AUGUST 1987

EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

£1·20

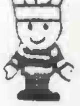
SHORT WAVE RADIO

TV Supersound ADAPTOR

DIGITAL CHIP TESTER

Immersion Heater Timer

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
4. 5 – surface mounting
5. 3 – electrical switches, white flush mounting
7. 4 – in flex line switches with neons
9. 2 – mains transformers with 6V 1A secondaries
10. 2 – mains transformers with 12V ½A secondaries
11. 1 – extension speaker cabinet for 6½" speaker
13. 12 – glass reed switches
17. 2 – ultrasonic transmitters receivers with circuit
19. 2 – light dependent resistors
25. 4 – wafer switches – 6p 2 way, 4p 3 way, 2p 6 way, 2p 5 way, 1p 12 way small one hold fixing and good length ¼ spindle your choice
28. 1 – 6 digit counter mains voltage
30. 2 – Nicad battery chargers
31. 1 – key switch with key
33. 2 – aerosol cans of ICI Dry Lubricant
34. 96 – 1 metre lengths colour-coded connecting wire
39. 1 – long and medium wave tuner kit
41. 8 – rocker switch 10 amp mains SPST
45. 1 – 24 hour time switch mains operated (s.h.)
49. 10 – neon valves – make good night lights
50. 2 – 12V DC or 24V AC, 3 CO relays
51. 1 – 12V 2 CO miniature relay very sensitive
52. 1 – 12V 4 CO miniature relay
54. 10 – rows of 32 gold plated IC sockets (total 320 sockets)
55. 1 – locking mechanism with 2 keys
56. 1 – miniature uniselector with circuit for electric jigsaw puzzle
60. 5 – ferrite rods 4" × 5/16" diameter aerials
61. 4 – ferrite slab aerials with L & M wave coils
63. 1 – Mullard thyristor trigger module
66. 1 – magnetic brake – stops rotation instantly
67. 1 – low pressure 3 level switch can be mouth operated
69. 2 – 25 watt pots 8 ohm
70. 2 – 25 watt pots 1000 ohm
71. 4 – wire wound pots – 18, 33, 50 and 100 ohm your choice
77. 1 – time reminder adjustable 1-60 mins clockwork
85. 1 – mains shaded pole motor ¾" stack – ¼ shaft
89. 1 – mains motor with gear box 1 rev per 24 hours
91. 2 – mains motors with gear box 16 rpm
96. 1 – thermostat for fridge
98. 1 – motorised stud switch (s.h.)
101. 1 – 2½ hours delay switch
103. 1 – mains power supply unit – 6V DC
104. 1 – mains power supply unit – 4½V DC
107. 1 – 5" speaker size radio cabinet with handle
112. 1 – heating pad 200 watts mains
114. 1 – 1W amplifier Mullard 1172
115. 1 – wall mounting thermostat 24V
118. 1 – teak effect extension 5" speaker cabinet
120. 2 – p.c. boards with 2 amp full wave and 17 other recs
121. 4 – push push switches for table lamps etc.
122. 10 – mtrs twin screened flex white p.v.c. outer
124. 25 – clear plastic lenses 1¾ diameter
127. 4 – pilot bulb lamp metal clip on type
128. 10 – very fine drills for pcbs etc.
129. 4 – extra thin screw drivers for instruments
132. 2 – plastic boxes with windows, ideal for interrupted beam switch
134. 10 – model aircraft motor – require no on/off switch, just spin to start
137. 1 – 6½" 4 ohm 10 watt speaker
142. 10 – 4 BA spanners 1 end open, other end closed
145. 2 – 4 feed relay kits 3V coil normally open or c/o if magnets added
146. 20 – pilot bulbs 6.5V.3A Philips
154. 1 – 12V drip proof relay – ideal for car jobs
155. 3 – varicap push button tuners with knobs
169. 4 – short wave air spaced trimmers 2-30f
172. 10 – 12V 6W bulbs Philips m.e.s.
178. 3 – oblong amber indicators with lilliputs 12V
180. 6 – round amber indicators with neons 240V
181. 100 – p.v.c. grommets ⅜ hole size
182. 1 – short wave tuning condenser 50 pf with ¼" spindle
184. 1 – three gang tuning condenser each section 500 pf with trimmers and good length ¼" spindle
188. 1 – plastic box sloping metal front, 16 × 95mm average depth 45mm
193. 6 – 5 amp 3 pin flush sockets brown
195. 5 – B.C. lampholders brown bakelite threaded entry
196. 1 – in flex simmerstat for electric blanket soldering iron etc.
197. 2 – thermostats, spindle setting – adjustable range for ovens etc.
199. 1 – mains operated solenoid with plunger 1" travel
200. 1 – 10 digit switch pad for telephones etc.
201. 8 – computer keyboard switches with knobs, pcb or vero mounting
206. 20 – mtres 80 ohm, standard type co-ax off white
211. 1 – electric clock mains driven, always right time – not cased
216. 1 – stereo pre-amp Mullard EP9001
232. 2 – 12V solenoids, small with plunger
236. 1 – mains transformer 9V 1 amp secondary C core construction
241. 1 – car door speaker (very flat) 6½" 15 ohm made for Radiomobile
241. 2 – speakers 6" × 4" 4 ohm 5 watt made for Radiomobile
243. 2 – speakers 6" × 4" 16 ohm 5 watt made for Radiomobile
244. 1 – mains motor with gear-box very small, toothed output 1 rpm
245. 4 – standard size pots, ½ meg with dp switch
249. 1 – 13A switched socket on double plate with fused spur
266. 2 – mains transformers 9V ½A secondary
267. 1 – mains transformers 15V 1A secondary p.c.b. mounting
291. 1 ten turns 3 watt pot ¼ spindle 100 ohm
296. 3 car cigar lighter socket plugs
298. 2 15 amp round pin plugs brown bakelite
300. 1 mains solenoid with plunger compact type
301. 10 ceramic magnets Mullard 1" × 3/8 × 5/16
303. 1 12 pole 3 way ceramic wave charge switch
305. 1 tubular dynamic microphone with desk rest
308. 1 T.V. turret tuner (black & white T.V.)
310. 2 oven thermostats
313. 5 sub miniature micro switches
316. 1 round pin kettle plug with moulded on lead
453. 2 – 2¼in. 80ohm loudspeakers
454. 2 – 2¼in. 8ohm loudspeakers
463. 1 – mains operated relay with 2 sets c/o contacts
464. 2 – packets resin filler/sealer with cures
465. 3 – 5A round 3 pin plugs will fit item 193
466. 4 – 7 segment l.e.d. displays
470. 4 – pc boards for stripping, lots of valuable parts
473. 1 – 5" 4ohm speaker with built in tweeter Radio mobil
480. 1 – 3A double pole magnetic trip, saves repairing fuses
498. 4 – 1000uf 25V axial electrolytic capacitors

3" DISCS For our £27.50 F.D.D.—Amstrad 664, Einstein, etc, pack of 10 £25, ref 25P3 or sample £3, ref. 3P24.

COMPACT FLOPPY DISC DRIVE For Only £27.50

As used in the Amstrad 664/6128, the Einstein and other popular computers. Drives the new standard disc, only 3" but with a capacity of 500k per disc, this is equivalent to the 5¼" disc. Other features are:

1. **It has the shugart compatible interface (34 way edge connector).**
2. **It is plug compatible with the 5¼" disc, the recording method, data transfer rate and rotation speed are the same as 5¼".**
3. **Is fitted with long life brushless motor and uses steel band driving for reliability and assessing at 3mS.**
4. **Its touch loading mechanism makes easy handling and disc slot protects against dust.**
5. **The back of the disc in use can be seen, and up to four drives may be daisy chained.**

We include the operator's manual and other information showing how to use this with popular computers BBC, Spectrum, Amstrad etc. Brand new and at only £27.50 including post and VAT.

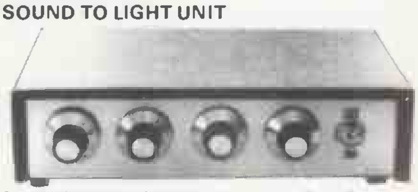
Data available separately £2, refundable if you purchase the drive.

Ex-Electricity Board. Guaranteed 12 months.

VENNER TIME SWITCH

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

SOUND TO LIGHT UNIT



Complete kit of parts of a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four pin plug and socket facilitate ease of connecting lamps. Special price is £14.95 in kit form.

NEW ITEMS

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

RE-WIRING?

Here's a bargain for you – M.E.M. 3 circuit splitter 45A switch with 3x15A rewirable fuses normal cost over £10, but yours for only £5. Our ref 5P100.

AUTO TRANSFORMER BARGAIN

200W 230/115V encapsulated into a very neat unit, size 4×4×1½ appr. Only £3, plus £2 post, our ref 3P22.

HOW ARE YOU GOING TO KEEP YOUR CHILDREN OUT OF MISCHIEF THIS SUMMER?

Why not buy them a computer, they can have fun and be learning at the same time. We have a real bargain the "Acorn Electron" it comes complete with mains adapter, TV lead, starter cassette and two handbooks. The only extra you need is a cassette recorder. It's ideal for all the family and Dad, while the kids are not playing their games on it you can even do some of your office work with it. This computer as its 300 page handbook shows can do most things that the BBC computer can do but will only cost you a fraction of the price only £39.50 plus £2 post.

SOFTWARE

To go with the Acorn. £1 each or 5 for £4.00

Desk Diary	Hopper
Business Games	Sphinx Adventure
Starship command	Arcadians
Chess	Boxer
Snapper	

9" VDU

Ideal to work with computers or video cameras uses Philips black and white tube ref M24/306W. Which tube is implosion and X-ray radiation protected. VDU is brand new and has time bases and EHT circuity, requires only a 16V d.c. supply to set it going. It's made up in a lacquered metal frame work but has open sides so should be cased (if you are handy with a drill and file you could make a case out of two of our 6½ speaker cabinets). The VDU comes complete with circuit diagram and has been line tested and has our six months guarantee. Offered at a lot less than some firms are asking for the tube alone only £16 plus £3 post. We also have some that failed the line test again brand new but offered without guarantee at £8 plus £3 post.

IONISER KIT

Refresh your home, office, shop, work room, etc. with a negative ION generator. Makes you feel better and work harder – a complete mains operated kit which we guarantee is ten times more powerful than other popular kits. Price includes case and instructions. £9.50 plus £2.00 post.

TELEPHONE BITS

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

J & N BULL ELECTRICAL

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

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

£2 POUNDERS*

- 2P2 –Wall mounting thermostat, high precision with mercury switch and thermometer
- 2P3 –Variable and reversible 8-12v psu for model control
- 2P4 –24 volt psu with separate channels for stereo made for Mullard UNILEX
- 2P6 –100W mains to 115V auto-transformer with voltage tappings
- 2P8 –Mains motor with gear box and variable speed selector. Series wound so suitable for further speed control
- 2P9 –Time and set switch. Boxed, glass fronted and with knobs. Controls up to 15 amps. Ideal to program electric heaters
- 2P10 –12 volt 5 amp mains transformer
- 2P12 –Disk or Tape precision motor – has balanced rotor and is reversible 230v mains operated 1500 rpm
- 2P14 –Mug Stop kit – when thrown emits piercing squawk
- 2P15 –Interrupted Beam kit for burglar alarms, counters, etc.
- 2P17 –2 rev pr minute mains driven motor, ideal to operate mirror ball
- 2P18 –Liquid/gas shut off valve mains solenoid operated
- 2P19 –Disco switch-motor drives 6 or more 10 amp change over micro switches supplied ready for mains operation
- 2P20 –20 metres extension lead, 2 core – ideal most Black and Decker garden tools etc.
- 2P21 –10 watt amplifier, Mullard module reference 1173
- 2P22 –Motor driven switch 20 secs on or off after push
- 2P26 –Counter resettable mains operated 3 digit
- 2P27 –Goodmans Speaker 6 inch round 8ohm 12 watt
- 2P28 –Drill Pump – always useful couples to any make portable drill
- 2P31 –4 metres 98 way interconnecting wire easy to strip
- 2P32 –Hot Wire amp meter – 4½ round surface mounting 0–10A – old but working and definitely a bit of history
- 2P34 –Solenoid Air Valve mains operated
- 2P38 –200 R.P.M. Geared Mains Motor 1" stack quite powerful, definitely large enough to drive a rotating aerial or a tumbler for polishing stones etc.
- 2P43 –Small type blower or extractor fan, motor inset so very compact, 230V
- 2P46 –Our famous drill control kit complete and with prepared case
- 2P49 –Fire Alarm break glass switch in heavy cast case
- 2P51 –Stereo amplifier, 3w per channel
- 2P55 –Mains motor, extra powerful has 1½" stack and good length of spindle
- 2P62 –1 pair Goodmans 15 ohm speakers for Unilox
- 2P64 –1 five bladed fan 6½" with mains motor
- 2P66 –1 2Kw tangential heater 115v easily convertible for 230V
- 2P67 –1 12v–0–12v 2 amp mains transformer
- 2P68 –1 15v–0–15v 2 amp mains transformer
- 2P69 –1 250v–0–250v 60 mA & 86.3v 5A mains transformer + 50p post
- 2P70 –1 E.M.I. tape motor two speed and reversible
- 2P72 –1 115v Muffin fan 4" × 4" approx. (s.h.)
- 2P75 –1 2 hour timer, plugs into 13A socket
- 2P82 –9v–0–9v 2 amp mains transformer
- 2P84 –Modem board with press keys for telephone redialler
- 2P85 –20v–0–20v ½A Mains transformer
- 2P88 –Sangamo 24 hr time switch 20 amp (s.h.)
- 2P89 –120 min. time switch with knob
- 2P90 –90 min. time switch with edgewise engraved controller
- 2P97 –mains transformer 24V 2A upright mounting
- 2P98 –20m 4 core telephone cable, white outer
- 2P99 –500 hardened pin type staples for telephone cable
- 2P101 –15V mains transformer 4A upright mounting
- 2P105 –capillary type thermostat for air temperature with c/o switch
- 2P108 –mains motor with gear box giving 110rpm
- 2P109 –5" wide black adhesive pvc tape 33m, add £1 post if not collecting

OVER 400 GIFTS YOU CAN CHOOSE FROM

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

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

£4 POUNDERS*

- 4P9 Ace Prestel Unit new but less most ICs. Contains useful Modem. Add £1 post
- 4P14 Mains transformer upright mounting 43V 3.4V output, add £2 post
- 4P15 Motor with gearbox final speed 60rpm very powerful would operate gate etc.
- 4P17 Uniselector 3 pole 25 way, as used on automatic telephone exchange etc.

£5 POUNDERS*

- 5P1 12 volt submersible pump complete with a tap and switch, an ideal caravan unit.
- 5P2 Sound to light kit complete in case suitable for up to 750 watts.
- 5P6 12V alarm bell with heavy 6" gong, suitable for outside if protected from direct rainfall. Ex GPO but in perfect order.
- 5P12 Equipment cooling fan – mini snail type mains operated.
- 5P15 –Uniselector 4 pole, 25 way 50 volt coil
- 5P18 –motor driven water pump as fitted to many washing machines
- 5P20 –2 kits, matchbox size, surveilance transmitter and FM receiver
- 5P23 –miniature (appr. 2½" wide) tangential blow heater, 1·2kw
- 5P24 –¼ hp motor, ex computer, 230V, mains operation 1450rpm. If not collect add £3 post
- 5P25 –special effects lighting switch. Up to 6 channels of lamps can be on or off for varying time periods
- 5P41 –5" extractor fan, very quiet runner (s.h.), gntd 12 mths.
- 5P48 –telephone extension bell in black case, ex-GPO
- 5P52 –mains transformer 26V 10A upright mounting, add £2 post
- 5P54 –mains motor with gear box, final speed 5rpm
- 5P58 –Amstrad stereo tuner FM and LM. AM
- 5P62 –2½kw tangential blow heater, add £1.50 post if not collecting
- 5P73C high pressure mains operated gas or water valve with tube connection suitable soldering
- 5P82 1 25rpm mains 60w motor with gearbox
- 5P84 1 delay time switch, adjust 0–20 seconds
- 5P69 1 light box size 14" × 12" for circuit tracing pcb's. Add £3 for postage and packing
- 5P81 1 stepper motor bi-directional, 7.5° steps 12–14V coil
- 5P88 1 24V 5A mains transformer in waterproof case, ideal for garden lighting, pond pump etc. Add £2 post.
- 5P90 18" tangential blower with mains motor
- 5P91 14" tangential blower with mains motor in centre.
- 5P92 10 metres twin screened computer co-ax.
- 5P93 6" alarm bell 24 volt d.c. on 50V a.c.
- 5P94 Current transformer 1 amp thro. primary=14V
- 5P95 Photo magic-original "vintage" photo cell

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

EVERYDAY ELECTRONICS

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ABC

VOL 16 No.8 AUGUST '87

The Magazine for Electronic & Computer Projects

ISSN 0262-3617

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

Our September 1987 issue will be published on Friday, 21 August 1987. See page 412 for details.

Projects

Series

Features

GREENWELD ELECTRONIC COMPONENTS

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All prices include VAT; just add 60p P&P
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orders from schools etc. welcome — min invoice charge £10.
Our shop has enormous stock of components and is open
9–5.30 Mon–Sat. Come and see us!!!

EE

SUMMER SALE

SEND FOR YOUR FREE SALE LIST NOW!!

Yes, folks, it's time for our Super Summer Sale again, with hundreds of Bargains!
Up to 66% off our already low, low prices!!
Dozens of **half price items!!**
But stocks are limited, so it's first come, first served!
ORDER NOW to be sure of your share!!
Our SALE list and Bargain Lists are FREE!!
Our 80 page Catalogue **costs** just £1, with vouchers worth £1.50.

½ PRICE PANELS

Z914 1W Mono Amp	75p
Z915 1W Stereo Amp	£1.75
Z916 Am Tuner	75p
Z925 Relays	95p
Z926 Relay/Triac	92p
Z927 Reeds	30p
Z918 Inverter	£1.25
Z919 Inverter	£1.10
Z912 RF Panel	75p
Z910 RF Panel	75p
Z911 RF Panel	35p
Z913 RF Panel	35p
Z942 Joystick Interface	£1.00
Z974 Mixer Amp	£1.25
Z469 10W Amp Panel	£1.25
Z955 'Simon' Panel	50p
Z497 AM/FM Tuner	£6.45

7 SEG DISPLAYS—
MAN6740 40p; 10/£3.00
Others on P.78 of Cat. 30p; 10/£2.00; 100/£15.

FIBRE OPTICS—66% OFF!!
20m coils 1mm core—
single £4.00 £2.00
twin £6.00 £2.00

COMPUTER BOOKS—up to 90% off!! £9.95, £6.95, £5.95
Now 10 for £6!

UHF Modulator 50% off!
Aztec UM1286 £6.00 £3.00

½ PRICE PACKS

K547 Zener diodes	£4.50	£2.25
K544 Mullard polyesters	£4.75	£2.35
K556 Fuseholders	£2.00	£1.00
K557 Terminal strips	£2.40	£1.20
Z525 Vero offcuts	£3.80	£1.90

25% OFF PACKS

K548 Tantalum caps	£6.50	£4.85
K549 Variable caps	£5.75	£4.30
K546 Mica/ps/cer caps	£2.75	£2.05
K554 Thermistors	£8.00	£6.00
K555 Fuses	£3.95	£2.95
K538 Diodes	£2.50	£1.85
K541 PCB Panels	£7.00	£5.25
K542 Reed Relays	£4.30	£3.20
K530 Polyesters	£3.95	£2.95
K518 Disc Ceramics	£1.00	75p
K503 Wirewound Resistors	£2.00	£1.50
K505 Pots	£1.70	£1.25
W4700 Push button banks	£2.95	£2.20
K526 Heatsinks	£5.50	£4.10
K527 Hardware	£4.00	£3.00
K534 Sleeve Pack	£1.00	75p
K536 74 Series Pack	£4.00	£3.00
K537 I.C. Pack	£6.75	£5.05
K538 Diode Pack	£2.50	£1.85
K539 L.e.d. Pack	£5.95	£4.45
K540 Resistor Pack	£2,50	£1.85
K535 Spring Pack	£1.70	£1.25
K524 Opto Pack	£3.95	£2.95
K525 Preset Pack	£6.75	£5.05
K528 Electrolytic Pack	£3.95	£2.95
K531 Precision resistors	£3.00	£2.25
K532 Relays	£6.00	£4.50
K517 Transistors	£2.75	£2.05
K523 Resistors	£2.50	£1.85
K520 Switches	£2.00	£1.50

'NEWBRAIN' PANELS

Z494 Motherboard microprocessor panel 265 × 155mm. Complete PCB for computer. Z80, char EPROM, etc. 68 chips altogether + other associated components, plugs, skts, etc. £4.00

Z495 RAM panel. PCB 230 × 78mm with 14 × MM5290–2 (4116) (2 missing) giving 28k of memory. Also 8 LS chips. These panels have not been soldered, so chips can easily be removed if required. £3.75

'NEWBRAIN' PSU

BRAND NEW Stabilized Supply in heavy duty ABS case with rubber feet. Input 220/240V ac to heavy duty transformer via suppressor filter. Regulated DC outputs: 6·5V @ 1·2A; 13·5V @ 0·3A; –12V @ 0·05A. All components readily accessible for mods etc. Chunky heatsink has 2 × TIP31A. Mains lead (fitted with 2 pin continental plug) is 2m long. 4 core output lead 1·5m long fitted with 6 pole skt on 0·1" pitch. Overall size 165 × 75 × 72 mm.
£4.75 ea 10 for £32

SCOPES! 5% OFF ALL MODELS

10% OFF all ANTEX PRODUCTS!!

10% OFF all VERO PRODUCTS!!

Full details of all sale items in Catalogue/Bargain Lists

.... ALL ABOVE ARE **SALE** ITEMS: MIN ORDER VALUE £10 + £2 POST ....

SOLDER SPECIAL!!!

★ 15W 240Vac soldering iron
★ High power desolder pump
★ Large tube solder

ALL FOR £7.95

NEW PANELS

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

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

Details of other similar PCB's in latest list.

Z621 Teletext Unit. Keyfax T100 manufactured for the US market, hence 120V ac supply (but Tx can easily be changed for 240V model). Smart wooden case 430 × 257 × 68mm, housing chassis with Rx/decoder circuitry, Mullard VM6700 module, channel display, I/p & o/p skts. Believed to be new & working, but no data. £20.00

Z622 As above but no wooden case £15.00

sinclair

QL BOARD

PCB 370 × 117, partially assembled with 16 × 4164's giving 128k of RAM; 2 × LS257, LS245, 1488, 1489, HAL16L8. Also 2 × Ferranti ULA's for microdrives. None of the chips have been soldered so can easily be removed. £12.00

SPEAKERS

Z578 Sub-min speaker 30 × 30 × 3mm thick by Fuji. 16R 0.4W. 60p ea; 10 £3.70; 25 £7; 100 £22; 1000 £180.

Z575 70 × 45mm 45R 0.5W 55p ea; 10 £3.30; 25 £6; 100 £20

SOLDER

500g reels resin cored. 18g £5.95
500g reels resin cored 22g £7.95

sinclair

MICROVISION

We have a quantity of these units in varying states. From labels attached to some of the PCB's it seems after assembly on the production line they did not function correctly. No attempt has been made to repair them, though — instead the following parts were removed:
a) RF Tuner
b) Vol control & switch
c) ZN401E chip

Because of the varying needs of constructors and the differing states of the microvisions, we are offering the following alternatives:

Z555 Grade A: PCB in good condition with CRT fitted. Supplied as seen with circuit diagram and notes. £6.95

Z556 PCB in good condition with CRT that has been removed, but maybe repairable. Conductive paint (15ml bottle £3.45) will probably be needed to remake contacts £3.95

Z558 CRT in 'as seen' condition — possibly repairable £2.00

Z559 PCB in good condition without CRT £2.50

Z560 Circuit diagram and notes: 7 pages detailing tech. spec., description, cct operation, fault diagnosis & repair, aid to fault-finding chart, picture set up procedure, PCB layout, info on the various possibilities. £2.00

RF Tuner £6.95; ZN401 chip £9.95; Vol control + switch with knob £1.00

1987 CATALOGUE

Out now!! Bigger and better than ever — 80 pages packed with components and equipment, from humble resistors to high tech scopes! Bargain List, Order Forms and £1.50 Discount Vouchers all included for just £1.00 inc. post.

+ FREE! KIT-CAT

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

ENTERPRISE SIXTYFOUR

Z601 Complete PCB from above — Z80A, 64k of RAM, UHF modulator. Just needs keyboard, TV & PSU. Supplied with lots of data: Full circuit diagram, connections for expansion port, ROM bay, joysticks ports, printer port, video output, serial port. Also demo cassette + 2 booklets that were supplied with complete machine. £20.00
Data only £2.00

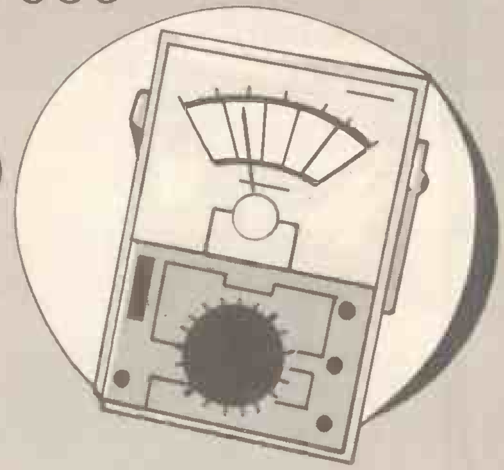
LOGIC PROBE

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

SEPTEMBER FEATURES...

USING A MULTIMETER

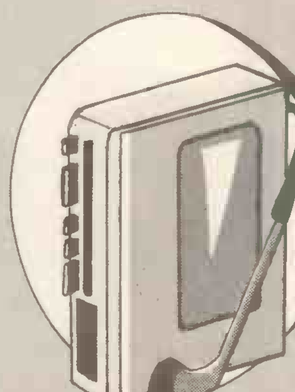
SPECIAL FEATURE



Perhaps the most common and most versatile item of test gear for anyone involved with electronics is a multimeter. Next month we look at how to use one, the general limitations and at just how useful a multimeter can be.

CAR OVERHEATING ALARM

It's the time of the year when steaming cars appear in traffic jams. Our alarm makes sure you are aware of an imminent problem. An excellent aid for those who tow caravans and trailers.



