EVERYDAY ELECTRONICS

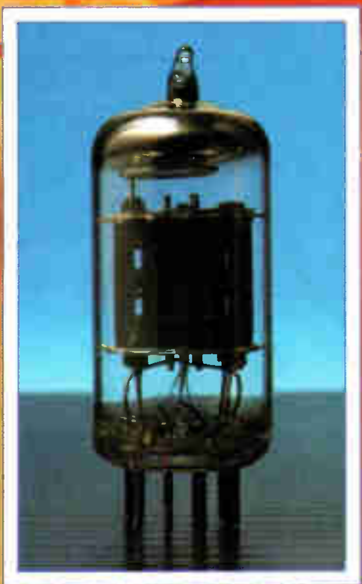
P. Jones FEBRUARY 1988

INCORPORATING ELECTRONICS MONTHLY £1.20

FREE INSIDE 1988 YEAR PLANNER & DATA CARD

ONE VALVE RECEIVER

EMERGENCY LIGHT UNIT



SPECIAL FEATURE
London to Sydney in 3 hours!

The Magazine for Electronic & Computer Projects

£1 BAKERS DOZEN PACKS

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

1 – 5 13 amp ring main junction boxes
2 – 5 13 amp ring main spur boxes
5 – 3 flush electrical switches
7 – 4in flex line switches with neons
8 – 2 80 watt brass cased elements
9 – 2 mains transformers with 6V 1A secondaries
10 – 2 mains transformers with 12V ½ A secondaries
11 – 1 extension speaker cabinet for 6½" speaker
12 – 5 octal bases for relays or valves
13 – 12 glass reed switches
14 – 4 OCP 70 photo transistors
16 – 4 tape heads, 2 record, 2 erase
17 – 1 ultrasonic transmitter and 1 ditto receiver
18 – 2 15000 mfd computer grade electrolytics
19 – 2 light dependent resistors
20 – 5 different micro switches
21 – 2 mains interference suppressors
22 – 2 25 watt crossover units 2 way
23 – 1 40 watt 3 way crossover unit
28 – 1 6 digit counter mains voltage
30 – 2 Nicad battery chargers
31 – 1 key switch with key
32 – 2 humidity switches
34 – 96 x 1 metre lengths colour-coded connecting wires
36 – 2 air spaced 2 gang tuning condensors
37 – 2 solid diaelectric 2 gang tuning condensors
38 – 10 compression trimmers
41 – 6 Rocker Switches 10 amp mains SPST
43 – 5 Rocker Switches 10 amp SPDT Centre Off
44 – 4 Rocker Switches 10 amp OPOT
45 – 1 24 hour time switch mains operated (s.h.)
46 – 1 6 hour clock timeswitch
48 – 2 6V operated reed switch relays
49 – 10 neon valves – make good night lights
50 – 2 x 12V OC or 24V AC, 4 CO relays
51 – 1 x 12V 2C O very sensitive relay
52 – 1 12V 4C relay
55 – 1 locking mechanism with 2 keys
56 – Miniature Uniselector with circuit for electric jigsaw
57 – 5 Dolls' House switches
60 – 5 ferrite rods 4" x 5/16" diameter aerials
61 – 4 ferrite slab aerials with L & M wave coils
62 – 4 200 ohm earpieces
63 – 1 Mullard thyristor trigger module
64 – 10 assorted knobs ¼ spindles
65 – 5 different themostats, mainly bi metal
66 – Magnetic brake – stops rotation instantly
67 – Low pressure 3 level switch
69 – 2 25 watt pots 8 ohm
70 – 2 25 watt pots 1000 ohm
71 – 4 wire wound pots – 18, 33, 50 and 100 ohm
73 – 4 3 watt wire wound pots 50 ohm
77 – 1 time reminder adjustable 1-60 mins
78 – 5.5 amp stud rectifiers 400V
85 – 1 mains shaded pole motor ¾" stack – ¼ shaft
86 – 2 5" ali fan blades fit ¼" shaft
87 – 2 3" plastic fan blades fit ¼" shaft
88 – Mains motor suitable for above blades
89 – 1 mains motor with gearbox 1 rev per 24 hours
91 – 2 mains motors with gearbox 16 rpm
93 – 4 11 pin moulded bases for relays
94 – 5 B7G valve bases
95 – 4 skirted B9A valve bases
96 – 1 thermostat for fridge
98 – 1 motorised stud switch (s.h.)
101 – 1 2½ hours delay switch
103 – 1 6v mains power supply unit
104 – 1 4½ V mains power supply unit
105 – 1 5 pin flex plug and panel socket
107 – 1 5" speaker size radio cabinet with handle
109 – 10 ¼" spindle type volume controls
110 – 10 slider type volume controls
112 – 1 heating pad 200 watts mains
114 – 1 1W amplifier Mullard 1172
115 – 1 Wall mounting thermostat 24V
118 – 1 Teak effect extension 5" speaker cabinet
120 – 2 p.c.b. with 2 amp full wave and 17 other recs
122 – 10 mtrs twin screened flex white p.v.c. outer
132 – 2 plastic boxes with windows, ideal for interrupted beam switch etc
155 – 3 varicap push button tuners with knobs
188 – 1 plastic box, sloping metal front, 16 x 95mm, average depth 45mm
241 – 1 car door speaker (very flat) 6½" 15 ohm made for Radiomobile
243 – 2 speakers' 6" x 4" 15 ohm 5 watt made for Radiomobile
266 – 2 mains transformer 9V ½ A secondary split primary so OK also for 115V
267 – 1 mains transformers 15V 1A secondary p.c.b. mounting
330 – 2 6V 0.6V mains transformer .3a p.c.b. mounting
350 – 40 double pole leaf switches
365 – 1 7uf 660V 50hz metal cased condenser
453 – 2 2¼in 60 ohm loudspeakers
454 – 2 2¼in 8 ohm loudspeakers
463 – 1 mains operated relay with 2 sets c/o contacts
464 – 2 packets resin filler/sealer with cures
465 – 3 5A round 3 pin plugs will fit item 193
466 – 4 7 segment l.e.d. displays
470 – 4 pc boards for stripping, lots of valuable parts
480 – 1 3A double pole magnetic trip, saves repairing fuses
498 – 4 1000uf 25V axial electrolytic capacitors
504 – 1 Audax PM 8" speaker 15 ohm 5 watt rating
515 – 100 4BA 1½" cheesehead plated screws and 100 4BA nuts
541 – 1 pair stereo tape head as in cassette recorder/players
546 – 1 bridge rectifier 600V international rectifier ref 3SB100
548 – 2 battery operated relays (3-6v) each with 5A c/o contacts 2 pairs
553 – 2 lithium 3V batteries (everlasting shelf life)

OVER 400 GIFTS YOU CAN CHOOSE FROM

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

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

THIS MONTHS SNIP

3½ floppy Disk Drive, made by the Chinon Company of Japan. Beautifully made and probably the most compact device of its kind as it weighs only 600g and measures only 104mm wide, 162mm deep and has a height of only 32mm, other features are high precision head positioning – single push loading and eject – direct drive brushless motor – 500K per disc – Shugart compatible interface – standard connections – interchangeable with most other 3½ and 5¼ drives. Brand new with copy of makers manual. Offered this month at £28.50 post and VAT included.

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

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

MULLARD UNILEX AMPLIFIERS

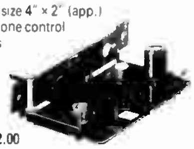
We are probably the only firm in the country with these now in stock. Although only four watts per channel, these give superb reproduction. We now offer the 4 Mullard modules – i.e. Mains power unit (EP9002) Pre amp module (EP9001) and two amplifier modules (EP9000) all for £6.00 plus £2 postage. For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

CAR STARTER/CHARGER KIT

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

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

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



LIGHT BOX

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

TANGENTIAL HEATERS

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

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

FANS & BLOWERS

5" £5 + £1.25 post. 6" £6 + £1.50 post
4" x 4" Muffin equipment cooling fan 115V £2.00
4" x 4" Muffin equipment cooling fan 230/240V £5.00
9" Extractor or blower 115V supplied with 230 to 115V adaptor £9.50 + £2 post.
All above are ex computers but guaranteed 12 months.
10" x 3" Tangential Blower. New. Very quiet – supplied with 230 to 115V adaptor on use two in series to give long blow £2.00 + £1.50 post or £4.00 + £2.00 post for two

9" MONITOR

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

LOW COST OSCILLOSCOPE – kit to convert our 9" monitor into an oscilloscope with switched time bases to allow very high and very low frequency waveforms to be observed and measured. Signal amplitudes from as low as 10mV and as high as 1kV can easily be observed and measured. Ideal for servicing, also for investigating TV, radio and audio circuits.
Kit containing all the parts for the conversion and the power supply to operate from mains £25 our ref 25P3.

TELEPHONE LEAD

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

COMPACT FLOPPY DISC DRIVE EME-101

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

POWERFUL IONISER

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

J & N BULL ELECTRICAL

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

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

NEW ITEMS

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

SUPER WATER PUMP – Approx ⅓hp mains operated originally intended to operate a £300 shower unit at a controlled pressure – but of course suitable for many other water or liquid moving operations – where a good flow at a constant pressure is required – Price £25 each V.A.T. and Post Paid. Our Ref. 25P2.
VERY USEFUL MULTI TESTERS – These have all usual ranges AC & DC volts – DC MA and OHMS etc but an unusual and very useful feature is a "low OHMS" range. Very useful for checking dry joints etc. They are ex G.P.O., and may have faults but we test and guarantee the movement to be O.K. Price £3 each. Ref. 3P30.
AGAIN AVAILABLE – 12" mini fluorescent tubes – Price £1 each. Ref. BD314.
POWER PACK OR AMPLIFIER CASE – Size approx 10" × 8¼" x 4¾" plated steel – with ample perforations for cooling. Front panel has on/off switch and E.E.C. mains inlet plug with built in RF filter – undoubtedly a very fine case which would cost at least £50 from regular sources, our price is £5 each and £3 post. Ref. 5P111.
MINIATURE BCD THUMB WHEEL SWITCH – Matt black edge switch engraved white on black – gold plated, make before break contats – size approx. 25mm high 8mm wide 20mm deep – made by the famous Cherry Company and designed for easy stacking – Price £1 each. Ref. BD601.
EDGE METER – miniature, whole size approx 37mm x 13mm 100 ua fsd – centre zero scaled 0 to – 10 and 0 to + 10. Price £1 each. Ref. BD602.
LARGE 2 SPEEO MOTOR – 1 hp at 2500 rpm and ¼ hp at 200rpm – continental make, intended originally to power an industrial machine – regular price over £60 our Price £15 plus £5 carriage. Ref 15P5.
RUBBER FEET – Stick on – ideal for small instruments and cabinets – pack of 56 for £1. Ref. BD603.
CLEANING FLUID – Extra good quality – intended for video and tape heads – regular price £1.50 per spray can – our Price – 2 cans for £1. Ref. BD 604.
DON'T FREEZE UP! – We have had the strongest winds for over 200 years and who knows we may be in for the coldest winter, so if you have not already protected your water pipes you should do so now – our heating wire wound around the pipes will do this and will cost only about 50p per week to run – 15 metres (minimum length to connect to 230/240 v mains). Price £5. Our Ref. 5P 109.
PIEZO ELECTRIC FAN an unusual fan, more like the one used by Madame Butterfly, than the conventional type, it does not rotate. The air movement is caused by two vibrating arms. It is American made, mains operated, very economical and causes no interference. So it is ideal for computer and instrument cooling. Price is only £1 each. Ref BD605.
SPRING LOADED TEST PROOS – heavy duty, made by the famous Bulgin company. Very good quality. Price four for £1. Ref. BD599.
CURLY LEAO four core, standard replacement for telephone handset, extends to nearly two metres. Price £1 each. Ref. BD599.
TELEPHONE BELLS – these will work off our standard mains through a transformer, but to sound exactly like a telephone, they then must be fed with 25 hz 50v. So with these bells we give a circuit for a suitable power supply. Price 2 bells for £1. Ref. BD600.
ULTRA SENSITIVE POCKET MULTIMETER – 4k ohms per volt – 11 ranges – carry one of these and so be always ready to test ac/dc volts to 1000, DC milliams and have an ohms range for circuit testing – will earn its cost in no time. Price only £7. Ref. 7P2.
BLOW YOUR ROOF OFF 140 watt speaker systems – new type you must not hide! they have golden cones and golden surrounds and look really "Bootiful" 12" Woofer, Midrange and Tweeter and comes with a crossover at a special introductory price of £49, carriage paid. Two sets for £95 carriage paid. 140w Woofer only £35 carriage paid.
3½ & 5¼ FLOPPY DISC DRIVES now in stock all are new and made by famous Epson company. All are double sided drives with storage capacity of 1 meg byte. They have standard connections and are fully compatible with conventional systems. Both are small size and light weight. Price – either model is £57.50 plus £3 post. Price includes copy operating data.
APPLIANCE THERMOSTATS – spindle adjust type suitable for convector heaters or similar price 2 for £1. Ref. BD582

COMPUTERS

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

NOVEL NIGHT LIGHT – plugs into a 13A socket. Gives out a surprising amount of light, certainly enough to navigate along passages at night or to keep a nervous child happy. Very low consumption, probably not enough to move the meter. Price £1. Ref. BD563.
CASE WITH 13A PRONGS – to go into 13A socket, nice size and suitable for plenty of projects such as car battery trickle charger, speed controller, time switch, night light, noise suppressor, dimmers etc. Price – 2 for £1. Ref. BD565
SPEAKER EXTENSION CABLE – twin 0.7mm conductors so you can have long runs with minimum sound loss and for telephone extensions or burglar alarms, bells, intercoms etc. 250m coil only £3 plus £1 post. Ref. 3P28.
ALPHA-NUMERIC KEYBOARO – this keyboard has 73 keys with contactless capacitance switches giving long trouble free life and no contact bounce. The keys are arranged in two groups, the main area field is a QWERTY array and on the right is a 15 key number pad, board size is approx. 13" x 4" – brand new but offered at only a fraction of its cost namely £3, plus £1 post. Ref. 3P27.
TELEPHONE EXTENSIONS – it is now legal for you to undertake the wiring of telephone extensions. For this we can supply 4 core telephone cable, 100m coil £8.50. Extension BT sockets £2.95. Packet of 500 plastic headed staples £2. Dual adaptor for taking two appliances from one socket £3.95. Leads with B.T. plug for changing old phones. 3 for £2.
MOOULAR SWITCH – Panel mounting highest quality and ideal where extra special front panel appearance is required, can be illuminated if required d.p.d.t. and latching. Price – 2 for £1. Ref. BD607.
WIRE BARGAIN – 500 metres 0.7mm solid copper tinned and p.v.c. covered. Only £3 + £1 post. Ref. 3P31 – that's well under 1p per metre, and this wire is ideal for push on connections.
INTERRUPTED BEAM KIT – this kit enables you to make a switch that will trigger when a steady beam of infra-red or ordinary light is broken. Main components – relay, photo transistor, resistors and caps etc. Circuit diagram but no case. Price £2. Ref. 2P15.
3-30V VARIABLE VOLTAGE POWER SUPPLY UNIT – with 1 amp DC output. Intended for use on the bench for experimenters, students, inventors, service engineers etc. This is probably the most important piece of equipment you can own. (After a multi range test meter). It gives a variable output from 3-30 volts and has an automatic short circuit and overload protection, which operates at 1.1 amp approximately. Other features are very low ripple output, a typical ripple is 3mV pk-pk, 1mV rms. Mounted in a metal fronted plastic case, this has a voltmeter on the front panel in addition to the output control knob and the output terminals. Price for complete kit with full instructions is £15. Ref. 15P7.
TRANSMITTER SURVEILLANCE (BUG) – tiny, easily hidden, but which will enable conversation to be picked up with FM radio. Can be housed in a matchbox, all electronic parts and circuit. Price £2. Ref. 2P52.

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ABC

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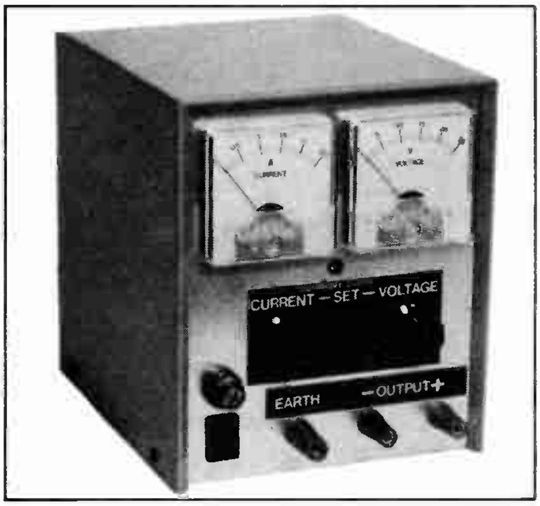
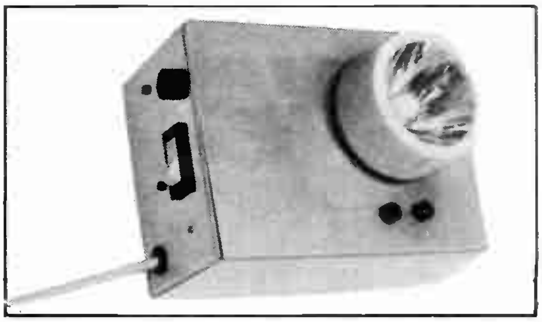
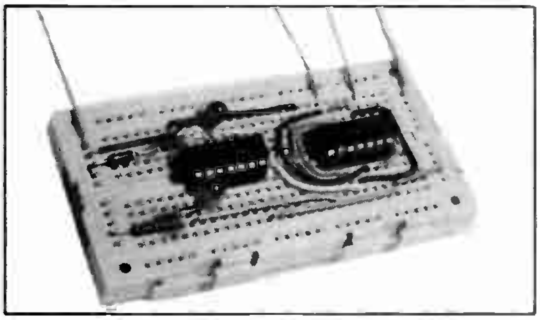
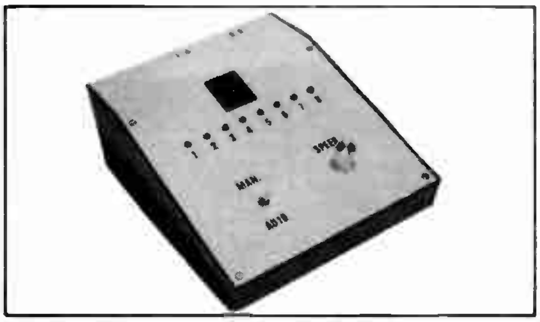
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .









Our March 1988 issue will be published on Friday, 5 February 1988. See page 75 for details.

Projects

Series

Features

Full Kits inc. PCBs, or veroboard, hardware, electronics, cases (unless stated). Less batteries.
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 – 80p each. Reprints available separately 80p each + p&p £1.00.

EE PROJECT KITS MAGENTA

THIS MONTH'S KITS (sae or 'phone for prices)

VARIABLE 25V-2A

BENCH POWER SUPPLY Feb 88	£49.73
QUIZMASTER Jan 88	£18.96
CAPACITANCE METER Jan 88	£29.35
TRANSISTOR CURVE TRACER (BBC)	£14.98
CONTINUITY TESTER Jan 88	£9.67
AUDIO SIGNAL GENERATOR Dec 87	£12.99
DUAL MAINS LIGHTS FLASHER Dec 87	£19.98
ACCENTED BEAT METRONOME Nov 87	£19.95
ACOUSTIC PROBE Nov 87 (less bolt & probe)	£15.49
BBC SIDEWAYS RAM/ROM Nov 87	£26.22
VIDEO CONTROLLER Oct 87	£27.75
TRANSTEST Oct 87	£9.24
AUTOMATIC PORCH LIGHT Oct 87	£16.35
CARAVAN FRIDGE ALERT Oct 87	£5.18
STATIC MONITOR Oct 87	£8.25
ELECTRONIC MULTIMETER Sept 87	£44.72
NOISE GATE Sept 87	£22.14
PERSONAL STEREO AMP Sept 87	£13.63
CAR OVERHEATING ALARM Sept 87	£8.21
BURST-FIRE MAINS CONTROLLER Sept 87	£12.91
SUPER SOUND ADAPTOR Aug 87	£36.56
IMMERSION HEATER TIMER Aug 87	£17.99
3 BAND 1.6-30MHz RADIO Aug 87	£25.27
BUCCANEER I.B. METAL DETECTOR inc. coils and case, less handle and hardware July 87	£25.19
DIGITAL COUNTER/FREQ METER (10MHz) inc. case July 87	£67.07
MONOMIX July 87	£20.00
FERMOSTAT July 87	£11.56
VISUAL GUITAR TUNER Jun 87	£21.99
MINI DISCO LIGHT Jun 87	£11.99
WINDSCREEN WASHER WARNING May 87	£4.88
FRIDGE ALARM May 87	£9.41
EQUALIZER (IONISER) May 87	£14.79
BULB LIFE EXTENDER April 87 (less case)	£4.99
EXP. SPEECH RECOGNITION April 87	£19.98
COMPUTER BUFFER INTERFACE Mar 87	£11.96
ACTIVE I/R BURGLAR ALARM Mar 87	£33.95
VIDEO GUARD Feb 87	£7.99
MINI-AMP Feb 87	£14.99
CAR VOLTAGE MONITOR Feb 87	£11.98
SPECTRUM SPEECH SYNTH. (no case) Feb 87	£19.92
SPECTRUM I/O PORT less case. Feb 87	£8.99
STEPPING MOTOR BOOSTER (for above) Feb 87	£5.19
STEPPING MOTOR MD200 Feb 87	£16.80
HANDS-OFF INTERCOM (per station) inc. case Jan 87	£9.99
CAR ALARM Dec 86	£10.97
DUAL READING THERMOMETER (less case) Dec 86	£39.98
RANDOM NUMBER GENERATOR Dec 86	£14.97
8 CHANNEL A-D (SPECTRUM) CONVERTER Dec 86	£34.29
BBC 16K SIDEWAYS RAM Dec 86	£12.35
MODEM TONE DECODER Nov 86	£18.99
OPTICALLY ISOLATED SWITCH Nov 86	£11.99
CAR FLASHER WARNING Nov 86	£7.92
200MHz DIG. FREQUENCY METER Nov 86	£59.98
10 WATT AUDIO AMPLIFIER Oct 86	£34.95
LIGHT RIDER LAPEL BADGE Oct 86	£9.71
LIGHT RIDER DISCO VERSION	£18.69
LIGHT RIDER 16 LED VERSION	£12.99
SCRATCH BLANKER Sept 86	£53.17
INFRA-RED BEAM ALARM Sept 86	£26.99
FREEZER FAILURE ALARM Sept 86	£14.76
CAR TIMER Sept 86	£8.30
BATTERY TESTER Aug 86	£6.85
TILT ALARM July 86	£7.45
HEADPHONE MIXER July 86	£27.69
CARAVAN BATTERY MONITOR July 86	£16.35
SQUEEKIE CONTINUITY TESTER July 86	£3.35
ELECTRONIC SCARECROW July 86	£8.45
VOX BOX AMP July 86	£12.73
PERCUSSION SYNTH June 86	£28.98
LIGHT PEN (less case) June 86	£5.80
PERSONAL RADIO June 86	£10.98
WATCHDOG June 86	£7.85
MINI STROBE May 86	£13.11
PA AMPLIFIER May 86	£24.95
LOGIC SWITCH May 86	£14.93
STEREO REVERB Apr 86	£25.18
VERSATILE PSU Apr 86	£23.51
FREELOADER Apr 86	£8.08
STEPPER MOTOR DRIVER Apr 86	£4.89
BBC MIDI INTERFACE Mar 86	£26.61
INTERVAL TIMER Mar 86	£17.97
STEREO HI-FI PRE-AMP	£46.85
MAINS TESTER & FUSE FINDER Mar 86	£8.40
FUNCTION GENERATOR Feb 86	£23.66
POWER SUPPLY FOR ABOVE	£7.62
TOUCH CONTROLLER Feb 86	£12.25
SPECTRUM OUTPUT PORT Feb 86	£10.72
TACHOMETER Jan 86	£24.57
ONE CHIP ALARM Jan 86	£8.29
MUSICAL DOOR BELL Jan 86	£17.83
TTL LOGIC PROBE Dec 85	£9.45
DIGITAL CAPACITANCE METER Dec 85	£39.57
SOLDERING IRON CONTROLLER Oct 85	£5.21
VOLTAGE REGULATOR Sept 85	£7.46
PERSONAL STEREO P.S.U. Sept 85	£9.89

R.I.A.A. PRE-AMP Sept 85	£15.94
FRIDGE ALARM Sept 85	£7.50
LOW COST POWER SUPPLY UNIT Aug 85	£18.39
TRI-STATE THERMOMETER (Batt) Aug 85	£6.66
TREMOLO/VIBRATO Aug 85	£37.92
STEPPER MOTOR INTERFACE FOR THE BBC COMPUTER less case Aug 85	£13.99
1035 STEPPER MOTOR EXTRA	£14.50
OPTIONAL POWER SUPPLY PARTS	£5.14
CONTINUITY TESTER July 85	£5.90
TRAIN SIGNAL CONTROLLER July 85	£9.66
AMSTRAD USER PORT July 85	£16.83
ACROSS THE RIVER June 85	£19.77
ELECTRONIC DOORBELL June 85	£7.20
GRAPHIC EQUALISER June 85	£25.66
AUTO PHASE May 85	£17.98
INSULATION TESTER Apr 85	£18.65
LOAD SIMPLIFIER Feb 85	£18.68
GAMES TIMER Jan 85	£8.39
SPECTRUM AMPLIFIER Jan 85	£6.58
TV AERIAL PRE-AMP Dec 84	£14.83
Optional PSU 12V £2.44 240V	£11.83
DOOR CHIME Dec 84	£17.89
BBC MICRO AUDIO STORAGE SCOPE INTERFACE Nov 84	£34.52
PROXIMITY ALARM Nov 84	£21.58
MAINS CABLE DETECTOR Oct 84	£5.27
MICRO MEMORY SYNTHESISER Oct 84	£57.57
DRILL SPEED CONTROLLER Oct 84	£8.27
GUITAR HEAD PHONE AMPLIFIER Sept 84	£7.66
SOUND OPERATED FLASH less lead Sept 84	£6.98
TEMPERATURE INTERFACE FOR BBC Aug 84	£23.64
CAR RADIO BOOSTER Aug 84	£16.64
CAR LIGHTS WARNING July 84	£9.58
VARICAP AM RADIO May 84	£12.52
EXPERIMENTAL POWER SUPPLY May 84	£22.46
SIMPLE LOOP BURGLAR ALARM May 84	£16.34
MASTERMIND TIMER May 84	£6.52
FUSE/DIODE CHECKER Apr 84	£4.14
QUASI STEREO ADAPTOR Apr 84	£13.08
NI-CAD BATTERY CHARGER Mar 84	£11.82
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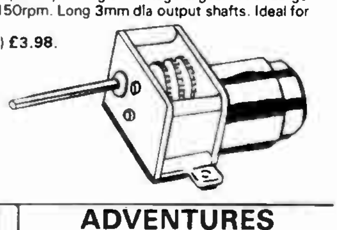

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INCORPORATING ELECTRONICS MONTHLY

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Editorial Offices
EVERYDAY ELECTRONICS EDITORIAL,
6 CHURCH STREET, WIMBORNE,
DORSET BH21 1JH
Phone: Wimborne (0202) 881749
Fax: (0202) 841692
See notes on **Readers' Enquiries** below—we regret that lengthy technical enquiries cannot be answered over the telephone

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VALVES

THAT valve on the front cover is there to set the scene for our *One Valve Receiver*. There may be a number of readers who have never even seen a valve before, let alone know how one works. We feel this interesting and useful project will provide an insight into the world of electronics and construction before solid state devices.

In fact that valve on the cover is not the type used in the project as we did not have one to hand when we needed to take the photo. The valve shown is from a mono 10W amplifier built by myself in 1968 – just 20 years ago. The amplifier is still in working order, although relegated to the garage long ago. I wonder how many solid state amplifiers will last that long with rough handling! Perhaps one of the advantages of valves was the ease with which they could be changed when they died, as of course they did at regular, but not too short, intervals.

The design of the receiver project is also dated now, but this type of receiver can give very good results and requires a little skill to operate which is all part of the fun. We hope many of you will build this fascinating design and gain from the experience.

Just compare this simple, old fashioned, project with the *GTi Car Computer*, using a microprocessor and a computer model of the car's performance, published last month, and you have an idea of the wide range of projects we cover.

YEAR PLANNER

We have included a free year planner in every copy of *Everyday Electronics* this month; hopefully you will find it useful. This year planner gives the publishing dates of the issues of *EE* for 1988. Regular readers will note that from next month *EE* will be published on the first Friday of the month instead of the third Friday. This change has taken place over a few months and brings us in line with other publications.

PRICE

The price of *Everyday Electronics* will be increased by 10p from next month. This is due to continuing price rises for paper, print and general overheads. However, *EE* will still be cheaper than its nearest competitor and we will endeavour to continue our policy of "value for money" publishing. By the way, a subscription now represents excellent value for money. Why not have your issue delivered by the postman – you will find a subscription form bound into this issue.

Mike Kenward

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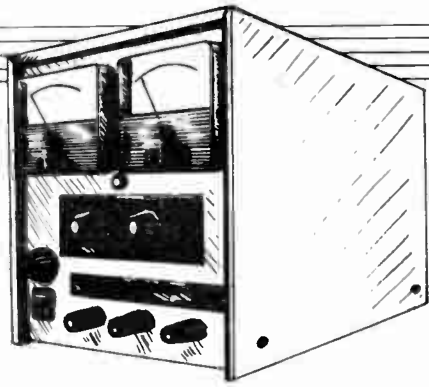
Constructional Project



VARIABLE BENCH POWER SUPPLY

MARK STUART

Fully controllable from 0 to 24V, up to 2.5A output. Current limit control allows maximum output current to be set anywhere between zero and maximum.

THE power supply to be described here was designed to be capable of a wide variety of jobs. Its high output voltage of 0 to 25V and output current capability of 2.5A are far better than the more usual bench power supplied with their 12V and 1A ratings.

Output voltage is fully variable right down to zero (unlike a lot of i.c. regulators which stop at 1.5V) and a "Current Limit" control allows the maximum output current to be set anywhere between zero and maximum. The current limit feature has two particular uses. One is to protect circuitry under test from being damaged due to faulty construction – a real delight for electronics experimenters. The other use is in the constant current charging of NiCad batteries.

Its uses in the school science lab are too numerous to list in full, but such uses as electrolysis, electroplating, polystyrene cutting, and the like come to mind as well as the more obvious uses for driving model motors, computer interfaces and robots. Two large meters continuously display Voltage and Current leaving the user in absolutely no doubt about what is being provided.

Ripple and noise in the output are at a very low level and the output voltage change in response to load current changes and fluctuating mains voltage is very small. A supply of this type can never be cheap, the cost of transformer, case, heatsink and above all the meters soon add up, but the amount of use that such a project gets justifies the initial cost and the two meters are very worthwhile features. This is a project that will be used almost every day and will soon become indispensable.

CIRCUIT CONSIDERATIONS

A number of options are available when designing a supply of this type. Variable voltage i.c. regulators are available but all seem to have some disadvantages. The circuit finally chosen uses a simple high power device to handle the output, controlled by a low power integrator circuit which does all the "intelligent" work.

A power MOSFET was chosen as the output device because they are rugged, that is, able to withstand voltage and current surges, and also because the insulated gate requires negligible drive current. This second feature is very useful because it enables a simple small-signal transistor to be used as the output driver.

To understand how the circuit works the various sections of it are shown separately in Fig. 1a to Fig. 1d. The final complete circuit diagram for the Variable Bench Power Supply is shown in Fig. 2.

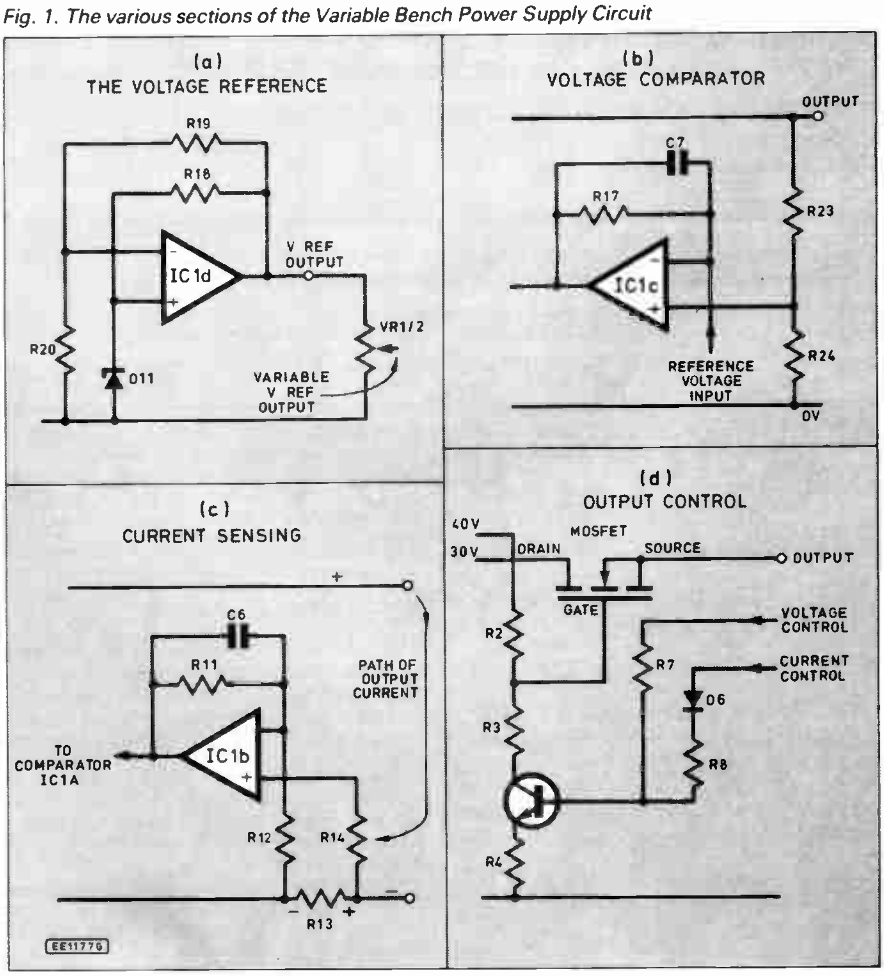
REFERENCE VOLTAGE

The first thing that a power supply control circuit needs is some sort of "reference voltage". This is used to set the output voltage and needs to be stable and noise-free if the power supply output is to be clean.

Fig. 1a shows the voltage reference section of the circuit. Zener diode D11 is the primary reference source. A 5.6 volt Zener diode has been chosen because these have the lowest variation with temperature (temperature co-efficient) of all Zener values. Above and below this voltage the stability is not so good.

To get the best performance from a Zener diode it is best to drive it with a constant current. This is achieved very neatly by IC1d and the associated resistors.

Fig. 1. The various sections of the Variable Bench Power Supply Circuit



Upon switch-on there is a low voltage across D11 which therefore does not conduct and acts like a very high value resistor. The pairs of components resistor R18, diode D11 and resistors R19, R20 are two potential dividers driven from the output of IC1d.

At low voltages, with D11 not conducting more of the output voltage from IC1d is connected to the non-inverting input (+) than to the inverting input (−). The net effect is overall positive feedback that pushes up the output of IC1d. At a certain point the voltage across diode D11 will reach 5.6V and it will begin to conduct. The non-inverting input of IC1d is now held at 5.6V.

The output of IC1d still continues to rise until the inverting input which is fed from the output via resistors R19 and R20 also reaches 5.6V. When this occurs the circuit stabilises

IC1c is connected as a high gain amplifier that amplifies the difference between its two (inverting, and non-inverting) inputs. If the tapped off voltage from the output exceeds the voltage from VR2 slider, the output of IC1c is driven positive. This rising voltage acts on the output control circuit (Fig. 1d) in such a way that the output voltage is reduced.

If the output falls so that the voltage tapped off from the output becomes less than that from VR2 slider, the opposite things happen and the power supply voltage increases. In this way the circuit stabilises itself so that the two inputs of IC1c are kept equal. Any tendency for the output voltage to vary due to loading or mains voltage changes is instantly corrected as IC1c re-balances its inputs and sends a signal to the output control circuits.

to be set anywhere between zero and a maximum of 2.5A.

OUTPUT CONTROL

The control of the output of the power supply is dealt with by the power MOSFET device transistor TR2 which is driven by transistor TR1. This particular type of MOSFET is an *N*-CHANNEL ENHANCEMENT type. This means that its gate (g) terminal must be at a voltage more positive than its source (s) in order for it to conduct.

For this particular device the minimum voltage required to start conduction is 3V, and up to 9V are required to give an output current of 3A. At maximum output, the voltage of transistor TR2 must be able to rise to 25+9

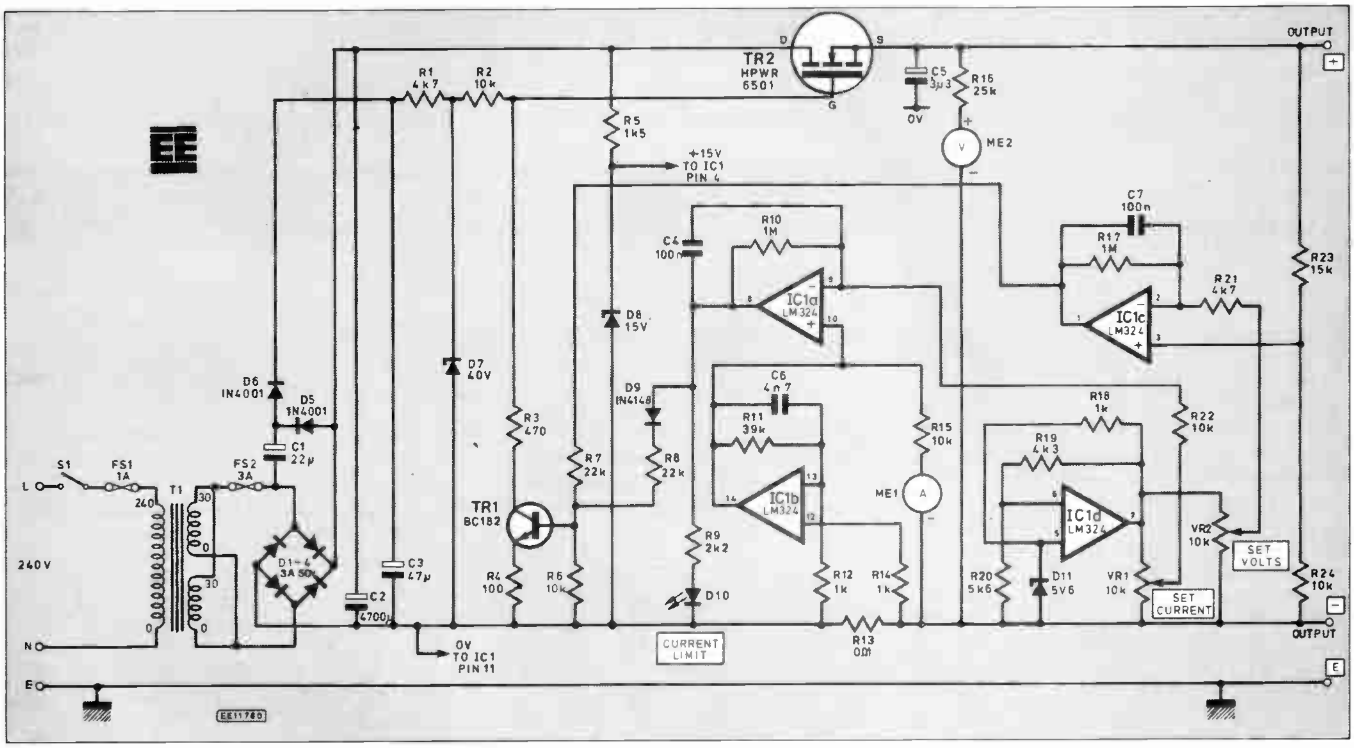


Fig. 2. Complete circuit diagram for the Variable Bench Power Supply. The operation of this circuit is best understood by referring to Fig. 1.

with the output voltage set by the Zener diode voltage and the ratio R19+R20/R20. The values chosen here give an output of 10 volts from IC1d. The current through D11 is fixed by the output which is at 10V and the Zener diode at 5.6V which leaves 4.4V across resistor R18 giving a current of 4.4mA.

The important thing is that all of these values are set up by diode D11. The power supply input and output voltages have no effect whatsoever.

The stable reference voltage from IC1d is fed to the two control potentiometers VR1 and VR2. The output from each of these is a voltage which varies between zero and 10V as the control is rotated clockwise.

VOLTAGE COMPARATOR

This voltage is used by the next stage of the circuit, the "voltage comparator", which is shown in Fig. 1b. A proportion of the power supply output voltage is tapped off by resistors R23 and R24 and fed to one input of IC1c. The other input of IC1c is fed from the slider (or wiper contact) of potentiometer VR2. The values of resistors R23 and R24 are selected so that at 25V output the voltage at their junction is 10V.

CURRENT SENSING

Output current control is carried out by IC1b, the "current sensing" circuit. Resistor R13 in Fig. 1c is connected in series with the power supply negative line. All of the output current flows through this resistor producing a voltage drop across it. This is used by IC1b, via resistors R12 and R14, and amplified to produce a voltage which varies from 0 to 10V as the current increases from zero to 1.5A

This voltage is used to drive the output current meter which is connected via R15 to give full scale deflection (f.s.d.) at 10V. The voltage is also fed to a second voltage comparator circuit (IC1a) and compared with the voltage from the slider of the Set Current control VR1.

Operation of this circuit is the same for current as Fig. 1b is for voltage. Its output is fed to the output control circuit via diode D9 and resistor R8, and also to the current limit indicator l.e.d. D10.

Whenever the output current attempts to exceed the value set by VR1, the output of IC1a rises, diode D10 is lit, and the output control circuit operates to reduce the drive to transistor TR2 and hold the current steady. Varying VR1 from zero to maximum allows the current limit

volts. This is provided, via resistor R2, from a 40V Zener regulated supply derived from the transformer by a voltage doubling circuit.

It is necessary to use a voltage doubler because the rectified transformer output voltage across the mains smoothing capacitor C2 is only 30V at full load. Driver transistor TR1 controls the gate voltage of TR2 via R3.

As the base of the TR1 is made positive it is turned on and the gate voltage of TR2 is pulled down lowering the output voltage. Signals from the voltage and current sensing circuits are both connected to TR1 base and so control the output.

Diode D9 is fitted in the current control circuit so that there is no interaction between this and the voltage control as long as the output current remains below the circuit limit setting. Once the circuit is in current limit mode D9 conducts and current control takes over from voltage control.

All the details of the circuit have already been explained individually. In Fig. 2 they are shown as a whole with a few additional (essential) components such as fuses, a mains transformer, smoothing capacitors, and voltage regulating Zener diodes.

Incoming mains to the transformer T1 passes via the power on/off switch and a 1A fuse in a panel fuseholder. Most transformers nowadays are wound with two equal secondary windings which can be series or parallel connected to give a choice of outputs.

Transformers with two 15V or two 30V secondaries may be used. In the first case connected in series and in the second connected in parallel.

From the transformer secondary the output passes via a 3A fuse to the bridge rectifier, D1-D4, and on to smoothing capacitor C2. This is the main supply which passes to the drain terminal (d) of TR2 and on to the output. Power to IC1 is derived from this supply via resistor R5 and is regulated to 15V by means of Zener diode D8.

A high voltage supply is produced from the transformer by coupling an additional a.c. output from the secondary via capacitor C1 which is rectified by diodes D5 and D6 and added to the main positive supply. The result is a voltage of almost 80V across capacitor C3 which is reduced to 40V by resistor R1 and Zener diode D7. Forty volt Zener diodes are not always easy to obtain so provision is made on the p.c.b. for two 20V Zener diodes in series. Output voltage is displayed by means of a 1mA panel meter connected as a voltmeter reading 0-25 volts with a series resistor R16.

CONSTRUCTION

Most of the components are mounted on a single printed circuit board. The component layout and full size printed circuit board foil master pattern is shown in Fig. 3. This board is available from the *EE PCB Service*, code EE593.

The board is mounted by means of the two potentiometers VR1 and VR2 which are direct p.c.b. mounting types. Other potentiometers may be used and can be wired "off board" to suit other case layouts.

Before fitting any components to the board eleven Veropins should be pressed firmly into the positions shown for external connections and soldered. Begin component insertion by fitting the low profile components such as diodes and resistors, and a socket for IC1.

Take particular care with the diodes to identify each type and its polarity because they all look very similar. Transistor TR1 should be fitted with its flat surface as shown, and must NOT be one of the types with "L" suffix as these have a completely different pin-out.

