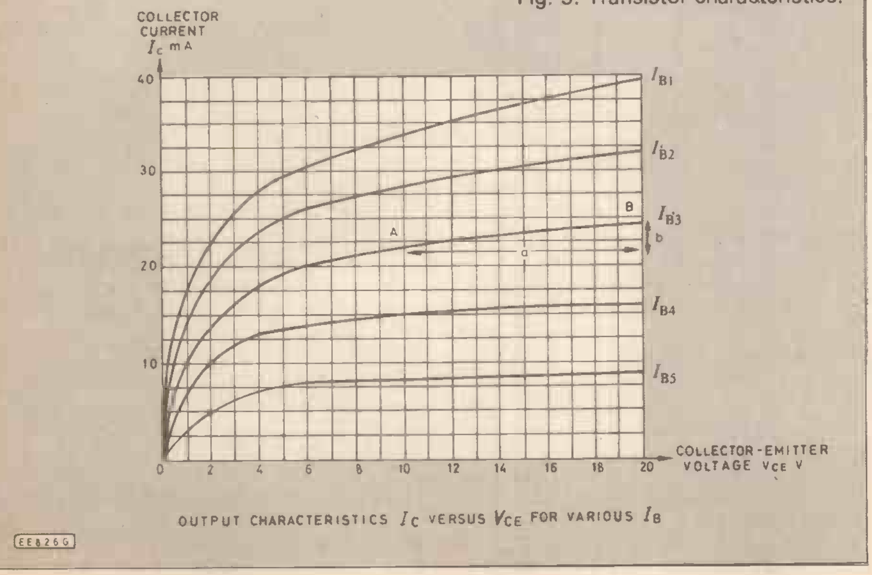
	Standard kit	Improved version
Resistors		
R1	68k1 Holco H8	68k Bulk foil
R2	33R2 Holco H8	33 Bulk Foil
R3,11,17,18,22,24, 46,50,53,55	47k 2% metal film (10 off)	47k5 Holco H8
R4,21	22k 1% metal film (2 off)	22k1 Holco H8
R5,8	100 1% metal film (2 off)	100 Holco H8
R6	22 1% metal film	22R1 Holco H8
R7,10	10k 2% metal film (2 off)	10k Holco H8
R9	470 1% metal film	475 Holco H8
R12,19,25,47,57	220k 2% metal film (5 off)	221k Holco H8
R13,20,49,51,56	1k 1% metal film (5 off)	1k Holco H8
R14,48,52,54	3k3 1% metal film (4 off)	3k32 Holco H8
R15	27k 1% metal film	27k4 Holco H8
R16	1k5 1% metal film	1k5 Holco H8
R23	4k7 1% metal film	4k75 Holco H8
R26,28,58	221 Holco H8	
R27,29,59	2k74 Holco H8	
Capacitors		
C	4n7 polystyrene	8n extended foil PS
C1	4µ7polyester	10µ Wonder cap
C2	1µ polyester	1µ Wonder cap
C3,10	470n polyester (2 off)	470n polypropylene
C4,11,26	220n polyester (3 off)	220n polypropylene
C5	33n 5% polyester	33n 1½% LCR type EXFS/RP
C6	100p polystyrene	100p silver mica
C7	100n 5% polyester	100n 1½% LCR EXFS/RP
C8,23	220n polyester (2 off)	250n LCR EXFS/RP
C9,24	4n7 polyester (2 off)	4µ Wonder cap
Semiconductors		
TR1	2SD786	
TR2	2SD786	BD243C
TR3,9,11,15,22,24,28	BC214C (7 off)	BD244C
TR4	2SB737	
TR5	2SB737	BD244C
TR6,8,12,14,21,25,27	BC184C (7 off)	BD243C
TR7,13,20,26	BC184C (4 off)	
TR10,23	BC214C (2 off)	
TR29	J112	
D1,2,3,4,5,6,7,8,9,10, 11,12,13,14,15,16,32	1N4148 (17 off)	
IC1,2,3	LM317T (Motorola) (3 off)	

Miscellaneous

14 double sided p.c.b. pins 1mm dia.; 6 p.c.b. mounting sockets, gold plated contacts; 2 p.c.b. selector plugs.

All the above components are duplicated for the other channel

Fig. 5. Transistor characteristics.



If the bias voltage was obtained by two equal value resistors then $V_{(bias)\,a.c.} = \frac{1}{2} V_{a.c.}$

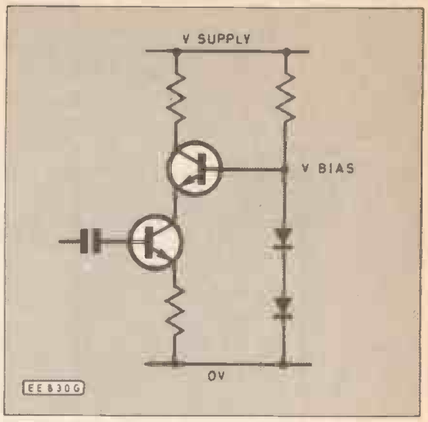


Fig. 4. Reducing ripple voltage.

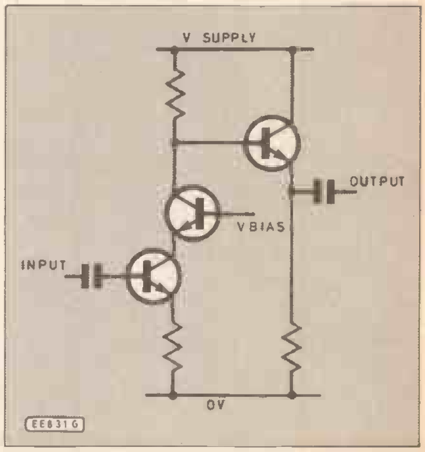


Fig. 6. The advantage of cascode is lost.

As the cascode transistor is conducting, its emitter voltage will be 0·6V below the bias voltage. Because almost the full ripple voltage appears at the collector of the cascode transistor, a small additional ripple voltage will be present at its emitter. This additional ripple is usually small compared to the ripple voltage component of the bias voltage but not always (i.e. if the ripple voltage at the bias point is very very low due to improved circuitry).

The transistor output characteristics shown in Fig. 5 show how the ripple voltage at the collector changes its gain. Consider the case of a transistor operating with base current I_{b3} with V_{ce} and I_c defined by point A. If the collector voltage is increased to point B, the collector current I_c will rise by a small amount. As I_b is constant, the current gain of the transistor will change. The effect of a.c. ripple on the collector of a transistor is to vary its gain, and such variations in gain give rise to audible distortion of a music signal. Whilst such distortion can be reduced by negative feedback, it cannot be eliminated.

The effect of cascode circuitry is to reduce the ripple voltage seen at the collector of an amplifying transistor and as a result reduces distortion and improves sound quality.

The current through collector load resistor in the cascode circuitry has a very low a.c. ripple, but its voltage is referenced to the supply voltage. If we feed that circuit into an emitter follower (Fig. 6), the full supply ripple $V_{a.c.}$ is seen at the output and we have lost the advantage of cascode. The

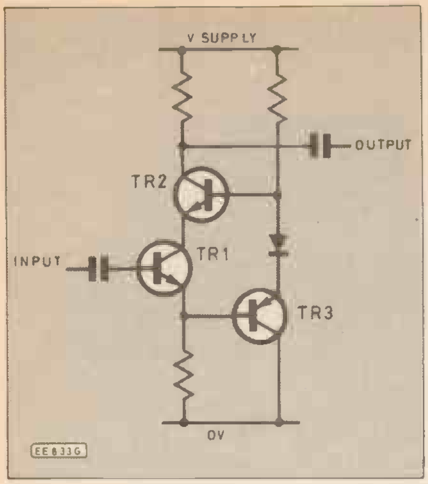


Fig. 8. The basis of the circuit used in the Apex.

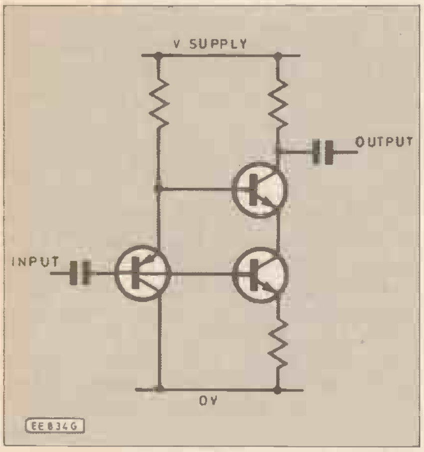


Fig. 9. This circuit has poor ripple rejection.

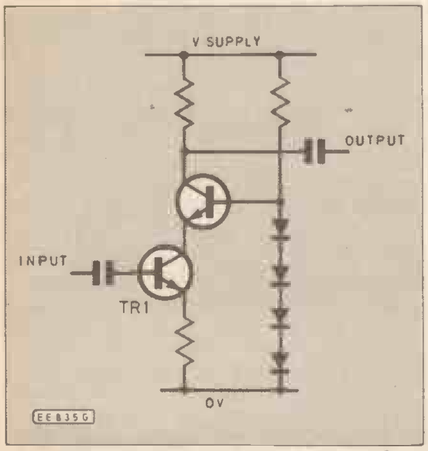


Fig. 10. This reduces the maximum voltage swing.

circuit of Fig. 7 corrects this and the output voltage at the collector resistor in the second stage has a very low ripple content.

A special point to note is that the bias voltages are referenced to the supply on the emitter side of the cascode transistor. Research which I have carried out shows that measured power supply ripple rejection is greatest (i.e. ripple voltages are lowest) if the dynamic impedance across V_{bias} is very low and the dynamic impedance to the other supply is as high as possible.

CIRCUITRY

The active circuitry for the disc and output amplifiers is based on using part or whole of the Fig. 8 circuit. The bias voltage

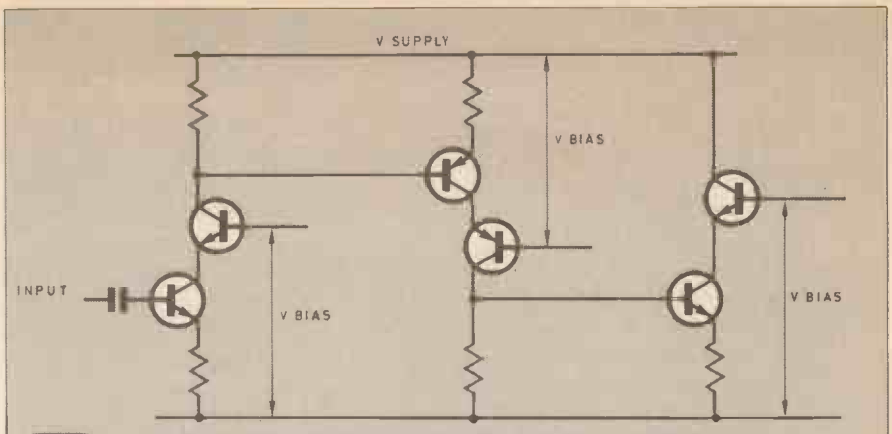


Fig. 7. This circuit overcomes the problems of Fig. 6.

COMPONENTS

Power amplifier

	Standard kit	Improved version
Resistors		
R1	100k 2% metal film	100k Holco H8
R2	3k3 2% metal film	3k32 Holco H8
R3	220k 2% metal film	221k Holco H8
R4	1k 2% metal film	1k Holco H8
R5	330 2% metal film	332 Holco H8
R6	1k 2% metal film	1k Holco H8
R7	4k75 Holco H8	4k7 Bulk foil
R8	47k 2% metal film	47k5 Holco H8
R9	47k 2% metal film	47k5 Holco H8
R10	221k Holco H8	220k Bulk foil
R11	68 2% metal film	68R1 Holco H8
R12	22k 2% metal film	22k1 Holco H8
R13	22k 2% metal film	22k1 Holco H8
R14	4k75 Holco H8	
R15	2k74 Holco H8	
R16	100 Holco H2	
R17	10 1W metal oxide	10 Holco H2
R18,19	2R2 metal film $\frac{1}{2}$W (2 off)	2R2 Holco H2
R20,21	OR15 4$\frac{1}{2}$ W/W (2 off)	(see text)
R32	33 2% metal film	33R2 Holco H8
Capacitors		
C1	470n polyester	470n polypropylene
C2	470p polystyrene	470p LCR EXRS/RP
C3	4μ7 polycarbonate	3·3μ polypropylene or 4μ Wonder cap
C4	47p polystyrene	47p Silver mica
C5,6	470n polyester (2 off)	470n polypropylene
C7	10n polycarbonate	8n LCR EXFS/RP
C8,9	10μ elect. 40V axial (2 off)	
C10	100n polycarbonate	100n polypropylene
Semiconductors		
TR1,2	BC184C (2 off)	MAT01
TR3,4	BC547C (2 off)	MAT01
TR5	BC547C	BD243C
TR6,7	BC184C (2 off)	
TR8,11	BD243C (2 off)	
TR9	BC214C	
TR10	BD244C	
TR12	BDT63A, BDW93B	
TR13	BDT62A, BDW94B	
TR14	2N3716	
TR15	2N3792	
D1,2,3,4	1N4148 (4 off)	
D5,6	1N4002 (2 off)	

See Shop Talk page 135

Miscellaneous

3 $\frac{1}{4}$" blade connectors; 6 1mm dia. double sided terminal pins; heat sink bracket for driver transistors TR8 and TR10; heat sink bracket for TR11–TR15; 4 mica or silicone insulators for TO–220; 2 mica or silicone insulators for TO–3—TR14 and TR15; 6BA nuts, bolts, washers and solder tags for mounting power transistors; 2 p.c.b. fuse clips; 20mm fuse XXA.

All the above components are located on the power amp p.c.b. and are duplicated for the second channel

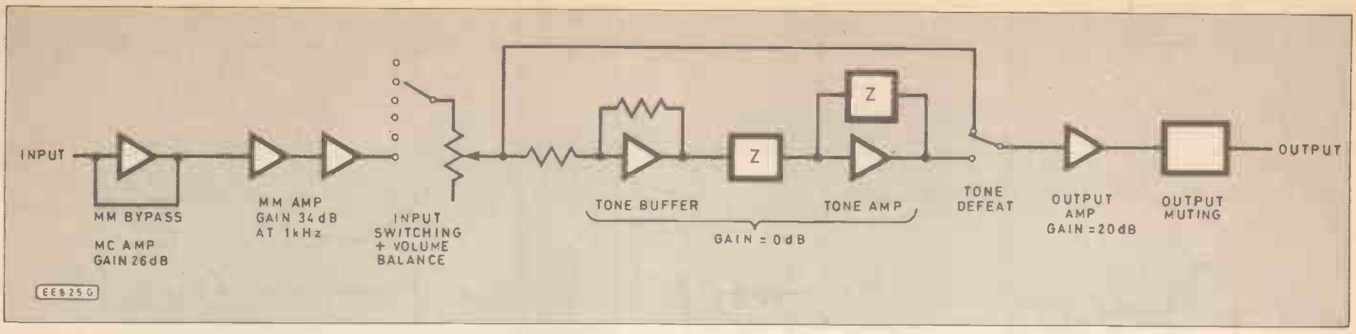


Fig. 11. Block diagram of the pre-amplifier.

All Holco H2 resistors are 100ppm/°C 1%

Holco H8 resistors are 0·5% 50ppm/°C specification

Power amp power supply

	Standard kit	Improved version
Resistors		
R23,26,123,126	200 Holco H8	
R24,25,124,125	4k75 Holco H8	
R27,28	10k metal film	
R29	VDR 60j	VDR 110J
R30,31	47 4W W/W	
Capacitors		
C11,12,111,112	1000µ elect. 40V (4 off)	
C13,14,113,114	470n polyester (4 off)	470n polycarbonate
C15,16,115,116	10µ elect. 40V (4 off)	
C17,18	10,000µF elect. 40V (2 off)	
Semiconductors		
D7,8,9,10,107,108 109,110	1N4002 (8 off)	
BR1	25A 200V bridge	Motorola BYW62
IC1,101	LM317T Motorola (2 off)	
IC2,102	LM337T Motorola (2 off)	

Miscellaneous

S1 2 pole mains switch; T2)–240V primary, 0–25, 0–25 secondaries at 300VA, mains transformer; Mains fuseholder 20mm; 2 low voltage fuseholder —chassis type 20mm; fuse 20mm 5A; 2 Fuses 20mm 6·3A; 14 6BA × $\frac{3}{8}$" spacers; 2 red loudspeaker socket terminals 4mm; 2 black loudspeaker socket terminals 4mm; (use Michell amplifier terminals for loudspeakers for improved version); 2 chassis phono sockets (use gold plated for improved version); 1 stereo headphone $\frac{1}{4}$" jack socket; mains cable (use Kimber cable mains lead for improved version); 1mm dia. p.v.c. covered cable for high current leads (use Kimber cable for improved version); 0·63mm dia polythene insulated cable for all other leads; $\frac{3}{8}$" dia grommet at mains cable entry; cable clamp 4·75mm dia × 9·5mm width; knob for mains switch.

is derived from the emitter of TR1 and is raised 1·2 volts by the base emitter junction of the transistor and forward voltage drive of the diodes. This has advantages over alternative circuits of Figs. 9 and 10.

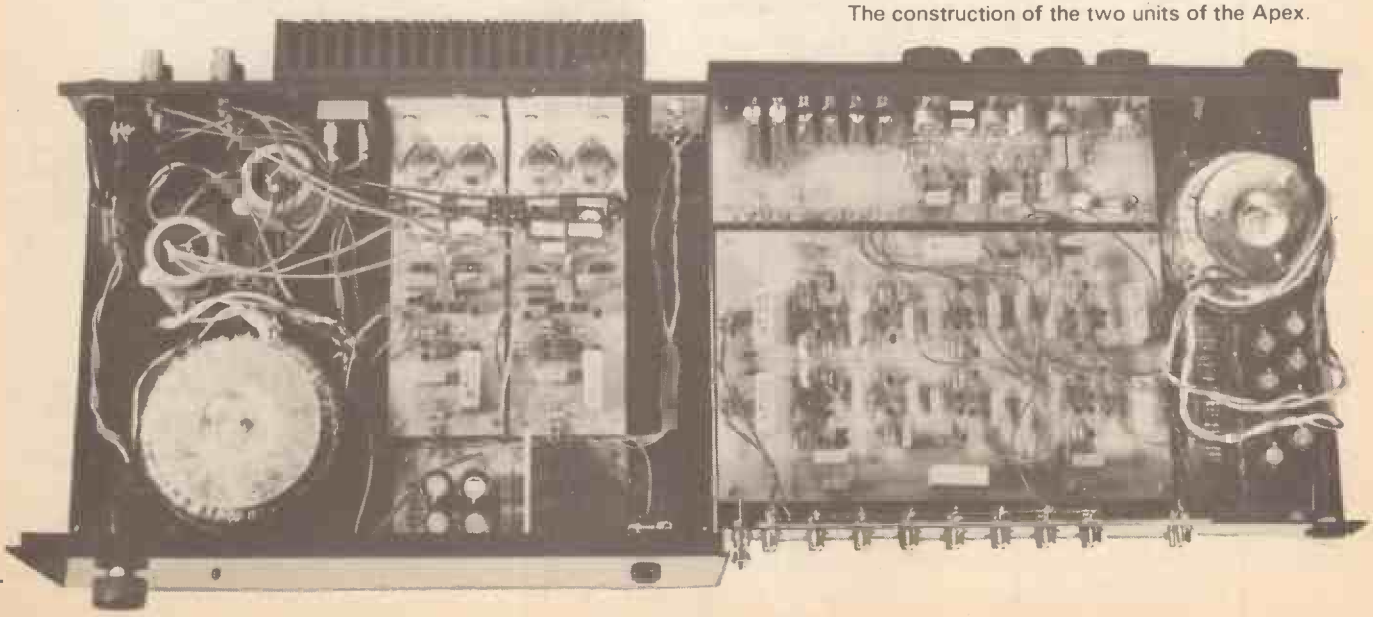
The circuit of Fig. 9 has much poorer power supply ripple rejection (which can be verified by measurement) due to the higher impedance to ground at the base. The circuitry of Fig. 10 reduces the maximum available voltage swing. Also the collector to emitter voltage of TR1 varies to the same magnitude as the input signal increasing temperature generated distortion. The unique advantage of Fig. 8 is that TR1 is kept at near constant collector to emitter voltage enabling high gain small signal transistors to be used without temperature generated distortion. At the same time TR2 and TR3 can be low gain high power transistors which exhibit far lower temperature generated distortion than small signal types.

PRE-AMPLIFIER

A block diagram of the pre-amplifier is shown in Fig. 11. Each stage of amplification is fed from a separate rectifier and regulator and each channel is powered from separate windings of the mains transformer.

The moving coil amplifier, which is the equivalent of the old fashioned moving coil "head amp" has a gain of 20 and raises the signal level from the typical 100mV of moving coil cartridges to 2mV, which is about the same as the typical magnetic cartridges. Inputs from the magnetic cartridges are switched directly to this point by means of p.c.b. selector plugs on the p.c.b. This has the disadvantage that you cannot change your cartridge without removing the

The construction of the two units of the Apex.



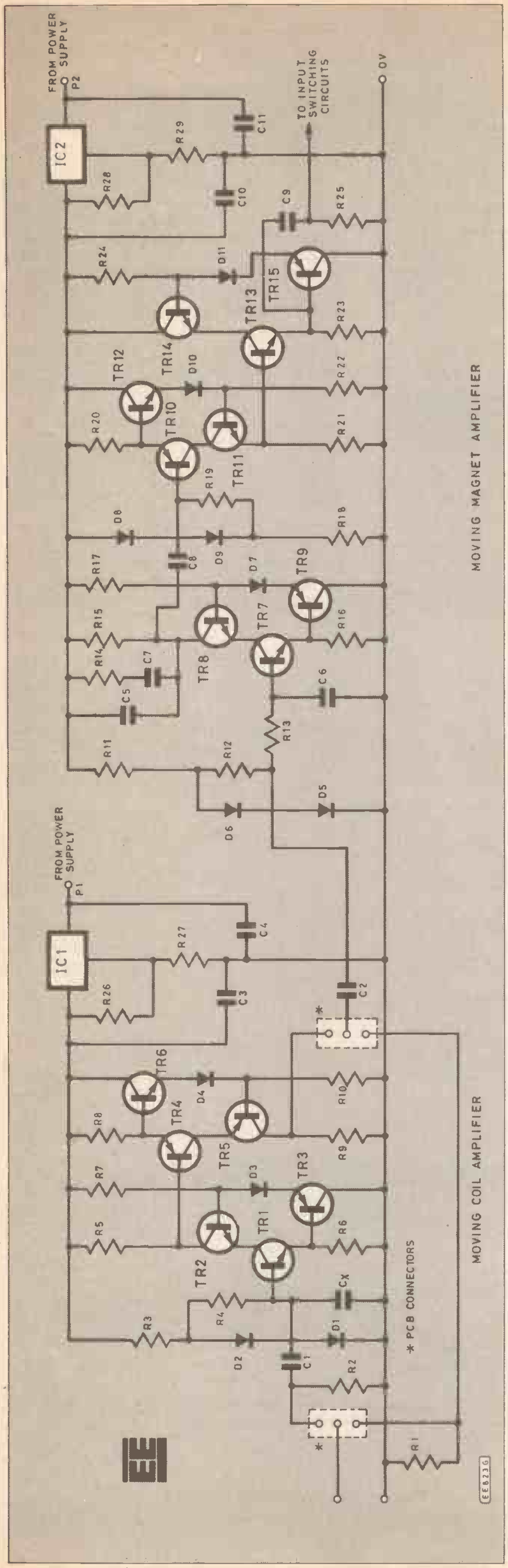
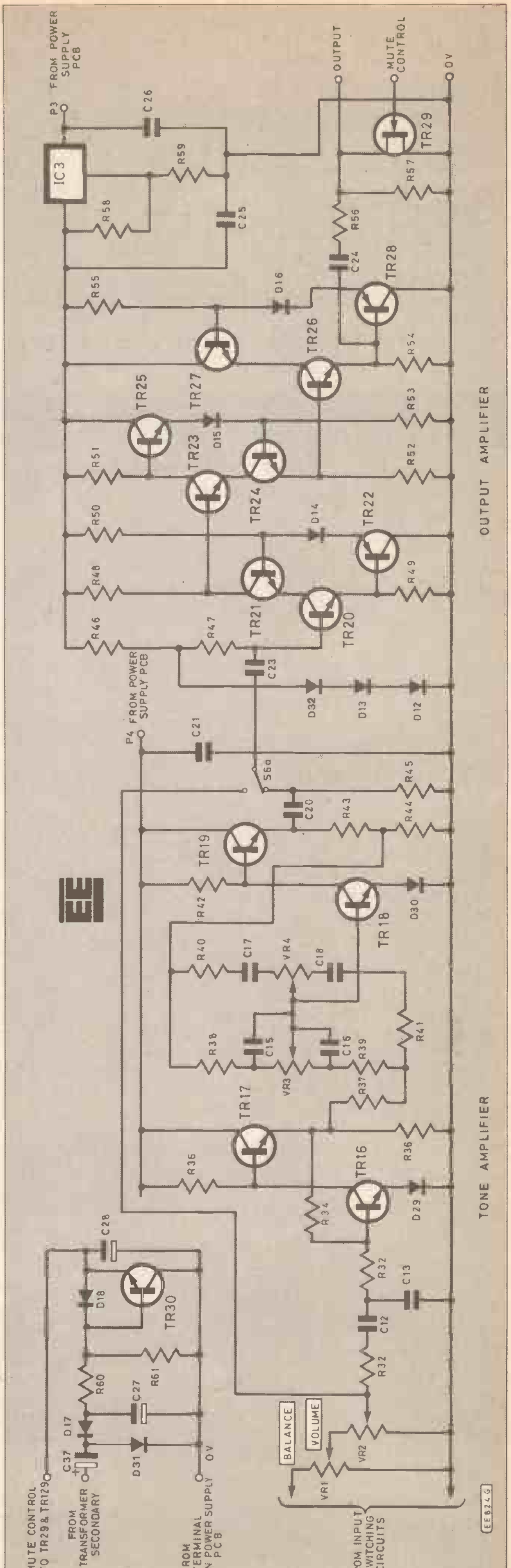


Fig. 12. Circuit diagram of the pre-amplifier. Component values have been omitted for clarity.