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BC107B	0.15
BC108	0.15
BC108A	0.18
BC108B	0.15
BC108C	0.15
BC109	0.18
BC109B	0.18
BC109C	0.18
BC182	0.12
BC182B	0.12
BC183	0.12
BC183B	0.12
BC184	0.12
BC212	0.12
BC212B	0.12
BC213	0.12
BC213B	0.12
BC214	0.12
BC327	0.16
BC337	0.16
BC548	0.12
BCY70	0.22
BCY71	0.22
BD131	0.60
BD132	0.60
BD135	0.34
BD136	0.35
BD239A	0.50
BF258	0.60
BFX85	0.40
BFX88	0.40
BFY50	0.37
BFY51	0.37
BFY52	0.39
TIP31	0.42
TIP31A	0.48
TIP31B	0.56
TIP31C	0.54
TIP32A	0.42
TIP32C	0.42
TIP33A	1.00
TIP41A	0.63
TIP42A	0.55
TIP3055	0.76
TIP2955	0.76
ZTX300	0.17
ZTX500	0.17
2N3053	0.60
2N3054	1.60
2N3707	0.12
2N3703	0.12
2N3705	0.12
2N3771	1.40
2N3904	0.15
2N3906	0.15

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IN4001	0.05
IN4002	0.05
IN4003	0.06
IN4004	0.06
IN4007	0.08
IN4148	0.06
IN4448	0.06

IC SOCKETS

low profile

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14 pin DIL	0.12
16 pin DIL	0.13
24 pin DIL	0.20
40 pin DIL	0.30

OPTO ISOLATORS

TIL111 transistor o/p	1.10
TIL113 Darlington o/p	1.20
3021 Triac driver	1.50

LEDs

T1¾ 5mm

Red	0.18
Yellow	0.18
Green	0.18

Super bright T1¾ 5mm

Red	0.35

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4V7	0.10
10V	0.10
12V	0.10

BZX55C 500m W

24V	0.10

BZX85C 1.3 Watt

4V7	0.20
10V	0.20
12V	0.20
24V	0.20

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LM7905 1.5 Amp −5V	0.70
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10uF	25V	0.08
47uF	25V	0.10
100uF	25V	0.12
470uF	25V	0.28
1000uF	25V	0.36
220uF	25V	0.15

Tantalum

0.1uF	35V	0.10
0.22uF	35V	0.10
0.47uF	35V	0.10
1uF	35V	0.10
2.2uF	35V	0.15
4.7uF	35V	0.20

Ceramic

220pF	500V	0.06
470pF	500V	0.06
1000pF	100V	0.06
2200pF	100V	0.06
4700pF	100V	0.06

RESISTORS

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2p each
100R 680R 1K 1K2 2K2
4K7 5K6 6K8 10K 12K
15K 22K 27K 33K 39K
47K 56K 68K 82K 100K
120K 150K 180K 220K
270K 330K 390K 470K
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Miniature horizontal or vertical Values: 100R 220R 470R 1KΩ 2K2 4K7 10KΩ 22KΩ 47KΩ 100KΩ 220KΩ 470KΩ 1MΩ 0.19

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Maroon	31.26
Grey	31.26

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Red	26.04
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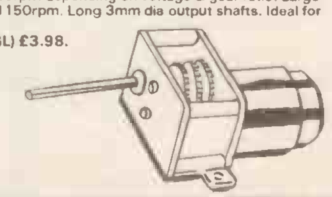

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1987 CATALOGUE

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The Magazine for Electronic & Computer Projects

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SMDs

SOME of you are now wondering what SMDs are, others are wondering why they are featured in my leader and no doubt some of you couldn't care less. If you are truly interested in electronics perhaps you should care just a little about SMDs.

Surface Mounted Devices (that's what SMDs are, but don't worry if you did not know, because none of us did at one time) have not made the impact on electronics that they were forecast to a couple of years ago. SMDs look like tiny blocks of material with a couple of solder pads on and no connection leads. They are designed to be glued to the copper side of a miniature p.c.b. and then connected by heating the whole assembly so that the solder makes the joint.

As far as the hobbyist is concerned SMDs could be a problem as they are very small and not designed for hand insertion or soldering. At one time there were forecasts of SMD domination of the electronics industry to the virtual exclusion of "normal" wire ended components. This could have raised the price of our hobby dramatically and even limited the designs to some extent. However SMDs have not changed the face of the electronics industry and even now are not commonplace in commercial equipment.

WIRES ARE IN

For the time being our wire ended components are safe, they are still being manufactured in vast quantities and therefore they are still very cheap to buy. That is not to say that this will always be the case but at least for the next few years we will not need magnifying glasses and tweezers to build projects.

Much the same can be said of the type of chips we use. The good old 74' series of i.c.s have been around for a long time and they still serve us very well. Maybe, for the present time at least, the technology is ahead of our general requirements. While the R and D labs go on miniaturising everything, packing more onto each chip and designing the mega computer we see little advancement of this type in our home hi fi or even our test gear.

When the home android arrives we may see a use for all this development but right now we can go on with our radial electrolytics and 741's.

Mike Kenward

BACK ISSUES & BINDERS

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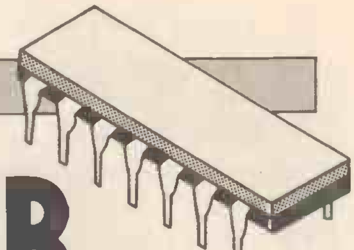


DIGITAL CHIP TESTER

JOHN BECKER

Use your computer as a digital chip tester with this useful project.

MANY digital integrated circuits are essentially gates of some sort, and as such are suitable for computer analysis in conjunction with a simple interface unit. Once the basic pin function data has been entered the computer can then be used as a chip tester, and as an educational logic analyser.

The interface unit to be described here has been designed specifically for use with the BBC, Commodore 64, and PET series of computers. The simplicity of the unit and the controlling program should however, enable it to be converted for use with other computers having similar facilities. The primary requirements are that the controlling computer should have an eight-bit User or IEEE output port, and two handshake lines. The unit is suitable for a wide variety of 14 and 16 pin gates, buffers, counters and flip flops from the CMOS and TTL ranges, including 4000, 5400, 7400, standard, LS and high speed series.

MULTIPLEXING

Most computers available to the average home constructor process information in accordance with an eight-bit binary code. These codes determine whether a particular control line is at a high or low logic level, represented by "1" and "0" respectively. Using a computer that has an eight-bit output port, these logic levels can be applied to exterior equipment as control signals. Although there are only eight bits available, by using an external multiplexed memory storage device codes greater than eight bits long can be generated.

This unit has been designed so that essentially the control data bits can be switched to two main destinations, and in reality generate a 16-bit code. By also using the two handshake lines, ATN and DAV for multiplex control, the code is effectively extended to 18 bits.

VIA CHIP

The control routing is performed by a special interface chip IC1, that can be programmed to allow 16-bit data storage, and for each of the 16 interface port pins to be latched either as inputs or outputs. Consequently this permits the input pins of the chip under test to be held at the required logic levels, whilst the output pins have their levels read by the computer.

The interface chip is known as a Versatile Interface Adapter, and owners of the BBC computer will recognise it as the same chip that controls the output port. A similar chip is used on the PET and C64. In its full capacity it has considerably more functions than are used here. In conjunction with the two bidirectional ports and their input data latching capability, there are two programmable registers allowing selection of the data direction, both input and output, on an individual line basis. It also has two timer-counters and several other control registers, including serial to parallel, and parallel to serial registers, though none of these are used here.

The majority of digital i.c.s require power to be applied to their top right hand pin, and are grounded via their bottom left hand pin. This enables test socket pin 16 to be held permanently at +5V, irrespective of whether the test chip has 14 or 16 pins. Test socket pin eight is held permanently grounded for 16 pin chips. Test pin seven though is routed via S2, so that it can be held at ground for 14 pin chips, but otherwise under computer control for 16 pin devices.

Since only a maximum of seven test pins have to be computer controlled this simplifies the control requirements, as only seven of the eight computer lines need to be multiplexed to the test chip. VIA Port B can thus control pins one to seven of the test socket, and VIA Port A control pins nine to 15.

INITIALISING

Prior to testing, the VIA needs to be told which pins are to be used as inputs, and which as outputs. As will be seen from the circuit diagram, the VIA has a set of eight data lines, one of which is grounded. The routing of these lines depends upon the setting of three control lines. Two of these control the data direction registers, and the other selects read and write modes. VIA pin 22 when held low, routes the data lines into the VIA as inputs in Write mode. When held high, data can be read back from the VIA. Pin 38 determines which port register is being read from or to. With this pin high the data lines are routed to the internal control register for Port A, and for Port B when low.

Pin 37 controls the register functions. In Write mode, with the pin high, the data input sets the registers so that the respective Ports A or B have their lines preset as inputs or outputs. A high data bit sets the relevant line as an output to the test chip, and a low bit sets it as a read back line.

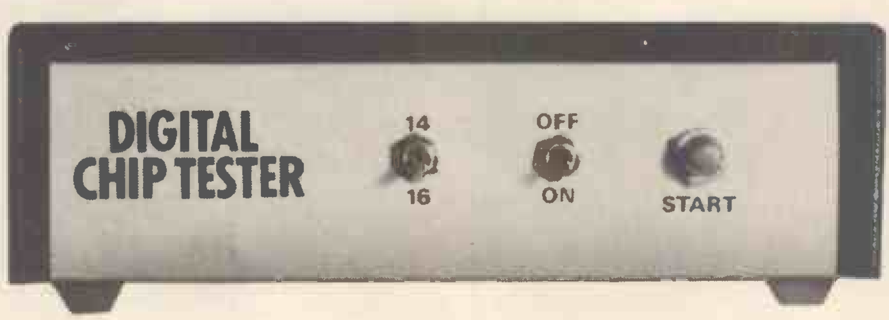
CLOCKING IN

The transfer of information between the Data lines and the registers and ports, is triggered by a clocking oscillator. With the particular VIA used here, this needs to be at around 2MHz. There is a certain amount of latitude on this frequency, but if it is too far below 2MHz, the data transfer could become erroneous. However it does not need to be crystal controlled in this application and is readily generated by the high frequency oscillator around IC2a to IC2d.

The frequency is primarily set by the values of R2 and C1. Interestingly though, it was noted during work on the prototype that the circuit still oscillated at a little over 2MHz with C1 omitted. This is probably due to the capacitive characteristics of IC2 itself.

STARTING

At the start of testing, the computer is programmed to wait for a Start signal from the unit. This is generated by the low frequency oscillator around IC2e and IC2f, producing a frequency of about 250kHz as set by R3 and C2. This goes to the gating multiplexer IC3. With S1 open, the gate is closed to the high frequency oscillator, and the DAV line of the computer is held low. When S1 is pressed, the gate opens and sends a stream of pulses to the computer. It simultaneously opens another gate at pin three, taking pin 37 of the VIA high. The computer responds by putting the VIA into write mode through ATN, and routes data



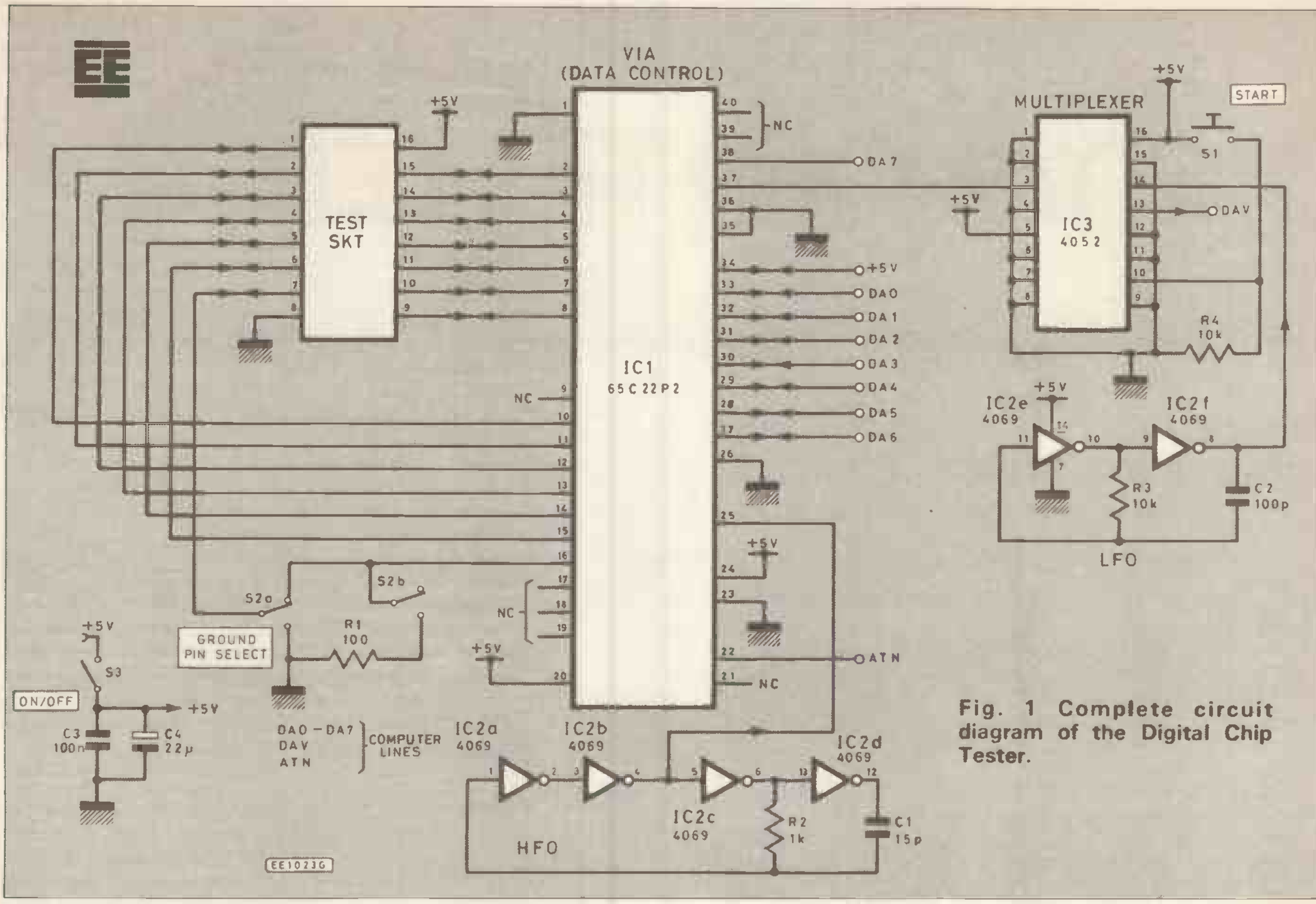


Fig. 1 Complete circuit diagram of the Digital Chip Tester.

COMPONENTS

See Shop Talk page 434

Resistors

R1	100
R2	1k
R3, R4	10k (2 off)

All $\frac{1}{4}$W 5% Carbon

Capacitors

C1	15p polystyrene
C2	100p polystyrene
C3	100n polyester
C4	22µ elect. 16V

Semiconductors

IC1	65C22P2
IC2	4069
IC3	4052

Switches

S1	push to make
S2	min d.p.d.t.
S3	min s.p.d.t.

Miscellaneous

P.c.b. clips (4 off); printed circuit board (see Shop Talk); case approx. 150 × 120 × 45mm.; 14-pin i.c. socket; 16-pin i.c. socket (2 off); 40-pin i.c. socket; 3.5mm jack socket; fixings, wire etc.

COMPONENTS approximate cost £33

lines DA0 to DA6 through to the Port A register, as directed by DA7. The first block of data is now sent and sets the relevant VIA port lines as inputs and outputs as required. DA7 is then taken down, so routing the data lines to the Port B register and the second block of data is sent, setting the Port B lines as inputs and outputs.

The precise sequence of computer instructions is actually slightly more complex than this, as study of the program will reveal. Having set both registers, the computer displays a screen prompt stating that S1 can be released. When this is done, VIA pin 37 goes low again, and the low frequency oscillator signals on DAV cease, whereupon the computer knows that it can commence the testing procedure.

TESTING SEQUENCE

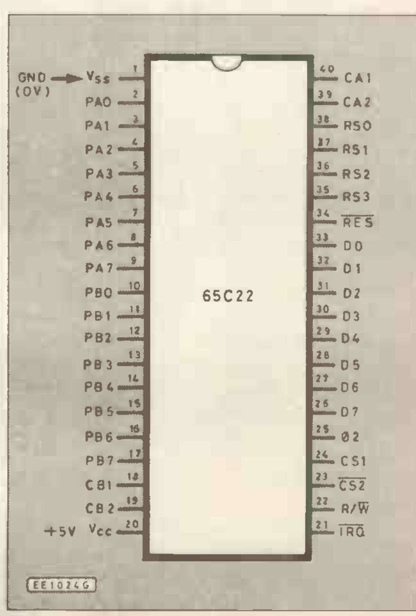
With ATN low and the VIA in write mode, in a manner similar to the above, the computer now sends two blocks of control data, one destined for test pins one to seven, and the other for pins nine to 15. In both cases the data is latched into the VIA when ATN is taken high. Once latched, Ports A and B of the VIA then apply the relevant logic levels to the test chip input pins. In response, the output pins of the chip assume their respective levels as they would under normal circuit conditions. The internal registers of the VIA latch in these levels and await reading by the computer. The exact sequence of events will be seen in the program listing.

The latching process is practically instantaneous, taking about eight cycles of the 2MHz clock. Since the computer is operating in BASIC, which is responding at a rate far slower, handshaking back to the computer is not required. As soon as it has sent its data, the response can be immediately read back. ATN is taken high, putting the VIA into read mode. In conjunction with DA7 the computer reads the register states of both Port A and Port B. The resulting data bytes are stored, and the next block of control instructions is sent to the unit. This process continues indefinitely until the computer is told to stop via a keyboard instruction.

DATA ASSESSMENT

Throughout the testing cycles the computer screen displays in graphic form, the

Fig. 2 Pin connections of the 65C22 chip.



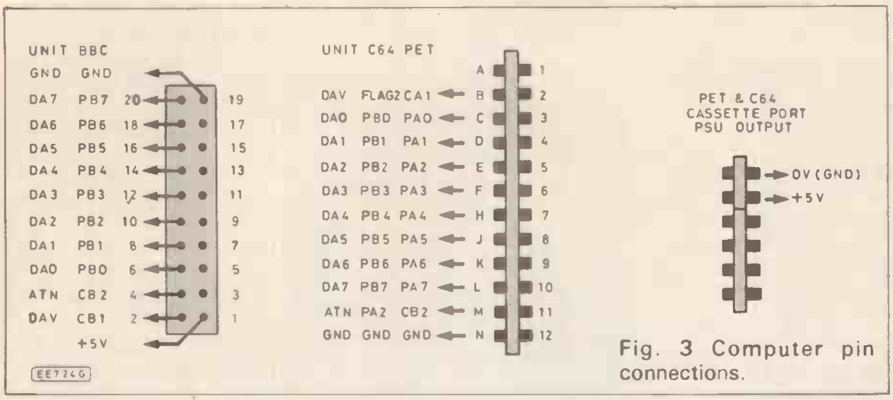


Fig. 3 Computer pin connections.

data being sent to and from the test chip (see illustrations). At the end of each main cycle, it assesses the data received back and decides whether the chip has responded correctly. If it considers that one or more pins have behaved incorrectly, it high-lights these pins on the display.

The logic behind this assessment is based upon the reasoning that if the pins of a gate are cycled through all possible permutations of high and low, then the respective output pin should toggle up and down at least once during the cycle. If the output does not change state, then the chip is probably faulty.

In theory it is possible for the computer to check the returning data against a predetermined truth table, so that the correctness of each response can be automatically checked. Although the rules behind such truth tables are simple, as shown later, the amount of memory needed to implement them for many different types of integrated circuit, is likely to exceed the capacity of most home computers. Consequently this facility has not been put under program control. In the majority of chip testing situations, it is usually only necessary to detect whether an output has toggled at least once.

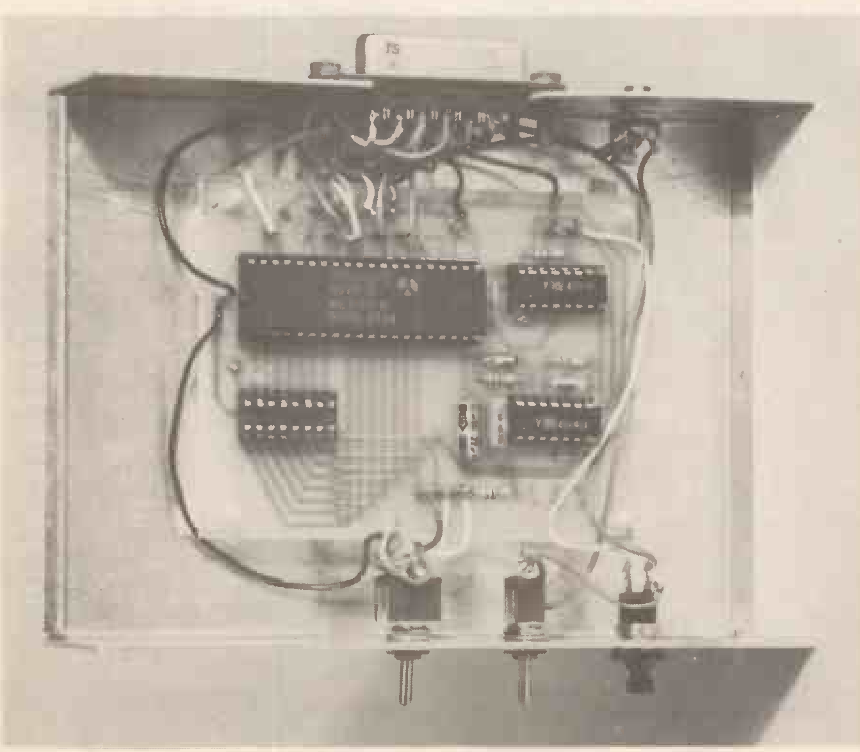
However, the program has been written so that the testing sequence can be stepped through stage by stage, and at each stage the user can observe from the screen display, which data is going out to the chip under test, and what response is received. Using the normal rules of binary logic, the correctness of each step can be observed. This facility enables the unit to be used not only for checking the viability of a particular integrated circuit, but also for use as a logic analyser.

POWER SUPPLY

The unit requires a power supply of +5V, basically at less than 10mA in its quiescent state. During testing this can rise to around 30mA, but the total current required will depend upon the chip under test. For most CMOS chips the extra current drawn will usually be negligible, but standard TTL tends to be quite hungry, and can often require several tens of milliamps. Many computers can supply the power directly to the unit, providing the manufacturer's limits are not exceeded. The BBC has up to 100mA available on its user port. The PET and C64 cassette ports can deliver up to 250mA and 100mA respectively. Alternatively a separate stabilised 5V power supply can be used.

ASSEMBLY

As will be seen in the p.c.b. layout, there is not much assembly required, and it is very straightforward. All soldered joints should of course be checked in close up with a magnifying glass for shorts or omissions before connecting to a power supply. The computer connection socket shown may be wired differently if it suits the computer lead better, as long as the leads arrive at the correct destinations. Alternative sockets may of course be substituted instead. The box used for the prototype is 15cm × 11.3cm × 4.5cm, leaving plenty of space for the board, controls and sockets. No special testing or setting up is required, since running the program with a chip under test will confirm the correctness of the assembly. Note that prior to chip insertion or removal, the power should be switched off by S3.



COMPUTER PROGRAM

The program has been written entirely in BASIC, and so is readily translatable for machines other than the three stated. Apart from some dialect differences, BASIC between various computers is normally fairly consistent. The main differences will be in the memory control locations and cursor movement codes. All the data necessary for direct use with the BBC, PET and C64 is included in the program listing. With all the data statements listed, the program requires just under 16K of memory when run.

DATA FORMAT

The information for testing chips is held by the program as DATA statements. The listing already contains the data for over 30 digital chips. Further information can readily be put into the program for other chips, and can be taken from manufacturer's data sheets, or from circuit diagrams. It will be seen from the listing that the data is held in three main sections. The first holds the i.c. type number. The second holds the pin data in numerical order. The third part holds the type description. Examination of the listing shows that the second and third parts can be used as pointers to data statements that are common to several different i.c. type numbers.

The pin functions are coded in a very simple manner, and it is easy to enter new information for other chips, or to amend existing data in order to examine specific aspects of a particular device. Chip input pins are designated by numbers between one and nine. Letters A to Z represent output pins. The ampersand symbol "&" is used for clock inputs. P.S.U ground and positive supply pins use "–" and "+" respectively. The hash symbol "#" indicates no connection, but can also be used to hold a pin deliberately low. The upwards arrow "↑" can be used to hold a pin deliberately high. Study of the listing shows practical examples of these coding implementations.

AUTOMATIC PREPARATION

All normal inputs are assumed to have the same status as each other, with the exception of clock inputs. The notation for the inputs and outputs will normally depend on the internal sections of the chip. For example with a quad two-input gate, there are four identical sections. The first section would have both its inputs designated by "1", and its output by "A". The inputs for the second section would be marked "2" and the output as "B", and so on.