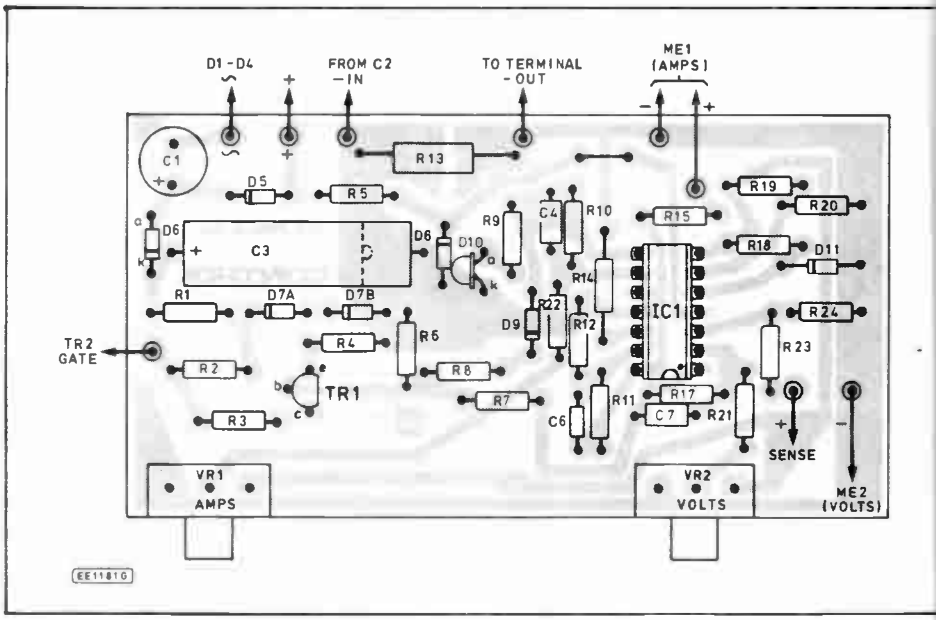
Capacitors C1 and C3 are polarised so must be fitted the right way round. Note that two holes are provided for C3 to enable different sized items to be accommodated. When the board assembly is complete, inspect the underside for solder bridges etc. Provided everything looks in order, the next stage is the wiring.

ASSEMBLY AND WIRING

A full wiring and assembly drawing is shown in Fig. 4. Fig. 5 shows details of the insulation of TR2 from its heatsink and the mounting of a toroidal type transformer is shown in Fig. 6.

Take great care with the mains wiring to fully insulate *every* joint with a good length of sleeving and to make all connections mechanically good before soldering them. A mains cable entry clamp is used to secure the cable firmly and prevent it from being pushed, twisted or pulled from the case. An additional "p" clip near to the front of the case is also needed to keep the cable in position. The mains Earth connection is made to a solder tag on the bottom of the case and brought out to a terminal on the front panel.

The rest of the wiring is quite straightforward but the wiring between the transformer, rectifier, capacitor C2, TR2, the board and the output terminals must be done



COMPONENTS

Resistors

R1	4k7 ½W carbon film	
R2, R6, R22	10k (3 off)	
R3	470	
R4	100	
R5	1k5	
R7, R8	22k (2 off)	
R9	2k2	
R10, R17	1M	0.25W 1% metal film (2 off)
R11	39k	0.25W 1% metal film
R12, R14, R18	1k (3 off)	
R13	0Ω1	2.5W wirewound
R15, R24	10k	0.25W 1% metal film (2 off)
R16	25k	0.25W 1% metal film (made from 10k + 15k in series)
R19	4k3	0.25W 1% metal film
R20	5k6	0.25W 1% metal film
R21	4k7	
R23	15k	0.25W 1% metal film

All 0.25W 5% carbon film, except where stated

Potentiometers

VR1, VR2	10k lin. (2 off)

Capacitors

C1	22µ radial elec. 63V
C2	2,500µ + 2,500µ tag-ended elec. 63V
C3	47µ axial elec. 100V
C4, C7	100n min. polyester (0.3in pitch) 100V
C5	3.3µ axial elec 40V
C6	4n7 Mylar or polyester 63V

Semiconductors

D1-D4	3A 50V bridge rectifier
D5, D6	1N4001
D7	40V 500mW Zener diode (or 2 × 20V in series)
D8	15V 500mW Zener diode
D9	1N4148
D10	3mm low current red l.e.d.
D11	5V6 500mW Zener diode
TR1	BC182 *npn* silicon
TR2	HPWR 6501 MOSFET (*N*-channel)
IC1	LM324 Quad op. amp.

Shop Talk
See page 105

Miscellaneous

S1	s.p.s.t. miniature rocker switch
T1	120V/A Toroidal mains transformer – primary 240V mains, sec. two 30V windings (see text)
ME1, ME2	1mA 65 ohm, moving coil panel meter (2 off)

Printed circuit board, available from the *EE PCB Service*, code EE593; heatsinks; insulating kit (TO3); knobs (2 off); screw terminals, 1 red, 1 black, 1 green; capacitor clip; wire, mains and low voltage; fuse, primary 1A 1¼in with panel holder, secondary 3A 20mm with chassis holder; case; feet for case; nuts, screws, etc.

Approx. cost Guidance only £52.50

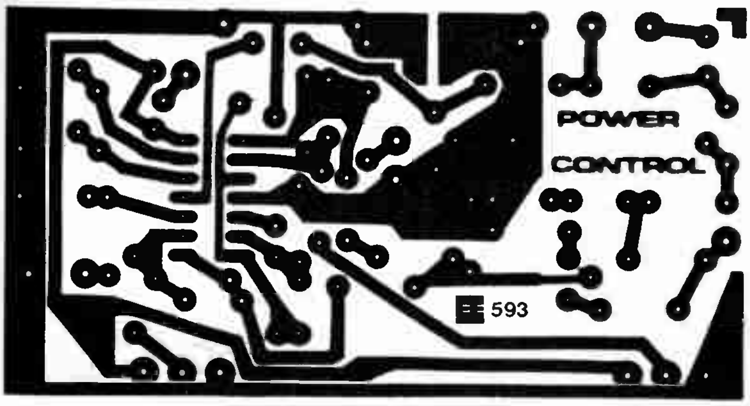


Fig. 3. Full size foil master pattern and component layout. This board is available from the EE PCB Service, code EE593.

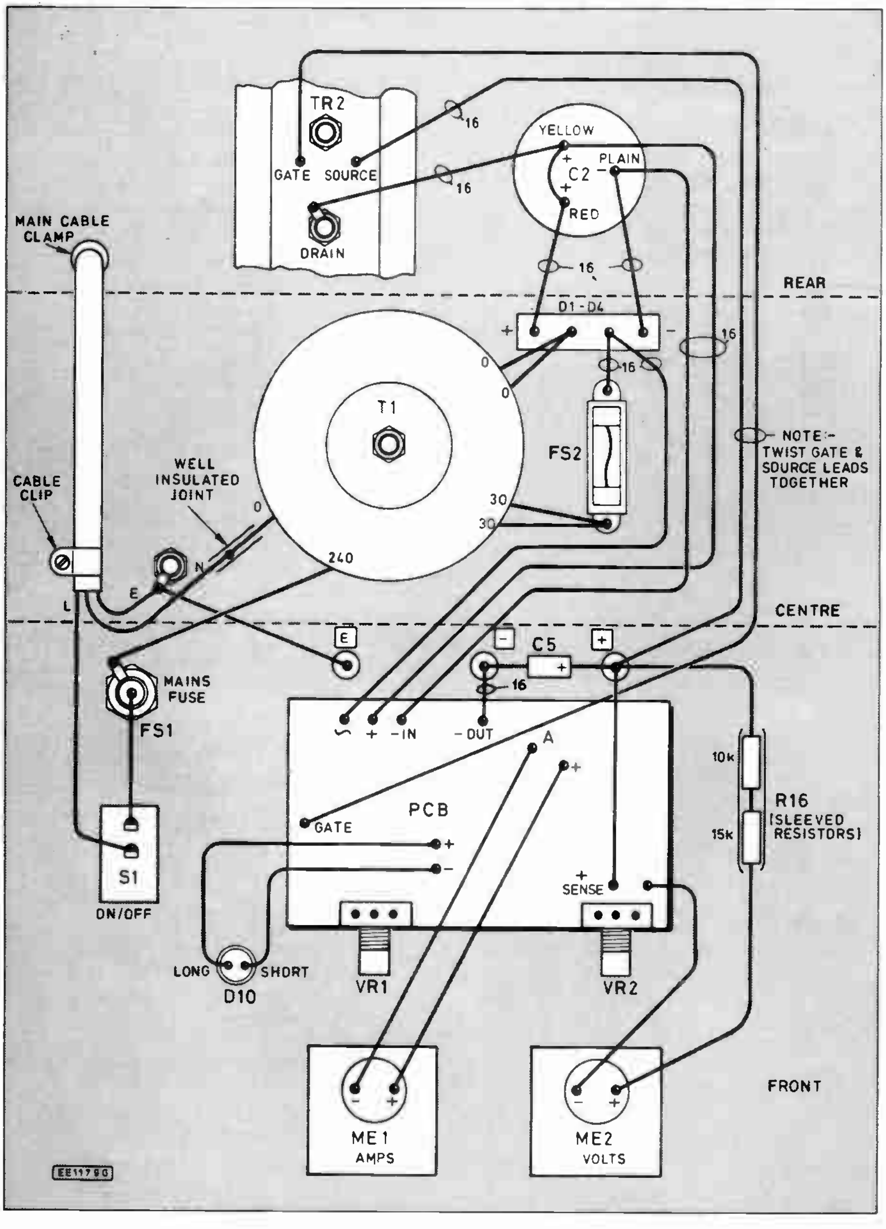


Fig. 4. Full wiring and assembly details to the circuit board, transformer and case mounted components. Heavy duty wires which carry the full output current are indicated by the number 16.

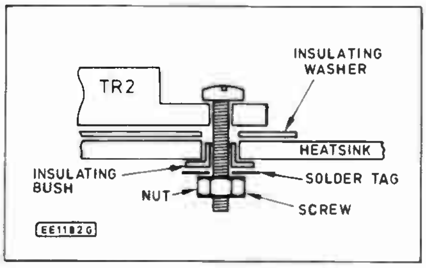


Fig. 5. Details of mounting the MOSFET device on the heatsink.

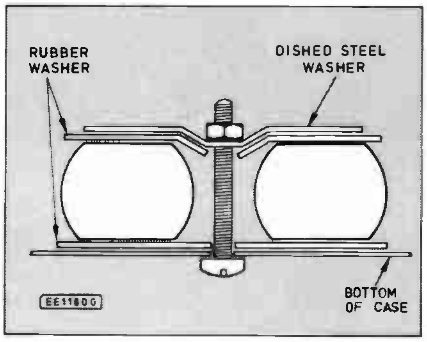


Fig. 6. Method of mounting the toroidal transformer in the case.

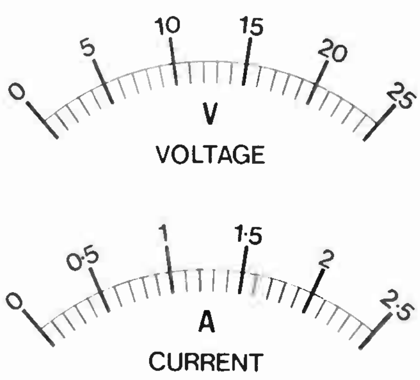
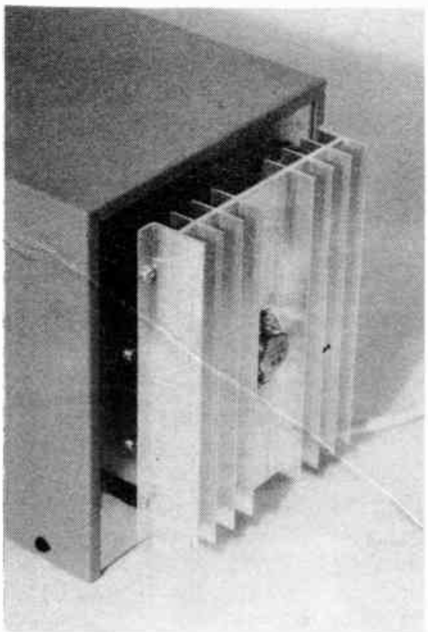
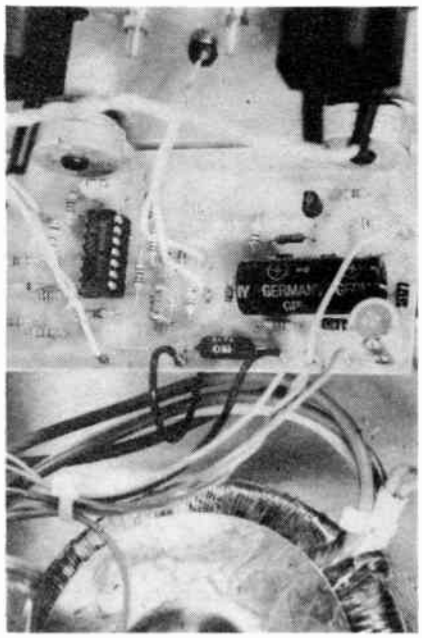


Fig. 7. Full size Voltage and Amps scales for the power supply





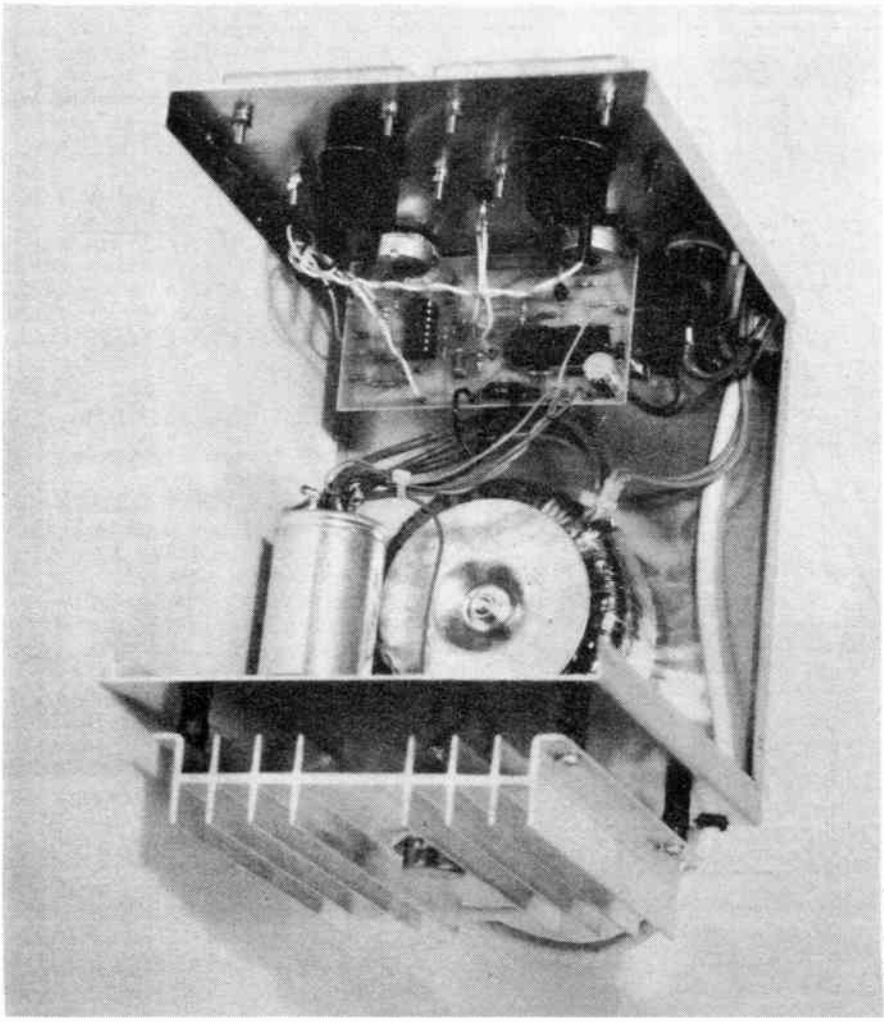
exactly as shown to keep ripple currents to a minimum.

Some wires carry the full output current, and so should be thicker than others. These wires have been marked with a circle and the number 16 to indicate that at least 16/0.2 wire should be used. All other connections may be made using 7/0.2 wire.

The leads to the gate and source of TR2 should be twisted together. When mounting TR2 to the heatsink it is necessary to use thermal compound on *both* sides of the insulating washer to ensure good heat transfer.

TESTING

Commence testing by first checking and double checking everything; make sure the mains wiring is correctly insulated and switch on. If the fuse does not blow it is possible that everything is working correctly.



Set VR1 halfway, vary VR2 and see if the voltage reading on the output meter is varying. If it is, well done. If not, the next step is to check a few voltages around the circuit.

There should be 40V across C2 and 80V across C3. If these are not correct check the voltage across diode D4 which should be 40V and across D8 which should be 15V. If any of these are low it is likely that they have been fitted the wrong way round, or that IC1 is reversed. As these are standard power supply circuits it should be fairly simple to trace any faults here.

The next thing to check is the voltage across Zener diode D11 which should be 5.6V and then the output of IC1d (pin 7) which should be 10V. If things are still not right then it could be TR1 which is at fault.

Check the base voltage and collector voltages of transistor TR1. If the base voltage is less than 0.6V the collector voltage should be high. TR2 is unlikely to be at fault, but if its drain and gate are at high voltages and the source is very low or zero it is faulty.

After these tests it is really rather more of a detective job to find faults, but remember that 99 out of 100 faults are due to bad soldering or wiring.

OPERATION

Once the Voltage control is working correctly, connect a load (100 ohm resistor) across the output and check that the current reading increases as the voltage increases. At 25V a 100 ohm resistor should take 250mA.

Now reduce the current limit setting so that the current reading falls and note that the voltage reading also falls. The current limit l.e.d. should light at the point where the current just begins to reduce. Decrease the voltage setting and the circuit will resume voltage control as the l.e.d. goes out.

When testing a suspect (or newly built) circuit use the Voltage and Current limit controls to prevent excess power from being taken in the event of a fault. Start with both controls at zero and gradually increase them little by little until the expected circuit working current is reached.

If the controls are now advanced further and the current does not increase, then all is well. If the current continues to increase above the expected level then it is probably necessary to do some fault finding.

To charge NiCad batteries set the voltage to twice the total voltage of the batteries to be charged, and set the charge current using the current limit control. Note that you *must* remember to switch off after the correct time has expired to fully charge the batteries, especially when charging at higher rates. ***Failure to do this can result in the battery being damaged and at worst exploding.***

In some circumstances the heatsink can get very hot. This is especially so when a *High* current is being delivered at a *Low* voltage. In this instance TR2 is carrying the high current and is dropping most of the voltage as well.

At 2A and 25V this can be so much as 50 watts. Just think how hot a 60 watt light bulb gets and you get some idea of the heat dissipation requirement. For moderate durations this sort of power can be tolerated, but prolonged use at this level is not recommended.

When *full* current and voltage are being used, the power transistor has just a few volts across it and so is perfectly happy, and at medium output levels power is divided between the load and the power transistor which only generates moderate heat.

If continuous use at high currents and low voltages is anticipated a larger heatsink would be a good idea. □

S.O.S. ALERT

This unusual project can flash a lamp or sound a warning in the Morse "SOS" Code. It could be a life saver to an elderly person or invalid.

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NEXT MONTH

Constructional Project

EMERGENCY LIGHTING SYSTEM

T. R. DE VAUX-BALBIRNIE

Don't be left in the dark when the mains fails

ALTHOUGH emergency lighting is installed in public buildings, it is rarely used in private houses. There are, however, situations where the use of some simple form of home emergency lighting is justified. In the village where the author lives, mains failure is common – often caused by a thunderstorm or other severe weather condition. At night, with the street lights off too, the house is suddenly plunged into total darkness. This would be frightening to old people and could present special difficulties for the handicapped.

One answer is to keep a battery-operated torch handy but this will need to be fumbled for, may not be where expected due to having been "borrowed" and assumes that the batteries are in good condition. A better solution is to use an automatic circuit which will provide adequate light in the event of mains failure and this is the purpose of the present article.

BASIC DESIGN

Two variations are described. The first is housed in a box which is permanently fixed in position – probably on the ceiling – and connected to the mains. The light will come on if (a) the mains supply fails and (b) it is sufficiently dark. Since it uses the "front end" of a standard battery torch, it gives a beam of light which can be pointed in the most suitable direction. The light will go off when the mains supply is restored and the internal batteries will then re-charge ready for future use. Approximately 12 hours' continuous operation (more or less according to the exact choice of batteries and bulb) are obtained from a set of fully-charged nickel-cadmium batteries. Several units could be constructed to cover different rooms or areas of the house – kitchen, living room, staircase and bedroom as required.

The unit is fitted with three switches. The first is a mains on-off switch – while a mains supply is connected, a green l.e.d. indicator glows on the front panel. The second switch provides a boost charge which will restore the batteries to a fully-charged state more rapidly than by leaving the circuit on its continuous "trickle charge". With boost charge operating, a red l.e.d. glows. Finally, a system on-off switch is provided. This allows continuous trickle charging while disabling the lamp. This will be useful when the unit is left unattended for a long period, such as during a holiday. Elderly people may simply leave the switches alone with the mains and system on and the circuit on "trickle charge".

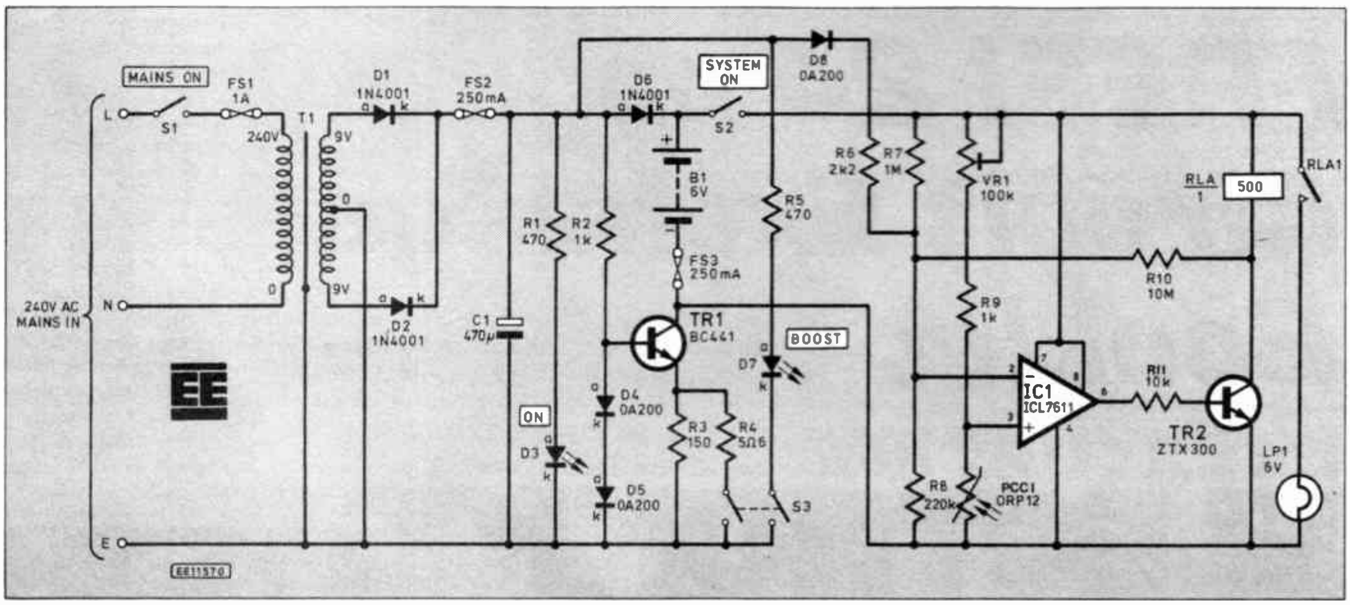
The second version of the circuit is the "big brother" of the first. It comprises a master unit which can drive a number of ceiling-mounted lamps in several areas. This will involve wiring between the various lamps and the unit so before constructing this, it would be wise to check that such wiring is possible. This system derives power from a 12V no maintenance lead-acid accumulator situated close to the main unit. Mains and system on-off switches are provided as in the smaller version of the circuit. No charge-rate switch is needed since the current is self-regulating. This circuit could also be used to operate a 12V 8W fluorescent light of the type used in caravans and boats. This would give approximately 2-3 hours of service. A larger capacity battery could be used but this would increase the constructional cost.

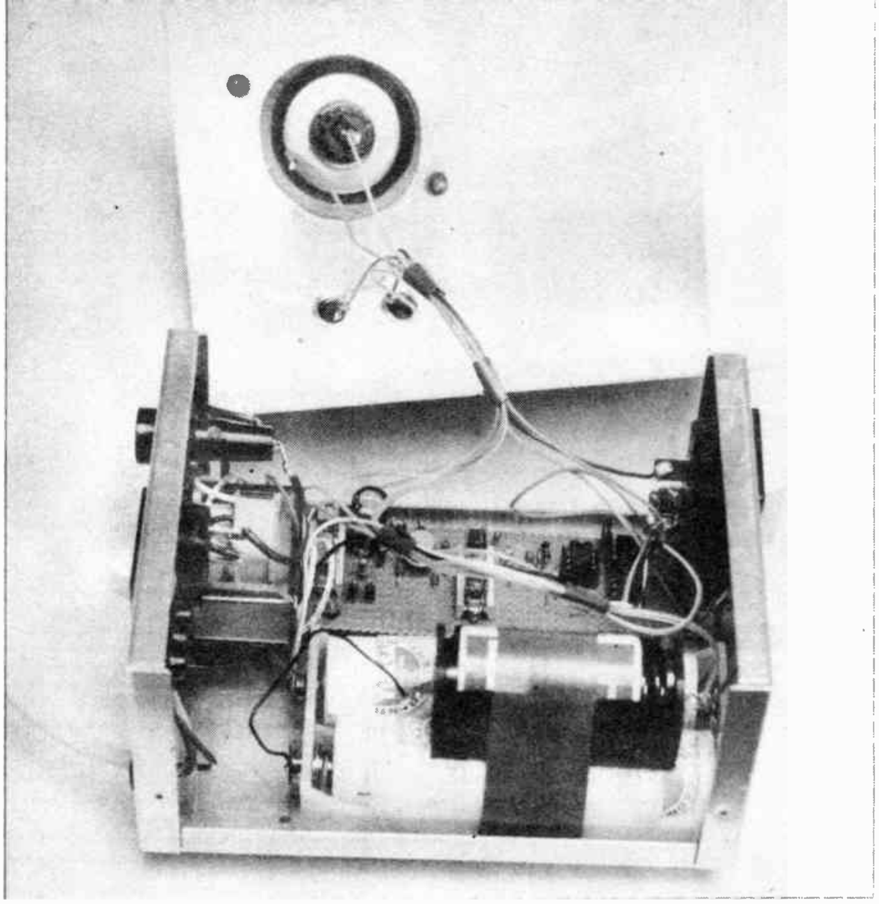
CIRCUIT DESCRIPTION

The entire circuit for the smaller version of the Emergency Lighting System is shown in Fig. 1. Transformer T1, in conjunction with mains on-off switch, S1, fuses FS1 and FS2, rectifier diodes D1 and D2 and smoothing capacitor C1, form a conventional low-voltage power supply producing a nominal 12V. The green l.e.d. indicator, D3, glows when the mains supply is on. R1 limits its operating current to the correct working value.

Transistor TR1 and associated components form a constant current supply to charge the 6V battery bank, B1, which consists of five separate 1.2V cells. Such a circuit is necessary

Fig. 1. Circuit diagram of the Emergency Lighting System – small version.





for charging nickel-cadmium batteries so that whatever the exact supply voltage and whatever the terminal voltage of the batteries themselves (which varies with the state of charge) the charging current will remain constant and be maintained within safe limits. This section operates in the following way. Current flows from the supply through resistor R2 and diode pair D4/D5. Since 0.7V approximately exists across a silicon diode in forward bias, there will be 1.4V (2 × 0.7V) between TR1 base and the negative supply line. Since 0.7V approximately exists between base and emitter, the difference of 0.7V must appear across R3 – or R3 in parallel with R4 if S3 (BOOST) is switched on. Since this voltage is fixed, the values of R3 and R4 determine the current flowing in TR1 emitter circuit.

The emitter and collector currents are virtually the same (the difference being the small base current which flows in the emitter but not the collector circuit). It may be considered, therefore, that the emitter current charges B1. With S3 off, this is 5mA approximately – a "trickle charge" which flows continuously while the mains supply is on and keeps B1 fully charged. With S3 on, the value of the parallel arrangement R3 and R4 is much less than R3 alone and 125mA approximately flows. This may be used after a period of mains failure to bring B1 back to a fully charged condition quickly. From a completely discharged state this will take 15 hours approximately. Red light-emitting diode, D7 operates through current-limiting resistor R5 and the second pole of S3 to show that the higher charge rate is being used. It would not be directly harmful to leave the unit on boost charge continuously but it would probably reduce battery life.

The rest of the circuit, centred around IC1, is the light-sensing and lamp switching section. When the mains fails – there is no longer a 12V feed from supply positive to IC1 pin two through D8 and R6. The action of this may therefore be disregarded for the moment. IC1 is an op-amp chosen for its very low quiescent current requirement since, on mains failure, it receives power from the batteries alone. IC1 is used as a voltage comparator – that is, it compares the voltages applied to its two inputs. If the voltage at its non-inverting (+) input (pin three) exceeds that at its inverting (–) one (pin two), the device is on with pin six high (positive supply voltage) otherwise it is off with pin six low (negative supply voltage). The inverting input (pin two) receives about two volts from the potential divider R7/R8. The non-inverting input (pin three) receives a voltage which depends on the potential divider action of VR1 and R9 in the upper section and the light-dependent resistor, PCC1, in the lower one.

With PCC1 under dark conditions its resistance is high and the voltage across it correspondingly high. At some light level, this will exceed the inverting input voltage and the op-amp will switch on. The exact light level at which the transition occurs can be chosen by adjusting VR1. When the op-amp is on, it operates TR2, relay RLA/1 and hence the lamp, LP1 through its make contacts. The reason for using a relay in this application is to provide the full working voltage for the lamp and to give a sharp switching action. This sharp action is further assisted by resistor R10 which supplies a small amount of positive feedback to IC1 non-inverting input. RLA has a high resistance coil to minimise the continuous current drain on the battery when the lamp is operating. Note that the specified relay has an internal diode which removes the destructive effects of the high voltage "spike" which occurs when the coil is suddenly switched off – no external diode is therefore needed.

When the mains supply is on, the behaviour of the circuit is modified. D8 and R6 now allow a positive 12V feed from the supply to IC1 pin two. This maintains the inverting input at very near positive supply voltage. Thus, whatever lighting conditions exist, the non-inverting input voltage will never exceed the inverting one. Thus, the op-amp, TR2 and LP1 remain off. D6 prevents a feed from B1 positive terminal doing this since it is reverse biased.

CONSTRUCTION

This project requires a mains transformer with ample current rating. Do not substitute a

COMPONENTS

(Small version)

Resistors

R1, R5	470 2 off
R2, R9	1k 2 off
R3	150
R4	5Ω6
R6	2k2
R7	1M
R8	220k
R10	10M
R11	10k

Shop Talk See page 105

Fixed resistors 0.25W ±5%

Potentiometer

VR1	100k sub-miniature vertical preset

Capacitor

C1	470µ p.c.b. elect. 16V

Semiconductors

D1, D2, D6	1N4001 3 off
D4, D5, D8	OA200 3 off
D3	Green l.e.d. indicator
D7	Red l.e.d. indicator
TR1	BC441 *npn* silicon
TR2	ZTX300 *npn* silicon
IC1	ICL7611 op-amp

Miscellaneous

PCC1	ORP12 light dependent resistor
T1	Mains transformer with 240V mains primary and 9V-0-9V secondary rated at 250mA
RLA/1	d.i.l. reed relay with 5V 500Ω coil and make contacts rated at 500mA
S1	SPST rocker switch with 240V mains contacts rated at 1A minimum
S2	SPST rocker switch with 1A rated contacts
S3	DPST rocker switch with 1A rated contacts
FS1	20mm panel fuse holder with 1A fuse to suit
FS2, FS3	20mm chassis fuse-holders. 250mA anti-surge fuse for FS2, 250mA quick-blow fuse for FS3

D.I.L. integrated circuit sockets – 8-pin 1 off, 14-pin 1 off; aluminium box size 152 × 114 × 76mm; 0.1in matrix stripboard size 14 strips × 44 holes; rubber grommet for mains wire; 6V bulb to suit torch (see text); torch or car lantern (see text); "C" size nickel cadmium batteries – 5 off (see text); battery holders to suit the above – 1 off quadruple, 1 off single; sheet aluminium for ceiling bracket.

Approx. cost Guidance only £15 plus battery

smaller one. Note also that it must be built in an earthed metal box. A properly wired mains ceiling outlet with earth connection is also needed. Anyone not certain of being able to make a safe job should consult a qualified electrician.

Construction is based on a circuit panel made from 0.1 inch matrix stripboard sixe 14 strips × 44 holes. Fig. 2 shows the topside and underside views of the layout used in the prototype unit. Begin by drilling the mounting holes, making the breaks in the copper tracks and soldering the inter-strip link wires as indicated. Note that the copper tracks **are not broken** between the rows of pins on the relay socket.

Follow with the on-board soldered components paying particular attention to the polarities of all diodes and of capacitor, C1. Note the manner in which PCC1 is mounted using the full length of its connecting leads. These should be bent gently so that this component points in the direction shown. Complete construction of the panel by soldering 15cm pieces of light-duty stranded connecting wire to strips *A*, *C*, *D*, *E* and *H* along the left-hand side as indicated. Solder similar wires to strips *J* and *M* at the right-hand side and at matrix position A39. The use of different colours here will reduce the possibility of error. Do not insert IC1 and RLA/1 into their sockets yet. Leave VR1 sliding contact adjusted to approximately mid-track position.

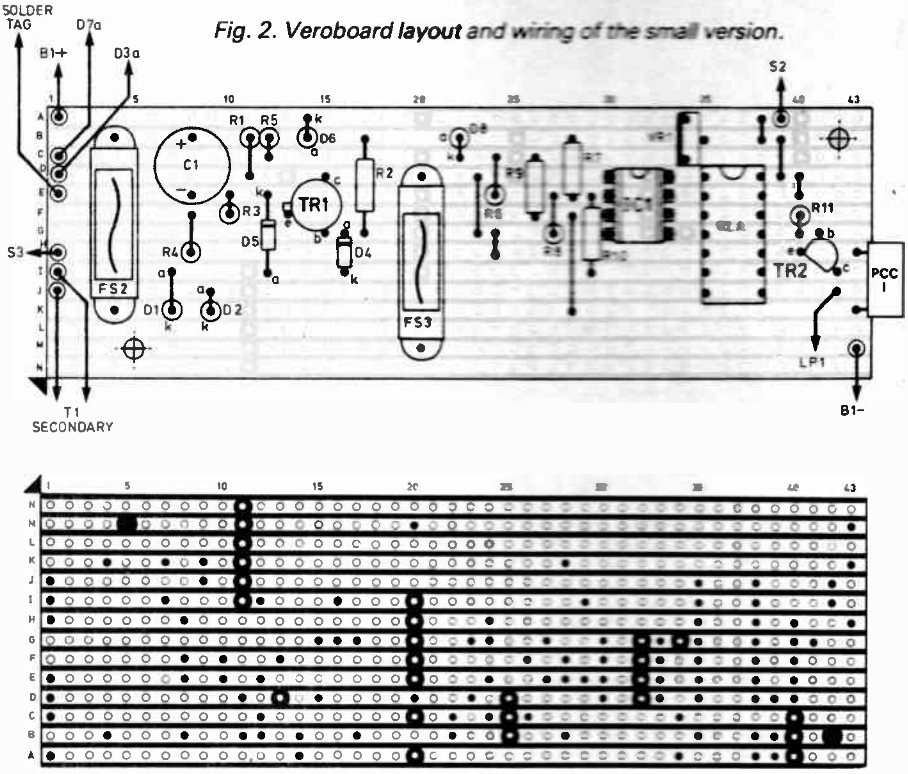


Fig. 2. Veroboard layout and wiring of the small version.

BATTERIES AND BULB

The "C" size nickel-cadmium batteries used in this circuit appear to be available in two capacities – 1.2Ah and 1.8 (or 2) Ah. Those of the higher capacity are more expensive but operate for longer compared with the lower capacity ones. Using a 100mA bulb, the smaller type will give approximately 12 hours' service before becoming discharged. A 500mA bulb would give a greater light output but the author has found that the relay contacts sometimes stick together under this load. The types of bulb available will depend on the choice of torch as to whether a prefocus or standard M.E.S. type is used. It seems that 6V 100mA bulbs are available in standard M.E.S. form only. 6.5V rating bulbs should also be suitable and these are available in 150mA and 300mA versions.

PREPARATION OF CASE

The specified aluminium box has ample space for all the components including the batteries. It is deep enough to accommodate the torch front end since this will protrude through the front panel. It is also large enough to dissipate the small amount of heat generated by the transformer and other components. **An earthed metal case must be used.**

Drill holes for transformer mounting also for the circuit panel, terminal block, battery holder, switches, panel fuse holder and for the l.e.d. indicators, D3 and D7 (see photograph). Drill a hole for mains lead entry and fit this with a rubber grommet. Drill a hole approximately 8mm in diameter near PCC1 position. Holes will need to be drilled for the ceiling bracket and a large hole will also need to be made in the front panel to accommodate the torch front. The easiest way to do this is to drill a circle of small holes then to join them together using a small hacksaw blade or coping saw. The method of attachment of the torch front will depend on the type – the method used in the prototype unit is shown in the photograph.

Mount all internal components and, referring to Fig. 3, complete the wiring. The circuit panel should be mounted using short stand-off insulators. Make sure that this will

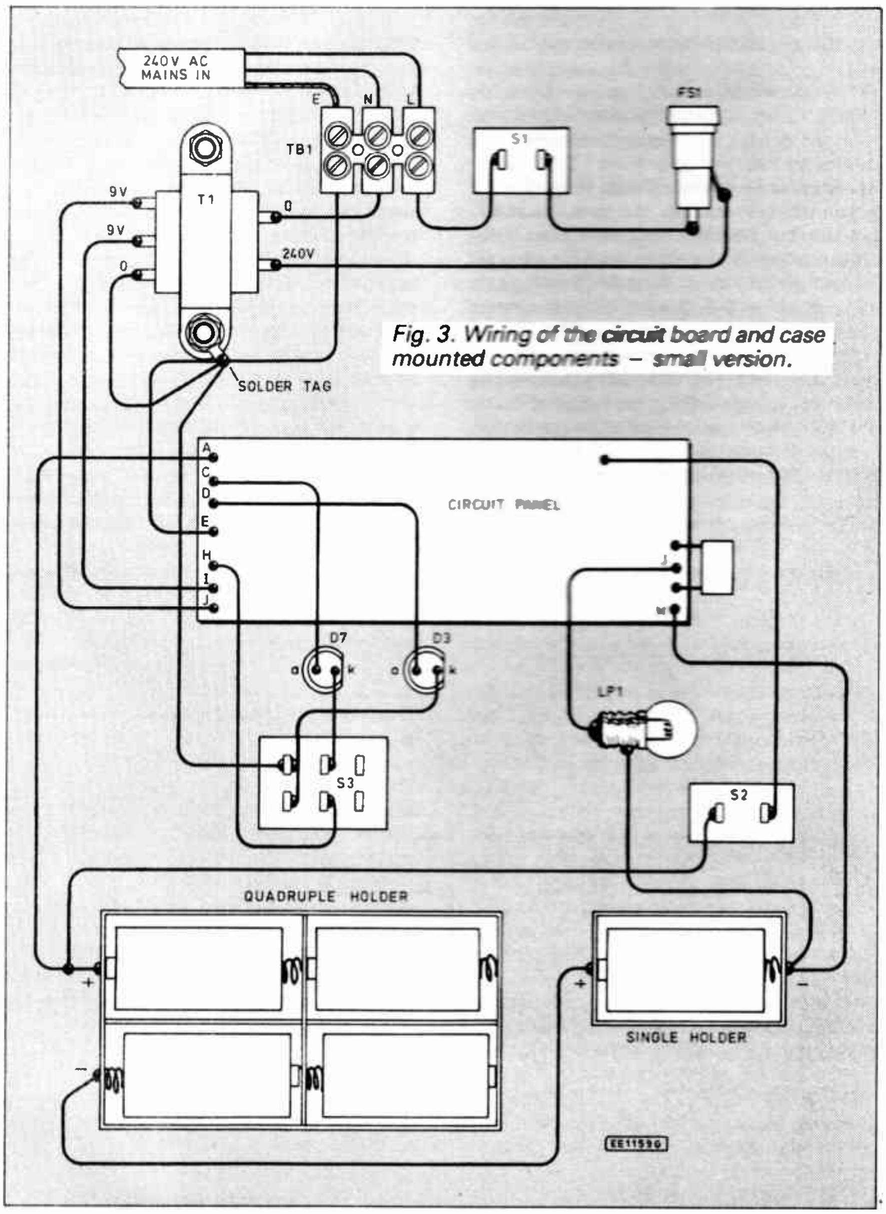
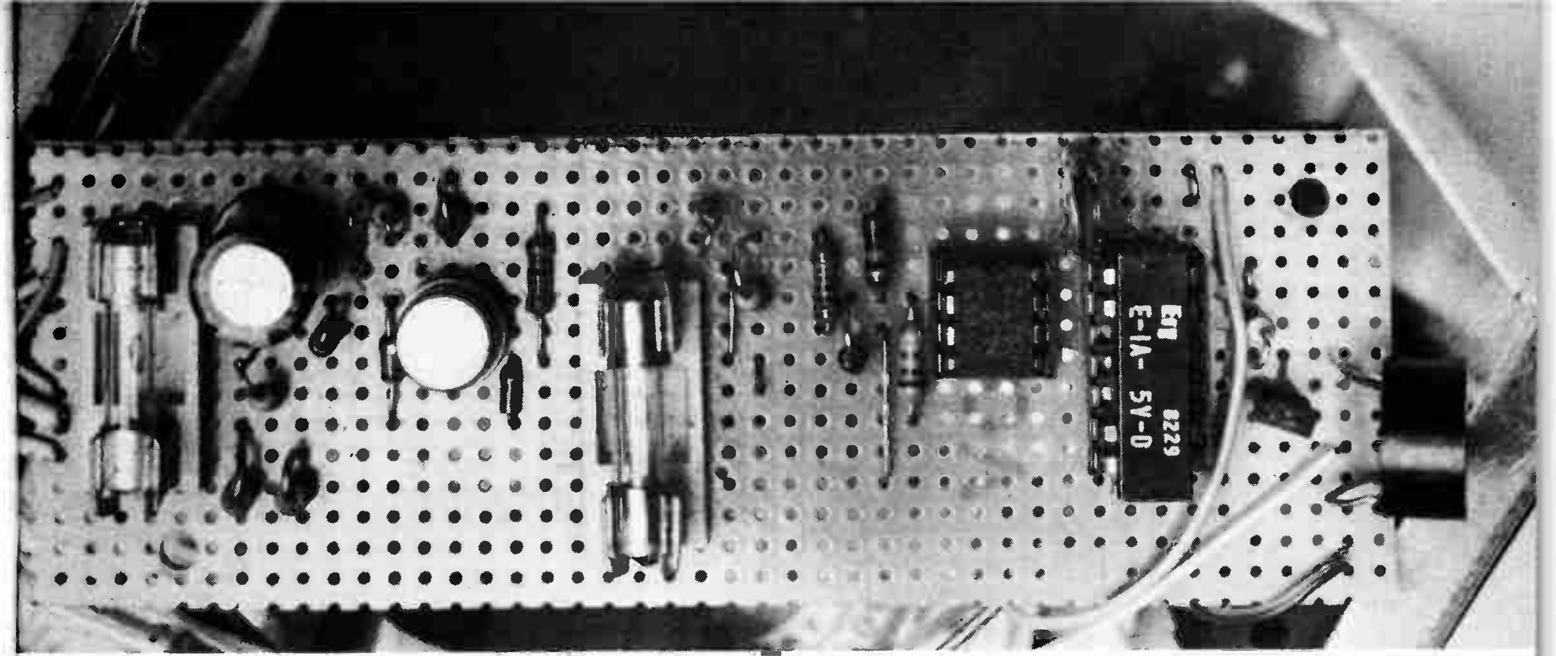


Fig. 3. Wiring of the circuit board and case mounted components – small version.



keep the soldered connections on the copper strips side clear of the metalwork. It seems that holders for five "C" size batteries are not available. You will need to use a holder for four cells and a single holder. These may be held firmly together using several layers of p.v.c. tape. This cannot be done until the batteries have been inserted and this should be left until the end of construction. Note the solder tag at one transformer mounting – this is essential to earth the case and transformer core.

MAINS WIRING

All mains wiring should be completed using proper mains wire of 3A rating minimum. This includes the interwiring between TB1, S1 and FS1. The mains input wire should be fitted with a strain relief bush inside the case. Insert all fuses into their holders. Check that neither bulb holder connection makes metal-to-metal contact with the case – **this is important**.