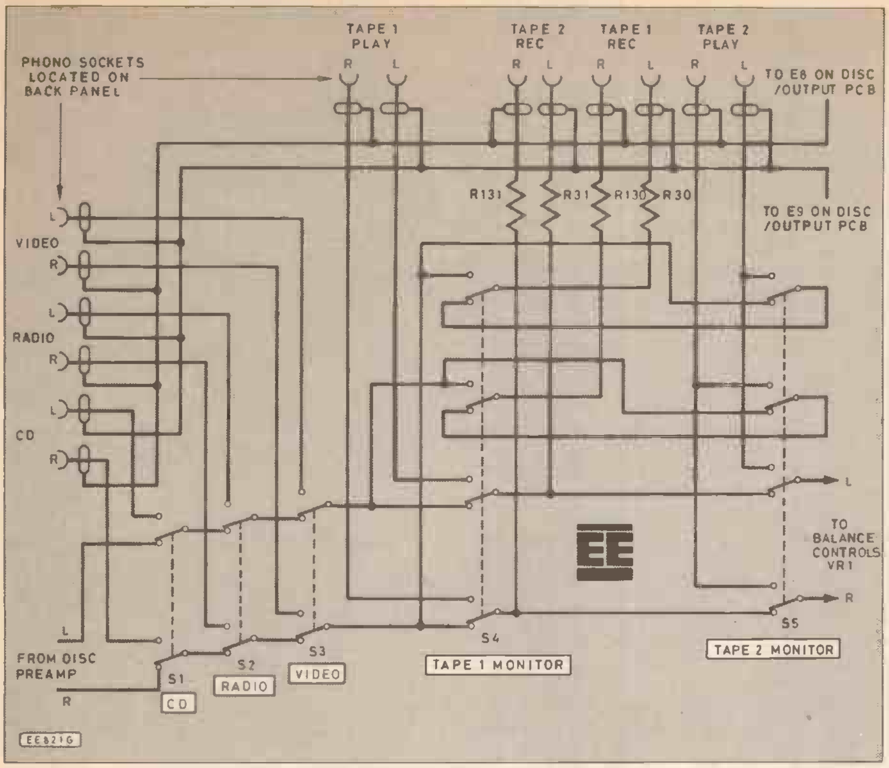


Fig. 13. Circuit of the input switching.

cover to the case, but it makes building the amplifier a lot easier.

Noise levels on the moving coil amplifier are kept very low by use of two ultra low noise transistors (Fig. 12) 2SD786 (*npn*) and 2SB737 (*pnp*). These are specially designed for moving coil input circuits and their noise levels are extremely low (typically $0{\cdot}55\text{nV}\sqrt{\text{Hz}}$ at 10Hz).

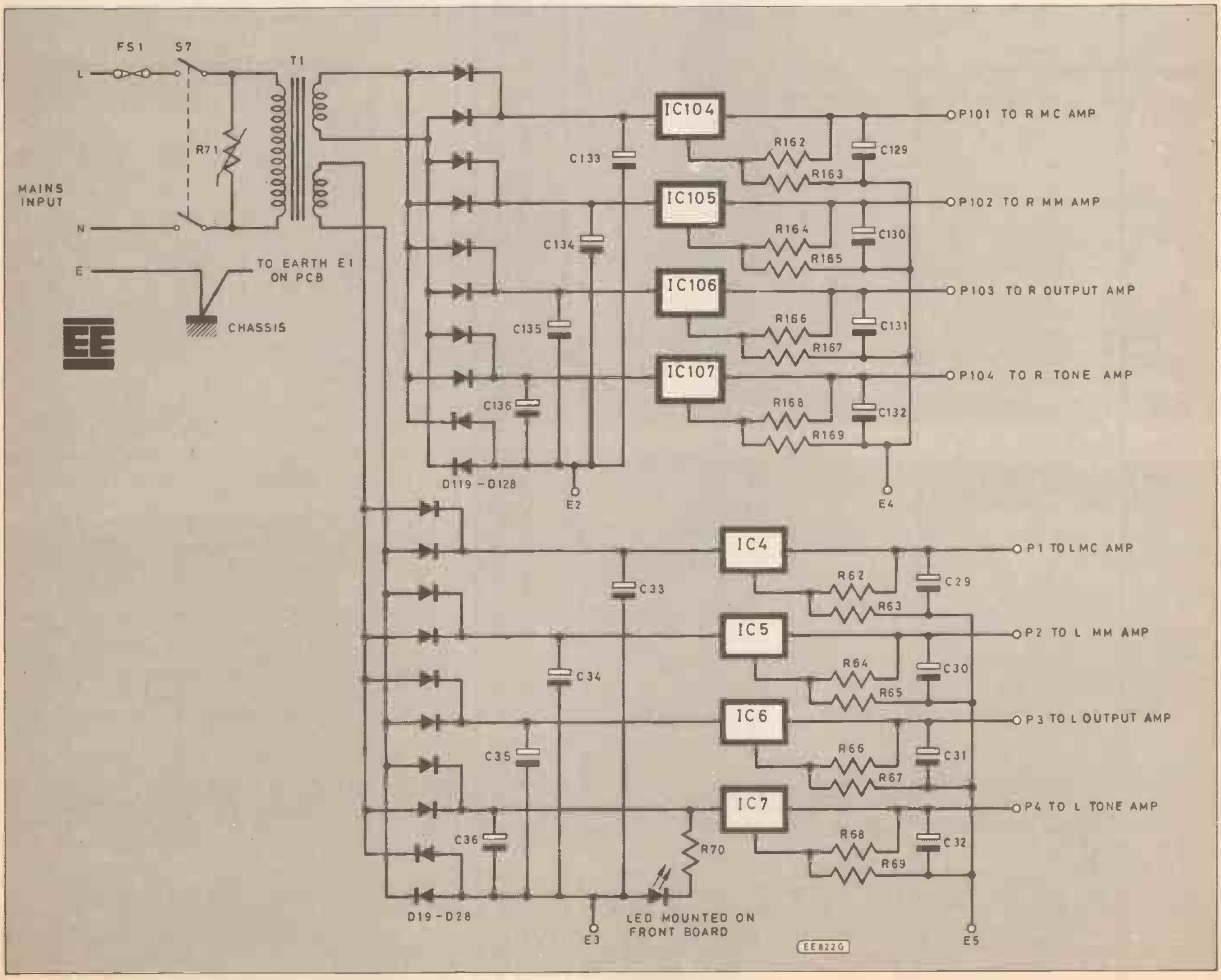
The RIAA amplifier is broken into two stages to increase its gain. Equalisation is carried out by two resistors and two capacitors in the collector load of the first stage. After equalisation the output level from the RIAA is typically 100mV at 1kHz. The tone amp is broken into two stages. As the tone control stage is an inverting amplifier, the input buffer amplifier also inverts and has near unity gain. As a result, the tone amplifier can be switched in and out of circuit without change of gain or phase. The final part is the output amp which raises the signal level from 100mV to about 1V. Output muting is carried out by a f.e.t. with a slow turn on—fast turn off control circuit.

COST

The approximate cost of "standard" components for the Apex Preamp is £150 and for the Power Amp £100. The cases are extra.

Next month: Power Amplifier and Power Supply

Fig. 14. Circuit of the pre-amplifier power supply.



a regular feature for the Spectrum Owner...

by Mike Tooley BA

THIS month sees *On Spec* reaching its quarter century and, in this our twenty-fifth instalment, we shall be taking a look at Hisoft BASIC (the last of our three compilers) and describing some novel LOGO routines for driving our *Speech Synthesiser*. For good measure, we have thrown-in a number of useful hints supplied by readers. We begin, however, with a few general points.

Points Arising

Several readers have taken me to task concerning the choice of the AD7581 in the *Multi-Channel ADC* described in the December '86 issue. Yes, I know that this chip is expensive (I, too, have to "fork out" for components out of my own pocket!), but, when one considers what this chip does and the cost and complexity of alternative methods of implementing an 8-Channel ADC, it really does not work out all that costly!

Provided that the circuit board wiring is carefully checked before switching off and connecting the ADC module to the Spectrum, no harm should come to the device. In common with all *On Spec* projects I do, however, strongly recommend the fitting of i.c. sockets. The marginal saving in cost in not fitting sockets is far outweighed by the ease of removal and replacement of the chip.

Another comment regularly received from readers is that I should be including full wiring layout for each *On Spec* project. Whilst I recognise the desirability of this, it would certainly have to be at the expense of something else. Ultimately it would mean that less projects could be covered.

At the present, I aim to include a hardware project every other month (our latest *On Spec Update* has a full list of them). Adding full constructional information would probably stretch this to one project every three or four months. It could then be some time before the project of one's dream actually appears in print (by which time, dare I say it, readers may well have moved onto a BBC Master, Atari-ST, or even a Commodore Amiga!).

Whilst on the subject of projects, the *Escape Interface* continues to generate a great deal of interest amongst readers. Any misgivings I had about the likely popularity of this piece of hardware seem now to be totally unfounded. Indeed, it seems that the advantage of having an "Escape" key is recognised by every serious Spectrum owner!

Many readers have reported satisfactorily working interfaces though it appears, from one letter at least, that there may be problems with certain "Issue 4" boards. I cannot suggest any reasons for this and have tested the interface with my own Issue 2, 3 and 6A (Spectrum Plus) machines. If anyone out there can throw any light on this (or can confirm that the *Escape Interface* does work correctly with an Issue 4 board!) please drop me a line!

Whilst on the topic of correspondence from readers, I do attempt to answer every query received provided, of course, that it is accompanied by a stamped addressed envelope. If you just require an Update, the response should be fairly quick (usually within a fortnight). If, however, you have requested assistance with a number of problems, please be prepared to wait a little longer. All letters are dealt with in strict order of receipt. On occasions, my "in-tray" gets a little full so please be patient!

Finally, for the benefit of overseas readers, please do NOT, as many readers have done, send envelopes with stamps in your own currency—they will just be wasted! Just enclose the relevant number of International Reply Coupons (IRC). Bearing in mind that it costs several pounds to mail a complete set of *Update* sheets by Air Mail to the other side of the globe, if you do not enclose adequate postage I shall simply send you as much as I can up to the limit of the postage which you supply!

Hints and Tips

One of the nice things about *On Spec* is that readers often supply me with some quite novel and unusual hints and tips derived from their own experience of the Spectrum. Whilst only a few of these could be expanded to form a complete project, taken collectively they represent a most useful collection of ideas. Here are just a few of the crop:

Getting Overheated?

Overheating was a regular problem with early issues of the Spectrum and resulted from a lack of ventilation coupled with inadequate heatsinking. *Unni Krishnan* writes from Kerala, India, with a simple and very effective dodge to provide more effective cooling of the Spectrum's innards.

Remove all of the case securing screws and substitute longer screws with small plastic spacers between the case halves (glue the same spacers onto the leg springs to maintain their action). Also, fix a small U-shaped copper or aluminium heat sink onto the ULA chip using epoxy resin based adhesive.

Sound Aid!

Andrew Stephens writes from Harlow with a tip for those who find the Spectrum's sound output a little limited. The reason for this, says Andrew, is that the "puny" transducer fitted to the Spectrum is wasting most of its effort directing the sound downwards into the table or workbench.

Andrew recommends removing the transducer completely, fititng a 2.5mm (or 3.5mm) miniature jack socket to the rear of the bottom case half and wiring this to the pads previously occupied by the transducer. A small 40 ohm (or higher impedance) loudspeaker mounted in a plastic box or enclosure, may then be connected in place of the internal transducer and plugged into the jack socket as, and when, sound is required. The difference in sound level provided by this modification has to be heard to be believed, says Andrew.

Under Strain?

David Williams, from Cardiff, writes on a topic which is bound to affect most Spectrum owners sooner or later. The problem is associated with the need to remove and reconnect the power lead in order to reset the machine (Spectrum Plus, 128, and Plus Two models excluded). This causes premature failure of both the power lead (usually within the last few mm) and the p.c.b. mounted connector (which often becomes detached from the p.c.b. due to an inordinate amount of flexing).

Both of these problems can be eliminated by wiring a reset button to the edge connector. All that is required is a miniature (normally open) push-button switch fitted in a suitable position (i.e. not vulnerable to accidental operation!). The switch should then be wired between pins 6B and 20B of the Spectrum's edge connector (our *Update* contains the pin-connecting information).

Short of Memory?

M. Tucker writes from Coventry with a handy tip for anyone who needs to know how much of the Spectrum's memory remains available at any particular time. Mr. Tucker recommends a short machine code routine which can be conveniently tucked away (forgive the pun!) in the area of memory normally reserved for User Defined Graphics (UDG).

The machine code can be loaded from BASIC and (the BASIC loader removed) alternatively, the routine can be incorporated as part of any BASIC program's initialisation. The routine is as follows:

```
10 for i=0 TO 15
20 READ x
30 POKE USR"t"+i,x
40 NEXT i
50 DATA 33,0,0,57,237,91,101,92
60 DATA 167,237,82,229,193,201,0,0
```

Thereafter, if you need to know how much memory is available you need only include the following line within your program:

```
190 PRINT USR"t"; "bytes free".
```

Alternatively, you can simply type the command directly from the keyboard omitting the line number.

HELP!

Finally, two pleas for help! The first comes from *Professor J. King* of York who needs to interface a Spectrum 128 (in 48K mode) with a Serial 8056 printer driven from the 9-pin D-type socket on Interface 1. If anyone out there can offer some advice on making up an adaptor lead to convert from the 9-pin D-type connector at Interface 1 to the 6-way BT-style connector at the 8056 printer please let me know!

Secondly, *Kim O'Kane* from Portrush in Northern Ireland requires information on using FORTH (preferably on the Jupiter Ace rather than the Spectrum) to control a u.h.f. aerial when tracking an amateur satellite. If any reader can suggest a source of software for this particular application, or is already using FORTH in a similar situation, please drop me a line so that I can pass the message on!

HiSoft BASIC

Like Mega BASIC, Beta BASIC, and Laser BASIC, one might be forgiven for thinking that HiSoft BASIC is yet another enhanced BASIC interpreter. This is not so; Hisoft BASIC is, in fact a compiler. Just why Hisoft chose a somewhat misleading name for their latest Spectrum utility is open to speculation!

Hisoft BASIC has much to commend it. Firstly it is a full floating point compiler (unlike most other compilers available for the Spectrum) and secondly, dare I say it, it is fast. In fact, it is as fast, if not faster, in operation than *ANY* of the integer compilers which I have tested.

Again, unlike most other Spectrum compilers, Hisoft BASIC is also able to handle numeric and string arrays (of up to two dimensions) and generates extremely compact code. The compiler is compatible with *ALL* versions of the Spectrum and there are a number of additonal features available for those lucky enough to own a Spectrum 128 or Spectrum Plus Two.

Hisoft BASIC is about 11K in length and can compile a BASIC program of up to about 30K without requiring microdrive storage or any cumbersome tape swapping (a feature which mitigates heavily against compilers such as the ill-fated BLAST compiler produced by OCP Software). The A5 format manual supplied with the program comprises 49 pages and is both neatly presented and extremely thorough.

The introductory section is particularly pleasing and "talks" the beginner through the initial stages of using the compiler in a friendly yet informative manner. Full instructions are provided for tape backup or copying to microdrive.

As with the previous compilers tested, I put the program through its paces by giving it the task of compiling our TV/Monitors Test Program (see *Update* for a listing). The program compiled without any modification whatever (unlike the other two compilers) in a matter of seconds. The length of the machine code generated by Hisoft BASIC was 2598 bytes plus 317 bytes for variable storage. This compared with 2170 bytes for the BASIC program.

The machine code was then tested using:

RANDOMISE USR 62543

Execution Speed

As with other compiled programs this produced somewhat variable results in terms of speed of execution. There was little, if any, increase in speed for the Cross Hatch routines. Colour Bars were produced in about half the time taken by the BASIC program, whilst the Dot display was virtually instantaneous (as compared with about two seconds for the BASIC program).

At this point, I felt that it was worthwhile saving the machine code program for future "stand alone" use. This was easily achieved by NEWing the BASIC program and creating a short, auto-running BASIC loader. This was then SAVEd to tape before also SAVEing the machine code program using:

SAVE "tvcode" COD 62543,2598

Hisoft BASIC is a joy to use and can be unreservedly recommended to anyone requiring the services of a compiler. It undoubtedly represents the very best of Spectrum compilers and must be yet another winner for Hisoft!

Hisoft is at Dept. EE, The Old School, Greenfield, Bedford MK45 5DE. Tel: (0525) 718181.

Speech Synthesiser

Regular readers will know that last month's constructional project featured A. J. Harper's *Simple Speech Synthesiser*. This month we shall deal with the operation of the interface.

From BASIC, two short machine code routines are required to drive the SP0256 voice synthesiser chip via the Z80-PIO (interface controller). The first routine initialises the Z80-PIO whilst the second outputs allophone data to the SP0256:

```
INIT   LD A,255      ; Sept Port A
       OUT (95),A    ; to Mode 3
       LD A,128      ; Set A0 to A6 as
       OUT (95),A    ; outputs and A7 as
                       input
       RET           ; Get back to BASIC.
START  IN A,(31)     ; Read Port A
       BIT 7,A       ; Check if READY is
                       high
       JR Z,START; Go back if READY
                       is low
       LD A, (nn)    ; Get allophone code
                       from nn
       RES 6,A       ; Set ALD low
       OUT (31),A    ;
       SET 6,A       ; Set ALD high
       OUT (31),A    ;
       RET           ; Get back to BASIC
```

For those not in possession of an assembler, both of these routines are short enough to be easily "hand-assembled" and then POKEd from BASIC. Alternatively, readers may wish to make use of the Hex Code Loader contained within the *On Spec Update*.

A BASIC program for driving the *Speech Synthesiser* would include lines of the following form (where INIT and START are the symbolic addresses of the machine code routines previously placed in protected memory):

10 RANDOMIZE USR INIT: REM Calls the PIO initialisation routine etc

200 POKE nn,code: REM Place the allophone code in address nn

210 RANDOMIZE USR START: REM Call the routine to output the code, etc.

Lines 200 and 210 (or whatever) would simply be executed repeatedly with different codes to produce complete words. Complete programs can be developed in BASIC which will generate quite complex sentences, however, as Mr. Harper points out, LOGO contains many procedures which offer powerful word/list handling capability and thus is better suited as a software environment from which to drive the allophone generator chip.

Mr. Harper has provided four LOGO procedures (fully documented in our latest *Update*). Anyone unfamiliar with the language is, however, advised to refer to the Spectrum LOGO manual for further information. The first procedure, START, loads the machine into an array L then calls MCODE which pokes (.DEPOSIT) the codes into the appropriate storage locations. START then calls (.CALL) the routine which sets up the PIO.

The second procedure, MCODE, places the machine code into RAM. Space must be reserved for the code by using the LOGO equivalent of CLEAR (.RESERVE N). This **must be typed in immediately LOGO has loaded**. Failure to remember this results in having to reload LOGO!

The third procedure, SAY, generates the words and sentences. It accepts individual words and phrases and passes them to the fourth procedure, TALK, which outputs the individual allophone codes.

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) stamped addressed envelope:

Mike Tooley, Dept of Tech, Brooklands Technical College, Heath Road, Weybridge, Surrey, KT13 8TT.

Next month, by popular request (and for those of you who may be still struggling with a recalcitrant Plus Two!), we shall be dealing with cassette storage problems.

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74LS00	.24	74LS55	.34	74LS156	.60	74LS258	.56
74LS01	.28	74LS73	.40	74LS157	.48	74LS259	.86
74LS02	.24	74LS74	.30	74LS158	.48	74LS260	.52
74LS03	.24	74LS75	.38	74LS160	.62	74LS265	.80
74LS04	.24	74LS76	.40	74LS161	.68	74LS266	.64
74LS05	.20	74LS83	.60	74LS162	.68	74LS273	.70
74LS08	.24	74LS85	.60	74LS163	.68	74LS279	.61
74LS09	.25	74LS86	.50	74LS164	.68	74LS283	.72
74LS10	.25	74LS90	.46	74LS165	.80	74LS290	.72
74LS11	.25	74LS92	.46	74LS166	1.20	74LS293	.72
74LS12	.25	74LS93	.82	74LS170	1.40	74LS295	2.41
74LS13	.32	74LS95	1.15	74LS173	.68	74LS298	1.78
74LS14	.40	74LS96	1.40	74LS174	.58	74LS299	4.14
74LS15	.24	74LS107	.30	74LS175	.58	74LS365	.55
74LS20	.24	74LS109	.30	74LS191	.75	74LS366	.55
74LS21	.26	74LS112	.40	74LS192	.75	74LS367	.55
74LS22	.26	74LS113	.40	74LS193	.75	74LS368	.55
74LS26	.26	74LS122	1.03	74LS194	1.10	74LS373	.74
74LS27	.26	74LS123	.70	74LS195	.68	74LS374	.74
74LS28	1.20	74LS125	.71	74LS197	.68	74LS375	.55
74LS30	.25	74LS126	.40	74LS221	.80	74LS377	.98
74LS32	.25	74LS132	.50	74LS240	.83	74LS390	.74
74LS33	.25	74LS133	.95	74LS241	.80	74LS393	.74
74LS37	.25	74LS136	.40	74LS242	.75	74LS399	1.18
74LS38	.25	74LS138	.84	74LS243	.75	74LS541	1.40
74LS40	.25	74LS139	.80	74LS244	.75	Z80A	1.80
74LS42	.40	74LS145	.90	74LS245	.75	Z80APIO	1.90
74LS47	.89	74LS148	1.30	74LS247	.80	Z80ACTC	2.10
74LS48	.90	74LS151	.50	74LS248	1.04	Z80ADMA	4.80
74LS49	.90	74LS153	.50	74LS251	.56	Z80ADART	4.80
74LS51	.26	74LS154	1.50	74LS253	.56	Z80ASIO1	4.80
74LS54	.34	74LS155	.60	74LS257	.92	8085AHC	3.40

DIODES

1N4001	1A	50v	5p
1N4002	1A	100v	5p
1N4003	1A	200v	6p
1N4004	1A	400v	6p
1N4005	1A	600v	7p
1N4006	1A	800v	8p
1N4007	1A	1000v	8p
1N4148			4p
1N5400	3A	50v	13p
1N5401	3A	100v	14p
1N5402	3A	200v	16p
1N5404	3A	400v	18p
1N5406	3A	600v	19p
1N5407	3A	800v	20p
1N5408	3A	1000v	22p

ZENERS

BZY88 RANGE	500mw	9p
BZX61 RANGE	1.3w	16p

VOLTAGE REGULATORS

7805	1A	5v	50p
7812	1A	12v	50p
7824	1A	24v	78p
7905	1A	−5v	55p
7912	1A	−12v	55p
7915	1A	−15v	55p
78L05	.1A	5v	[illegible]
78L12	.1A	12v	[illegible]
78L15	.1A	15v	[illegible]
79L05	.1A	−5v	[illegible]
79L12	.1A	−12v	[illegible]
79L15	.1A	−15v	36p

LM317K 1.5A 1.2v to 37v voltage regulator £2.30

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DIGITAL Trouble Shooting

Part Five

MIKE TOOLEY BA

Our nine part series on Digital Troubleshooting 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.