When the program is run, a screen

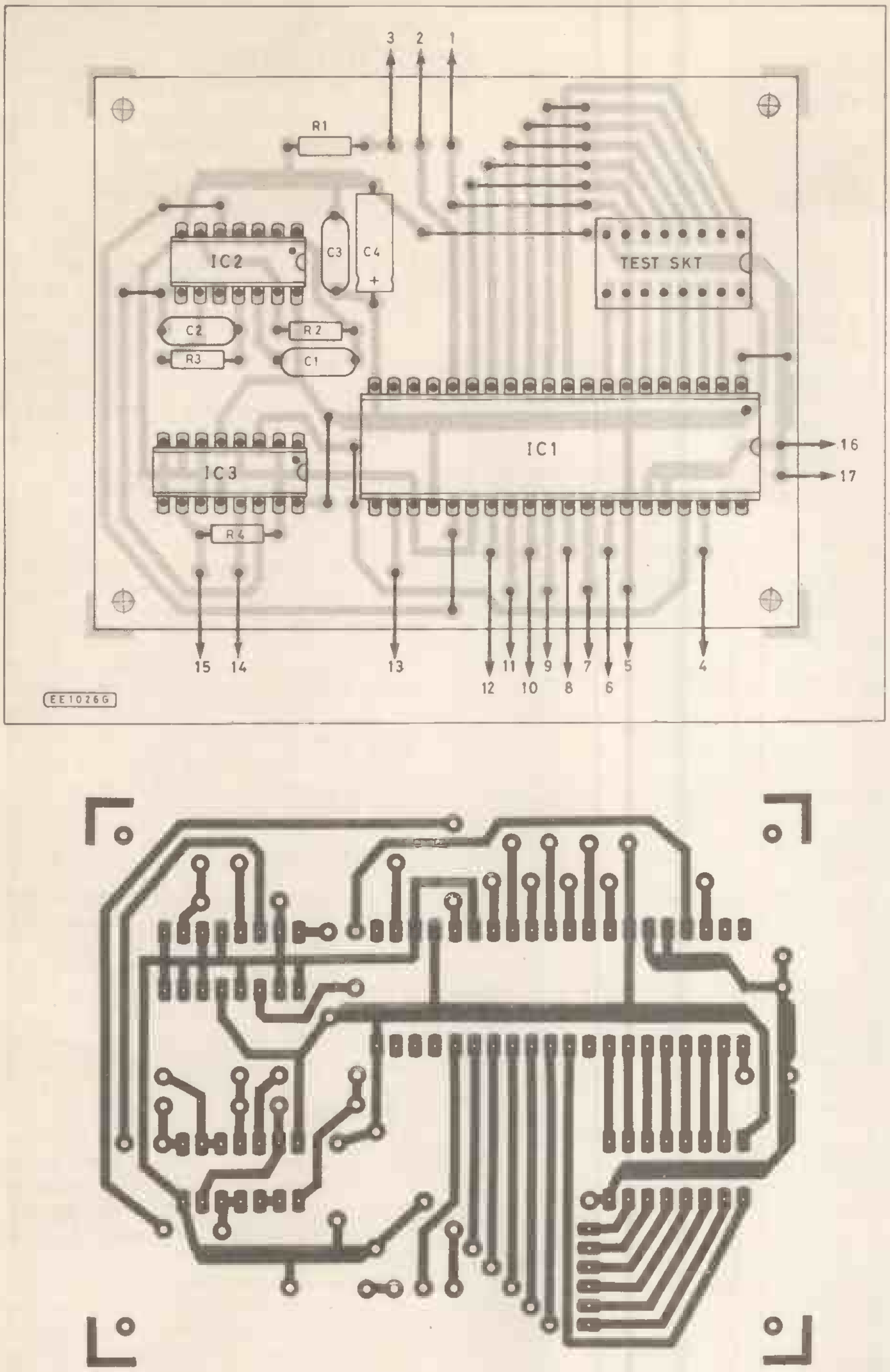
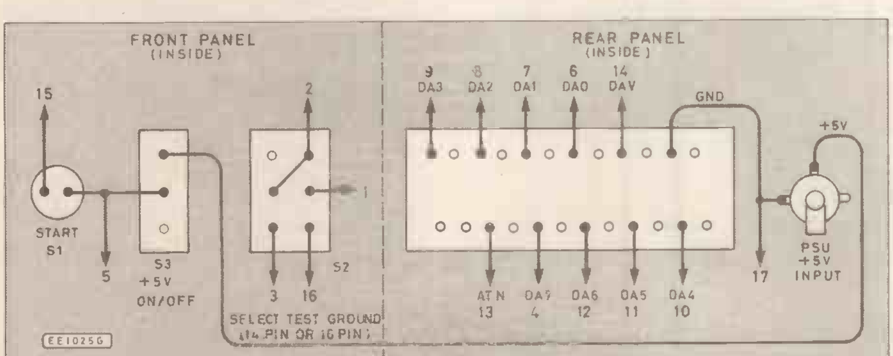


Fig. 4 The printed circuit board layout and wiring for the Digital Chip Tester.

Fig. 5 Front and rear panel wiring and connections to the printed circuit board.



prompt requests the type number of the chip to be tested. It then searches its data library, and having found the relevant data it proceeds to analyse it. It first looks for all pins designated by "1", and then calculates and stores all possible permutations of high or low that those pins can go through, irrespective of the quantity. If only one pin has that number there are two permutations, either the pin is high or it is low. For two pins of the same number four permutations are possible. For 14 pins of the same number over 16000 permutations are possible

The program then searches for pins having the next number, works out the permutations for this series, and stores them. This continues until all inputs are accounted for together with special function pins such as clock inputs, and static logic functions. From the analysis the program also determines the instruction codes to be sent to the VIA concerning which pins are inputs and which are outputs.

Upon completion of the analysis, the results of which are simultaneously displayed on the screen, the computer displays a prompt stating that it is ready to start testing and indicates how Ground switch S2 should be set. The Start switch S1 can then be pressed, and the testing sequence initiated. Additional screen prompts indicate the action to be taken to stop testing, and to select another chip for testing. A menu of the chips in the data library can also be called up. The option for continuous or stepped testing can be selected at any time during the sequence, together with a reset facility to restart a sequence if desired.

GATING TRUTH

The logic behind the functioning of most gates and many counters follows a well defined sequence of events from which truth tables can be readily determined. The term truth table, simply means a table that shows all possible permutations of what happens in response to certain specified events. In other words, if one condition prevails, then the truth is that another condition will result.

The majority of gates fall into one of six categories, namely OR, NOR, AND, NAND, Exclusive OR, Exclusive NOR. Under some input conditions the output will be at a level depending on the gate function. Under other conditions the output will assume the opposite level.

With an OR gate, if both inputs are low then the output will also be low. However if either input A OR input B is high then the output (C) will likewise be high. This is also true if both A and B are high together. Representing the low by "0" and the high by "1", four permutations exist. A0:B0 = C0. A0:B1 = C1. A1:B0 = C1. A1:B1 = C1. The truth table thus becomes 00=0, 01=1, 10=1, 11=1. With a NOR gate the output response is simply the inverse of that for an OR gate, and the table becomes 00=1, 01=0, 10=0, 11=0.

For an AND gate the output response depends on the levels of both input A AND input B. If either input is low then the output will also be low. It will only be high if A AND B are both high. The situation is similar for a NAND gate, except that the output will be in the opposite state to that for an AND gate. The respective truth tables are thus 00=0, 01=0, 10=0, 11=1, and 00=1, 01=1, 10=1, 11=0.

The output of an Exclusive Gate only changes if the two inputs are at different

CHIP TESTER SOFTWARE

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100 REM PROG262 EE MICRO CHIP-TEST 03AUG86. THIS PROG CAN BE USED WITH THE
110 REM BBC, C64 AND PET COMPUTERS. BBC USERS SEE END NOTES BEFORE TYPING IN.
120 REM C64 & PET USERS TYPE IN AS PER THIS LISTING.
130 DATA1-PET USER:REM SUBSTITUTE RIGHT  NO & NAME IN THIS LINE = 2-C64, 3-BBC
140 GOSUB1380:DIMA,B,B%,C,D,E,F,G,H,J,K,L,M,N,P,S,T,U,V,W,X,Y,H$,R$,U$,V$
150 DIMA$,B$,C$,L$,Q$,S$,T$,Z$,A(2),L(2),H(2),B(2),C(2),J(2),S(8),V(2),W(2)
160 DIMQ%(256,2),I(1,2),B$(255),R$(15),D$(15),A$(24),K$(3),T$(6),C$(24,1)
170 S$="************************":C$="  ":FORA=1TO4:C$=C$+CHR$(CL):NEXT
180 R$=CHR$(CR):U$=CHR$(CU)+CHR$(CU)
190 FORA=1TO15:D$(A)=D$(A-1)+CHR$(CD):NEXT:H$=CHR$(CH)+D$(2):V$=CHR$(CH)+D$(1)
200 K$(1)="INPUTS":K$(2)="RECEIVED":K$(3)="OUTPUTS":T$(0)="SETTING UP"+D$(1)
210 PRINTD$(3);TAB(7);"CREATING BINARY FILE":FORA=0TO15:A$="":D=A:B$=""
220 FORB=3TO0STEP-1:E=2↑B:W=D/E:IFW<1THENA$="-o"+A$:B$=R$+"※"+B$:GOTO240
230 D=D-E:A$="-●"+A$:B$=R$+R$+B$
240 NEXT:A$(A)=A$:B$(A)=B$:NEXT:C=0:FORA=0TO15:FORB=0TO15
250 B$(C)=A$(B)+A$(A)+"-":C=C+1:NEXT:NEXT:L$=LEFT$(B$(0),16)+LEFT$(B$(0),9)
260 FORC=0TO15:A$(C)="":NEXT
270 REM INPUT STAGE
280 POKEDRT,255:POKEOUT,0:POKEAT,DN:GOSUB1390:PRINTD$(4);TAB(13);"[M] MENU"
290 RESTORE:FORB=0TO1:FORA=1TOV:Q%(A,B)=0:NEXT:C(B)=0:J(B)=0:I(0,B)=0:I(1,B)=0
300 W(B)=0:H(B)=0:V(B)=0:B(B)=0:NEXT
310 PRINTTAB(91);:INPUT"I.C. TYPE ";A$:T$=A$+"/":L=LEN(T$):IFA$<>"M"THEN360
320 GOSUB1390:PRINT
330 C=4:READA$:IFA$="*"THENRESTORE:PRINT:GOTO310
340 IFMID$(A$,C+1,1)<>"/"THENC=C+1:GOTO340
350 PRINTLEFT$(A$,C),:GOTO330
360 READB$:IFB$="*"THEN280
370 IFT$<>LEFT$(B$,L)THEN360
380 A$(4)="":B$=B$+"/":E=L+1:D=0:FORC=ETOLEN(B$):IFMID$(B$,C,1)<>"/"THEN400
390 D=D+1:A$(D)=MID$(B$,E,C-E):E=C+1
400 NEXT:T$(1)="*":T$(2)="#":FORB=1TO2:IFLEN(A$(B))>3THENT$(B)=A$(B):GOTO440
410 READB$:IFB$<>T$(B)THEN410
420 FORC=1TOVAL(A$(B)):READB$:NEXT:C=3:IFVAL(B$)>9THENC=4
430 T$(B)=MID$(B$,C)
440 NEXT:Q$=T$(1):T$=T$(2)+" "+A$(3)+" ":T$(2)=""
450 REM SCREEN FORMAT
460 T$(1)=A$:E=1:N=1:T=2:FORC=1TOLEN(T$):IFMID$(T$,C,1)<>" "THEN500
470 IFLEN(T$(T))+C-E>12THENT=T+1:T$(T)=""
480 IFMID$(T$,C+1,1)="*"THENN=VAL(MID$(T$,C+2))*2
490 T$(T)=T$(T)+MID$(T$,E,C-E+1):E=C+1
500 NEXT:P=LEN(Q$):IFP=14THENB(0)=128:B(1)=128
510 PRINTCHR$(CC);D$(1):FORA=0TOT:PRINTTAB(26);T$(A):NEXT:T$(A)=""
520 PRINTV$:FORA=1TO3:PRINTLEFT$(L$,P+1):PRINT"| ";TAB(P+1);"| "
530 PRINT")  ";K$(A);TAB(P+1);"| ":PRINT"| ";TAB(P+1);"| ":PRINTLEFT$(L$,P+1)
540 PRINT:PRINT:NEXT:PRINT"[*] NEXT  [G] GO  [R] RESET  [BAR] STEP"
550 REM STANDARDISE DATA
560 PRINTCHR$(CH);D$(9):FORC=PTO(P/2)+1STEP-1:PRINTR$;MID$(Q$,C,1);:NEXT
570 PRINTD$(1):FORC=1TOP/2:PRINTR$;MID$(Q$,C,1);:NEXT:PRINT
580 IFP=14THENQ$=LEFT$(Q$,7)+"***"+MID$(Q$,8):GOTO600
590 Q$=LEFT$(Q$,8)+"*"+MID$(Q$,9)
600 A$="":FORC=16TO9STEP-1:A$=A$+MID$(Q$,C,1):NEXT:Q$=LEFT$(Q$,8)+A$
610 REM TRUTH TABLE CALC
620 FORC=1TO16:A$(C)=MID$(Q$,C,1):NEXT:G=0:FORC=1TO16:IFA$(C)=""THEN840
630 IFVAL(A$(C))=0THEN730
640 C$(C,0)=A$(C):S=1:S(1)=C:FORD=C+1TO16
650 IFA$(D)=A$(C)THENS=S+1:S(S)=D:C$(D,0)=A$(D):A$(D)=""
660 NEXTD:FORF=1TO2↑S:D=F-1:G=G+1:FORB=0TO1:Q%(G,B)=0:NEXTB
670 FORA=S-1TO0STEP-1:E=2↑A:W=D/E:IFW<1THEN690
680 D=D-E:B=INT((S(A+1)-1)/8):K=S(A+1)-(B*8):Q%(G,B)=Q%(G,B)OR(2↑(K-1))
690 NEXTA:FORB=0TO1:J=Q%(G,B):I(0,B)=I(0,B)ORJ:PRINTV$
700 IFB=0THENPRINTD$(3):PRINTLEFT$(B$(J),P):PRINT:GOTO720
710 PRINT"-o";LEFT$(B$(J),P-2)
720 NEXTB:NEXTF:GOTO840
730 A$=A$(C):B=INT((C-1)/8):K=C-(B*8):M=2↑(K-1):A=240:IFB=1THENA=2
740 IFA$="-"ORA$="#"THEN760
750 GOTO770
760 C$(C,0)=A$:C$(C,1)=A$:B(B)=B(B)ORM:I(0,B)=I(0,B)ORM:GOTO840
770 IFA$="↑"THENC$(C,0)=A$:C$(C,1)=A$:B(B)=B(B)ORM:H(B)=H(B)ORM:GOTO840
780 IFA$<>"&"THEN810
790 C(B)=C(B)ORM:J(B)=K*2-2+A:C$(C,0)="&":IFN=1THENN=2
800 GOTO840
810 IFA$<"A"ORA$>"Z"THEN840
820 I(1,B)=I(1,B)ORM:E=ASC(A$)-ASC("A")+1:IFE>9THENC$(C,1)=A$:GOTO840
830 C$(C,1)=STR$(E):IFLEFT$(C$(C,1),1)=" "THENC$(C,1)=MID$(C$(C,1),2)
840 A$(C)="":NEXTC:FORB=0TO1:FORC=1TOG:Q%(C,B)=Q%(C,B)ORH(B):NEXT:NEXT
850 FORC=0TO1:FORB=1TO0STEP-1:PRINTV$:IFC=1THENPRINTD$(13)
860 I(C,B)=I(C,B)ORH(B)ORC(B):J=I(C,B):IFB=1THEN900
870 PRINTD$(3):PRINTLEFT$(B$(J),P):PRINTU$;
880 FORD=1TOINT(P/2):IFC$(D,C)=""THENPRINTR$;
890 PRINTR$;C$(D,C);:C$(D,C)="":NEXT:PRINT:GOTO920
900 PRINT"-o";LEFT$(B$(J),P-2):PRINTR$;"+";:FORD=9TOP:IFC$(D,C)=""THENPRINTR$;
910 PRINTR$;C$(D,C);:C$(D,C)="":NEXT:PRINT
920 NEXTB:NEXTC:V=G:IFV=0THENV=1
930 PRINTCHR$(CH);"TESTS";V;:IFN>1THENPRINT"*";N;"+";V;"=";V*N+V
940 PRINTCHR$(CH);D$(9):PRINTTAB(26);"SET GROUND":PRINTTAB(26);"SWITCH TO"
950 PRINTTAB(66);"***";P;"***";D$(2)
960 PRINTTAB(66);"o = LOW":PRINTTAB(26);"● = HIGH":PRINTTAB(26);"※ = SUSPECT"
970 PRINTH$;TAB(26);"TEST 0     "
980 PRINTCHR$(CH);TAB(25);"*PRESS START*":POKEDRT,0:L=PEEK(IN)
990 FORA=1TO20:L=PEEK(IN):K=PEEK(DAV):NEXT:L=PEEK(IN):A=0
1000 K=PEEK(DAV)ANDSET:L=PEEK(IN):GETZ$:IFZ$="*"THEN280
1010 IFK=0THEN1000
1020 POKEDRT,255:POKEAT,DN:POKEOUT,I(0,0):POKEAT,UP:POKEOUT,I(0,1)OR128
1030 POKEAT,DN:POKEAT,UP:PRINTCHR$(CH);TAB(25);"** RELEASE ** ":PRINTCHR$(CH);
1040 K=PEEK(DAV)ANDSET:L=PEEK(IN):IFK=SETTHEN1040
1050 POKEAT,DN:POKEOUT,0:POKEOUT,I(0,0):POKEOUT,128:POKEOUT,I(0,1)OR128
1060 POKEOUT,0:POKEOUT,128:POKEAT,UP
1070 PRINTTAB(25);"                    ":B(1)=B(1)OR128:IFP=14THENB(1)=B(1)OR64
1080 Z$="":FORB=0TO1:H(B)=B(B):D(B)=255-B(B):L(B)=D(B):NEXT:L=0:Y=0
1090 REM TESTING SEQUENCE
1100 X=0:W=0:PRINTH$;TAB(34);Y:FORK=1TOV:X=X+1:IFLTHEN1120
1110 GETZ$:IFZ$=""THEN1170
1120 IFZ$="*"THEND=PEEK(IN):GOTO280
1130 IFZ$=" "THENL=1:GOTO1160
1140 IFZ$="G"THENPRINTCHR$(CH);TAB(24);"           ":L=0:GOTO1170
1150 IFZ$="R"THENFORB=0TOH:W(B)=0:NEXT:K=V:Y=0:Z$="":GOTO1170
1160 IFL=1THENGETZ$:IFZ$=""THENPRINTCHR$(CH);TAB(26);"HOLDING":GOTO1160
1170 POKEDRT,255:POKEAT,DN:FORB=0TO1:IFC(B)=0THEN1210
1180 W(B)=W(B)+1:IFW(B)>NTHENW(B)=0:W=0:GOTO1210
1190 W=W+1:IFW(B)AND1THENQ%(K,B)=Q%(K,B)ORC(B):GOTO1210
1200 Q%(K,B)=Q%(K,B)AND(255-C(B))
1210 POKEOUT,Q%(K,B)OR(128*B):NEXT:POKEAT,UP
1220 REM SCREEN PRINT
1230 PRINTH$;TAB(32);C$;X:IFN=1THEN1260
1240 FORB=0TO1:IFC(B)THENPRINTV$;TAB(J(B)+2);C$;W(B)
1250 NEXT
```

Continued

CHIP TESTER SCREEN DUMPS

```
TESTS 16                      HOLDING

-o-o-o-o-o-●-●-               TEST 16  3
|+ 4 4     3 3 |
)  INPUTS      |              4081
|1 1     2 2 - |              QUAD 2-INPUT
-o-o-o-o-o-o-o-               AND


-o-o-o-o-●-●-●-
|+ 4 4 D C 3 3 |              SET GROUND
)  RECEIVED    |              SWITCH TO
|1 1 A B 2 2 - |
-o-o-o-o-o-o-o-               *** 14 ***


-o-o-o-●-●-o-o-
|+     4 3     |              o = LOW
)  OUTPUTS     |              ● = HIGH
|    1 2     - |              ※ = SUSPECT
-o-o-●-●-o-o-o-


[*] NEXT  [G] GO  [R] RESET  [BAR] STEP
```

```
TESTS 8 * 2 + 8 = 24          HOLDING
       2
-o-o-o-o-o-o-o-●-             TEST 14  4
|+     &       1 1 |
)  INPUTS          |          4052
|    &       1 # - |          ANALOGUE
-o-o-o-o-o-o-o-o-             MULTIPLEXER
       2                      DUAL 4 CHAN

-o-o-●-o-●-●-o-●-
|+ A A & A A 1 1 |            SET GROUND
)  RECEIVED      |            SWITCH TO
|B B & B B 1 # - |
-●-o-o-●-●-o-o-o-             *** 16 ***


-o-●-●-●-●-●-o-o-
|+ 1 1   1 1     |            o = LOW
)  OUTPUTS       |            ● = HIGH
|2 2   2 2   # - |            ※ = SUSPECT
-●-●-●-●-●-o-o-o-


[*] NEXT  [G] GO  [R] RESET  [BAR] STEP
```

```
TESTS 16                      HOLDING

-o-●-●-o-o-o-o-               TEST 12  3
|+ 4 4   3 3   |
)  INPUTS      |              7400
|1 1   2 2   - |              QUAD 2-INPUT
-o-o-o-o-o-o-o-               NAND


-o-●-●-o-o-o-●-
|+ 4 4 D 3 3 C |              SET GROUND
)  RECEIVED    |              SWITCH TO
|1 1 A 2 2 B - |
-o-o-●-o-o-●-o-               *** 14 ***


-o-o-o-●-o-o-●-
|+     4     3 |              o = LOW
)  OUTPUTS     |              ● = HIGH
|    1     2 - |              ※ = SUSPECT
-o-o-●-o-o-●-o-


[*] NEXT  [G] GO  [R] RESET  [BAR] STEP
```

```
TESTS 4 * 20 + 4 = 84         HOLDING
     9
-o-o-●-o-o-o-o-o-             TEST 9   4
|+ 1 & 1         |
)  INPUTS        |            4017
|              - |            DECADE
-o-o-o-o-o-o-o-o-             COUNTER *10


-o-o-o-o-●-●-●-●-
|+ 1 & 1 K J E I |            SET GROUND
)  RECEIVED      |            SWITCH TO
|F B A C G H D - |
-o-o-o-●-●-●-●-o-             *** 16 ***

SUSPECT
-o-o-●-o-※-※-※-●-
|+       K J 5 9 |            o = LOW
)  OUTPUTS       |            ● = HIGH
|6 2 1 3 7 8 4 - |            ※ = SUSPECT
-●-●-●-※-※-※-●-o-