If the torch was designed to operate from two or three 1.5V cells then the bulb already fitted will be less than 6V rating and therefore unsuitable. You will need to buy a 6V or 6.5V replacement. Such bulbs are available for car-type lanterns and for 6V (four cell) torches. Note the previous comments regarding the current rating of such bulbs.

TESTING

Whenever this circuit is connected to the mains, the lid must be on. To adjust VR1, isolate from the mains then remove the lid.

Place the batteries in their holders then tape and secure the battery pack. Insert IC1 and RLA/1 into their respective sockets. When handling IC1, do not touch the pins – it is a CMOS device and vulnerable to damage by static charge which may exist on the body.

For testing purposes, connect a mains plug to the input lead. Set S1 to OFF, S2 to SYSTEM OFF and S3 to BOOST. Plug in and switch on. The green MAINS ON l.e.d. and the red BOOST one should both glow. Check at intervals to make sure that the case does not become hot in operation. It is, however, normal for it to become warm after a prolonged period. Allow two hours for the batteries to become sufficiently charged then proceed to the operational test.

Switch S2 to SYSTEM ON. The lamp should remain off. S1 should now be switched off to simulate mains failure. Cover the hole near PCC1 position and wait a few seconds. The lamp should come on and go off cleanly when the hole is uncovered.

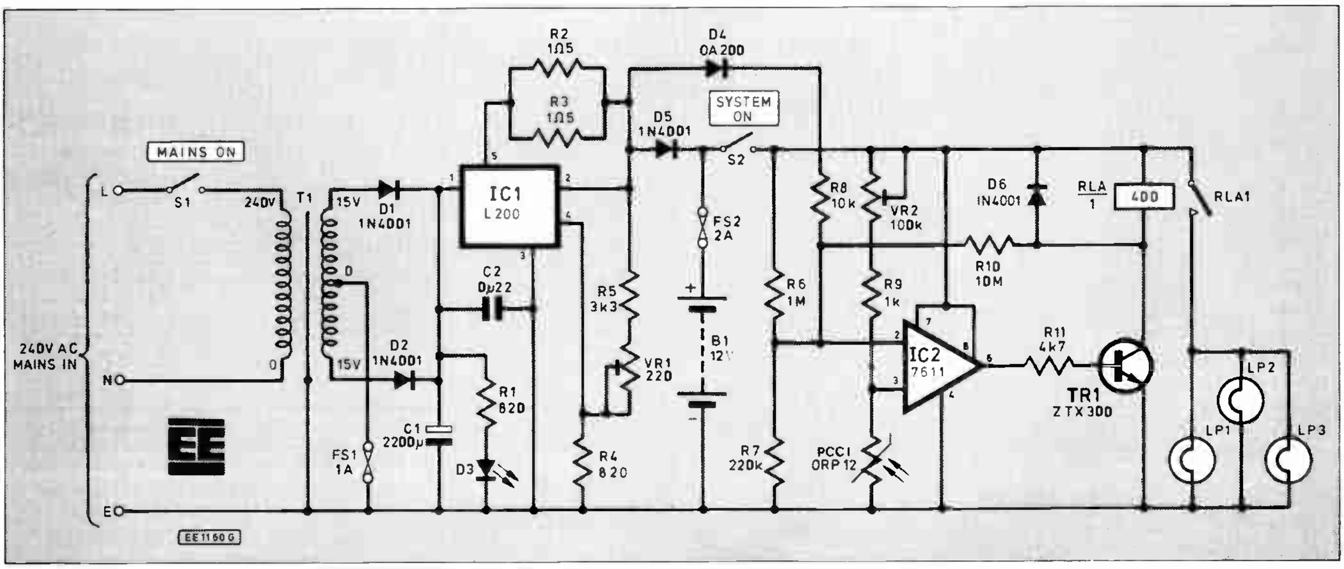
If all is well, the mounting bracket may be attached to the case, the unit secured and its final position and the mains connections made. PCC1 should not point directly at a window. If necessary, it should be shielded to prevent this. VR1 may then be adjusted so that the lamp comes on at the correct light level.

LARGE VERSION

The circuit for the larger version of the Emergency Lighting System is shown in Fig. 4. Here, a 12V lead-acid battery, B1, is used so the charging method is different from that used for nickel-cadmium cells. Also, since the charging current is higher, the mains transformer is uprated in current as well as voltage output. It is important with this type of battery, to charge from a constant voltage supply and to employ current limiting to prevent possible damage. Note that a leakproof no-maintenance battery is used – a car-type battery is not suitable, unless it is of the fully sealed type.

IC1 is an integrated circuit regulator which not only provides the required voltage but gives a predetermined current limit also. This i.c. receives power from the mains by the standard arrangement of switch S1, transformer T1, fuse FS1, diodes D1/D2 and smoothing capacitor, C1. The unregulated input voltage is applied to pin one of IC1 while the regulated output is drawn from pin two. The correct charging voltage is 13.5V so, taking into account 0.7V dropped across diode D5, the output voltage from IC1 pin two will be 14.2V. This is determined by resistors R4, R5 and preset potentiometer VR1. R4 and R5 are close-tolerance components so the output voltage is quite accurately predicted. However, use of a volt meter is necessary to ensure that the voltage is accurately adjusted at the testing

Fig. 4. Circuit diagram of the Emergency Lighting System – large version.



COMPONENTS

(Large version)

Resistors

R1	820
R2, R3	1Ω5 (or single 0Ω68 resistor)
R4	820
R5	3k3

R4 and R5 must be ±1% tolerance types 0.4W or 0.25W rating

R6	1M
R7	220k
R8	10k
R9	1k
R10	10M
R11	4k7

Shop Talk
See page 105

All resistors except R4 and R5 may be ±5% tolerance 0.25W rating. Alternatively, all fixed resistors may be ±1% tolerance types.

Potentiometers

VR1	220 standard preset potentiometer – horizontal mounting
VR2	100k miniature preset potentiometer – vertical mounting.

Capacitors

C1	2200μ elect. 25V – p.c.b. or axial lead type.
C2	0μ22

Semiconductors

IC1	L200 regulator
IC2	ICL7611 op amp
TR1	ZTX300 *npn* silicon
D1, D2, D5, D6	1N4001
D3	Red l.e.d. indicator
D4	OA200

Miscellaneous

S1, S2	SPST rocker switches with mains contacts of 1A rating minimum
RLA/1	Miniature relay with 3A changeover (or single pole) contacts, 12V 400 ohm coil
T1	Transformer with 240V mains primary and 15-0-15V (or twin 15V) secondary windings rated at 400mA minimum
PCC1	ORP12 light dependent resistor
FS1	20mm chassis fuseholder with 1A fuse to fit
FS2	Line fuse holder (car radio type) with 2A fuse to fit
TB1	3A terminal block – 3 sections required.

Aluminium box size 133 × 102 × 64mm; non-spillable 12V lead acid battery 2.6Ah (or higher capacity – see text); 8-pin d.i.l. socket; tag board – 2 rows of 7 tags required; 0.1 in. matrix stripboard size 13 strips × 42 holes; stand-off insulators; small fixings; sleeved grommets, 2 off; solder tag.

Approx. cost Guidance only £18 plus battery

stage. This will prolong the life of the battery.

Resistors R2 and R3 connected in parallel (or a single resistor of the appropriate value) limit the charging current to approximately 600mA. In use, the current will be maximum when the battery is in a state of low-charge. Later in the charging cycle, the terminal voltage will rise and the current correspondingly fall. At the end point this will be 20mA or thereabouts and safe to use as a continuous trickle charge. The red l.e.d. indicator, D3, operating through current-limiting resistor, R1, shows that the mains is on. Switch, S2 (SYSTEM ON), is provided as in the smaller version to disable the action of the lamps when the unit is left unattended for long periods. Diode D5 prevents the battery from discharging through R5, VR1 and R4 (as well as by other paths) when the mains is off.

The light sensing and lamp switching section of the circuit is essentially the same as in the smaller version. However, RLA/1 had contacts of higher rating to allow for a greater current output. Also, external diode, D6 must now be connected in parallel with the coil to bypass the high voltage pulse which occurs when the magnetic field in the core collapses – the specified relay does not have an internally-connected diode as in the smaller circuit. FS2 is a line fuse connected in the battery positive lead. **This fuse must not be omitted** since a lead-acid battery will deliver a very large current if short-circuited accidentally.

CONSTRUCTION

IC1 is mounted on the metal case which then acts as a heat sink. The associated resistors, R2, R3, R4 and R5 together with VR1 and C1 which set the output voltage and current limit are arranged on a piece of tag board having two rows of seven tags (see Fig. 5). Most of the remaining components are mounted on the main circuit panel (see Fig. 6). This uses a piece of 0.1 inch matrix stripboard size 13 strips × 42 holes. Cut this to size and make the breaks and inter-strip links. Drill the two mounting holes then mount all on-board components noting the polarities of the diodes and of C1.

The specified relay has a moving contact connection which does not directly fit into the 0.1 inch matrix. Here, a small hole will need to be drilled so that the pin may be passed through the circuit panel, gently bent, and soldered to strip G as shown. Note the way in which PCC1 is mounted – see photograph. Make a careful check for errors – particularly for copper tracks accidently "bridged" with solder. Complete construction of the circuit panel by soldering 15cm pieces of light-duty stranded connecting wire to strips A, B, C, D, E and J on the left-hand side and to strips E and J on the right-hand side as indicated. Leave VR1 and VR2 adjusted to approximately mid-track position.

CASE

Note that **an earthed aluminium case must be used for this circuit.** The battery must be situated outside the case and not placed inside as in the smaller version. This circuit is designed to be plugged into a mains socket using a fused plug fitted with a 3A fuse. In other cases, a mains fuse must be provided inside the case. Whenever the unit is plugged into the mains, the lid of the case must remain on. **Unplug before removing the lid** to adjust VR1 and VR2.

Prepare the case by making holes for mounting IC1, T1, TB1, S1, S2, D3, the tag strip and circuit panel – see photograph. Drill an 8mm diameter hole near PCC1 position to allow the light to enter. Make holes for mains input, battery and lamp output leads – fit these holes with sleeved rubber grommets.

Mount the remaining components and complete the wiring – note that IC1 is mounted direct to the metalwork. A solder tag at one transformer fixing is essential to earth this component and the case.

The circuit panel should be attached using short stand-off insulators on the bolt shanks or

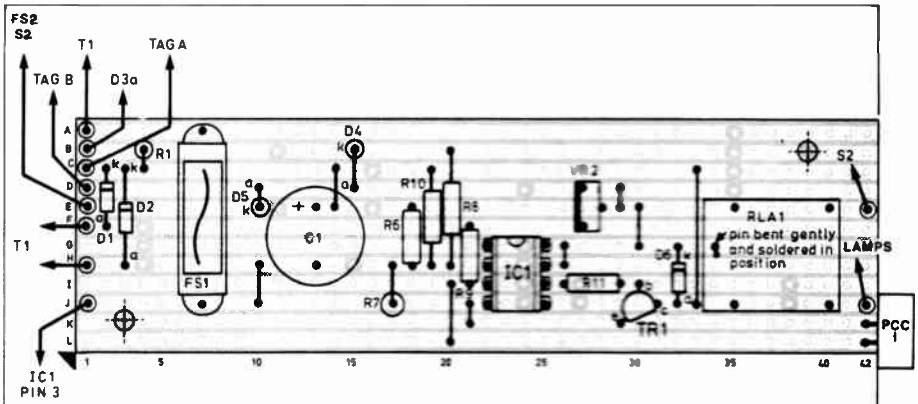
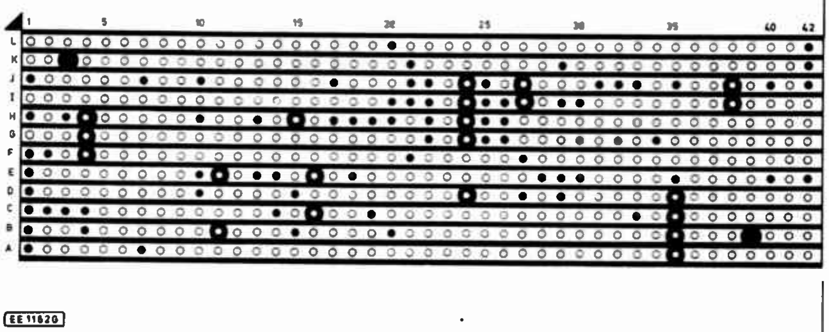
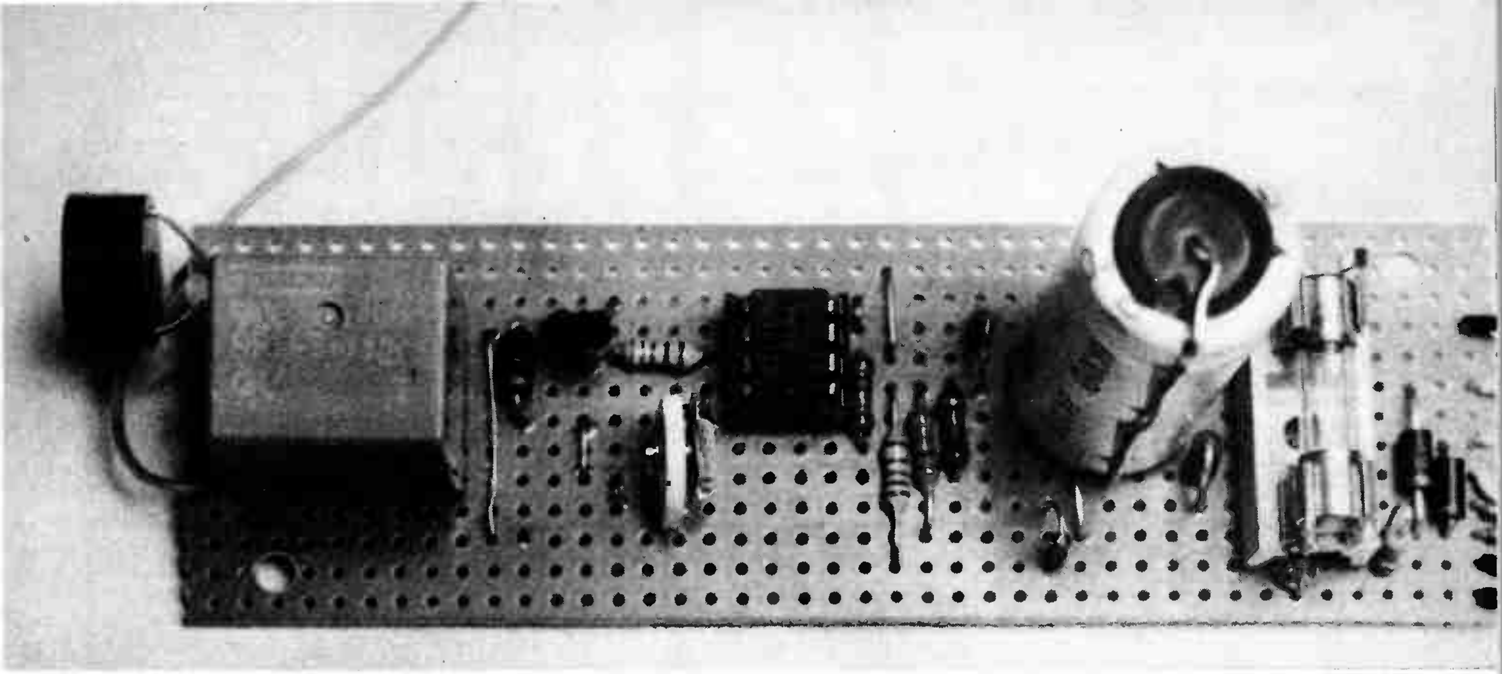


Fig. 6. Veroboard layout and wiring for the large version.





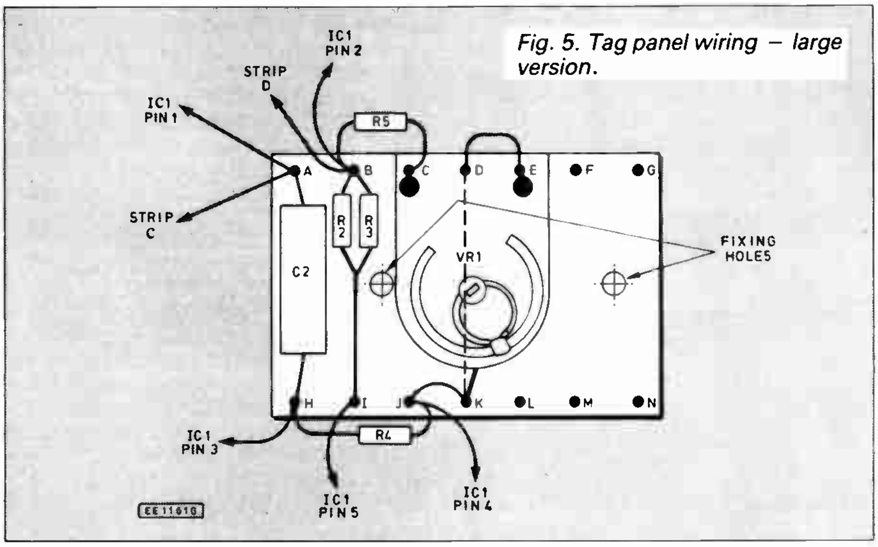


Fig. 5. Tag panel wiring – large version.

with thick cardboard on the underside. This will make certain that the soldered connections are insulated from the case. Place a thick piece of cardboard between the tag board and the metalwork for the same reason. Fit an input lead consisting of mains wire of 3A rating minimum and secure it on the inside of the case with a strain relief bush. Connect a 12V test bulb – twin mains wire may be used for this purpose. Make battery leads using stranded wire of 3A rating – red for positive, black for negative. Include a line fuse holder in the positive wire and fit it with a 2A fuse. Solder the correct type of connectors to the battery ends. Leave both switches in the off position.

TESTING

Plug the unit in and switch on S1. D3 should light. Measure the voltage at the battery wires – this should be 13.5V and VR1 should be adjusted to make it so. Connect the battery observing polarity. The charging current may now be checked. With a poorly-charged battery this should be the preset maximum – that is, 600mA approximately. With a fully charged battery the current will fall to 20mA or thereabouts. Allow one hour for the battery to charge sufficiently for the operational test. Check at intervals that the case remains quite cool. Switches S1 off and S2 (SYSTEM ON) on. Cover the l.d.r. hole and wait for a few seconds. The light should come on. Uncover it and the light should go off again.

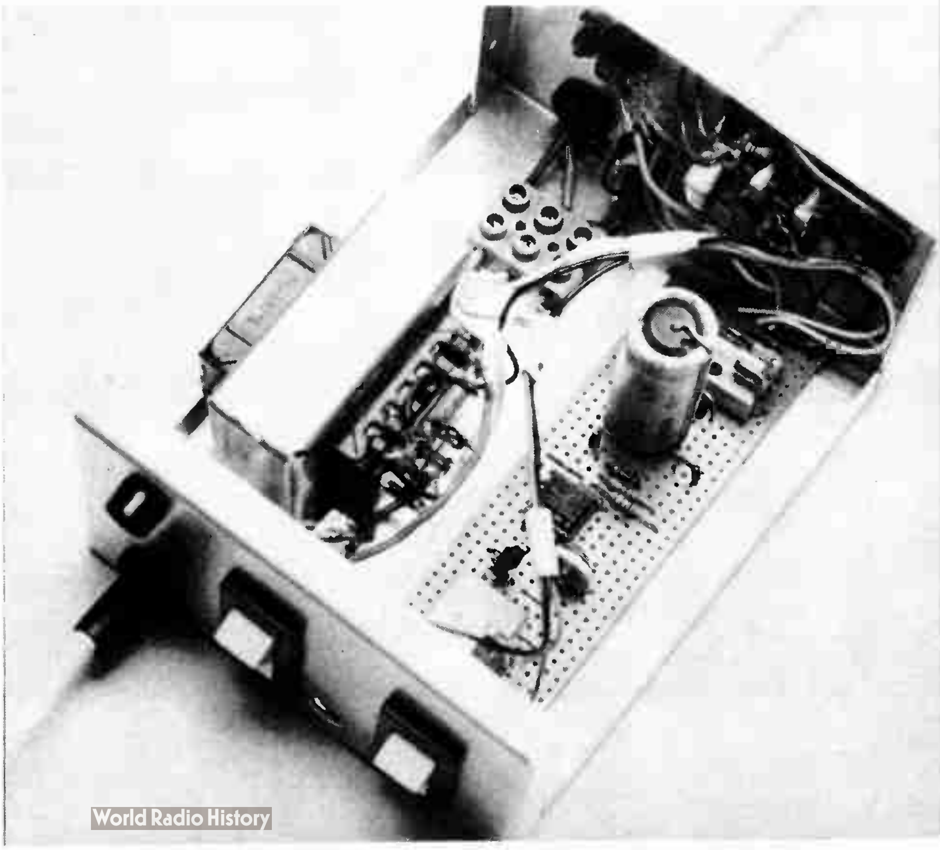
When the unit has been installed in its final position, adjust VR1 for the correct light operating level. Note that direct light from a window should not shine on PCC1. Also, the light from any lamp operated by the system should not be allowed to fall on PCC1 or relay chatter – rapid on-off switching – may occur.

It is possible to reduce the end-point charging current to an even lower value by reducing the output voltage a little – perhaps to 13.4V. This is a point for experiment.

CHOICE OF LAMPS

The 12V (car-type) bulbs are available in a wide variety of types and power ratings. These are connected in parallel. The temptation is to use those of a high rating; however, this will discharge the battery too rapidly. With the specified battery, 500mA can be provided for five hours approximately. It will be found that 12V 2.2W (180mA) lamps give adequate light output so three of these can be operated for five hours from one charge.

A battery of higher capacity could be used with no change to the circuit (6AH for example) if higher powered bulbs are to be used or if a longer operating time is required. Light duty twin stranded wire is suitable for connecting the lamps to the unit. However, over long distances or where more powerful bulbs are used, there could be an excessive voltage drop with consequent dim operation. In such cases, main type twin wire of 3A rating should be used instead. □



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

CAPACITORS

Pak No	Qty	Description	Price
VP5	200	Assorted Capacitors, all types	£1.00
VP6	200	Ceramic Capacitors, Min. mixed values	£1.00
VP9	100	Assorted Polyester/Polystyrene Capacitors	£1.00
VP10	60	C280 Capacitors, metal foil, mixed values	£1.00
VP11	50	Electrolytics, all sorts	£1.00
VP12	40	Electrolytics, 0.47mf-150mf, mixed volts	£1.00
VP13	30	Electrolytics, 150mf-1000mf, mixed volts	£1.00
VP14	50	Silver Mica Caps, mixed values	£1.00
VP15	25	.01/250v Min. Layer Metal Caps	£1.00
VP180	25	Tantalum Bead Caps, assorted values	£1.00
VP182	4	1000uf 50v Electrolytics	£1.00
VP192	30	Min. Electrolytics, mixed values, 0.47mf-1000mf 6/16v	£1.00
VP193	8	Sub Min. Electrolytics, 2 x 1000/2200/3300mf 10/16v	£1.00

OPTOS

Pak No	Qty	Description	Price
VP24	10	.125" clear showing Red LEDs	£1.00
VP25	10	Mixed shape and colour LEDs	£1.00
VP26	15	Small .125" Red LEDs	£1.00
VP27	15	Large .2" Red LEDs	£1.00
VP28	10	Rectangular .2" Red LEDs	£1.00
VP57	25	Opto special pack. Assorted. Super Value	£3.00
VP130	6	RED 7 Seg. CC 14mm x 7.5mm RDP FND353 LED Display	£2.00
VP131	4	GREEN 7 Seg. CA .6" LDP XAN6520 LED Display	£2.00
VP133	6	RED Overflow .6" 3 x CA 3 x CC 6630/50 LED Display	£2.00
VP134	5	GREEN Overflow .6" CA XAN6530 LED Display	£2.00
VP138	20	Assorted LED Displays. Our mix, with data	£5.00
VP147	1	Pair Opto Coupled Modules	£0.80
VP198	4	LD707R LED Displays CA	£1.00
VP203	15	Triangular shape LEDs. Mixed colours	£1.00
VP204	10	Large Green LEDs, 5mm	£1.00
VP205	10	Small Green LEDs, 3mm	£1.00
VP206	10	Large Yellow LEDs, 5mm	£1.00
VP207	10	Small Yellow LEDs, 3mm	£1.00
VP208	10	Large LEDs clear showing Red, .2"	£1.50
VP241	2	ORP12 Light Dependent Resistor	£1.50
VP242	8	Tri-colour LEDs. 5mm Dia. 5mA 2v R.G.Y	£1.00
VP243	3	Tri-colour LEDs. Rectangular 5mm R.G.Y	£1.00
VP266	10	Orange LED's, 5mm large	£1.00
VP267	8	Stackable LED's. Rectangular, mixed, R.G.Y	£1.00
VP268	15	LED Panel Mounting Clips, metal and plastic. 3-5mm	£1.00
VP269	2	Red Flashing LED's, 5mm	£1.00
VP284	2	Opto-Isolator IL74-4N27, single	£1.00
VP285	1	Dual Opto-Isolator ILD74	£1.00

OIOOES ANO SCRS

Pak No	Qty	Description	Price
VP29	30	Assorted volt Zeners. 50mw-2w	£1.00
VP30	10	Assorted volt Zeners. 10w, coded	£1.00
VP31	10	5A SCRs T066, 50-400v, coded	£1.00
VP32	20	3A SCRs T066, up to 400v, uncoded	£1.00
VP33	100	Sil. Diodes like IN4148	£1.00
VP34	200	Sil. Diodes like 0A200/BAX13-16, 40v 200mA	£1.00
VP35	50	1A IN4000 Diodes, all good, uncoded 50v min	£1.00
VP49	30	Assorted Sil. Rectifiers. 1A-10A, mixed volts	£1.00
VP141	40	IN4002 Sil. Rectifiers. 1A 100v, preformed pitch	£1.00
VP142	4	40A Power Rectifiers, silicon, T048 300 PIV	£1.00
VP143	5	BY187 12kv Sil. Diodes, in carriers, 2.5MA	£1.00
VP184	3	4A 400v Triacs, plastic	£1.00
VP187	10	SCRs 800MA, 200v, 2N5064, plastic, T092	£1.00
VP194	50	0A91 point contact germ. Diodes, uncoded	£1.00
VP195	50	0A47 gold bonded germ. Diodes, uncoded	£1.00
VP196	50	0A70-79 detector germ. Diodes	£1.00
VP197	50	0A90 type germ. Diode, uncoded	£1.00
VP198	40	BA248 Sil. Diodes, 350v 2A, fast recovery	£1.00
VP222	20	3A Stud Rectifiers, 50-400v Assorted	£1.00
VP274	12	SCR's (Thyristors) 1A 100-400v, TO-39	£1.00
VP275	3	5A 400v SCR's, T0220, TIC106D	£1.00
VP276	5	SCR's standard type, 5-16Amp to 400v	£1.00
VP277	4	Triacs 2Amp 400v T0-39	£1.00
VP278	4	6Amp 1000v plastic Silicon Rectifiers	£1.00
VP283	5	Diac BR100, triac trigger	£1.00

TRANSISTORS

Pak No	Qty	Description	Price
VP38	100	Sil. Trans. NPN plastic, coded, with data	£3.00
VP39	100	Sil. Trans. PNP plastic, coded, with data	£3.00
VP47	10	Sil. Power Trans. similar 2N3055, uncoded	£1.00
VP48	5	Pairs NPN/PNP plastic Power Trans. 4A, data	£1.00
VP50	60	NPN Sil. Switching Trans. T0-18 and T0-92	£1.00
VP51	60	PNP Sil. Switching Trans. T0-18 and T0-92	£1.00
VP60	100	All sorts Transistors, NPN/PNP	£1.00
VP150	20	BC183B Sil. Trans. NPN 30v 200mA Hfe240+ T092	£1.00
VP151	25	BC171B Sil. Trans. NPN 45v 100mA Hfe240+ T092	£1.00
VP152	15	TIS90 Sil. Trans. NPN 40v 400mA Hfe100+ T092	£1.00
VP153	15	TIS91 Sil. Trans. PNP 40v 400mA Hfe100+ T092	£1.00
VP154	15	MPSA56 Sil. Trans. PNP 80v 800mA Hfe50+ T092	£1.00
VP155	20	BF595 Sil. Trans. NPN eqvt BF184 H.F. T092	£1.00
VP156	20	BF495 Sil. Trans. NPN eqvt BG173 H.F. T092	£1.00
VP157	15	ZTX500 series Sil. Trans. PNP plastic	£1.00
VP158	15	ZTX107 Sil. Trans. NPN eqvt BC107 plastic	£1.00
VP159	15	ZTX108 Sil. Trans. NPN eqvt BC108 plastic	£1.00
VP161	25	BC183L Sil. Trans. NPN 30v 200mA T092	£1.00
VP162	5	SJE5451 Sil. Power Trans. NPN 80v 4A Hfe20+	£1.00
VP163	2	NPN/PNP pairs Sil. Power Trans. like SJE5451	£1.00
VP164	4	2N6289 Sil. Power Trans. NPN 40v 40w 7A Hfe30+	£1.00
VP165	8	BFT33 NPN Sil. Trans. 80v 5A Hfe50-200 T039	£1.00
VP166	5	BFT34 NPN Sil. Trans. 100v 5A Hfe50-200 TO39	£1.00
VP167	1	BUY69C NPN Trans. TO3 VCB 500, 10A, 100w, Hfe15+	£1.00
VP168	10	BC478 eqvt BCY71 PNP Sil. Trans. TO18	£1.00
VP169	10	BX521 eqvt BC384 NPN Sil. Trans. 80v 50mA TO18	£1.00
VP170	10	Assorted Power Trans. NPN/PNP coded and data	£1.00
VP171	10	BF355 NPN T0-39 Sil. Trans. eqvt BF258 225v 100mA	£1.00
VP172	10	SM1502 PNP TO-39 Sil. Trans. 100v 100mA Hfe100+	£1.00
VP200	30	OC71 type germ. AF Transistors, uncoded	£1.00
VP201	25	OC45 germ. RF Transistors	£1.00

TRANSISTORS (cont).

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

I.C.S.

Pak No	Qty	Description	Price
VP40	40	TTL I.C.s all new gates – Flip Flop – MSI. Data	£4.00
VP54	20	Assorted I.C. DIL Sockets, 8 – 40 pin	£2.50
VP59	20	Assorted I.C.s linear, etc, all coded	£2.00
VP209	12	74LS00	£2.00
VP210	12	74LS74	£2.00
VP211	10	CD4001B	£2.00
VP212	10	CD4011B	£2.00
VP214	10	CD4069B	£2.00
VP215	10	741P 8 pin	£2.00
VP216	10	555 Timers 8 pin	£2.00
VP223	50	Asst 74 TTL I.C.s "ALL GATES" new and coded our mix 7400-7453	£8.00
VP224	100	Asst 74 TTL I.C.s "ALL GATES" new and coded our mix 7400-7453	£10.00
VP282	1	Prog. Sound Gen. Chip. AY-3-8912	£3.00
VP291	1	Z80ACPU Microprocessor, 40 pin DIL	£2.00
VP292	1	Z80AP10 Parallel Interface Controller, 40 pin DIL	£2.00
VP293	1	Z80ACTC Counter Timer Circuit, 28 pin DIL	£2.00
VP294	1	2732D 32K Eprom	£3.00
VP295	1	6821P Peripheral Interface Adaptor (PIA)	£1.50
VP296	6	LM324 14 pin DIL Quad Op-Amp	£2.00
VP297	5	CA3130E MOS-FET I/P, CMOS O/P, Op Amp	£2.00
VP298	3	MC1310P Stereo Decoder, 14 pin DIL	£2.00
VP299	3	CA3085 Pos. Volt. Regulator, 1.7v 46v, 8 pin TO5	£2.00
VP400	1	27128 128K Eprom	£2.50
VP401	2	LM317T Adjst. Voltage Regulator, 1.5A	£1.00
VP402	1	2114 4K Static Ram	£2.00
VP403	1	TA7204 Audio Amp I.C. 4.2w, 13v, 2-4 ohms	£1.00
VP404	1	TBA461 Audio Power Amp, 4.5w	£1.50
VP432	8	CD4016B	£2.00
VP433	8	CD4017B	£2.00
VP434	10	CD4024B	£2.00
VP435	10	CD4028B	£2.00
VP7413	4	7413 Dual Nand Schmitt Trigger, 4 input	£1.00
VP7440	4	7440 Dual 4-input, Positive Nand Buffer	£1.00
VP7470	4	7470 And-gated Positive-edge-triggered Flip-Flop with preset	£1.00
VP7480	4	7480 Gated full Adder	£1.00
VP7481	4	7481 16 bit Random Access memories	£1.00
VP7490	4	7490 Decade Counter	£1.00
VP7491	4	7491 8-Bit Shift Register	£1.00
VP7492	4	7492 Divide by 12 Counter	£1.00
VP7493	4	7493 4-bit Binary Counter	£1.00
VP7494	4	7494 4 bit Shift Register	£1.00
VP7495	4	7495 4 bit Shift Register	£1.00
VP74111	4	74111 Dual J-K Master Slave, Flip Flop	£1.00
VP74141	4	74141 BCD – Decimal Decoder/Driver	£1.00
VP74151	4	74151 1 of 8 Data Selectors/Multiplexers	£1.00
VP74153	4	74153 Dual 4 line to 1 line Data Selectors/Multiplexers	£1.00
VP74164	4	74164 8-bit Parallel Output Serial Shift Registers	£1.00
VP74167	4	74167 Synchronous Decade Rate Multipliers	£1.00
VP74174	4	74174 Hex D type Flip-Flops	£1.00
VP74181	4	74181 Arithmetic Logic Units/Function Generators	£1.00
VP74193	4	74193 Synchronous Up/Down Dual Clock Counters Binary Clear	£1.00
VP74279	4	74279 Quad S-R Latches	£1.00
BPX6	1	TTL Data Book 74 Series, Including "LS". Complete with Pin out diagrams. 7400-74670. TT1 interchangeability guide. Function selection guide and explanation of function tables. "NO VAT"	£1.00
BPX5	1	IC555 PROJECTS BOOK (TIMER). 167 pages. Over 50 project circuits to build and other information on IC555 Timers. Plus FREE with our compliments, 3 x IC 555 Timer, worth 80p. "NO VAT". Special offer price just	£2.95
BPX4	1	INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE. Babani Publishing's latest edition BP85, plus FREE with our compliments, 10 popular Silicon Transistors, worth £1.00. "NO VAT". Special offer price just	£3.50

MISC.

Pak No	Qty	Description	Price
VP17	50	Metres PVC single strand Wire, mixed colours	£1.00
VP18	30	Metres PVC multi strand Wire, mixed colours	£1.00
VP19	40	Metres PVC single/multi strand Wire, mixed colours	£1.00
VP22	200	Sq. Inches total copper clad board	£1.00
VP23	10	40mm track slider pots 100K Lin	£1.00
VP42	10	Black heatsinks, fit TO3 and TO220, drilled	£1.00
VP43	4	Power-fin heatsinks, 2 x TO3, 2 x TO66	£1.00
VP44	15	Assorted heatsinks, TO1/3/5/18/220	£1.00
VP56	100	Semiconductors from around the world, mixed	£4.00
VP82	1	Electronic Buzzer, 3v, 25MA	£0.95
VP83	1	Electronic Buzzer, 6v, 25MA	£0.95
VP84	1	Electronic Buzzer, 9v, 25MA	£0.95
VP85	1	Electronic Buzzer, 12v, 25MA	£0.95
VP86	1	TECASBOTY Components Pack, semiconductors, caps, wire, etc	£8.00
VP87	1	Telephone pick-up coil with 3.5mm jack plug	£1.25
VP88	1	Pillow Speaker with 3.5mm jack plug	£1.45
VP107	1	Piezo Buzzer, miniature, 12v	£1.25
VP108	1	Piezo Buzzer, miniature, 240v	£1.25
VP113	1	Coax Antenna Switch, 2 way	£4.50
VP114	1	Coax Antenna Switch, 3 way	£4.75
VP115	1	High Pass Filter/Suppressor CB/TV	£0.80
VP116	1	Low Pass Filter, VHS/TV Band	£3.00
VP122	1	Precision Morse Key, fully adjustable	£1.85
VP144	4	100K Lin multi turn Pots, ideal vari cap tuning	£1.00
VP145	10	Assorted Pots, inc. dual and switched types	£1.00
VP148	30	Presets, horizontal and vertical, mixed values	£1.00
VP174	5	DIL Switches, 1 and 2 way slide, 6 way SPST, assorted	£1.00
VP176	30	Fuses, 20mm and 1¼" glass, assorted values	£1.00

MISC. (cont.)

Pak No	Qty	Description	Price
VP177	1	Pack assorted Hardware, nuts, bolts, etc	£1.00
VP178	5	Assorted Battery holders and clips PP3/9, AA/O, etc	£1.00
VP223A	6	Tag Boards, 18 way paxaline	£1.00
VP225	20	DIN Plugs, plastic 2-8 pin, 180°/240°/360° mixed	£2.50
VP226	20	DIN Chassis Skts, metal 2-8 pin 180°/240°/360° mixed	£2.50
VP227	18	DIN In-line Skts, plastic 2-8 pin 180°/240°/360° mixed	£2.50
VP228	10	C15 Computer Cassette Tapes, leadless	£3.00
VP232	1	Cassette Head Cleaner/Demagnetizer, in case	£2.00
VP233	1	Revolving Cassette Rack, holds 32, smokey perspex	£2.50
VP244	1	High Power Piezo Electric Siren. Emits earpiercing warbling sound. Ideal alarm. White plastic body with mounting bracket. Power 12vDC 150mA. Output 100db (A) at 1m typ. freq. 2.5KHz. Size: 57 x 42 x 37mm	£8.00
VP260	1	9" x 6" Elliptical 8 ohms 10W RMS Speaker. Freq. Res. 60-10000 Hz. Gauss 10000. Centre HF cone	£4.50
VP260A	1	2¼" Transducer Waterproof Speaker. Polyester film diaphragm. Moisture res. 8 ohms 300mW Freq. Res. 20-20000 Hz	£1.00
VP273	10	10K Lin Rotary Potentiometers, slim spindle	£1.00
VP281	4	Plug-In Relays. Mixed volts, etc	£1.00

TOOLS

Pak No	Qty	Description	Price
VP95	1	Plastic Vice, small, with suction base	£1.75
VP97	1	Logic Probe/Tester, supply 4.5v – 18v, DTL.TTL, CMOS	£8.50
VP99	1	Universal Tester, with ceramic buzzer	£5.00
VP103	1	6 pc Stanley screwdriver set, flat and crosspoint	£3.50
VP139	1	Pick-up Tool, spring loaded	£1.75
VP217	1	Helping Hand	£4.00
VP218	1	Watchmakers Screwdriver Set, 6 pieces	£1.75
VP219	1	Miniature Side Cutters	£1.55
VP220	1	Miniature Bent-nose Pliers	£1.55
VP221	1	Miniature Long-nose Pliers	£1.55
VP237	1	Universal Ni-Cad Battery Charger, AA-HP11-HP2-PP3	£8.00
VP238	4	AA Ni-Cad Batteries. 1.25v 500mAh C/R mA	£4.00
VP239	2	C7HP11 Ni-Cad Batteries, Rechargeable	£3.50
VP240	2	D-HP2 Ni-Cad Batteries, Rechargeable	£4.00
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VP305	1	1.5m cable 5 pin DIN Plug – 3.5mm Jack Plug. Pin 1 & 4 connect	£1.00
VP306	1	2m Typewriter/Calculator Lead. 3 pin Plug, angled European IEC configuration	£2.00
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VP308	1	1.2m Patch Lead. PL259 Plug to PL259 Plug	£1.50
VP309	1	1.2m Lead 4 Phono Plugs to 4 Phono Plugs	£1.50
VP310	1	20cm Lead 2 x 2 pin DIN Plug to Stereo Inline Jack Skt	£1.00
VP311	1	2m Lead Scart Plug to 5 pin DIN Plug & 2 BNC Plugs	£8.00
VP312	1	1.2m Video Lead. BNC Plug to Phono Plug	£1.00
VP313	1	3m Headphone Lead. 3.5mm Jack Plug to 3.5mm Jack Skt.	£1.00
VP314	1	2m Coax Lead BNC Plug to BNC Plug. 75 ohms	£3.00
VP315	1	2m Coax Lead BNC Plug to UHF Plug. 75 ohms	£3.00

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

TONY SMITH G4FAI

SHORTWAVE LISTENING

The *Simple Shortwave Radio* published in the August 1987 issue of *EE* has proved to be a very popular project, demonstrating the continuing interest in shortwave listening which many people have. Such a receiver is capable of receiving signals from all parts of the world, re-creating something of the old "magic of wireless" and giving enormous pleasure to its constructor and user. *For those readers who wish to capture some of the nostalgia and magic of the early days of SW listening, why not build the One "Valve" Radio described in this issue? – Ed.*

For many, SWLing, as we call it, is the ideal way to obtain a good general background to radio communication while they study to become radio amateurs themselves. Others enjoy listening so much that it becomes a hobby in itself and they feel no need to go on to obtain a transmitting licence.

At one time it was possible to tune almost any domestic radio having a shortwave section, to find amateurs around the world talking to each other. Most nowadays use single sideband (SSB) which requires a special receiver to make sense of it. (I will be explaining how SSB works in a later column.) Some expensive receivers today can resolve SSB but in the main specially designed "communications" receivers are required although, paradoxically, SSB transmissions can also be resolved on simple home-made regenerative receivers.

Some amateurs transmit speech using frequency modulation (f.m.), and other transmissions involve teleprinters, television, Morse Code, computers and so on. Other activities include satellite, moon-bounce, aurora and meteor scatter operations, and some SWLs acquire the necessary knowledge, skill and equipment to receive these specialised transmissions.

EMERGENCIES

Stories are sometimes told of amateurs picking up emergency calls and alerting the authorities to send help. Not only transmitting amateurs but SWLs as well. On the evening of 27 January, 1978, for example, Dennis Shields, a keen SWL in Wiltshire, heard a *"Mayday"* distress call from the Spanish ship *Marbell* which was drifting without engine power in an Atlantic storm.

Realising that no one was responding to the SOS, he telephoned Portishead Radio which, in turn, contacted Boulogne Radio. Within four minutes Boulogne had established two-way radio contact with the *Marbell* and rescue operations were put in hand. Sadly, the ship ran aground and sank on the coast of Spain before a rescue could be effected.

Dennis Shields was subsequently presented with an Award of Merit by the Spanish Ambassador, recording the events of that night and expressing appreciation for his part in alerting the authorities. Obviously this is not the sort of everyday occurrence experienced by SWLs but it does illustrate the potentially serious, as opposed to the recreational, side of shortwave listening.

SWLs send reports to amateur stations which they hear, in the hope of receiving a QSL card in return. The report cards are often printed, much in the same style as a QSL card. Listeners who are members of the Radio Society of Great Britain (RSGB) are allocated a British Receiving Station (BRS) number which is printed on the card in lieu of a call-sign.

It is not, however, just a question of sending a card and automatically getting one back. The more powerful stations, which can frequently be heard over great distances, receive many listeners' cards and are only inclined to respond to them when they provide information of value or interest.

HE ALREADY KNOWS!

A high-powered American station which consistently works British amateurs is unlikely to be interested in a report which merely tells him his signals are being received in this country. He knows that already! If he was using very low power, however, when contacts over thousands of miles rate as fine achievements, he would probably be delighted to receive a detailed reception report and would gladly send a QSL card in return.

The same applies to stations who are heard to mention during a contact that it is unusual for their signals to be heard in the UK, and receipt of a report from a British SWL would obviously be of interest to them.

Newly licensed amateurs may welcome cards, or any operator who refers to the new equipment or antenna which he has just brought into use may be pleased to know how it is performing. Reports of reception over a period of time are often of interest, and it may even be possible for the SWL to provide further information on a subject which has been discussed over the air.

Reports should be clear and concise and should include the date, the time (UTC) and frequency of the contact (QSO) heard, and the call-signs of both stations in the QSO. A signal report should be included using the RS or RST codes (see *EE*, March 1986), together with any other relevant information in legible handwriting or typewriting.

RSGB members can use the QSL bureau to send and receive cards. Non-members can also send cards to known members via the bureau. Any reports sent direct to amateur stations should include stamps or international reply coupons, with a self-addressed envelope, to increase the chance of a reply.

SERIOUS LISTENING

If it is to be taken seriously, a shortwave listening station should be properly equipped, almost as if it were a transmitting station. It should have a log book to record details of all transmissions monitored, either home-made or commercially printed; a supply of printed report cards and possibly an index system (or computer index program).

The station should also carry a list of the call-sign prefixes of the various countries of the world; an atlas or map of the world to identify where the stations heard are situated; a good reference book, such as the RSGB's *Amateur Radio Operating Manual* and an Amateur Call-Book. If the v.h.f. bands are listened to, a map of the QRA locator system would be helpful, particularly for contests. (More on this in a later column.)

Most amateur radio contests and awards have sections for SWLs. Success in these can be almost as satisfying, in some ways, as taking part in full transmitting events.