IN PART four of our *Digital Troubleshooting* we introduced some common i.c. timers and showed how these versatile devices can be used as monostable and astable pulse generators. This month, we turn to another new topic—microprocessors. We will describe the basic characteristics of four of the most commonly used 8-bit microprocessors as well as giving a number of pointers to fault-finding in systems based on such devices.

For the benefit of those who have not yet got to grips with the new technology, we shall begin with a general introduction to microprocessors and microprocessor based systems. Our companion Digital Test Gear project involves the construction of an integrated circuit tester which can be used to carry out simple "go"/"no-go" testing of the majority of common TTL and CMOS devices.

MICROPROCESSORS

Microprocessors are VLSI and SLSI integrated circuit devices which are capable of accepting, decoding and executing instructions presented to them in binary coded form. Microprocessors form the "heart" of all microcomputer systems. However, they are not, in themselves, "computers" since they require a certain amount of external hardware and other support devices, not the least important of which is those which provide a "memory" for the sequence of software instructions (i.e. "programs") and transient information (i.e. "data") used during processing.

Some specialised microprocessors incorporate their own internal memory (for data and program storage), and input/output ports. These devices require a minimum of external support circuitry and are ideal for use in low-cost control systems. They are rather aptly known as "single-chip microcomputers".

Microprocessors can be divided into two categories depending upon the size of the binary number on which they fundamentally perform operations. Most modern microprocessors perform operations on groups of either eight or sixteen binary digits (bits). Clearly, 16-bit microprocessors will tend to be more powerful than their 8-bit counterparts. However, for many purposes there is little to choose between the two. Indeed, the relative cost and complexity of 16-bit microprocessors make them generally unsuitable for control applications. Hence, for the purpose of this series, we shall concentrate on 8 rather than 16-bit devices.

An 8-bit microprocessor fetches and outputs data in groups of 8-bits (known as "bytes"). This data is moved around on eight separate lines (labelled D0 to D7) known as a "data bus". Microprocessors determine the source of data (when it is being "read") and the destination of data (when it is being "written") by outputing the location of the data in the form of a unique "address". This process involves placing a binary pattern on an "address bus". In the case of 8-bit microprocessors, the address bus invariably comprises sixteen separate lines, labelled A0 to A15.

The address at which the data is to be placed or from which it is to be fetched can either constitute part of the "memory" of the system (e.g. RAM or ROM) or can be considered to be "input/output" (I/O). The allocation of the 64K memory address range of an 8-bit microprocessor can usefully be described using a "memory map" (see later).

A further bus is used for determining the direction of data movement (i.e. whether a "read" or "write" operation is being performed) and for other general housekeeping functions, such as "reset". This bus is known as the "control bus" and often has between five and thirteen lines depending upon the microprocessor.

HISTORY

The first generation of 8-bit microprocessors appeared a little over fourteen years ago in the shape of an Intel device, the 8008. At the time, this was something of a minor miracle—a device which could replace countless other chips and which could address a staggering 16K of memory! By modern standards, the 8008 is extremely crude but it was not long before Intel introduced another device, the 8080. This time NMOS technology was employed instead of the PMOS technology which was used in the 8008. The 8080 had sixteen address lines (thus being able to address 64K of memory) and 78 software instructions for the programmer to use. The 8080 was an instant success and led the way to enhanced devices such as the 8085 and "all-singing-all-dancing" Z80.

Other manufacturers were also developing microprocessor chips hard on the heels of Intel. These included Motorola (with the 6800) and MOS Technology (with the 6502). In subsequent years industry has not been content to stand still and much effort has been devoted into huge advances into 16 and 32-bit technology. Despite this, all of these simple 8-bit microprocessors (and their various enhancements and derivatives) are still in common use today. Costs have fallen very significantly and it is eminently possible to put together a microprocessor system (comprising CPU and a handful of support chips) at a very moderate cost. Hence, if one had the task of designing, for example, an environmental control system, one would almost certainly use a microprocessor (or single-chip microcomputer) to form the basis of the controller.

Not only would such a system be capable of fulfilling all of the functions of its conventional counterpart but it would also provide us with a far more sophisticated means of processing our data coupled with the ability to store it and examine it at a later date or even transmit it to a remote supervisory computer installation. The vast saving in hardware development can usefully be devoted to the software aspects of a project and future modifications can simply involve the substitution of "firmware" (ROM based software).

INTERNAL ARCHITECTURE

The principal internal elements of a microprocessor are as follows:

(a) registers for temporary storage of instructions, data, and addresses
(b) an arithmetic logic unit (ALU) able to perform a variety of arithmetic and logic functions

(c) control logic which accepts and generates external control signals (such as "read" and "write") and provides timing signals for the entire system.

The internal arrangement (or "architecture") of a microprocessor tends to vary from one family to another. There are, however, a number of common themes. The major microprocessor families, for example, tend to retain a high degree of upward compatability both in terms of internal architecture and the software "instruction set" and this is clearly an important consideration in making a new product attractive to the equipment manufacturer.

Internal registers are simply arrangements of bistable latches (see Part Three) into which data (in binary form) can be placed during processing. Some registers are directly accessible to the programmer (i.e. he can set or read their contents at will) whilst others are reserved for the machine's own use. Registers may also be classified as "dedicated" (i.e. they have a specific purpose such as pointing to a memory location or holding the results of an ALU operation) whilst others are described as "general purpose".

The following registers are particularly important:

Program Counter (PC) or Instruction Pointer (IP)

The program counter (or instruction pointer) of an 8-bit microprocessor is invariably a 16-bit register which contains the address of the next instruction byte to be executed. The contents of the program counter (or instruction register) is automatically incremented each time an instruction byte is fetched.

Accumulator (A)

The accumulator functions both as a source and destination register; not only is it the source of one of the data bytes required for an ALU operation but it is also the location in which the result of an ALU operation is placed. In the case of 8-bit microprocessors, the accumulator is naturally an 8-bit register!

Flag Register (F), Status Register (S), Condition Code Register (CCR)

The flag (or status or condition code) register contains information on the internal status of the microprocessor and, in particular, signals the result of the last ALU operation. It is important to note that the flag register is not a register in the conventional sense; it is simply a collection of bistable latches which can be "set" or "reset" depending upon the result of an ALU operation. The output of each bistable can be considered to act as a "flag". Commonly available flags are; zero (Z), overflow (V), negative (N), and carry (C).

Stack Pointer (SP)

Most microprocessor needs to have access to an external area of read/write memory (RAM) which permits temporary storage of data. This area of memory is known as a "stack" and it may typically occupy between 16 and 256 bytes of memory. (Note, however, that the stack is a dynamic structure and its size varies continuously during processing).

The stack operates on a "last-in first-out" (LIFO) basis; data is "pushed" onto the stack and later "pulled" off it. The "stack pointer" keeps track of the extent of the stack by holding the address of the last used stack location. Some popular microprocessors (e.g. 6809) have two independent stack pointers; a "system stack pointer" (SSP) and a "user stack pointer", (USP).

Instruction register

The instruction register is not directly accessible to the programmer but is used to contain the current instruction byte so that it can be decoded by an arrangement of logic gates known as an "instruction decoder". The outputs from the instruction decoder are passed to the microprocessor's control logic which, amongst other things, determines the direction of data transfers and responds to external signals which arrive on the control bus.

The simplified internal architecture of a typical 8-bit microprocessor is shown in Fig. 5.1. Note that the external bus lines are isolated from the internal bus lines by means of "buffers" and that a high-speed internal bus is used to link the principal internal elements.

EXTERNAL CONTROL LINES

We will now briefly discuss the function of each of the more important external control lines provided by some common microprocessors:

Read/Write (R/$\overline{W}$)

This line is taken low when the microprocessor is performing a "write" operation or high when the microprocessor is performing a "read" operation. Some microprocessors (e.g. Z80) have separate $\overline{READ}$ and $\overline{WRITE}$ lines.

Interrupt request ($\overline{IRQ}$, $\overline{INT}$)

This line serves as an input to the microprocessor and is taken low by an external device wishing to signal the fact that it requires attention. Provided the "interrupt flag" is reset (i.e. logic 0) this request will be honoured and the microprocessor will cease normal processing and execute the required "interrupt service routine".

Non-maskable interrupt ($\overline{NMI}$)

The response to an ordinary interrupt ($\overline{IRQ}$ or $\overline{INT}$) is determined by the interrupt status flag and thus the interrupt may be "masked". Instructions may be placed within the program which "set" or "reset" the interrupt flag hence disabling or enabling interrupts. This technique provides us with a flexible method of responding to interrupts; we can accept them or reject them at will! There are, however, some situations in which it is desirable that an interrupt should be serviced regardless of what else is going on. Hence a separate "non-maskable interrupt" line is provided. When this line is taken low, normal program execution is interrupted regardless of the state of the interrupt flag (i.e. regardless of whether interrupts are currently enabled or disabled).

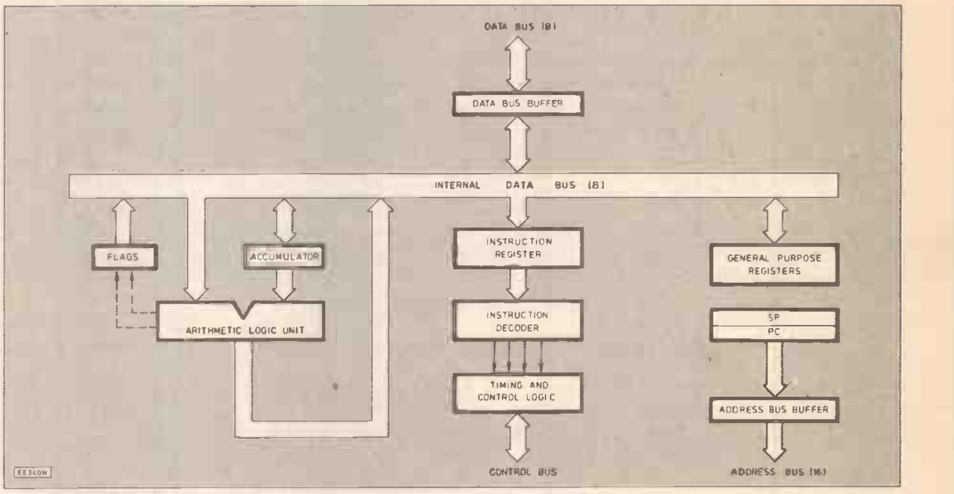


Fig. 5.1. Simplified internal architecture of a representative 8-bit microprocessor.

Reset ($\overline{RES}$)

This active low input to the microprocessor is used to initialise the system into a known state prior to normal execution of the program. When the reset line is taken low, the program counter (PC) is placed in a defined state (either by loading it with zero or by placing a pre-defined address "vector" in it) and interrupts are disabled. Various other internal operations are performed which tend to vary from processor to processor.

CLOCKS

In order that data flow within a microprocessor is orderly, it is necessary to synchronise all data transfers using a clock signal. This signal may be generated by an external oscillator (see Fig. 5.2) or equivalent circuitry may be provided inside the microprocessor chip. For accuracy and stability, microprocessor clocks are invariably crystal controlled and usually function within the range 1MHz to 8MHz.

A clock cycle (known as a T-state) is the fundamental timing interval used by the microprocessor. A "machine cycle" (M-cycle) is the smallest indivisible unit of microprocessor activity and usually comprises between three and five T-states. An instruction cycle (i.e. that associated with fetching an instruction, decoding and executing it) normally requires between one and five M-cycles.

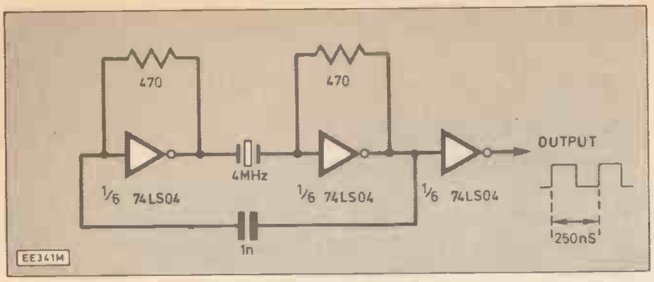


Fig. 5.2. Typical microprocessor clock circuit.

To put this into context it is worth considering what sort of time interval we are talking about. Suppose that we are dealing with a Z80 microprocessor operating at 4MHz. The fundamental clock cycle (T-state) will be 250ns. A machine cycle (M-cycle) will then occupy from 0·75µs to 1·25µs whereas an instruction cycle will require some 1·25µs to 6·25µs depending upon its complexity. To put this another way, the microprocessor is capable of executing between 160,000 and 800,000 instructions every second!

MICROPROCESSOR SYSTEMS

Even the most sophisticated microprocessor is of little use unless supported by a number of other devices. These can be divided into three main groups:

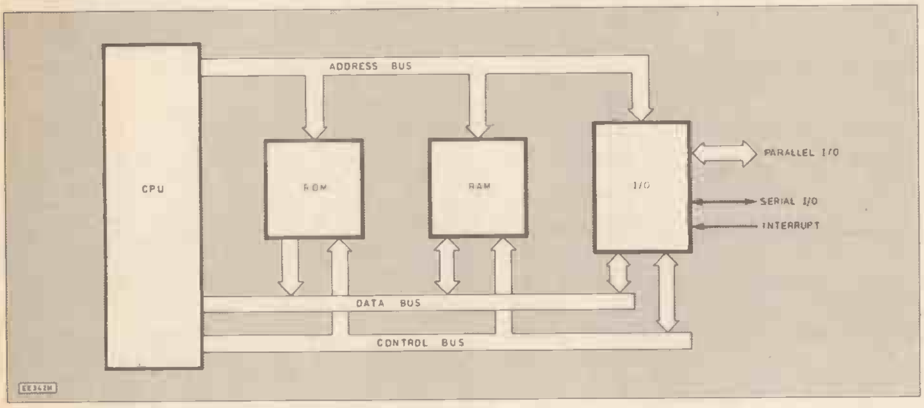


Fig. 5.3 Basic elements of a microprocessor system.

Random access memory (RAM)

As explained earlier, all microprocessors require access to read/write memory and, whilst single-chip microcomputers contain their own low-capacity area of read/write memory, this is invariably provided by means of a number of semiconductor random access memories. (These will be explained more fully next month).

Read-only memory (ROM)

Microprocessors generally also require more permanent storage for their control programs and, where appropriate, operating systems and high-level language interpreters. This is invariably provided by means of semiconductor read-only memories. (These will also be examined next month).

Input/output devices (I/O)

To fulfil any useful function, the microprocessor needs to have links with the outside world. These are usually supplied by means of one, or more, VLSI devices which may be configured under software control and are thus said to be "programmable". I/O devices fall into two general categories; "parallel" (a byte is transferred at a time) or "serial" (one bit is transferred after another along a single line).

The basic configuration of a microprocessor system is shown in Fig 5.3, the principal elements shown are; microprocessor (CPU), ROM, RAM, and I/O. Note that the three bus systems; address, data, and control are used to link the elements and thus an essential requirement of a support device is that it should have "tri-state" outputs. It can thus be disconnected from the bus when it is not required.

Support devices (such as ROM, RAM etc) are invariably "enabled" or "selected" by taking their active-low enable ($\overline{EN}$) or chip select ($\overline{CS}$) lines low. These lines are usually driven by address decoding logic with inputs driven from the address bus. The address decoder effectively divides the available memory into blocks which each correspond to a particular support device. Hence, where the processor is reading and writing to RAM, for example, the address decoding logic will ensure that only the RAM is selected and the internal buffers in the ROM and I/O chips are kept in the tri-state output condition.

The allocation of memory space within a microprocessor system can be usefully illustrated by means of a "memory map". An 8-bit microprocessor having 16 address lines can address any one of 65536 (2^{16}) different memory locations and thus the memory map will range from 0 to 65535 (the highest address possible). Fig. 4 shows a typical memory map in which addresses are given both in decimal and hexadecimal. A block of 24K of RAM is provided as are two adjacent 8K blocks of ROM (each contained within a different memory chip). A further 8K block is assigned to I/O. The two remaining 8K blocks are "unpopulated" and are thus available for "expansion".

MICROPROCESSOR FAULT FINDING

Fault-finding on microprocessor systems can be a daunting task, particularly when one is a relative newcomer! There is, however, no need to despair since many faults are quite trivial and can be detected with basic test gear. Wherever possible, it is useful to obtain a circuit diagram and service information on the equipment before starting work as this will often point the way to "stock faults" which may be prevalent on a particular item of equipment.

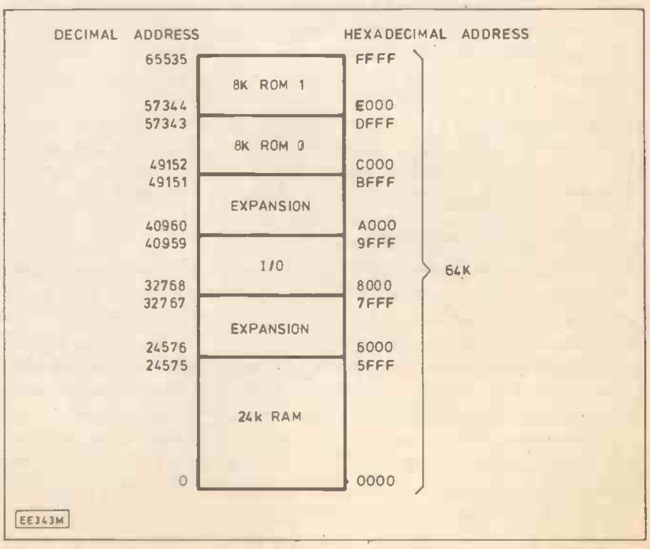
A good starting point after gaining access to the circuit board is to identify all the major devices, including the microprocessor and support chips. Semiconductor memory is usually grouped together and should be fairly easy to spot (see next month for more information) whilst the I/O devices tend to be grouped near to their respective connectors. The clock circuit should be easily recognised by looking for the crystal whilst the address decoding will either be provided by means of LS-TTL logic or by custom logic arrays (PLA or ULA chips).

Having found one's way around and identified the principal chips, the general procedure involves answering the following questions:

(a) What state is the sytem in—is there any display produced or does the system appear to be totally "dead"? If the latter is the case, check the power supply first starting, of course, with the main +5V supply rail. If this is low (or zero) disconnect the supply from the system p.c.b. and establish whether the absence of power is due to failure of the power supply or excessive loading due to short-circuit failure within the system itself.

(b) Press the "reset" button and see if there are any changes. If a "partial" reset occurs (i.e. if a copyright message is displayed or if some initial prompt appears) the fault is unlikely to be within the microprocessor itself and is likely to be attributable to failure of a support device (e.g. RAM).

Fig. 5.4. Typical memory map for an 8-bit microprocessor control system.



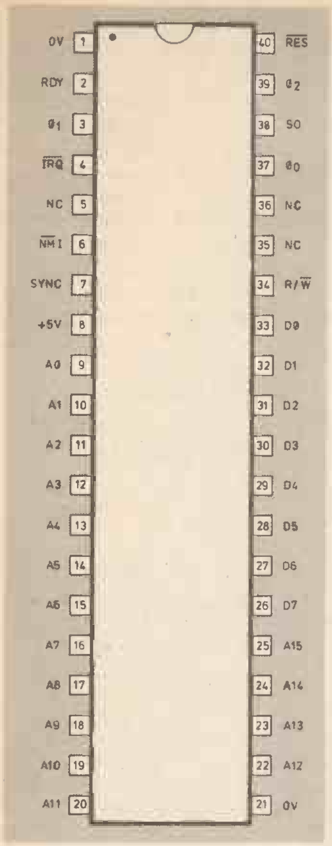


Fig. 5.5. Pin connections for the 6502 microprocessor.

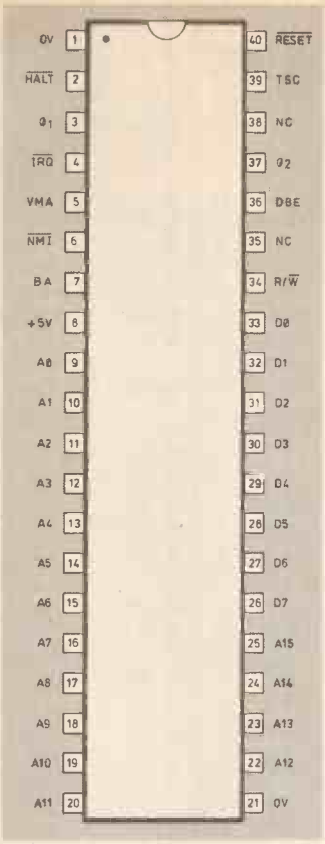


Fig. 5.6. Pin connections for the 6800 microprocessor.

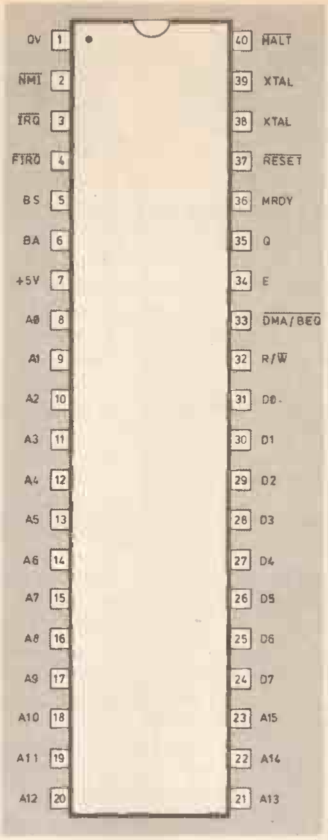


Fig. 5.7. Pin connections for the 6809 microprocessor.

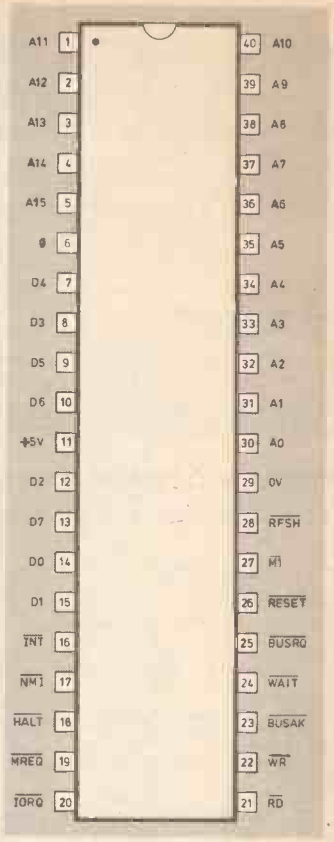


Fig. 5.8. Pin connections for the Z80 microprocessor.

(c) If the fault is intermittent (the system runs for a time before "locking up" at an unpredictable point) check all "off-board" connectors. Indirect edge connectors are very prone to poor connections and should be regularly cleaned to prevent problems such as this. If the principal chips are socketed these, too, can cause problems. Gently press each of the larger chips into its socket to see if normal operation can be restored. In some cases it may be necessary to carefully remove the chips before replacing them; the action of removal and replacement can be instrumental in wiping the contacts clean!

(d) If the microprocessor appears to be running and the fault is not intermittent in nature, the next stage involves a few simple checks of the control signals present at the microprocessor itself. Figs. 5.5 to 5.8 show the pin connections for four popular 8-bit microprocessors. In each case, use a logic probe (see Part Two) to confirm that:

(i) The clock input is active (i.e. a pulse is indicated). If this is not the case, check the clock circuitry.

(ii) The reset line is not held permanently low (also check that the line goes low for a short period when the reset button is depressed). If this is not the case, check the reset circuitry.