[*] NEXT  [G] GO  [R] RESET  [BAR] STEP
```

Continued

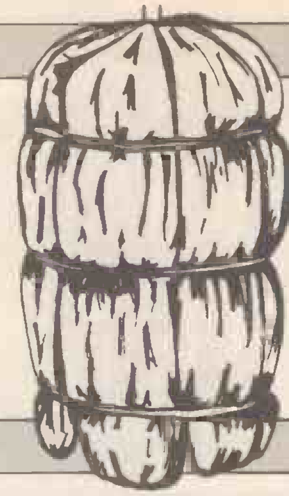
```
1260 FORB=0TO1:POKEDRT,255:POKEOUT,Q%(K,B)OR(128*B):POKEAT,DN:POKEAT,UP
1270 POKEDRT,128:A(B)=PEEK(IN):H(B)=H(B)ORA(B):L(B)=L(B)ANDA(B):NEXT
1280 PRINTH$;TAB(2);LEFT$(B$(Q%(K,1)),P-2);TAB(160);LEFT$(B$(Q%(K,0)),P)
1290 PRINTD$(2);TAB(2);LEFT$(B$(A(1)),P-2);TAB(160);LEFT$(B$(A(0)),P)
1300 IFWTHENK=K-1
1310 NEXT:Y=Y+1:H=0:FORB=0TO1:C=H(B)AND(255-L(B)):IFC=V(B)THEN1370
1320 B%=C/16:A=C-(B%*16):PRINTCHR$(CH);D$(15):IFBTHEN1340
1330 PRINTD$(4);LEFT$(B$(I(1,B)),P):PRINTCHR$(CU);R$(A);R$(B%):GOTO1350
1340 PRINT"¬o";LEFT$(B$(I(1,B)),P-2):PRINTCHR$(CU);"¬o";R$(A);R$(B%)
1350 IFC<255THENPRINTCHR$(CH);D$(15);"SUSPECT":H=1:GOTO1370
1360 IFH=0THENPRINTCHR$(CH);D$(15);"        "
1370 H(B)=B(B):V(B)=C:L(B)=D(B):NEXT:GOTO1100
1380 READA$:A=VAL(A$):ONAGOSUB1670,1700,1730
1390 PRINTCHR$(CC);TAB(48);"EE MICRO CHIP-TEST"
1400 PRINTTAB(42);"COMPUTER AIDED DIGITAL IC CHECKER":RETURN
1410 REM LIBRARY
1420 DATA4001/1/3/NOR,4008/1111111-&ABCDE1+/ADDER 4-BIT
1430 DATA4011/1/3/NAND,4012/3/1/NAND,4013/AA&111-222&BB+/8/DUAL D
1440 DATA4015/&HCBA12-&DGFE34+/DUAL 4-BIT SHIFT REG *4
1450 DATA4017/FBACGHD-IEJK1&1+/6/,4023/4/2/NAND,4024/&1GFED-#C#BA#+/5/*128
1460 DATA4027/AA&1111-2222&BB+/8/DUAL J-K,4040/LFEGDCB-A&1IHJK+/5/*4096
1470 DATA4042/DAA1&↑2-BBCC34D+/12/
1480 DATA4051/EG&HF1#-111DABC+/11/8 CHAN,4052/BB&BB1#-11AA&AA+/11/DUAL 4 CHAN
1490 DATA4053/BBC&C1#-111AA&&+/11/TRI 2 CHAN,4066/1AB223-3CD441+/QUAD SWITCH
1500 DATA4069/5/9,4070/1/3/EXCLUSIVE OR,4071/1/3/OR,4072/3/1/OR
1510 DATA4077/1/3/EXCLUSIVE OR
1520 DATA4075/4/2/OR,4081/1/3/AND,4082/3/1/AND,4160/6/6,4161/6/5/*16
1530 DATA4174/&A12B3C-&D4E56F+/8/HEX D,4502/3C1&A2B-D4E#5F6+/9/STROBED
1540 DATA4511/11↑↑#11-EDCBAGF+/10,4520/&1ABCD1-&2EFGH2+/7/*16
1550 DATA4531/1112222-A&33331+/12 BIT PARITY TREE
1560 DATA7400/11A22B-C33D44+/3/NAND,7402/A11B22-33C44D+/3/NOR,7404/5/9
1570 DATA7410/11222B-C333A1+/2/NAND,7420/11#11A-B22#22+/1/NAND
1580 DATA7447/11↑↑111-↑↑↑↑↑↑↑+/10,7472/##111A-A222&#+/8/J-K
1590 DATA7474/11&1AA-BB2&22+/8/DUAL D
1600 DATA74390/&1A&BCD-HGF&E2&+/7/*10
1610 DATA*,1/11AB22-33CD44+,2/UNUSED,3/A1111#-#2222B+
1620 DATA4/11222B-1AC333+,5/1A2B3C-D4E5F6+,6/1&####↑-↑↑DCBAE+
1630 DATA#,1/DUAL 4-INPUT,2/TRIPLE 3-INPUT,3/QUAD 2-INPUT
1640 DATA4/UNUSED,5/BINARY COUNTER,6/DECADE COUNTER *10
1650 DATA7/DUAL COUNTER,8/FLIP FLOP,9/HEX INVERTER,10/BCD 7-SEGMENT DECODER
1660 DATA11/ANALOGUE MULTIPLEXER,12/QUAD LATCH
1670 REM PET CURSOR & CONTROL CODES
1680 CU=145:CD=17:CL=157:CC=147:CH=19:CR=29:DN=205:SET=2:UP=237:DAV=59469
1690 DRT=59459:IN=59457:OUT=59471:AT=59468:POKE59467,0:RETURN
1700 REM C64 CURSOR & CONTROL CODES
1710 CU=145:CD=17:CL=157:CC=147:CH=19:CR=29:DN=251:SET=16:UP=199:DAV=56589
1720 DRT=56579:IN=56577:OUT=56577:AT=56576:RETURN
1730 REM BBC CURSOR & CONTROL CODES
1740 CU=11:CD=10:CL=8:CC=12:CH=30:CR=9:DN=14:SET=16:UP=206:DAV=&FE6D
1750 DRT=&FE62:IN=&FE60:OUT=&FE60:AT=&FE6C:RETURN
1760 REM BBC USER NOTES
1770 REM THE BBC USES '?' INSTEAD OF 'PEEK' AND 'POKE', THUS 'POKEDRT,255'
1780 REM WOULD BECOME '?DRT=255'. FOR 'PEEK' THE '?' CAN BE SUBSTITUTED
1790 REM DIRECTLY, THUS 'L=PEEK(IN)' BECOMES 'L=?(IN)'.
1800 REM 'GETZ$' BECOMES 'Z$=INKEY$(0)'. 'DIM' - ONLY BRACKETED VARIABLES
1810 REM SUCH AS 'A(2),L(2) ETC CAN BE DIMMED IN THIS WAY. FOR SINGLE
1820 REM VARIABLES ENTER THEM AS 'A=0:B=0:B%=0:A$="":B$=""', ETC.
1830 WHEN TYPING IN THE NORMAL BBC REQUIREMENTS FOR A SPACE BETWEEN SOME
1840 STATEMENTS SHOULD BE OBSERVED, IF NECESSARY SPLITTING LINES INTO TWO
1850 PARTS WITH THE SECOND PART GIVEN A LINE NUMBER INCREASED BY 5.
READY.
```

levels, in other words, if the logic Excludes one of the inputs. For an Exclusive OR gate the table thus becomes 00=0, 01=1, 10=1, 11=0. Exclusive NOR is the inverse again, so the table becomes 00=1, 01=0, 10=0, 11=1.

A similar principle holds true however many inputs there are. All that changes is the number of possible input permutations available. So for example a three input AND gate would have a table of 000=0, 001=0, 010=0, 011=0, 100=0, 101=0, 110=0, 111=1. Likewise a three input NOR gate would produce 000=1, 001=0, 010=0, 011=0, 100=0, 101=0, 110=0, 111=0. Armed with this simple knowledge, truth tables for a wide variety of chip types can be assembled, and used to cross check the functioning of a chip under test. It is also possible of course to actually produce a truth table by watching the screen display associated with a chip under test. Decade and binary counters are particularly interesting to observe during their test sequences.

FINALLY

As previously stated, the unit is capable of examining a wide variety of devices, though it does not claim to be all inclusive. Chips such as those that require external components like resistors and capacitors, cannot be readily examined by it. Nor can some that are edge sensitive, that is, those that respond to the actual moment of level change. For a wide range of purposes though, many of the chips in general use will only be interested in whether a control voltage is high or low. For these devices this unit offers ideal facilities for both testing and analysing their functions. It will have obvious appeal to experimenters and educationalists alike. □



IMMERSION HEATER TIMER

T.R. de VAUX-BALBIRNIE

Reduce costs with this energy-saving project

Any way of saving household energy is welcome. One item for consideration is the immersion water heater—if used indiscriminately the cost can be excessive. This project is an electronic timer designed to control the immersion heater. By heating water for the required time only, substantial savings can be made. In this system, three operating times are provided—30 minutes, one hour and two hours plus a continuous option. Although intended for immersion heaters, it would be possible to use this timer to control other mains appliances up to 15A rating (3,600W on 240V mains).

CIRCUIT DESCRIPTION

The entire circuit of the Immersion Heater Timer is shown in Fig. 1. The principal component is the integrated circuit timer, IC1. A nominal 12V d.c. supply is provided by the conventional arrangement of mains transformer, T1, fuse, FS1, bridge rectifier, D5 to D8 and smoothing capacitor, C3. IC1 requires an accurately-maintained 5V supply but stabilisation is provided on the chip and operates in conjunction with R1. By connecting IC1 pin one to supply negative, timing is initiated when the supply is switched on, this being convenient for the present purpose.

When S2 is switched on, T1 primary receives current from the mains via FS2. IC1 begins a timing cycle and RLA "make" contacts (RLA1) operate. S2 may now be switched to standby with T1 continuing to receive current via RLA1 make contacts. Although there is a short interruption of supply as S2 moving contact travels from one fixed contact to the other, this has no effect since C3 maintains the current for IC1 and hence RLA.

The delay time is determined by the values of R2, R3, R4 and timing capacitor C2. The set time switch, S1, connects either R4 alone (30 minutes), R4 and R3 in series (one hour) or R4, R3 and R2 in series (for two hours). Long timings are possible despite C2 having a low value due to an on-chip binary divider which counts 4095 charge/discharge cycles before the sequence ends. At this point, the outputs (pins two and three) change state. With timing in progress, pin three is high and pin two low. When timing is complete, pin two becomes high and pin three low. Pin three output operates relay, RLA/1 through Darlington pair, TR2/TR3 and hence the mains load. Additionally, it lights the red timing l.e.d., D2 through current-limiting resistor, R8. Pin two output operates TR1 hence the green waiting l.e.d., D1, through current-limiting resistor, R7.

Potentiometer VR1 provides an adjustment for the time period. At the end of the timing cycle, RLA coil switches off and the "make" contacts part. This switches off the load and T1. The green waiting l.e.d. provides a reminder in the event of S2 being left switched on and not at standby.

This circuit requires high current mains connections to be made. Anyone not certain of being able to make a safe job must seek the assistance of a qualified electrician.

CONSTRUCTION

During construction work, it is essential to follow certain safety procedures. In particular, an *earthed* metal case must be used and all external wiring must be of the type approved for immersion heater installations.

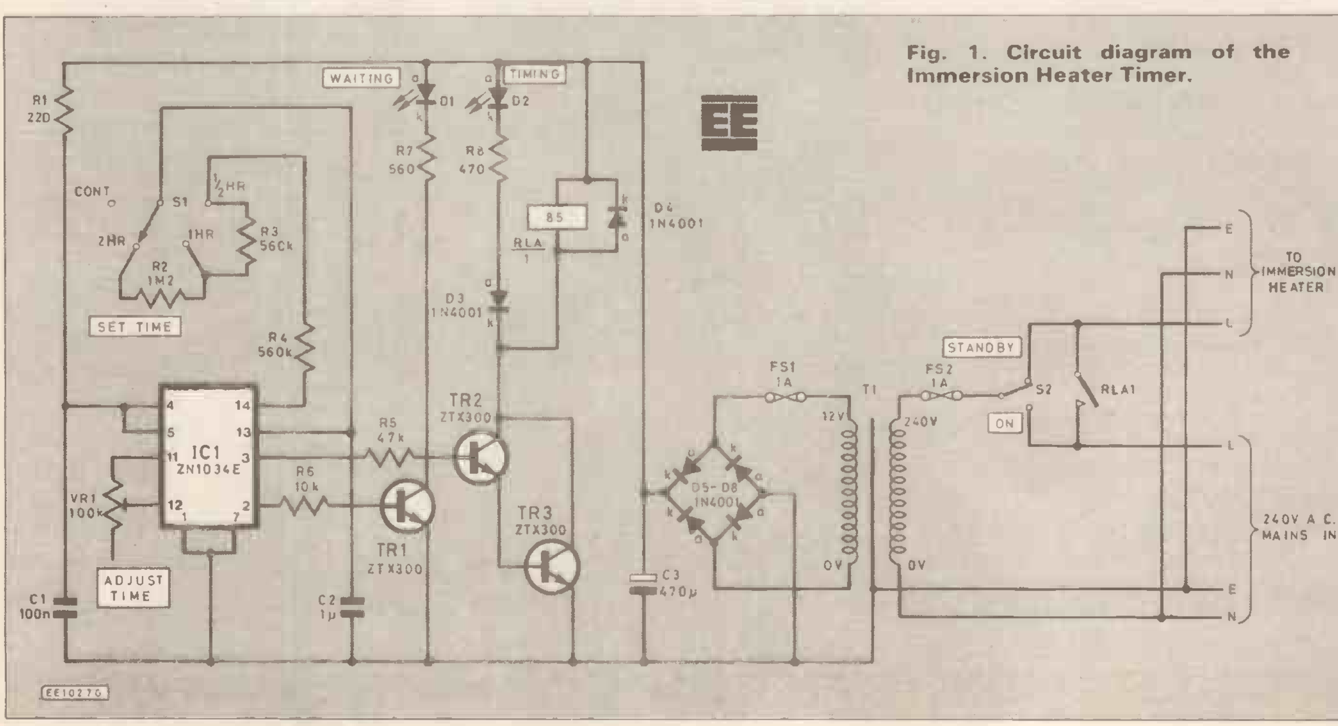


Fig. 1. Circuit diagram of the Immersion Heater Timer.

The choice of relay is important—it must have a 12V coil and mains "make" contacts of 30A rating minimum. Use a heavy-duty relay—a miniature component is likely to fail quickly in service. Note also that T1 must have adequate power rating—see components list.

Refer to Fig. 2 and begin construction by cutting a piece of 0.1 inch matrix stripboard to size 12 strips by 28 holes. Drill the two fixing holes, make all copper track breaks and inter-strip links then follow with the soldered on-board components. Take particular care over the polarities of all diodes and C3. Do not insert IC1 into its holder until the end of construction. For testing purposes connect short "stalks"—discarded

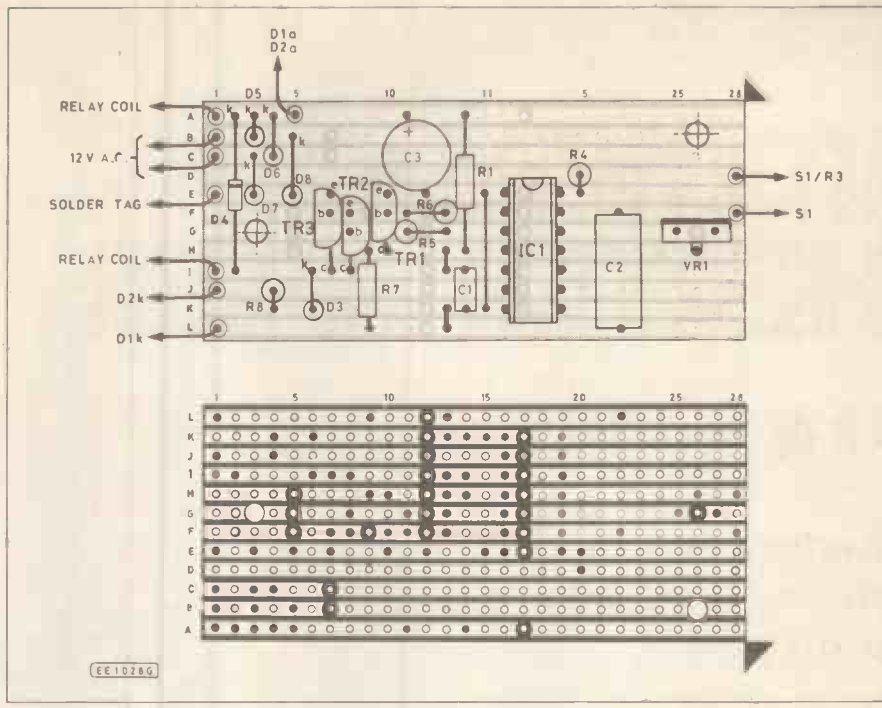
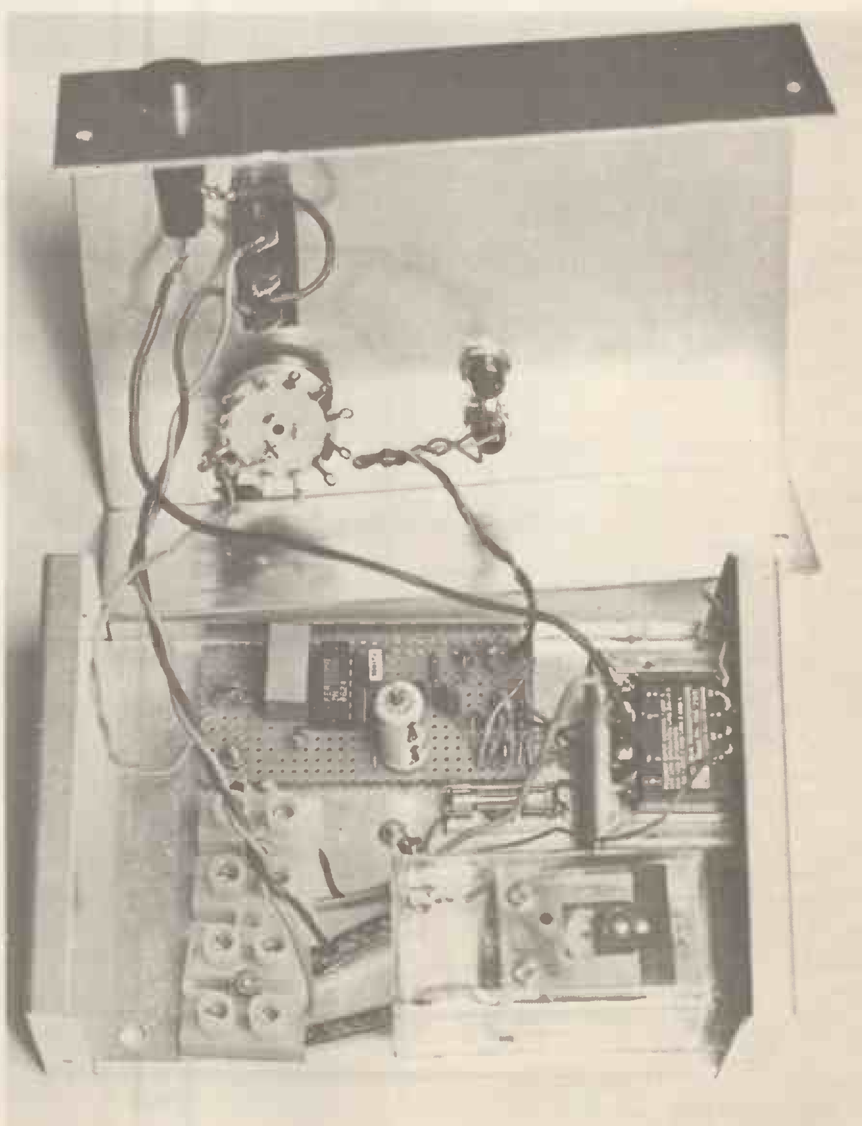


Fig. 2. Veroboard layout and wiring.

Photograph of the inside of the completed unit.



COMPONENTS

See Shop Talk page 434

Resistors

R1	220
R2	1M2
R3,R4	560k (2 off)
R5	47k
R6	10k
R7	560
R8	470

All fixed resistors 0.5W 5% types

Potentiometer

VR1 100k vertical preset

Capacitors

C1	100n
C2	1μ non-electrolytic type (additional 10n capacitor for testing if required—see text)
C3	470μ elect. 16V p.c.b. or axial lead type.

Semiconductors

IC1	ZN1034E Timer
D1	green l.e.d. panel indicator
D2	red l.e.d. panel indicator
D3 to D8	1N4001 (6 off)
TR1 to TR3	ZTX300 *npn* silicon (3 off)

Miscellaneous

T1 mains transformer with 12V 250mA secondary (3W or 6W rating).

RLA heavy-duty relay with 12V 85 ohm coil and mains-rated "make" contacts rated at 30A minimum.

S1 4-position 3-pole wafer switch.

S2 s.p.d.t. rocker switch with 1A mains-rated contacts.

FS1 20mm chassis fuseholder with 1A fuse.

FS2 20mm panel fuseholder with 1A fuse.

0.1 inch matrix stripboard size 12 strips by 28 holes; aluminium box size 152 × 102 × 51mm; 30A terminal block—4 sections required; approved immersion heater type cable; 3A mains wire; knob; fixings etc.

Approx. cost Guidance only £16.50

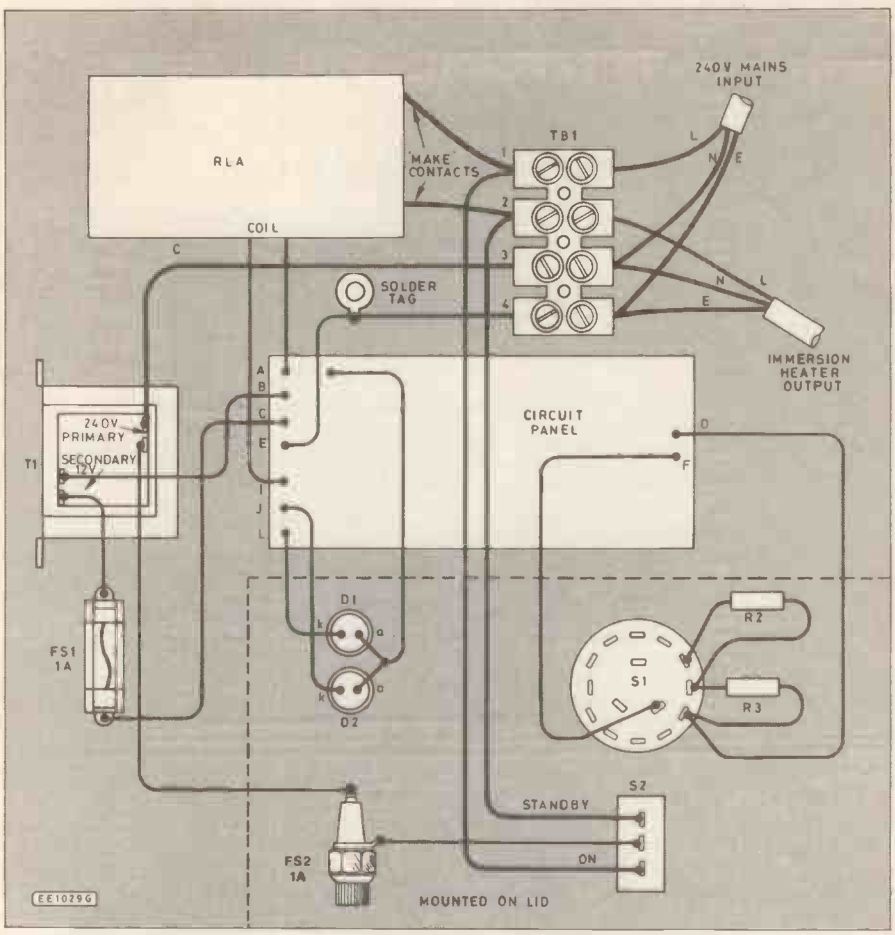


Fig. 3. Interwiring of the Immersion Heater Timer components.

resistor ends—at C2 position and solder a 10nF capacitor to these instead of the value specified—this will make all timings 100 times shorter and simplify the testing procedure. With the circuit panel checked for errors, connect 10cm pieces of light-duty stranded connecting wire to each of strips A (2 off), B, C, D, E, F, I, J and L as indicated.

Prepare the case by drilling holes for transformer, relay, solder tag, fuse holder FS1, circuit panel and terminal block mounting. Drill two holes in the back of the case for attaching the unit to the wall. Drill holes of ample diameter in the side adjacent to TB1 for mains input and output leads —fit these with large rubber grommets. Mount all base-section components. Include short stand-off insulators on the circuit panel attachment bolts to keep the copper strips and soldered connections clear of the metalwork. Take care to avoid short-circuits between FS1 connections and the case—if necessary use a plastic shield. Make sure that a small space is left between RLA and T1. Adjust VR1 to approximately mid-track position.

Drill holes in the lid section for the switches, fuse holder FS2 and l.e.d. indicators—mount these components. Refer to Fig. 3 and complete all wiring. Note that the solder tag earths the case and **must not be omitted**—use stranded mains-type wire for its connection to TB1/4. The wires between RLA "make" contacts TB1/1 and TB1/2 must be made with mains-rated stranded wire of 30A capacity minimum. The specified relay has "pigtail" leads already attached—shorten these as necessary. S2, FS2 and T1 primary connections should be made with mains wire of 3A rating.

Remove IC1 from its special packing and *without touching the pins* insert it into its holder. This procedure is necessary since the i.c. is a CMOS device and vulnerable to damage by static charge. Insert the fuses into their holders. Carefully offer the lid into position looking for possible trapped wires and short-circuits—check particularly that all mains connections remain well clear of the case.

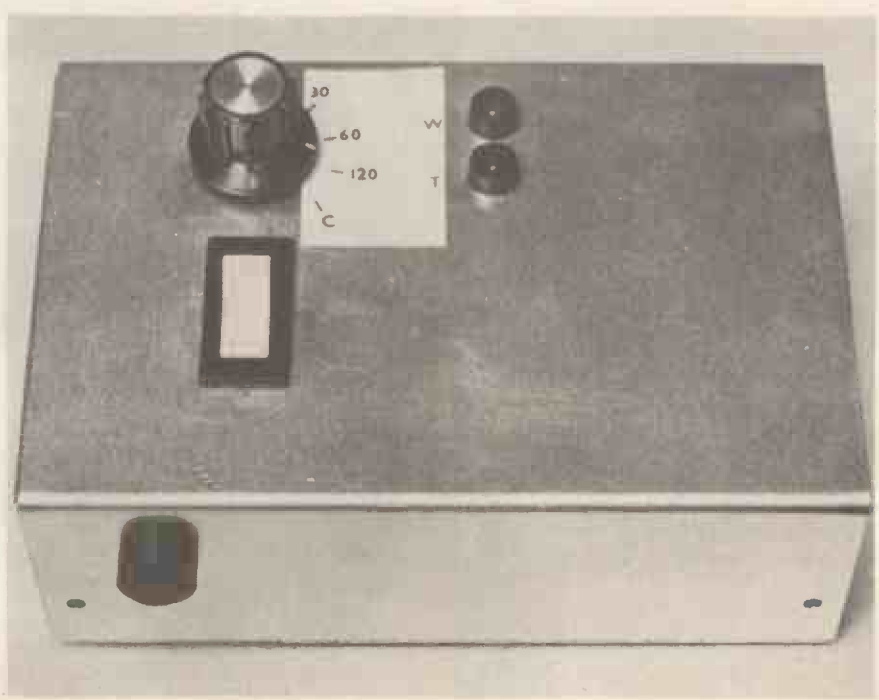
INSTALLATION AND TESTING

Switch off the immersion heater at the fuse box and remove the fuse. The existing wall switch must be retained and used as an isolating switch for the new circuit. Refer to Fig. 3 and make the external connections to TB1. Fix the case in position using thick washers on the screws between the box and the wall. This will allow clearance for any protruding bolt heads and prevent the case from distorting. Replace the lid. Note that whenever the supply is connected, the lid of the case must remain on—when making adjustments, the timer must be isolated at the fuse box. Select the 30 minute setting, switch on S2, leave it on. The relay should clunk and the red timing l.e.d. operate. When the cycle is complete, the timing light should go off and the green waiting one come on instead.

If C2 has been replaced temporarily with a 10nF component, then an operating time of approximately 18 seconds may be expected. Test the other timings—the one-hour setting should take 36 seconds and the two-hour one, 72 seconds. If these prove to be approximately correct, C2 may be de-soldered from the "stalks" and replaced with the correct value. VR1 may then be adjusted to give the best timings—clockwise rotation of the sliding contact (as viewed from the circuit panel fixing) reduces them.

IN USE

If timing is initiated by switching S2 to on then standby, the circuit consumes current only while timing. If S2 is left on a small current will be used by the circuit when timing is complete. Note that where S2 is moved from on to standby, this should not be done slowly. If it is, the interruption to supply will cause RLA coil to de-energize and the circuit to switch off. If the mains supply is interrupted even for a short time, timing is cancelled and the cycle begins again. After a period of operation, check that T1 does not become excessively hot. Note, however, that it is normal for the case to become warm. To cancel the timing at any time, switch off the mains at the isolating switch for a few seconds. □



Robot Roundup

NIGEL CLARK

MECHATRONICS BUS

There is a new word in the land of the robot. Following the other attempts to encapsulate the world of the robot, its controllers and ancillary workpieces, such as robotics and flexible manufacturing systems, not to mention advanced manufacturing technology, there now appears mechatronics. And the Department of Trade and Industry has lost no time at all in adopting the latest popular terminology in its attempts to interest industry and education in the automated systems thought likely to dominate manufacturing in the near future.

It has kitted-out a bus with a complete integrated system which is touring schools, colleges and industry throughout the country spreading the news under the banner of *The Mechatronics Bus*. It made its first tentative forays around Britain in the early part of this year and is now on a busy schedule throughout the country touring a region at a time.

ON BOARD SYSTEM

On board is a system put together by TecQuipment, makers of the MA2000 Open University 6-axis arm. Two MA2000s are included in the layout which also has a bandsaw, c.n.c. lathe, c.n.c. milling machine, pedestal drill, four indexing carousels and an MA3000, the larger and more robust of TecQuipment's arms.

The MA3000 supervises the rest of the system and has been given an extra axis on its present five by the simple method of mounting it on a transverse table. The 2000s have both carrying and inspection roles, one measuring length after sawing, the other performing the final inspection with the help of a vision system.

The system, controlled by a BBC Master 128, carries out a sequence of cutting a length of steel and working it on the mill, lathe and drill before final inspection. The vision system, with a definition of 32 × 32, compares the outline of the finished article with the image stored in its memory and, if acceptable, places it in the appropriate bin.

The DTI intends the bus to increase the awareness of what is possible with modern technology. It is particularly aimed at further education colleges to persuade them that there would be a benefit in providing courses using the training aids available. The department is especially keen that they should be used in the teaching of new skills.

The system makes use of a number of connected technologies including computing, computer-aided design, robotics, hydraulics and pneumatics as well as electronics and mechanics. It was put together as the result of a collaboration between the department, TecQuipment, British School Technology, which specialises in preparing buses of this kind, ORT, a worldwide technical training organisation and several UK toolmakers.

Its itinerary to date has included the north west of England, the east Midlands and various parts of the Home Counties. Future destinations are not known until quite close to the date so that it is flexible enough to respond to demand.

ROBOT STATISTICS

The rate of growth of numbers of robots being installed in Britain fell sharply last year. In 1986 the figure increased by only 15 per cent compared with 22 per cent the previous year and 50 per cent in 1984.

The figures are revealed in Robot Facts 1986, the latest of the annual round-ups produced by the British Robot Association. The association contrasts the UK figures with those for West Germany, our major trading partner, which show a rise of 41 per cent for 1986, 33 per cent in 1985 and 38 per cent in 1984.

In Britain the BRA puts the total number of installed robots at the end of 1986 at 3,683 against 12,000 for Germany. These figures understate the true totals for what most people would count as robots because of the BRA's tight definition, but the comparative positions and rates of increase are probably valid.

A robot is defined by the BRA as being a reprogrammable device designed to both manipulate and transport parts, tools, or specialised manufacturing implements through variable programmed motions for the performance of specific manufacturing tasks.

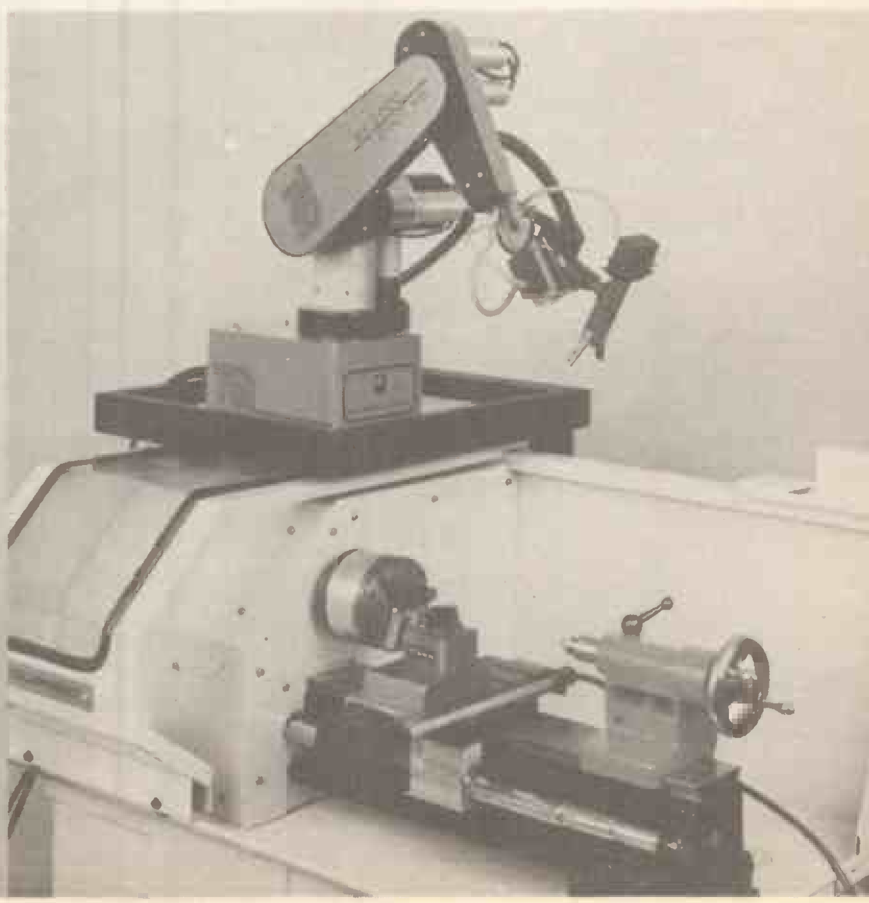
There was an above average increase in the number of robots used in education and training where 46 were installed in the period, an increase of 28 per cent and the fourth highest for the year. It took the sector from seventh to sixth in the applications league just ahead of surface coating. The most popular uses remained injection moulding, spot welding and arc welding. The industry which boasts the most installations by far is the automotive, with rubber and plastics in second place.

UK SUPPLIES

A surprisingly large number of machines used in this country are supplied by UK companies, they being the major source. European companies provide the next largest number with those from Japan and the US tying for third place. However in 1986 Japan was the second largest source, just ahead of Europe with the US a very poor fourth.

British-built robots had a near monopoly of the less expensive machines supplying nearly all the robots installed in Britain at prices up to £20,000. Japan was the major supplier in the £20,000 to £35,000 range with Europe the prime source for robots at £35,000 plus. Also surprising was what appears to be a healthy export market. More than 57 per cent of British output was exported.

As might be expected with the automotive industry featuring as the major user, the BRA's geographical analysis showed the West Midlands as the area for most new installations in 1986, emphasising its overall lead. A long way behind came the south east of England and central England with Northern Ireland having the least number.



POWER GENERATION

ANDREW GREY

ELECTRICITY is a secondary form of energy, some primary forms being coal, oil and gas. Therefore, there is bound to be some waste in converting from primary to secondary form. This waste is in the form of heat loss as well as friction in turning the generators.

But electricity has advantages. It is clean, quiet and no storage space is required in homes and factories. In any case, some devices like radios will not run off the other three energy sources! Another wasteful thing about electricity is that it cannot be easily stored, although limited storage is possible in batteries and accumulators. Therefore the Central Electricity Generating Board (CEGB) has to ensure that the correct amounts are generated to meet demands, particularly when the annual fuel bill is over £4000 million.