Evidence of the interest in SWLing is to be found in the various SWL clubs which exist and the various publications available. SWL membership is welcomed in most amateur radio clubs and organisations, while radio magazines have SWL columns with the latest news on band conditions etc., together with "league" tables to record the successes of individual readers/listeners.

OTHER SERVICES

While this piece is concerned with SWLing on the amateur bands it should not be overlooked that the shortwave spectrum as a whole contains transmissions from many other sources including international broadcast stations, official and commercial services, marine, aircraft, weather and so on. Some bands are allocated exclusively for amateur use but some are on a shared basis with other services.

Some SWLs like to listen to all types of services, and for them a receiver which covers all bands – a "general coverage" receiver – is the ideal choice. For those interested only in amateur transmissions an amateur bands only receiver is best since these are designed to provide the best possible reception of weaker amateur signals compared to those from higher-powered stations.

SWLing is the ideal way to begin to take an interest in amateur radio. You can hear the amateurs in action, learn the language, and gain valuable experience in preparation for becoming a fully-fledged amateur yourself. By joining a local club as an SWL member you can meet others with similar interests and gain much from the help and advice which will be freely available for the asking.

If you made the EE *Simple Shortwave Radio* you are already on your way! Obviously it won't compare with the performance of expensive commercial sets, but it will pick up amateur and other transmissions surprisingly well to give you a good introduction to the fascinating world of shortwave listening.

City and Guilds

C+G

INTRODUCING MICROPROCESSORS

MIKE TOOLEY B.A.

Part 4

REVISION

In Part Three we explained how a microprocessor fetches, decodes and executes the sequence of instructions which constitute a program. We concluded by mentioning some of the facilities offered by a typical system monitor. In this part, we shall develop this theme a little further in preparation for the first Practical Assignment which readers should now be able to tackle. We also provide readers with some guidance in preparation for the first Written Assessment before dealing with points raised by readers in our first Readers' Forum.

LEARNING OBJECTIVES

The learning objectives for Part Four of Introducing Microprocessors are encompassed in those already stated for Parts One, Two and Three.

REGISTRATION

Readers who wish to take the necessary assessments in order to qualify for a City and Guilds Introductory Microprocessor Certificate should now register with a local centre. A list of approved centres was published in *EE* October 1987 (pages 541 and 542) but readers should note that not all of these centres will have the necessary resources required to provide assessment for the Introductory Microprocessor module.

A telephone call to the centre should establish whether or not the necessary facilities are available. Note that, since it may be difficult to reach the person responsible for course administration (due to teaching and other commitments), you may have to leave a daytime telephone number and wait for the centre to call back.

The cost of registration, access to microprocessor workshop/laboratory facilities, and fees for assessment should all be negotiated with the centre concerned. Most centres will wish to make a charge which at least covers the cost of staff supervision. In many cases this could be shared amongst a group of candidates presenting themselves for assessment at some mutually convenient time, thereby reducing the cost to individuals. We would normally expect the fee levied by a centre to be in the region of £15 to £45 depending upon your individual needs and the centre's resources.

USING A MONITOR PROGRAM

In Part Three we mentioned the use of a monitor program as an aid to understanding the operation of a microprocessor. We also stated that such a program can also allow us to enter, test and debug simple programs. In small microcomputer systems (of the sort used for education purposes) monitor programs are invariably provided in ROM. In other systems (such as the IBM PC and compatibles) the monitor program is resident in RAM and must be loaded from disk. Naturally, with more powerful and more modern systems, monitor programs offer a number of extended facilities. These programs (usually referred to as "debuggers") are often provided as an extension of the operating system and, as their name might imply, they can be an invaluable aid for programmers and software developers. One of the most popular debuggers is that which runs under the MS-DOS operating system on the IBM PC (and compatibles). This program is known simply as "DEBUG".

For the purpose of this series, we shall assume that readers only have access to a fairly basic monitor and we shall discuss each of the features of a monitor with which readers should be familiar. Such a discussion will obviously be more meaningful if readers have reasonably immediate access to a microprocessor system and can try out the various monitor commands (usually single letters followed by one or more parameters) as they are introduced.

Memory Display

A memory display facility can be used to display the contents of a given memory address or range of addresses. The display is usually presented in hexadecimal format though systems which provide output to a TV, monitor, or VDU terminal generally also provide an ASCII representation of the data. This latter facility can be useful when the region of memory currently under investigation contains text rather than a machine code program.

A typical memory display command would take the form:

D 4000 (Display an 80 byte block of memory starting at address 4000 hex.)

A typical memory display (in hexadecimal and ASCII) is shown in Fig.4.1. Note that some monitors use a Memory Pointer which must be set before the contents of a given block of memory

Memory addresses (hex) — Contents (hex) — Contents (ASCII)

```
0000   F3 AF 11 FF   s/..
0004   FF-C3 CB 11   .CK.
0008   2A 5D 5C 22   *]\"
000C   5F 5C 18 43   _\.C
0010   C3 F2 15 FF   Cr..
0014   FF FF FF FF   ....
0018   2A 5D 5C 7E   *]\~
001C   CD 7D 00 D0   M}.P
0020   CD 74 00 18   Mt..
0024   F7 FF FF FF   w...
0028   C3 5B 33 FF   C[3.
002C   FF FF FF FF   ....
0030   C5 2A 61 5C   E*a\
0034   E5 C3 9E 16   eC..
0038   F5 E5 2A 78   ue*x
003C   5C 23 22 78   \#"x
0040   5C 7C B5 20   \|5 
0044   03 FD 34 40   .}4@
0048   C5 D5 CD BF   EUM?
004C   02 D1 C1 E1   .QAa
```

Contents of registers shown in hex — Contents of Flag Register shown in binary with single letters representing individual flags

	Register	Contents	SZ H PNC
Main set of general purpose registers	AF	0F	01010100
	BC	01	04
	DE	02	8F
	HL	80	20
			SZ H PNC
Alternate set of general purpose registers	A'F'	00	00010100
	B'C'	00	A0
	D'E'	1A	0F
	H'L'	3C	0B
Special purpose registers	IR	3F24	
	IX	03D4	
	IY	5C3E	
	SP	FF7F	
	PC	8002	

Fig. 4.1 (far left) Typical memory display in hexadecimal and ASCII
Fig. 4.2 (below) Typical display of CPU registers (Z80 based system)
Fig. 4.3 (above) Typical disassembly of memory (Z80 based system)

can be displayed. A typical sequence of commands would then be:

N 4000 Set memory poiNter to 4000 hex.)
L (List 80 bytes of memory starting from 4000 hex.)

Other monitors require that start and end addresses are specified as part of the command as shown in the following command which prints a 32 byte block of memory starting from hexadecimal address 4000:

P 4000 401F (Print 32 bytes of memory starting from 4000 hex.)

Memory Edit

A memory edit facility can be used to change the value of a byte or bytes stored in read/write memory. Values are invariably specified in hexadecimal. A typical sequence of monitor commands to place a bype of 2A hex. into memory location 8000 hex. would take the form:

M 8000 4E – 2A (Modify the byte present at 8000 hex.)

The system responds by displaying the hex. value (4E) of the byte currently present at address 8000H and the user then supplies the new value to be stored at the address. Note that there are many other variations of this command including those which pre-set (fill) a block of memory with a given byte value. A typical command to fill a 1K block of memory from 4000 hex. to 43FF hex. with a byte of 0F hex. would take the form:

F 4000 43FF 0F (Fill 1024 bytes of memory starting from 4000 hex. with a byte value of 0F hex.)

CPU Register Display

The register display facility allows users to examine the contents of the CPU registers. No parameter follows the command which is typically entered using the single letter R. A typical register display for a Z80 CPU is shown in Fig.4.2.

CPU Register Modify

The register modify command allows

Memory address (hex) — Instruction bytes (hex) — Inst

```
0E88 7C     LD   A,H
0E89 0F     RRCA
0E8A 0F     RRCA
0E8B 0F     RRCA
0E8C 3D     DEC  A
0E8D F650   OR   50
0E8F 67     LD   H,A
0E90 EB     EX   DE,HL
0E91 61     LD   H,C
0E92 68     LD   L,B
0E93 29     ADD  HL,HL
0E94 29     ADD  HL,HL
0E95 29     ADD  HL,HL
0E96 29     ADD  HL,HL
0E97 29     ADD  HL,HL
0E98 44     LD   B,H
0E99 4D     LD   C,L
0E9A C9     RET
```

users to load the CPU registers with values prior to testing machine code routines. The command usually needs to be followed by a mnemonic for the register concerned, a typical example being:

S BC 00FF (Set the BC register pair to 00FF hex.)

which loads the BC register pair with the hexadecimal word. (Note that 00 appears in register B whilst FF hex. appears in register C). Again, there are many variations of this command.

Disassemble Memory

The facility to disassemble the contents of a block of memory into assembly language mnemonics can be extremely useful. A typical command would take the form:

U 0100 011F (Unassemble memory from 0100 hex. to 011F hex.)

which would disassemble (unassemble) 32 bytes of memory starting from address 0100 hex. Note that some variations of this command use the second parameter as the number of bytes to disassemble rather than the end address. A typical disassembly is shown in Fig.4.3. It is important to note that the "disassemble memory" command cannot distinguish between regions of memory in which programs are resident and those which contain text or data. The result of using the command will be meaningless in the latter case!

Insert Breakpoints

Breakpoints are codes (usually a single byte) which are inserted into programs during testing or debugging. When a breakpoint is subsequently encountered, execution of the program is suspended and control is returned to the monitor program. This facility allows the user to examine the state of the microprocessor's registers and any relevant memory locations when a certain point is reached.

A typical command to insert a breakpoint takes the form:

B 801F (insert a Breakpoint at address 801F hex.)

which inserts a breakpoint at address 801F hex. Most monitors allow users to insert a number of breakpoints thus allowing for programs which use conditional branching.

Execute a Program

This command should be self-explanatory! The command usually expects a single parameter which is the hexadecimal address from which execution is to commence. Some monitors (including DEBUG) allow further parameters which constitute addresses at which breakpoints are to be placed. A typical command would take the form:

G 8000 (Go from address 8000 hex.)

This command sets the Instruction Pointer (or Program Counter) to 8000 hex. and commences program execution from that address. Note that this command is a little dangerous as, unless breakpoints have been appropriately placed, control may not be returned to the monitor program and the user may thus effectively lose control of the system!

Trace Program Execution

A "program trace" facility is similar to the previous command but can be used to produce a continuous display of the state of the CPU registers (as well as certain locations in memory). The display is updated as each instruction is executed. A typical command would take the form:

T 8000 801F (Trace program execution between 8000 hex. and 801F hex.)

which can be used to trace program execution starting at a hexadecimal address of 8000 and ending at 801F. Note that some variations of this command use the second parameter to specify the number of instructions to be traced rather than the address at which control is to be returned to the monitor program. The trace facility is sometimes known as a "single-step" facility.

FIRST PRACTICAL ASSIGNMENT

Readers are now ready to undertake the first Introductory Microprocessors Practical Assignment. This assignment involves using a Monitor Program and the module objective reference is 2.4.1.

The Practical Assignment must be undertaken at an approved local centre where candidates will be provided with supervision and appropriate working conditions. Candidates should, however, provide their own A4 note paper, pens and pencils. For its part, the Centre will supply candidates with any data sheets, books or handbooks required. Full documentation for the microcomputer system used should be available (including a summary of monitor commands).

During the Practical Assignment, candidates will normally be required to perform the following operations using the monitor program:

(a) Display the contents of a block of ROM (e.g. the first 256 bytes of the system ROM)

(b) Display the contents of a block of RAM (e.g. the first 256 bytes of user RAM)

(c) Examine the state of the CPU registers (e.g. the Accumulator, Status or Flag Register, Program Counter or Instruction Pointer, and general purpose registers as appropriate to the microprocessor concerned)

(d) Change the state of given CPU registers

(e) Preset a block of memory to a given byte value (e.g. the first 1K of screen RAM)

(f) Change the contents of specified addresses in RAM and verify that the change has been successful.

In order to accomplish sub-tasks (a), (b), (e) and (f), candidates will have to refer to the documentation provided and draw a memory map for the system clearly showing:

(i) Addresses at boundaries (stated in decimal and hexadecimal)

(ii) Areas occupied by ROM, RAM and I/O (where appropriate)

(iii) Identify any areas reserved for special use (e.g. screen memory, system variables, etc.)

In order to complete sub-tasks (c) and (d) it will be necessary to obtain information about the internal architecture of the microprocessor in the form of a "register model". Candidates should sketch this model clearly showing the nomenclature used to identify individual internal registers (e.g. SP = stack pointer, IP = instruction pointer, etc.).

There is no set time limit for this assessment; however it is expected that candidates who are adequately prepared will complete the assignment in approximately three hours (i.e. one half day or evening). The period during which the assignment is taken is left to the discretion of the individual centre. Note that candidates who are, in the opinion of the centre concerned, not adequately prepared should expect to have their assessment prematurely terminated!

Marking

Candidates will have satisfactorily completed this first Practical Assignment if they can demonstrate success in ALL items marked with a square and at least THREE out of FIVE items marked with a circle in the list below:

Memory map (showing address at boundaries)	○
Memory allocation	○
Display contents of ROM	□
Display contents of RAM	□
Microprocessor architecture (including nomenclature)	○
Display contents of CPU registers	□
Change state of CPU registers	□
Preset a block of RAM	○
Change contents of RAM and verify	○

Where candidates are deemed unsuccessful, a period of at least seven days must elapse before a retake is permitted. This should give candidates an opportunity to prepare themselves. Note also that most centres will expect candidates to use a different microcomputer system for their second, and any subsequent, attempts.

FIRST WRITTEN ASSESSMENT

By now, readers should also be adequately prepared for the first Written Assessment. This is a straightforward multiple choice test containing 22 questions each of which is provided with four answers. Candidates should choose the answer which they think is correct and mark the Answer Sheet accordingly. Note that only ONE answer is correct in each case.

In order to assist readers with preparation (and dispell any fears concerning formal examinations!) the following Pre-Test has been devised. The questions are similar (although not identical!) to those with which candidates will be confronted.

FIRST WRITTEN ASSESSMENT PRE-TEST

The following questions are provided in order to prepare readers for the style and format of the first written assignment. Prospective candidates should carefully read through and then answer each question in turn. When completed, answers should be compared with those given on page 88. The time allowed for the test is extremely generous and has been set so that candidates should not be constrained by having to answer questions in a hurry. Adequately prepared candidates should be capable of answering the questions within approximately 25 minutes!

Candidates' Instructions

This test contains 22 multiple-choice questions. In order to pass you must answer a minimum of 16 of them correctly. The first number for each question is the test question number whilst the number in bracket relates to the module reference.

1. (1.1.1) A read-only memory (ROM) is best defined as
   a a volatile memory
   b a form of read/write memory
   c a permanently programmed memory
   d a memory which can only be written to.
2. (1.1.2) A VLSI integrated circuit having CPU, internal clock, RAM and I/O ports can best be described as
   a a microprocessor
   b a microcomputer
   c a single-chip microprocessor
   d a single-chip microcomputer.
3. (1.2.1) The term SSI refers to integrated circuits having
   a less than 10 devices per chip
   b between 10 and 100 devices per chip
   c between 100 and 1000 devices per chip
   d more than 1000 devices per chip.
4. (1.2.2) Which one of the following is FALSE?
   a CMOS devices can operate over a wide range of supply voltages.
   b CMOS devices consume negligible current in a "standby" condition.
   c CMOS devices offer better noise immunity than comparable TTL devices.
   d The supply current consumed by a CMOS device decreases with the speed at which it is switching.
5. (1.2.3) Which one of the following gives the normally accepted upper voltage limit for a TTL low state (logic 0)?
   a 0V
   b 0.8V
   c 2.0V
   d 5.0V
6. (1.3.1) Which one of the following gives the constituent elements of a computer?
   a INPUT, MEMORY, OUTPUT

b INPUT, CENTRAL PROCESSING UNIT, OUTPUT
c CENTRAL PROCESSING UNIT, MEMORY, OUTPUT
d INPUT, CENTRAL PROCESSING UNIT, MEMORY, OUTPUT

7. (1.3.2) The computer element responsible for permanent storage of programs and data is called the
a read only memory
b read/write memory
c arithmetic logic unit
d central processing unit

8. (1.3.3) The components of a microprocessor system are linked together by means of
a input/output lines
b address, data and control buses
c a serial data path (e.g. RS-232C)
d a control bus (including a CLOCK line).

9. (1.3.4) When a microprocessor is fetching an instruction from memory, the operation code for the instruction appears on the
a address bus
b control bus
c data bus
d I/O bus.

10. (2.1.1) The block marked 'X' in Fig.4.4 represents the
a data bus buffer
b instruction decoder
c instruction register
d CPU registers (including Instruction Pointer).

11. (2.1.2) The Instruction Register provides a means of
a locating the next instruction in memory
b locating the start address of a program in memory
c storing an instruction whilst it is being decoded
d storing the result produced when an instruction is executed.

12. (2.1.3) Which one of the following statements is TRUE?
a Both RAM and ROM devices are connected to the address bus
b neither RAM nor ROM devices are connected to the address bus
c RAM devices are connected to the address bus whilst ROM devices are not connected to the address bus
d ROM devices are connected to the address bus whilst RAM devices are not connected to the address bus.

13. (2.1.4) The clock in a microprocessor system provides
a a common time reference
b a control signal for read/write memory
c a signal used within the address decoder
d a means of determining the execution time of a program.

14. (2.1.5) The clock input to a microprocessor comprises
a a sine wave signal of typically 1kHz to 4kHz
b a square wave signal of typically 1kHz to 4kHz
c a sine wave signal of typically 1MHz to 4MHz
d a square wave signal of typically 1MHz to 4MHz.

15. (2.2.1) Which one of the following is an essential part of any microprocessor instruction?
a Label
b Address
c Operand
d Operation code

16. (2.2.2) The first byte of a three-byte instruction comprises
a a label
b an address
c an operand
d an operation code.

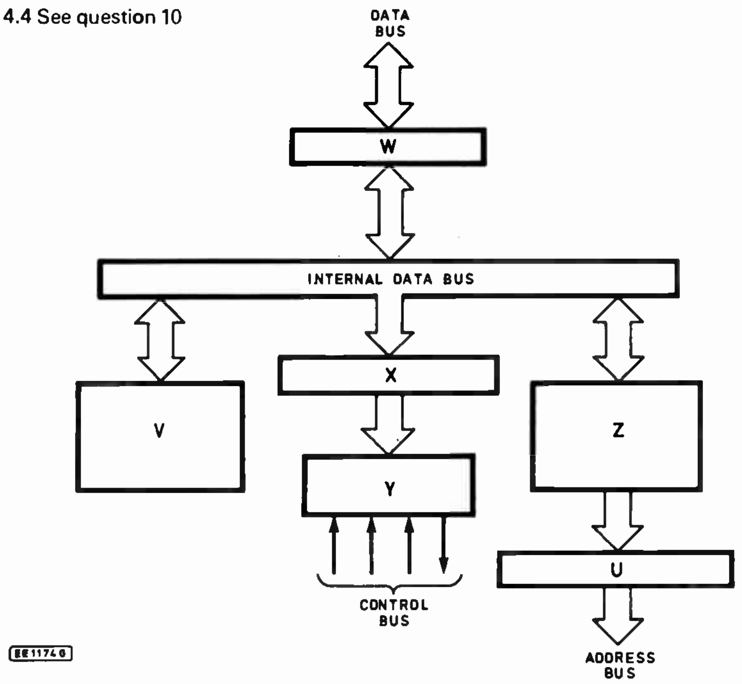
17. (2.2.3) Which one of the following does NOT represent a data transfer instruction?
a JMP
b LDA
c MOV
d STA

18. (2.2.4) In which one of the following addressing modes are there no data or address bytes present within an instruction?
a Absolute
b Extended
c Implied
d Immediate

19. (2.3.1) Which one of the following gives the correct sequence of events within the fetch-execute cycle of an instruction which loads the accumulator with an immediate data byte?
A = Decode the Operation Code
B = Increment the Instruction Pointer
C = Fetch Operand
D = Latch Operand into Accumulator
E = Fetch Operation Code
a A E B C D
b A B E D C
c E B A C D
d E C B A D

20. (2.3.2) Which one of the following gives the action which takes place in the Instruction Pointer during the fetch-execute cycle?
a Set to zero and then incremented as each instruction byte is fetched hence counting the total bytes in a program
b Set to the first address of the program and maintained constant so that the program can be restarted when a system RESET occurs.
c Incremented during the fetch-execute cycle so that it eventually holds the address of the next instruction to be fetched.
d Contains first the operation code and then each operand byte in strict sequence thus allowing the instruction to be decoded.

Fig. 4.4 See question 10



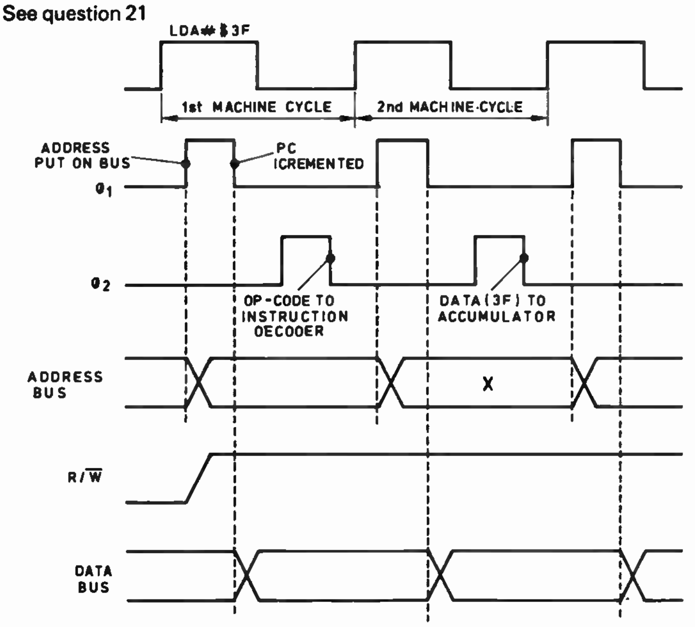
CORRESPONDENCE

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

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

Please include a stamped addressed envelope (and be prepared to wait a little!) if you require an individual reply. General queries will be dealt with in "Readers' Forum" which will next appear in Part Nine of the series.

Fig. 4.5 See question 21

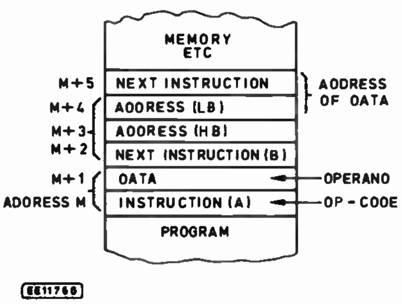


21. (2.3.3) The feature marked X in Fig. 4.5 represents
   a the address of the data byte
   b the data byte present on the bus
   c the address of the operation code
   d the operation code present on the bus.

22. (2.3.4) Fig. 4.6 shows two instructions (A and B) located within the memory of a microprocessor system. During the FIRST fetch cycle
   a the address M + 1 is loaded with the operand
   b the address M is loaded with the operation code
   c the Instruction Pointer is loaded with the operand
   d the Instruction Pointer is loaded with the operation code.

Now CHECK YOUR ANSWERS before seeing how you scored!

Fig. 4.6 See question 22



READERS' FORUM

Many readers have taken me to task over the two errors which unfortunately appeared in Part One. Hopefully, the corrections which were printed last month will have put the record straight. Anyone who is still puzzling over Problem 1.14(a) should refer to last month's *EE* for the correct answer!

The diagram which appeared in Figs. 5 and 6 of Part One also seem to have caused a few headaches. The direction of the bus lines was intentionally made somewhat vague so that readers had to give some careful thought to the problem. This was, perhaps, something of a dirty trick on my part and readers can rest assured that the questions used in the Written Assessments will be less vague in this area.

S. Lloyd, G. Kay and M. Painter all queried my description of the use of the HL register pair in Part Two of the series. The registers can be used individually as 8-bit registers for general purpose temporary storage of data but they are more commonly used for storing 16-bit addresses.

Software instructions are available for loading data bytes into either H or L. Other instructions deal with the HL register pair as a single entity, loading HL with two bytes of data (the first byte of data following the operation code is loaded into L whilst the second byte of data is placed in H). IMP, like many other popular 8-bit microprocessors deals with data in reverse order (i.e. low byte followed by high byte).

Alan Jones asks whether the microprocessor clock signal can be used as the basis of a "real-time" clock for time keeping purposes. The answer is a qualified "yes" – the clock would have to operate at a frequency which can be divided down (by a chain of binary or decade dividers) to some meaningful frequency (e.g. 1Hz). A typical operating frequency for the oscillator of a "real-time" clock i.c. would be 32.768kHz. This is obviously too low for a microprocessor clock input (it would make the system painfully slow by comparison with systems operating with clocks at several MHz). One possibility, however, might be that of using a crystal controlled clock at 3.2768MHz and dividing this frequency by 100 (achieved with one standard CMOS device) to provide the requisite input for a "real-time" clock i.c.

Whilst on the subject of clocks, David King asks about the order of stability required for a microprocessor clock. In practice, most microprocessor clocks operate with a frequency accuracy and stability of better than 100 parts per million over a working temperature range of – 10 deg.C to + 60 deg.C. From this, readers should appreciate that these clocks are really quite stable. Stability and accurary is not always vitally important as witnessed by the ZX81 (a forerunner of the Sinclair Spectrum) which, on the grounds of cost, completely dispensed with a quartz crystal frequency determining element!

Finally, Don Adams and Dianne George have both written to ask why so many microprocessor manufacturers have insisted on using different sets of signals within the control bus. The use of a common set of control signals would indeed make life much easier for system designers and this has undoubtedly been a prime consideration in the specification of modern processor-independent "backplane" bus systems. These systems allow complete microcomputer systems to be assembled from modules. Not only do they permit the use of virtually any type of microprocessor but they can accommodate several microprocessors working simultaneously – all with different architectures and dissimilar local bus structures!

NEXT MONTH: we shall be dealing with RAM and ROM devices and introducing the second Practical Assignment.

BACKGROUND READING

The following background reading in preparation for next month:
Chapter 6 (Microcomputer Memories and Bus Systems) of *Microelectronic Systems 2* by R. Vears. **Available from the *EE* Book Service, see page 116.**

PRE-TEST ANSWERS

1. d	7. d	13. a	19. c
2. d	8. b	14. d	20. c
3. a	9. c	15. d	21. a
4. d	10. c	16. d	22. d
5. b	11. c	17. a	
6. d	12. a	18. c	

How well did you do?

Score less than 12
Don't underestimate the amount of work that you still need to do! We suggest that you carefully work through Parts One to Three before making a second attempt at the Pre-Test.

Score 12 to 16
You have still got plenty of work to do before you are ready to sit the Written Test! Check the answers to those which you answered incorrectly, referring to the relevant parts of Introducing Microprocessors in order to see where you went wrong.

Score 17 to 22
Well done! You should be well able to cope with the Written Test. It is, however, still worth checking the answers to those questions which you answered incorrectly.

Actually Doing it!!

THERE must have been thousands of electronics projects published over the past fifty years or more that the hobby of electronics construction has been in existence, and probably the number of projects copied from these designs runs into millions. I wonder just how many of these copies are faithful to the original, or even very close copies? I suspect that relatively few constructors follow the constructional information to the letter, and use exactly the same components as those in the prototype.

There is actually a lot to be said for "customising" projects slightly to suit individual preferences, and the more experienced constructor can make quite drastic changes to their versions of projects. This offers more fun and interest than producing perfect clones of the published designs. At a more practical level, it can be difficult to find exactly the same components that were used in the prototypes, and straightforward cloning might prove to be difficult anyway.

For the experienced constructor it is unlikely to be too difficult to sort out suitable substitutes for any awkward components, but for the newcomer things are less easy. Beginners would be well advised to use the specified components wherever possible, and leave substitutions until they have gained some experience.

However, there are some substitutions that can be safely made by those of limited experience, and in this article we will look at some basic "dos" and "don'ts" when selecting alternative components. We will also consider the riddle of *"when is the right component the wrong component"*.

SWITCHES

Switches are a good example of a component where there is unlikely to be any problem if an alternative type is used. The basic types of switch (s.p.s.t., s.p.d.t., etc. – described last month) are available as toggle, miniature toggle, push-button, slider, and rotary types, amongst others.

Provided the switch you choose has the right contact arrangement and contacts of adequate ratings, the type of switch is not normally of any real importance. The exceptions are the non-locking push-button switches (i.e. types which spring back to their original position when released) which are not interchangeable with toggle types etc.

Be careful when using very small switches, as these can have quite low voltage and current ratings. Many sub-miniature switches are unsuitable for operation at the 240 volt mains supply voltage. The larger toggle types mostly have quite generous voltage and current ratings, but in terms of physical size they are massive when compared to modern miniature switches.

Before deciding to use a larger type make quite sure that there is sufficient space for it. Some of the larger toggle switches protrude a long way behind the panel on which they are mounted, and require a lot more space than you might expect.

LOUDSPEAKERS

In catalogues loudspeakers are listed by size and impedance, with the maximum power rating usually being provided as well. Provided there is sufficient space for a larger loudspeaker there is no danger in fitting one. Using a smaller type is more dubious, since the power ratings of loudspeakers are generally related to their physical size.

Miniature types are quite tough and can withstand quite severe overloads (but your ears might not be able to tolerate the severely distorted sounds). With larger types there is a definite danger of overloads causing the speaker to literally shake itself apart, or the coil could burn out!

The impedance of a loudspeaker is effectively a measure of its resistance to an a.c. signal at audio frequencies. Using a higher impedance than that specified in the components list is almost invariably perfectly safe, but the maximum output power will be reduced. For example, an amplifier that would give 500 milliwatts r.m.s. into an 8 ohm loudspeaker would give only about 50 milliwatts into an 80 ohm type.

The difference in the apparent maximum volumes would be somewhat less than these figures would suggest, due to the way in which human hearing operates and the fact that high impedance loudspeakers often have comparatively high efficiencies. Such a substitution might work quite well, but would obviously be inadvisable where optimum volume is required.

Using a low impedance loudspeaker in place of a high impedance type is definitely not a good idea. It could easily result in a massive overload. This would put the loudspeaker in danger of being severely damaged, but it would more probably be components in the circuit driving the speaker that would sustain damage first. *Never substitute a low impedance loudspeaker where a high impedance type is specified.*

Semiconductors

There is a vast range of semiconductor devices available, and in these thousands of different components there are actually many families of almost identical types. There are some clear-cut and safe substitutions, and some that are decidedly dubious.

A good example of safe substitution would be using (say) a 1N4007 rectifier in place of a 1N4002 type. The only substantial difference between the devices in the 1N4001 to 1N4007 series is the maximum reverse voltage that they can withstand. The higher the number, the higher the voltage rating.

It is perfectly safe to substitute a higher voltage type for a lower voltage device (but NOT the other way round). The higher voltage types tend to be more expensive, but you may wish to use some of these if they happen to be available in your spares box.

Also, a number of component suppliers now only offer a limited range of 1N4001 series devices, presumably with the intention that they can offer a higher numbered type if the particular device the customer requires is not stocked.

There are two basic types of small signal diodes, the silicon and germanium variety (or "geranium" diodes as hastily prepared advertising material would sometimes have it!). The 1N4148 is the standard silicon type these days. If an older type such as 1N914 or an OA200 is specified (which is quite likely if you try to build some projects that date back a few years or more), the 1N4148 should be perfectly suitable.

Similarly, an OA90 or OA91 should suffice where a difficult to obtain device such as an AA119 is specified. If a specialised type such as a variable capacitance ("varicap") diode or a Schottky diode is stipulated, do not consider trying alternatives as the chances of a successful substitution being made are very limited.

There are ranges of virtually identical devices in the transistor world, and there are numerous versions of the BC107/8/9 series. The BC109 for instance, is available as the BC169, BC239, and BC549 amongst others. The *pnp* complements of these are the BC177/8/9 series, and these are again available under a number of different type numbers (BC557/8/9 for example).

The silicon chip at the heart of these components is much the same, but the encapsulation is different. In fact the BC107/8/9 are all pretty much the same device, but the BC107 is guaranteed to operate at a higher maximum voltage, and the BC109 is guaranteed to have a low noise level. The BC108 is the so-called "bog standard" device.

I have often made substitutions such as using the BC239 for BC109, or using a BC177 in place of a BC557, and have never run into any difficulties. The only point to watch is that the different encapsulations and leadout configurations are taken into account, and that the substitute is connected correctly.

Some of the larger component catalogues are a valuable source of transistor leadout data. Using a BC109 etc., or a BC107 etc., in place of a BC108 series transistor should not give any problems, but otherwise it is advisable to avoid substitutions of this general type.

Some transistors have an "A", "B" or "C" suffix (e.g. BC169C), and this additional letter indicates the gain group of the component. "A" devices have the lowest gain – "C" types have the highest. Transistors without the suffix letter have not been gain graded, and could be in any of the gain groups.

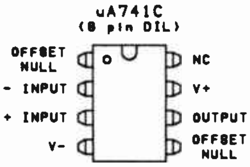
Using (say) a BC239C instead of a BC169C is not likely to give any problems. The same is not true of using a transistor having the wrong gain group, or no suffix letter where a particular gain group is called for.

Even fitting a higher gain type than that specified is not totally safe, although in most cases it will be entirely successful. Obviously there is no reason for not using a device having any suffix letter where a non-graded device is specified, and a BC109C, for instance, is perfectly satisfactory if used in place of a BC109.

INEGRATED CIRCUITS

Due to their specialised nature, integrated circuits are generally non-substitutable. The exceptions are where the same device is available under several different type numbers. Many popular devices (including the NE555P and μA741C) are manufactured by several companies, and the type numbers usually differ slightly from one manufacturer to another.

Some component retailers simply sell these devices as "555s", "741s", etc. An integrated circuit from one manufacturer should not be



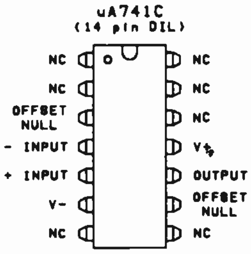
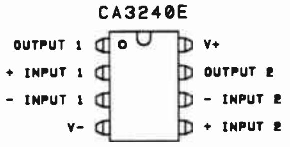


Fig. 1. Different packages but the same component. Pinout details for the 8 and 14 pin d.i.l. versions.



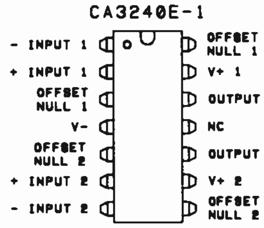
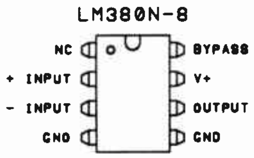


Fig 2. Pinout details for the CA3240E and CA3240E-1



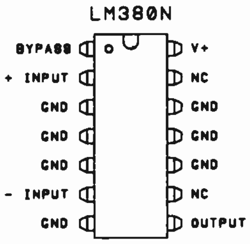


Fig. 3. The LM380N is another device which exists in both 8 and 14 pin versions.

significantly different to an exact equivalent from another manufacturer.

There are a lot of operational amplifiers that are pin-for-pin compatible with the μA741C, and these mostly offer improved performance in one or two respects. These are mostly suitable as substitutes for the μA741C, but there is little point in using them in a circuit where the humble μA741C will suffice, as they are invariably more expensive.

An exception is where an improved device is to hand but a μA741C is not. Under these circumstances I often plug in an improved device, and swap over to a μA741C as soon as I have restocked.

Fitting a μA741C in place of a higher quality type such as a CA3140E or an LF351 is not to be recommended. In some circuits the use of a high quality type does, admittedly, give what may be a barely noticeable improvement in performance.

Particularly in audio circuits, the advantages of many improved operational amplifiers have perhaps been overstated at times, and this has led to scepticism about the advantages of the more expensive operational amplifiers. In many cases though, the μA741C will not function at all if used to replace a higher quality device. This is generally the position with circuits that use the CA3130E and CA3140E.

Occasionally I receive letters along the line, "I obtained the parts in your *xyz* project, but one of the integrated circuits has too many pins!" This is not quite as ludicrous as it may at first appear. Unfortunately, some integrated circuits are available with more than one type of encapsulation.

The μA741C is one such component, and it is produced in both 8 and 14-pin d.i.l. versions, see Fig. 1. There is no problem in using the 8-pin type in place of the 14-pin variety. However, most designs assume the use of an 8-pin device, and the circuit boards may not provide sufficient space to accommodate the extra pins of the 14-pin type. It is advisable to always buy the 8-pin type (which is all most suppliers sell these days).

There were originally TO-99 metal cased versions of many operational amplifiers, but I have not encountered one of these for many years now. They can easily be wired in place of either of the other types.

Another occasional cause of problems is the CA3240E, which is the standard dual version of the CA3140E. It has an 8-pin package. Difficulties arise when constructors are supplied with the 14-pin CA3240E-1 (which is available through RS components outlets).

Unlike the two versions of the μA741C, these do have slightly different type numbers, and the pinout configurations are totally different (see Fig. 2). In theory the 8-pin types can be used in place of the 14-pin version, but not vice versa as the 8-pin device does not give access to the offset null connections.

In practice it would be very difficult to fit the CA3240E-1 into a component layout designed to suit the CA3240E. Note that these are different components, and if you order a CA3240E, that is what you should get.

The popular LM380N audio amplifier is probably the chip that gives the most problems. This has a 14-pin package in its standard form, but there is also a "shrunken" 8-pin version. Pinout details for both types are shown in Fig. 3.

This is again a case of where the two devices actually have slightly different type numbers. The 8-pin version has a "–8" suffix, and you should not be supplied with the 8-pin device if you order a plain LM380N. If you are supplied with the wrong type, you should take it up with the component retailer, not the publisher of the design.

Robert Penfold

New Book

Title: Practical Digital Electronics Handbook; Author: Mike Tooley; **Pages:** 208; **Format:** 216 × 138mm; **Illustrated:** 100 line drawings; **ISBN:** 1 870775 00 7; **Price:** £6.95.

We are pleased to bring you this new book; published in association with PC Publishing it has been reprinted and updated from the *Digital Trouble Shooting* series published in EE.

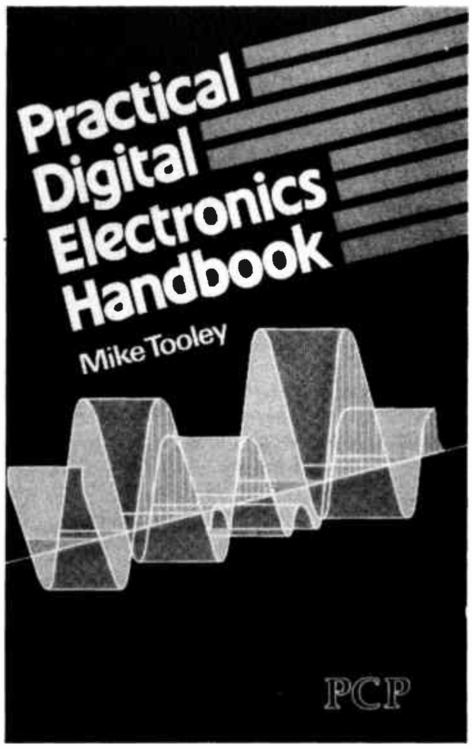
The vast majority of modern electronic systems rely heavily on the application of digital electronics, and the *Practical Digital Electronics Handbook* aims to provide readers with a practically based introduction to this subject. The book will prove invaluable to anyone involved with the design, manufacture or servicing of digital circuitry, as well as to those wishing to update their knowledge of modern digital devices and techniques.

The book introduces digital circuits, logic gates, bistables and timers, as well as microprocessors, memory and input/output devices, before looking at the RS-232C interface and the IEEE-488 and IEEE-1000 microprocessor buses.

A special feature of the book is the section on digital test gear projects, and the practical emphasis is continued with appendices on test equipment and useful reference data.

Contents:

Introduction to integrated circuits; Basic logic gates; Monostable and bistable devices; Timers; Microprocessors; Memories; Input and output devices; Interfaces; Microprocessor buses; Appendix 1: Data; Appendix 2: Digital test gear projects; Tools and test equipment, Regulated bench power supply, Logic probe, Logic pulser, Versatile pulse generator, Digital IC tester, Current tracer, Audio logic tracer, RS-232C breakout box, Versatile digital counter/frequency meter. Appendix 3 The oscilloscope; Appendix 4 Suggested reading; Appendix 5 Further study.



The book is available through the *EE Book Service* – see page 116.

FOR YOUR ENTERTAINMENT

BY BARRY FOX

Phone Chop

Here's an oddity on telephones.

More and more of Britain's new telephone exchanges are digital, for instance BT's *System X*. The analogue speech signal from a telephone spreads over the frequency range of 300Hz-3.4kHz. It is converted into digital code in two steps.

First the waveform is sampled at 8kHz, equivalent to chopping up the waveform 8,000 times a second. This figure is chosen because the sampling frequency must be twice the highest analogue frequency to be encoded.

Each of the 8,000 samples a second is now described in 8-bit code, which gives a range of 256 levels (2^8). Simple arithmetic ($8{,}000 \times 8$) says that a data stream of 64 kilobits per second (or 8 kilobytes a second) is needed to convey the original analogue speech signal without loss of quality.

Sometimes on digital exchanges you will hear an odd audio effect, with the sound chopped and clicks in the background. It's as if the sampling rate has been drastically reduced. This is bad enough for speech, but it plays havoc with electronic mail, facsimile or data transmission.

In London, the 404 exchange suffered badly but BT says the problem was cured. Now the 405 exchange has been suffering.

What happens is this. The local London exchanges, for instance 405 at Holborn, are all slaved to the main *Mermaid* exchange at Baynard House. Each exchange has its own clock which controls the digital sampling, and all these clocks are slaved to a master clock at Mermaid. If for some reason the master clock crashes, then the local exchange clocks free-wheel.

So the master and local exchanges lose synchronisation. They are still sampling speech at the standard 8kHz, but they are out of step. So when the signal from one exchange is routed through another the result is chops and clicks.

BT says engineers are working on the problem. If you hear it, you should try telling a supervisor or engineer, logging the numbers affected and the time of the call. Of course, finding a supervisor or engineer who is interested enough to make a note is difficult, but that's another story for another day. I've just dialled Directory Enquiries eight times and got engaged tone each time . . .

Tongue Tied

As regular readers will know I have always seen computers – whether desk top, portable or pocket – as a tool, not a plaything. I never wanted to be a computer buff any more than I wanted to be a typewriter buff, a pen and pencil hobbyist or a Tipp-ex expert. I would rather spend time learning a foreign tongue, than computing language.

But the whole, crazy computer industry has decided differently. If you want to get the most from a system you need to do some quite hard work. Starting from scratch, it can take a long time to get the simple answer to a stone wall problem. Often someone else somewhere, has done the same work before you. It makes sense to pool knowledge.

When reviewing the Psion Organiser as a business tool, it seemed to me that the beast would be very useful as a pocket store for a database assembled in a desk top PC running the Xchange/PC-Four/Archive program. Getting the data from the desk top to the Organiser is one problem, now neatly solved by the latest Comms Link. But you still need to structure the data coming from Archive so that it sits neatly in the Organiser, without a welter of the punctuation marks used by Archive to separate the different "fields" in each file record.

Starting from scratch, and after a lot of hard work – despite help from Psion – I ended up with a program which runs in Archive to export data in neat and tidy fashion for import into the Organiser. Doubtless it would have taken a real buff all of five minutes to do what took me ages. But this is intended to help real live business users, not computer hobbyists.

Procedure

What you must do, is create a "procedure" in Archive; the Archive manual explains how to do this quite clearly. Sorry, there are no short cuts here – unless you have a friend who has already played around with procedures.

Everyone will have a different database layout, but the fields will always be represented by a string of identifying names like country$, continent$, capital$; or author$, title$, subject$; or, more simply, a$, b$, c$ and so on, depending on how many fields the database is using.

The following procedure assumes that there are nine fields, a$ to i$. It also assumes that the existing database file is called "file.dbf" and that it will be exported to the A drive of the computer as a new file "filexp.lis". The "trace" commands ensure that the screen gives a telltale of what is going on.

When loaded and run this procedure will first of all put all the entries into alphabetical order, depending on the content of the first field (a$) and then compile them neatly as a plain text database which can be loaded into the Organiser via the Comms Link.

Then, using the "find" command in the Organiser, you have a pocket version of the PC database. Alter the procedure to suit number and names of your fields, and which one you want to govern the alphabetical ordering.

```
proc filexp
  REM orders and compiles all
  "file.dbf" records as "a:filexp.lis"
  trace
  order a$;a
  spoolon "filexp"
  first
  all
    lprint a$;" ";b$;" ";c$;" ";d$;
    " ";e$;" ";f$;" ";g$;" ";h$;" ";i$
    endall
  lprint chr(26)
  spooloff
  trace
  endproc
```

Granted

Recently I was involved in a seminar with the rather grand title *Science, Technology and Cultural Power*.

On the panel was a lady with several chips on her shoulder, who had written a chapter in a book about women in television. She was also on committees for the EEC which spend their time debating the role of television in Europe.