(iii) The non-maskable interrupt is not permanently held low. If the line is permanently low try disconnecting external devices until it clears. Also check the I/O chip (this can be temporarily removed from its socket after disconnecting power, of course) to see if the fault clears.

(iv) The read and write (or read/write) lines are active. If the microprocessor is fetching instructions and executing them, these lines should be pulsing continuously. If this is not the case, depress the reset button to see whether there is any brief activity on the read line. If the line is static and reset is occurring the problem is likely to be attributable to the microprocessor itself.

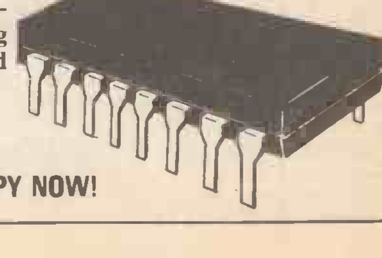
(e) If the previous stage fails to pinpoint the problem, apply the logic probe to each of the data and address lines in turn (if you have access to an oscilloscope this may be usefully employed at this stage). Examine the signal present on each line and, if any line is permanently "low" or "high" (i.e. "stuck") or permanently "tri-state" (i.e. "floating") disconnect the power and remove each support device in turn until the fault clears. If it does not clear, the fault may be attributable to the failure of one of the microprocessor's internal buffers. It will then be necessary to remove and replace the microprocessor itself.

(f) Finally, and if all else fails, the following "less scientific" (but nevertheless effective!) measures should be tried:

(i) Leave the sytem running for some time. Then touch the centre of each chip in turn in order to ascertain its working temperature. If a chip is running distinctly hot (i.e. very warm or too hot to comfortably touch) it should be considered a prime suspect. (If possible, compare with the heat produced by a similar chip fitted in the same unit or in another functional unit).

(ii) Where the larger chips have been fitted in sockets, carefully remove and replace each one in turn (disconnecting the power, of course, during the process). Replace with known functional devices.

Next month we shall be dealing with semiconductor memories and our companion Digital Test Gear Project involves the construction of a Current Tracer which can be invaluable in detecting failed chips and components.



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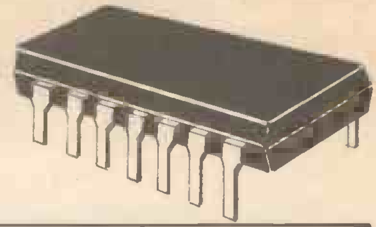


MIKE TOOLEY BA

Is it Go? Is it No-Go? Remove the guess-work with this low cost Tester

OUR fifth Digital Test Gear Project deals with the construction of a Digital I.C. Tester. This unit provides a means of testing many of the most commonly used TTL and CMOS logic gates without having to remove them from the circuit in which they are connected. The instrument described has been designed for 14-pin d.i.l. devices having "standard" supply connections (i.e. pins 7 and 14 respectively connected to 0V and +5V). If desired, the design may be readily modified for other supply conventions or for 16-pin devices.

In order to test a given i.c., all that is required is a functional device of the same type and a knowledge of the pin-connections of the chip in question. In common with our other Digital Test Gear Projects, the Digital I.C. Tester uses low-cost readily available components and is based on a standard Verobox and Veroboard.

CIRCUIT DESCRIPTION

Before describing the circuit of the digital i.c. tester it is worth spending a little time explaining the principle upon which the device operates. Happily, this is quite simple; by duplicating the logical function of the device on test (using a known functional device of the same type) and then comparing the output produced by the suspect device with that produced by the functional device, we can establish whether, or not, the device is faulty.

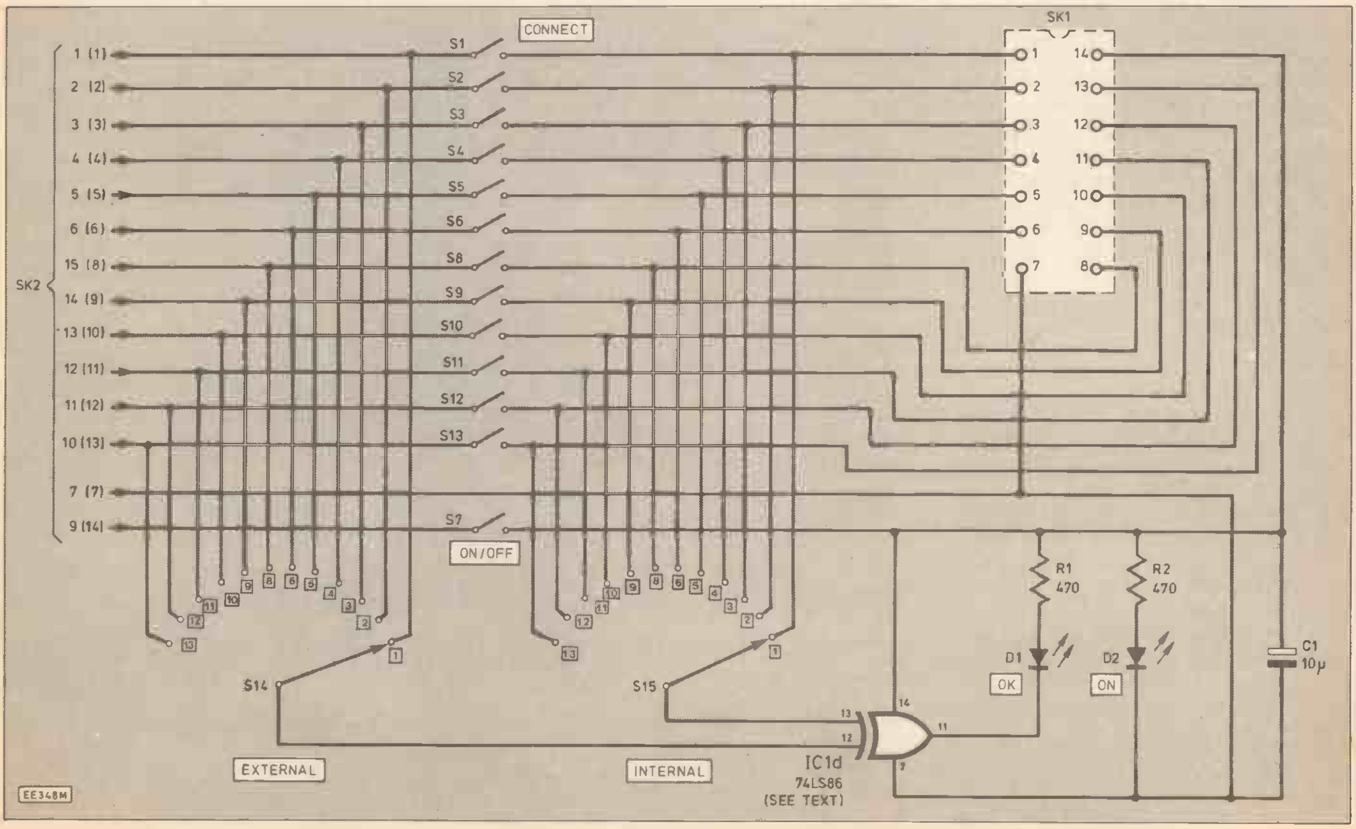
The comparison may be carried out using nothing more than an exclusive-OR gate (see Part Two for details). When the inputs of an exclusive-OR gate are similar (i.e. both low or both high) the output of the gate will be low. Conversely, where there is a difference in the logical states of the gate's inputs the output of the gate will go high.

The complete circuit of the Digital I.C. Tester is shown in Fig. 1. Inputs from the suspect device are obtained by placing an i.c. test clip or "glomper" onto the chip in question. The test chip is connected to the tester by means of a short length of ribbon cable which terminates at a 15-pin D-type connector, SK2. The pins on which logical signals may be found (i.e. pins 1 to 6 and 8 to 13) are connected to a bank of single-pole switches (S1 to S13 excluding S7). Note that these switches have been numbered to correspond with the pin numbers in question.

Switches S1 to S13 (excluding S7) facilitate direct connection of the pins of the suspect device with the corresponding pins of the known device which is inserted into a 14-pin d.i.l. socket, SK2. It is important to note that, in normal use ONLY THE INPUT pins are linked by means of the "connect" switches. When testing a 7400 quad two-input NAND gate, for example, the following "connect" switches should be placed in the "on" position; 1, 2, 4, 5, 9, 10, 12 and 13.

The pins used for comparison purposes are selected by means of S14 ("external") and S15 ("internal"). When testing a 7400 device, for example, these should both be switched, in turn, to; 3, 6, 8 and 11. The result of the comparison is indicated by means of D1. This l.e.d. is illuminated

Fig. 1. Complete circuit diagram for the Digital IC Tester. The numbers inside the "squares" around switches S14 and S15 refer to the front panel labels and pin selection of the test socket SK1.



COMPONENTS

Approx. cost Guidance only £25

See Shop Talk Page 135

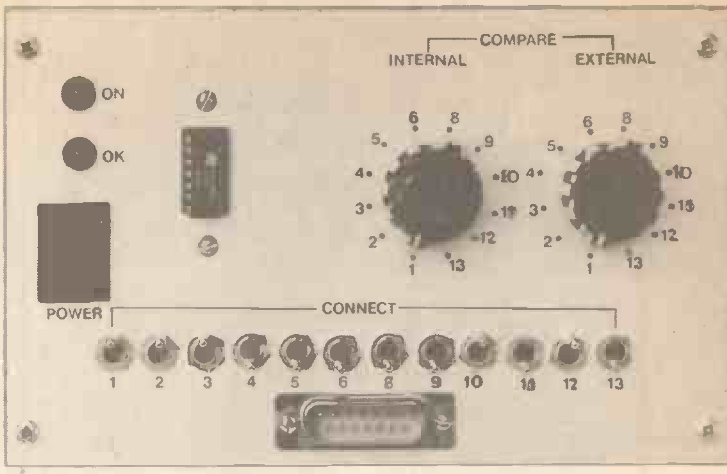
Resistors
R1 470
R2 470
Both 0·25W 5% carbon

Capacitor
C1 10µ p.c. elect. 16V

Semiconductors
IC1 74LS86
D1 red l.e.d. (fitted with bezel)
D2 green l.e.d. (fitted with bezel)

Miscellaneous
S1 to S6 and S8 to S13 miniature s.p.d.t. toggle switches (12 off)
S7 s.p.d.t. rocker switch
S14, S15 1-pole 12-way rotary switches (2 off)
SK1 14-pin low-profile d.i.l. socket
SK2 15-pin D-type chassis mounting plug
PL1 15-pin D-type cable mounting socket

14-pin i.c. test clip; 14-pin low-profile d.i.l. socket (2 off); 500mm length of 14-way ribbon cable; case, Verobox measuring 205 × 140 × 110mm approx.; Veroboard, 0·1" matrix measuring 95 × 63mm; single-sided 1mm terminal pins (7 off); insulated threaded mounting pillars (2 off); mounting bolts (6 off); mounting nuts (2 off); knobs (2 off).



Front panel lettering and component layout of the tester.

whenever the output of IC1d goes low. This low state output results from an identical input condition and hence serves to indicate that the two devices are performing in a similar manner.

Switch S7 provides a means of interrupting the power to the i.c. tester whilst a second l.e.d., D2, serves to indicate that power is being received from the unit under test. C1 provides local decoupling of the +5V rail.

CONSTRUCTION

The i.c. tester is quite simple to construct but involves considerably more wiring than the other projects in this series. Furthermore, it is worth marking out the front panel, drilling and mounting the various controls and l.e.d. indicators before starting work on the main stripboard. SK1, in particular, should be mounted on an off-cut of stripboard (the precise dimensions are immaterial) and mounted using double ended threaded pillars so that it protrudes through a small rectangular hole cut in the front panel. The i.c. socket should be soldered in place and the links between opposite sides cut (using a spot face cutter or sharp drill bit) and the various links made to the "connect" switches as shown in Fig. 3.

Components IC1d, R1, R2 and C1 are mounted on a small piece of matrix board comprising 19 strips of 17 holes. The stripboard component layout is shown in Fig. 2. Readers should note that seven track breaks are required and these should be made using a spot face cutter (e.g. Maplin stock code FL25C). If such a tool is unavailable, a sharp drill bit of appropriate size may be used.

The following sequence of component assembly is recommended; i.c. socket, link, capacitor, resistors, and terminal pins. Before mounting the Veroboard in its final position, however, constructors are advised to carefully check that components, link, and the seven track breaks have been correctly placed. Constructors should also examine the underside of the Veroboard for dry joints, solder splashes, and bridges between tracks.

When the board has been thoroughly checked, it should be mounted immediately below SK1 using the other end of the two threaded pillars used to attach the off-cut of stripboard upon which SK1 is mounted. IC1 can then be inserted into its socket, taking care to ensure correct orientation. Finally, the remainder of the wiring can be completed, as shown in Fig. 3.

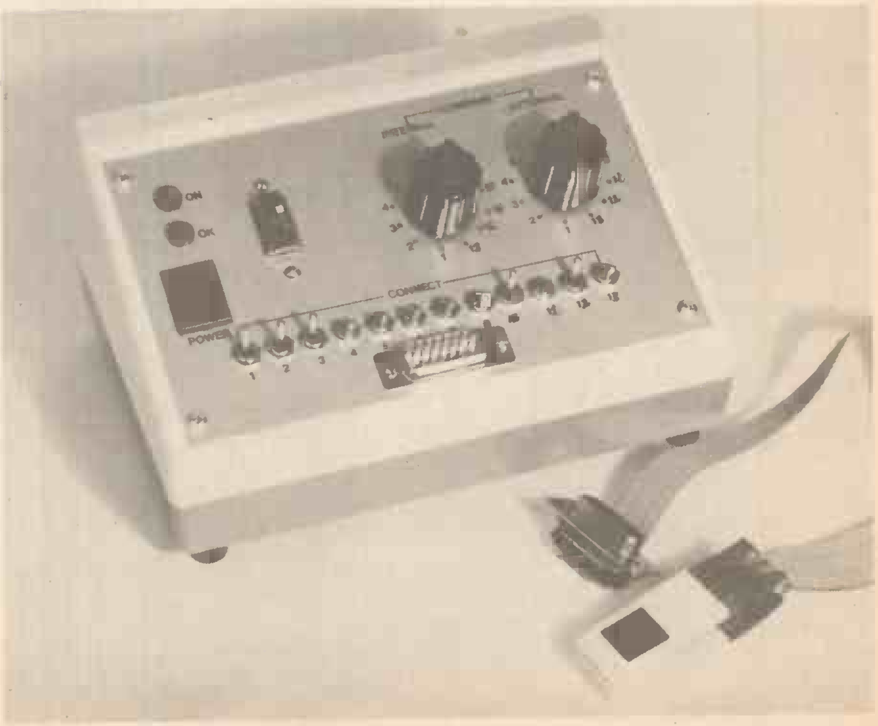
Controls, switches, indicators, and output connectors are mounted on the front panel according to the front panel photograph above and the layout shown in the interwiring diagram Fig. 3.

The i.c. test clip should be wired to a 15-pin cable-mounting D-type socket using a 500mm length of stranded ribbon cable. The pins should be connected according to the following schedule:

TEST CLIP WIRING

I.C. test clip	15-way D-connector
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	15
9	14
10	13
11	12
12	11
13	10
14	9

(Note: Pin-8 of the D-connector is unused)



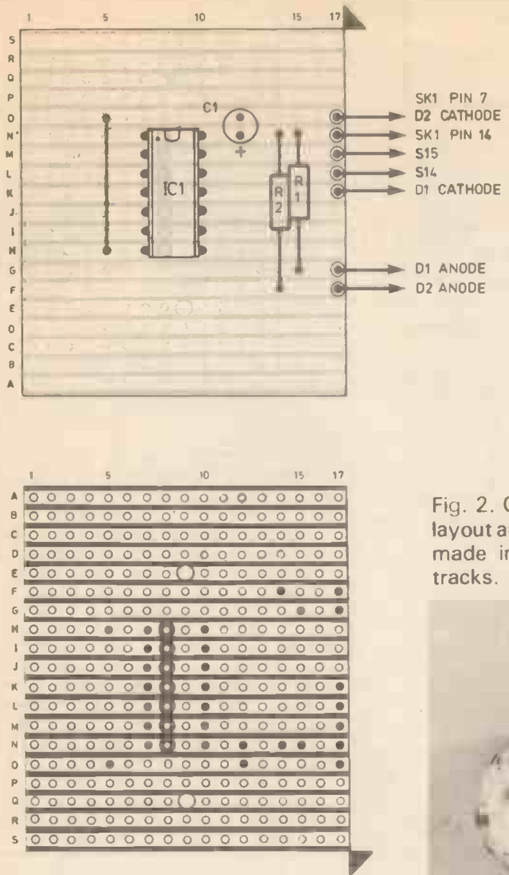


Fig. 2. Circuit board component layout and details of breaks to be made in the underside copper tracks.

Short lengths of heat-proof sleeving should be used to insulate the connections made at the test-clip. Furthermore, to assist in identification, the use of colour coded ribbon cable is highly recommended.

As usual, constructors should carefully check the internal wiring (particularly that associated with SK1 and SK2) upon completion. The "connect" switches should then all be set to the "off" position.

TESTING

In order to test the instrument it will be necessary to enlist the use of a functional item of equipment which uses a commonly available 14-pin d.i.l. i.c. having conventional pin connections. Furthermore, it will be necessary to have a known functional example of the same device to hand. The circuit selected should preferably be a low-frequency one (complications may arise in the case of high-speed logic due to the stray capacitive reactance introduced by the tester and its associated ribbon cable!).

Assuming that a 7400 device is available for use in the initial testing process; insert the known chip into SK1 (taking care to align pin-1 correctly), switch "off" the power to the circuit concerned and then connect the test clip (again, taking care to align the clip correctly using pin-1 as a reference point). Now link the inputs using the "connect" switches (using the information given earlier under "Circuit Description") and then restore the power to the circuit. Switch S7 to the "on" position and check that D2 is illuminated. (If D2 is not illuminated, switch "off" and check the wiring—including the ribbon cable, connector and test clip).

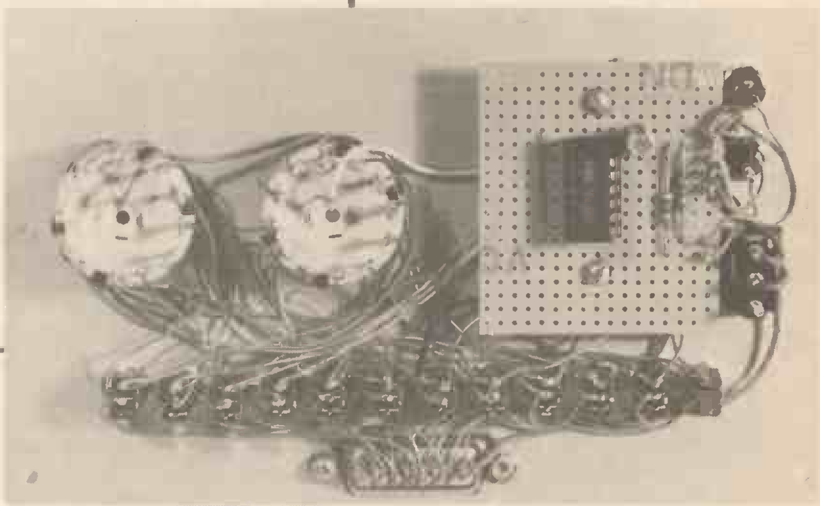
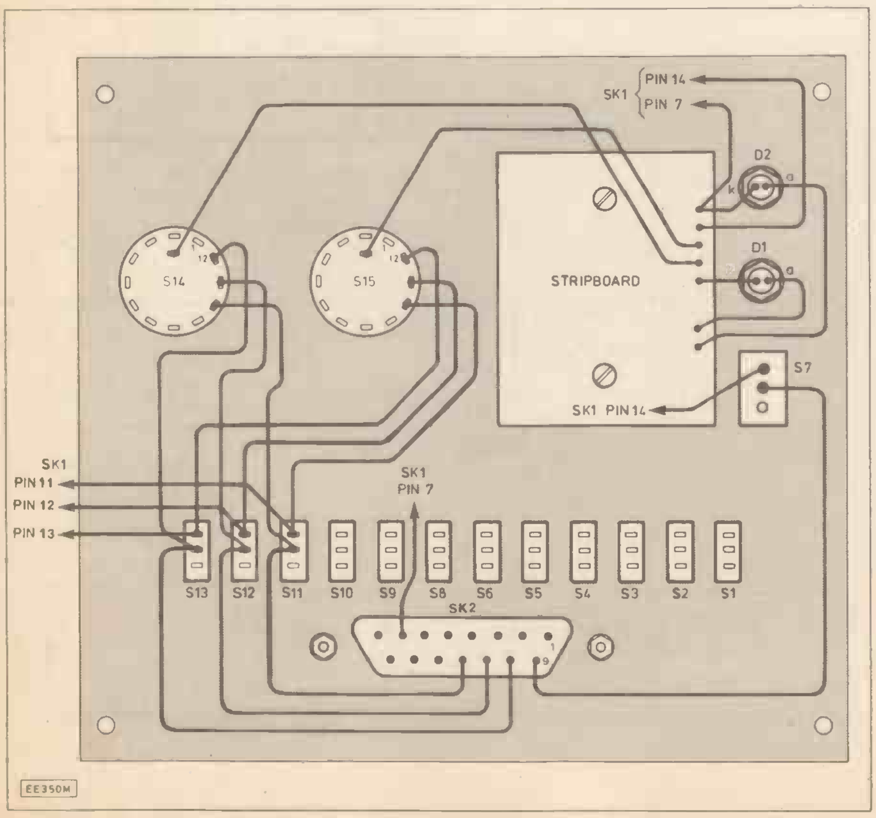
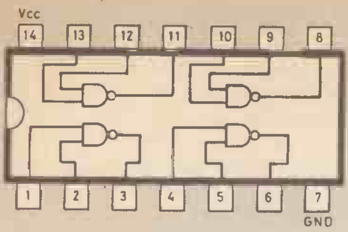


Fig. 3 (below). Interwiring between the front panel mounted components and the circuit board. The remainder of the "connect" and "compare" switch wiring follows the pattern shown.



Having checked that power is being received by the tester, turn both "compare" switches (S13 and S14) to position 3 (the output of the first NAND gate). Check that D1 becomes illuminated and remains illuminated for all conditions of the test circuit. If D1 is extinguished or is flashing this indicates that one or other of the integrated circuits is faulty (or that your wiring is not correct!). Repeat the procedure for all four gate outputs (by turning the two compare switches to positions 6, 8 and 11) and check that all four NAND gates give the same result.