ELECTRICAL POWER GENERATION

Regardless of what energy source is used, the primary source of energy (coal, oil, gas, nuclear) is used to turn water to high pressure steam which rotates a turbine to generate electricity.

In Fig. 1, coal or oil is used to heat water in a boiler. In a nuclear reactor, carbon dioxide gas is heated. The heat causes water to evaporate through pipes leading to the turbine housing. When the steam has done its job in driving the turbine blades, it passes through a condenser where it is turned back to water, ready to be boiled again.

Condensers require large volumes of water. Typically, a large power station generating 2000MW needs fifty million gallons of cooling water per hour. Such quantities can only be obtained from the sea or large estuaries. Therefore a power station is often sited near a coastline. Power stations are also sited near coalfields or with easy rail access to coalfields. If coal is used as a fuel, this is ground into a powder at the rate of about 200 tonnes per hour. Also to avoid polluting the atmosphere, metal plates are inserted in the chimney. An electrostatic charge on the plates ensures that dust is attracted to them. To clean the plates, they are struck with a hammer so that the dust falls to the bottom of the chimney.

Kingsnorth, on the Hoo peninsula, is a typical large power station. It is built on reclaimed land on the north Kent coast. Kingsnorth generates 2000MW employing four 500MW steam generators and the site includes nine fuel storage tanks, ash lagoons and water treatment plant.

It is a dual fired station and can use either coal or oil. Water for the boiler comes from the town mains. It is filtered, de-ionised, degassed and demineralised. Water for cooling the condensers comes from the Medway and is returned to the Medway.

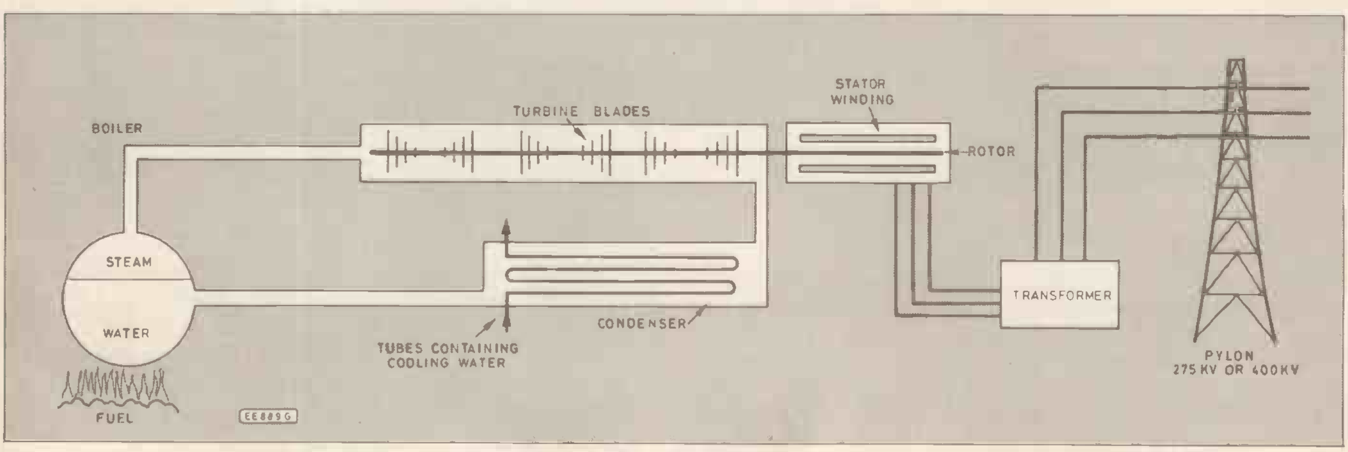
In addition to supplying alternating current, Kingsnorth also supplies 266,000 volts direct current. D.C. is easier to control than a.c., though the transmission loss is greater.

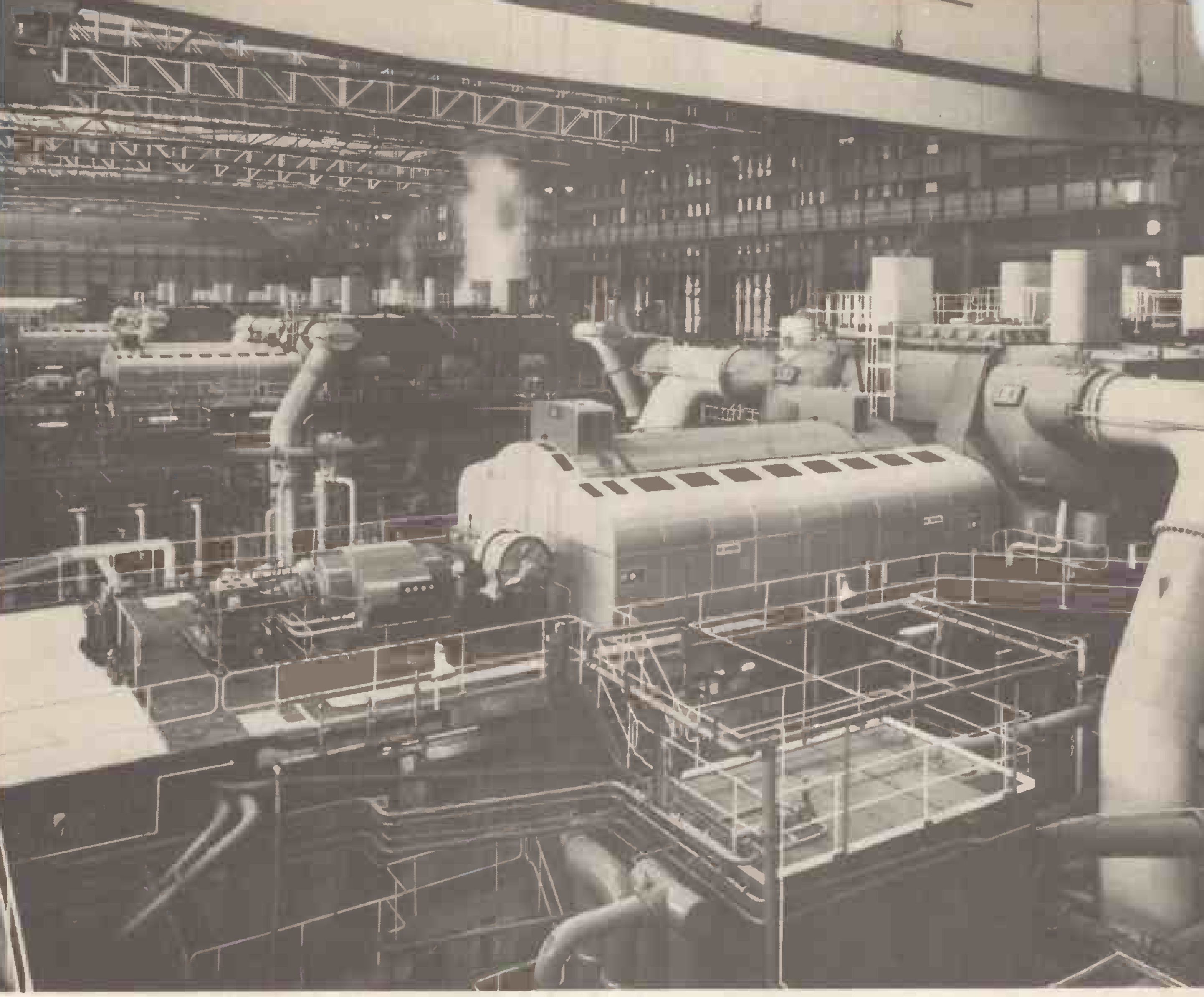
POWER DISTRIBUTION

Large generators can easily put out 25kV and a transformer then steps this up to 132kV or 275kV or 400kV. The power is then routed via an isolator, circuit breaker and isolator again, to busbars within the station compound. There is another set of isolator, circuit breaker and isolator before power is applied to the grid (the cable network that feeds the country). Each generator has its own transformer, isolator and circuit breaker but the busbars are shared. Isolators are used on either side of a circuit breaker so maintenance work can be carried out on the circuit breaker without danger from any accidentally applied voltages.

The circuit breaker is similar to a switch except that with low voltages in a home, any arcing between contacts is soon broken. With high voltages, the arc would persist and burn out the contacts. The contacts are immersed in an oil bath to extinguish the arc or compressed air can be used to open the contacts as well as blow out the arc.

Fig. 1. Steam powered generator.





The turbine hall at the 2,000MW coal-fired Cottam power station near Retford which contains four 500MW turbo-generator units.

The layout of a generating compound with sets of circuit breakers and isolators is shown in Fig. 2. The domestic supply employs two wires carrying a single phase but factories require a three phase supply which uses three conductors. These three wires are called a circuit and power pylons usually carry two circuits.

At the high voltages mentioned above the power is fed over the supergrid, the arteries of the country. It is stepped down to 33kV for towns, villages and industrial areas. Intermediate substations step this down further to 11kV for hospitals and light industries. This part of the network can be thought of as the veins of the network. And finally down to capillaries as distribution substations drop the voltage down to 240V for schools, shops and homes, Fig. 3. Railway lines draw their supply directly from the grid, some rail links operating at 25kV.

POWER REQUIREMENT

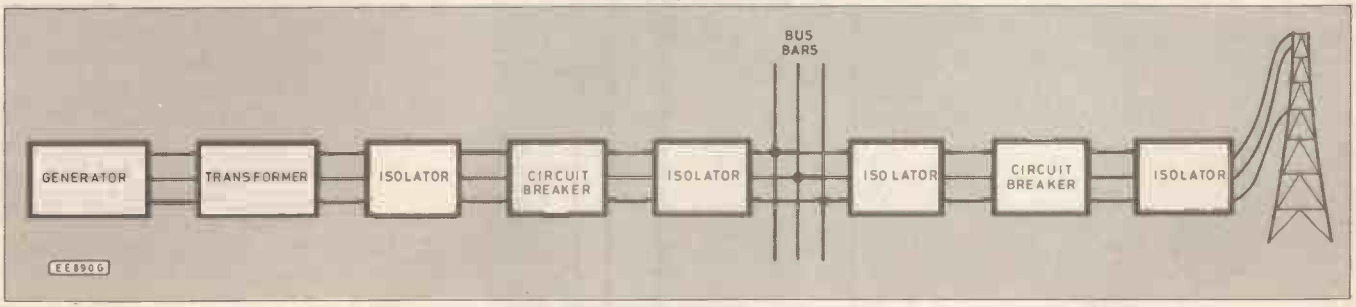
The UK's electrical power requirement was 17,350MW in 1955, 34,360MW in 1965, 56,129MW in 1979 and about 52,000MW today. In the 1920s there was a 132kV grid, followed by 275kV in the 1950s and 400kV more recently.

The annual power demand is shown in Fig. 4. This is of course lowest in the summer. Fig. 5 shows a typical daily power demand in the winter; highest at about 6pm, when most people get home from work, turn on the heat and cook their meals. Fig. 5 also shows the fuels which might be employed. Nuclear power is the most efficient, coal is cheapest, and to meet higher demands other plant may be used together with more expensive fuels like oil. To meet peak demands hydro-electric plant of the pumped variety can be used.

PUMPED STORAGE

There are no large waterfalls in the UK which would make it worthwhile to generate hydro-electric power only. The next best thing is to pump water to a height, ready to drop like a waterfall

Fig. 2. Generating compound.



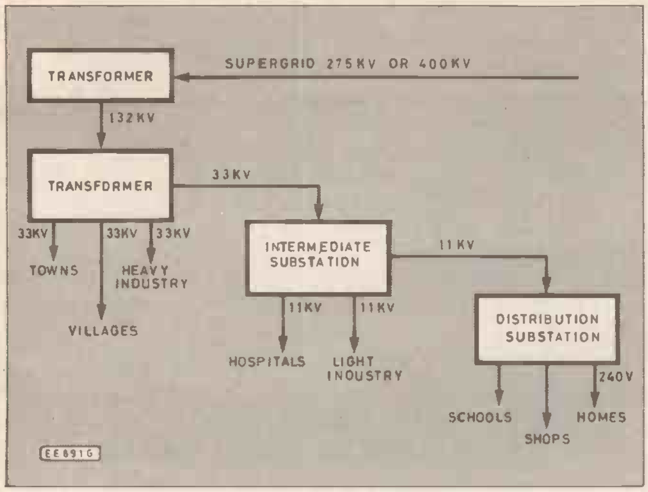


Fig. 3. Power distribution.

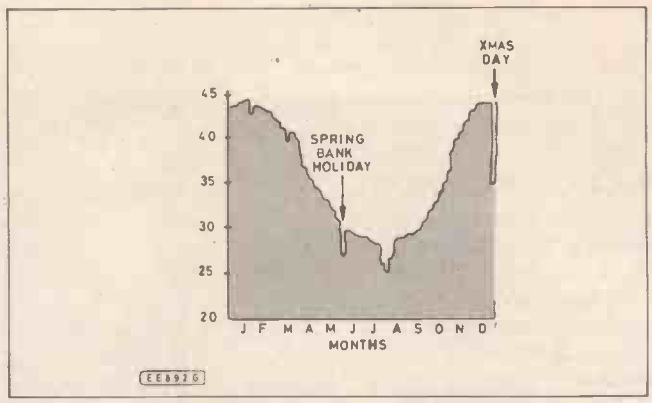


Fig. 4. Annual power demand.

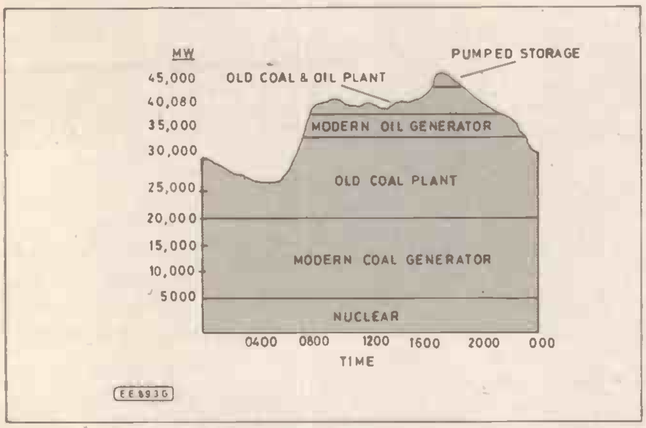


Fig. 5. Typical daily winter demand.

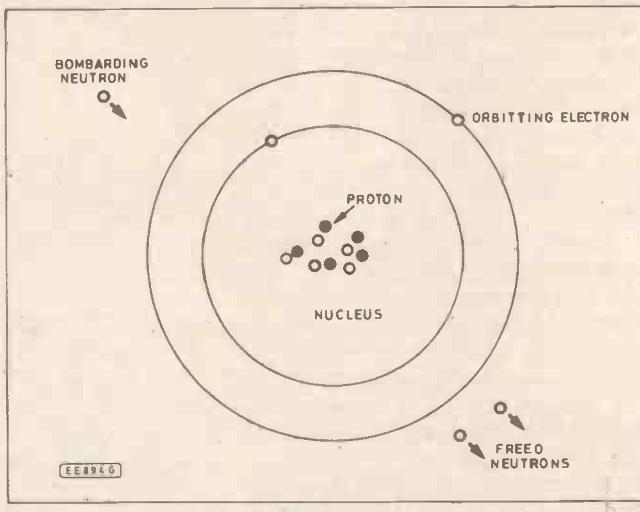
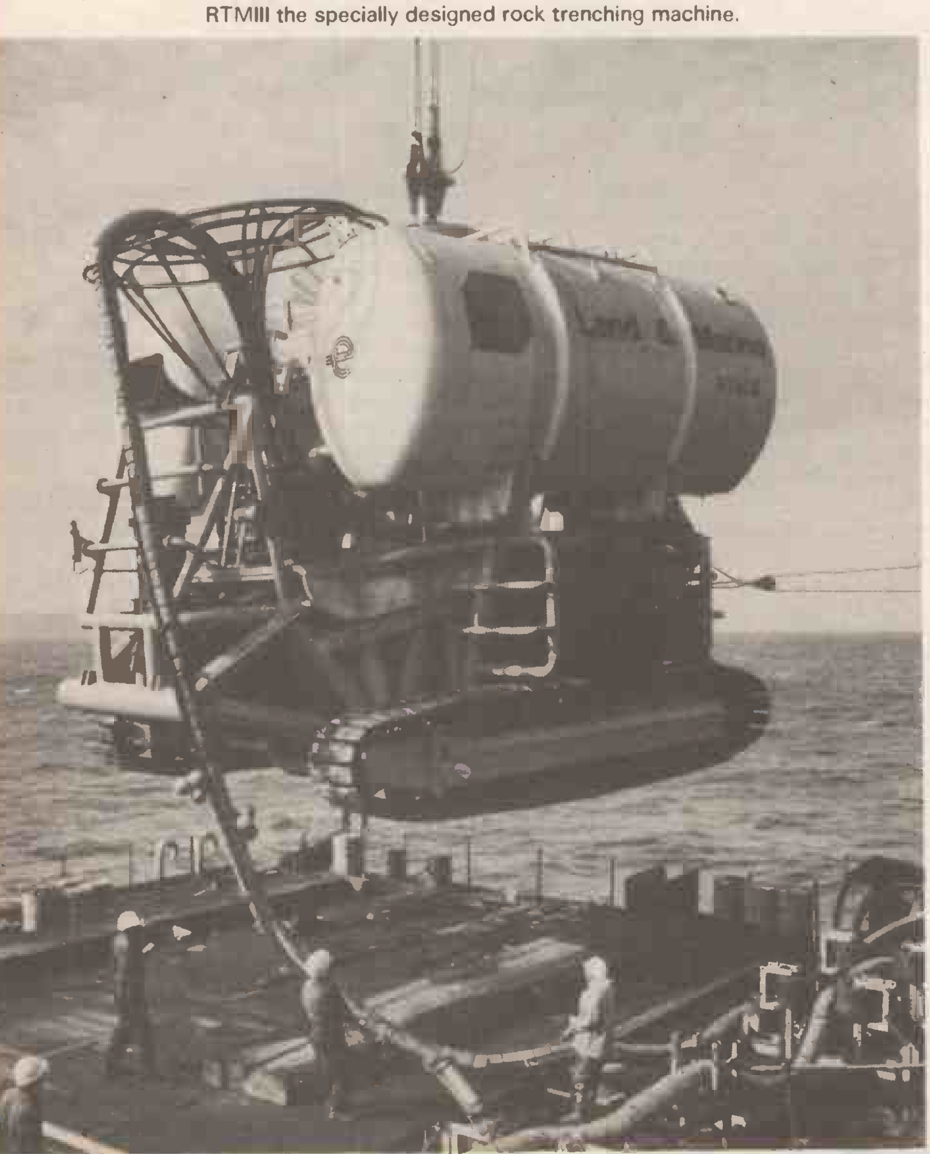


Fig. 6. Splitting the atom.

RTMIII the specially designed rock trenching machine.



during peak demands. It is, of course, pumped to a height during off-peak hours.

There are two such pumped storage stations in Wales, one of which is Dinorwig at the foot of the Llanberis Pass. It has been made environmentally acceptable by excavating deep into Elidir Fawr mountain. It cost £450 million to build and is expected to recover its cost in eight years.

In an emergency or to meet peak demands, Dinorwig can produce 1320MW in ten seconds. Water falls from the upper reservoir to the lower reservoir through pipes and drives turbines in the process. There are sudden peak demands after popular TV programmes or during commercial breaks when people put the kettle on.

The reservoir level rises and falls 34m as the water transfers from one reservoir to the other. Six Francis reversible pump turbines produce 313MW each or consume 285MW when used as pumps.

Another method of managing this non-storable commodity is to trade it across the border. To this end a 2000MW cross channel link to France has been installed. This costs only half as much to install as a new power station and helps trade surplus power.

Two pairs of French and two pairs of British cables run from Folkestone to Calais. They are buried 1·5m deep and

1000m apart for security. Burial is by means of a trencher like RTM III which can cut about 5km of trench in a day. The power is converted from a.c. to d.c., for more precise control, just before it leaves the coast.

NUCLEAR REACTORS

Heat for turning water to steam can also be generated by splitting the atom, Fig. 6. An atom consists of a nucleus with electrons orbiting. The nucleus contains protons with a positive charge and neutrons of no charge. When a neutron is used to smash open this nucleus, tremendous heat is generated and the process is called nuclear fission.

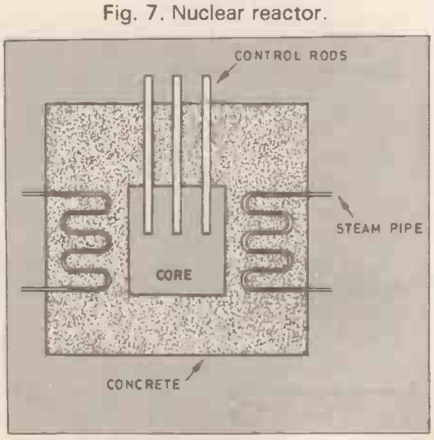
A naturally fissile element is uranium but the ore contains uranium 235 as well as 238 and it is U235 that is easy to split. Unfortunately the ore contains only one per cent of U235 so this is enriched to about three per cent by British Nuclear Fuels (BNFL).

The fuel rods, one inch in diameter, are inserted in metal tubes and placed in graphite eight inches apart. Bundles of 36 tubes are called a fuel element, this weighs 56kg and produces as much electricity as 3,000 tonnes of coal. A chain reaction can be started by bringing a critical amount of uranium together. Since some neutrons escape, there must be sufficient uranium to keep the reaction going. The graphite is called a moderator and slows down the neutrons without capturing them.

It's no use unleashing a Frankenstein monster if one cannot control it. To slow the reaction, boron steel rods, Fig. 7, are lowered into the reactor and these absorb the neutrons. If the rods are lowered to a depth such that the power is not increasing or decreasing, then the reactor is balanced.

The spent fuel is placed in a cooling pond of water for about a hundred days then transported in steel flasks weighing 43 tonnes to BNFL, Sellafield, for reprocessing. Unburnt uranium and plutonium are removed and used in a fast reactor which takes oxides of U238 and plutonium. If U238 is converted to plutonium then the energy obtained is 60 times that of the thermal reactor described above.

Fig. 7. Nuclear reactor.



The main control room at the coal-fired Ratcliffe-on-Soar power station.

Fast reactors are still under development.

A reactor is typically 63 feet in diameter, spherical, with a four inch thick steel shell and 12 feet of concrete around it. Sizewell A on the Suffolk coast is one such nuclear power station. Two turbines run at 3000 r.p.m. and provide 325MW each. The steam, which reaches 360 degrees C, is cooled by 27 million gallons of water per hour. This water is drawn through two ten-foot diameter tunnels and returned to sea via two similar tunnels. Most of the water is used for condensing the steam and only a small proportion for cooling equipment.

Two types of reactor operating in the UK are the Magnox and the advanced gas cooled reactor (AGR). The Magnox reactor gets its name from the fact that the uranium is clad in magnesium alloy. It is cooled by carbon dioxide gas and operates at a relatively low temperature.

Higher temperatures produce greater efficiency and the AGR uses uranium oxide pellets clad in stainless steel tubes. Worldwide there are 374 power-producing reactors in 25 countries and 150 more under construction. Half of them are pressurised water reactors (PWR) rather than AGR since they are cheaper to build and the UK is following this trend.

The world's first nuclear reactor for feeding electricity to a national grid was built at Calder Hall, Cumbria in 1956. This reactor is still working. Nuclear reactors have been producing electricity for 30 years in the UK and provide 20 per cent of our electricity. In France, 60 per cent of their electricity is produced from nuclear fuel.

There has been much publicity recently with the Russian nuclear disaster at Chernobyl but the escaping radiation from a properly controlled nuclear reactor is low, as shown in the chart of Fig. 8. The location of power stations and the fuel used is given in Fig. 9.

Fig. 8. Radiation Doses

37%	Radon + Thoron gas in buildings
19%	Terrestrial gamma rays
17%	Internal from one's body
14%	Cosmic rays from space
11·5%	Medical X-rays
0·5%	Weapon test fall-out
0·5%	Air travel, luminous objects
0·4%	Occupational (industry etc.)
0·1%	Waste from nuclear stations

We have considered fission, but fusion, i.e. joining of nuclei of light atoms, produces even more energy. The raw materials are deuterium from water and lithium from rocks. Only a little is required and both are plentiful, but high temperatures are required. This is the process that keeps the sun and stars burning and may well be the technology of the 21st century.

PRIMARY SOURCES OF ENERGY

The CEGB uses about 100 million tonnes of coal per year, half the nation's annual output. Also three to four million tonnes of oil is burnt per year. And just as coal fired stations are built near coalfields, oil fired stations are built near refineries in Southern England and Wales.

Apart from the energy sources already considered, coal, oil, gas, nuclear and waterfalls, other sources of energy are: wind, waves, tides, solar and geothermal. Unfortunately, none of these provide significant power outputs. Large windmills in valleys be-

Fig. 9. Power stations under CEGB control.

Fig. 10. Grid control centres.

come environmentally unacceptable although an experimental windmill producing 200kW is operating in Carmarthen Bay.

To produce as much electricity as a 2000MW generator by wave energy requires devices 60 miles long. A consortium of firms, the Severn Tidal Power Group, is studying the possibility of installing a barrage across the Severn to harness the tides.

POWER CONTROL

Each generating station has its own control room mainly consisting of lots of meters to monitor the large numbers of steam and water valves and hundreds of other temperatures and pressures associated with each generator.

The main highway of transporting this electricity is the supergrid at 400kV and 275kV owned by the Central Electricity Generating Board (CEGB). The large, modern power stations are connected directly to the supergrid. A large generator produces electricity at a lower unit cost compared to a small generator, but then it needs a large artery like the supergrid.

The National Control Centre (NCC) is located in London and controls the six Grid Control Centres (GCC). Fig. 10 shows the GCCs and the amount of electricity that it is possible to generate in each area controlled by each GCC. The NCC trades electricity with France and also the South of Scotland Electricity Board.

Electricity consumption varies with the time of day and day of week. It also depends on the weather and special occurrences like television programmes. Therefore it is important to generate more electricity before the lights start to dim. For each period of the day and a few hours before the event, each GCC receives a power transfer programme from the NCC. This selects generators in order of merit according to electricity production costs. The order of merit is updated every day taking into account fuel costs and individual generator performance. Each GCC is in direct contact with power stations and grid supply points in its area.

The CEGB has five regions and sells power to the twelve Area Electricity Boards and to other bulk customers like British Rail.

At March 1986 there were 79 power stations using fuels as follows: 41 coal, one coal/oil, eight oil, ten nuclear, two pumped storage, ten gas, seven hydroelectric. In March 1986 the first import of electricity from France also took place. In May 1986, Europe's largest coal fired station was completed at Drax in North Yorkshire. By the year 2000 six to eight new power stations will be required.

When Michael Faraday plunged a bar magnet into a coil of wire in October 1831, I'm sure he did not think he was setting the cities alight. □

Acknowledgement: The author wishes to thank the CEGB for photographs and other material used in this article.

The National Control Centre in London.

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D.C. VOLTAGE	RESOLUTION	ACCURACY
200mV	100μV	
2V	1mV	
20V	10mV	±(0·25% of reading + 1 digit)
200V	100mV	
1000V	1V	

Input Impedance: 10M on all ranges. Overload Protection: 1000V d.c. or peak on all ranges.

D.C. CURRENT	RESOLUTION	ACCURACY	MAX. F.S. VOLTAGE DROP
200μA	100nA	±(0·5 % rdg+1d)	0·25V
2mA	1μA	±(0·5 % rdg+1d)	0·25V
20mA	10μA	±(0·5 % rdg+1d)	0·25V
200mA	100μA	±(0·75% rdg+1d)	0·25V
2000mA	1mA	±(2 % rdg+5d)	0·75V
10A	10mA	±(2 % rdg+5d)	0·30V

Overload Protection: mA Input: 2A/250V fuse. 10A Input: Unfused up to 15A for 15 seconds.

A.C. VOLTAGE	RESOLUTION	ACCURACY	FREQ RANGE
200mV	100μV		
2V	1mV		
20V	10mV	±(0·5% rdg+5d)	45Hz–500Hz
200V	100mV	on all ranges	on all ranges
750V	1V	±(1% rdg+5d)	

Conversion: Calibrated for rms of sine wave. Input Impedance: 10M shunted by 100pF on all ranges except 200mV range. Overload Protection: 1000V d.c. or 750V r.m.s. a.c. continuous, except 15 sec max above 300V on 200mV range.

A.C. CURRENT	RESOLUTION	ACCURACY	MAX. F.S. VOLTAGE DROP
200μA	100nA	±(0·75% rdg+5d)	0·25V rms
2mA	1μA	±(0·75% rdg+5d)	0·25V rms
20mA	10μA	±(0·75% rdg+5d)	0·25V rms
200mA	100μA	±(0·75% rdg+5d)	0·25V rms
2000mA	1mA	±(2 % rdg+5d)	0·75V rms
10A	10mA	±(2 % rdg+5d)	0·30V rms

Overload Protection: mA Input: 2A/250V fuse. 10A Input: Unfused up to 15A for 15 seconds.

RESISTANCE	RESOLUTION	ACCURACY	MAX. OPEN CIRCUIT V
200Ω	100mΩ	±(0·5 % rdg+3d)	2·8V
2KΩ	1Ω	±(0·3 % rdg+1d)	2·8V
20KΩ	10Ω	±(0·3 % rdg+3d)	500mV
200KΩ	100Ω	±(0·3 % rdg+3d)	500mV
2MΩ	1KΩ	±(0·75% rdg+5d)	500mV
20MΩ	10KΩ	±(3 % rdg+5d)	500mV

Max allowable input: 500V d.c. or rms.

CONTINUITY TEST

Resistance range: Buzzer sounds at approximately less than 200Ω.

DIODE TEST

Test voltage: 2·8 Volts. Maximum test current: 3mA.

TEMPERATURE	RESOLUTION	ACCURACY
−20°C to 1370°C	1°C	±(3°+1d) up to 150°C ±3% of rdg over 150°C

Sensor: Type K (NiCr–NiAl).

CONDUCTANCE	RESOLUTION	ACCURACY
200nS	0·1nS	±(1·5% rdg+10d)

CAPACITANCE	RESOLUTION	ACCURACY
2000pF	1pF	±(1·5 % F.S.+5d)
2μF	0·001μF	±(2 % F.S.+5d)
20μF	0·01 μF	±(2 % F.S.+5d)

hFE TEST Test condition: 10μA 2·8V. hFE gain 0–1000 (npn. pnp).

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exploring electronics

OWEN BISHOP

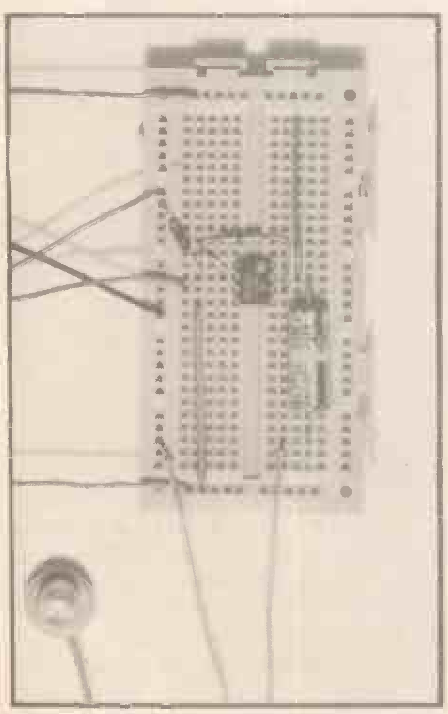
This series is designed to explain the workings of electronic components and circuits by involving the reader in experimenting with them. There will not be masses of theory or formulae but straightforward explanations and circuits to build and experiment with.

Part 14 Audio amplifiers using the 741 Op-Amp

SIMPLE AUDIO AMPLIFIER

THIS month, continuing with applications of the 741 op-amp, we amplify signals in the audio-frequency range. The circuit diagram for a Simple Audio Amplifier is shown in Fig. 14.1 and can be used as an amplifier for a microphone or a record player cartridge (*magnetic* or *crystal*). You can also use it to amplify the output of the Simple Diode Radio Receiver described earlier in this series (EVERYDAY ELECTRONICS, July 1986).

The output of the amplifier can be used to drive either an earphone or a loudspeaker. Although you may obtain higher fidelity if you use a specially-designed audio amplifier i.c., circuits based on the ordinary 741 operational amplifier circuits are adequate for many purposes.



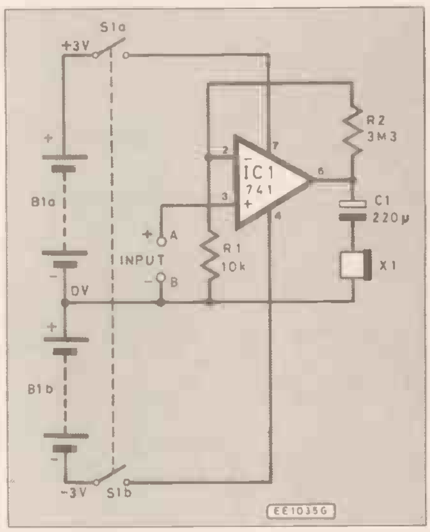


Fig. 14.1. Circuit diagram for Simple Audio Amplifier for use with crystal earphone.

Fig. 14.2 (right). Crystal earphone amplifier demonstration component layout.

HOW THEY WORK

Small voltage changes at the non-inverting input (+) of the op-amp (IC1) are amplified and appear at the output. In the Simple Audio Amplifier, with earphone output (Fig. 14.1), changes in output voltage charge and discharge capacitor C1. This causes currents to flow between the other plate of C1 and the earphone X1.

To obtain enough current to work a loudspeaker we must use a transistor TR1, fed by the output from the amplifier (Fig. 14.3). The resistor R3 provides a steady base current which holds the transistor on at low level. Current is added to or subtracted from that base current as the charge varies on capacitor C2, causing the current through the loudspeaker LS1 to vary correspondingly.

The amount of amplification depends on the value of the *feedback resistor* R2. The greater its resistance,

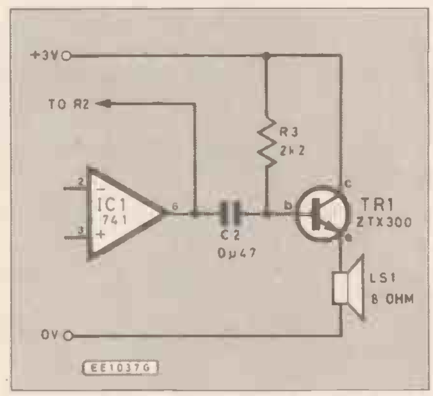
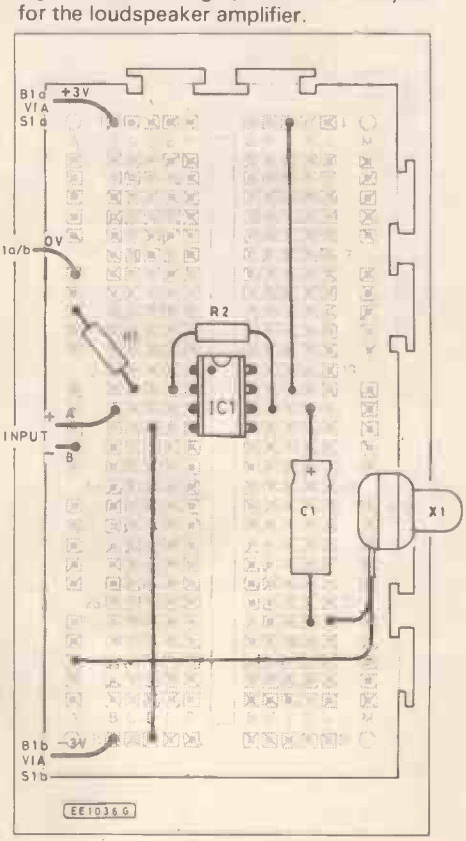
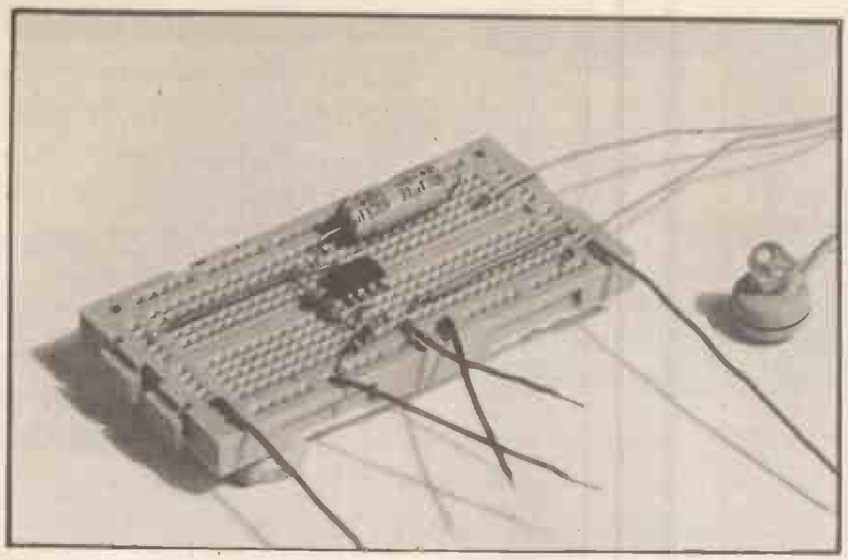
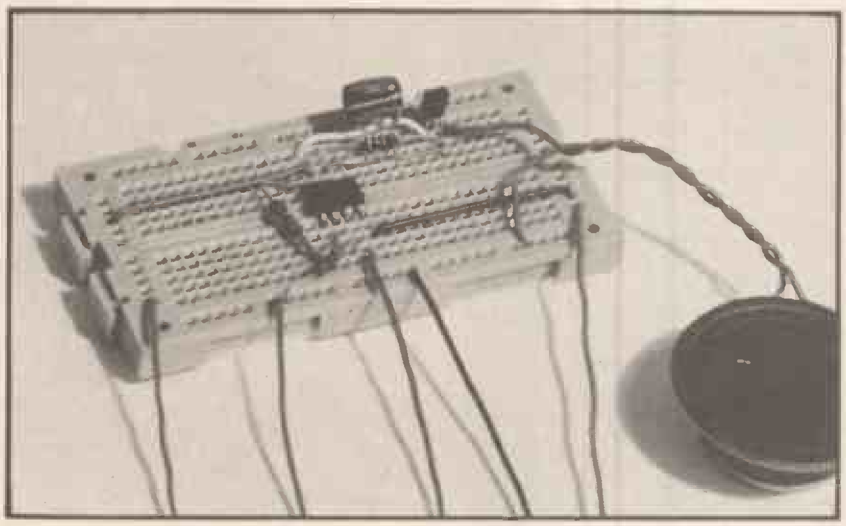


Fig. 14.3. Modifying the Simple Audio Amplifier circuit for use with a loudspeaker.

Fig. 14.4 (below right). Breadboard layout for the loudspeaker amplifier.







COMPONENTS

See Shop Talk page 434

Resistors
R1 10k
R2 3M3
R3 2k2 (*L*)
All 0·25W ±5% carbon

Potentiometer
VR1 2M log. carbon (optional—see text)

Capacitors
C1 220µ elec. (*C*)
C2 0µ47 polyester (*L*)

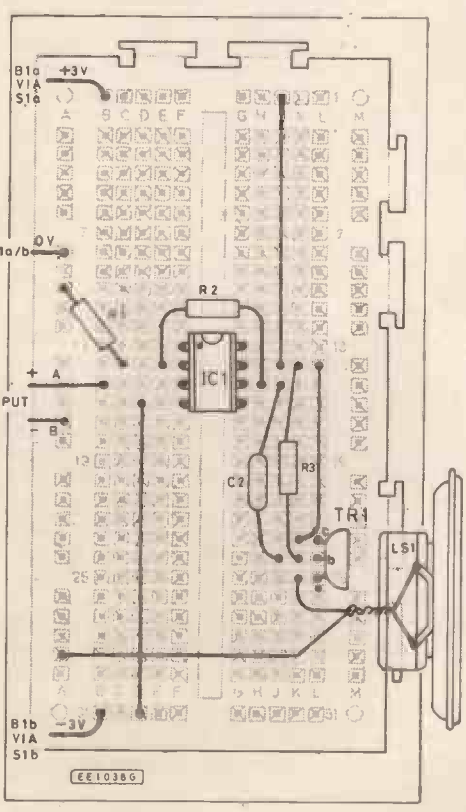
Semiconductors
TR1 ZTX300 *npn* transistor (*L*)
IC1 741 operational amplifer

Miscellaneous
S1 d.p.d.t. toggle switch; breadboard (e.g. Verobloc); B1a, B1b Four 1·5V cells and battery holder; crystal earphone or 8ohm loudspeaker; 8-pin d.i.l. socket; connecting wire.

C = crystal earphone amplifier only

L = loudspeaker amplifier only

Approx. cost Guidance only £5



up to a given point, the greater the amplification. This is because, with R2 connected to the inverting input (–) of the op-amp, the *negative* feedback action of the circuit acts so as to keep the two inputs at equal voltages.

If resistor R2 has a low resistance, only a small feedback current is required to maintain the inverting input voltage at the same level as the non-inverting input voltage. So output voltage swings need only be small (low volume of sound). But, if R2 has high resistance, much bigger voltage swings are needed at the output to feed back enough current to keep the two inputs at equal voltage. The volume of sound is louder.

CONSTRUCTION

The demonstration breadboard component layouts for crystal earphone and loudspeaker outputs is shown in Fig. 14.2 and Fig. 14.4. Commence construction by inserting the link wires, i.c. holder, resistors, capacitors and transistor on the "test bed". This should be followed by the lead-off wires and when the wiring has been checked the i.c. can be inserted in its holder.