Needless to say, she thought women had a raw deal in television. She also thought women had a raw deal in computers – because computers and software are aimed at men rather than women.

Then there was a chap who had advised the GLC on leisure and was now on another committee I had never heard of.

Finally, there was a lecturer from a university who was spending six years researching the place of computers in the home. He too reckoned that computers suffered from "genderization" but found his research made difficult because there are different types of computers. I reckoned his work could be well done in six months or less, rather than six years.

I have to say that it was probably one of the most boring evenings of my life. And it seemed to appal my fellow panel members, that as far as I am concerned I will work for anyone, whether they are male, female, transvestite, black, white, khaki or green with blue spots – provided that they are competent and command respect.

On many publications my copy is edited by women. I have never heard any of them complain that computers were designed for men only.

Yes, it takes time and effort to learn how to use new electronic technology. There is a straight choice; either give up, take early retirement and rot, or devote some time and effort to learning new technology skills.

No one expects learning a foreign language to be easy; no one expects to be born with the ability to touch type. So why should using information technology be any different? – Poorly designed equipment is harder to use, but that is another story.

What fascinated me, was that I was the only one on the panel who wasn't on some kind of grant. Governments give grants to perpetuate bureaucracies; large companies give grants to cut their tax bill or appear human and concerned; councils grant money through the political old boy net.

Winning grants has become a full-time job. The snag is that the real talent of people who get grants, is getting grants. The people who really know their subject are too busy at the sharp end to learn the rules of the grant game.

Constructional Project

ONE VALVE RADIO

P. E. ROBERTS

1968 or 1988? Build this valve radio and get the feel of a traditional receiver that might have been built two decades ago.

EVER FELT like a change from anonymous plastic packages and printed circuit boards? Imagine that the year on the front of this magazine is 1968 rather than 1988. ICs were only just out of the laboratory and transistors still a bit on the dear side. Valves ruled the roost and, even nowadays, are very far from being dead and buried.

The project to be described is a one valve shortwave receiver built in the traditional way on a metal chassis with wired connections. This method of construction doesn't really involve any more work than making up a printed circuit board and then having to prepare a case to fit it in.

At the high frequencies involved absolute rigidity of the tuning capacitor and coil is vital for best performance and a rigid metal chassis is far better than a p.c.b. in this respect. Wired construction also allows easy modification and experimentation, something which is lacking from many modern designs. Whilst this little circuit works well as it stands, there is plenty of scope for experimenting with different component values, particularly as valves are far more tolerant of accidental abuse than transistors.

Despite being an old design, all the parts needed for this project are available new, including the valve and special coil. In fact a well stocked spares box could well come up with most of the parts needed.

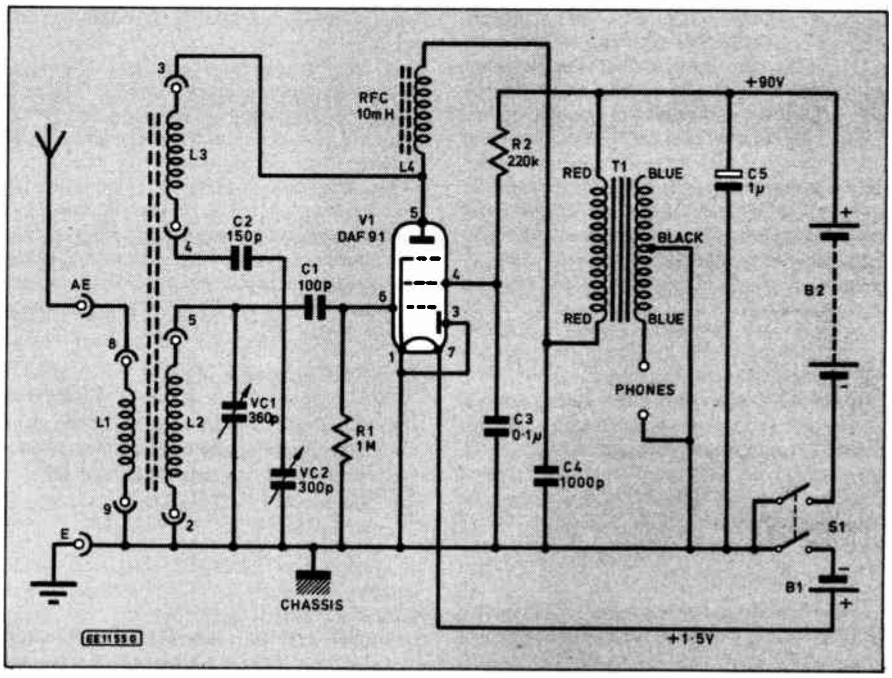


Fig. 1. Circuit diagram of the One Valve Receiver

CIRCUIT DESCRIPTION

The circuit is designed around a DAF91 valve (or 1S5 in American nomenclature). This comprises a pentode and diode in one envelope, with a 1.5V filament designed for battery operation. We don't use the diode part in this project and it's simply connected to ground.

The circuit glorifies in the name of a *"regenerative grid leak detector"* in which the valve carries out two tasks: detection and amplification. Let's split these functions up and consider detection first.

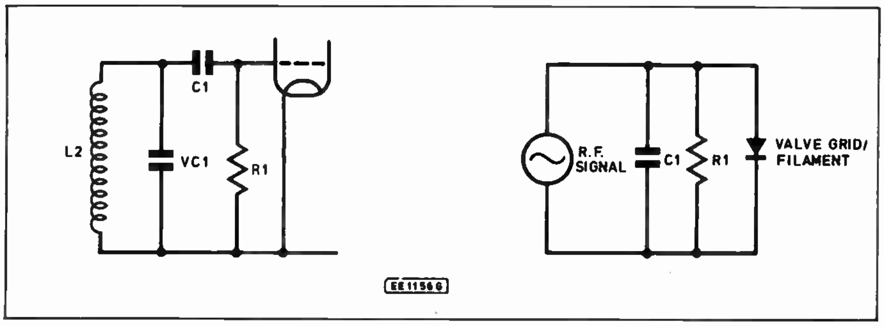
Whilst Fig. 1 details the complete circuit diagram for the One Valve SW Radio, Fig. 2 covers the grid circuit on its own. The first grid is the valve's input electrode and is known as the control grid. Physically it is a spiral of very fine wire mounted very close to the filament and as such can be used as a diode.

When the grid is taken a little positive, with respect to the filament, electrons will flow from the filament to the grid but when the polarity is reversed, i.e. with the grid now negative, no flow will take place. This diode action will take place at even very small applied voltages unlike solid state diodes which need at least 0.3 of a volt for germanium and as much as 0.7 volts in the case of silicon devices to start conduction. Bear in mind that you're trying to detect signals that may only be a few millivolts in strength.

The r.f. signal from the aerial is coupled by the coil L1 into the tuned circuit L2/VC1. It then passes to the control grid via the grid capacitor C1. The diode action within the valve causes pulses of rectified r.f. to charge capacitor C1 in such a way that the grid is driven negative.

Any diode detector circuit needs a load, and this one is no exception. The grid leak resistor R1 does the job and its value of one megohm together with the 100pF of the grid capacitor

Fig. 2. Actual grid and equivalent circuit for r.f.



COIL RECEPTION RANGE

Range 1.	Long Wave — 150kHz-400kHz
Range 2.	Medium Wave — 515kHz-1.54MHz
Range 3.	Trawler and Top Band — 1.67MHz-5.3MHz
Range 4.	Short Wave — 5.0MHz-15MHz
Range 5.	Short Wave — 10.5MHz-31.5MHz

Coil Ranges with 315pF tuning capacitor

Range 4 is strongly recommended as a starter as it covers the very popular 7MHz broadcast band.

gives a time constant which is short enough to follow the audio frequency (a.f.) modulation on the r.f. signal. Should capacitor C1 be too large in value the reproduction could become badly muffled.

COMPONENTS

Shop Talk
See page 105

Resistors

R1	1M
R2	220k

Both 0.25W carbon film

Capacitors

C1	100p silver mica
C2	1500p silver mica
C3	0µ1 polyester 250V
C4	1000p high voltage ceramic
C5	1µ elec. 100V
VC1	360p Jackson type "O" variable, single gang
VC2	300p Jackson "Dilecon" variable

Valve

V1	DAF91 or 1S5 Pentode/diode

Inductors

L1, L2, L3	Maxi Q tuning coil (Denco GREEN plus range)
L4	10mH r.f. choke
T1	250V/3V-0-3V 100mA miniature mains transformer (see text)

Miscellaneous

Aluminium chassis; 5-way tag strip; B7G valveholder; B9A valveholder; S1 d.p.s.t. toggle switch; JK1 3.5mm stereo jack socket; 10:1 reduction drive; SK1, SK2 and PL1, PL2 4mm red, green plugs and sockets (2 off each); pointer knob; ⅜in. rubber grommets (2 off); HP2 battery and holder; PP3 battery connector; PP3 batteries (10 off); solid core hook-up wire; 6BA solder tags (3 off); 4BA × ¼in. screws (10 off); 4BA washers (10 off); 4BA full nuts (9 off); 6BA full nuts (4 off); 6BA × ¼in. screws (4 off); 6BA washer (4 off); insulated wire for the aerial (see text).

Approx. cost Guidance only **£25** *plus batteries*

The detected audio is now amplified by the valve and appears at the anode. The audio passes through the r.f. choke and is developed across the primary of the output transformer T1.

The valve requires an anode load of several kilohms. Whilst special high impedance headphones are available, they tend to be difficult to obtain as well as expensive. The transformer T1 allows the use of ordinary 32ohm personal stereo headphones. Should you be lucky enough to have a pair of high impedance headphones then these can be wired in place of the transformer.

The transformer itself is a miniature mains transformer with a 3V-0-3V 100mA secondary. The 240V winding is used as the primary and the headphones are wired across one half of the secondary winding. Any residual r.f. which manages to sneak past the choke is safely shunted to ground by capacitor C4.

TUNED CIRCUITS

On its own the circuit would only deliver an audible signal in the headphones when receiving a strong signal. In addition, as only a single tuned circuit is used, selectivity would be very poor, which means that several strong signals could very well be heard at once.

If you'll bear with me for a bit I'll now digress a little and give a potted lecture on tuned circuits!

You've probably all heard about the squad of soldiers who brought a bridge down by marching at just what happened to be the mechanical resonant frequency of the structure. The small shocks from the soldiers' feet eventually built up a sympathetic vibration in the bridge sufficient to physically wreck it. The same happens in our tuned circuit – without wrecking it, though!

When the circuit is tuned to an incoming carrier, the very small r.f. signal is effectively amplified by an amount depending on the *"magnification factor"* or *Q*. The Q also determines the selectivity, or ability to reject adjacent unwanted stations. The higher the Q the better the sensitivity and selectivity.

A tuned circuit's Q is affected by the quality of the components used and its loading. The specified coil uses materials designed for the best possible performance. Its associated tuning capacitor must be of comparable quality which for shortwave purposes means an air spaced job such as the specified Jackson type "O".

Whilst the tuning capacitor is one of the most costly parts used in this project the entire performance of any shortwave set, valve or transistor, ultimately depends on this component and the coil.

Loading is determined by the input impedance of the stage following the tuned circuit. A low impedance absorbs power from the tuned circuit causing damping and lowering the Q. One advantage of valve circuits is the extremely high input impedance which results in very little damping.

REGENERATION

However, as mentioned previously, even using the best possible components we've still got to raise the Q of the tuned circuit somehow. This is where the extra components coil L3, variable capacitor VC2 and capacitor C2 come in.

The audio signal at the valve's anode carries with it a fair bit of left over r.f. ripple which is prevented from going any further by the r.f. choke. Now, what happens if we feed some of this "waste" r.f. back into the tuned circuit in such a way that it reinforces the incoming signal? What we then have, of course, is *positive feedback* and if excessive this will cause oscillation.

Should the amount of feedback, or *"regeneration"* be adjusted to just below the point of oscillation the tuned circuit's Q is considerably improved to the point where even weak stations can be heard. The amount of feedback is controlled by the setting of VC2 which is still usually known by its old fashioned name, *"Reaction"*.

When operating at maximum sensitivity tuning becomes extremely critical. This may be no problem should you have the touch of a brain surgeon but if you've got "two left hands" then a reduction drive is needed. The one used here has a reduction of 10:1.

This drive is fitted with a 0 to 100 scale together with a vernier scale for reading to one tenth of a division. The specified Tuning capacitor has a linear capacity to wavelength relationship which, together with the info. supplied with the coils, should allow easy correlation between the logging scale and actual wavelength.

The Reaction tuning capacitor, VC2, does not need any form of reduction drive as its adjustment is not as critical. In addition, being a solid dielectric device, its operation is considerably stiffer when compared to an airspaced item. As long as you fit a fairly large knob, adjustment should be a piece of cake after a bit of practice.

As the coils are designed to be used with a 100pF reaction capacitor which don't seem to be readily available, capacitor C2 is wired in series with 300pF Dilecon type to reduce the effective maximum to around 100pF. If you can get hold of a 100pF variable then C2 can be omitted.

Well, that's covered most of the circuit except for R2, C3 and C5. Resistor R2 feeds the valve's screen grid and, again, without delving too deeply into valve theory, the screen grid voltage determines the anode current and gain.

With a value of 220k for R2 the total current drawn is around 1mA. There's nothing wrong with experimenting with other values for R2. The screen grid should be held at a constant voltage and capacitor C3 serves to decouple any noise or spurious signals present to ground.

The third grid in a pentode valve is called the suppressor grid, and prevents something called "secondary emission". The suppressor is usually connected to ground and in this case is internally connected inside the valve.

The final component, C5, is an electrolytic capacitor of between 1 to 10 microfarads. Its job is to ensure stability as the HT battery ages. Its working voltage must be at least 100V. Make sure that you wire it the right way round, as at this sort of voltage incorrect connection will result in a loud bang! All the other capacitors in the circuit should also be rated at least 100V. In practice this means 250 volt working.

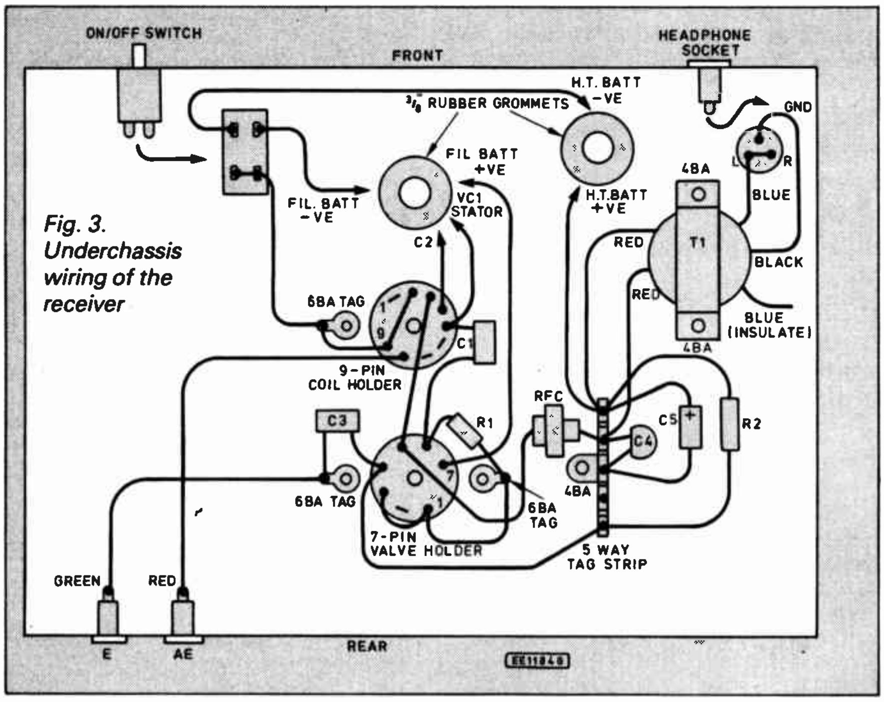


Fig. 3. Underchassis wiring of the receiver

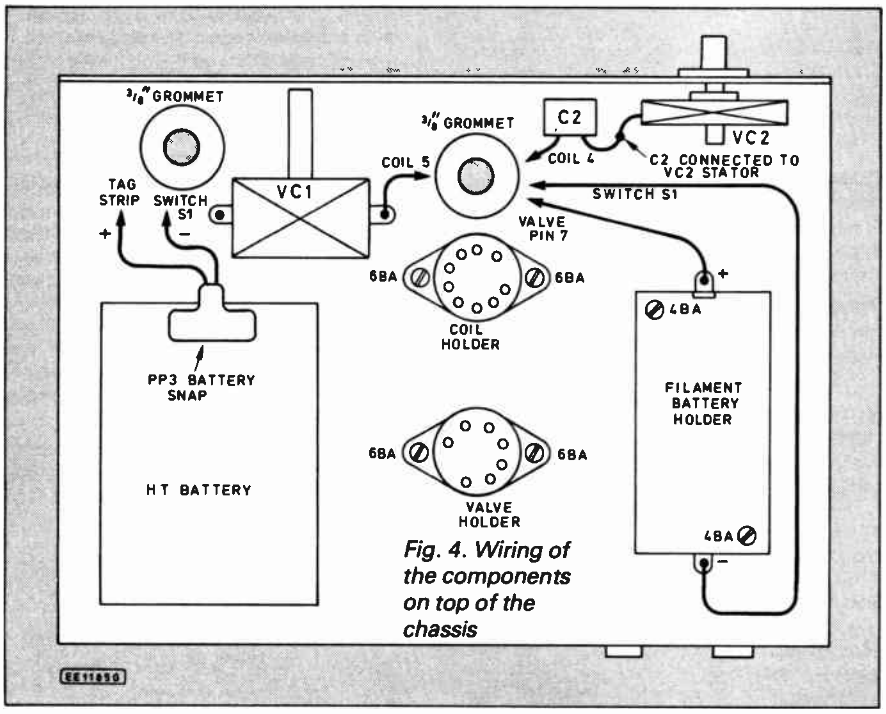
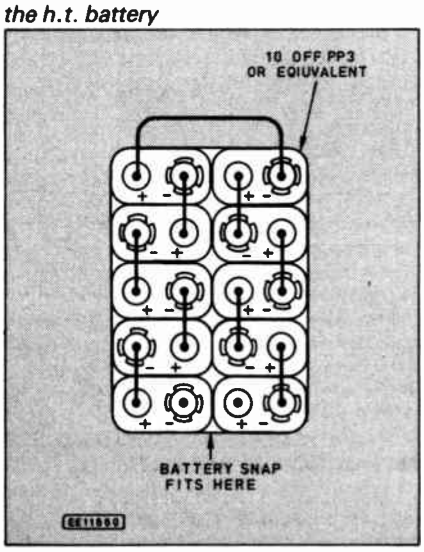
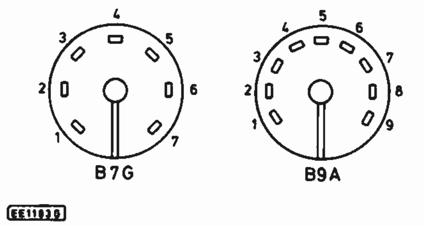


Fig. 4. Wiring of the components on top of the chassis

Fig. 5. Construction of the h.t. battery





Pin 1. Filament	Pin 1. Not used
Pin 2. Not used	Pin 2. L2 Earth
Pin 3. Diode	Pin 3. Reaction, anode
Pin 4. Screen Grid	Pin 4. Reaction, earth via capacitor
Pin 5. Anode	Pin 5. Grid
Pin 6. Control Grid	Pin 6. Not used
Pin 7. Filament	Pin 7. Not used
	Pin 8. Aerial
	Pin 9. Earth

Valve and coilholder connections are numbered reading clockwise looking at the underneath of the socket

CONSTRUCTION

Construction should be fairly straightforward. Instead of having to make a p.c.b. all that is needed is to drill or punch the aluminium chassis as detailed in Figs. 3 and 4. There's nothing to stop you using a different chassis as long as you adjust the measurements to suit.

Keep the valve, coil and both variable capacitors as near to each other as possible. The baseplate supplied with the prototype chassis was used as a front panel.

After preparing the chassis and front panel, bolt the front panel in place using four 4BA nuts and bolts. Fit the Aerial and Earth sockets in the rear of the chassis, the tuning capacitor, valve and coil holders, rubber grommets and filament battery holder to the top, and the tagstrip and output transformer to the underneath of the chassis, see Figs. 3, 4.

Take care when mounting the tuning capacitor that the fixing screw does not foul the vanes. Mount the reaction capacitor, headphone socket and switch to the front panel. There's no need to fit the Vernier drive and reaction control knob yet.

WIRING-UP

Wire all components as shown in the wiring layout, Figs. 3 and 4. Cross check with the circuit diagram whilst wiring up and take particular care when wiring the valve and coil holders. The tags won't take too much bending and easily break. The numbering of the tags is clockwise looking from the underneath.

Capacitor C2 is mounted on VC2's stator tag, which, if fitted as shown, is the upper of the two tags. The lower earth terminal is not used as the capacitor's rotor is earthed to the chassis via its mounting bush.

Keep all leads carrying r.f. signals as short as possible. This means all connections between the valve and coil holders, tuning and reaction capacitors.

All wiring after the r.f. choke is only carrying audio signals so it is not so critical. Make sure, when wiring the valve filament and HT supplies, that there is no chance of the 90V supply finding its way into the filament supply as this would result in instant destruction of the valve.

Now fit the Vernier drive to the Tuning capacitor and the pointer knob to the Reaction capacitor. Before tightening the set screw, ensure that with the vanes fully meshed the drive is set to read 100. The reaction knob should be set to point to the 5 o'clock position with the reaction capacitor vanes fully meshed. After doing this the set is ready for use.

If you haven't already done so, now is the time to make up the HT battery as shown in Fig. 5. Take care when soldering the link wires not to overheat the terminals and soften the plastic tops.

The batteries should be held together with strong parcel tape. Bear in mind that with all links in place 90V is present across the output terminals which, whilst not lethal, can still give a nasty bite, particularly with sweaty hands!

TESTING

Plug the valve, coil and headphones in and fit the 1.5V filament battery. Switch on and check that the valve filament is glowing bright orange. Switch off and connect the HT battery, Aerial and Earth.

Switch on again and lightly tap the valve with your fingernail. A faint ringing sound should be heard, although some valves are less microphonic than others.

With the Reaction capacitor half meshed, tune back and forth across the band. A fairly loud whistling indicates a signal and the reaction should now be carefully reduced until the signal is audible.

The optimum position of the Reaction control varies with the tuning so both controls have to be operated together. As I said earlier, this set has to be "driven" for best results.

RECEPTION

Whether using a simple circuit such as this or the most sophisticated communications receiver, a good Aerial and Earth are essential. The aerial should comprise around 30 feet of insulated wire slung between the house and a tree or clothes post.

The earth connection should be as short as possible and in older houses may be taken to the incoming water main. In new houses the plumbing is most likely plastic, in which case you should use an earthing spike; a stout metal spike driven deep into damp ground. These should be available from electrical contractors.

The earth pin in the 13-amp mains socket is NOT suitable as not only may there be a shock hazard under certain circumstances, but the mains earth is electrically very noisy. **NEVER UNDER ANY CIRCUMSTANCES USE A GAS MAIN AS AN EARTH.**

Using a long wire aerial and a spike earth Radios Moscow, Israel and Tirania (Albania) were received within five minutes of switching on. These came in on the very active 7MHz band and the Range 4 coil (5.6MHz to 15MHz) which covers this band, is recommended as the first coil to buy.

The coils specified are Denco Maxi Q miniature dual purpose type GREEN. Unlike the more familiar blue types these coils have the third reaction winding. These coils are available direct from the makers, see Shoptalk. For the really keen, blank coil formers and cores are also available for you to experiment with making your own coils.

As a matter of interest, should anyone have one of the old Codar valve or transistor receivers and no coils, then the coils specified for this project are exact replacements.

Finally, a word about headphones. Personal stereo headphones seem to come in widely differing sensitivities. Always use the most sensitive that you can get, bearing in mind that the more expensive does not necessarily mean the better in this respect.

HEADPHONES

Of all the headphones tried, the special waterproof ones supplied with the Sony Sports Walkman were not only very sensitive but gave excellent sound quality. These should be available from a Sony dealer.

With the headphone socket wired as shown the headphones are driven in parallel and in phase, which will result in a "normal" sound image appearing somewhere above your nose. Don't forget, there's plenty of scope for experimenting, and battery life should be at least 100 hours. Happy listening! □

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WANTED: Tech specs, pcb layout, circuit diagrams for Amstrad CBs HCB-1 for repair. Expenses refunded. Joseph Fox, 25 McDonnell Street, Belfast BT12 4JY.

WANTED: Cassette deck and printer for VIC 20. Must be cheap. Mr D. Harries, 17 Eccleshall Avenue, Oxley, Wolverhampton WV10 6TN.

NASCOM manuals wanted for ZEAP, original memory board and keyboard. Will pay for photocopying. Peter Simpson, 22 Queen Victoria Road, Totley Rise, Sheffield S17 4HT.

FOR SALE: PCBs and all sorts of electronic components. Send sae for list. Mr J. Norman, 25 Milton Rd., Corby, Northants NN17 2NY.

WANTED: Satellite Monthly magazines back numbers, equipment, clubs or anything connected with this subject. Thank you. Mr R. Mackay, Brochrobbie, Brora, Sutherland, Scotland KW9 6NE. Tel: (0408) 21870

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COMPLETE Commodore 64 system. Everthing! Diskdrive, printer, etc. Great condition. £300 ono. Literature and manuals included. U. Lunn, 1 Rydal Ave., Formby, Lancs. L37 2UD. Tel: Formby 73712.

WANTED: Crystal for 19.995MHz for JR 310 trio or scrap set for spares. Please help. S.H. Harmer, 9 Park Square East, Jaywick, Essex CO15 2NL.

CONSTRUCTED Maplin Burglar Alarm LW57M plus Break Contact Module Panic Button. Checked by Maplin. £45. Ring Melbourne, Derbys. (03316) 2378.

WANTED URGENTLY: Circuit diagram for an old Brenell MK5 mono tape recorder. Chris Phillips, 170 Ives Road, Norwich NR6 6DL or Tel: (0603) 787638.

WANTED: Opus Discovery, RAM Electronic Music, Disciple or anything educational for Spectrum 48K. Cash or otherwise. Ivan Comiskey, 33D Nth, Gt. Clarence St., Flats, Dublin 1, Ireland.

NOTTINGHAM: Unemployed computer users meet every Wednesday. Tel: 413881, ask for Brian.

30A fully protected 13.8V power supply £55. Audio oscillator 20-30K £10. FRG 8800 £400. Tel: (0375) 378783.

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TRANSFORMER 240V primary, 24V 40A. Two only. Buyer collects. £18 each. Tel: Sheffield 372672.

WANTED: Books, magazines, to help me learn more about basic electronics and loudspeaker and audio systems. Steve Graham (J91917), H.M.P. Wormwood Scrubs, PO Box 757, Ducane Road, London W12 0AE.

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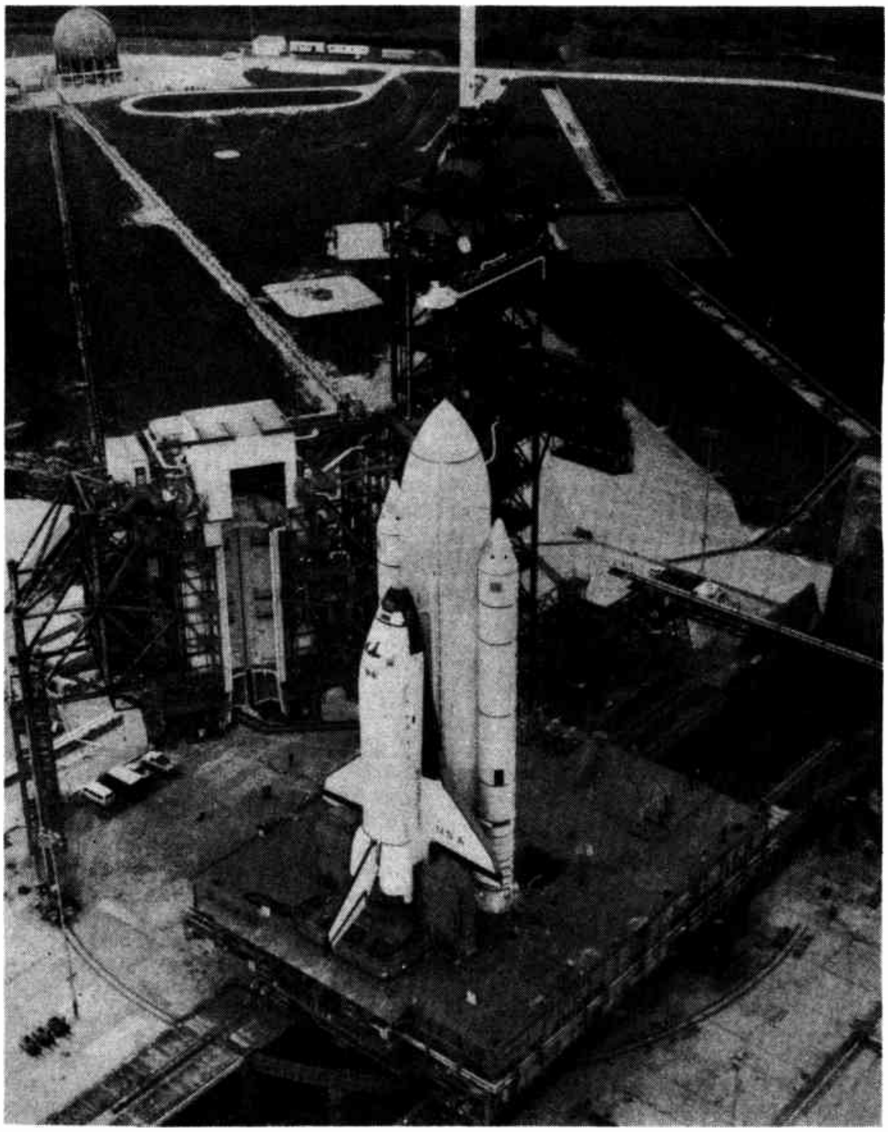
LONDON TO SYDNEY

IN THREE HOURS

IAN GRAHAM

Concorde made transatlantic day trips possible. Will the next generation of spaceplanes make the 11,000 mile journey from Sydney to London a day's return hop?

THE FIRST flight between Britain and Australia in 1919 took almost a month. Captain Ross Smith and his brother, Lt. Keith Smith, who made the historic flight, could scarcely have imagined that their journey time might be slashed to only three hours by the end of the century. But that is exactly what aerospace designers in Britain and America are suggesting.



Columbia prepares for its first flight in April 1981. Say "space shuttle" to anyone and it probably conjures up a mental image of this arrangement of Orbiter, external fuel tank and two solid rocket boosters. Photo: NASA.

The Challenger space shuttle disaster had far-reaching effects on the space industry world-wide. Following the accident, the three remaining orbiters (Columbia, Discovery and Atlantis) were grounded for at least two years while the cause of the accident was determined and the necessary re-design and development work carried out to improve shuttle safety. This hiatus in shuttle flights released funds that were previously committed to shuttle-based projects. The unexpected availability of extra funding allied to the dramatic reduction in launch capacity and consequent disruption of international space programmes led several nations to increase their efforts to develop their own independent space transportation systems.

We have all become accustomed to the hardware configuration adopted by NASA — a manned orbiter launched with the aid of an external fuel tank and two solid rocket boosters. That arrangement has become synonymous with "space shuttle" to most of us. However, it is far from satisfactory and certainly not the only hardware configuration. It was a compromise between low development costs and low operating costs. Earlier, more ambitious designs proposed in the 1960s would have cost much more to develop, but would have been far less expensive to operate. After initial enthusiasm, they were dropped because of budgetary restrictions or disagreements between the developers.

NEXT SHUTTLE

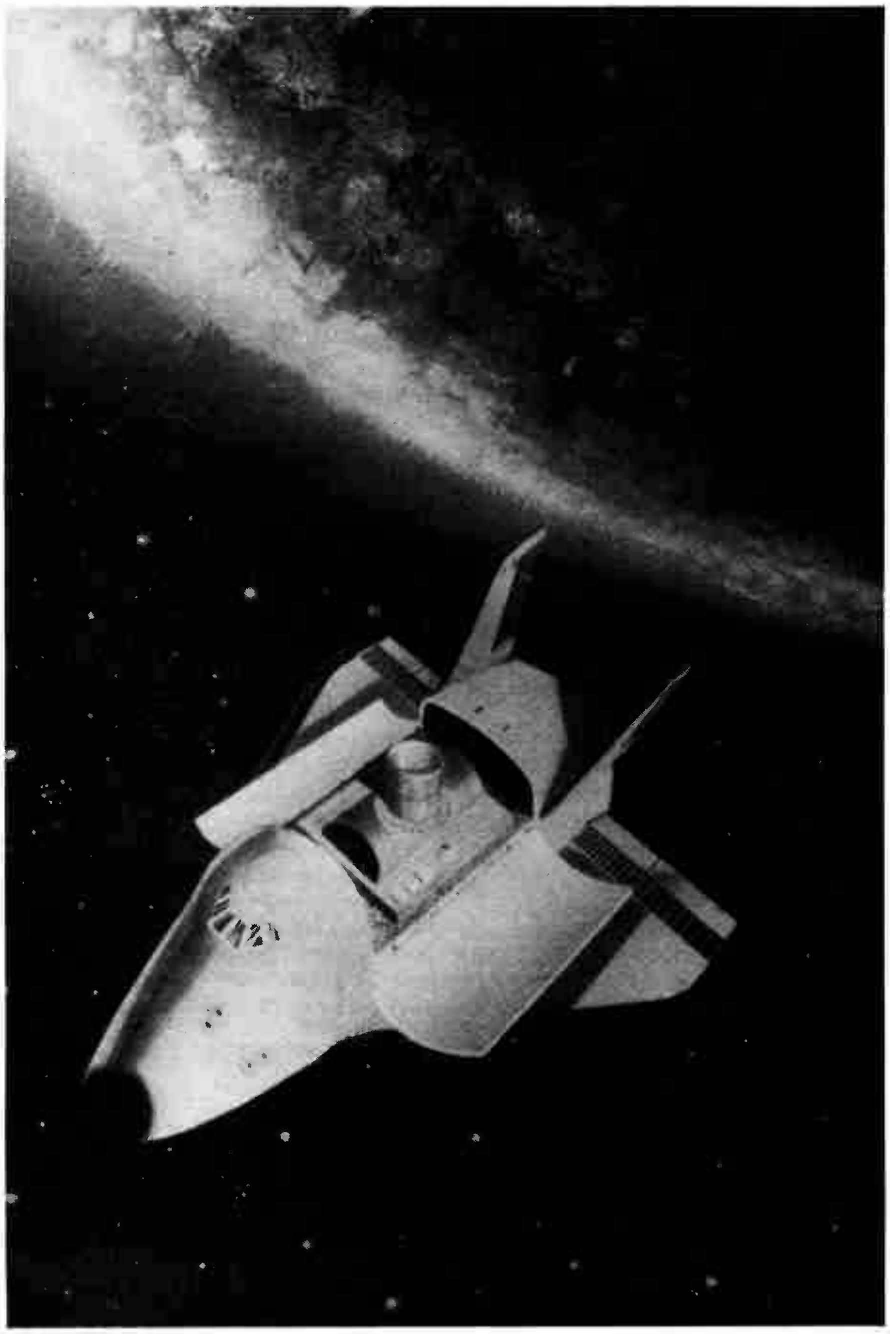
Research teams working on shuttle designs in several countries now acknowledge that the next space shuttle will have to be cheaper, easier and more convenient to operate. That is, it must be fully reusable (no "throw away" fuel tanks or rockets), be capable of using virtually standard airport facilities and not require months to prepare for each flight as NASA's shuttle does.

Two design proposals have come to the fore in Europe, offering different solutions to the problem. The European Space Agency has been developing more powerful versions of the successful Ariane rocket to launch heavier satellites. In 1976, the French national space agency, CNES (Centre Nationale d'Etudes Spatiales), proposed the development of a small manned space shuttle to be launched on the nose of the next and most powerful model, Ariane 5.

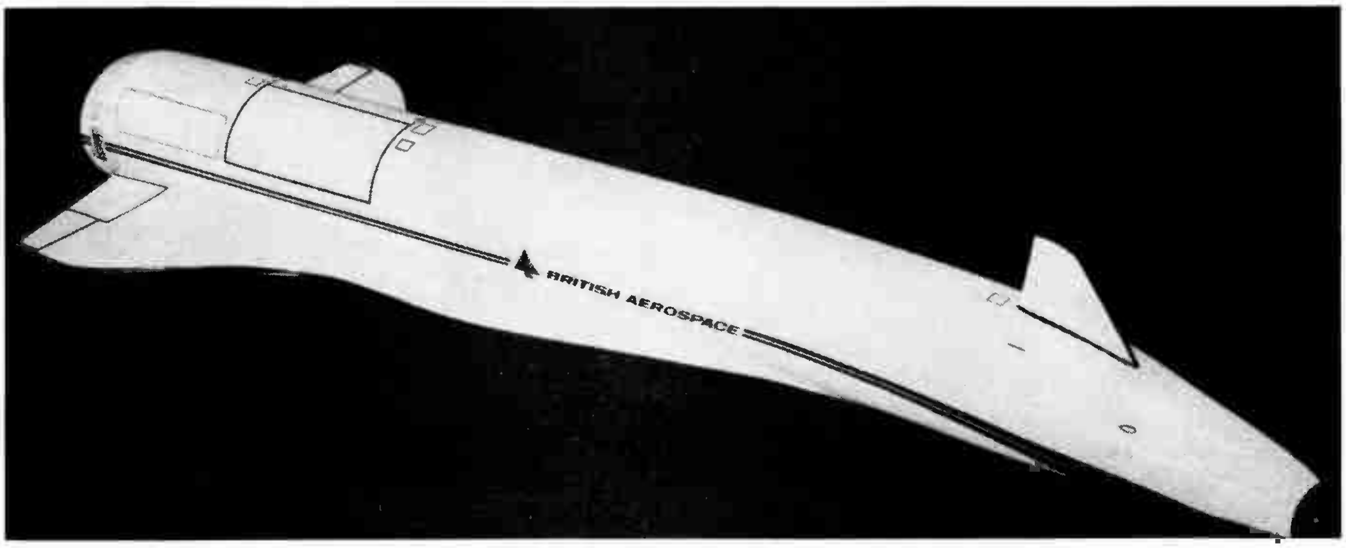
An artist's impression of the vehicle depicts it as a small scale version of the American space shuttle. It's smaller, because the French have opted for a much smaller pressurised payload bay. Large payloads would still have to be launched by Ariane rockets. The project, known as Hermes, was adopted by the European Space Agency at the end of 1986 — that is, although the project was instigated by the French, it has now been taken up by ESA as a Europe-wide project, attracting funding and technology input from many of the Agency's participating countries. Nevertheless, Hermes has been criticised as little more than a cut-down NASA shuttle with more up-to-date computers and avionics — old technology that cannot compete commercially with the next generation of spaceplanes.

HOTOL AND NASP

British Aerospace believes that the more advanced technology of its HOTOL launcher is much more economically competitive with the spaceplane that will be developed in America in the near future — the National Aerospace Plane (NASP), also known as "Orient Express". Britain's HOTOL (Horizontal Take-Off and Landing) is a fully reusable vehicle. Intended initially as an unmanned satellite launcher, it could also be converted for passenger travel. The payload bay would simply be replaced by a pressurised passenger cabin. By skipping out of the atmosphere and dropping back in again shortly before landing, a spaceplane could cut the Sydney to London travel time (excluding immigration and baggage reclaim) to around three hours (by HOTOL) or Washington to Tokyo in two hours (by



An artist's impression of the French space shuttle, Hermes, now a European Space Agency project. Hermes' design clearly owes a great deal to NASA's shuttle, although it is launched rather differently — on top of an Ariane 5 rocket. Photo: CNES.



HOTOL — an unmanned, fully reusable launch vehicle. Launch weight is kept to a minimum by using a combination of air-breathing and rocket propulsion. Photo: British Aerospace.

Orient Express); making a day trip around the world a real possibility.

HOTOL's revolutionary feature is its propulsion system. To keep the vehicle's take-off weight to a minimum, its engines use oxygen from the atmosphere as a propellant. Of course, at high altitudes there is not enough oxygen in the air to fuel the engines. At this point, the engines switch to an on-board oxygen supply, which also fuels the engines outside the atmosphere.

The centrally mounted payload bay is of shuttle dimensions (much larger than Hermes), sitting between the forward hydrogen tank and rear oxygen tank. This arrangement has the advantage of producing the minimum shift in centre of gravity during a flight. As HOTOL's weight on landing is only one fifth that at take-off, it doesn't make sense to carry a heavy undercarriage built to withstand the stresses of take-off all the way to orbit and back. So, HOTOL will take off from a separate trolley or sled and will land on its own lightweight retractable undercarriage.

COST

It is estimated that HOTOL will cost around £4 billion to develop. It is unlikely that a British government will approve funding of that level and so HOTOL is unlikely to be built unless some international collaboration can be arranged. Ideally, British Aerospace would like HOTOL to be taken up by ESA in the same way as Hermes. A proof-of-concept study is under way and both British Aerospace and Rolls-Royce hope that it will lead to "Europeanisation" of the project. Paradoxically, Britain is also committed to contributing to Hermes, possibly because it is questionable whether ESA will see any benefit in supporting *two* spaceplane projects. If HOTOL is not taken up by ESA, involvement in Hermes could be Britain's only remaining opportunity to gain invaluable experience of spaceplane technology outside the USA.

If current forecasts are accurate, Hermes is expected to fly by 1996-7, whereas the more advanced technology required to be developed for HOTOL means that it is not expected to enter service until 2005 at the earliest.

NASA and the Pentagon are expected to boost their current expenditure of almost $US50 million per year on spaceplane research to several hundred million US dollars a year for NASP. They estimate that it will cost around $US2 billion to build a single prototype. By the time that NASP enters service, it will have cost a great deal more than HOTOL. One reason for this is that HOTOL's designers will avoid using expensive shuttle-style thermal protection by limiting its speed to Mach 5 (five times the speed of sound) inside the atmosphere. NASP will be capable of flying at Mach 25 (orbital velocity) inside the atmosphere.

Whilst HOTOL's role has been clearly defined as that of a satellite launcher, with the possibility of passenger operations at a later date, NASP's role has yet to be specified. Its military applications are not difficult to speculate on — a lifting vehicle for SDI (Strategic Defence Initiative, or "Star Wars") hardware, a quick reaction reconnaissance platform, etc. But its civilian role has not yet been quantified.

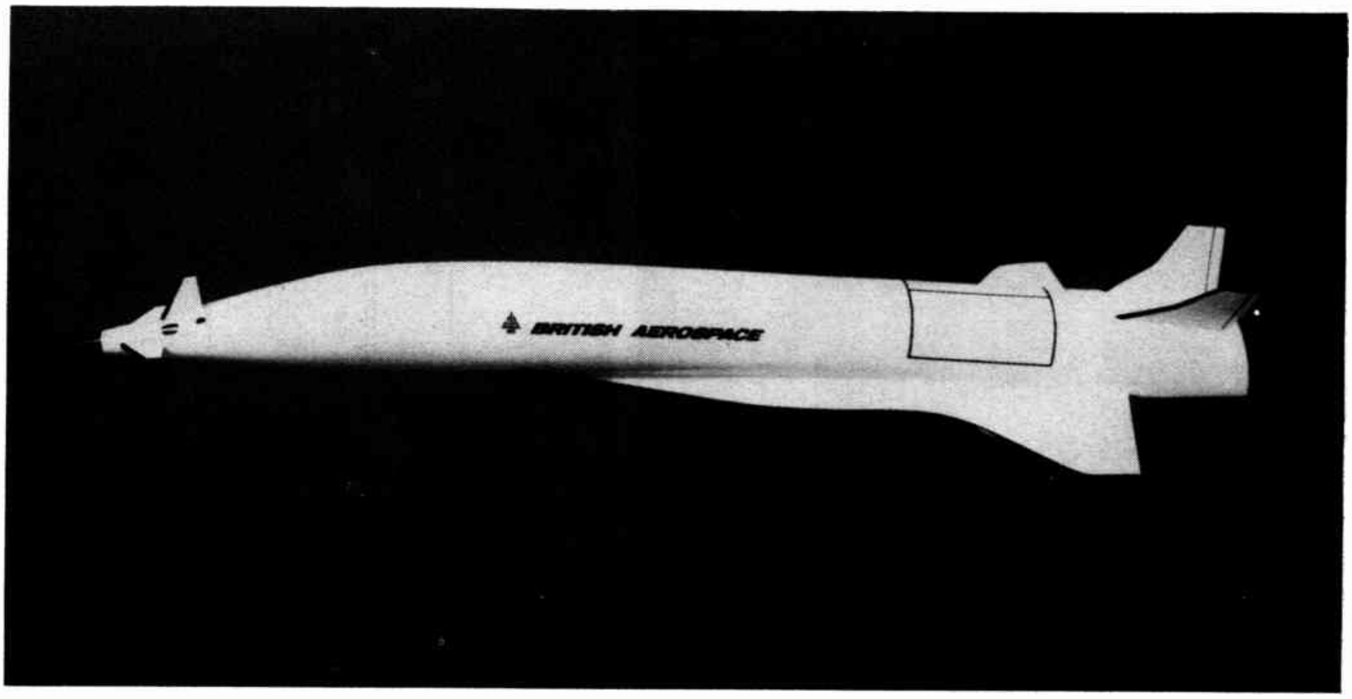
SOVIET SHUTTLE?