The tester may also be used in reverse; where a "loose" chip is to be tested (rather than a suspect device soldered into a circuit) it may be inserted in SK1 and the i.c. test clip fitted to a functional device in a working circuit. The procedure for use is otherwise exactly the same as before. □



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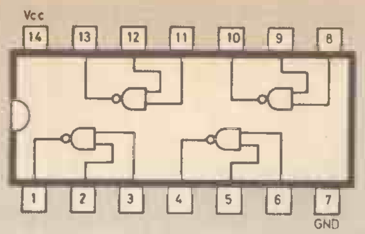

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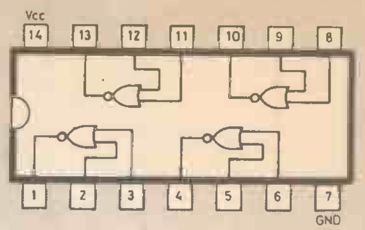

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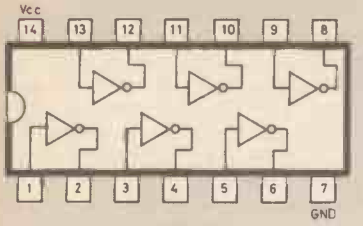
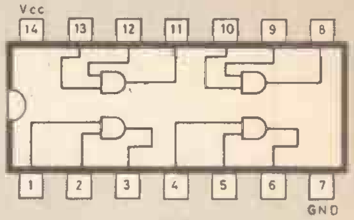


D

COMMON I.C. PIN CONNECTIONS

I.C. type	Pin-out reference
7400	A
7401	B
7402	C
7403	A
7404	D
7405	D
7406	D
7407	Q
7408	E
7409	E
7410	F
7411	G
7412	F
7413	H
7414	D
7415	G
7416	D
7417	Q
7420	I
7421	J
7422	I
7427	K
7428	A
7430	L
7432	M
7433	C
7437	A
7438	A
7440	J
7474	N
7486	O
74107	P



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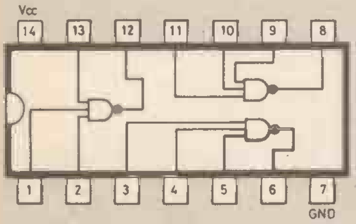

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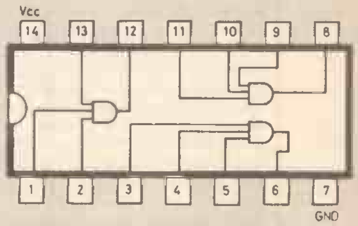

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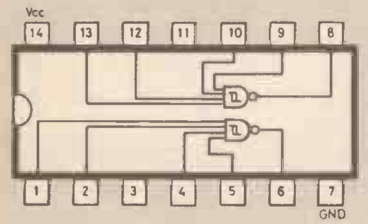

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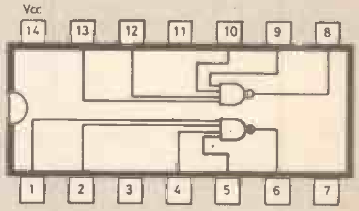

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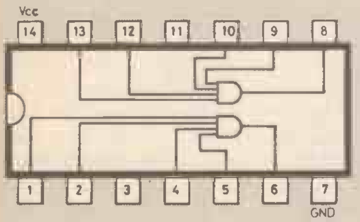

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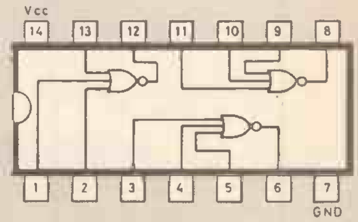

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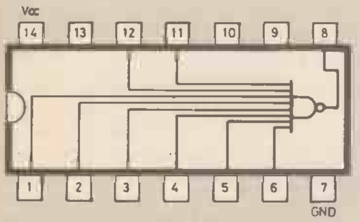

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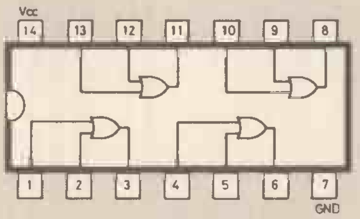

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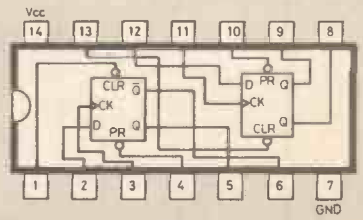

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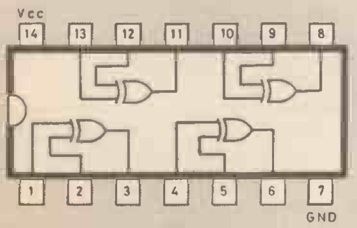

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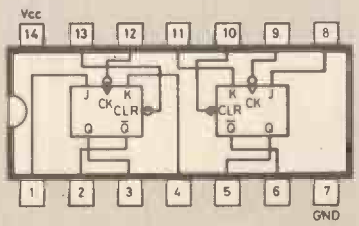

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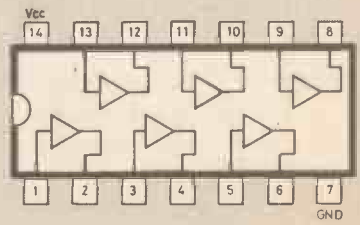

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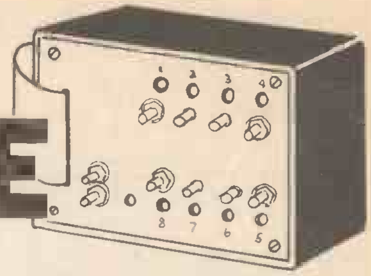
COMPUTER BUFFER/INTERFACE



R. J. EVANS

This simple output port buffer has eight channels each providing 500mA out at up to 50V

THE user port on the BBC Micro and other computer connections can, when used as outputs, only provide a very small current. It is thus first priority when using such outputs to buffer them. This applies not only when using the outputs for interfacing to other equipment, but also when using long transmission lines (i.e. over one metre with the BBC micro). Buffering also has a third function, to protect the computer.

This article describes a buffer/interface "module" which can be used in a great variety of ways to overcome many problems encountered with computers, peripherals and logic circuits. The basic ways in which it can be used are:

(1) As described here, an interface for the BBC user port suitable for experimentation and semi-permanent connection.

(2) As above, but fitted with 4mm sockets for use with educational equipment.

(3) As a line driver—the circuit board is built into a small box on the cable to overcome transmission or network problems for logic circuits.

(4) As a module used on home-constructed peripherals to avoid building special circuits each time.

The unit uses one p.c.b. and used as (1) the only cable required is for connection to the computer. The circuit is reliable, rugged, and easy and inexpensive to build.

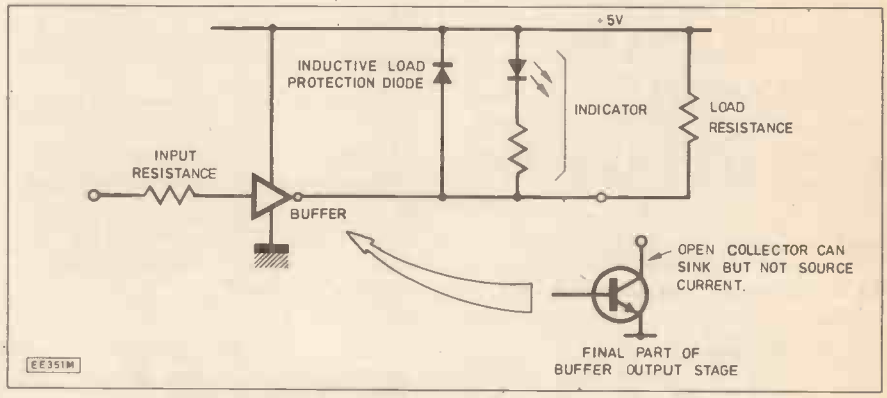


Fig. 1. Single channel arrangement for the buffer/interface.

SPECIFICATION

The unit has up to eight channels per board, and draws 0·3mA from the computer when the input is high, giving out up to

COMPONENTS

See Shop Talk page 135

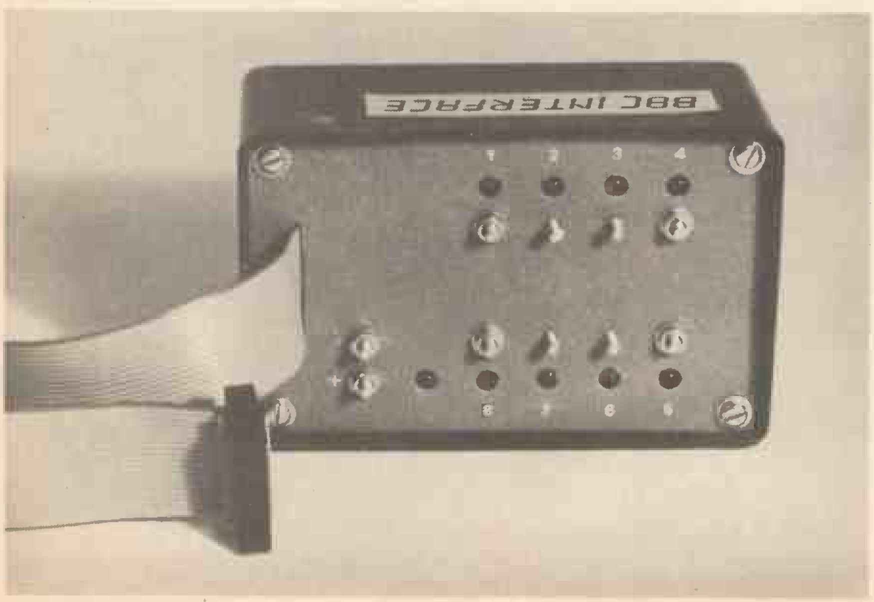
Resistors
R1 to R8 10k (8 off)
R9 to R17 220 (9 off)

Capacitor
C1 47µ axial elect. 25V

Semiconductors
IC1 ULN2001, 2003 (seven channels) ULN 2803 (eight channels)
D1 to D9 5mm dia. l.e.d. red TIL209 (9 off)

Miscellaneous
20-way IDC cable, 1m; 20-way IDC socket; 16-way i.c. socket (ULN2001,3 only); 18-way i.c. socket (ULN2803 only); M3 × 25 (6BA × 1in.) bolts (10 off); M3 (6BA) washers (20 off); M3 (6BA) nuts (20 off); Spacers, plastic, 12mm ($\frac{1}{2}$in.) (9 off); p.c.b. available from the *EE PCB Service*, order code EE560; case.

COMPONENTS approximate cost £10



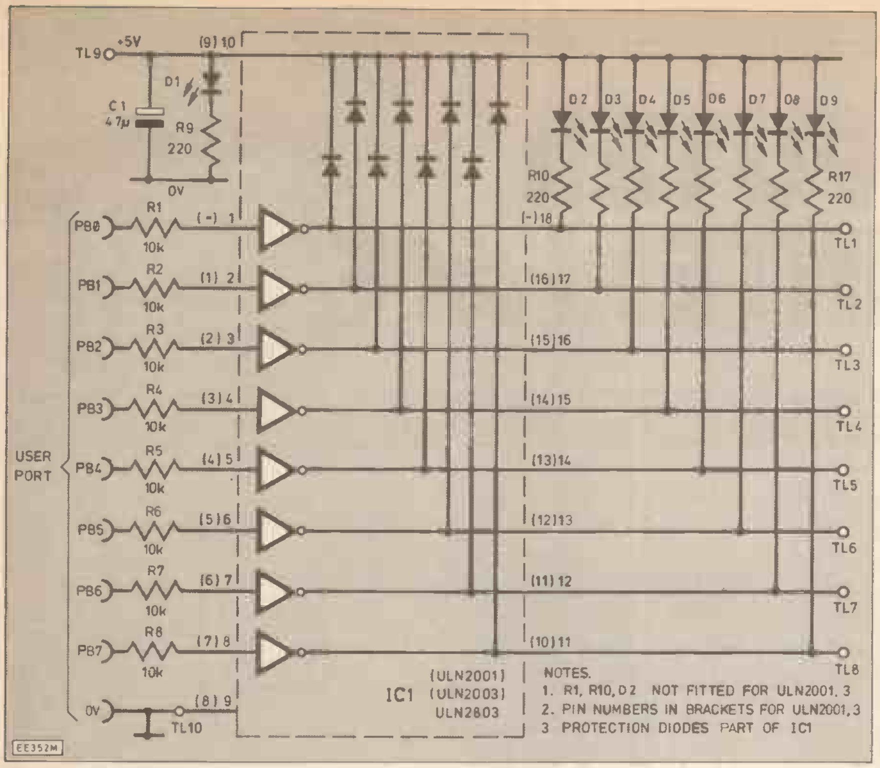
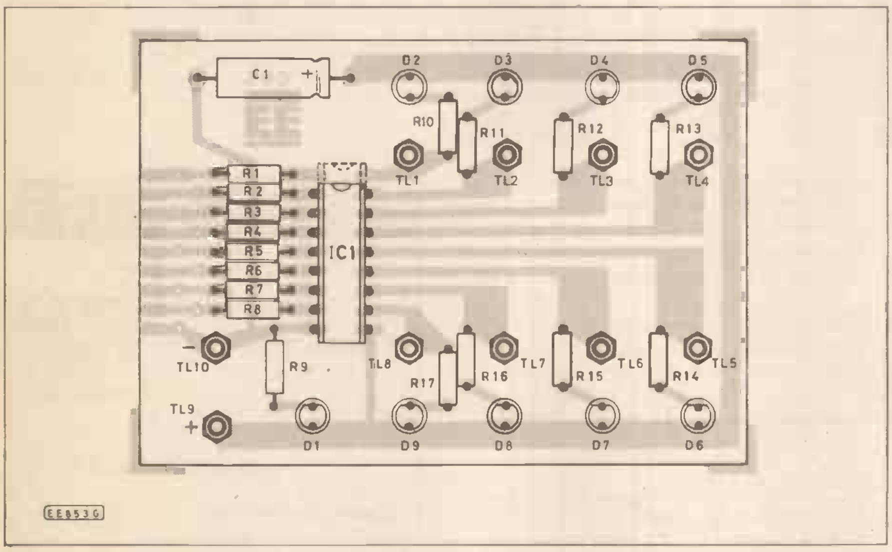
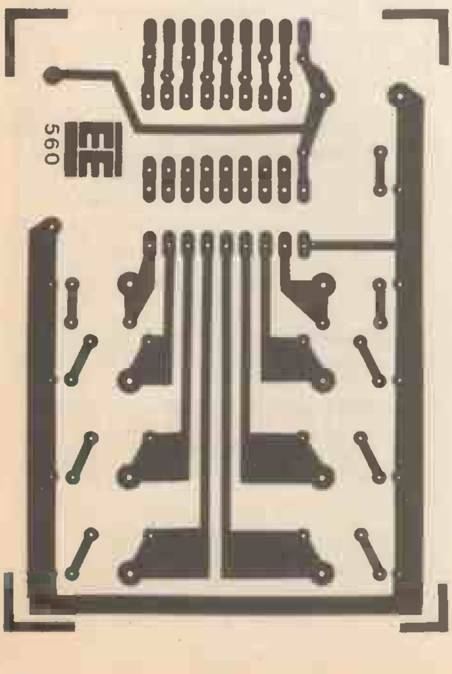


Fig. 2. Complete circuit diagram for the Computer Buffer/Interface.





500mA (a gain of over 1600). (The BBC computer and Commodore 64 can provide up to 1mA in the high state.) The output is an open-collector type, which can have a voltage across it up to 50V, though the l.e.d. resistors will need to be changed to higher values when operating at voltages over 8V (see Fig. 1).

The board does not provide pull-up resistors, which are unnecessary for an interface anyway because the load is sufficient. The channels can be chained together to provide larger maximum currents.

CIRCUIT

The circuit is based on the ULN2000 series buffer/driver i.c.s as shown in Fig. 2. The ULN2001,3 provide seven channels —the ULN2803 provides eight channels. The circuit board can be used with any of these. The indicators are optional and can be omitted if desired.

Resistors R1 and R8 are input current limiting resistors, and C1 is an optional reservoir capacitor.

CONSTRUCTION

Construction is exceptionally simple; all the components fit on the one p.c.b. The p.c.b. is shown in Fig. 3. Starting with the low-profile components on the p.c.b., the best order is resistors, i.c. socket, capacitor, l.e.d.s and last of all terminals. The terminals are made of either M3 × 25 or 6BA × 1 inch bolts, and although crude are simple, cheap and satisfactory for semi-permanent connections using solder tags or spade terminals.

After the board is assembled, check the polarity of the capacitor and l.e.d.s. The flat on the case of a l.e.d. represents the cathode. Ensure that IC1 is fitted in the socket.

The cable to the computer (in the case of the BBC computer is made up out of a length of 20-way IDC (insulation displacement connector) cable terminated in a 20-way IDC socket. After fitting the connector on the end of the cable in a vice, ascertain the connections for the p.c.b. by using a multimeter and a piece of single strand wire in the socket. The connections can be obtained by consulting the computers' user guide and then double checking by plugging the socket into the computer and measuring the output voltages for various output settings. Do not solder the other end of the cable to the board until the cable has been passed through the slot in the front panel.

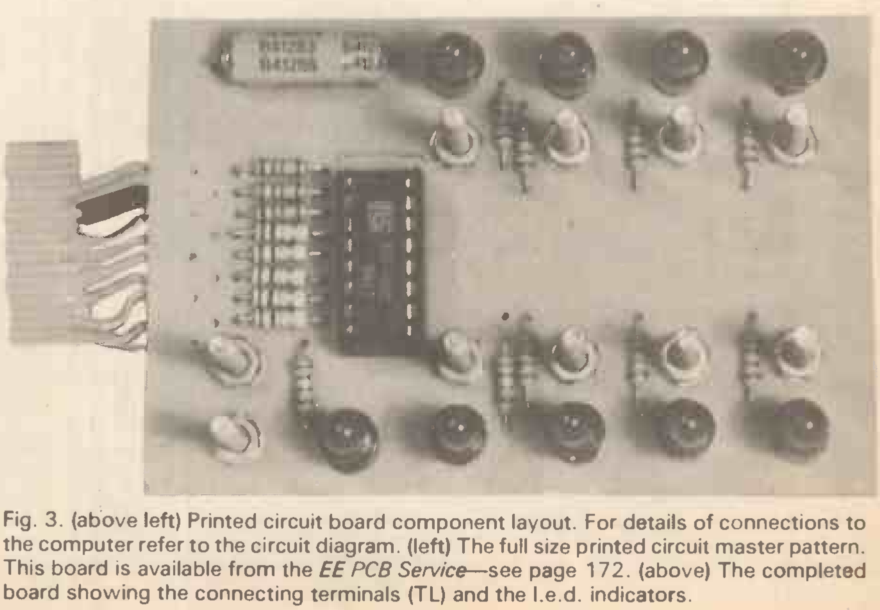


Fig. 3. (above left) Printed circuit board component layout. For details of connections to the computer refer to the circuit diagram. (left) The full size printed circuit master pattern. This board is available from the *EE PCB Service*—see page 172. (above) The completed board showing the connecting terminals (TL) and the l.e.d. indicators.

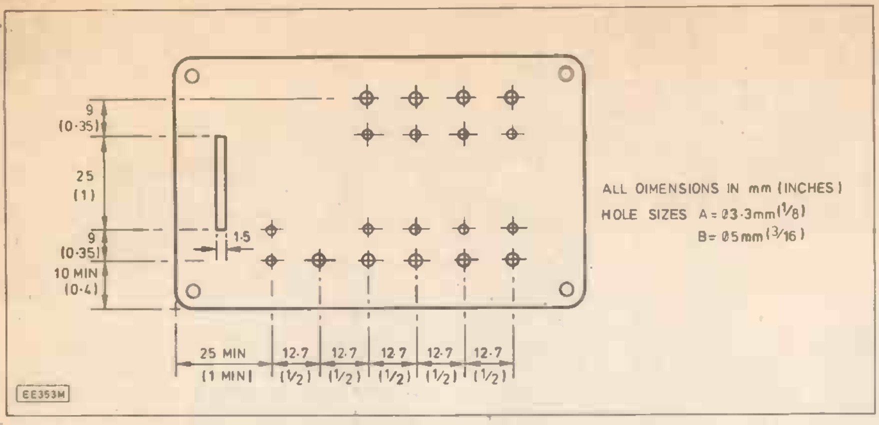


Fig. 4. Front panel drilling details and dimensions.

The front panel is made as shown in Fig. 4. The size and shape of the outside edge of the front panel will depend on the case being used. The drawing gives minimum recommended clearances after allowing for front panel mounting pillars and the p.c.b. The board is mounted in the centre of the front panel and final assembly is shown in Fig. 5. The spacers are short lengths of plastic tubing—they should have a minimum internal diameter of 3mm.

TESTING

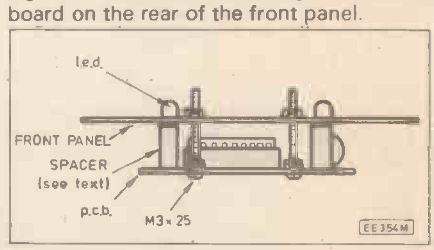
In order to test the circuit connect up 5V across the power terminals. The l.e.d. next to them should light. If it does not check the polarity of the connections—the negative terminal is above the positive one. Then, using another piece of single strand wire, test the circuit by applying 5V (or, if possible, 3·5V because this is a more realistic value) to each channel at the connector. The respective indicator should light up in each case. If one channel fails to function, measure the voltage at the terminal. If it has switched the 0V, check the l.e.d. circuit. If not, check the input connection and resistor. Measure the input current for each input—it should be around 0·3mA (when using ULN2003—it will be slightly higher for the ULN2001). If all is well connect to the computer and (for the BBC Micro) type:

?&FE62=&FF (set user port for all outputs)

?&FE60=&X (output the binary equivalent of X at the port, with the most significant bit at PB7)

You should find that the indicators will light in the binary pattern set by **X** (i.e. 0 = not lit, 1 = lit), in which case you now have a completed interface which should now give years of service. □

Fig. 5. Method of mounting the circuit board on the rear of the front panel.



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Commodore 16 computer with cassette player and 14 games. Hardly used. Make excellent present £65. Mr. T. Ratcliffe, 35 Woodlands Lane, Shirley, Solihull, W. Midlands B90 2PX.

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EE MARKET PLACE
MARCH '87

...REPORTING AMATEUR RADIO...

TONY SMITH G4FAI

PACKET EXPERIMENT

The DTI recently announced its approval for the establishment of ten experimental amateur radio packet relay stations. The Radio Society of Great Britain has planned a 14-month experiment with the DTI, believing that packet communication will eventually be possible throughout the UK with links via h.f. and satellites to similar networks in other countries.

It was also announced that the satellite team at Surrey University plan to use their amateur radio and educational satellite (*UDSAT 11*) to re-transmit packets to overseas stations.

FOR COMPUTER BUFFS?

We are talking about what is claimed to be the fastest-growing mode in amateur radio. It is so new that anyone taking it up now becomes involved in the development of a new technology. Let's assume you are a home micro enthusiast and you have a modem plugged into a telephone socket to link up with other computers, databases, or bulletin boards.

With packet radio you plug into a two-way amateur radio transceiver instead. This transmits to a similarly connected station, sending a line at a time of the message or data, plus synchronising, addressing, and control information. This is a "packet".

The receiving station is able to verify from the control information that the message has been accurately received, and automatically sends back an "acknowledgement" that all is well. The next packet is then sent, and the process repeated. If there appears to be some error, the receiving station asks for a repeat, and continues to do so until the received packet is error free.

In function, this is an improved form of radio teletype (teleprinter) operation. It requires a personal computer or other terminal with an RS232 output; a packet control unit, called a TNC (Terminal Node Controller); and an amateur transceiver. A disc drive and printer are optional, but obviously very useful extras. The operator of such a set-up does, of course, have to be a licensed radio amateur.

DIGIPEATERS

The relay stations approved by the DTI are known as "digipeaters" (digital repeaters) and are used to relay packet signals from one station to another when the distance or path involved prevents reliable direct station to station r.f. communication. A digipeater receives a packet, holds it in its memory, and re-transmits it at a time when no other signals can be heard on the frequency. Each packet is a brief burst of a signal, typically one or two seconds.

The addressing information in the packet indentifies both the sending and receiving station, usually by their call-signs. If a packet is to be relayed, the call-sign of the relay station(s) is included in the routing instructions, and up to eight relay stations can be addressed in this way.

Each relay passes the packet along to the next one on the pre-determined route to its final destination, and passes back the final acknowledgement of correct reception. Packet stations, including relays, automatically ignore transmissions not addressed to them, and only accept packets from stations they "know" are currently participating in an exchange with them.

All the work is done by the TNC and the computer terminal. When the operator reaches the end of a line of his typed message, the transmitter sends a high-speed burst of data. If all is well, the receiving station acknowledges receipt and the channel goes quiet again until the next line is ready. With so little occupation of the channel a number of contacts can take place at the same time, and it is only when a large number of stations are on the same frequency that delays occur and a need for more channels arises.

USES

The uses of packet radio are limited only by the capabilities of the radio and computer installations used. These include point to point written communication, enhanced by a "store and retrieve" facility; and transfer of computer programs, with its error free capability making packet particularly suitable for this application.

The same applies to emergency communications, especially where names and addresses or requests for specific assistance must be received accurately. Other uses include digital transmission for voice, slow-scan TV, facsimile, etc; bulletin boards; shared use of "network" resources, e.g. printers or extra computing power; and remote monitoring and control of unattended facilities. A packet station can even act as a digipeater if required.

ENTHUSIASTS

The experimental unattended digipeaters approved by the DTI are sited to give the best possible coverage over a given area and will considerably enhance the communication potential of those amateurs already using packet radio on the 2 meter v.h.f. band in the UK. These relay stations are financed and constructed by groups of enthusiasts dedicated to experimentation with, and expansion of, packet radio.

One example is digipeater GB3HP located at Olivers Battery, near Winchester. Constructed by members of AMRAC (Amateur Radio and Computer Club), this operates on 144·650MHz, using the AX.25 protocol.