The input points *A* and *B* may be connected to a microphone or to a recorder-player cartridge. If you have built the crystal set radio (EVERDAY ELECTRONICS, July 1986) you can connect the cathode of the diode D1 to *A* and the earthed line of the set to *B*.

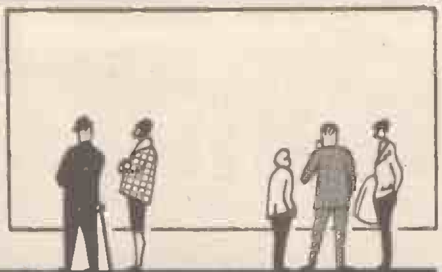
You may find that the quality of reproduction is improved if you alter the value of resistor R3 (Fig. 14.3), so as to make the steady base current to TR1 just right. The volume can be altered by changing resistor R2, but not to more than 6·8Megohm.

If you would prefer a variable volume control, use a variable resistor (potentiometer), value 2M in place of R2. If possible, fit one that has a "logarithmic" track, for this means that equal amounts of turn of the knob produce roughly equal amounts of difference of volume as *heard by your ear.*

Find out by trial and "error" which one of the outer solder tags or end of the potentiometer/resistor should be connected to the circuit so as to get the required effect. The unused solder tag can be left unconnected or linked to the "wiper" or centre solder tag.

Next month: Introducing Logic Circuits.

SHOP TALK



BY DAVID BARRINGTON

Catalogue Received

We have just received our copy of the **Cirkit** "Summer 1987 Electronic Constructor's Catalogue" and, at a quick glance, it seems to contain well over 3000 different components, which makes it a must for the serious experimenter and student. As to be expected from this progressive company, they have expanded some sections and introduced many completely new product lines including a ROM based software for reception, decoding and display of weather satellite transmissions.

The Satpic software is intended for use with their weather satellite receiver kit and, a soon to be announced, interface. The software package is for use with the BBC B and Master machines.

Among the new items featuring and in keeping with their policy of "staying in touch with new technology," Cirkit have introduced a range of surface mount devices (SMD's). The first products are two ranges of surface mounting chip inductors covering inductances from 1μH to 1mH and 0.1μH to 220μH. The latter range being "ultra miniature" devices.

Containing over 160 pages, all prices appear alongside each product entry but does *not* include VAT. Also a flat rate postage and packing charge of only 70p is levied on all orders. (Some larger individual items have an additional carriage charge but this is listed against the product entry in the catalogue.)

Once again they are running a simple free entry competition with the opportunity to win one of six multimeters. The top prize this time is a digital multimeter.

Available from most W.H. Smith's stores or direct from Cirkit Distribution, the catalogue costs £1.20. Even if you do not win a prize, the catalogue contains redeemable vouchers for use with each single order (one per order) of £15 and over, excluding VAT.

Knowing that their commitment to electronics education is as strong as EE's, witnessed by their joint sponsorship of the annual "Young Electronic Designer Awards", it was surprising to note that the pages did not include the excellent range of "Godiva Electronics Teaching System" modules (designed by Coventry Education Authority Microelectronics Technology Centre) that the Education Division distribute to schools and colleges.

If you want further information write to: **Cirkit Distribution Ltd., Dept EE, Park Lane, Broxbourne, Herts EN10 7NQ.**

Video Guard

With a claimed figure of over 30 per cent of households now owning or renting video machines, it is not surprising that reports of the number of youngsters watching "adult" movies, without supervision, is increasing monthly. Short of locking the tapes and machine away out of reach, this leads to the question of how do you stop the young viewing or re-recording over your favourite tapes, particularly as it is virtually impossible for you to be in constant attendance.

To date there has been very little that responsible parents can do about the above situation, but now an enterprising company has invented a low-cost Video Cassette Lock to keep your recordings safe.

As our photograph shows, the lock looks very similar to a sink or bath stopper. However, you simply press the plastic "lock" into the cassette tape take-up sprocket, after recording or viewing, and remove the special key from the centre of the lock to release two retaining tongues.

Once installed, the recording cannot be played back until the lock is extracted with the key. This should stop children from viewing any tapes that parents feel are unsuitable. Also, it can be used to stop over-recording of treasured family tapes.

The Video Cassette Lock costs £1.99 (pack of 3) and is available from large stores and electrical shops. It can also be obtained direct from: **V.C.L., Dept EE, PO Box 202, Leicester.**

Super Sound Adaptor

We have only been able to locate two sources for the stereo simulator chip TDA 3810 called for in the *Super Sound Adaptor*. This device is currently stocked by **Super Alpha** and **Xen Electronics**.

For those readers who would like further technical details on the stereo simulator chip TDA3810, we understand that, for a small charge, Super Alpha will be happy to supply the data sheet separately. The charge for this information is £1, including postage. Overseas customers will be charged at cost.

A suitable heatsink for the voltage regulator i.c. should be available from most of our advertisers. The printed circuit boards are available through the *EE PCB Service*—order codes EE572 and EE573 (see page 460).

Digital Chip Tester

Most of the components used in the *Digital Chip Tester* are fairly common items and should not cause purchasing problems. However, the data chip (IC1), or Versatile Interface Adaptor, 65C22P2 and the printed circuit board are only available from Phonosonics.

A full kit of parts (£34.40 inclusive p&p), including the printed circuit board, may be obtained from **Phonosonics, Dept EE, 8 Finucane Drive, Orpington, Kent, BR5 4ED.** The printed circuit board may be purchased from them separately for the sum of £4.75 inclusive: quote order code 262A.

Immersion Heater Timer

It is important that readers tackling the *Immersion Heater Timer* project should only use heavy duty "approved immersion heater type cable" where specified. This cable should be available from most good electrical shops.

The 12V heavy duty relay used in the prototype was purchased from RS Components. This device may be purchased through their **Electromail** mail order service (phone 0536 204555) and the order code to quote for this relay is: 345-404. Other relays may be used but the contacts must be mains rated and capable of handling a minimum of 30A.

Shortwave Radio

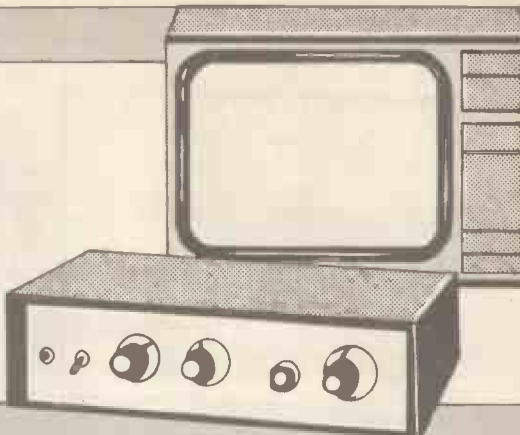
The only stockist we have been able to find for the frequency selective chip UA3086 used in the *Shortwave Radio* is Magenta Electronics. The Toko coils and miniature "tuning" capacitors are available from Magenta and also Cirkit.

The rest of the parts for this project appear to be standard components and should be available from most component suppliers. However, for those readers who experience difficulties, a complete kit (£25.27, including p.c.b.) may be purchased from **Magenta Electronics, Dept EE, 135 Hunter Street, Burton on Trent, Staffs DE14 2ST**. Add £1 for p&p per order.

The printed circuit boards are obtainable through the *EE PCB Service*—order codes EE575 and EE576 (see page 460).

We do not expect any component buying problems for the *Joystick Interface* (On Spec) or *Simple Audio Amplifier* (Exploring Electronics) projects.

SUPER SOUND ADAPTOR



R. A. PENFOLD

Why wait for stereo TV sound when you can have it now!

TECHNICALLY the sound channel of a 625-line television transmission is capable of a very high quality of reproduction, although after listening to a selection of television sets one might find this a little difficullt to believe. The lack of sound quality is mainly due to the less than hi-fi audio stages of many television receivers, especially the loudspeaker itself which is often an inexpensive type in a far from optimum enclosure. The "buzzing" sound that afflicts some sets is probably due to breakthrough from the video circuits due to misalignment rather than a true fault.

A considerable improvement in television sound quality can often be achieved simply by tapping off the audio signal from a "Tape" or "Earphone" output and feeding it through an audio system. This does not require the use of highly advance and expensive audio equipment, and even quite a modest system can provide a surprising improvement in quality.

The obvious limitation of this method is that the television sound channel provides only a monophonic signal, and such a signal does not make the most of a stereo sound system. In fact it can sound quite terrible in that the sound is focused at a point half way between the two loudspeakers, and when listening to music it can sound almost as if the orchestra or band are on the other side of a wall with the music being heard through a hole in the middle of the wall. Because of this, many people prefer to listen to mono signals with one of the loudspeakers switch out.

There are systems for encoding high quality stereo sound into a PAL television signal, but as yet none of these have been adopted for use in Britain, and it is likely to be some time yet before true stereo television sound is available. In the mean time the best that can be achieved is synthesized stereo, and this is a built-in feature of some of the more expensive television receivers.

It is also something that can be added to any television receiver which provides an audio output of some kind. This normally manifests itself in the form of an output for a tape recorder, or an earphone or headphone output, and a large number of sets now sport an audio output socket of some description.

CAUTION

It has to be pointed out that to attempt to tap off the audio signal from a receiver that does *NOT* have a suitable socket as this could be extremely dangerous. It is common for television receivers to have a "*live*" chassis, and the audio signal can only be safely tapped off using an isolation circuit. Any audio output socket should be connected via such a circuit, and should therefore be totally safe.

The Super-Sound Adaptor unit described in this article simply connects between an audio output of the television receiver and a couple of bookshelf loudspeakers placed one on each side of the television, and it gives quite a good pseudo-stereo effect. If preferred, the two built-in power aplifiers can be omitted, and the unit can then feed into a stereo hi-fi system to provide an even higher quality output.

STEREO SYNTHESIS

Although quite convincing results can be obtained using stereo simulators, they provide what is no more than a stereo type effect, and there is no way of generating a true stereo output from a mono source. The two main approaches to pseudo stereo are to use either phase or frequency anomalies to provide differences between the two channels, and thus give what is an illusion of real stereo sound.

Really what is happening is that wereas the sound from each loudspeaker is normally identical, giving a stereo image that is set firmly half way between the two loudspeakers, phase and (or) frequency difference between the two channels spread out the sound between the loudspeakers.

There is a custom chip intended specifically for stereo synthesis, and aimed primarily at improved television sound applications. The chip in question is the TDA3810, and there is no magic performed in the device itself which is really just a collection of amplifiers plus some electronic switching and control logic circuits.

It can be switched to the mono mode (where the input signals are simply passed straight through to the output without being processed in any way) and the spatial mode (which gives enhanced stereo separation when used with a true stereo source) as well as the pseudo stereo mode.

The spatial effect is intended for use where the physical separation of the loudspeakers is very restricted, and its effect is merely to cancel out the central image to some extent, so that a more spatial effect is produced. It is not of any real use in the present context where the signal source will never be a real stereo type.

The mono mode is useful as it enables the pseudo stereo effect to be easily switched out. While the effect can be extremely good with music signals, it tends not to work too well with voice signals where it still tends to spread the signal out across the sound stage, even though a voice would normally be focused at a certain point within the sound stage.

The mono mode places a voice at the middle of the stage (where the television should be situated) and provides what most users will probably find are more acceptable results.

The generation of quasi-stereo using differences in the frequency responses of the two channels is the more easily understood of the two systems. To produce a central image a sound must be reproduced at equal volume from the two loudspeakers. Reproducing a sound more loudly from one loudspeaker than from the other moves the apparent source of the sound towards the loudspeaker that is providing the greater volume.

Only a small difference in the two volume levels is needed in order to move the apparent source of the sound right over to one or other of the loudspeakers. By boosting certain frequencies on one channel and providing complementary cut on the other, the overall frequency response of the system is left unaltered, but sounds within the affected frequency bands are moved out of the central image area.

KEEP IN PHASE

For a good central stereo image to be produced it is important that the signals from the two loudspeakers are in-phase. In other words, as the diaphragm of one loudspeaker moves backwards and forwards, the diaphragm of the other loudspeaker should move in unison with it, rather than in opposition.

By introducing phase shifts over portions of the audio spectrum, the central stereo image at these frequencies will be destroyed, and the signal will be spread out between the loudspeakers. The signals should be left unaffected at some frequencies so that some central image remains, and the "hole in the middle" effect is avoided.

On the face of it the frequency tailoring method is the better system since signals can be moved to one side or the other of the sound stage, whereas the phase system tends to either have sounds positioned centrally, or spread out to both sides. In practice systems which rely solely on frequency response differences are often unsatisfactory.

The most simple system just sends high frequencies to one channel and low frequencies to the other, but a common complaint about this method is that it also sends all the "hiss" type noise to one channel and any mains "hum" to the other. This renders it rather unconvincing and often unpleasant to listen to.

It also tends to give a lack of central stereo image. More complex systems are possible, and no doubt give better results, but at the cost of greatly increased complexity.

The phasing method gives quite good results if the signals are left in-phase at low and high frequencies, but are in or close to antiphase at central frequencies. It is important that the signals are in-phase at low frequencies, as otherwise a cancelling effect gives an effective reduction in bass response. High frequency signals can give a very vivid central stereo image, and it is therefore advantageous to have signals at these frequencies in-phase so that the "hole in the middle" is completely abolished.

CIRCUIT OPERATION

The main circuit diagram for the Super-Sound Adaptor is shown in Fig. 1. The power supply section is shown in Fig. 2. The main circuit is based on the chip manufacturer's application circuit.

The mono input signal is coupled to the two inputs of the TDA3810 (IC1) by way of a d.c. blocking capacitor C12. There are numerous resistors and capacitors associated with IC1, including a twin T-type filter (R10, R11, R13, C5, C6, and C7), but the purpose of these components is primarily to produce phase and not frequency changes.

Analysis of a circuit as complex as this is difficult, but checking its performance with an oscilloscope reveals that its main effect is to give no large phase or frequency response differences at high or low frequencies, but to give a large phase differences over a broad range of frequencies around the middle of the audio spectrum.

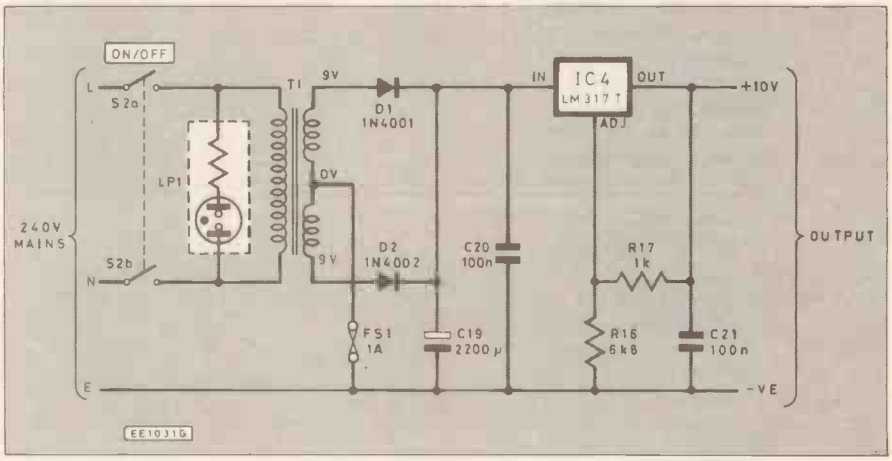
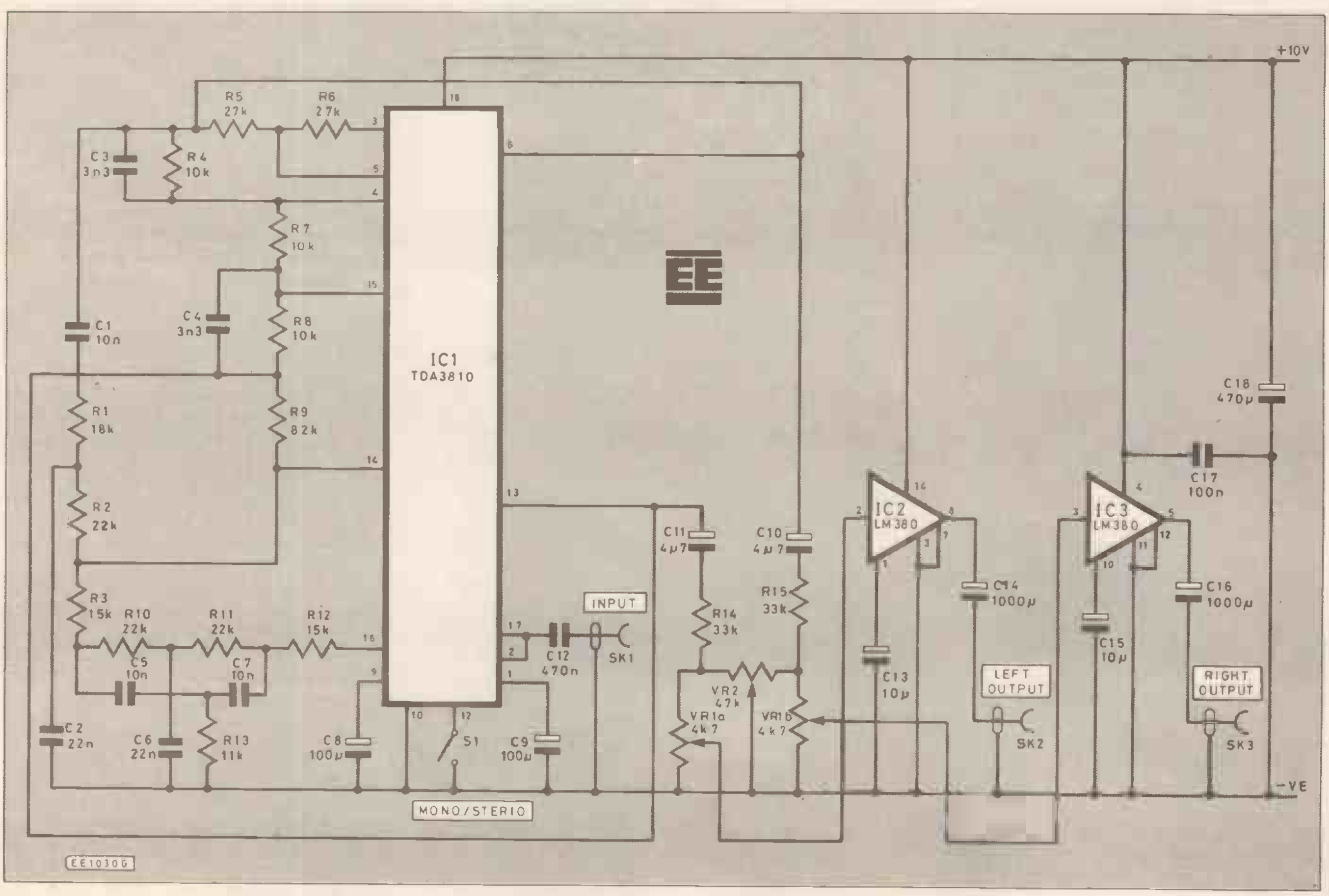


Fig. 2. Circuit diagram for the sound adaptor power supply.

Fig. 1. The main circuit diagram for the Super Sound Adaptor.



COMPONENTS

Resistors	
R1	18k
R2, R10, R11	22k (3 off)
R3, R12	15k (2 off)
R4, R7, R8	10k (3 off)
R5, R6	27k (2 off)
R9	82k
R13	11k
R14, R15	33k (2 off)
R16	6k8
R17	1k
All 0.25 watt 5% carbon	
Potentiometers	
VR1	47k log dual-gang
VR2	47k lin
Capacitors	
C1, C5, C7	10nf polyester layer (3 off)
C2, C6	22nf polyester layer (2 off)
C3, C4	3n3 polyester layer
C8, C9	100µf radial elec. 10V (2 off)
C10, C11	47µ radial elec. 63V (2 off)
C12	470nf polyester layer
C13, C15	10µf radial elec. 25V (2 off)
C14, C16	1000µf radial elec. 16V (2 off)
C18	470µf radial elec. 16V
C19	2200µf radial elec. 16V
C20, C21	100nf ceramic (2 off)
Semiconductors	
D1, D2	1N4002 100V 1A rectifier (2 off)
IC1	TDA3810 stereo simulator
IC2, IC3	LM380N audio power amp (2 off)
IC4	LM317T adjustable voltage regulator
Miscellaneous	
S1	s.p.s.t. miniature toggle switch
S2	Rotary mains on/off switch
SK1	3.5mm jack socket
SK2, SK3	Standard jack sockets
LP1	Mains panel neon indicator
T1	Mains primary, 9V–0V–9V 1A secondary

See Shop Talk page 434

Metal instrument case about 230 × 133 × 63mm; printed circuit boards, available from the EE PCB Service—codes EE572 and EE573; small bolt-on heatsink; 18-pin DIL i.c. socket; 14-pin DIL i.c. socket (2 off); control knob (3 off); FS1 1A 20mm antisurge fuse; fuse clip (2 off); mains lead; connecting wire; fixings, etc.

Approx. cost Guidance only £23 (excluding case)

Although electronic measurements reveal no great differences between the two channels, listening tests are a totally different matter, and produce a result which sounds remarkably like a true stereo signal. Being no stranger to stereo synthesisers, this particular type is undoubtedly the best I have yet come across. In a way it is surprising that such minor differences in the two signals provide such a convincing stereo simulation, but real stereo is a very subtle illusion with there often being far less difference between the left and right hand channels than one might have expected.

The output of IC1 is coupled to a conventional volume control and balance circuit, and from here the two signals are fed to separate audio power amplifier stages IC2 and IC3. These are both based on the well known LM380N which provides a reasonable level of performance but requires little in the way of discrete components.

The maximum output power is not very great at something over 1W r.m.s. per channel into 8ohm impedance loudspeakers, or around 2W r.m.s. into 4ohm types. Using reasonably efficient loudspeakers this provides quite respectable volume levels though, and should be adequate for most purposes.

If greater volume is required the best solution is to leave out the volume and balance controls, and the power amplifiers. The signals from capacitors C10 and C11 can then be taken to an output socket, and from here the signal can be coupled to a hi-fi system.

No headphone output is provided, and although it would not be difficult to add one, this is probably not worthwhile. One might reasonably expect the phasing system of stereo simulation to work well with headphones, giving a signal which, like binaural stereo, has little channel separation in the conventioal sense, but has subtle phase anomalies.

However, the effect with headphones is not very good. The unit seems to focus the sound more precisely rather than spreading it out, and certainly fails to give any sort of realistic stereo simulation.

Switch S1 is the Pseudo-Stereo/Mono switch, and the circuit is switched to the pseudo-stereo mode when it is closed.

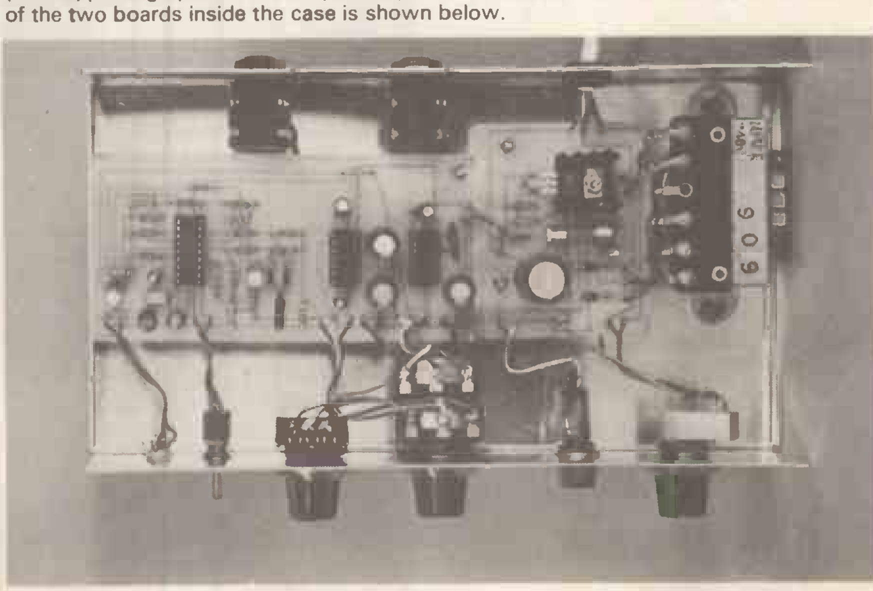
POWER SUPPLY

If the unit is to be built *without* the power amplifier stages then it is quite feasible to use a 9V battery such as a PP7 as the power source since the current consumption will only be about seven milliamps. The situation is very different if the power amplifiers *are* included, as the current consumption will often be of the order of several hundred milliamps, and a mains power supply is then the most practical solution. The circuit diagram of the power supply unit appears in Fig. 2.

This is a standard push-pull rectifier circuit which full-wave rectifiers the output of isolation and step-down transformer T1. Capacitor C19 provides smoothing of the supply, and voltage regulator IC4 then gives electronic smoothing and stabilisation to produce a low noise output at approximately 10V. Capacitors C20 and C21 are the usual decoupling capacitors to aid the stability of the voltage regulator.