Soviet spokesmen discount talk of a Soviet space shuttle. They say that inexpensive, mass-produced rockets make a space shuttle unnecessary. Current intelligence reports, if correctly interpreted, contradict this. The Royal Australian Air Force has photographed a small scale shuttle type of vehicle being recovered in the Indian Ocean after it had made a single orbit of the Earth. There have been four such orbital test flights. And a site claimed to be a shuttle launch facility has been photographed by the French Spot satellite at the Baikonur Cosmodrome complex near Tyuratam, Soviet Central Asia.

Suggested applications for the Soviet shuttle range from the obvious to the fantastic. It is said to be a service and transport vehicle for space stations like Mir and its successors, or alternatively, it may be developed as a weapons platform, able to swoop down from orbit on unsuspecting American warships! In reality, it is probably being developed for the self-same reasons as NASA's shuttle, the Orient Express, HOTOL and Hermes — as a satellite launcher and to transport men and materials into Earth orbit.

Whilst Hermes and, it appears, the Soviet Shuttle are natural extensions of existing shuttle technology, vehicles like HOTOL and the Orient Express represent a new technology that will take us into the next stage of space transport. The cost savings and greatly improved performance they offer are vital to transport the numbers of people and quantity of hardware into orbit that will be required to construct and maintain the large orbital structures (space stations and free-flying unmanned platforms) that are envisaged for the first quarter of the 21st century.

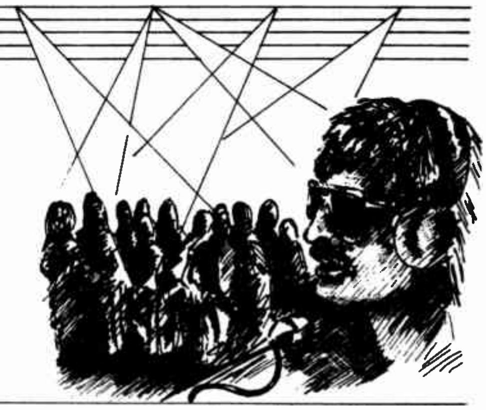
Whether or not businessmen or holidaymakers will also be using them to hop around the world depends largely on how economical the vehicles are to operate and, with Challenger still fresh in our minds, how safe they are perceived to be by the travelling public. □



This earlier model of HOTOL shows how the vehicle's design has changed subtly since it was unveiled in 1984. The two vertical tail fins and nose canards have now disappeared. Photo: British Aerospace.

Constructional Project

DISCO LIGHT SEQUENCER



GEOFF PHILLIPS

An 8-channel EPROM controlled light sequencer. Ideal for disco chaser light and many other programmable "psychedelic" lighting effects

THE ELECTRONICS engineer normally thinks of an EPROM in terms of a programme storage device for use with a computer or a dedicated microprocessor system. EPROMs have many other applications however and now that prices have plummeted they are very appealing for use in all kinds of control applications where complex sequences have to be stored and called up at will.

An ideal application for an EPROM is an eight-channel light sequencer or chaser for use in a disco. There have been other light sequencer projects published over the years but few have used the EPROM approach as described here.

The Disco Light Sequencer is designed to drive a row of eight lamps. Pin spotlamps are ideal as they produce a narrow parallel beam. The effect of sequenced patterns of eight beams cutting through a disco's smoky atmosphere is quite stunning.

The most obvious pattern or sequence of eight lights is the single lamp "chase" where only lamp No. 1 is illuminated and then No. 2 only and so on. This can be represented by a grid chart of 64 squares where the rows represent the eight steps in time and the vertical columns represent the lamp number. A "1" denotes that a lamp is lit at that step in time and a "0" denotes that the lamp is extinguished.

The single lamp chase is represented by the first pattern shown in Fig. 1. Take a sheet of graph paper, sit down and see how many different eight step sequences of eight lamps you can devise. It's quite a stimulating exercise.

BASIC CONCEPT

Each pattern is stored in eight consecutive memory addresses of the EPROM. Thus up to 256 different patterns may be programmed into a 2K × 8-bit 2716 EPROM.

The light sequencer has two modes of operation, manual and auto. In the auto mode, a pattern is repeated eight times after which the next pattern in the EPROM is selected and it is repeated eight times and so on.

In the manual mode a pattern may be selected by means of two hexadecimal switches.

Each hexadecimal switch may be set to any one of 16 positions 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E or F. Thus two switches will give 16 × 16 different positions – 256.

Once a pattern has been selected it will be repeated until a new pattern is chosen. The speed of the light show may be controlled by a potentiometer and the pattern selected is displayed on eight front panel l.e.d.s.

	MSB							LSB	HEX		ADDRESS
0	X								8	0	00
1		X							4	0	
2			X						2	0	
3				X					1	0	
4					X				0	8	
5						X			0	4	
6							X		0	2	
7								X	0	1	

0	X	X							C	0	01
1		X	X						6	0	
2			X	X					3	0	
3				X	X				1	8	
4					X	X			0	C	
5						X	X		0	6	
6							X	X	0	3	
7	X							X	8	1	

0	X	X	X						E	0	02
1		X	X	X					7	0	
2			X	X	X				3	8	
3				X	X	X			1	C	
4					X	X	X		0	E	
5						X	X	X	0	7	
6	X						X	X	8	3	
7	X	X						X	C	1	

0	X	X	X	X					F	0	03
1		X	X	X	X				7	8	
2			X	X	X	X			3	C	
3				X	X	X	X		1	E	
4					X	X	X	X	0	F	
5	X					X	X	X	8	7	
6	X	X					X	X	C	3	
7	X	X	X					X	E	1	

0	X	X	X	X	X				F	8	04
1		X	X	X	X	X			7	C	
2			X	X	X	X	X		3	E	
3				X	X	X	X	X	1	F	
4	X				X	X	X	X	8	F	
5	X	X				X	X	X	C	7	
6	X	X	X				X	X	E	3	
7	X	X	X	X				X	F	1	

	MSB							LSB	HEX		ADDRESS
0	X	X	X	X	X	X			F	C	05
1		X	X	X	X	X	X		7	E	
2			X	X	X	X	X	X	3	F	
3	X			X	X	X	X	X	9	F	
4	X	X			X	X	X	X	C	F	
5	X	X	X			X	X	X	E	7	
6	X	X	X	X			X	X	F	8	
7	X	X	X	X	X			X	F	9	

0	X	X	X	X	X	X	X		F	E	06
1		X	X	X	X	X	X	X	7	F	
2	X		X	X	X	X	X	X	B	F	
3	X	X		X	X	X	X	X	D	F	
4	X	X	X		X	X	X	X	E	F	
5	X	X	X	X		X	X	X	F	7	
6	X	X	X	X	X		X	X	F	B	
7	X	X	X	X	X	X		X	F	D	

0	X	X	X	X					F	0	07
1	X	X	X	X					F	0	
2					X	X	X	X	0	F	
3					X	X	X	X	0	F	
4	X	X	X	X					F	0	
5	X	X	X	X					F	0	
6					X	X	X	X	0	F	
7					X	X	X	X	0	F	

0	X	X			X	X			C	C	08
1	X	X			X	X			C	C	
2			X	X			X	X	3	3	
3			X	X			X	X	3	3	
4	X	X			X	X			C	C	
5	X	X			X	X			C	C	
6			X	X			X	X	3	3	
7			X	X			X	X	3	3	

0	X		X		X		X		A	A	09
1	X		X		X		X		A	A	
2		X		X		X		X	5	5	
3		X		X		X		X	5	5	
4	X		X		X		X		A	A	
5	X		X		X		X		A	A	
6		X		X		X		X	5	5	
7		X		X		X		X	5	5	

Fig. 1 (right) Chart setting out typical light sequences

CIRCUIT DESCRIPTION

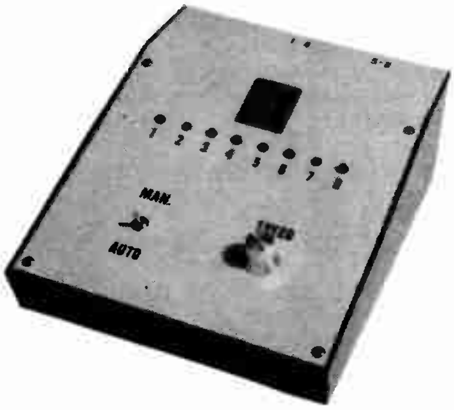
The full circuit diagram of the Disco Light Sequencer is shown in Fig. 2. IC2 is connected as a free running astable multivibrator whose frequency may be set by VR1. The OV going pulses at pin 3 are fed to the clock input of the first binary counter, IC3. The three least significant bits (LSB) of this counter are fed to the three LSBs of the EPROM, IC6.

Eight consecutive addresses of the EPROM are called up in turn as IC3 counts. If all the outputs of the counters IC4 and IC5 are at logic "0" then EPROM locations 000 and 007 are addressed in turn and then the same cycle of addressing repeats eight times.

On the eighth time Q6 of IC3 goes to logic "1" which clocks IC4 and thus the next set of eight EPROM locations are addressed in turn and so on. In each set of eight EPROM locations is a different sequence pattern. Up to 256 different patterns may be stored.

If switch S1 is switched to manual any one of the 256 pattern sets may be selected by means of the Hexadecimal thumbwheel switches, S2 and S3. This is achieved by virtue of the pre-set inputs of the counters IC4 and IC5 when S1 enables their Pre-set enable pins 1.

Transistor TR1 to TR8 act as emitter followers which provide sufficient current drive for the triacs CSR1 to CSR8. It is important to note that the OV of the control circuitry is



connected to *neutral* of the mains supply so if you inadvertently interpose live and neutral, the circuit board will be at mains potential.

PROGRAMMING THE EPROM

If you have decided to program your own light show you will need to draw up an eight by eight chart for each pattern. Graph paper is ideal for this. Fig. 1 gives a few examples of some interesting light patterns.

The two digit hexadecimal number for each time step in the pattern must then be determined. If the 8-bit binary number representing each time step is split into two 4-bit numbers, they may be replaced by their equivalent hexadecimal numbers according to the chart in Table 1.

Table 1: Hexadecimal equivalent digits for light patterns

BINARY NUMBER or LIGHT PATTERN	HEXADECIMAL DIGIT
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

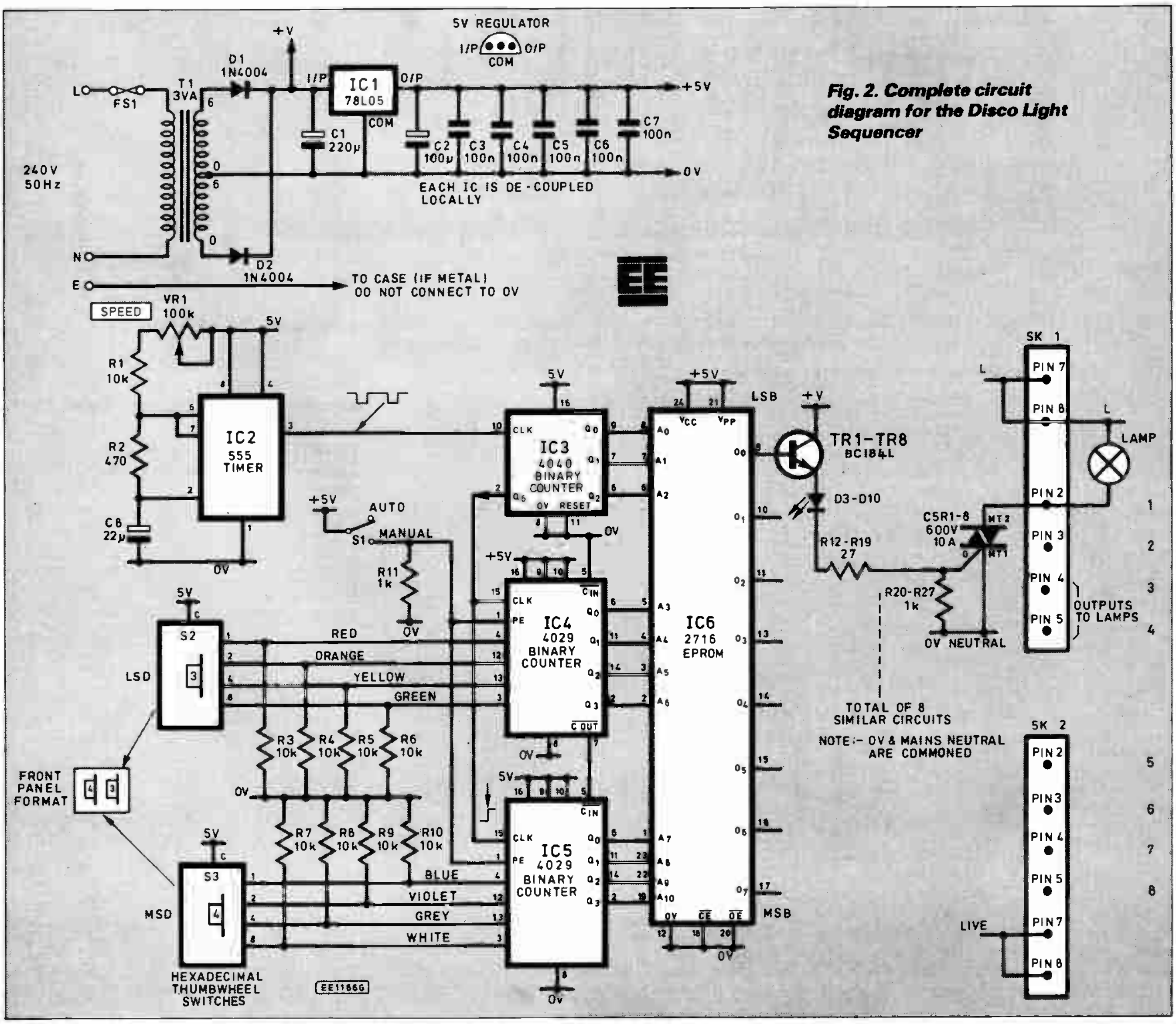


Fig. 2. Complete circuit diagram for the Disco Light Sequencer

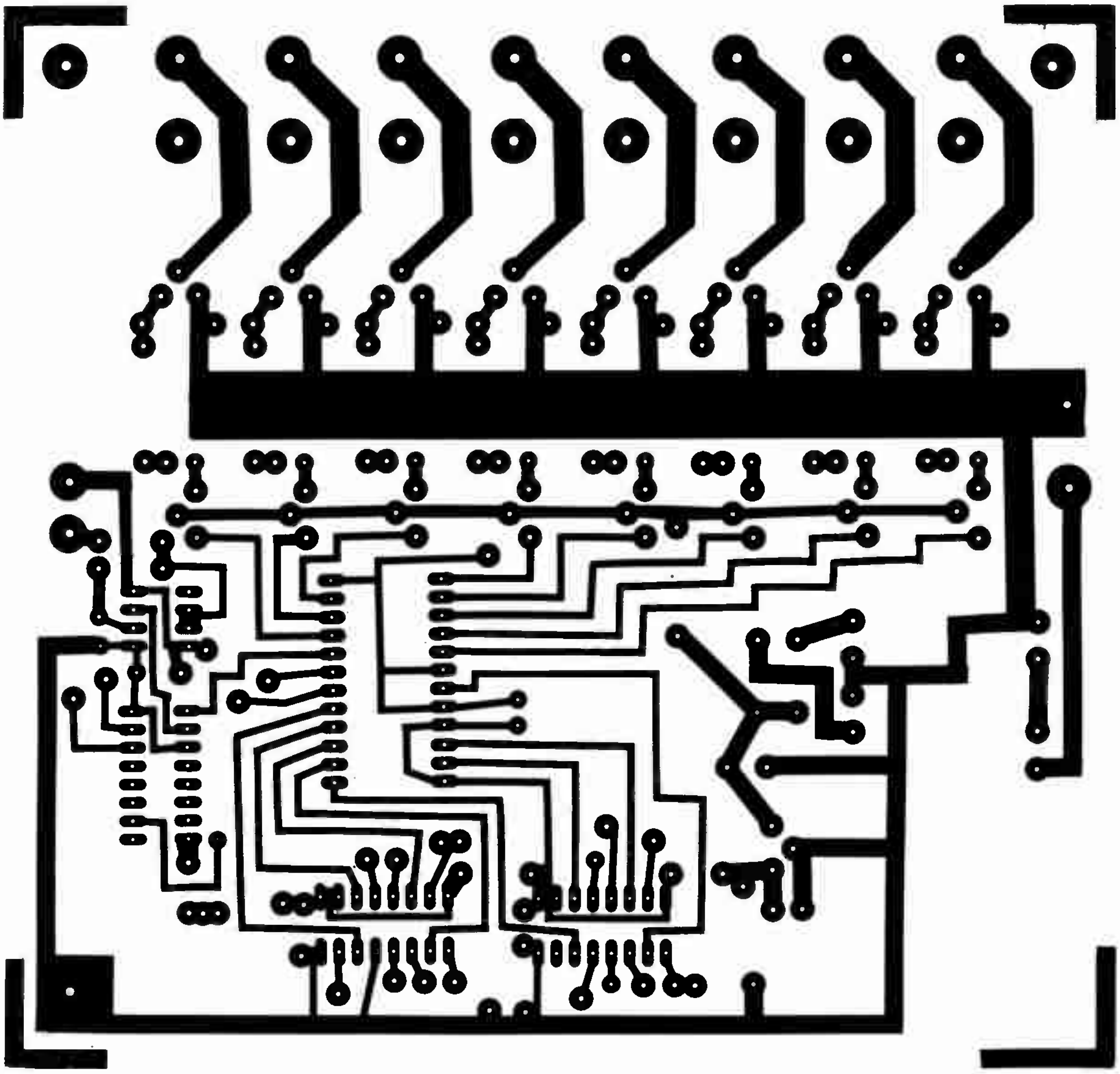
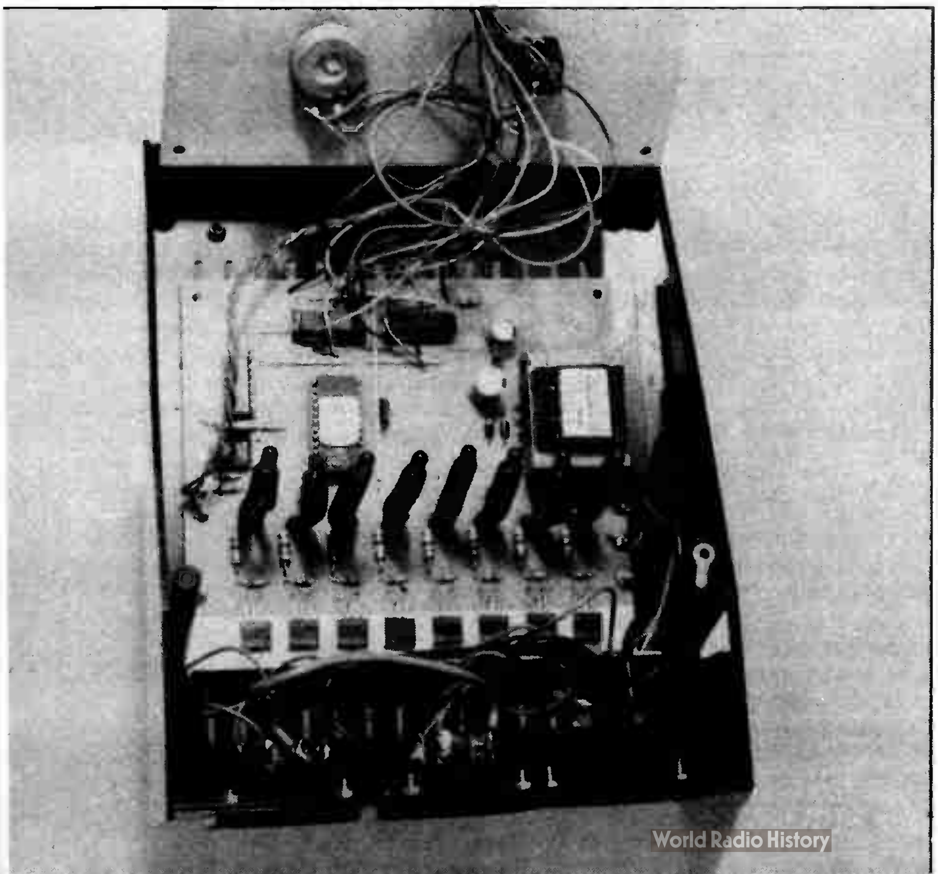
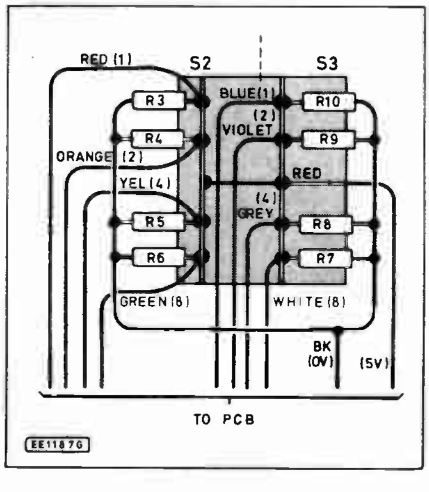


Fig. 3. Full size foil master pattern, board component layout for the light sequencer is shown on the opposite page. Make sure that all insulated link wires are inserted and that the Neutral wire is capable of carrying the total lamp current.



(left) Completed unit showing board mounted l.e.d.s with insulated leads.

Fig. 4. Details of the resistor and p.c.b. wiring to the hexadecimal switches. See photo opposite



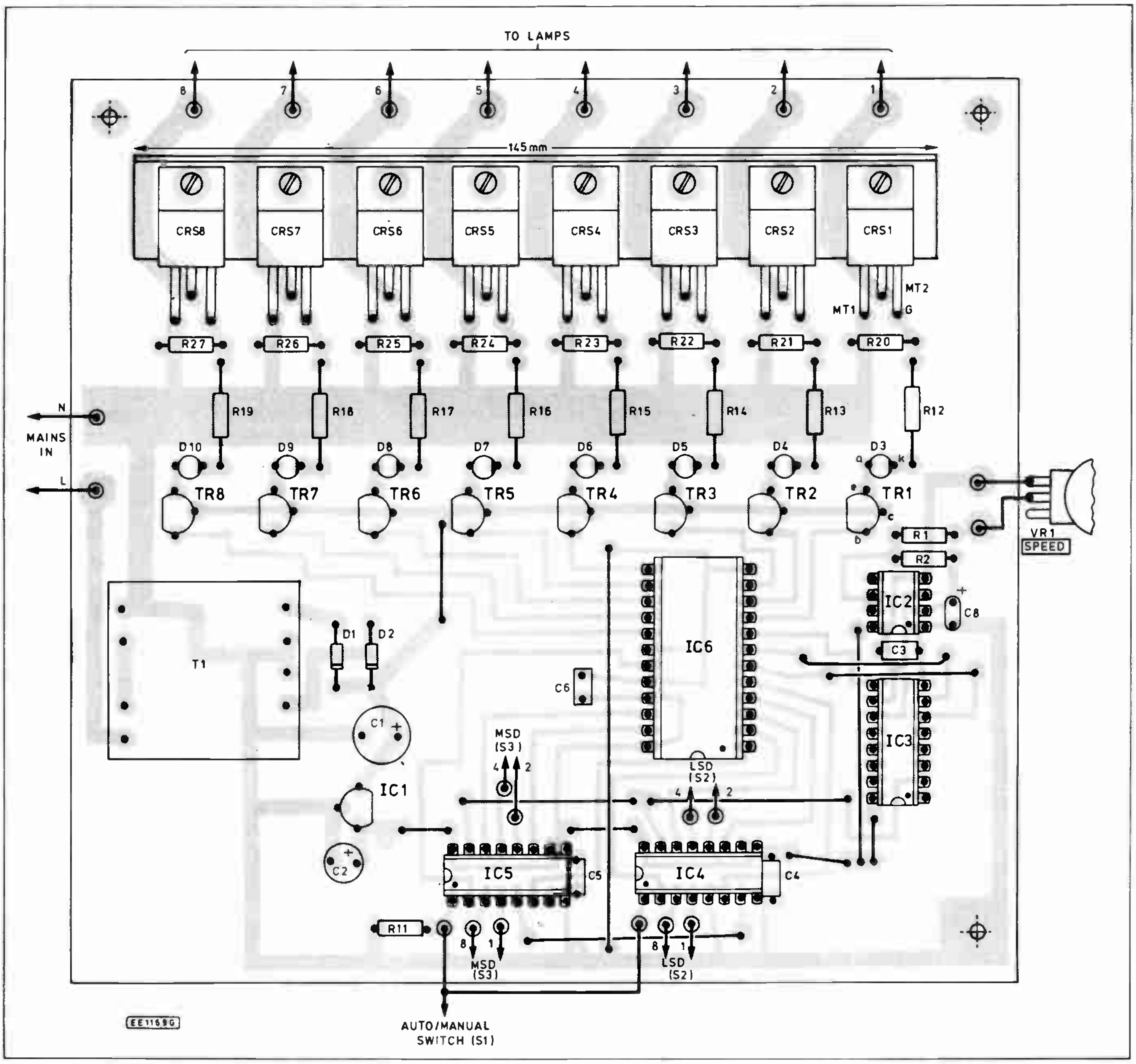
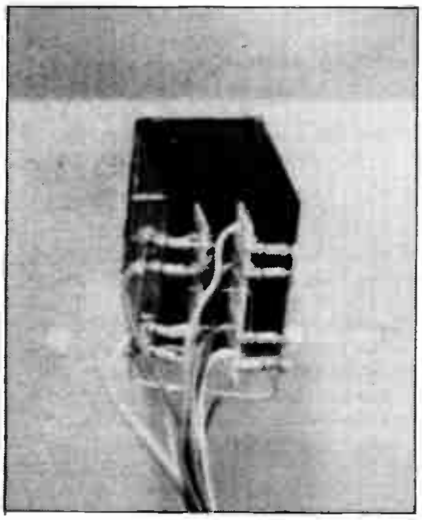
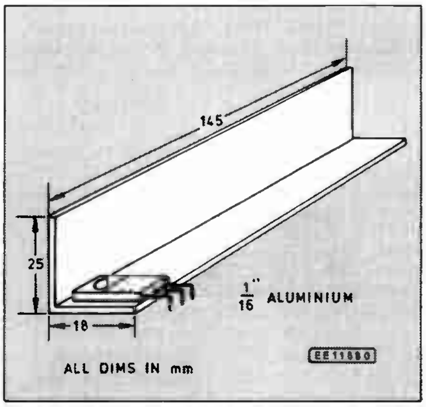
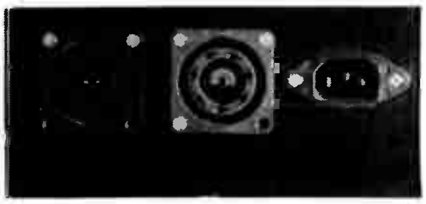


Fig. 5 (right) Details of the triack heatsink. Note that a mica washer and bush set must be used if the alternative triacs are used.

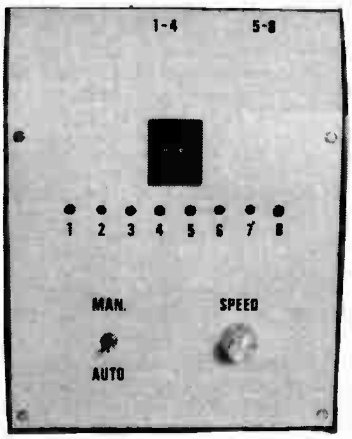




The rear mounted lamp and mains sockets.



Front panel lettering and layout of the "mimic" l.e.d.s.



The pairs of hexadecimal digits may then be typed into consecutive addresses of an EPROM programmer. Table 2 gives a listing of 64 suggested patterns. A pre-programmed EPROM is available for those who do not have access to a programmer or are too lazy to type all the numbers in – see Shoptalk.

CONSTRUCTION

The component layout and full size printed circuit board copper foil master pattern for the Disco Light Sequencer is shown in Fig. 3. Make sure that all electrolytic capacitors and semiconductors are fitted the right way round. Do not overlook any of the link wires.

All the components are p.c.b. mounted except the connectors, front panel controls and the resistors associated with the hexadecimal switches, S2 and S3. These resistors are connected between each pole of the switches (1, 2, 4 and 8) and a common bus bar which is connected to OV of the p.c.b. The wipers of the switches are connected to +5V (see Fig. 4).

The leads of the front panel l.e.d.s are extended to 60mm with lengths of wire so that when they are soldered into the p.c.b. they can be made to protrude through holes in the front panel. Insulated sleeves should be fitted over the l.e.d. leads to prevent them shorting to each other. Isolated triacs are used which are bolted to a heat sink which is manufactured from a length of 1/16in aluminium see Fig. 5.

The mains neutral connection to the p.c.b. has to carry the return current of all eight triacs and therefore should be made in a stout gauge of wire capable of carrying the total lamp current. Two Bulgin 8-way mains connectors are used for the outputs to the lamps.

The cable from the p.c.b. triac outputs to the Bulgin connectors need only be of suitable gauge wire for one lamp load current. The common live connections to pins 7 and 8 of the Bulgin sockets however, should be in the heavier gauge wire. The live connection to the p.c.b. only has to supply the very small current to the mains transformer.

All exposed metalwork of the case must be securely Earthed.

SOFTWARE: Table. 2 Suggested Light Pattern Programs

```
&80,&40,&20,&10,&08,&04,&02,&01,
&C0,&60,&30,&18,&0C,&06,&03,&81,
&E0,&70,&38,&1C,&0E,&07,&83,&C1,
&F0,&78,&3C,&1E,&0F,&87,&C3,&E1,
&F8,&7C,&3E,&1F,&8F,&C7,&E3,&F1,
&FC,&7E,&3F,&9F,&CF,&E7,&F3,&F9,
&FE,&7F,&BF,&DF,&EF,&F7,&FB,&FD,
&F0,&F0,&0F,&0F,&F0,&F0,&0F,&0F,
&CC,&33,&CC,&33,&CC,&33,&CC,&33,
&AA,&55,&AA,&55,&AA,&55,&AA,&55,
&C3,&C3,&3C,&3C,&C3,&C3,&3C,&3C,
&FF,&FF,&00,&00,&FF,&FF,&00,&00,
&88,&88,&00,&00,&88,&88,&00,&00,
&44,&44,&00,&00,&44,&44,&00,&00,
&22,&22,&00,&00,&22,&22,&00,&00,
&11,&11,&00,&00,&11,&11,&00,&00,
&CC,&CC,&00,&00,&CC,&CC,&00,&00,
&66,&66,&00,&00,&66,&66,&00,&00,
&33,&33,&00,&00,&33,&33,&00,&00,
&F0,&F0,&00,&00,&F0,&F0,&00,&00,
&80,&40,&20,&10,&08,&04,&02,&01,
&88,&44,&22,&11,&88,&44,&22,&11,
&81,&42,&24,&18,&18,&24,&42,&81,
&81,&42,&24,&18,&81,&42,&24,&18,
&81,&C3,&E7,&FF,&81,&C3,&E7,&FF,
&81,&C3,&E7,&FF,&00,&FF,&00,&FF,
&81,&C3,&E7,&FF,&E7,&C3,&81,&00,
&88,&44,&22,&11,&11,&22,&44,&88,
&A8,&54,&2A,&15,&15,&2A,&54,&A8,
&88,&CC,&EE,&FF,&88,&CC,&EE,&FF,
&88,&88,&44,&44,&22,&22,&11,&11,
&88,&88,&44,&44,&88,&88,&44,&44,
&88,&88,&22,&22,&88,&88,&22,&22,
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&81,&81,&C3,&C3,&E7,&E7,&FF,&00,
&81,&81,&C3,&C3,&66,&66,&3C,&3C,
&81,&C3,&E7,&FF,&7E,&3C,&18,&00,
&81,&A5,&5A,&24,&18,&24,&5A,&A5,
&C3,&C3,&C3,&C3,&3C,&3C,&3C,&3C,
&C3,&C3,&3C,&3C,&C3,&C3,&3C,&3C,
&C3,&3C,&C3,&3C,&C3,&3C,&C3,&3C,
&F0,&F0,&F0,&F0,&0F,&0F,&0F,&0F,
&F0,&F0,&0F,&0F,&F0,&F0,&0F,&0F,
&AA,&AA,&AA,&AA,&55,&55,&55,&55,
&AA,&AA,&55,&55,&AA,&AA,&55,&55,
&AA,&55,&AA,&55,&AA,&55,&AA,&55,
&80,&C0,&E0,&F0,&F8,&FC,&FE,&FF,
&FF,&FE,&FC,&F8,&F0,&E0,&C0,&80,
&A4,&49,&A2,&15,&68,&94,&29,&54,
&DA,&29,&92,&4D,&A2,&18,&C5,&2A,
&F6,&C4,&A2,&81,&7E,&4C,&2A,&09,
&80,&40,&20,&10,&08,&04,&02,&01,
&A0,&50,&28,&14,&0A,&05,&82,&41,
&A8,&54,&2A,&15,&8A,&45,&A2,&51,
&AA,&55,&AA,&55,&AA,&55,&AA,&55,
&FF,&FF,&FF,&FF,&00,&00,&00,&00,
&FF,&FF,&00,&00,&FF,&FF,&00,&00,
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&FF,&00,&FF,&00,&FF,&00,&FF,&00,
&C0,&C0,&00,&18,&18,&00,&03,&03,
&C0,&00,&30,&00,&0C,&00,&03,&00,
&F0,&00,&00,&00,&0F,&00,&00,&00,
&C3,&00,&00,&00,&3C,&00,&00,&00,
&99,&99,&99,&99,&66,&66,&66,&66,
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&18,&24,&5A,&A5,&A5,&5A,&24,&18,
&18,&3C,&7E,&FF,&FF,&7E,&3C,&18,
&18,&3C,&7E,&FF,&18,&3C,&7E,&FF,
&F0,&78,&3C,&1E,&0F,&1E,&3C,&78,
&90,&48,&24,&12,&09,&12,&24,&48,
&C3,&66,&3C,&18,&00,&18,&3C,&66,
&80,&01,&40,&02,&20,&04,&10,&08,
&18,&00,&3C,&00,&7E,&00,&FF,&00,
&88,&00,&88,&00,&88,&00,&88,&00,
&44,&00,&44,&00,&44,&00,&44,&00,
&22,&00,&22,&00,&22,&00,&22,&00,
&11,&00,&11,&00,&11,&00,&11,&00,
&A0,&50,&A0,&50,&0A,&05,&0A,&05,
&88,&44,&88,&44,&22,&11,&22,&11,
&FF,&3C,&C3,&66,&18,&E7,&7E,&3C,
&A8,&A8,&15,&15,&A8,&A8,&15,&15,
&E0,&38,&0E,&03,&0E,&38,&E0,&80,
&80,&20,&40,&10,&20,&08,&10,&04,
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&C0,&00,&18,&00,&03,&00,&18,&00,
&AA,&6D,&96,&E3,&55,&DA,&4D,&B6,
&E7,&DB,&BD,&7E,&BD,&DB,&E7,&FF,
&FF,&00,&FF,&00,&FF,&FF,&00,&00,
&C3,&3C,&C3,&18,&C3,&24,&C3,&18,
&81,&42,&81,&24,&81,&18,&81,&00,
&81,&42,&81,&42,&81,&42,&81,&42,
&81,&18,&81,&18,&81,&18,&81,&18,
&80,&80,&80,&80,&01,&01,&01,&01,
&80,&80,&01,&01,&80,&80,&01,&01,
&80,&01,&80,&01,&80,&01,&80,&01,
&FF,&FF,&FF,&FF,&FF,&FF,&FF,&FF,
&00,&00,&00,&00,&00,&00,&00,&00,
```

COMPONENTS

Resistors

R1	10k
R2	470
R3-R10	10k (8 off)
R11	1k
R12-R19	27 (8 off)
R20-R27	1k (8 off)
All ½W 5% carbon	

Shop Talk
See page 105

Potentiometer

VR1	100k carbon 1in.

Capacitors

C1	220µ elec. 16V
C2	100µ elec. 16V
C3-C7	100n ceramic (5 off)
C8	22µ elec. 16V

Semiconductors

D1, D2	1N4004 1A 400V (2 off)
D3-D10	l.e.d. (8 off)
CSR1-CSR8	600V 10A triac, with isolated tab (8 off) (e.g. TAG T1010MJ or TIC206M)
TR1-TR8	BC 184L *npn* silicon (8 off)
IC1	78L05 +5V 100mA regulator
IC2	555 timer
IC3	4040 CMOS 12-stage binary counter
IC4, IC5	4029 CMOS presettable up/down binary counter
IC6	2716 2K EPROM (must be programmed)

Miscellaneous

T1	3VA mains transformer, 6V-0-6V sec.
S1	single-pole toggle switch
S2, S3	Hexadecimal thumbwheel switches (2 off) (two sidecheeks for above)

Case 170m × 213m × 82/31mm (sloping top); printed circuit board; heavy duty wire to suit loads; PL1, PL2 8-way mains sockets, Bulgin P552; control knob; connecting wire, etc.

Approx. cost Guidance only £42 plus case

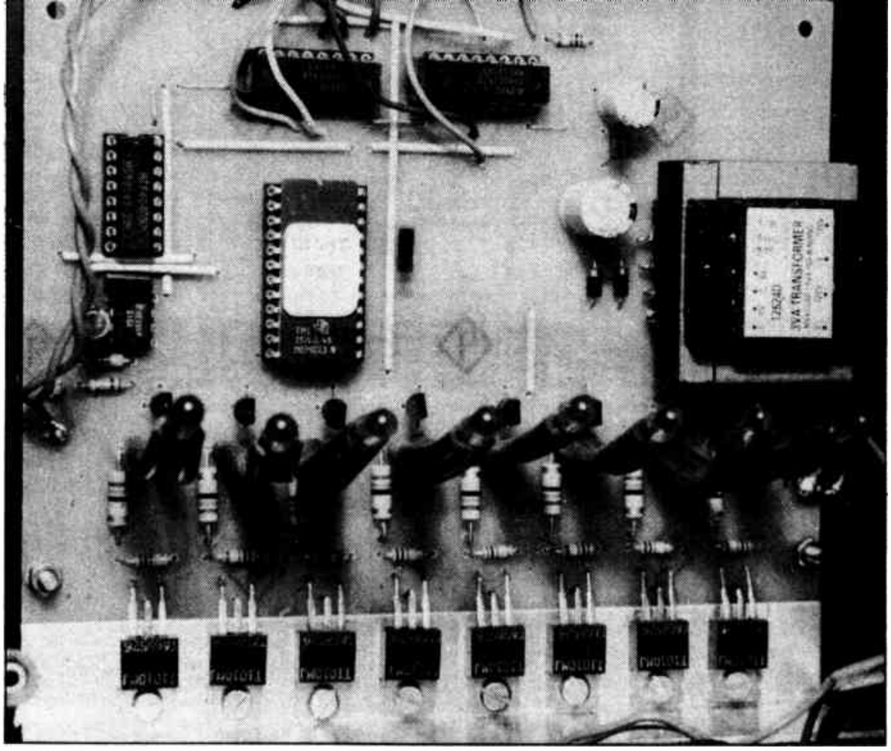
TESTING

The control circuit may be tested first by simply leaving the Bulgin plugs from the lamps disconnected from the unit. Connect mains to the p.c.b. (*ensure correct polarity*) and set the auto/manual switch (S1) to manual. Dial up the number 00 on the hexadecimal switches. This selects the simple one lamp chase.

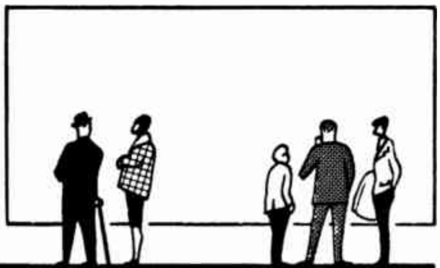
Only l.e.d. 1 should light and then l.e.d. 2 and so on. If nothing happens at all, check that the 5V rail is present. If the +5V supply is healthy turn the Speed potentiometer fully anti-clockwise and check that the oscillator IC2 is operating.

If you do not have access to an oscilloscope, the square wave at pin 3, IC2 should be a low enough frequency to be seen on an analogue meter. It should then be possible to check each address lead of the EPROM. Pins 6, 7 and 8 should be oscillating and all the other address leads should be at logic 0.

Assuming you have reached the stage there the l.e.d.s are displaying the patterns selected, the lamps may then be lugged in. You are now ready to give your firs ublic performance and on your way to becor g the number one local DJ. □



SHOP TALK



BY DAVID BARRINGTON

Variable Bench Power Supply

Practically all the components required to build the *Variable Bench Power Supply* are standard items and should not cause purchasing problems. However, the HPWR 6501 MOSFET device (TR2) is most likely to prove difficult to source. This appears to be a Hewlett-Packard type number and is being stocked by **Magenta Electronics**. They are also able to supply the Zener diodes.

A suitable toriodal transformer should be available from **Jaytee Electronic Services, Barrie Electronics** or **Magenta Electronics**. To obtain the best results from the p.s.u. it is recommended that close tolerance resistors are used as specified.

For those readers who may experience difficulties in obtaining parts, a complete kit (£49.73) may be purchased from **Magenta Electronics, 135 Hunter Street, Burton on Trent, Staffs DE14 2ST**. Add £1 for post and packing per order.

The printed circuit board is available through the *EE PCB Service*, code EE593.

Disco Lights Sequencer

A ready programmed EPROM chip for the *Disco Lights Sequencer* is available from **G.P. Electronic Services** for the sum of £6.95, including VAT and P&P. They can also supply a pre-drilled printed circuit board for the sum of £10.40 inclusive. Orders should be sent to: **G.P. Electronic Services, 87 Willowtree Avenue, Gilesgate, Durham DH1 1DZ.**

If any readers experience problems purchasing the triac, the TIC206M triac may be used in place of the one specified. However, it is most important that a mica insulating washer and insulating bush sets are used for each triac. Other suitable (although not tested) triacs, such as the TIC226M, are available from **Omni** and **Greenweld Electronics.**

When ordering the triac driver transistors TR1 to TR8, it is important to specify the *L* suffix of the BN184L as pinout connections for this device vary. The choice of metal case is left to the individual constructor, but the one used in the designer's model is the Maplin M6007 type (code LH67X), with sloping top.

The Bulgin mains input socket and the 8-way mains chassis sockets (type P552) are currently stocked by Cirkit and Maplin. The Hexadecimal thumbwheel switches should now be available from most advertisers, remember to ask for sidecheeks when ordering.

A suitable mains transformer should be available from most component suppliers. The one in the prototype is a 3V/A **STC** transformer code number STC 12624D.

Emergency Light Unit

The d.i.l. reed relay called for in the small version of the *Emergency Light Unit* should be available from most component suppliers. However, if readers do have trouble locating this device it is currently listed by **Maplin,** order code FX88V (Dil Reed 1p 5V). It is quite in order to use a standard relay, provided it will operate down to 5V and the coil rating is identical to the d.i.l. type. The 3A relay used in the prototype of the larger version was also purchased from Maplin, code YX86E.

Some readers may find that locating a source for the i.c. type ICL7611 and the BC441 transistor a little difficult. The i.c. should be stocked by **Omega, Omni** and **Xen Electronics.** The transistor is currently listed by **Marco, Greenweld** and **Maplin.**

One Valve Radio

We are sure, just like us, that many readers will experience numerous problems trying to source locally some of the special components required to build the *One Valve Radio.*

The first obstacle to be encountered, which was a common item in bygone days, is bound to be the DAF91 pentode/diode valve. Most of our advertisers gave up stocking valves long ago and looking through the catalogues of those that still do the DAF91 is certainly not listed.

We have tracked the elusive valve down to two suppliers who carry stocks and these are **PM Components** of Gravesend, Kent (tel: ***0474 605212*** and **Progressive Radio** of Liverpool (tel: ***051 236 0982***).

The r.f. choke, reduction drive and Jackson type tuning capacitors should be carried by **Cirkit, Marco, Greenweld, Magenta** and **Maplin.** The metal chassis and the reduction drive used in the prototype radio was purchased from Maplin, code XB68Y and RX41U respectively.

The Denco range coils (£2.29 each coil, including VAT and P&P) are available direct from the makers **G&P Powles, 10 Conway Units, Stephenson Road, Gorse Lane Industrial Estate, Clacton on Sea, Essex CO15 4XA** (tel: ***0255 424152***). Order as Min D.P. GREEN together with range. They can also supply the B7G and B9A valveholders.

Be extra careful when wiring up the "high tension" (HT) battery pack. Note the use of high voltage capacitors, these can be greater than specified but must not be less.