For the technically minded, the hardware comprises a standard PK-80 TNC, supplied at a discount by I.C.S., and a 25W f.m. PMR transeiver generously donated by Pace Mobile Radio. The antenna is an Isopole, and it is hoped to add an IMB PC clone to the repeater later to provide a mailbox/bulletin board service.

As well as packet radio, AMRAC is concerned with other computer applications in amateur radio, and I shall be referring to these at a later date. AMRAC, which is growing rapidly, provides its members with a bi-monthly user magazine; a "hot news" sheet in the intervening months; technical help; and a conventional bulletin board.

Membership is currently £5 p.a., and further details can be obtained from the Secretary—Phil Bridges G6DLJ, 9 Hollydene Villas, Hythe, Hants. SO4 5HU. (Mention this column when requesting information.)

QUESTION TIME

Q. Can radio amateurs use their equipment anywhere they like?

A. Almost. The regulations allow a licensed amateur to establish a sending and receiving station for amateur radio activities at various defined places in the United Kingdom.

These include the "main" address of the station, usually the home address of the licensee; a "temporary" address or location, for periods of up to four consecutive weeks; and an "alternative" to the main address for any period of time, provided due notice is given to the Radio Investigation Service.

Transmissions can be made by pedestrians, or from any vehicle, except aircraft or public transport vehicles, or from a vessel on inland waters, but *NOT* on the sea or within any estuary, dock, or harbour.

Operators must, however, indicate in their transmissions if they are operating from a temporary address or location. Details of this must be given at the beginning and end of each contact, and at 15-minute intervals during the contact, and a special suffix must be added to the call-sign. For example, /A is added to indicate a temporary address; /P (portable) indicates a temporary location or pedestrian operation; and /M (mobile) operation from a vehicle or vessel.

Additionally, a station normally based in one part of the UK and operating from another part uses the prefix relating to the country operated from. If I operate in a field in Scotland during the *National Field Day* contest, my call-sign will be GM4FAI/P. If I go to stay with relatives in Wales and operate from their home for a fortnight, my call will be GW4FAI/A. On a canal boat in the heart of England I would be G4FAI/M.

It all sounds rather complicated, but it's one of the things you have to answer questions about in the Radio Amateurs Examination, so by the time you get your licence you are already reasonably familiar with the rules and take them in your stride!

NEWS ...from the world of electronics

LASER BANK

A credit card sized "memory bank" which can hold up to 800 pages of text as well as photographs is to be supplied by British Telecom.

A licence to sell the tamperproof cards—known as "LaserCards" —has been purchased from the Drexler Technology Corporation of California, which holds the patents.

British Telecom will also supply the equipment for recording and reading data on the cards. Currently these cards and the recording equipment are made in the United States and Japan, but there is a possibility of local manufacture.

The Drexler LaserCard makes available in a low-cost credit card format up to 2Mbytes of data—the equivalent of 800 text pages or eight photographs. The data can be imprinted by photographic techniques at the time of manufacture or subsequently by low-cost lasers.

The cards are claimed to be secure and difficult to corrupt either accidentally or deliberately. They are also cheaper and faster to produce than other data storage media such as floppy discs.

BT is negotiating with a major London hospital which is considering the use of LaserCards for holding maternity records. Photographs of X-rays, sonic scans, and medical notes can all be held on the same card.

The Scottish Office has given the go-ahead for a £1·5 million scheme to boost training provision for electronic and software engineers.

The Scottish Development Agency (SDA) and the University of Strathclyde are joining forces on a project aimed at tackling an urgent need for more scientists, engineers and technologists well trained in information technology.

Sonobuoy

A contract to supply lithium batteries to power the "BARRA" sonobuoy has been awarded to Crompton Vidor, by Plessey Naval Systems. The contract, worth around £200,000 include a battery type-approval programme.

With lightweight, high power and exceptional low temperature capability, the batteries have been specially developed to meet the stringent electrical and environmental requirements of the "BARRA" specification. The batteries are being manufactured at Crompton Vidor's South Shields Factory.

The "BARRA" is an advanced sonobuoy being supplied to the UK Ministry of Defence. It will provide the principle means by which the RAF's long range maritime patrol aircraft detect and track submarines.

An airborne pod carrying a thermal imager and a laser target designator/ranger is to be built by Ferranti for subsequent evaluation by the Royal Aircraft Establishment.

Matsushita Electric has chosen South Wales as the sife for its first Office Automation factory outside Japan.

The Newport factory will cost £6M to build and will initially employ 100 people when production starts in 1987. Output from the plant is expected to run at 20,000 electronic typewriters and 50,000 printers in the first year.

Modems for Schools

A £250,000, contract to supply its Schools Modem to schools in the UK has been jointly won by Miracle Technology (UK) Ltd and its distributor PMS Communications Ltd.

Already 500 modems have been ordered for schools in the West Midlands Examination Board area.

Miracle's Marketing Manager David Baxter anticipates further major contracts with other educational authorities. *"Our Schools Moden is tailored precisely to the real needs of schools,"* he said.

SOFTWARE SEARCH

A nationwide search has been launched to find software writers with the ability to become "millionaires almost overnight." The man behind the hunt for star programmers is Simon Barnard, the recently appointed software development manager of MicroProse.

It is claimed that he is able to offer the potential of far greater rewards that can normally be expected in the UK, because he is backed by the third largest entertainment software house in the US. *"We believe that the UK has the best software writers. And my job is to find them and offer them not only money but international recognition"* he says.

Simon Barnard points to the fact that MicroProse in the States spends in excess of $1 million developing its simulation blockbusters. Each of these is eventually marketed not only in America but also Europe and Australasia.

International Rectifier Corporation and National Semiconductor Corporation have announced a joint development programme to advance the companies to the forefront of the power integrated circuit business. The five-year agreement establishes a shared product development effort and exchange of technology.

UK Power for Algeria

Instrumentation and monitoring systems for flow, liquid and gas analysis, to a total value of £900,000, are being supplied by Brown Boveri Kent companies for the 3 × 210MW natural gas fired power station to be built at Jijel, Algeria.

The order was won by Kent Deutschland GmbH in the Federal Republic of Germany and much of the instrumentation will be manufactured by Kent Industrial Measurements factories in the UK.

British Telecom have announced a pre-tax profit for the six months to September 30, 1986 of £1,006 million—£104 million higher than in the corresponding period last year. Profit for the three months to September 30, at £504 million, was £52 million higher. These represent increases of 11·5 per cent over the corresponding periods last year.

WHATS ON

A listing of some forthcoming events:

Name: The Electron and BBC Micro User Show.
Location: UMIST, Sackville Street, Manchester.
Dates: March 20–22, 1987.
Admission fees: Adults £3, children (under 16) £2. £1 off for advance tickets. Tel: 061 456 8835.
Opening times: 10am–6pm Friday, Saturday. 10am to 4pm Sunday.

Name: Compact Disc Systems
Location: *Royal Institution, London*
Date: *March 18, 1987 (One-day Seminar)*
Info: *Society of Electronic & Radio Technicians, Tel: 01-401 2351*

Name: Quality and the Market-place
Location: *University of Sheffield*
Date: *April 27–29, 1987 (Open Learning Weekend Workshop)*
Info: *SERT, Tel: 01-403 2351*

Name: Drives Seminar '87
Location: *Lincoln College of Technology*
Date: *April 3, 1987*
Info: *Lincoln College Tech., Tel: 0522 306441*

FOR YOUR ENTERTAINMENT

BY BARRY FOX

FAVOURITE WASTE OF TIME

TV has been dubbed the biggest time waster of all time. But without the searing TV news coverage of famine in Africa, Bob Geldof would never have organised Live Aid and without the worldwide TV coverage of the Wembley concert there would today be many more dead and dying in Africa.

Only a visitor from outer space can have failed to notice that Britain recently celebrated 50 years of regular TV from the BBC. Apart from the BBC's own broadcasts there were three public exhibitions.

For my sins I got to see them all; *The Golden Box*, at the Commonwealth Institute, *Television in the Home*, at the Royal Festival Hall, and the two new permanent galleries at the National Museum of Photography, Film and Television in Bradford. If you missed the RFH exhibition you missed a good 'un. If you missed The Golden Box you missed very little. If you haven't yet been to Bradford now is the time to go. It's a fine show. But think carefully about HOW you go . . .

BRADFORD

Bradford boasts the largest cinema screen in Britain, with pictures sourced from an Imax projector. Imax uses 70mm film, running sideways, to give the highest definition pictures in the world. One film is in 3D. Bradford recommends booking an Imax seat in advance. But when I made a test call to the Museum, all I got was a recorded announcement. Wake up Bradford. And wake up too over photography. For a Museum of Photography the publicity photographs given to the press, to illustrate articles telling the world about the new TV galleries, were rotten.

British Rail isn't helping Bradford either. Wisely recognising that short-sighted Londoners regard Bradford as only marginally more convenient to reach than the North Pole, the museum organisers organised a train from Kings Cross, complete with the same cinema coach that was used in 1936 to screen Pathe newsreels. But when the train stopped for signals on an incline the wheels slipped, so the driver shut down the diesel engine. This meant that the generator powering the 16mm projectors died. End of film show.

Another train had to be summoned to push from the rear. Even with a full load of press on board the BR train crew couldn't be bothered to make an apology on the train PA system. The grand opening was delayed and as Cliff Michelmore said when the ceremony finally got under way; "like everything in television, it's starting bloody late". Pity the poor family which invests in a handful of day returns to visit Bradford . . .

Pity also the 35 TV and electronics companies which provided money and materials for the Royal Television Society's show at the Commonwealth Institute.

GOLDEN!

The Golden Box is a 75 minute multi-screen, video "spectacular" telling the now familiar story of half a century of TV. I couldn't go to the press launch so went on a Saturday night. There were four people in the cold tent where it is held.

Despite the fact that The Golden Box was shown on 73 screens it was still nothing more than a £2.50 version of the kind of clip-compilation which the BBC was broadcasting free as part of its 50 year celebrations. The 73 screen Philips Vidiwall worked fine but was for most of the time redundant, or a distraction. And who on Earth cooked up the idea of staging the winter event in a tent? The night I went it was like camping with the wind flapping the canvas and chilling anyone lightly clad to the marrow.

Also full marks for wonderful lack of sensitivity to the Box producers for including clips of the racially obnoxious Black and White Minstrel Show—at the Commonwealth Institute!

Television in the Home, organised by the Museum of the Moving Image and British Vintage Wireless Society at the Royal Festival Hall was so much better—and free. It gives a taste of what we may expect when (in September 1987) the MOMI moves into its permanent premises, now being built alongside the National Film Theatre near the RFH.

There was a fascinating reconstruction of programmes broadcast in the early 30s using Baird's original 30 lines system, and a wide range of the first cathode ray tube sets sold in 1936. Personally I can't wait for the MOMI opening and another trip to Bradford . . . if British Rail can get there!

Playful Audio

Japanese hi fi companies have finally owned up. They are now aiming equipment at people who enjoy playing with the knobs as much as listening to the music. Technics the hi fi division of Matsushita, which is the largest consumer electronics company in the world, has coined a phrase for it: "playful audio".

"Playing is more fun than just listening" says the company's Japanese publicity material.

One of the latest hi fi cassette recorders from Technics gives hi fi listeners the chance to be very "playful". The RS-T80R, costing around £350, has two separate cassette mechanisms, each able to record or play back and each able to reverse its running direction when a photosensor registers that the end of the tape is coming up.

This doubles the recording or playing time available from each cassette to give a total of three hours virtually continuous running from the two decks. The system can make two simultaneous recordings of the same material, start recording on one cassette after the other has finished, copy or "dub" from one cassette to the other, or keep on playing from one cassette after the other to give up to 24 hours continuous background music.

The difficult trick is to make the tape reverse direction so quickly that there is no noticeable break in the recording. In any cassette recorder only one half of the tape width is used at a time; the cassette is normally taken out of the machine, turned round and replaced so that a second recording is made on the other half of the tape in the opposite direction. Obviously this takes time and manual intervention. In the Technics deck the recording heads are mounted on pivots. As the tape in the cassette comes to the end of its run, the entire recording head spins on its axis to align with the other side of the tape. At the same time the drive motor stops and reverses.

Editing

The twin deck technology has a new name, too. The electronics industry used to boast of double deck "dubbing" but the record industry objects to people copying recordings from one tape to another. The British government has promised a tax or levy on blank tape to compensate for this.

With an election due, the government is having second thoughts on this. Taxing tape is a sure fire vote loser, especially with young tape-using voters holding considerable power at the ballot box. All mention of the copyright law reform which would tax tape was dropped from the Queen's speech.

Playing safe, however, Japanese companies no longer describe their double decks as ideal for "dubbing". The new Technics deck, the makers say, is ideal for "editing".

ARCHIVE HEADACHES

Here's a fascinating fact. British broadcasters have difficulty accessing old programmes if they were recorded on two inch Quad tape in the original 405 line format. There are only a few 405 line playback machines still working. A lot of the old programmes are stored on film, or have been converted to 625 line for re-recording. But there are enough 405 line tapes around in archives to cause headaches.

The fascinating fact, which came out of the exhibition of old TV held at the Royal Festival Hall, is that modern VHS and Beta machines will quite happily record 405 line pictures instead of the 625 line pictures they are designed to record!

The exhibition organisers just fed 405 line signals into the video inputs of a bank of VHS machines and recorded them. For replay through original thirties sets they built a modulator which mimicked the 45MHz frequency used for the first BBC transmissions. None of the old sets packed up during the exhibition, but three of the rented video recorders did.

There is only one problem for anyone using a 625 line recorder to tape 405 line pictures. They have a drop out compensator which delays each picture line and uses it when another line is missing. For 405 line working the compensator puts the delayed line in at the wrong place in the picture, which makes drop-outs even more noticeable. The best thing is to get inside the machine and switch out the compensator circuit.

Will VHS and Beta now start advertising, that they are "backwards compatible?"

PCB SERVICE

Printed circuit boards for certain constructional projects are now available from the PCB Service, see list. These are fabricated in glass-fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for overseas airmail. Remittances should be sent to: The PCB Service, Everyday Electronics and Electronics Monthly Editorial Offices, 6 Church Street, Wimborne, Dorset BH21 1JH. Cheques should be crossed and made payable to Everyday Electronics. *(Payment in £ sterling only.)*

Please note that when ordering it is important to give project title as well as order code. Please print name and address in Block Caps. **Do not send any other correspondence with your order.**

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

NOTE: Please allow 28 days for delivery. We can only supply boards listed in the latest issue. Boards can only be supplied by mail order on a payment with order basis.

PROJECT TITLE	Order Code	Cost
— JULY '83 —		
User Port Input/Output *M.I.T. Part 1*	8307-01	£4.82
User Port Control *M.I.T. Part 1*	8307-02	£5.17
— AUGUST '83 —		
Storage 'Scope Interface, BBC Micro	8308-01	£3.20
Car Intruder Alarm	8308-02	£5.15
High Power Interface *M.I.T. Part 2*	8308-03	£5.08
Pedestrian Crossing Simulation *M.I.T. Pt 2*	8308-04	£3.56
— SEPTEMBER '83 —		
High Speed A-to-D Converter *M.I.T. Pt 3*	8309-01	£4.53
Signal Conditioning Amplifier *M.I.T. Pt 3*	8309-02	£4.48
Stylus Organ	8309-03	£6.84
— OCTOBER '83 —		
D-to-A Converter *M.I.T. Part 4*	8310-01	£5.77
High Power DAC Driver *M.I.T. Part 4*	8310-02	£5.13
— NOVEMBER '83 —		
TTL/Power Interface for Stepper Motor *M.I.T. Part 5*	8311-01	£5.46
Stepper Motor Manual Controller *M.I.T. Part 5*	8311-02	£5.70
Speech Synthesiser for BBC Micro	8311-04	£3.93
— DECEMBER '83 —		
4-Channel High Speed ADC (Analogue) *M.I.T. Part 6*	8312-01	£5.72
4-Channel High Speed ADC (Digital) *M.I.T. Part 6*	8312-02	£5.29
Environmental Data Recorder	8312-04	£7.24
Continuity Tester	8312-08	£3.41
— JANUARY '84 —		
Biological Amplifier *M.I.T. Part 7*	8401-02	£6.27
Temp. Measure & Control for ZX Comprs		
Analogue Thermometer Unit	8401-03	£2.35
Analogue-to-Digital Unit	8401-04	£2.56
Games Scoreboard	8401-06/07	£9.60
— FEBRUARY '84 —		
Oric Port Board *M.I.T. Part 8*	8402-02	£9.56
Negative Ion Generator	8402-03*	£8.95
Temp. Measure & Control for ZX Comprs		
Relay Driver	8402-04	£3.52
— MARCH '84 —		
Latched Output Port *M.I.T. Part 9*	8403-01	£5.30
Buffered Input Port *M.I.T. Part 9*	8403-02	£4.80
VIC-20 Extension Port Con. *M.I.T. Part 9*	8403-03	£4.42
CBM 64 Extension Port Con. *M.I.T. Part 9*	8403-04	£4.71
Digital Multimeter Add-On for BBC Micro	8403-05	£4.63
— APRIL '84 —		
Multipurpose Interface for Computers	8404-01	£5.72
Data Acquisition "Input" *M.I.T. Part 10*	8404-02	£5.20
Data Acquisition "Output" *M.I.T. Part 10*	8404-03	£5.20
Data Acquisition "PSU" *M.I.T. Part 10*	8404-04	£3.09
A.F. Sweep Generator	8404-06	£3.55
Quasi Stereo Adaptor	8404-07	£3.56
Simple Loop Burglar Alarm	8405-01	£3.07
Computer Controlled Buggy *M.I.T. Part 11*		
Interface/Motor Drive	8405-02	£5.17
Collision Sensing — MAY '84 —	8405-03	£3.20
Power Supply	8405-04	£4.93
Infra-Red Alarm System	8406-01	£2.55
Spectrum Bench PSU — JUNE '84 —	8406-02	£3.99
Speech Synthesiser *M.I.T. Part 12*	8406-03	£4.85
Train Wait	8406-04	£3.42
Ultrasonic Alarm System	8407-01	£4.72
Electronic Code Lock — JULY '84 —		
Main Board	8407-03	£2.70
Keyboard	8407-04	£3.24
— AUGUST '84 —		
Microwave Alarm System	8408-01	£4.36
Temperature Interface—BBC Micro	8408-02	£2.24
— SEPTEMBER '84 —		
Op-Amp Power Supply	8409-01	£3.45
Micro Memory Synthesiser — OCT '84 —	8410-01*	£8.20
Drill Speed Controller	8410-04	£1.60
— NOVEMBER '84 —		
BBC Audio Storage Scope Interface	8411-01	£2.90
Proximity Alarm	8411-02	£2.65
TV Aerial Pre-Amp	8412-01*	£1.60
Digital Multimeter — DEC '84 —	8412-02/03*	£5.20
Mini Workshop Power Supply	8412-04	£2.78
Power Lighting Interface	8501-01	£8.23
Games Timer — JAN '85 —	8501-02	£1.86
Spectrum Amplifier	8501-03	£1.70
Solid State Reverb — FEB '85 —	8502-01	£3.68
Computerised Train Controller	8502-02	£3.38
— MARCH '85 —		
Model Railway Points Controller	8503-01	£2.78
Insulation Tester — APRIL '85 —	8504-02	£2.53
Fibrelarm	8504-03	£3.89
Auto Phase	8505-01	£3.02
Amstrad CPC464 Amplifier		
Mains Unit — MAY '85 —	8505-02	£2.56
Micro Unit	8505-03	£2.56
Voltage Probe	8505-04	£2.67
Graphic Equaliser — JUNE '85 —	8506-01	£3.21
Computerised Shutter Timer	8506-02	£2.09
Mono-Bi-Astables (Experimenters Test Bed)	8506-03	£2.45
Across The River	8506-04	£2.63
Amstrad User Port — JULY '85 —	8507-01	£3.17
Nascom Printer Handshake	8507-02	£1.90
Electronic Building Blocks—1 to 4†	8508-01	£2.98
Tremolo/Vibrato	8508-02	£4.03
Stepper Motor Interface— AUGUST '85 —	8508-03	£2.40
Drill Control Unit	8508-04	£2.90
— SEPTEMBER '85 —		
RIAA Preamplifier Input Selector	8509-01	£2.36
Transducers Resistance Thermometer	8509-03	£2.64
Transducers Semiconductor Temp. Sensor	8509-04	£2.72
Transducers Strain Gauge — OCT '85 —	501	£2.87
Soldering Iron Power Controller	504	£2.09
Transducers— — NOV '85 —		
Magnetic Flux Density Amplifier	505	£3.93
Hallowe'en Projects (single board price)	506	£2.68
Electronic Building Blocks — 5 to 8†	508	£3.07
Opto Intensity Transducer — DEC '85 —	509	£2.70
Digital Capacitance Meter	512	£5.22
Mains Delay	503	£2.13
Musical Doorbell — JAN '86 —	507	£2.91
Tachometer—Transducers	513	£2.52
Touch Controller	510	£2.65
Function Generator — FEB '86 —	514	£3.10
Function Generator PSU Board	515	£2.09
pH Transducer	516	£2.75

*Complete set of boards.
M.I.T.—Microcomputer Interfacing Techniques, 12-Part Series.
†Four separate circuits.

PROJECT TITLE		Order Code	Cost
Mains Tester & Fuse Finder	— MAR '86 —	517	£2.27
BBC Midi Interface		518	£3.26
Stereo Hi Fi Preamp		519	£5.70
Interval Timer		520	£2.36
Stereo Reverb	— APRIL '86 —	521	£2.89
PA Amplifier	— MAY '86 —	511	£2.67
Mini Strobe		522	£2.24
Auto Firing Joystick Adaptor		523	£2.73
Watchdog	— JUNE '86 —	524	£2.81
Percussion Synthesiser		525	£5.65
Personal Radio		526	£2.07
Tilt Alarm	— JULY '86 —	527	£2.13
Electronic Scarecrow		528	£2.28
VOX Box Amplifier		529	£2.35
Headphone Mixer		530	£4.56
Solar Heating Controller	— AUG '86 —	533	£3.32
Car Timer	— SEPT '86 —	538	£2.02
Freezer Failure Alarm		534	£1.90
Infra Red Beam Alarm (Trans)		536	£3.32
Infra Red Beam Alarm (Rec)		537	£3.32
Scratch Blanker		539	£5.43
10W Audio Amp (Power Amp)		543	£2.58
(Pre-Amp) £4.78 Pair		544	£3.18
Light Rider—Lapel Badge		540 & 541	£2.70
—Disco Lights		542	£4.55
—Chaser Light	— OCT '86	546	£3.23
Modem Tone Decoder	— NOV '86 —	547	£2.76
200MHz Digital Frequency Meter		548	£4.12
Dual Reading Thermometer	— DEC '86 —	549	£5.87
Automatic Car Alarm		550	£2.35
BBC 16K Sideways RAM		551	£2.38
(Software Cassette)		551S	£4.95
Random Light Unit	— JAN '87 —	552	£4.70
Car Voltage Monitor	— FEB '87 —	553	£2.00
Mini Amp.		554 & 555	£4.55
Video Guard		556	£3.05
Spectrum I/O		557	£3.78
Spectrum Speech Synthesiser		558	£3.88
Computer Buffer/Interface	— MAR '87 —	560	£2.66
Infra Red Alarm			
Sensor Head		561	£3.35
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TEACH-IN SOFTWARE

To complement each published part of the Teach-In series (Oct. '85 to June '86), we have produced an accompanying computer program. The Teach-In Software is available for both the BBC Microcomputer (Model B) and the Sinclair Spectrum (48k) or Spectrum-Plus. The programs are designed to reinforce and consolidate important concepts and principles introduced in the series. The software also allows readers to monitor their progress by means of a series of multi-choice tests, with scores at the end.

Tape 1 (Teach-In parts 1, 2 and 3), Tape 2 (parts 3, 4 and 5) and Tape 3 (parts 6, 7, 8 and 9) are available for £4.95 each (inclusive of VAT and postage) from Everyday Electronics and Electronics Monthly, 6 Church Street, Wimborne, Dorset BH21 1JH. **IMPORTANT** *State BBC or Spectrum; add 50 pence for overseas orders; allow 28 days for delivery.*

Prices for *ELECTRONICS MONTHLY* PCBs are shown below.