Fuse FS1 must be an antisurge type and not the more common quick-blow variety, as the latter would tend to blow at switch-on due to the large current surge as capacitor C19 takes up its initial charge. Lamp LP1 is the on/off indicator neon, and it must be a type which has an internal series resistor for 240V mains operation.

(Above) photograph of the front panel layout and lettering. The interwiring and positioning of the two boards inside the case is shown below.



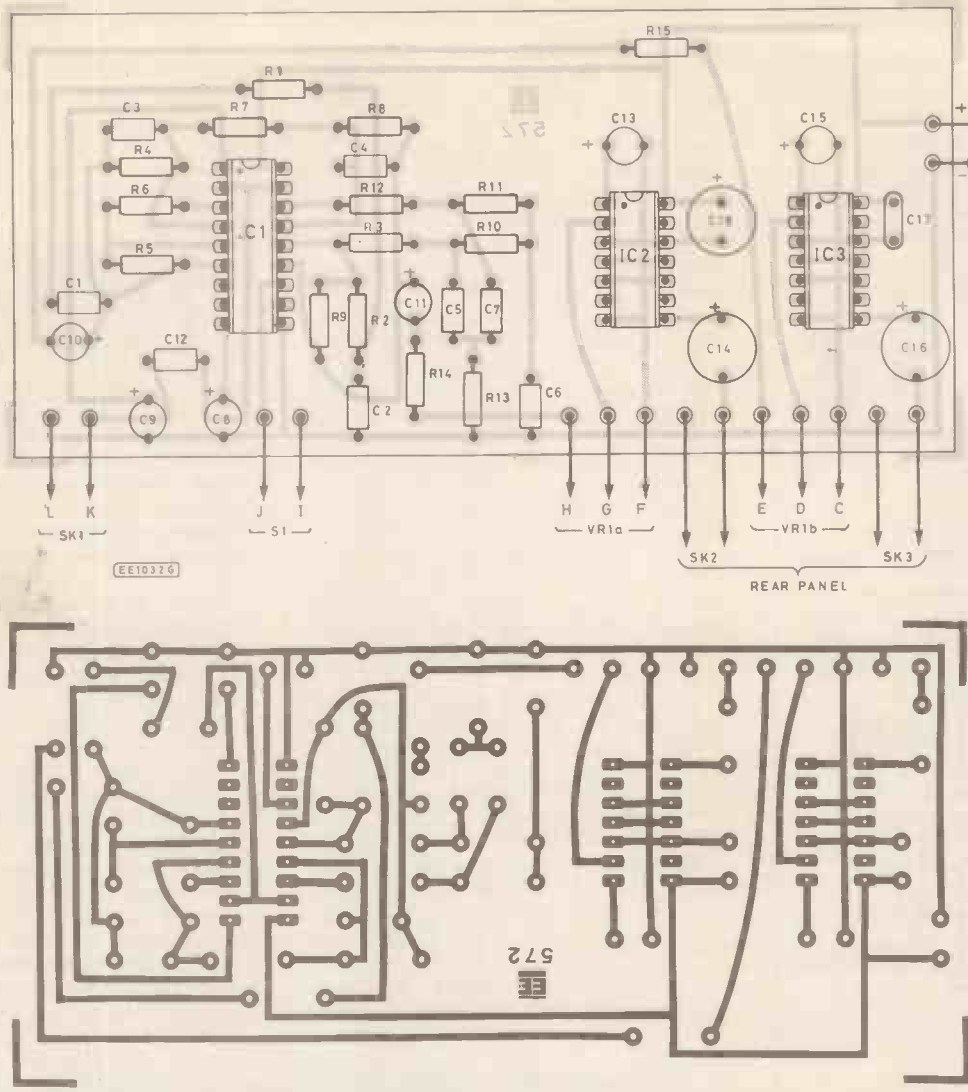


Fig. 3. Component layout and full size printed circuit foil master pattern for the main board.

CONSTRUCTION

The circuit is built on two printed circuit boards and the component layouts and p.c.b. masters are shown in Fig. 3 and Fig. 4. These boards are available from the EE PCB Service, codes EE572 and EE573.

Most of the components are assembled on the main printed circuit board, but a separate board is used for the power supply circuit, and components such as the controls, and sockets are mounted off-board. Construction starts with the main circuit board, full details are given in Fig. 3.

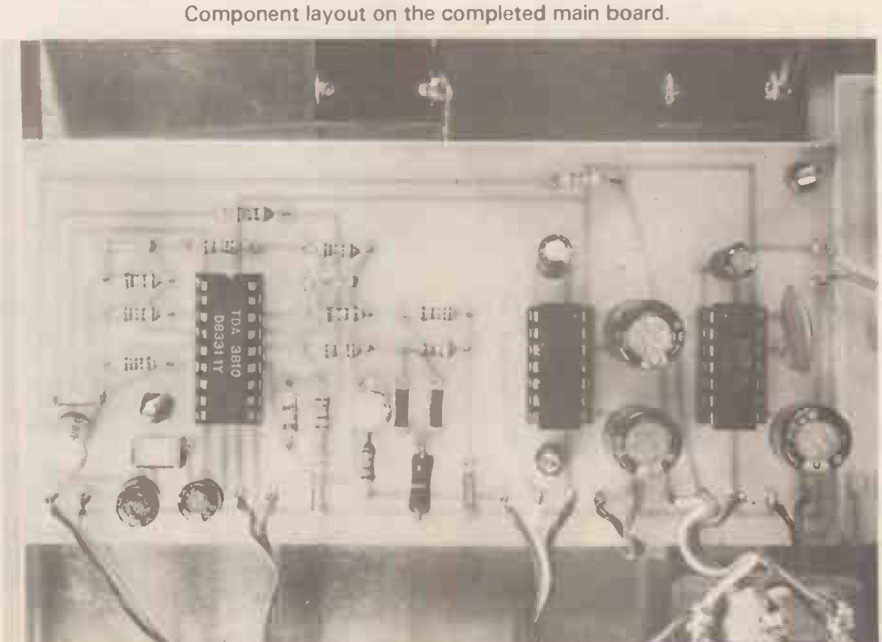
None of the integrated circuits are MOS types, but the TDA3810 is not a cheap device, and it should be fitted in an 18-pin d.i.l. i.c. socket. Construction of the board is very straightforward, but take care over such things as fitting the integrated circuits and electrolytic capacitors round the right way. At this stage only pins are fitted to the board at the points where connections to the off-board components will eventually be made.

The power supply board, Fig. 4, is also quite straightforward, but note that FS1 is mounted on the board in a pair of 20 millimetre printed circuit mounting fuse clips. Also, it is advisable to fit IC4 with a small heatsink which can either be a ready made type, or just a home made heatsink made by bending a small piece of aluminium into a "U" shape and then drilling a mounting hole in a suitable position.

An M3 nut and bolt are used to hold IC4 and the heatsink together and to fix them both to the board. Again, pins are fitted at the points where connections to off-board components will be made.

A metal instrument case about 230 millimetres or more wide is adequate to accommodate the two boards and the mains

Component layout on the completed main board.



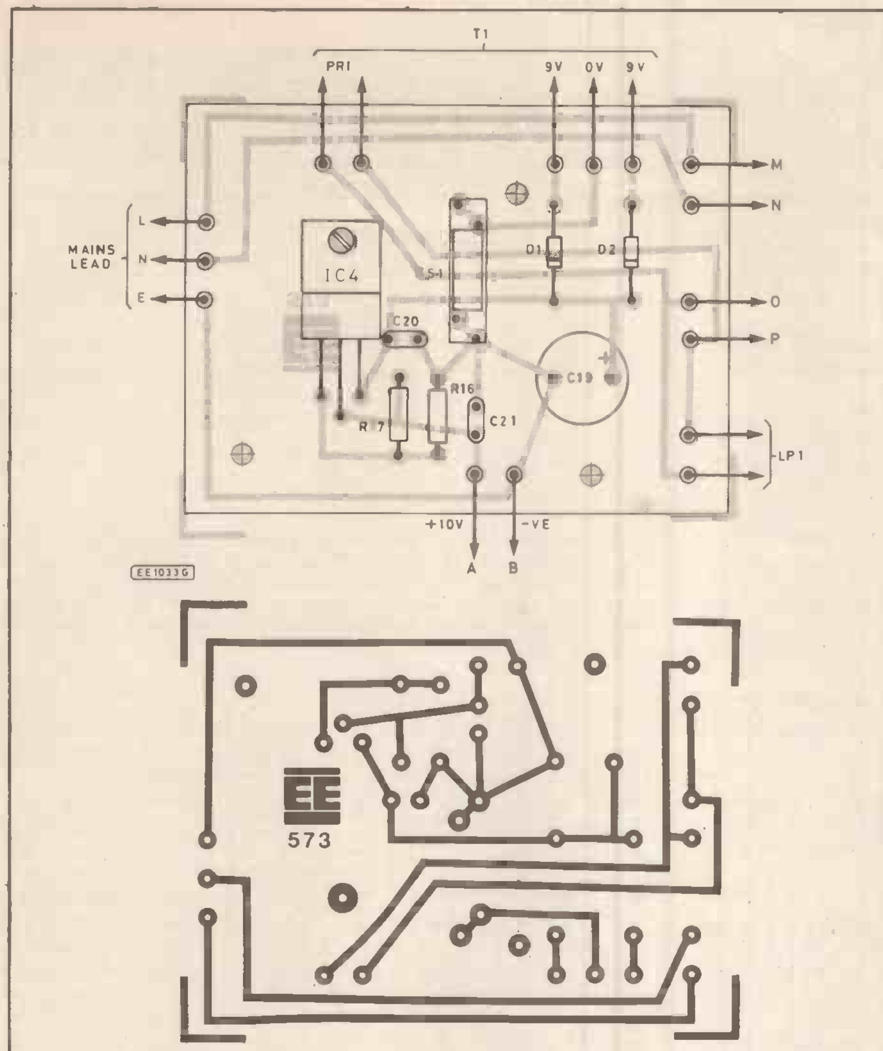
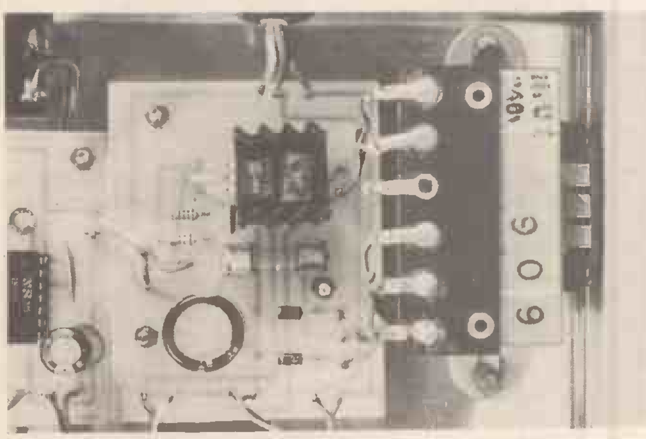
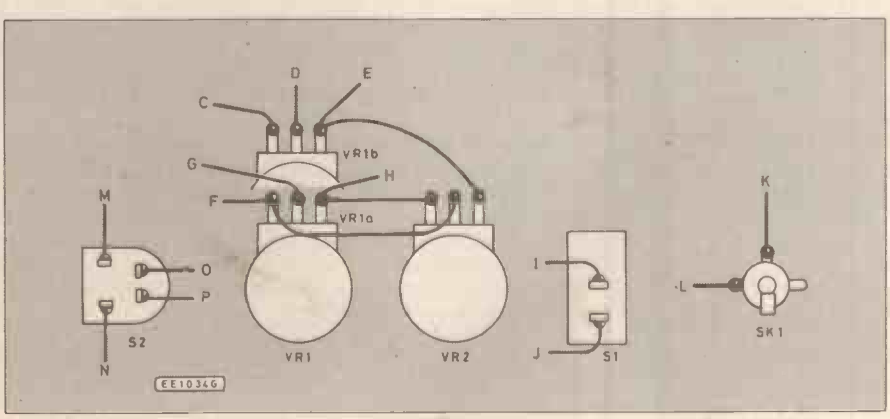


Fig. 4. Component layout and full size master pattern for the power supply board,



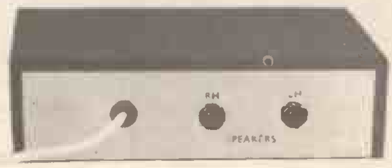
The completed power supply board showing wiring to the mains transformer.

Fig. 5 (below). Wiring from the front panel controls to the two boards.



transformer. The main board is mounted on the extreme left-hand side, with the mains transformer on the extreme right-hand side and the power supply board squeezed into the area left between these two.

Both boards are mounted on spacers which hold the connections on the underside about 10 to 15 millimetres clear of the metal case. This is especially important with the power supply board which carries some mains wiring.



The two output sockets (SK2 and SK3) are mounted on the rear panel of the case, and although standard jacks are specified for these, they can obviously be 2-way DIN types or whatever sockets match the plugs on the particular loudspeakers you will use with the unit. An entrance hole for the mains lead is also drilled in the rear panel, adjacent to the power supply board, and this hole should be fitted with a grommet to protect the mains lead. SK1, LP1, and the four controls are mounted on the front panel, and they should be positioned so that they match up reasonably well with their take off points on the printed circuit boards.

The unit is then ready for the final wiring up, and this wiring is shown in Fig. 5 (in conjunction with Fig. 3 and Fig. 4). While there is nothing particularly difficult about this wiring, some of it is carrying the mains supply, and great care therefore needs to be taken in order to avoid errors.

The finished wiring also needs to be very thoroughly checked. None of the audio signal wiring needs to be screened, but keep the wiring to SK1, VR1, and VR2 no longer than is absolutely necessary.

IN USE

If the unit is fed from an earphone socket, a screened lead fitted with a 3.5 millimetre jack plug at each end will be required to connect the earphone socket to SK1. With other types of output socket the plug at the television end of the lead and its method of connection should be varied to suit the socket concerned. The manual supplied with the television set should provide connection details for the socket. The lead *must* still be a screened type with the outer braiding carrying the "earth" interconnection.

The On/Off switch, Volume, and Balance controls are all conventional types which require no further explanation. However, if the unit is being fed from an earphone socket or other type where the audio output level is dependent on the television receiver's volume control setting, bear in mind that the volume control must be reasonably well advanced or the output level to the simulator might be inadequate.

S1 switches the unit between the Mono and Pseudo-Stereo modes, and with music signals the difference between the two will usually be very apparent. As explained previously, with voice signals the effect provided by the unit is not very good, and the Mono mode is usually preferable.

The loudspeakers should ideally be placed about two metres or so apart with the television set at a central position, but quite good results can be obtained with only about one metre of separation. □

NEWS
...from the world of electronics

LASER AMPLIFIER

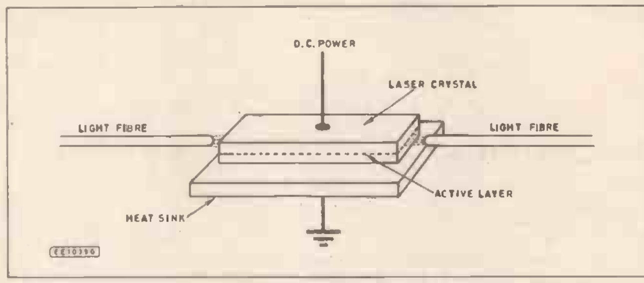
A NEW device developed by British Telecom Research Laboratories promises to simplify the optical fibre communications links which are now replacing trunk telephone cables.

The optical signals grow weaker as they travel along the optical fibres. To restore strength, amplifiers (called repeaters) must be inserted at intervals along the route. At the moment, the only way to make a repeater is to direct the incoming light on to a photodetector. This turns the optical signals into electrical ones. These are amplified and turned back into optical signals for retransmission.

This system is cumbersome and it will become more cumbersome still when optical multiplexing is introduced, that is, when two or more channels are created by sending signals on different optical wavelengths over the same cable. With the present type of repeater the channels will have to be separated by filters, the signals regenerated then recombined for onward transmission.

The new repeaters will neatly sidestep all these problems. They will amplify the incoming light itself, without any need to convert it into electrical signals. And they will be very simple as well: just a tiny chip of crystal with a d.c. power supply.

Moreover, they will amplify in two directions. Whether the fibres (as shown in the diagram) bring in light on the right or on the left the amplifier will still operate. So one fibre will be able to carry traffic in two directions.



Laser amplifier repeater. Light from one optical fibre is passed into the laser crystal. It travels through the crystal, stimulating the production of more light as it goes. On emerging at the far end it is collected by another fibre for onward transmission. Since the device is symmetrical light can be amplified in both directions (left to right and right to left) at once. The d.c. operating current is applied to a metallised surface.

Positive Feedback

The new repeaters are lasers operated "below threshold". That is, the laser crystal does not have the ability to generate light, but once light is passed into it (from an incoming fibre) the crystal intensifies It.

The word "laser" was coined as an acronym for "*l*ight *a*mplification by *s*timulated *e*mission of *r*adiation". However, lasers are not amplifiers but oscillators. Mirrors at each end of the laser reflect any light which is spontaneously produced back into the device. This is positive feedback and the laser oscillates, producing a light output when there is no light input.

In British Telecom's optical repeater the end mirrors have their reflectivity greatly reduced. This so diminishes positive feedback that oscillation is impossible. But light from outside can still be amplified.

On Test

The gain of the repeater tested at Martlesham Heath, where the BT Laboratories are, is fairly modest (17dB) but this is quite good enough. In the tests, optical signals at a rate of 565 Mbits/s were sent over a cable length of 120km. The "laser repeater" was shown to be capable of handling two light wavelengths (1.506 and 1.525 microns, both in the infra-red) simultaneously, without serious intermodulation.

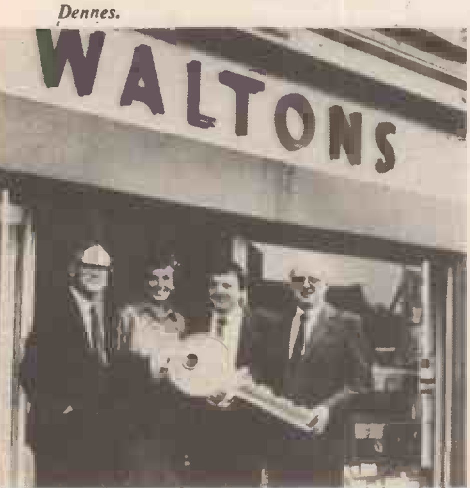
It will take time to get the laser repeater out of the laboratory and into practical trunk communications but the benefits will be great: simpler repeaters, multichannel working and greater reliability. Submarine optical cable links seem to be particularly likely to benefit, because the less complicated the repeater the less the likelihood of breakdown. With the cost of raising the cable to make a repair running at a million pounds a go the advantages are obvious.

SHOP FRONT

MARCO TRADING of Wem, Shropshire, the electronic components mail order and wholesale firm well known to readers of *EE*, have just purchased Waltons of Wolverhampton. The shop, based at 55A Worcester Street, has, until now, been in the Dennes family since 1947 and built up a very good relationship with the local community. Mr. and Mrs. Jack Dennes are now retiring and the new owners hope to keep up the good traditions and service they have established over the years.

The retail shop will continue to trade under the name of Waltons and will be under the management of Nigel Armitt. Customers calling at the shop will find the latest 100-page illustrated catalogue available over the counter.

The "key handover" being witnessed by Mr. Budgen, MP for Wolverhampton. (left to right) Mr. Budgen MP, Mrs Susan and Mr. Martin Cox Marco MD's, and retiring proprietor Mr. Jack Dennes.



Further additions planned for the shop are the introduction of test equipment, amateur radio accessories and the full Marco range of components.

This is Marco's second retail outlet, the first being at Wem, and customers old and new will receive a warm welcome at the new Worcester Street branch.

COPYCODE

THE THREAT posed to the European record industry by the introduction of Digital Audio Tape (DAT) recorders, capable of making near-perfect copies of compact discs (CD), was discussed at the largest gathering of European record industry executives recently.

To help combat this future threat, the gathering of 200 executives from 20 countries, were given a demonstration of the Copycode system developed by CBS Records Technology. This system, it is claimed, will inhibit the recording of Compact Discs on to blank DAT when both discs and DAT recorder have been specially encoded.

After extensive tests, the members of the International Federation of Phonogram and Videogram Producers have endorsed Copycode as the preferred technical standard for encoding of software. CBS is now manufacturing encoding equipment for use in recording studios and has produced detailed specifications for incorporating the system into microchips which are used in DAT machines.

Addressing the meeting, IFPI President Nesuhi Ertegun said *"We are always ready to accept every opportunity to broaden our markets through new technology. But DAT can only be endorsed by the music industry on condition that the interests of authors, performers and producers are taken into account. Copyrights constitute the fundamental roots of what we are and what we do. Our great fear is that DAT can destroy or significantly erode these Copyrights. This will hurt music and its creators . . ."*

We seem to remember having been through this scenario before with cassette tape recorders and records. We should like to hear readers' comments on this controversial subject.—Ed.

...REPORTING AMATEUR RADIO...

TONY SMITH G4FAI

DANGER SIGNALS

The expected report by management consultants, on the possible benefits obtainable from introducing market forces and a price mechanism into radio spectrum management, was published on 2nd April.* Over-optimistically, the Radio Society of Great Britain reported in January that amateur radio was thought to fall well outside the possible terms of reference of the new recommendations, and that no proposals affecting the hobby had been formulated.

The report, while recognising that amateurs have a special place in the radio spectrum does, in fact, make recommendations which, if adopted by the government, would eventually have an adverse effect on amateur radio round the world.

As was already known, the basic proposal is that licensing for use of the spectrum should be placed in the hands of Frequency Planning Organisations (FPOs). They would be granted Spectrum Management Licences (SMLs), and their main purpose would be sub-licensing use of the spectrum, on a commercial basis, to end users.

Radio amateurs are obviously not commercial users and the report recognises this fact, drawing an analogy with the use of land, "although most land is allocated to owners for their private use by the price mechanism, parks are maintained . . . for recreational use by the public".

NOT PROVEN

But, here is the most worrying aspect of the report for amateurs, it goes on to say, "It is our opinion that the quantity of the spectrum set aside for amateur use is *larger* than economic considerations would dictate, although this judgement is difficult to prove quantitatively. Therefore we would recommend that the UK government apply pressure in international discussion to avoid further increases in this allocation, or even to *reduce* existing allocations."

Amateurs have fought for and established their right to use the radio spectrum side-by-side with other users since wireless came into use before the turn of the century, and it seems incredible that a recommendation of this nature should be made to the government based on an opinion which "is difficult to prove quantitatively."

Traditionally, at international conferences which lay down regulations and allocations for use of the spectrum, the official UK delegation has been a major supporter of amateur radio in the face of hostility from some other countries. If it becomes government policy to withdraw such support, there could well be a change of emphasis in future conferences as the balance of opinion shifts.

BLURRED

Having produced such a bombshell, the report proceeds to blur the issue by proposing that so long as the principle of amateur use of the spectrum is to be recognised amateurs must have access at a price consistent with their amateur status (as opposed to commercial opportunity cost).

Specifically, it proposes that applicants for SML status should accept existing amateur allocations within their band for at least five years, and that FPOs should accommodate any future amateur allocations when internationally ratified.

Others may interpret it differently, but it looks very much as if what is being said is, "there should be protection for five years, or indefinitely—take it how you like; we must recognise that amateurs have a special position—but the government should re-examine it . . ."

However it is interpreted, its recommendation on frequency allocations is potentially one of the most serious threats to amateur radio in all its years of existence. The DTI is appraising the full implications of the report and has invited views and comment from affected parties.

The government will almost certainly decide its future policy on spectrum management on the basis of this report. In the long term, amateur radio could be in for a difficult time.

QSL card of station BY4AOM

AMATEUR RADIO IN CHINA

Back in 1949, the Chinese government, under Mao Tse-Tung, prohibited amateur radio, although before that a good many Chinese stations had been on the air. In the last few years stations from China have begun to appear on the amateur bands again, and foreign amateurs have succeeded in visiting a number of these and operating them.

One station, BY4AOM, meaning "All Old Men", is operated at the Shanghai Institute of Electronics by amateurs who all held licences before 1949, including some who operated in the mid-1920s with the old prefix XU, later changed to C. The average age of these operators is 64, and one can imagine the frustration they must have felt over the years at not being able to participate in the hobby they enjoyed so much in the years before 1949.

They are intent on catching up however. In the first five months operation last year they worked 800 stations in 34 countries over five continents. Old memories die hard. An Australian amateur worked BY4AOM and asked that his greeting be conveyed to Mr Feng, C1KF, who he remembered working in the 1940s. The greetings were passed on to Feng, now in his 70s, who was delighted to be remembered by his old friend in amateur radio from the past.

The station has a QSL card bearing two lines of ancient script, meaning, "Within four seas there are bosom friends", and "People in the remotest corners of the world are neighbours," which seem particularly appropriate to the activities of amateur radio.

TRAINING FOR THE FUTURE

So far only club stations have been authorised in China, and it may be some years yet before private stations are again licensed. Club stations are being set up at colleges and universities, and young people are being trained in radio theory and operating techniques to operate these stations.

They are still relatively rare at present so that whenever they do appear on the air there is a "pile-up" of stations round the world wanting to work them and obtain their QSL cards. Several foreign amateurs have been instrumental in re-awakening interest in amateur radio and in persuading the Chinese authorities to look favourably on it. A Canadian amateur, Tom Wong, VE7BC, who played a major part in this, has been honoured by the Chinese Radio Sports Association and has been awarded the only personal call-sign so far for Chinese operation, BX1BC.

Much of the equipment used by the Chinese has been provided with foreign help. BY4AOM, for instance, has a Drake transceiver donated by the Boeing Aircraft Company Amateur Radio Club. Its two-element cubical quad antenna is home-made, with a rotator made from a modified aircraft gear box. There is also a home-made antenna tuning unit and SWR meter, and because there is no suitable coaxial cable available the feed line to the antenna is made from 300ohm TV twin-lead.

It's still very early days for the re-emergence of amateur radio in China, but amateurs everywhere are glad to welcome them back and to offer whatever help they can "within the four seas".

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*"*Deregulation of the Radio Spectrum in the UK*" by CSP International, HMSO, £9.50.

...Beeb...Beeb...Beeb...Bee

...Computer to Computer link...Motor Speed Control...

LAST MONTH we looked at a little known aspect of the BBC computer's hardware—the shift register of the 6522 VIA. This can be accessed via the user port, and is presumably intended primarily for asynchronous serial communications. In this article we will consider a basic link of this type for two BBC machines, as well as another, and perhaps more interesting use for the shift register.

Serial Link

The shift register has four input and four output modes, as explained in last month's article. The obvious modes for an asynchronous serial link are the one where the signal is shifted out at a rate controlled by Timer 2, and the one where the input signal is clocked in at the rate set by an external clock signal. Of course, this external clock signal is provided by the 6522 VIA that acts as the sending device.

Only three connections are needed between the two computers, as shown in Fig. 1. These three connections simply link the "Ground", CB1, and CB2 terminals of one computer to the corresponding terminals on the user port of the second machine. CB2 carries the data while CB1 conveys the clock signal.

This system should actually work using any two computers which have a 6522 VIA with the relevant lines available to the user. For example, with appropriate software it should be possible to producd a communications link between a BBC machine and a Commodore VIC-20 (which has a similar user port).

The following two listings can be used to enable the sending computer to transmit characters typed into its keyboard, and the receiving computer to display received characters on the monitor or television screen.