Car Lamp Checking System

We do not expect readers to experience any difficulties when purchasing components for the *Carl Lamp Checking System.*

The dashboard mounted warning light LP1 should be available from any autospares shop. The 3W (or more) rated resistors should be generally available from most good component suppliers.

Finally, it is most important that if any car wiring does need extending this must be carried out using insulated automotive wire rated at a minimum of 5A. Also make sure that the project is built in a metal case.

We do not expect any component buying problems for this month's *Exploring Electronics* project – *Simple Half-Adder* demonstration circuit, or the *Game Timer.*

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 20 Doing sums by logic

ADDING is a logical operation. A few simple additions will show just how logical it is. The simplest addition we can do is to add two numbers together. The simplest numbers we can add are two binary numbers with only one digit each. There are only four possible sums of this kind:

Zero *plus* zero *equals* zero $0+0=0$
Zero *plus* one *equals* one $0+1=1$
One *plus* zero *equals* one $1+0=1$
and One *plus* one *equals* zero, carry one $1+1=10$

The result of 1 + 1 gives "0" and carry "1". We could put these statements in the form of two truth tables, one table for the "units" digit, the other table for the "carry" digit:

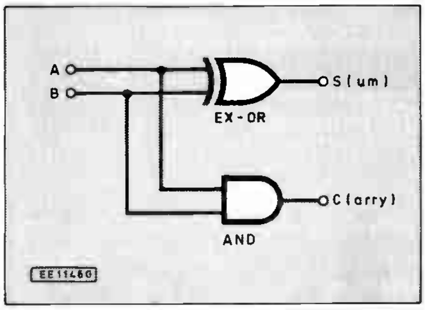


Fig. 20.1. Adding two 1-digit numbers A + B, using an exclusive-OR gate and an AND gate.

Digits to be added First number (A)	Second number (B)	*Units* Digit (S)	Digits to be added First number (A)	Second number (B)	*Carry* Digit (C)
0	0	0	0	0	0
0	1	1	0	1	0
1	0	1	1	0	0
1	1	0	1	1	1

Compare these tables with those in Table 20.1. The truth table for the unit (or sum, S) digit is exactly the same as the EXCLUSIVE-OR operation. The truth table for the carry digit is exactly the same as the AND operation.

INVESTIGATION ONE – ADDITION

To add two single-digit binary numbers we simply need an AND gate and an EXCLUSIVE-OR gate, this is shown in the circuit diagram Fig. 20.1. To show the result we need two lamps or l.e.d.s, one for S (sum) and one for C (carry).

Integrated circuits with AND and EXCLUSIVE-OR gates are obtainable, but it is little trouble to make equivalent gates from the NAND gates of the 7400 i.c.

A circuit diagram using two 7400 NAND gate i.c.s is shown in Fig. 20.2. This circuit is the logical equivalent of Fig. 20.1 and also includes the sum and carry l.e.d.s.

CONSTRUCTION

The demonstration breadboard component layout for the Half-Adder is shown in Fig. 20.3. Wire up the EXCLUSIVE-OR gate (IC1) first, to see how it works.

The AND gate is simply a NAND, followed by INVERT (IC2), to make the output AND again. Now try making the *A* and *B* inputs "0" or "1", by touching the flying leads to the 0V or +6V lines. See what outputs you obtain. Use the tables

Fig. 20.2 (right). Using two 7400 NAND gate i.c.s to produce the logical equivalent of Fig. 20.1. This circuit is known as a "Half-Adder".
Fig. 20.3 (below right). Demonstration breadboard component layout for the "Half-Adder" circuit Fig. 20.2.

Table 20.1: Truth Tables

In these tables, 0 = false and 1 = true.

AND: the result is true only if both A *and* B are true:

A	B	Result
0	0	0
0	1	0
1	0	0
1	1	1

Example: If it is (A) sunny AND (B) I have the fare, (RESULT) I go to the seaside.

OR: the result is true if either A *or* B *or both* are true:

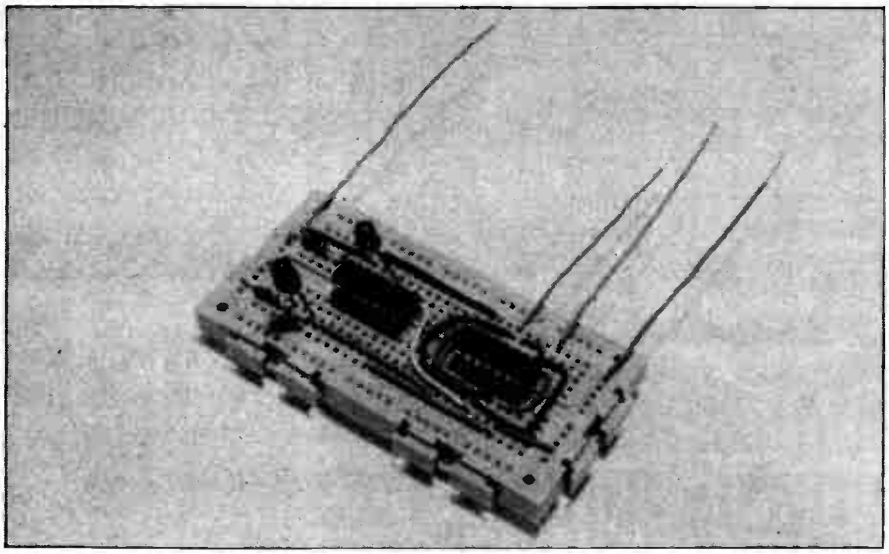
A	B	Result
0	0	0
0	1	1
1	0	1
1	1	1

Example: If it is (A) raining OR (B) it is windy, (OR raining and windy), I go to the cinema.

EXCLUSIVE-OR: the result is true if either A *or* B but *not* both are true:

A	B	Result
0	0	0
0	1	1
1	0	1
1	1	0

Example: For the sweet course the menu offered either (A) apple *or* (B) rice pudding.



COMPONENTS

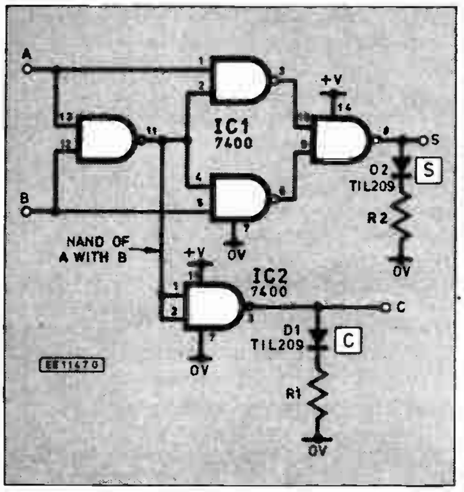
Resistors
R1 180
R2 180
All 0.25W 5% carbon

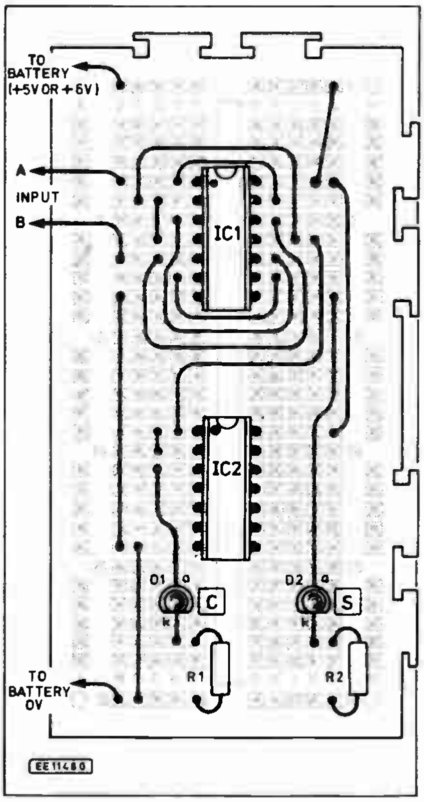
Shop Talk
See page 105

Semiconductors
D1, D2 TIL209 l.e.d (or similar) (2 off)
IC1,IC2 7400 quad 2-input NAND gate (2 off)

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

Approx. cost Guidance only **£5.00**





above to see what combinations or connections to try.

FULL ADDER

The circuit diagram shown in Fig. 20.2 can perform all additions up to 1 + 1 = 10 (or 1 + 1 = 2 in decimal), which does not take us far. This circuit is called a *half-adder*. A *full-adder* has an extra input, which allows us to carry-*in* a 0 or 1 from a previous addition. For example, suppose we were adding:

```
 1101
+1110
```

We could use the half-adder for the first step:

```
 1101
+1110        (1 + 0 = 1)
-----
 ...1
```

We could use it for the second step:

```
 1101
+1110        (0 + 1 = 1)
-----
  ..11
```

We could use it for the third step:

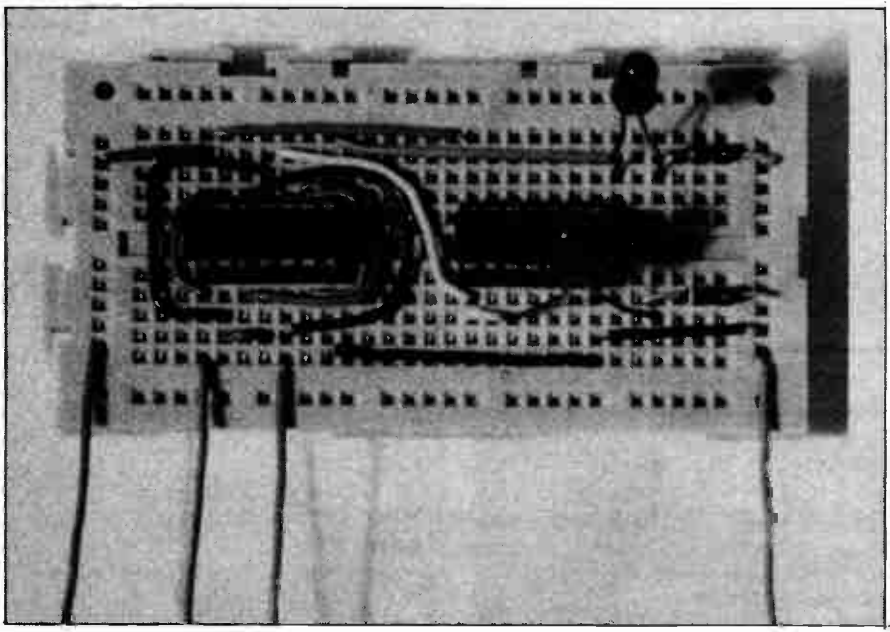
```
 1111
+1110        (0 + 1 = 0, carry 1)
-----
 .011
 1
```

But we could *not* use it for the fourth step, because we have to add 1 and 1 *and* another 1 for the carry:

```
 1101
+1110
-----
11011
```

To be able to add the carry-in we need a full adder, with three inputs, one for *A*, and one for *B* and one for the *carry-in* digit. It takes several more gates to build a full-adder and, to avoid the complications of wiring up so many gates, we can use an integrated circuit containing all the gates we need and already wired to make a full adder. This is the i.c. we use in next month's project.

Next month: More logic maths plus a 4-Bit Adder project.



Constructional Project

CAR LAMP CHECKING SYSTEM

T. R. DE VAUX-BALBIRNIE

Instant warning of a "blown" side, tail or brake light bulb

SOME cars have a bulb failure device already fitted. This is a worthwhile safety feature and the present circuit puts it within the reach of most motorists. In use, a dashboard-mounted indicator lamp operates if any one (or more) of the side, tail or brake lights fail.

As well as signalling blown bulbs, the system guards against poor connections which often occur when corrosion attacks the lampholders. Since the direction indicators are self-checking, they are not included.

This circuit is NOT suitable for positive-earth cars nor for those fitted to tow a trailer or caravan – this is because the additional loading would cause damage. The design assumes a loading of 24W approximately for the side and tail light circuit and 42W for the brake lights.

CIRCUIT DIAGRAM

The full circuit diagram for the Car Lamp Checking System is shown in Fig.1. This comprises two almost identical sections – one to monitor the side and tail lights and the other the brake lights.

Consider the side and tail lamp circuit first. With the lights on, main-line current flows through resistor R1 so a voltage is developed across it. With the chosen value and all four lamps operating, this is 0.5V approximately. With a nominal 12V supply, there will be approximately 11.5V appearing across the bulbs – the loss of 0.5V having negligible effect on their brightness.

The potential divider formed by resistors R2/R3 produces a nominal 8V at the non-inverting input (pin 2) of IC1a. This op-amp is one half of IC1 – the other being used to monitor the brake light bulbs in similar manner.

The inverting input (pin 1) receives a voltage which depends on the adjustment of preset potentiometer VR1 in conjunction with resistors R4 and R5. This can vary the voltage between nominal limits of 7V and 9V. With VR1 critically adjusted, the voltage at IC1a inverting input will just exceed that at the non-inverting one so the op-amp will be off with pin 12 low.

However, when a bulb fails, less current flows through resistor R1 and consequently less voltage is dropped across it. The op-amp input conditions reverse with the non-inverting input voltage now exceeding the inverting one. The op-amp switches on with pin 12 high (supply positive voltage) – this triggers transistor TR1, with base current entering through diode D1. Transistor TR1 operates the Bulb Fail warning light in the collector circuit.

A similar situation develops if a brake light fails. With the lamps on, main-line current flows through resistor R8 and operates IC1b – preset VR2 sets the correct operating point. If a lamp fails, IC1b output (pin 10) goes high and operates TR1, with base current entering through diode D2. This operates the warning light LP1 in the manner already described.

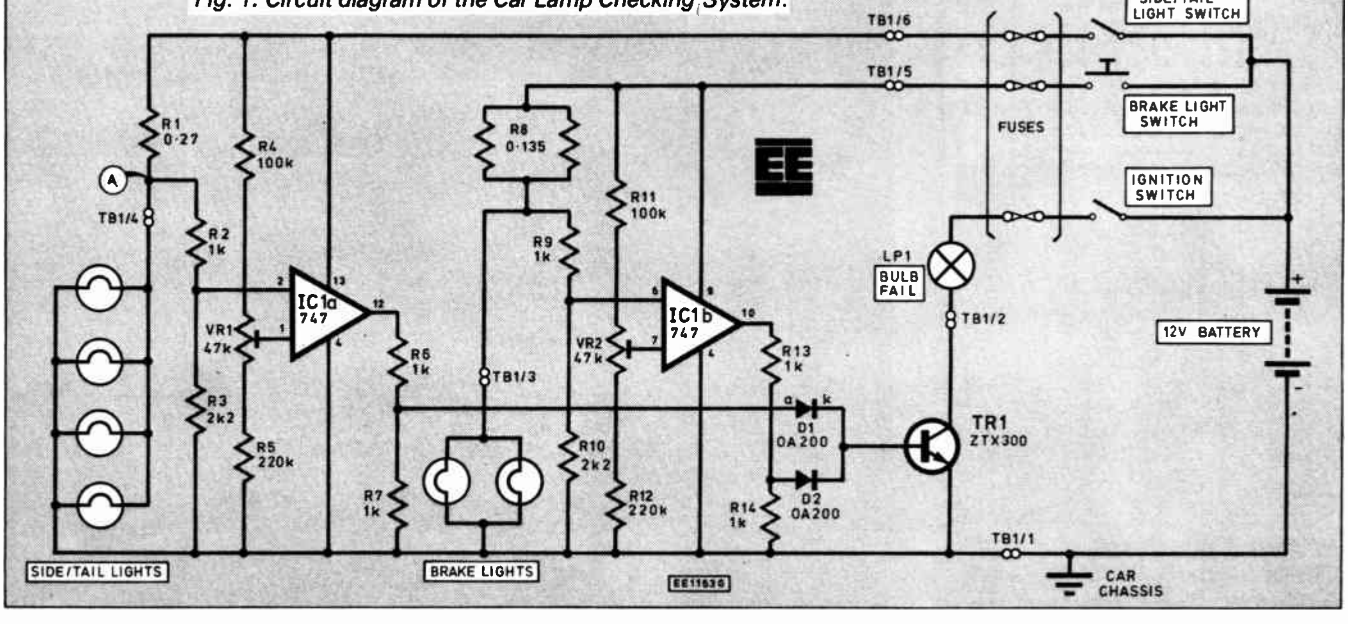
CONSTRUCTION

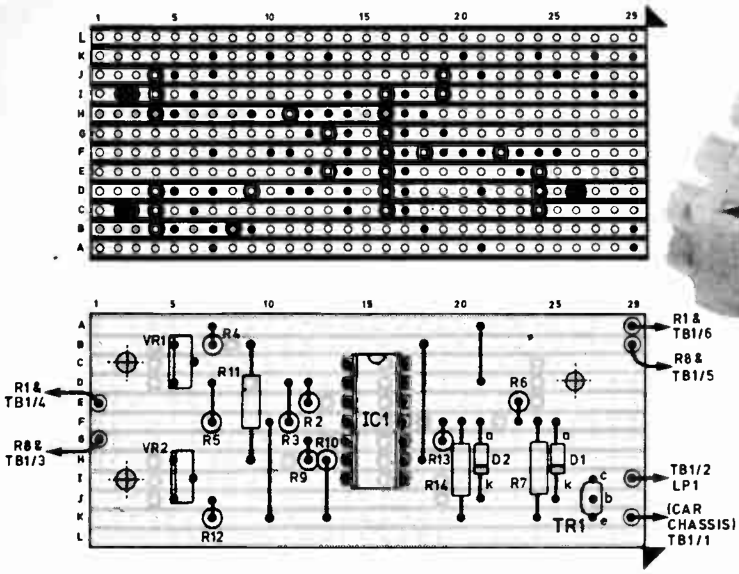
It is most important that an *aluminium* or *metal* box be used to house this circuit. Also, resistors R1 and R8 (two resistors connected in parallel) must be of sufficient power rating as specified in the components list.

Construction is fairly straightforward and is built on a single piece of 0.1in matrix stripboard, size 12 strips × 29 holes. The component layout and underside view showing breaks to be made in the copper strips is shown in Fig.2.

Begin by drilling the mounting holes, making the track breaks in the copper strips and soldering inter-strip link wires as indicated. Follow with the on-board components, noting the polarities of diodes D1 and D2. Solder

Fig. 1. Circuit diagram of the Car Lamp Checking System.





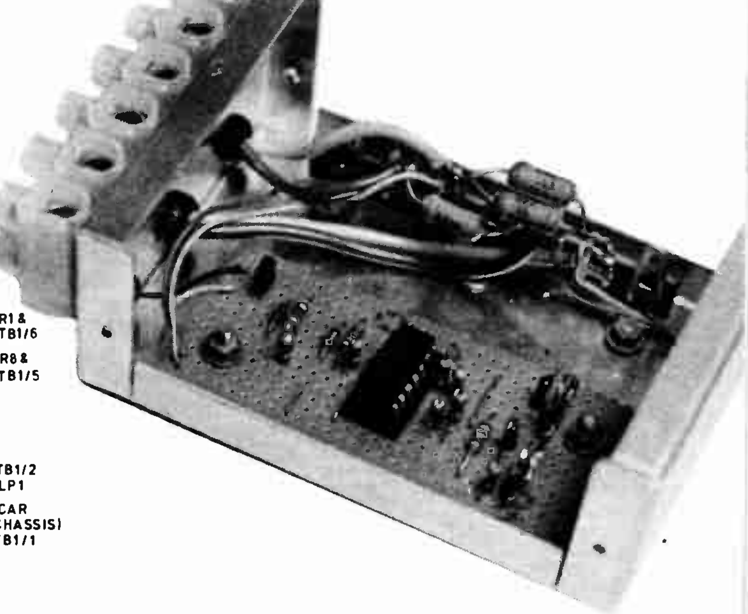


Fig. 2. Veroboard layout.

10cm pieces of light-duty stranded connecting wire to copper strips *E* and *G* at the left-hand side and *A*, *B*, *I*, and *K* at the right-hand side.

Drill holes in the base of the case to align with the mounting holes already drilled in the circuit board. Drill holes also for tag strip and terminal block mounting – see photograph. Drill holes near terminal block TB1 position to accommodate the wires passing through the case and fit rubber grommets. Attach remaining components using small fixings.

Mount the circuit panel with short spacers on the bolt shanks so that the copper strips remain clear of the metalwork. Complete all wiring noting that the connections between TB1/3,4,5 and 6 and the tag strip must be of stranded type with a rating of 5A minimum.

It is essential to route all internal wires well clear of resistors R1 and R8 otherwise the plastic insulation could be damaged by the heat. Note that the tags which are "earthed" to the case must NOT be used or short-circuits will occur.

The resistors connected to the tags must be soldered with care. Hook the ends through the holes in the tags firmly before soldering. Space the two resistors comprising R8 apart slightly to permit a free flow of air.

INSTALLATION

Before installing the unit, disconnect the car battery.

Locate the feed wire carrying current to the four side lights. This will probably feed the number plate light as well. Find a suitable place to break this wire following the switch and fuse. Refer to Fig.3 and connect the free ends to the terminal block TB1/4 and TB1/6 in the correct sense as indicated.

Next, locate the feed wire for both brake lights. This must be broken at a point following the switch and fuse. Connect the free ends to TB1/3 and TB1/5.

If any wires need to be extended, use automotive wire of 5A rating minimum and proper insulated connectors. Make certain that all connections are secure and will not dislodge in service. Connect TB1/1 to a nearby earth point (car chassis).

Choose a suitable place for the warning light LP1 and connect TB1/2 to one of its terminals. Connect the other terminal to the outlet side of a fuse which is live only when the ignition is switched on and mount the warning lamp on the dashboard.

SETTING UP

Re-connect the car battery and, with the lid of the case removed, switch on the side lights and ignition. Adjust preset VR1 until the indicator bulb is just off.

Now, remove a tail lamp to simulate failure of a filament. The warning light should come on. If it fails to do so, repeat VR1 adjustment more carefully.

Switch off the side lights and repeat the procedure with the brake lamps. If, as is usual, the tail light bulb has two filaments with the second one being used for a brake light then the operation is simplified. Otherwise, replace the tail light and remove a brake light bulb. Adjust preset VR2 until the warning light just remains off with the brake pedal pressed.

Check operation with the engine running – some small adjustments to VR1/VR2 may be needed. Over a trial period ensure that any heat developed by resistors R1 and R8 is not causing damage to wiring. The unit may now be mounted in position and put into permanent service. □

COMPONENTS

Resistors

R1,R8	0Ω27 3W (3 off – see text)
R2,R6,R7,R9, R13,R14	1k (6 off)
R3,R10	2k2 (2 off)
R4,R11	100k (2 off)
R5,R12	220k (2 off)

All resistors 0.25W 5% carbon (except for R1 and R8)

Potentiometers

VR1,VR2	47k sub-min. skeleton presets, vertical (2 off)

Semiconductors

D1, D2	OA200 (2 off)
TR1	ZTX300 *npn* silicon
IC1	747 dual operation amplifier

Miscellaneous

LP1 12V auto-type panel indicator with 12V bulb; Aluminium box, size 102 × 70 × 38mm external; 0.1in matrix stripboard, size 12 strips × 29 holes; Tag-strip – 7 tags required; 5A terminal block – 6 needed; 5A auto-type wire; light-duty auto wire; rubber grommets; Connectors and line fuses as necessary – see text.

Approx. cost Guidance only **£7.50**

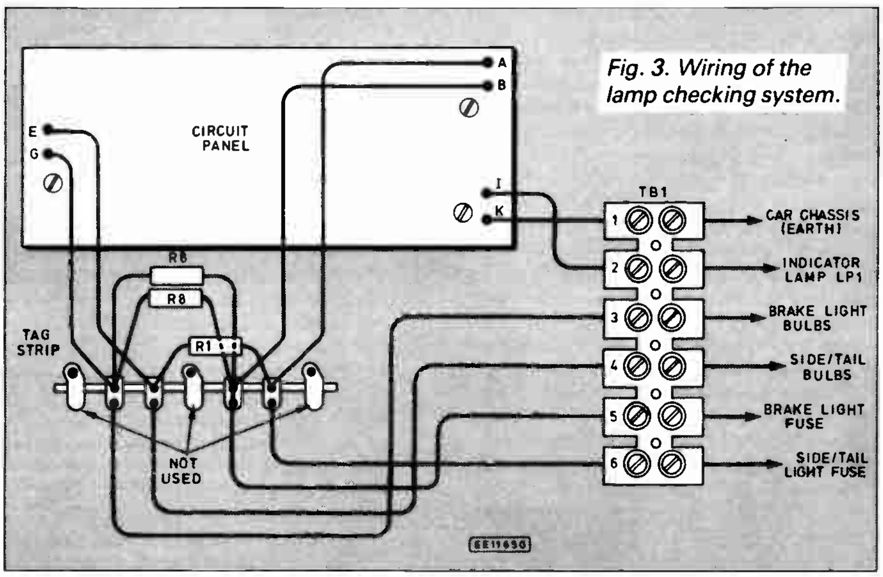


Fig. 3. Wiring of the lamp checking system.

DOWN TO EARTH

BY GEORGE HYLTON

FUNCTION GENERATORS

A READER asks: "What's a function generator?" It's really just a signal generator for producing special waveforms. The traditional kind of signal generator, used for testing radios, produces sine-wave signals. A sine wave contains no harmonics (overtones at multiples of the nominal frequency). This avoids the possible confusion of tuning a radio under test to a multiple of the wanted frequency in mistake for the true frequency. On the same lines is the audio signal generator, where purity of its sine-wave output is useful when testing amplifiers etc., for distortion. Many audio generators nowadays also produce square waves. This waveform is useful for checking amplifiers for types of distortion (transient distortion) such as "ringing" which don't show up on sine-wave tests.

VARIETY

A function generator is able to produce a wide variety of waveforms: square waves, triangular waves, ramp functions (waves which have a smooth linear increase in amplitude), sine waves and sometimes pulses. The generator is often based on a relaxation oscillator which produces symmetrical ("50-50") square waves; i.e. with positive and negative half-cycles of equal duration and amplitude. Other waveforms are produced by modifying these. For instance, passing a square wave through an integrating circuit turns it into a symmetrical triangular wave. This can then be distorted by diode circuits to shape it into an approximation for a sine wave.

The special waveforms of a function generator have applications in analogue computing and in testing servomechanisms and other types of control system. To give an easy example, suppose you have a fire alarm in which a temperature sensor generates a voltage which rises as the temperature increases. At some voltage the alarm is set to go off. It may be inconvenient to test this system by changing the temperature. The alarm part of the system (as opposed to the sensor) can however be checked by substituting a function generator for the sensor. The generator is set to produce, say, a slowly rising voltage ramp to simulate the sensor's output when a small fire makes the temperature creep up gradually. The user can then check that the alarm is triggered at the correct voltage.

In such tests it is often necessary for the generator's output to change very slowly. If the output is repetitive (e.g. a chain of ramps which fall back to zero after reaching a set amplitude then start rising again) the resulting frequency is low. This is why function generators commonly have low-frequency limits well below 1Hz. Indeed, the low limit may be only 0.01Hz or even 0.001Hz (one cycle per 1000 seconds) or less. The upper frequency limit may not be very high (100kHz, say) but tends to rise as improved models are produced. One reason for this trend is that function generators are nowadays often used to make tests on audio and sometimes video systems. Many now have a "swept frequency" facility for testing amplifier frequency response. In this case the generator is set to produce a constant-amplitude signal (usually a sine wave) whose frequency changes smoothly under the control of a ramp function. The ramp may in fact be the sawtooth time-base voltage of an oscilloscope used to monitor the amplifier output. In this case the amplitude of the vertical or Y axis gives the amplitude and the horizontal axis the frequency, so the amplitude versus frequency response can be observed.

A sweep function generator designed to be controlled by an oscilloscope in this way is described as having external sweep facilities. The ratio of highest to lowest frequency, the "sweep ratio" may be 1000, so that an audio amplifier response can be tested over a range such as 20Hz-20kHz. The upper and lower limits are selectable and in some generators the output frequency can be set to change logarithmically with time (which is handy for examining an audio or video response) or linearly (for looking at the response of a narrow-band tuned amplifier).

The simple Function Generator published as a project in our February 1986 issue (back numbers are available – see the Editorial page). This generator produces sine, triangle and square waves from 0.01Hz to 1MHz.

AUDIO TESTING

There is a case to be made for buying a function generator instead of an audio oscillator. As we've seen, the function generator can provide a bigger range of waveforms than the traditional sine and square of the oscillator, and in modern types can also provide swept frequency for looking at amplifier responses.

The main drawback is distortion. Since the sine wave output of a function generator is created by distorting its triangular wave output (usually, at any rate) and since this is not a precision process the distortion can easily be more than one per cent.

This is too great for making useful measurements of amplifier distortion. To measure distortion of 0.1 per cent (easily within reach of audio amplifier design) then you really want a sine wave with only a tenth of this distortion.

OUTPUT FILTER

The remedy is to pass the impure sine wave through a filter to remove the unwanted harmonics. For low frequencies such as 400Hz a low-pass LC filter is probably the best answer. The number of sections required will depend on how much reduction of distortion is needed. For most purposes a three-section filter should be adequate.

Higher audio-frequency sine waves can be cleaned up by driving a high-Q *LC* circuit through a high resistance. The resistance should be high enough to reduce the voltage of the generator by a factor of ten or more. Ferrite-cored coils from the frame circuits of TV receivers can sometimes yield suitable inductors.

Note that active filters based on op. amps are unsuitable. They may well generate too much distortion themselves.

RANGES

You may think from all this that the signal generator of the future will be a function generator with a very wide frequency range (say 0.001Hz to 1000MHz), with outputs of all waveforms likely to be needed for testing everything from burglar alarms to TV sets. The EVERYTHING GENERATOR, in fact. It would be rash of me to say that it will never happen, but I feel safe in saying that there's no immediate prospect for such a wonder.

Existing function generators are usually lacking in such features as high stability of frequency and wide-range, precise output attenuators. Their upper frequency limit is quite low – a megahertz or so. In fact, your average function generator is a source of relatively high-level (tens of volts), relatively low-frequency signals with a good variety of waveforms – and that's about it.

Even this limited performance can be expensive, on a hobbyist's budget scale (over £1000 for the best models). If you are in need of a general purpose signal source for your home laboratory and you don't need high frequencies then one of the cheaper function generators is worth considering, AFTER you have got yourself a decent oscilloscope and humdrum but essential aids like a multimeter and a versatile power supply unit.

...Beeb...Beeb...Beeb...Beeb

. . . RS423 Serial Port . . . Handshaking . . .

WHAT MUST be about the only standard BBC micro port to have so far eluded the attention of this series of articles is the Serial Port. This tends to be regarded by many as unsuitable for interfacing to user add-ons, and as something that is strictly for connecting to ready-made devices such as printers, plotters, modems, and the like.

While it is certainly true that the serial port is less easy to interface to user add-ons than the user port and 1MHz Bus, it is perfectly usable in this role. The added expense and complexity of using this route into and out of the computer is not justified in most cases, but there can be occasions when it represents the most practical port to use.

This is most likely to be the case when the other ports of the computer are already occupied, and will not provide an easy method of interfacing to your latest add-on. Another possible reason for opting for the serial port is that it enables bytes of data to be both transmitted and received over what is a maximum of five lines, and might need to be as few as three lines.

This could be useful for control of something like a "turtle" or another mobile device, where the fewer the connecting wires the better. Wide ribbon cables can be more than a little awkward with this type of unit.

A further advantage which could sometimes be crucial is that a serial link will work over relatively long distances. The maximum usable distance depends on the speed of data transfer and other factors, but at a modest baud rate a range of several hundred metres or more can generally be achieved. With parallel links even a range of two metres or so can be problematical, and long links are probably impractical anyway as the connecting cable would be prohibitively expensive!

Serial Basics

Before looking at interfacing user add-ons to the serial port, it would be helpful to take a more general look at this port. It is the 5-pin ("domino" style) DIN socket on the rear panel of the machine. Unfortunately, the matching plugs seem to fit into this port when they have the correct orientation, and when they are 180 degrees "out-of-phase".

Due care therefore needs to be taken when connecting anything to this port. With the 5-pin "domino" DIN plugs I have used, the cutout in the barrel of the plug is at the bottom when the plug is connected correctly.

Most serial ports are of the RS232C variety, but the serial interface fitted on the BBC machines is the very similar RS423 type (and *not* an "RS432" type as it often seems to be referred to). The two types of interface are largely compatible, and there should be no difficulty in using the BBC computer's serial port with RS232C equipment.

The main difference between these two standards is that many of the RS232C lines are not implemented on an RS423 interface, as can be seen from Fig.1 which gives connection details for a standard RS232C port and the BBC computer's version of an RS423 port. In

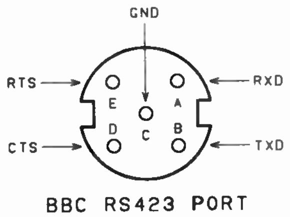
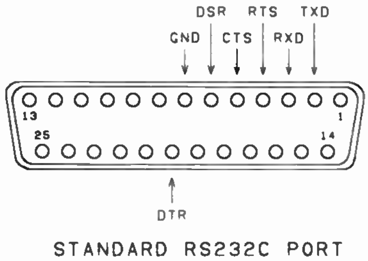


Fig. 1. The BBC computer's RS423 port, and the standard RS232C type (below).



fact a full RS232C port has more lines than are shown in Fig.1, but these are "secondary" types which are rarely implemented in practice Even with these, many of the terminals of the 25-way D-connector are not actually used.

Although there are clearly still a number of lines that are not available on the RS423 interface, this does not usually matter as the five lines that are included are sufficient for two-way data flow and handshaking. In fact, the extra connections available on an RS232C port seem to achieve nothing other than confusion!

There are other differences between the two types of interface, one of which is that the RS232C type operates with nominal signal levels of plus and minus 12V, whereas the RS423 type has signal levels of approximately plus and minus 5V. However, as an RS232C interface will operate at signal level of down to plus and minus three volts, this fact does not give any incompatibility problems.

The maximum output current of an RS423 port is higher than that available from an RS232C type, and RS423 interfaces are designed to be able to tolerate greater waveform distortion. This gives RS423 interfaces a longer operating range than RS232C types, but again, it does not introduce any compatibility problems between the two types of interface.

Timing Signals

In an earlier article in this series we considered the serial register of the user port 6522 VIA, and its use as a means of providing synchronous serial communications. The serial port operates in a somewhat different way, and it is a form of asynchronous serial interface.

Whereas a synchronous type has a data line plus a second line to provide some form of clock signal, an asynchronous system only has the data line (plus the earth connection of course). This can only operate properly if the

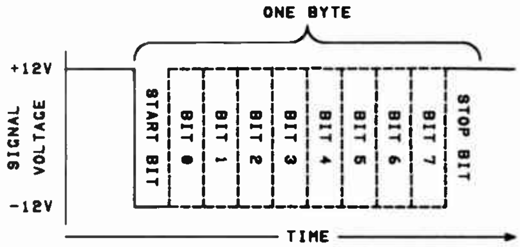


Fig. 2. The system used for RS232C/RS423 signals.

receiving equipment has some means of knowing when to test the state of the data line to determine the state of each bit of each byte. This is accomplished by having timing signals transmitted with each byte of data.

Strictly speaking, there is only one timing signal sent with each byte of data, and this is the start bit. This is simply a change from the quiescent state of the data line to the active level, and it indicates to the receiving circuit that it must check the state of the data line at regular intervals thereafter, until the state of each bit has been determined.

The bits are sent in sequence, starting with the least significant one and working through to the most significant bit. One or two stop bits are included after the data bits, but during these the data line is taken to its quiescent level.

The stop bit or bits are really just a minimum gap between bytes to ensure proper operation of the system. The serial waveform diagram of Fig.2 helps to explain how this system operates, and it assumes that the word format is the BBC computer's default type of one start bit, eight data bits, and one stop bit.

There is the option of using parity, which can be of the odd or even variety. This is a simple method of error checking, and the general idea is to always have either an odd or an even number of bits sent in each byte. This requires the sending device to add an extra bit into some bytes in order to provide parity, and any additional bit is sent immediately after the last data bit.

The receiving equipment can check that a suitable number of bits are present in each byte, and any dropped or added bit should be detected. A double glitch will go undetected though, and the parity system of error checking seems to be little used in practice.

Serial Numbers

For this system to work properly, it is essential that data is transmitted at a standard rate so that the receiving equipment can sample the data line at the appropriate times. There are a number of standard baud rates, ranging from 45.45 to 19200, and the BBC machine can handle most of these. The baud rate is merely the number of bits sent each second with a continuous stream of data.

An important point to note here is that it is the number of bits per second, and not the number of bytes. With about ten bits per byte (allowing for start and stop bits), a fairly high baud rate of 9600 will still represent a maximum transfer rate of under one thousand bytes per second. This relatively slow rate of data interchange is something of a drawback, although I suppose that most control and measurement applications do not require the transfer of large amounts of data, and serial links are adequate for most purposes.

A useful feature of the BBC computers is their ability to have different transmitting and receiving baud rates. These are controlled separately by the *FX7 and *FX8 series of operating system commands.

The serial port is properly integrated into the operating system, and it can be used as a standard input/output device. The *FX2 and *FX3 series of commands are used to control the input and output of the computer. All these commands are detailed in the appropriate section of the manual, and will not be considered further here.

One of the special chips in the BBC computer is the serial ULA. This has led to some users gaining the impression that this device is wholly responsible for providing the RS423 port. In fact the main device behind this port is an ordinary 6850 serial interface chip, supported by the ULA which generates a variety of firmware controlled clock frequencies that govern the baud rate.

The main function of the ULA incidentally, it to provide the cassette interface. The 6850 is also supported by line driver and receiver chips which interface the standard logic signals of the 6850 to the RS423 signal voltages and currents.

The 6850 occupies only two addresses in the memory map. Data is written to and read from address &FE09, while address &FE08 is the location of the control/status register. I have never experienced any problems in reading and writing direct to this chip when dealing with data (provided a second processor is not in use of course).

Direct use of the control register is a different matter, and one problem is simply ensuring that altering some bits to the required states does not result in other bits being accidentally altered. Apart from this, data sent to the control register seems to be quickly returned to the default settings by the operating system anyway.

The 6850 is capable of eight different word formats, but there is no official way of changing the default format on the BBC model B (this can be achieved via the "control panel" feature on the Master 128). The hackers method is to use the operating call: –

*FX156,x,227

where x is the value to be written to the appropriate three bits of the control register (bits 2, 3 and 4).

As this is not an official Acorn way of doing things I cannot guarantee that it will always be successful, but it seems to work properly with my BBC model B. The list below shows the available word formats, and the value for x needed to select them.

Data Bits	Stop Bits	Parity	x Value
7	Even	2	0
7	Odd	2	4
7	Even	1	8
7	Odd	1	12
8	None	2	16
8	None	1	20
8	Even	1	24
8	Odd	1	28

Compared to the number of word formats available from most other serial interface devices this list is decidedly short, but this range is sufficient for most purposes. For use add-ons the default setting of eight data bits, no parity, and one stop bit is probably the best. It gives full 8-bit bytes, and it uses the minimum possible number of bits (including stop and start bits) per byte which aids fast data exchange.

Interconnections

For the most basic form of two way communications only three interconnecting wires are required. The "ground" terminal on one port is connected to the "ground" terminal on the other, while the "TXD" (transmitted data) and "RXD" (received data) terminals are cross coupled.

This system is satisfactory for modems and other devices where the receiving device will always be able to keep up with the flow of data from the computer. With these, it is also assumed that the computer will be able to handle a continuous flow of data.

Some applications require the use of handshaking to control the flow of data. For

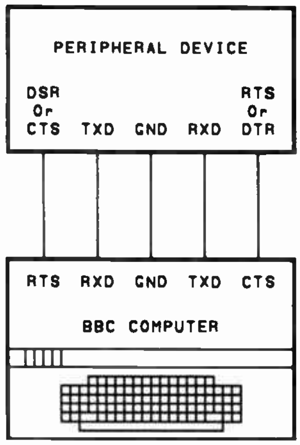


Fig. 3. Connections to provide two way communications with full handshaking.

example, with a printer it is quite possible that it would be unable to keep up with the flow of data, even if a fairly low baud rate was to be used.

The handshake lines enable a receiving device to indicate to the sending device that transmission of data must be halted and restarted, as required. This operates on the basis of the handshake line being taken high to enable data to be sent, or taken low to halt the data flow. Fig.3 shows the method of interconnection required for two way communications with full handshaking.

The BBC computer's RTS and CTS terminals will normally need to connect to the DSR and RTS terminals (respectively) of the other serial port. However, if this fails to work properly, then using the CTS and DTR terminals instead might give better results.

It is often necessary to do some experimentation with serial interfacing before satisfactory results are obtained. An RS232C Breakout Box (as in the June 1987 issue of *Everyday Electronics*) is more than a little useful for anyone engaged in this type of interfacing.

This covers the basic in and outs of the serial port.

Next month we will look at serial to parallel conversion, and using the serial port with user add-ons.

EE CROSSWORD ANSWERS

1 MASTER SLAVE
8 HUE
9 RAMP
10 IRON
11 TRACE
13 PAUSE
14 RADIAL
16 ANALOG
18 SLOTTED
20 TRAIN
21 ENABLES
22 CUE
23 EDIT
24 ALARMS

DOWN
2 ATE
3 THREE
4 RUMBLE
5 VIRTUAL
6 PHOTORESIST
7 KNEE
12 AUDIO HEAD
13 PIN
15 ATTRACT
17 GANGED
19 DELTA
20 TESLA
22 CPM

Robot Roundup

NIGEL CLARK

EURO PING-PONG

THE ROBOT ping-pong contest continues its unsteady course, overcoming huge apathy each year to find enough contestants to stage a competition of sorts. This year's European Finals in Portsmouth attracted another international field and British pride was again satisfied by producing the winner, the same as in past years.

Put that way it sounds fine. But the facts were that there were four contestants from three countries, the winner being decided by the machine which was most likely to achieve a hit of the ping-pong ball. As contest-watchers will realise, that is by no means a foregone conclusion.

The winner again was John Knight, a technician at Portsmouth Polytechnic. His was the only machine to manage a hit. The Swiss machine, despite vast expenditure on high-powered processors and television cameras providing vision, came second with an effort which was close to success but failed to connect.

Britain's second entry, as usual from the Teesside GP Dr John Marr, responded to the ball while in flight, but unlike previous contestants, failed to move to the correct position to make contact. The final entry from Finland hardly passed the starting line, let alone reached the finish, having, in the words of John Billingsley, the contest organiser, just twitched a bit.

The biggest disappointment was the lack of progression of the entries compared with the machines seen in the last contest earlier this year. Both Knight and Marr have been involved since the start, winning all the rounds in the contest so far but development work seems to have slowed considerably.

It is thought that the lack of competitors is taking the edge off the incentive to make improvements.

When Billingsley, head of the Department of Electrical Engineering at Portsmouth Polytechnic, came up with the idea of a robot ping-pong contest in 1983, there was a lot of interest from all over the world, particularly the US. Some started to develop devices and it was hoped that when contests began to take place others would be encouraged to follow. However, the opposite appears to have been the case.

ROBOT SCHOLAR

Opinions differ as to the level of education at which the problems could be tackled but everyone involved, both organisers and contestants, think that it would be an ideal subject for setting projects. It is, after all, an important area of robotics, trying to match human dexterity in hand-eye co-ordination. Systems can be much more flexible if they have the ability to react more quickly to changes in their environment.

Billingsley thought that schools would not have the necessary level of expertise but polytechnics and universities would have no problem. Dr Marr considered that much could be learnt by all levels of student even if they only tackled one of the problems involved. *"It would be ideal even just to the extent of building an arm under joystick control. To do that you need servo and feedback theory,"* he said.

Oxford University has already taken that on board and since 1985 final year degree students have been looking at the problem and appear to have got further than those who have been entering the contest. David Witt, lecturer in engineering picked up the idea and said that the students had succeeded in building a machine with a hit rate of about one-in-three.

He added that the mechanical side had been completed, more or less, but it was still short of a device to give a power hit rather than merely letting the ball bounce against the bat.

It is unlike other machines in that it does not have a vision system but uses sonar to locate the ball. The major effort at the moment is being put into developing a system for processing the information to allow the bat to be in the correct position every time.

The machine as it stands has been developed by successive students, usually two each year but only one this. They write up the work they have done as the practical part of their degree. New students take up where the previous ones have finished.

Witt thinks the idea worthwhile; there is such a diversity of disciplines involved.

INDIVIDUAL APPROACH

Not that it needs the resources available to educational establishments to be able to develop a worthwhile machine. As already mentioned, the regular winners of the contests held so far are both individuals who can call on little other than their own knowledge, experience and funds. Even a busy general practitioner like Dr Marr can find the time to build a device which, while not having a lot of success at the moment as modifications are made, has shown in the past that it can be an able competitor.

He did start with a small advantage, having a physics degree, taken before his medical qualifications. However, when he was doing his studying, valves were still the main driving force in electrical equipment. He then had to learn about transistors and eventually catch up with the latest chip developments.

The interest in robotics began when Dr Marr converted an old Big Trak into a computer-controlled mobile, with sensors, which understood Logo. He was attracted to the idea of robot ping-pong as soon as he saw a series of articles on it by Billingsley.