PROJECT TITLE		Order Code	Cost
Cymbal Synth	— DEC '84 —	EM/8412/2	£4.86
The Thing		EM/8412/4	£3.18
Speak Board	— JAN '85 —	EM/8501/2	£3.97
Headphone Amp	— FEB '85 —	EM/8502/1	£2.08
Intelligent Nicad Charger		EM/8502/2	£3.50
Anti Phaser		EM/8502/3	£4.56
Logical Lock		EM/8502/4	£3.58
Touch Dimmer		EM/8502/5	£3.29
Courtesy Light Extender	— MAR '85 —	EM/8503/4	£3.29
Disco Light Chaser		EM/8503/5	£8.11
Sound to Light Unit	— APRIL '85 —	EM/8504/1	£4.02
Car Audio Booster		EM/8504/2	£3.12
Short Wave Converter		EM/8504/3	£4.15
Car Burglar Alarm	— MAY '85 —	EM/8505/3	£2.88
Metal Detector	— JUNE '85 —	EM/8506/1	£4.24
Power Supply Module		EM/8506/3	£3.20
Flanger		EM/8506/4	£4.29
El Tom/El Tom+	— JULY '85 —	EM/8507/1	£4.10
El Cymb		EM/8507/2	£4.10
Heartbeat Monitor		EM/8507/3	£3.98
Real Time Clock		EM/8507/4	£4.62
Intelligent Windscreen Wiper (incl. Terminal Board)	— AUG '85 —	EM/8508/1/2	£4.12
HiFi Intercom (2 boards)		EM/8508/3	£2.92
Plug Power Supply		EM/8508/4	£2.28
Hot Water Alarm		EM/8508/5	£1.93
Sinewave Generator	— SEPT '85 —	EM/8509/1	£2.76
Household Battery Checker		EM/8509/2	£1.97
Audio Signal Generator		EM/8509/3	£3.65
Compressor Pedal	— OCT '85 —	EM/8510/1	£2.87
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AMBER	14p	12p	10p
YELLOW	14p	12p	10p
HOLDERS	3p	2p	1.5p
LEDs 5mm	1+	10+	100+
RED	9p	8p	6.8p
GREEN	14p	12p	10p
AMBER	14p	12p	10p
YELLOW	14p	12p	10p
HOLDERS	4p	3p	2.5p

EQUIVALENT BOOKS
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DIODES VOL 2 £10.65
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BC212	10p	8p	7p
BU208	£1.40	£1.37	£1.30
BU326S	£1.75	£1.69	£1.61
MJE305	£1.40	£1.34	£1.19
2N3055	65p	61p	53p
2N2222	30p	27p	23p
LM317K	£2.40	£2.32	£2.13
LM317T	£1.25	£1.17	£1.09

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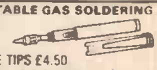

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BY GEORGE HYLTON

TWO-TERMINAL OSCILLATORS

"TWO-TERMINAL", as applied to oscillators, means that the frequency-controlling part of the circuit can be connected to the active part by two wires. In most cases the frequency-controlling elements are an inductance and a capacitance, or sometimes two capacitances. The active part, that is, the bit that keeps the oscillation going, is a transistor amplifier or other "electronic" device.

TRAD OSCILLATORS

If you look up oscillators in a textbook of electronics you are likely to find that as far as oscillators with tuned circuits are concerned (LC oscillators for short) a fair amount of space is given to describing named varieties. There's the Hartley oscillator, the Colpitts oscillator, and so on. A really comprehensive book will include the Meissner and the Franklin, and maybe even the Clapp-Gouriet!

These are "traditional" (or perhaps I should say "classical") types of LC oscillator. Only one of them (the Franklin) is a two-terminal oscillator. The rest require three (or more) connecting links to the active elements in the circuit. Does it matter? It does, if you are designing a multi-band radio and you want to minimise the number of switch contacts needed for changing tuning ranges; otherwise not. To me, the interest lies in the light shed on the way oscillators work by some two-terminal circuits.

PHASE REVERSAL

The reason why the trad oscillators are mostly three-terminal is that their LC circuits not only control the frequency, but provide a phase-inversion as well. The phase inversion is needed because a single active element (transistor, f.e.t., etc.) inverts the signal. If you feed back from collector to base, etc., this is negative feedback. To make an oscillator the feedback must be *positive*. The obvious way to achieve positive feedback (Fig. 1) is to use a transformer. I've drawn a f.e.t. oscillator because in f.e.t. circuits there are fewer bias components to hamper the description.

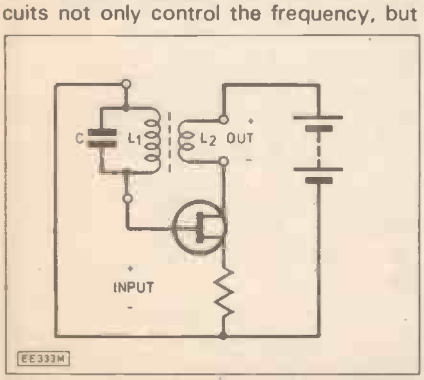

Fig. 1. A transformer to give positive feedback.

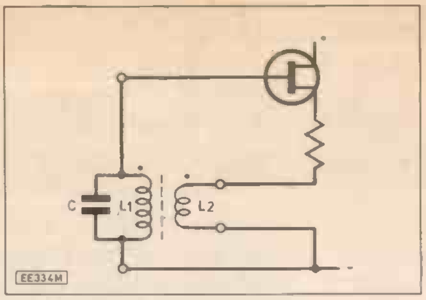

Fig. 2. A Hartley oscillator.

If there is an input signal voltage of the polarity shown (gate positive), then the drain goes negative. To keep the oscillation going, this negative must be inverted and fed back to the gate as a positive voltage. The transformer formed by L1 and L2 does the job (if you connect it correctly). Of course, in an oscillator there isn't an input signal in the usual sense. But there's always noise in a circuit, and noise exists at all frequencies. So there's some noise at the tuned frequency. If feedback is positive and the f.e.t. provides enough gain this is what gets the oscillation going.

The transformer type of feedback oscillator can be turned into a tapped-coil (Hartley) oscillator by going through the intermediate step of Fig. 2. Here the lower ends of L1 and L2 are both connected to the common negative rail. The "polarity dots" on the windings show that source and gate go positive (or go negative) together, which is what's needed to sustain oscillation. If instead of a two-winding transformer, a tapped-coil autotransformer is used (Fig. 3) the result is a Hartley oscillator in one of the commonest of its many varieties. The frequency-determining part now has three terminals (X,Y,Z) instead of the previous four but that's as far as you can go in terminal reduction in classical oscillators with only one active device in the circuit.

TWO-STAGE AMPLIFIER

To get down to two terminals it's necessary to provide a non-inverting amplifier. As we all know, one way of doing this is to cascade two inverting amplifiers. This leads to the type of circuit shown in its bare essentials in Fig. 4. where the terminals of the LC part are X and Y.

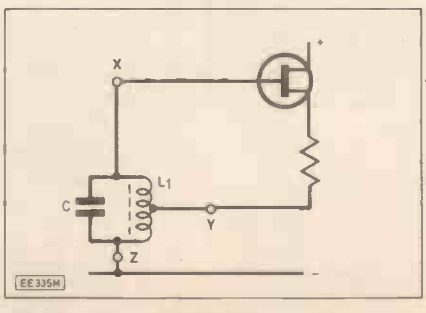

Fig. 3. Autotransformer Hartley oscillator.

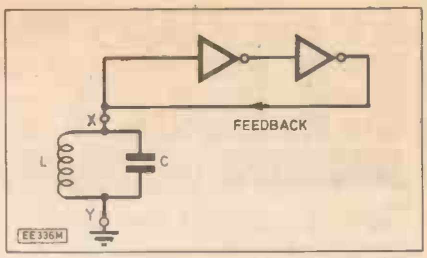

Fig. 4. Using two inverting amplifiers.

This form of presentation makes it clear that an oscillator must have in it some sort of amplifier, just to supply the energy needed to maintain oscillation. In Figs. 1 to 3 the maintaining amplifier is of course just the f.e.t.

A more general and more illuminating arrangement (Fig. 5) contains an "op. amp" form of amplifier with both inverting and non-inverting inputs. Feedback via resistance A to the LC circuit is positive; feedback via the two parts B and C of the potentiometer is negative. The "pot" enables the circuit to be set so that it just oscillates. This usually produces the purest sine-wave at the LC. If the pot is first set so that the circuit fails to oscillate then inched up very gradually towards the point where oscillation begins then you can often see the oscillation build up from noise. An oscilloscope on the output is the best indicator, but if the LC works at audio frequency you can listen to it with a crystal earphone.

NEGATIVE RESISTANCE

A rather special form of two-terminal oscillator is the "negative resistance" type. To understand it you need to know that, at its resonant frequency, an LC tuned circuit behaves like a resistance. This resistance absorbs energy, like a real, physical resistor. If oscillation is to be kept going, the active part of the circuit must supply energy at least as quickly as it is being lost.

One way of looking at this is to say that the active device in the circuit must produce a negative resistance which cancels out the positive resistance of the LC. Some electronic devices, notably the tunnel diode, behave as negative resistances. Connecting a negative resistance across the LC produces oscillation if the negative resistance is *lower* than the effective resistance of the LC at its resonant frequency. In practice, tunnel diodes act as very low negative resistances, down to a few ohms. LC tuned circuits commonly have very much higher effective resistances. Connecting a low-negative-resistance tunnel diode across them tends to produce oscillations with very poor waveform.

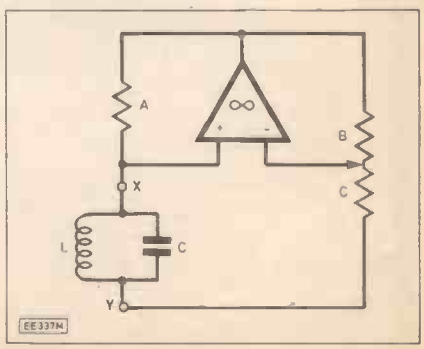

Fig. 5. An op.amp oscillator.

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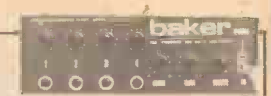

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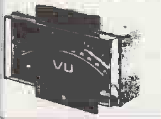

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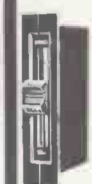

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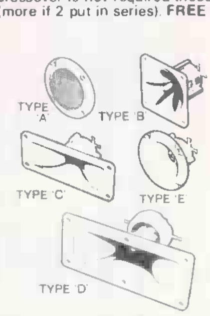

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EE MARCH 1987.

Guide to...

PROJECT BUILDING

This guide, written by John Becker is based on his experience of checking and repairing kits built by hobbyists. It is aimed at those with little or no experience of project construction although experienced hobbyists will also find much of the information of value.

If you have never built a project or if you need more details on construction, then this booklet is for you.

EVERY once in a while I am asked to examine a project that someone has assembled, and is unable to get to work. In this way I see at first-hand the problems that newcomers to electronics can run into when putting components together. In the vast majority of cases, the problems have arisen purely and simply because insufficient care and attention has been given to the soldering and subsequent checking.

The intention of this booklet is to run through some of the problems associated with project assembly, particularly general construction and soldering, and also to clarify a few other areas that some people find unclear, or of which they are unaware. In this way it is hoped that more people will be encouraged to persist in constructing some of the excellent projects published in leading electronics magazines like *Everyday Electronics*.

Sadly, I know that some who fail first time come to the conclusion that they do not have the abilities to construct electronic projects, and so abandon ideas of further construction. This is a great shame since electronics is a fascinating subject, and many of the projects published consist of original circuit ideas that are only available to the home constructor, and not available as ready-made items.

There is a great deal to be gained from these ideas, both in pleasure and in useful equipment. It is also possible to save money by doing your own assembly since it is you doing the work, rather than paying for someone else's professional assembly time.

TOOLS REQUIRED

For the construction of most projects, it is not necessary to possess sophisticated test equipment, but it is necessary to own or have access to, at least the following:

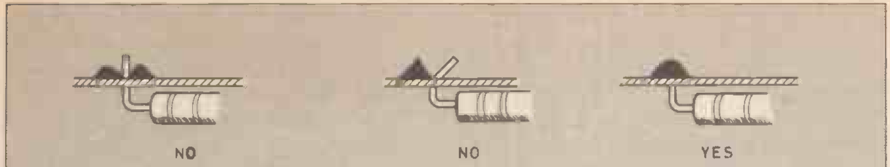
1) Soldering iron, between 15W and 25W, with a bevelled tip (preferably a temperature controlled iron).
2) Fine nosed pliers for shaping wires.
3) Small adjustable spanner or heavy pliers for tightening the nuts on switches and other controls.
4) Small screwdriver for adjusting preset potentiometers.
5) Small wire cutters for trimming component leads after soldering.
6) Drill and selection of bits for making holes in boxes. (A hammer and nails are not suitable for this, as I have occasionally witnessed!)
7) Sponge for cleaning soldering iron tip.
8) Powerful magnifying glass for close-up checking of joins.
9) Multimeter of at least 20,000 ohms per volt for taking test measurements. Many projects do not need a meter, but if you are intending to continue building projects it should be regarded as a vital piece of test equipment.

GENERAL RELIABILITY

Fortunately, when components come from reliable sources, their failure rate is usually very low. Consequently, if a project fails to work first time after assembly, the reason for the failure is more than likely due to an error in putting it together. The reliability of the assembly will depend, more than anything else, upon the quality of the soldered joints, and on checking for correct component positioning and orientation.

SOLDERING IRONS

A good soldering iron with a bev-



SOLDER JOINTS

elled tip is preferable, and should be rated at about 15W to 25W. If too small an iron or tip is used there is the danger that the heat transfer may be inadequate. Although the iron may be at the right temperature to melt the solder, the copper tracking on a p.c.b. (printed circuit board) may draw away some of the heat when bringing together the solder, the iron and the component. This is also true for soldering to the tags of switches, pots and other controls. (A temperature controlled iron will help to overcome this problem.)

If too much heat is drawn away, the solder may not melt sufficiently to fully cover the join, and go into a blob, or become crystaline. This can also contaminate the component lead so that a barrier builds up between the lead and the solder. Since the barrier may not be electrically conductive, the component is likely to be rendered out of circuit. The iron must, therefore, have sufficient heating capability so that it retains an adequate temperature during the few seconds that the join is being made.

Bring the iron tip into contact with the component lead and the circuit board solder pad, then bring the solder into contact with all three, feeding it in as it melts. With 22 s.w.g. solder, about a quarter of an inch should be enough to fully surround the pad and the lead. Once sufficient solder has been melted, remove the solder, then the iron and allow the joint to cool before touching the lead. Any movement during cooling can cause crystalisation of the solder, resulting in a poor connection.

SOLDERING TIME

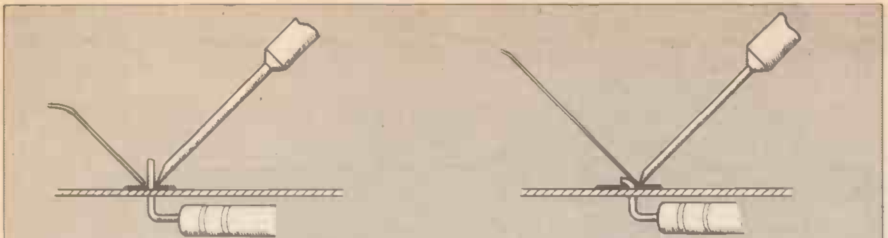
At one time some components were very susceptible to heat damage, but modern components are designed to take the rigours of mechanised soldering in industry, and so will withstand perhaps even five seconds of heat application from the iron. So leave the iron in contact with the joint until it is obvious that the solder has melted into a nice neat area fully around the lead and across the solder pad. If, on subsequent examination, insufficient melting is suspected, reheat the join until it has melted more thoroughly, if necessary applying more solder.

If a barrier deposit has built up, and the join refuses to make properly, it may be necessary to remove the component and scrape the surface with a sharp knife until the metal gleams again. It can then be reinserted and resoldered.

DESOLDERING

Should it become necessary to remove a component, most can be extracted by applying the iron to each end of the component in turn, pulling it with finger nails or fine pliers. Integrated circuits ought to be in sockets, and are extremely difficult to extract once they have been soldered. If they have to be unsoldered, the sophisticated though expensive way is to use a special desoldering tool.

Alternatively, solder braid can be used. This is applied to the soldered



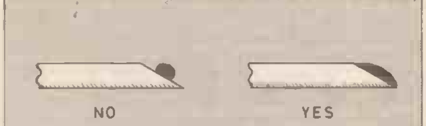
SOLDERING BEFORE LEAD CUT AFTER LEAD CUT

area, and when heated with the iron, sucks up the majority of the solder. The component can then be prised out with a screwdriver or IC removal tool. An alternative to the braid is to use the plaited wire screening found around some screened leads. It is not the best method, but is a reasonably satisfactory solution.

Ordinarily, once a part has been removed, solder may well block the hole. This can be removed by holding the board vertically and applying the iron. The solder then can be drawn slowly away from the area, along the tracking, and left there. If a lot of solder is to be removed, excess solder on the tip of the iron can be flicked off onto a suitable surface. Finally, insert a pointed tool into the hole to ensure that a component can be readily reinserted.

CLEANLINESS

To avoid barrier encrustation on a component, the tip of the iron should be kept clean and a good solder used. This should be of the multicore variety, of between about 18 s.w.g. and 22 s.w.g. in thickness. The soldering bit should be kept clean by wiping it with a damp sponge periodically during use. Make sure that it looks to be properly tinned, that is, coated with a shiny film of solder. If the tip is unclean, solder applied to it is likely to blob, and not cover the entire tip area.



SOLDER COATING ON IRON TIP

Copper when heated is very prone to oxidising, and this will prevent adequate solder flow. Proper cleaning is essential.

As soldering iron tips age, the surface tends to decay and become ragged. If a tip has reached this state, it can be carefully filed down again to a smooth flat surface, and immediately tinned with solder to cover the freshly bare metal. Components can also oxidise on their leads if kept in store for some time before use. If these look dull before soldering, scrape them until shiny once more. If soldering is attempted with oxidising leads, the contamination will prevent the solder from adhering to the surface.

Occasionally the paint used for colour coding components can have strayed on to the lead during manufacture. This too can prevent soldering from occuring, and so should be scraped off first.

IRON TIP SHAPE

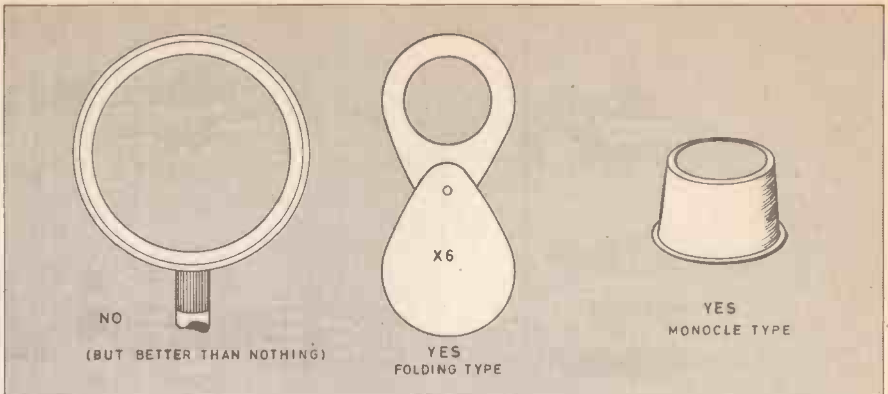
EXAMINATION

After p.c.b. soldering has been completed, and all the excess leads have been trimmed off close to the solder pad, the joins should be checked with a magnifying glass. It is impossible to stress too strongly the necessity for thorough examination. **DO NOT rely on normal eyesight** for this checking. Use a magnifying glass. In preference to the Sherlock Holmes' type, use a watch-maker's glass that can be held to the eye, and of at least x6 magnification—many opticians stock them. These enable a good close-up view within an inch or so to be obtained.

Only in this way can minute solder shorts, and inadequate solder melting problems, be properly observed. Do not just assume that the soldering is correct—**CHECK IT!** Even professional solderers can make mistakes, and so the amateur, part time, constructor is even more likely to make a soldering error.

WIRE PREPARATION

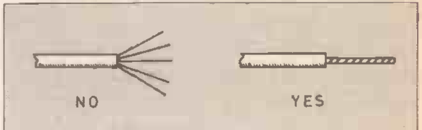
When soldering connecting wires between p.c.b.s and controls, these should also be tinned first. Strip off about a quarter of an inch of the plastic sheathing with a sharp knife or wire stripper. Make sure that the knife does not cut into the metal strands as this can weaken the wire and lead to breakage. Twist the stripped ends between finger and thumb so that all the strands are together. Now apply the iron and the solder, letting the solder melt evenly into and around the stripped end. This will ensure that when the lead is soldered to the control or p.c.b. pad, full solder adhesion occurs.



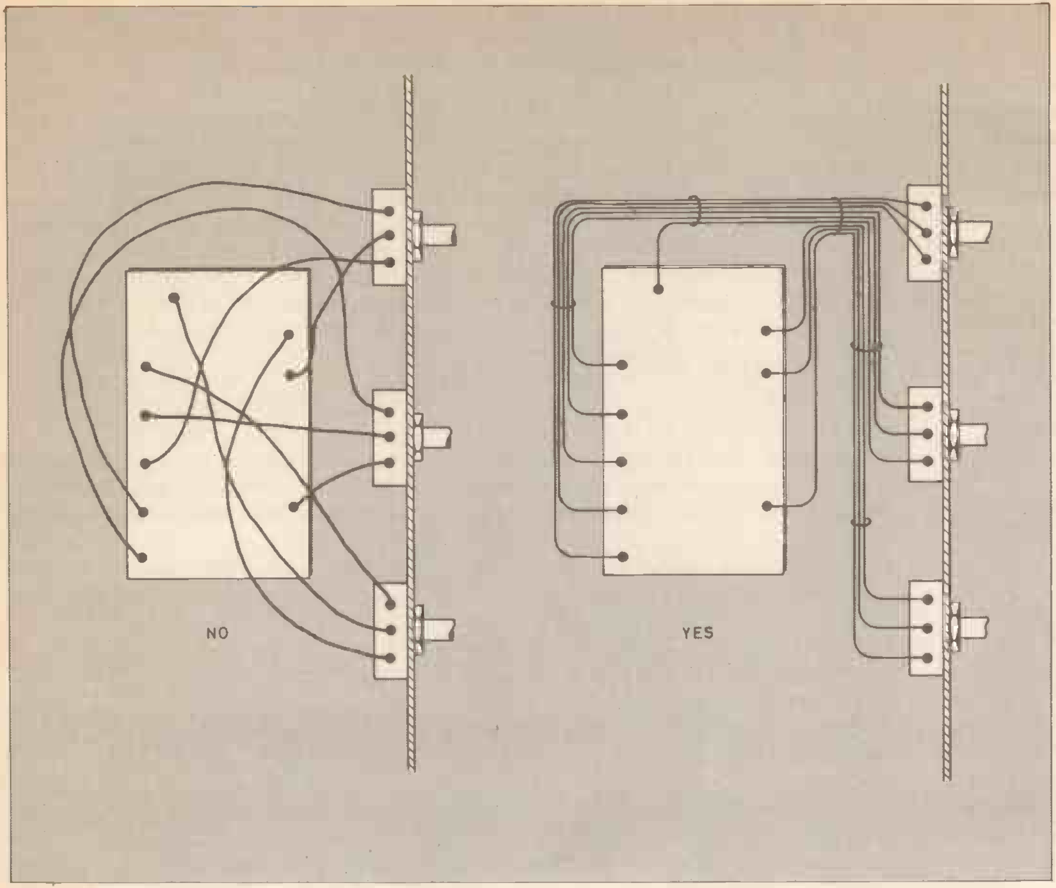
MAGNIFIERS

Pre-tinning of leads also helps when inserting the lead through a hole in the p.c.b. If an untinned lead is pushed into a p.c.b. hole, there is the danger that some of the strands may not go through the hole, and splay out on the top surface of the p.c.b. If this remains unnoticed, the delinquent strands could cause shorts across to other components.

I have an aversion to solid single strand connecting wire. This may help



WIRE STRIPPING



in neat wiring, but in the hands of the inexperienced, is more prone to breakage than the multi-stranded, especially if the p.c.b. is being repeatedly inverted for examination.

CONNECTING UP

Do make the wiring neat and short. the temptation to hurry through wiring up between controls and p.c.b.s is recognised, but all too often this can lead to untidy lead routing. Do not just bring leads across from p.c.b.s to controls in haphazard directions of varying lengths. It is much neater to route leads around the sides of boards in a methodical fashion. It also enables test probes to be readily placed on components on the board without having to push aside a bird's nest of wiring.

For ultimate neatness, leads can be secured in a harness held with cable ties. Alternatively, thin waxed string or strong thread can be used to tie them together. However, it is best to actually get the circuit working first, before drawing the wires into a permanent harness, just in case you've made an error that could necessitate a bit of rewiring. Note that on some projects (e.g. high power audio amplifiers) certain wires should not be tied together in a harness as this can cause instability—this is normally mentioned in the text of the project.

To minimise the risk of wiring error, lightly draw over each wire on the published chart when you have connected it. Remember that you may want to correct an overlooked error once the wiring is complete, or ultimately you or someone else may need to service the equipment, so whilst wiring should be kept short, it must be long enough for the p.c.b. to be removed from its supports and turned over for access to the soldered side. If you don't do this, either you will not be able to get at the p.c.b., or—if you keep turning the p.c.b. back and forth with short wires, the constant flexing may cause the wires to break off at the soldered ends. Using dissimilar colours for adjacent wires will also help with future servicing if necessary.

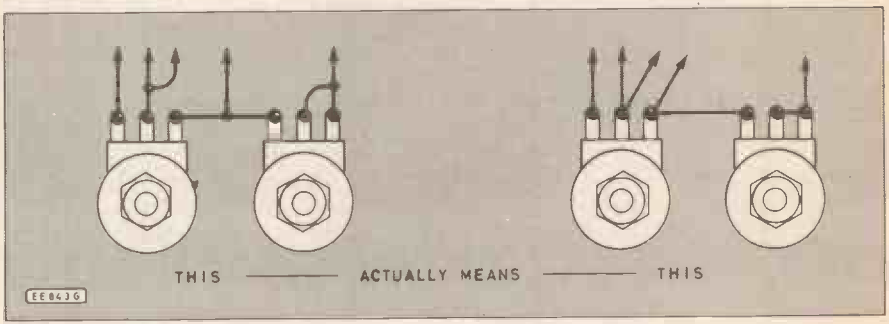
Note also that some wiring diagrams may show a solder connection that looks as though it is made along a lead some distance from a tag. This needs not be taken too literally, it is a schematic drawing for convenience only, and the connection can be made to the nearest relevant tag.

MAINS HUM AND SCREENING

Mains hum should not be experienced with battery operated units, and with these the use of screened wire is normally unnecessary. However, if mains hum or other external interference is experienced, first try soldering a lead to the back of one of the pots (scraping it first), and then to the main 0V or ground distribution point. Sometimes taking it to the nearest 0V point will suffice. Failing that, try using screened wire between any signal routes connecting sockets, controls and p.c.b.

Signal leads between the unit and other equipment should always be screened. If screened leads need to be used internally, the screen should usually only be connected to the 0V line electrically nearest to the origin of the signal being routed.

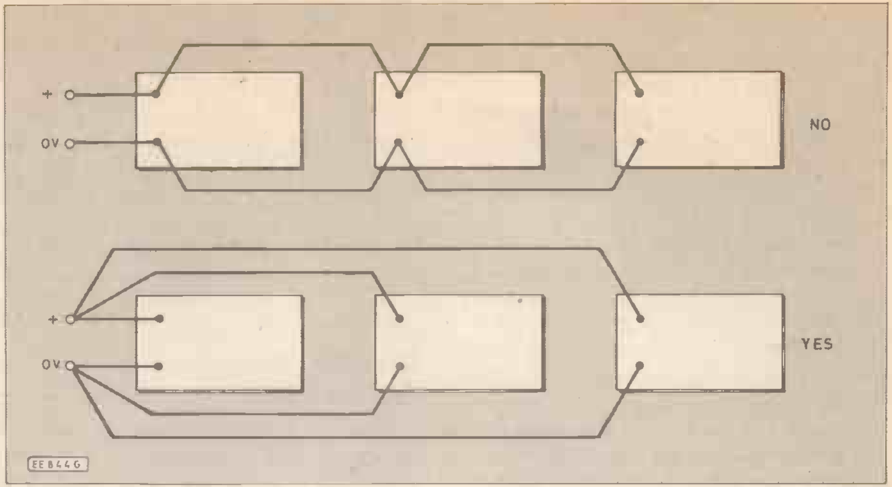
If it is necessary to take the chassis of the box to the 0V line, this connection should normally be made at the



main distribution point of the power line, as should the connection to mains earth if required. Remember, though, that multiple earth connections can also produce the forbidden earth loops if various circuits are intercoupled, and such connection should only be made if specifically instructed, or after full consideration of all the pros and cons, including the safety factor involved. If you are in doubt about earth connections to mains, consult your local electrical retailer.

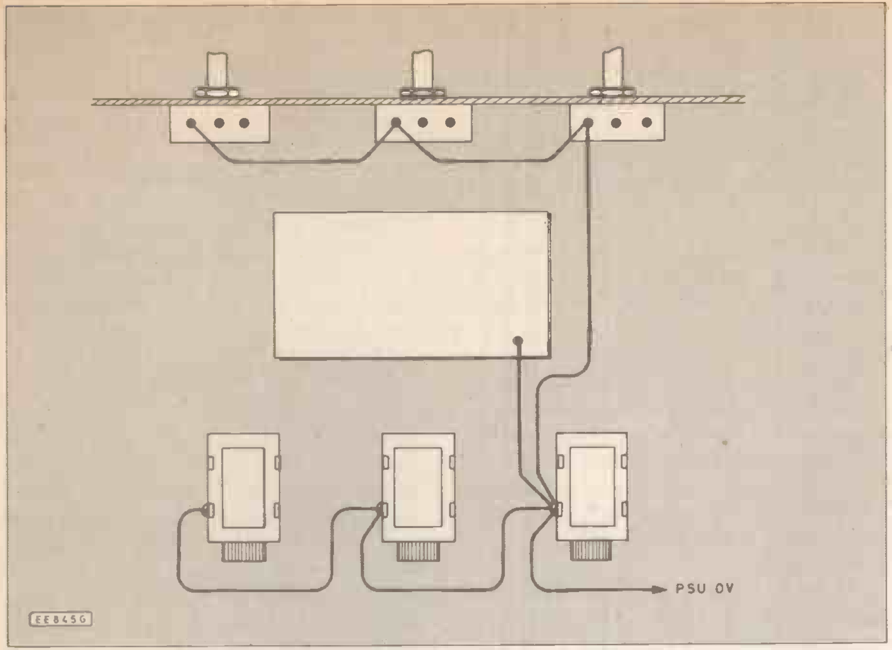
POWER LINES

Inadequate power line routing in even simple systems can be a major cause of unwanted noise and other problems. Of the various methods available, I have found the following to be the most reliable. For the sake of simplicity only 0V or ground lines are dealt with, but similar principles apply to +ve and −ve lines as well. Basically, 0V lines should be fanned out from a single distribution point, and no two points should be connected by more than one wire, irrespective of the route that the second connection might take. Failure to observe this, however unwittingly, is at best likely to increase "hum" levels, and in extreme cases can result in "howl".



The main distribution point should be taken as the relevant terminal on a battery, or the large capacitor of a conventional power supply (or to a terminal mounted close to it). From here, individual wires should radiate out to each p.c.b. separately, another wire to a common junction of all 0V line connections on panel sockets, and another to a common junction of all 0V line connections of panel pots and switches. Do not connect p.c.b.s in series with one another on power lines. (Sometimes it may be done, but currents flowing and the type of circuits must be fully considered.)

An additional factor in power line distribution is that any wire has resistance which causes a voltage drop across it, relative to the current flowing. In the case of a fluctuating current the resulting ripple in the voltage level may be picked up by all of the circuits connected to the resistive end of the power line, producing an effect similar to "cross-talk", with the action of one circuit undesirably affecting the



action of another. To minimise this problem, power lines should have adequate current carrying characteristics and be kept short.

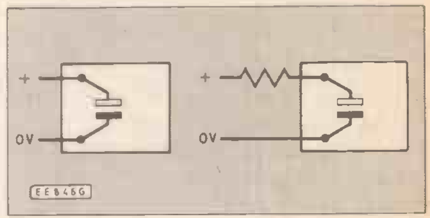
If necessary, additional smoothing capacitors may be soldered across the circuit end of the power lines. In extreme cases of intercircuit reaction, a small value resistor in series with the power line of the intrusive circuit may help, again aiding it with a capacitor across the power line.

COMPONENT ORIENTATION

Soldering is not the only area in which the inexperienced can find problems. Another is component orientation. That is, the way round that components should go into a printed circuit board.

Many component types are not at all concerned about which way they face. Amongst the "don't-care-which-way" items are resistors, polyester and polystyrene capacitors. Potentiometers and switches will not usually die if they are wrongly wired, but you may get odd results if they are. Jack sockets may now allow signals through if wrongly wired, but otherwise will not suffer.

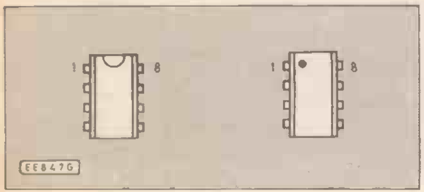
Some components, though, are extremely fussy about which way they are connected, and could die rapidly if given power in the wrong direction. Amongst these are electrolytic and tantalum capacitors, transistors, diodes, light emitting diodes (l.e.d.s), integrated circuits and some trans-

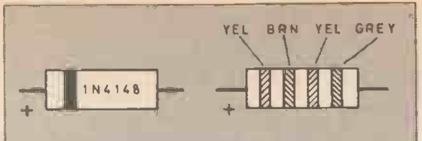


formers. All the electronics constructional magazines attempt to show diagramatically which way polarity sensitive components should go. Each magazine should be consistent to its own in-house standards, though sometimes the standards may differ between them, and occasionally the method of component manufacture does not always tie in the with the stylised published drawing.

I have come across two notable areas in which the latter conflicts can occur; integrated circuits and diodes.

The normal magazine representation for an integrated circuit orientation, is to show a notch in the middle of the end of the i.c. schematic. This is intended to tie in with the notch moulded into some i.c.s. However, some manufacturers do not use a notch, but rather, mould in a circular indentation close to an outside leg. This is normally near leg one of the i.c. and should point in the same direction





NOTATED AND CODED DIODE POLARITY

as the schematic notch in a layout illustration. Some i.c.s. may have a moulded dot at each end, in this case the deeper of the two is the location mark.

The second area is with diodes. these are frequently shown as a rectangle with a dark bar across one end. This is intended to illustrate the positive end of the idode. However, some diodes may have several bars on them, and the darkest does not always correspond with the positive end. The widely used 1N4148 is an example of this. Some manufacturers put a dark line at the positive end, and stamp the identity on in ink. Others, though, use a colour coded identity.

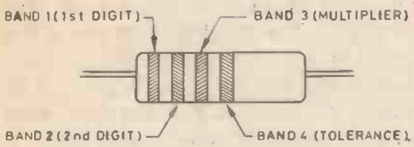
With the 1N4148, the colour code is the same as used on resistors, so it is yellow-brown-yellow-grey. This is read from left to right, and the positive end is at the start of the code, that is, at the left. Unfortunately, in the manufacturing, the grey of the code can show up as darker than the yellow, consequently it is all too easy for the inexperienced to look at the diode, see a dark band, and conclude that this is the positive end. Wrong! It is the negative end, and the circuit may not work if it is used in this direction. The answer is to study the diode first, look for a colour code, and then relate it to the type number. If all else fails, ring up the supplier who sold it to you and check with him.

RESISTOR CODES

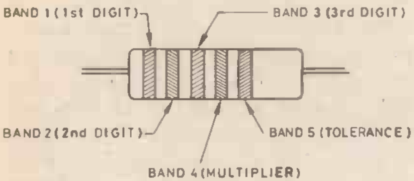
One occasional favourite error is to read a resistor code backwards. For example, 1k and 200 ohm resistors being swapped over—brown-black-red, and red-black-brown. Remember that they are read from left to right, and the way you can often find out which is which, is to look for a silver or gold band at one end. This indicates the tolerance factor, in order of 10% and 5%. It is on the right-hand side. The first three bands on the left are then the colour code in directional order.

Nowadays, 2% tolerance resistors are frequently used, the tolerance band here is red, and a little intelligence must be used to determine left

RESISTOR AND CAPACITOR IDENTIFICATION



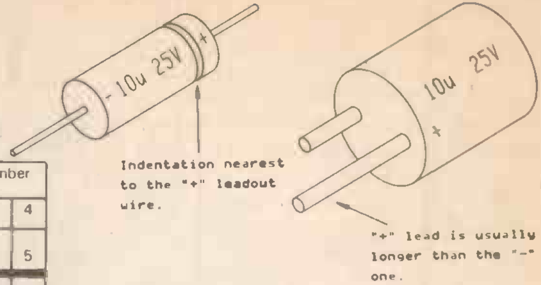
EE 236G

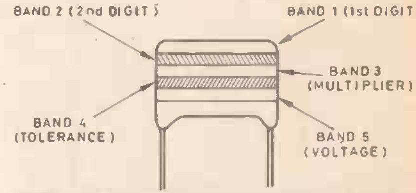


EE 237G

Four and five band resistor colour codes. Do not assume that a resistor having a similar code to the one you require will have a similar value. If the "multiplier" is wrong the value will be wrong by a factor of at least ten.

		Band Number				
	4 Band Codes	1	2		3	4
	5 Band Codes	1	2	3	4	5
Colour	Silver	—	—	—	0·01	10%
	Gold	—	—	—	0·1	5%
	Black	0	0	0	1	—
	Brown	1	1	1	10	1%
	Red	2	2	2	100	2%
	Orange	3	3	3	1000	—
	Yellow	4	4	4	10000	—
	Green	5	5	5	100000	—
	Blue	6	6	6	1000000	—
	Violet	7	7	7	—	—
	Grey	8	8	8		
	White	9	9	9		
	None					20%





C280 capacitor colour coding. This first three bands gave the value (in pF) using the same system as for the four band resistor coding.

		Band	
		4	5
Colour	Black	20%	—
	White	10%	—
	Green	5%	—
	Orange	2·5%	—
	Red	2%	250V
	Brown	1%	—
	Yellow	—	400V

from right, though usually there is a wider space before the tolerance band. Other variations exist, but usually follow a readily discernible pattern.

ELECTROLYTICS

Electrolytic capacitors sometimes cause confusion. Often they are schematically shown as having a slightly crimped end. This corresponds with the manufacaturing crimp used to hold the contents in the metal sleeve. It also indicates the positive end. This can be further established by examining the circular ends of the capacitor. The negative end normally has a wire directly connected to the metal sleeve. The positive end is usually surrounded by a darker plastic-looking material. Some manufacturers are helpful by stamping a "+" at the positive end, but can also confuse matters by stamping a circular line at the negative end. To the inexperienced, this line may be confused with the method of marking diode polarity.

Another maker has large arrows down the side of the capacitor. It is natural to expect that these point to the positive end. Closer examination, though, shows that the arrows contain the "–" symbol, so the arrows point away from positive. Examination of the circular ends of the capacitor will confirm the truth of the correct direction.

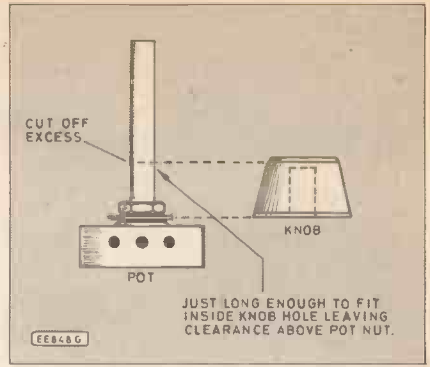
I.C. SOCKETS

A few times I have been asked if i.c. sockets need to be any particular way round. Basically, the answer is no, but it is useful to have their notch markings (if they exist) consistent with the i.c. direction, so that it is immediately obvious which way the i.c. should go in, without having to refer back to mislaid literature.

POTS AND SWITCHES

As said previously, pots and switches are not usually concerned about polarity from a "live-or-die" point of view. But they can be the cause of problems in other ways. The most notable problem concerns cutting off excess shaft lengths. Many panel potentiometers and rotary switches have more shaft than is needed for a satisfactory appearance on the front panel.

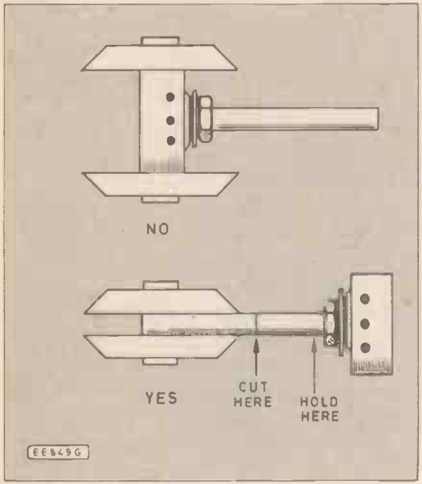
If the excess length is cut off carelessly, damage to the inner workings can occur. This is especially true with pots, which have a fragile resistance wafer inside. Damage can result from the vibration caused when the shaft is sawn through. Do not put the pot body into a vice to hold it while cutting the shaft. Rather, put the shaft into the vice, hold the shaft end nearest the body between finger and thumb, and then saw between the vice and fingers. This should prevent the cutting vibration from being passed through the wafer.

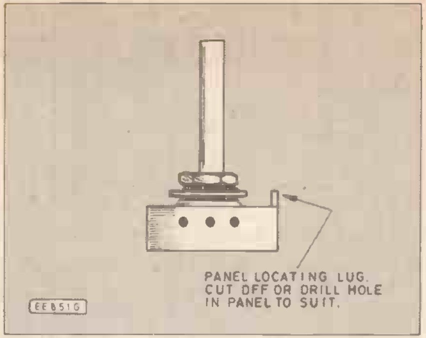


With plastic shafts there is a simpler, quicker way—use a pair of garden secateurs (pruning snippers). With care for the safety of fingers, the shaft can be cut through without too much wrist effort. If it is necessary to use a saw, beware that even if the wafer is not totally destroyed, abrasions to it could result in causing the pot to sound electronically noisy when used in a working circuit.

LOCATING LUGS

There is a small additional point on rotary switches, which often have a locating washer close to the body. This has a lug on it and sets the maximum click stops through which the shaft will rotate. Sometimes in manufacture a switch may be assem-





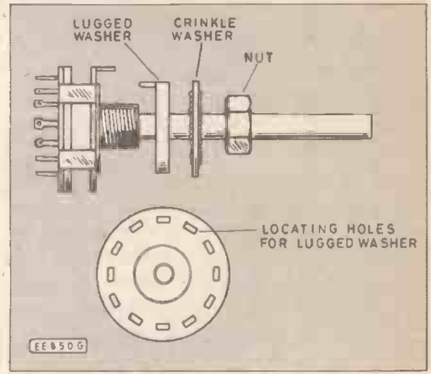
bled with it in the wrong position, and a 4-way switch, for example, may appear to only have three ways.

Before wiring the switch, check that the correct number of positions are obtainable, and if necessary prise out the washer, and relocate into the correct hole. Also where rotary switches do not have numbered or lettered tags, the correct tags to wire to must be checked by using a multimeter on its ohms checking mode. Alternatively, a simple continuity checker can ascertain which tags connect in the correct order.

Finally, on pots and switches, there is normally a locating lug alongside the screwthread. This is supposed to go through a small hole in the front panel to stop unrequired rotation of the complete component. On no account screw down the main nut with this lug hard up against the box. At best it will distort the panel and make the shaft look crooked. At worst it could cause the wafer to break, or for switch contacts to fail to make proper connection. If you are too lazy to drill the extra panel hole (and I usually am), cut or break the lug off with a pair of pliers. Several times I have found this lug to be the cause of malfunction on a project in for maintenance.

SUPPLIER'S HELP

If in doubt with any parts where polarity may be of vital importance,



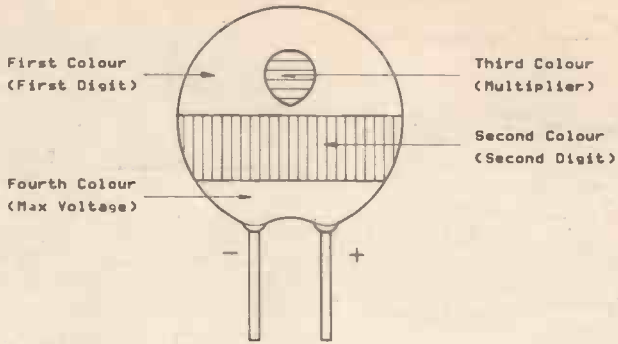
check with the supplier or check the supplier's literature. Many suppliers now provide charts showing common polarities with kits; reading this data will normally provide an answer.

LOGICAL

After reading this advice, don't think to yourself, "What a lot to remember—shall I ever?" There is a lot to electronics, yet it is all logical, and a little thought can often work out implications, even if memory has slipped. With practise, all the points that I have covered can become second nature. This too is one of the functions of magazines like *Everyday Electronics,* to enable you to learn about this remarkable technology, both by encouraging practical circuit construction, and providing theoretical information in its various forms.

As an avid reader of constructional magazines from my very early days, much of my initial knowledge was inspired by those pages. I thoroughly recommend electronics to anyone with even the slightest interest in technology. So, keep your soldering irons hot and clean, construct a few simple projects, learn from your errors, and progress to grander circuits. It is well worth your while. □

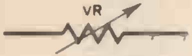
TANTALUM BEAD CAPACITOR IDENTIFICATION



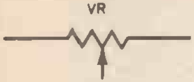
COLOUR	BAND 1	BAND 2	SPOT	BAND 3
BLACK	—	0	×1	10V
BROWN	1	1	×10	—
RED	2	2	×100	—
ORANGE	3	3	—	—
YELLOW	4	4	—	6.3V
GREEN	5	5	—	16V
BLUE	6	6	—	20V
VIOLET	7	7	—	—
GREY	8	8	×0.01	25V
WHITE	9	9	×0.1	3V
PINK	—	—	—	35V

CIRCUIT SYMBOLS

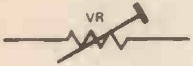
Fixed value resistor



Variable resistor



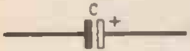
Potentiometer with control knob



Variable resistor with preset control

Potentiometer with preset adjustment

Fixed value capacitor



Fixed value electrolytic capacitor

Tantalum capacitor

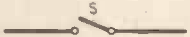
Variable capacitor

Capacitor with preset adjustment (trimmer)

Indicating or signal lamp

Illuminating lamp

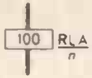
Neon lamp or indicator



Single pole single throw switch

Rotary switch, single pole three-way

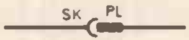
Single pole push-to-make switch



Relay with coil resistance of 100 ohms with *n* contacts

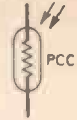
Relay make contact Additional sets of contacts are annotated RLA1, RLA2, etc

Fuse

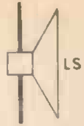


Single terminal socket and plug

Battery with more than one cell

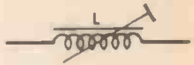


Light dependent resistor

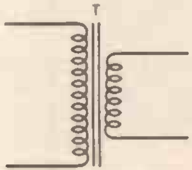


Loudspeaker

Fixed value inductance



Variable inductance coil with ferrite core



Transformer with laminated core, no tappings


Two conductors crossing with no connection

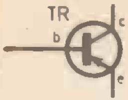

Junction of connection of three conductors

"Earth" connection:
(a) to earth
(b) to chassis


Continous screened lead

CIRCUIT SYMBOLS

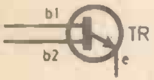
Transistor *npn*



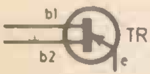
Transistor *pnp*

Junction field effect transistor, *n* channel

Junction field effect transistor, *p* channel



Unijunction transistor with *n* type base



Unijunction transistor with *p* type base

Semiconductor *pn* diode

Voltage reference diode (Zener diode)

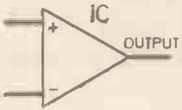

EX-OR


BUFFER

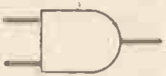
Light emitting diode

Controlled silicon rectifier (thyristor)

Triac



Integrated circuit differential operational amplifier


AND


OR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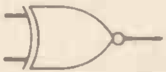
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