Like most builders, he began with the bat mechanics, producing an arm-like device with a bat on the end. Since then, working on it for about three evenings a week, he has been developing and processing the information needed to tell the bat where to go.

He followed the usual vision system path and at present is using a 32K RAM camera. He plans to use two to build up a three-dimensional picture of the ball in flight. That requires a large amount of software, the part of any ping-pong machine where the major difficulties seem to occur.

Information on the ball's position can be obtained easily but converting that into instructions quickly enough to be useful is much more complex.

ZURICH WORKSHOP

Despite the problems Billingsley will not give up. It is always possible that someone is already working on something which will advance the development and may even go a long way towards finding a solution. Whatever the state of their progress Billingsley would like to see them in Zurich next year where a workshop to swap ideas is being held.

Anyone with any interest in the event can contact him at Portsmouth Polytechnic.

Dr. John Marr with his ping-pong robot (Photo courtesy of Evening Gazette Middlesbrough).

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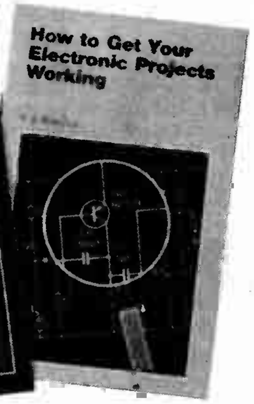

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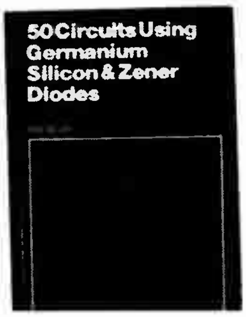

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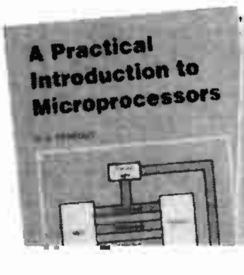

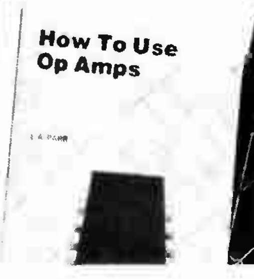

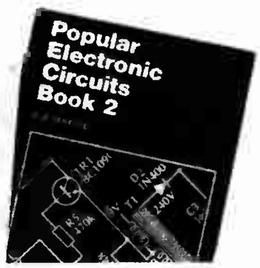

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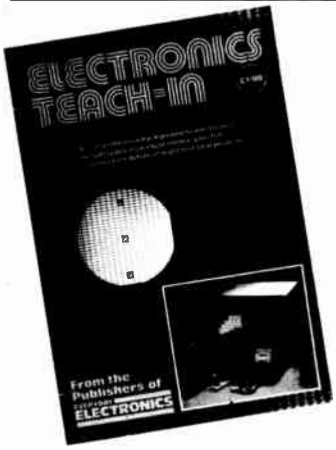

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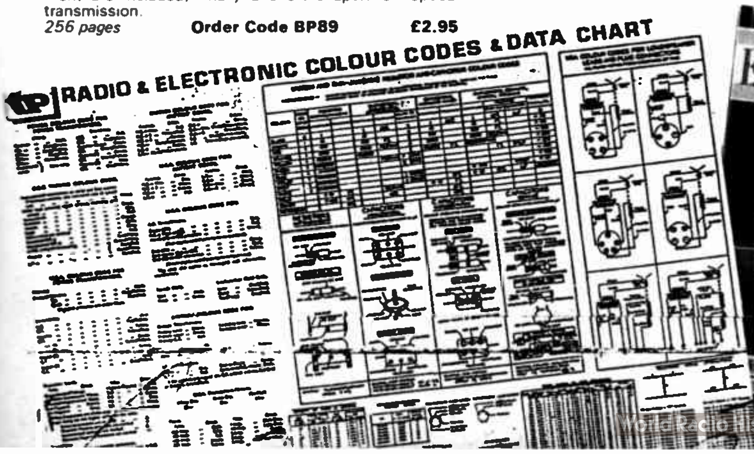

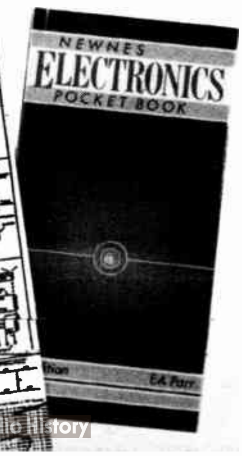

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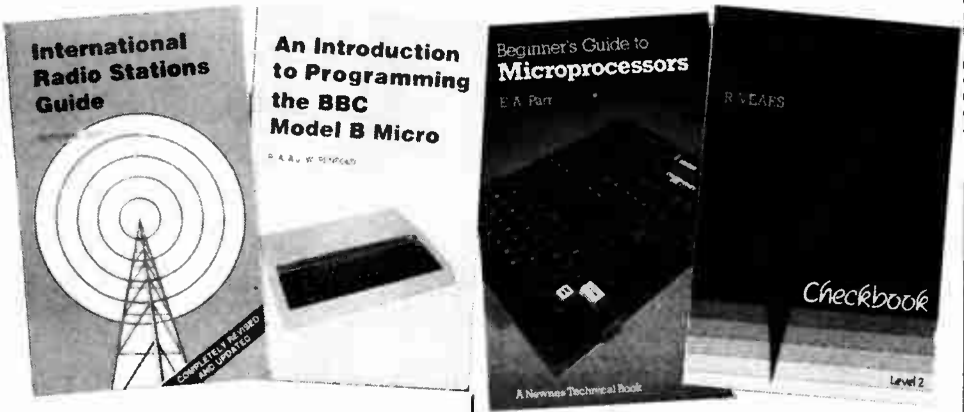

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a regular feature for the Spectrum Owner...

by Mike Tooley BA

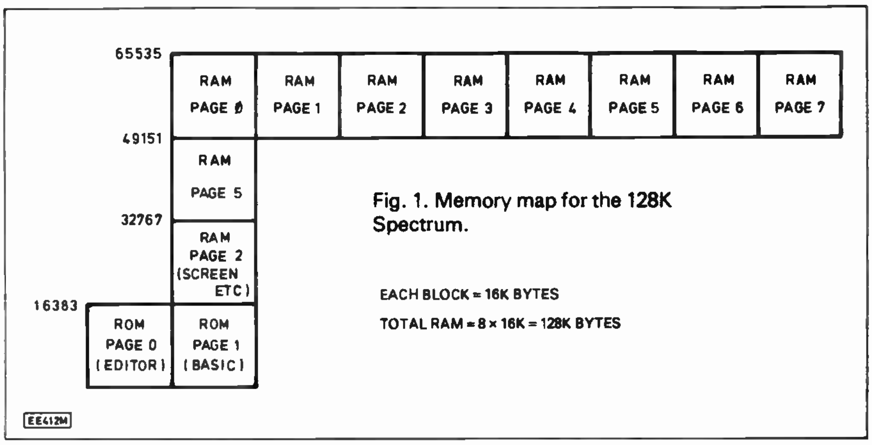


Fig. 1. Memory map for the 128K Spectrum.

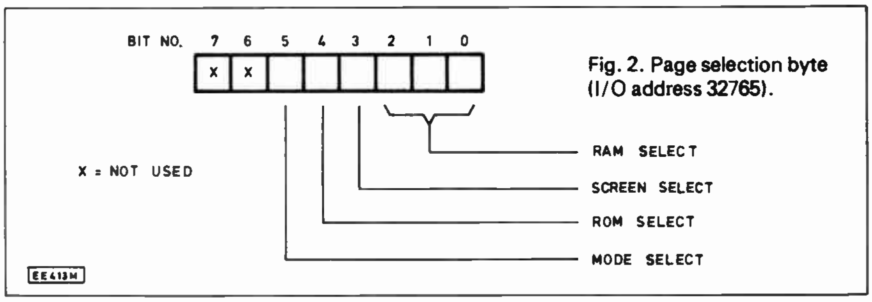


Fig. 2. Page selection byte (I/O address 32765).

LAST MONTH we discussed the topic of interrupts and interrupt handling. This month, as we enter our fourth year of *On Spec*, we shall be delving into the system of paging used on the 128K version of the Spectrum.

Owners of older versions of the machine have not been forgotten as we shall also describe some details for those of you who wish to attempt DIY keyboard modifications.

Which Version?

Last month I made some rather sweeping statements about the future of the +3 machine and several readers have taken me to task for taking a rather pessimistic view of the long term future for the Spectrum. In fairness, I did not (as other writers have done) suggest that the +3 will be the last Spectrum to appear. Indeed, I fervently hope that the good old "Speccie" is guaranteed at least a few more years of life! At the least, the appearance of the +3 shows that Amstrad is sufficiently interested to further continue the Spectrum line.

Unlike the vast majority of other low-cost microcomputers, the Spectrum is rapidly becoming something of an unusual beast simply by virtue of the fact that it has survived nearly six years in the face of considerable competition and the emergence of a number of arguably superior machines.

To put the record straight, the six versions of the Spectrum released in the UK are briefly summarised below:

Variant	Approx. year	Distinguishing features
Spectrum 16K	1982	Nasty rubber keyboard and notoriously unreliable.
Spectrum 48K	1983	Nasty rubber keyboard and still unreliable!
Spectrum +	1985	Improved keyboard (though still a membrane type). Larger case with improved ventilation. Improved reliability.
Spectrum + 128K	1986	Same styling and keyboard as the +2. Large heatsink fitted externally. Extra paged RAM.
Spectrum + 2	1986	Excellent keyboard and improved editor. Internal cassette drive.
Spectrum + 3	1987	Similar styling and keyboard to that used for the +2. Internal cassette drive replaced by a 3in disc unit.

Paging the 128K

In recent months, several proud owners of 128K and +2 machines have written to ask for details of the system of paging used in the later Spectrum machines. Most readers will be well aware that the Spectrum's Z80 microprocessor can only address a total of 64K of memory so the mechanism which allows the computer to support an additional 64K or RAM is of particular interest.

The memory provided within the 128K Spectrum is divided into 16K blocks or "pages" as shown in Fig. 1. Eight of these blocks are semiconductor Random Access Memory (RAM) whilst two are semiconductor Read Only Memory (ROM).

The two ROM devices occupy the same 16K area at the bottom of memory (addresses 0 to 16383 decimal). Naturally, only one ROM device can be selected at any particular time.

In 48K mode, the original Spectrum BASIC ROM is selected whilst, in 48K mode, the system selects either the 128K Editor ROM or the original BASIC ROM as required. The Editor ROM is said to occupy Page 0 of ROM whilst the BASIC ROM occupies Page 1.

The next 16K of memory (addresses 16384 to 32767 decimal) is read/write storage used for a variety of functions including the screen memory (7K), system variables, and program storage. Page 2 of RAM is reserved for this function.

The next block of memory (addresses 32768 to 49151 decimal) is again used for read/write purposes. This region of memory is almost invariably used for program storage. Page 5 of RAM occupies this area.

The highest 16K of memory (addresses 49151 to 65536 decimal) usually provides several functions. These may include further program storage, an area (protected above RAMTOP) for storing machine code routines such as printer drivers), and storage for User Defined Graphics (UDG). Page 0 is normally located in this area however Pages 1 to 7 may also be used (the latter is employed when the 128K Editor is in use).

Memory paging is controlled by means of I/O address 32765. The bit pattern written to this address operates on the following basis:

(a) Bits 7 and 6 are unused
(b) Bit 5 determines the mode of operation (when set to 1 the machine is operated in 48K Mode otherwise 128K Mode is selected)
(c) Bit 4 determines which ROM is selected (when set to 1 the BASIC ROM is selected otherwise the Editor ROM is selected)
(d) Bit 3 determines which Page of RAM is used for the Screen. The bit is normally 0.
(e) Bits 2 to 0 determine which Page of RAM occupies the top 16K of memory. Page 0 is selected when all three bits are 0, Page 1 when the bits are 001, and so on. Page 7 is used when the Editor is in operation in which case the bits are all 1s.

Unfortunately, moving pages of memory around is not quite as straightforward as it may seem; it is not just a simple question of writing the appropriate bit pattern to address 32765! Various precautions must be taken including

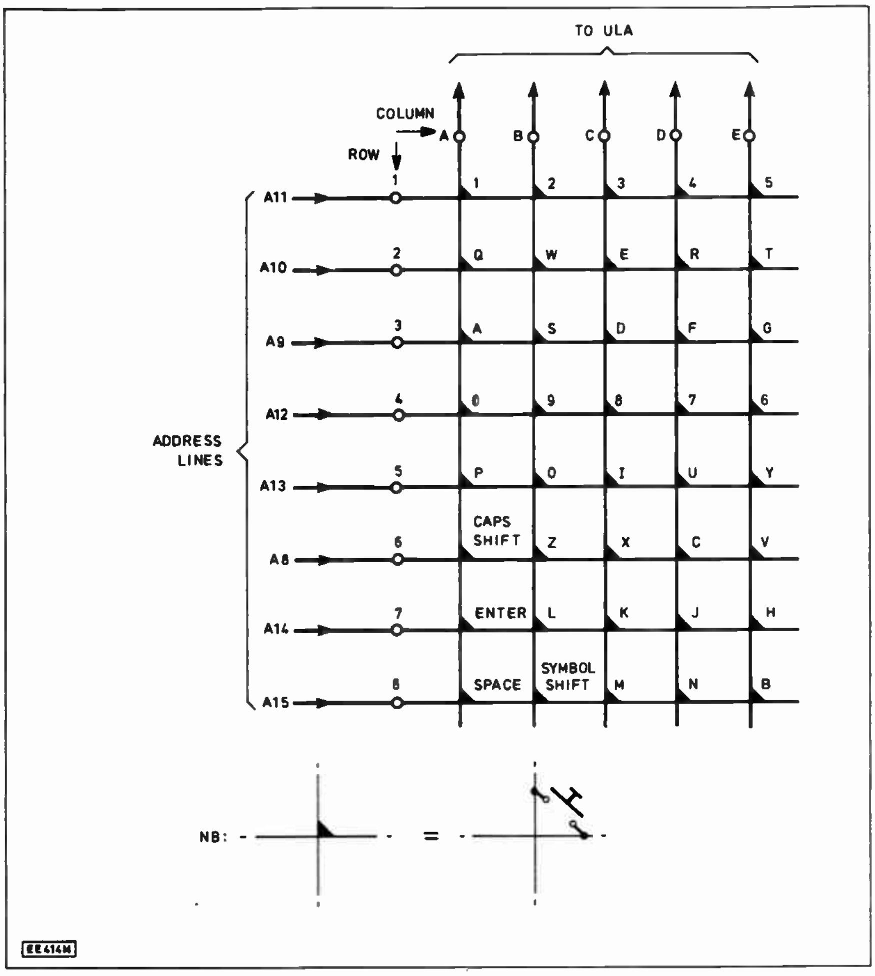


Fig. 3. 16/48K Spectrum keyboard matrix.

ensuring that the correct ROM is selected and that the stack (resident in Page 0) is replaced after using another page of RAM in the top of memory.

It is also essential to disable interrupts (see last month) before attempting to write data to I/O address 32765 and re-enable them after modifying the paging. A copy of the last byte written to I/O address 32763 is, however, held in the System Variables area at memory address 23388. This address can be PEEKed with impunity and will return a value which indicates the current state of paging.

DIY Keyboard Modifications

Another favourite query received from readers concerns modifications to the "dead-flesh" keyboard fitted on the early 48K versions of the Spectrum. In particular, readers often ask if it is possible to provide single key entry of BREAK, ;, and ".

This can be achieved quite easily with the aid of double-pole keyswitches or diodes. Fig. 3 shows the 5 × 8 keyboard matrix arrangement and its two connections to the Spectrum (easily identified on the p.c.b.) whilst Fig. 4 shows how the three aforementioned additional keys can be fitted. Each of these returns a character which would normally require two keys to be held down simultaneously.

Next month: we shall be rolling up our shirt sleeves in preparation for another hardware project. This will take the form of a Versatile Add-on I/O Port capable of generating and accepting TTL compatible signals as well as controlling high current d.c. and a.c. mains connected loads.

If you would like a copy of our *"On Spec Update"*, please drop me a line enclosing a large (at least 250mm × 300mm!) stamped addressed envelope. **Please note,** *due to an enforced change in my daytime workload, I am now unable to provide readers with individual replies to any queries.* I shall, however, still attempt to provide solutions to common problems via this column.

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

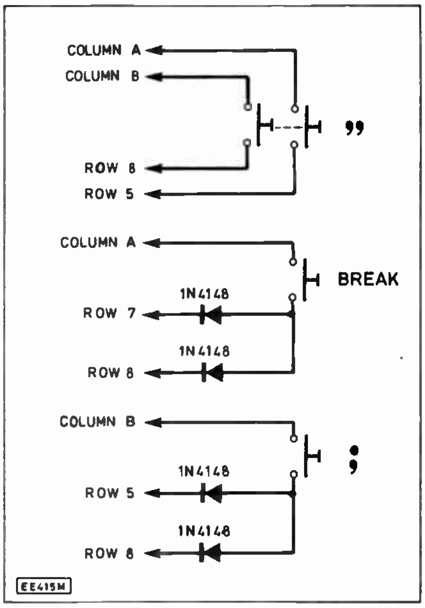
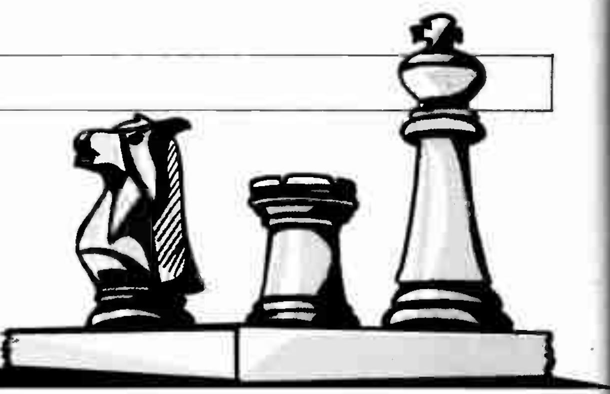


Fig. 4. Adding ", BREAK, and ; keys.



GAME TIMER

S. NIEWIADOMSKI

An easy-to-build project that will ensure everyone has an equal opportunity when game playing.

It can be very annoying if some people in a group playing a board game take much longer than everyone else to have their go. This can cause arguments and players might become so fed up that the game is finally abandoned. By using this Game Timer, however, you can ensure that everybody gets an equal amount of time and things should proceed much smoother.

The timer gives an audible indication of when most of the time for a turn has elapsed by sounding a series of bleeps. When all the time has gone, a continuous tone sounds and the next player presses a Reset button to time his go. The speed at which the timer runs is variable from a front panel control, allowing different settings to be used for different games or different levels of expertise of the players.

CIRCUIT DESCRIPTION

A block diagram of the Game Timer is shown in Fig. 1 and this should help to clarify the final circuit diagram, Fig. 2. The following explanation should be read in conjunction with the timing diagram, Fig. 3.

The three NAND gates IC1b, IC1c and IC1d form a low frequency oscillator whose frequency is determined by capacitor C1 and the series combination of resistor R1 and potentiometer VR1. Resistor R1 is required to set the minimum value of resistance between the output of IC1b and the input of IC1d to 22kilohm. The minimum and maximum resistance settings of VR1 give frequencies of approximately 3Hz and 0.7Hz respectively.

COUNTER

Positive edges of the output clock from IC1b increment IC2, a 4520B dual 4-bit counter, which is connected to act as a single 8-bit counter by connecting the Q4A output of the first counter (pin 6) to the Enable input of the second counter (pin 10). Only six bits of the counter are used in this application. The reset inputs (pins 7 and 15) of IC2 are pulled down to 0 volts (that is, to their non-resetting state) by resistor R2 while the Reset switch S1 is not pressed.

After 24 clock cycles the Q4A and Q1B outputs of IC2 are at logic 1, setting the output of NAND gate IC1a to logic 0. This allows clock pulses through IC3b.

While the Q2B output of IC2 is still at logic 0, these clock pulses are also allowed through IC3c, enabling bursts of oscillation of the audio frequency oscillator formed by IC4a, IC3d and IC4c. These bursts of oscillation warn the player that the allowed time period is coming to an end.

This oscillator operates at approximately 1.5kHz, and drives WD1, a piezo-electric transducer, via resistor R3. The frequency of this oscillator can be changed if desired by altering capacitor C2 and/or resistor R4, but do not reduce R4 to less than 22kilohm.

Different values of R3 can be tried to set the desired volume level from WD1. The volume obtained depends on the supply rail voltage used and on the prototype, which had a supply of 6V, a short-circuiting link was fitted for R3.

After eight bursts of tone output, the Q2B output (pin 12) of IC2 goes to logic 1, forcing the output of IC3c to logic 0 and permanently enabling the audio oscillator. This continuous tone output indicates that the time allowed is over and the next player must press the Reset button to turn off the audio oscillator and restart the timing period.

In fact, the eighth burst of tone and the continuous tone merge together, as can be seen from the timing diagram, and so only seven discrete bursts are heard before the continuous tone sounds.

Fig. 1. Block diagram of the Game Timer.

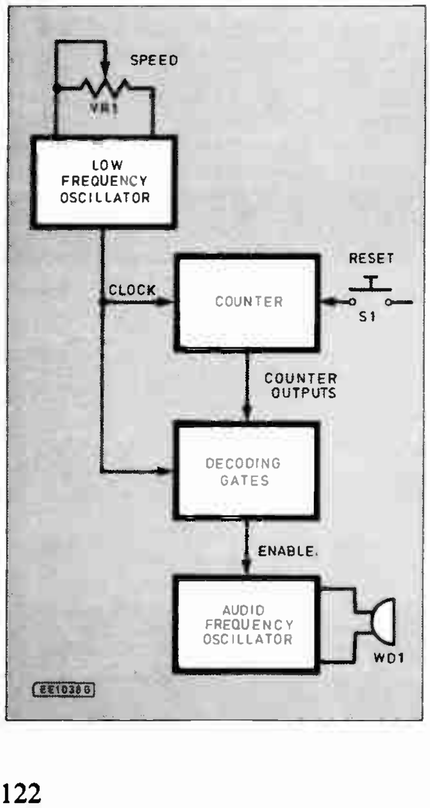
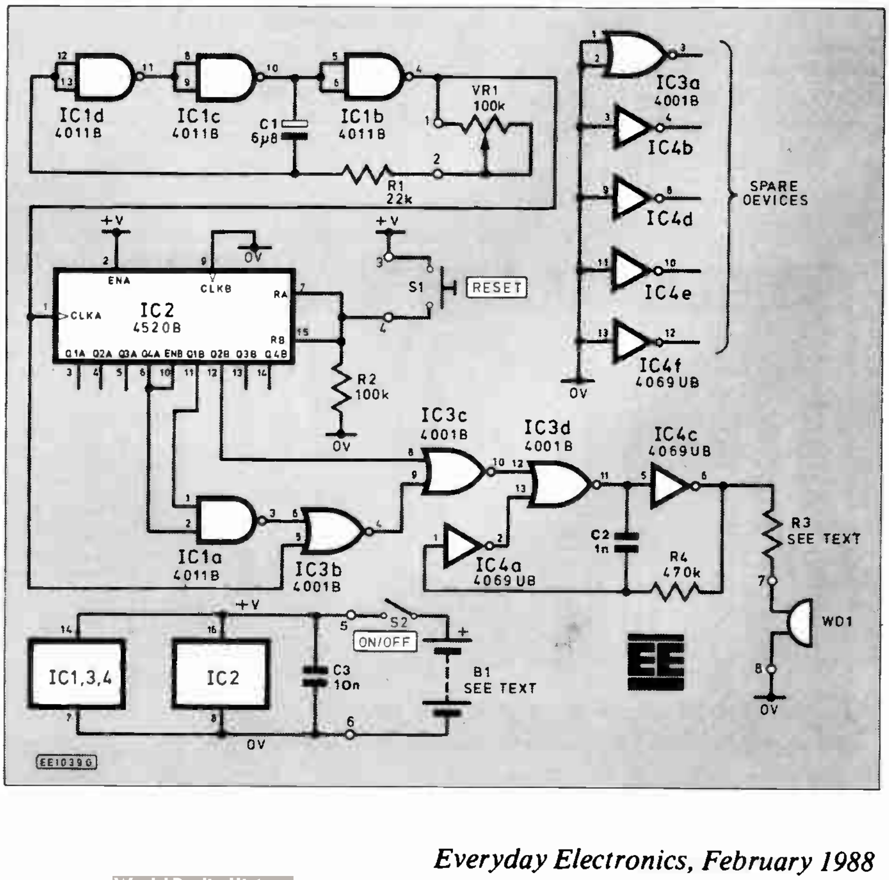


Fig. 2. The complete circuit diagram for the Game Timer. The terminal numbers on the circuit refer to solder pin locations on the circuit board.



The inputs of the unused gates in IC3 and IC4 are connected to 0 volts. This is especially important with CMOS devices as leaving inputs floating can lead to static damage and over-dissipation.

Using CMOS devices exclusively in this timer has two advantages: firstly, the current consumption is very low, giving the batteries an endurance close to their shelf life, and secondly, CMOS is very tolerant of the supply voltage applied to it, allowing a wide range of battery options.

It is possible to operate CMOS from 3 volts to 15 volts, and so with this timer, the batteries used could sensibly range from say two AA size batteries in series to a single PP3 type battery. The prototype used four AA size batteries mounted in a suitable holder.

ETCHING

When all the tracks and the common plane have been drawn, allow the ink to dry for at least 15 minutes. Then insert a length of insulated wire through two of the fixing holes. Immerse the board into a bath containing ferric chloride solution and gently agitate the board using the wire until etching is complete.

The bath *must* be non-metallic, of course. Take precautions to avoid coming into contact with the ferric chloride and be careful not to splash eyes, clothes, work surfaces, etc. Consult the supplier of the chemical for precise handling instructions.

Because so little of the original board surface is exposed, etching should be rapid and very little of the ferric chloride will be used up. When etching is complete, remove the board from the solution, rinse it and clean off the resist ink with a suitable solvent.

All the holes (other than the 3mm fixing holes) in the board should then be drilled with a 1mm drill and a start made on mounting the components on the board.

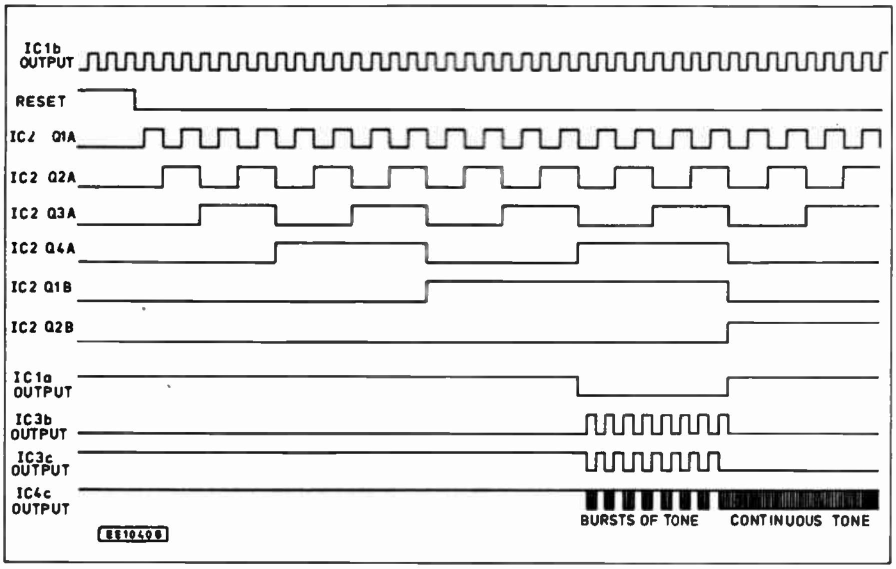


Fig. 3. Typical timing waveform sequence for the Game Timer.

MAKING THE PRINTED CIRCUIT BOARD

The etching pattern (full size) and printed circuit board component layout for the Game Timer is shown in Fig. 4. This board is available from the *EE* PCB Service, code EE583.

For those readers wishing to make their own boards, the component and track spacings have deliberately not been cramped so that the p.c.b. can be reproduced easily by hand using an etch-resist pen. Many of the component stockists also stock p.c.b. kits and are able to supply the etch-resist pen and ferric chloride separately.

The first stage in producing the p.c.b. is to photocopy the etching pattern or trace the hole positions onto a piece of translucent paper. Cut a piece of single-sided copper-clad board to the correct size and stick the photocopy or tracing onto the board.

Mark the position of each hole (including the 3mm fixing holes) onto the board with a centre punch or similar sharp tool. Then remove the paper and drill and de-burr the fixing holes. Clean the board with a liquid abrasive cleaner such as Jif, rinse and dry it.

The track pattern can then be drawn carefully on the board, using the hole marks as a guide to the track positions. Only the smallest amount of copper needs to be removed from the board, leaving a fairly large area of "earth" or common plane. An earth plane like this helps the performance of high frequency circuits but in this project simply saves ferric chloride and speeds up the etching of the board.

COMPONENTS

Resistors

R1	22k
R2	100k
R3	see text
R4	470k

All 0.25W 5% carbon

Potentiometer

VR1	100k lin. carbon

Capacitors

C1	6µ8 tantalum bead
C2	1n ceramic plate
C3	10n disc ceramic

Integrated Circuits

IC1	4011B quad 2-imput NAND gate
IC2	4520B dual binary counter
IC3	4001B quad 2-input NOR gate
IC4	4069UB hex inverter

Switches

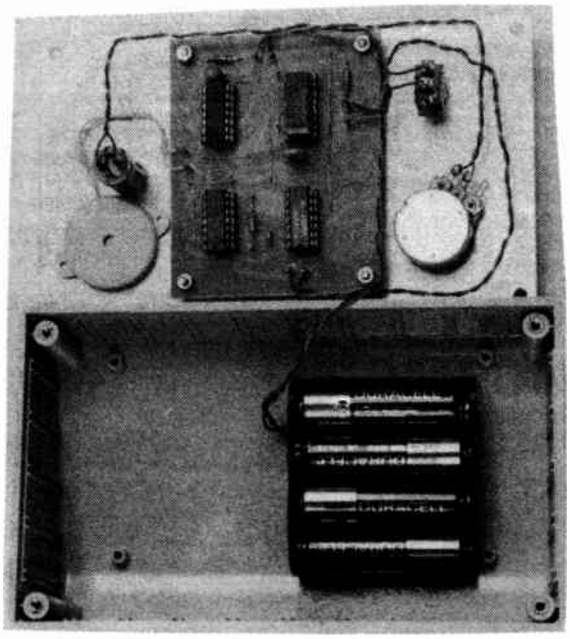
S1	momentary action push-to-make
S2	miniature single pole on/off toggle

Miscellaneous

WD1 piezo-electric encased element, type PB2720

Printed circuit board, available from *EE PCB Service*, code EE583 (see page ●); 16-pin i.c. socket; 14-pin i.c. sockets, 3 off; 1mm solder pins, 8 off; case, 161mm × 96mm × 61/39mm, with sloping front; 4 × AA battery holder, with batteries; control knob; connecting wire; 6BA countersunk screws, nuts etc.

Approx. cost Guidance only **£ 12.50**



CONSTRUCTION

Referring to the component layout, Fig. 4, the board construction can now commence. i.c. sockets can be used to mount IC1 to IC4 and these can be very helpful during testing, allowing a suspect i.c. to be removed without fear of damaging it or the p.c.b. Since all the i.c.s used are CMOS devices, take the normal handling precautions and ensure that your soldering iron is earthed.

The links required on the board can be made from bare wire as their spacing means there is no danger of adjacent links shorting together. In Fig. 4, R3 is shown as a resistor: it is probably best to fit a link in this position initially, fully assemble the timer into its case and then determine whether the volume level is acceptable. If it is too loud, the link can be removed and different values of resistance, starting at say 1 kilohm, can be tried.

On the prototype, 1mm solder terminals were used for off-board component connections. These give a neat finish and allow connections to be soldered and unsoldered without having to remove the board from its mountings to obtain access to its underside.

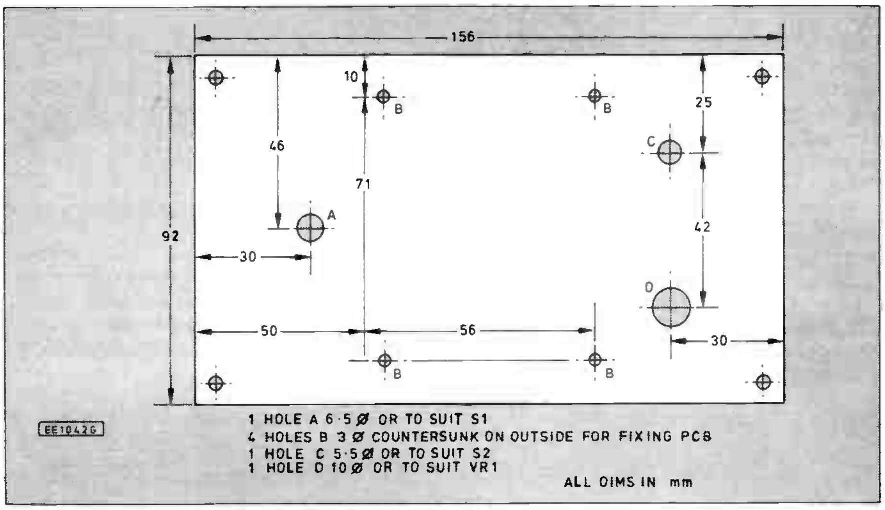


Fig. 5. Drilling details for the front panel (viewed from inside).

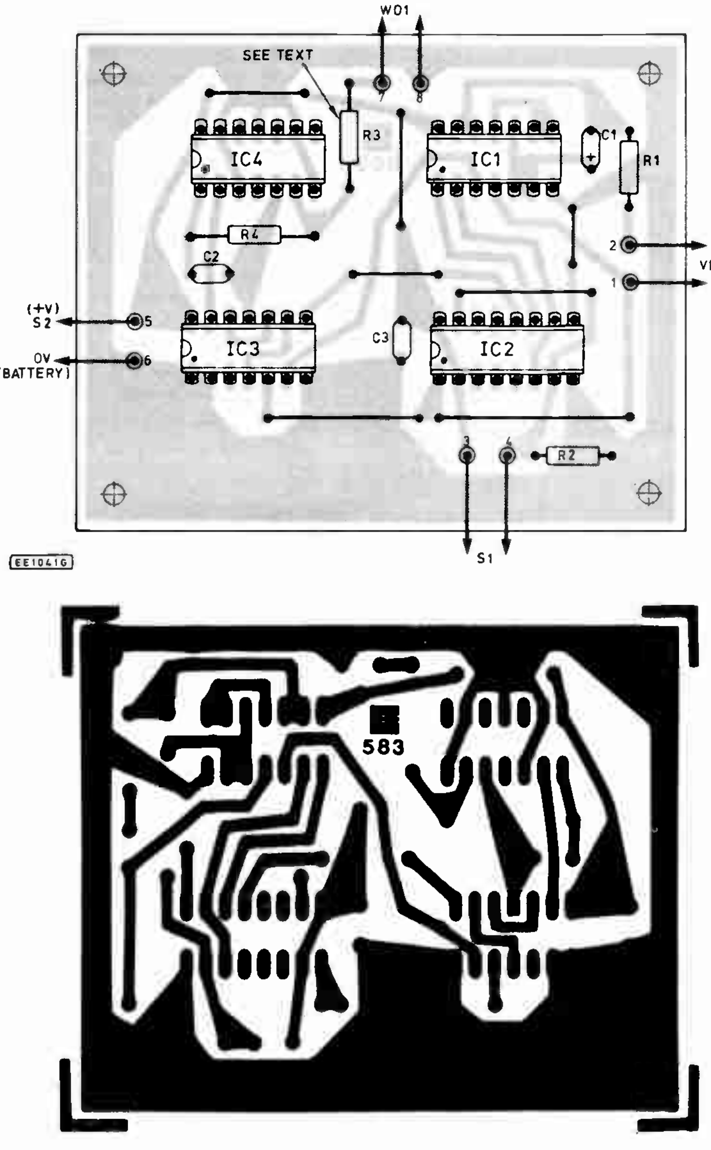


Fig. 4. Component layout and full size printed circuit foil master pattern for the Game Timer. This board is available from the *EE PCB Service*, code 583.

MECHANICAL DETAILS

The prototype timer was housed in a plastic case with a sloping aluminium front panel size 161mm × 96mm. All the components except the battery holder were mounted on the aluminium panel. Of course, there is no need to use this particular case, and any case big enough which is to hand can be used.

It is best to obtain all the components which are to be mounted on the panel, including the p.c.b., before drilling any holes so that the hole diameters and centres can be checked before starting the drilling. Drilling details for the front panel are shown in Fig. 5.

Unless you have a large drill available, the hole for the Time potentiometer VR1 will probably have to be finished with a round file or a tapered reamer. The four holes in the extreme corners of the panel are already drilled as supplied and are used to fasten the panel into the case.

The p.c.b. is suspended above the panel's inside surface by four 6BA screws and nuts. The holes for these screws are countersunk on the outside of the panel so that when the panel is covered with a self-adhesive material they are invisible. The piezo transducer, WD1, is simply glued to the panel using a "super-glue" type adhesive.

No details are shown for mounting the battery holder in the case. It can be screwed or glued to the inside bottom of the case, ensuring that it does not foul any of the components mounted on the panel.

ASSEMBLY AND WIRING

The interwiring between the circuit board and front panel mounted components S1, S2, VR1, WD1 and the p.c.b. is shown in Fig. 6. The p.c.b. is fixed to the front panel using ½in long 6BA countersunk screws and spaced away from the panel with extra 6BA nuts.

The buzzer WD1 is supplied with flying leads and these should be twisted together and soldered to terminal pins 7 and 8 on the p.c.b. These connections are not polarity conscious.

For the sake of neatness, the wires from each pair of solder pins can be twisted together. Take special care with the wiring to the battery holder, ensuring that the polarity is correct.

TESTING

After carefully checking the p.c.b. for solder splashes, verifying that the i.c.s are in the right way round and ensuring that the wiring to the other components is correct, the timer can be switched on. If a milliammeter is available, it can be connected in series with the positive

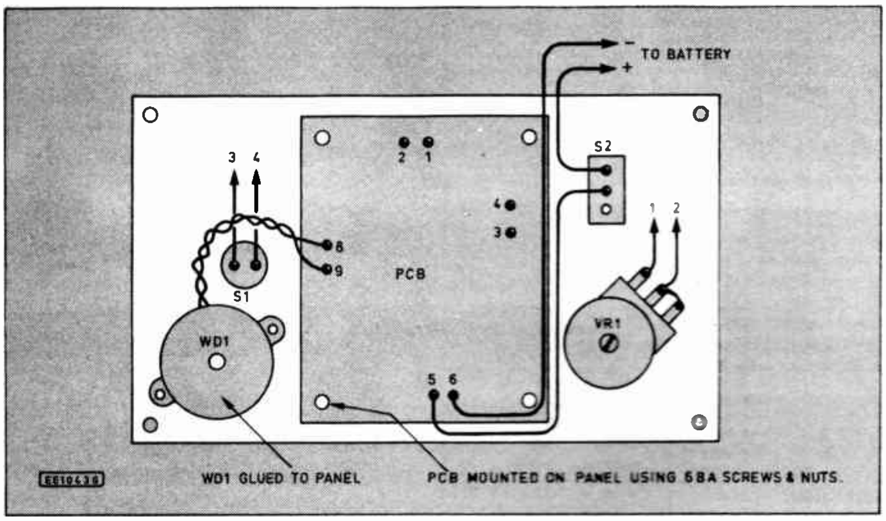


Fig. 6. Interwiring between the circuit board and front panel mounted components. The board is spaced away from the panel by 6BA nuts.

battery lead. The supply current should be less than 1mA with no audio output and about 1.5mA when the buzzer is sounding. If the current is much more than this, switch off quickly and recheck everything.

The low frequency oscillator can be checked first. If an oscilloscope is available it can be used to monitor the output of IC1b. A square wave of amplitude equal to the supply voltage should be visible. The frequency at the output of IC1b should be seen to vary as VR1 is rotated.

If you do not have access to an oscilloscope, a simple logic probe as shown in Fig. 7 can be constructed. Use a resistor value of say 2.2kilohm and a high intensity l.e.d. if possible. Of course, it is only really suitable for probing circuits operating at low speeds.

With the Reset button (S1) held pressed, all the outputs of IC2 can be monitored in turn to ensure that they do not change with the clock input as the device is held reset. S1 can then be released and a check made that as successive outputs of IC2 are monitored, half the previous repetition rate is produced.

The outputs of the counter output decoding gates (IC1a, IC3b and IC3c) can now be monitored, comparing them with the timing diagram, Fig. 3. If the output of IC3c is correct, tone outputs from buzzer WD1 should be heard at the correct points in the timing sequence.

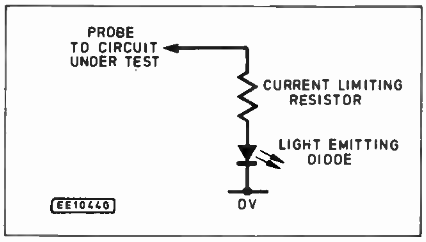


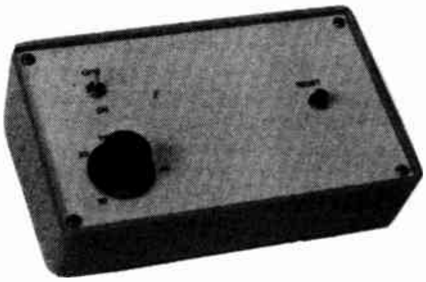
Fig. 7. Simple logic probe circuit.

FINISHING OFF

The front panel of the case can be painted or covered in a self-adhesive material such as Fablon. Using Letraset, or similar, the controls can be labelled as shown in the photographs.

A stopwatch, or a watch with seconds readout, can be used to calibrate the settings of the Time control VR1, measuring the time taken from releasing the Reset button to when the continuous tone begins. As can be seen from the photographs, the prototype was calibrated at 10, 20, 30 and 40 seconds.

Finally, the lettering should be protected either with clear lacquer or transparent Fablon. Stick-on feet should be fitted to the bottom of the case to prevent scratching any surface on which the unit is placed. □



EE CROSSWORD

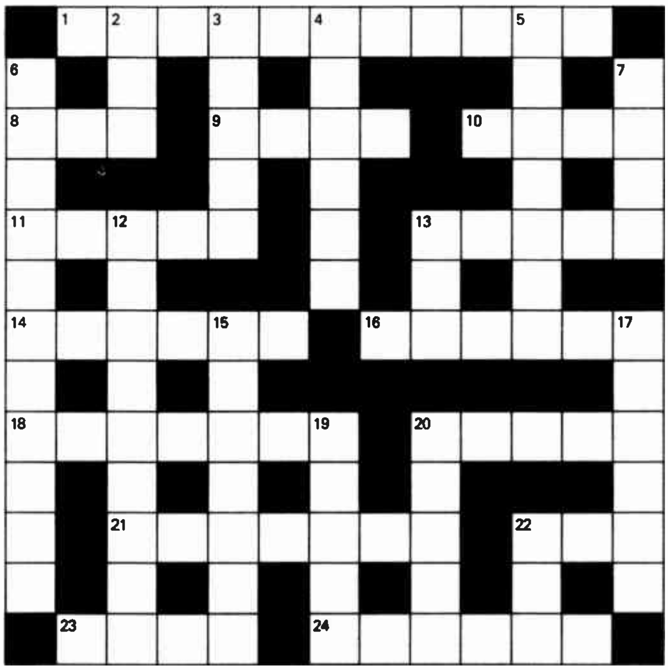
CLUES ACROSS

1 Flip-flop where everybody knows their place. (6,5)
8 Term used to describe the dominant wavelength. (3)
9 This pram can be used for scanning. (4)
10 Dashing away with the moving . . . (4)
11 Measurements lost without this? (5)
13 Wait awhile to get the full picture. (5)
14 A beam tube that can be used as a high speed switch. (6)
16 A signal that varies continuously. (6)
18 Type of waveguide that has nonradiative areas. (7)
20 Mode of transport for pulses? (5)
21 A strobe pulse does this. (7)
22 Signal given in studios for starting, fading, etc., programme sequences. (3)
23 To change or modify data input to a computer. (4)
24 These signify abnormal conditions. (6)

DOWN

2 Rearrange tea to have equipment tested automatically. (3)
3 Number of primary colours in ctv. (5)
4 Very low frequency noise. (6)
5 Appearing to be, rather than actually being, e.g. earth. (7)
6 Light sensitive material used in the manufacture of solid state devices. (11)
7 Non-linear part of a characteristic. (4)
12 Converts flux patterns into electrical signals. (5,4)
13 Diode containing an intrinsic layer. (1.1.1)
15 Unlike poles do this. (7)
17 Two or more circuits mechanically coupled. (6)
19 Three phase connection of motor windings in series. (5)
20 These tales give value to magnetic flux. (5)
22 A disc operating system. (1,1,1)

For fun only – answers on page 113



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