```
5 REM SENDER PROG
10 CLS
20 ?&FE6B = 20
30 ?&FE68 = 2
40 C = GET
50 PRINT CHR$(C);
60 ?&FE6A = C
70 GOTO 40
```

```
5 REM RECEIVER PROG
10 CLS
20 ?&FE6B = 12
30 START = ?&FE6A
40 REPEAT UNTIL (?&FE6D AND 4) = 4
50 C = ?&FE6A
60 PRINT CHR$(C);
70 GOTO 40
```

Sender Program

Taking the Sender program first, after clearing the screen it sets the shift register to the correct mode at line 20. The shift register is controlled by bits 2 to 4 of the auxilliary control register at ?&FE6B, and in this case 101 (binary) or 20 (decimal) is needed.

With data clocked out at a rate set by the low byte of Timer 2 we must write the required division rate to this timer at address &FE68. In fact any legal value is suitable here since the timer is effectively setting both the transmit and receive baud rates. A low value gives a high baud rate and ensures that data is transferred quickly. A suggested value of 2 is used in the listing, but you might like to try other values.

Line 40 waits for a character to be typed from the keyboard, and then the ASCII value of this character is assigned to variable "C". The next line prints the character on the screen (this function is not provided by the GET instruction) and then at line 60 the character is sent to the shift register at ?&FE6A.

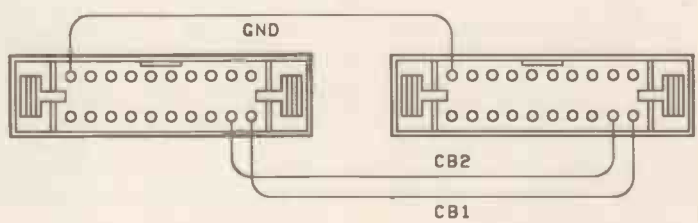


Fig. 1. User port connections for a synchronous communications link.

Data is sent automatically without any software triggering of the shift register. Finally, line 40 loops the program indefinitely so that each character typed onto the keyboard is transmitted.

Receiver Program

The Receiver program again starts by clearing the screen and then setting the shift register to the correct mode. A value of 12 (011 in binary) sets the mode where data is clocked in at a rate set by an external signal fed to CB1. Line 30 is merely a dummy read of the shift register, which seems to be necessary to initialise the system and get everything working correctly.

It is no use simply reading the shift register continuously and printing the characters on the screen. This would give multiple reading of characters, and unusable results. Instead, some means of determining when a new character has been received is needed. A software loop can then be used to provide a hold-off until each new character has been received.

Fortunately, the 6522 VIA makes things easy by providing a status flag at bit 2 of the interrupt flag register at ?&FE6D. This is set to 1 when 8 bits of data have been clocked in, and is automatically reset when it is read. Line 60 loops until this bit is set, and then the program progresses to line 50 where the contents of the shift register are placed in variable "C".

The ASCII values is converted back to a text character and printed on the screen at line 60. Line 70 then loops the program back to 40 where it waits for the next character to be received.

The shift register certainly works, and if you have access to two BBC machines it is interesting to try out this method of communications. However, I failed to obtain totally reliable results even over a fairly short operating range!

Possibly a better quality connecting cable would improve matters. A lower baud rate did not seem to provide any improvement. For communications between two BBC computers the RS423 serial port (with its operating system support) would seem to be a more practical solution.

Motor Controller

An interesting use of the shift register is as the basis of a simple pulsed type motor speed controller. In this application the shift register is used in the free-running mode where the last value sent to the register is transmitted continuously.

The waveforms of Fig. 2 help to explain the way in which this system operates. The top waveform represents the clock signal, and this is at a frequency which is determined by Timer 2 and the system clock. This signal is available on CB1, but it is of no real value in this application.

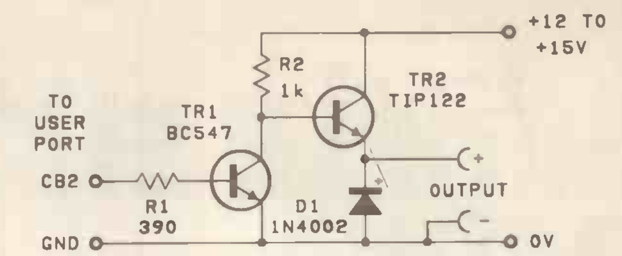
The other nine waveforms represent those produced with certain key numbers written to the shift register. With a value of 0 the output is continuously low. With a value of 1 the output is high for one clock cycle and then low for seven of them. This gives a 1 to 7 mark-space ratio.

A value of 3 sends the output high for two consecutive clock cycles, and then low for the next six, giving a 2 to 6 (or 1 to 3) mark-space ratio. With other values the mark-space ratio can be taken though to a 7 to 1 type, and finally, with a value of 255, a continuously high output is obtained.

The electric motor responds to the average signal voltage, and the dashed lines in Fig. 2 show the average potential for the pulsed waveforms. This gives "off", "full on", and seven intermediate speeds. Because the motor is driven at full power during each pulse from the controller, excellent results are obtained with good immunity to stalling at low speeds.

In practice this arrangement seems to give good results, with quite accurate control of the motor's speed being possible. "Off" plus eight speeds should be adequate for most purposes.

Fig. 3. The power controller interface circuit.



up to 2A or so without difficulty, which is sufficient for most small d.c. motors. Due to the switching nature of the output signal TR2 does not have to dissipate very much power, but with some motors a small heatsink will be required.

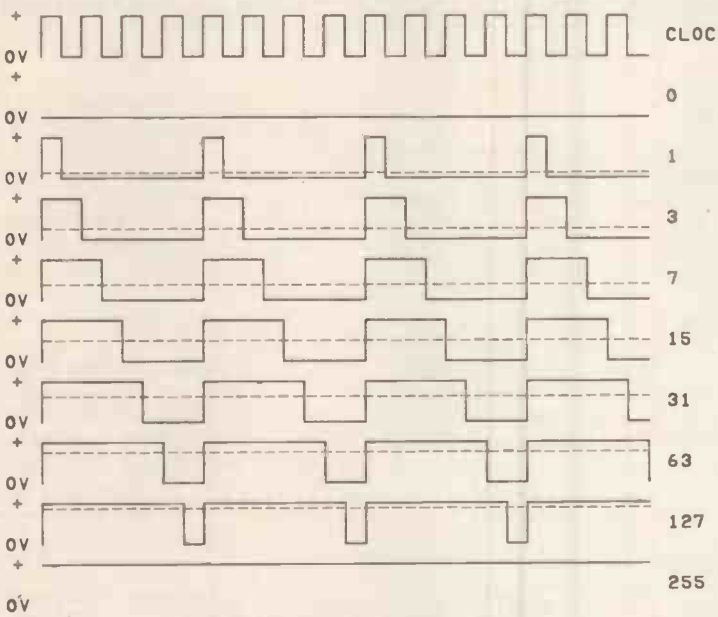


Fig. 2. Power controller waveforms.

Of course, the signal direct from CB2 is at inadequate voltage and current levels to drive even a fairly small d.c. electric motor. However, all that is needed to interface CB2 to a motor is a simple amplifier circuit such as the one shown in Fig. 3. This is just a common emitter amplifier (TR1) followed by an emitter follower buffer stage (TR2).

The TIP122 transistor used in the emitter follower, TR2, is a Darlington power device which provides the high gain demanded by this application. It can handle currents of up to 2A or so without difficulty, which is sufficient for most small d.c. motors. Due to the switching nature of the output signal TR2 does not have to dissipate very much power, but with some motors a small heat-sink will be required.

This circuit does not incorporate any form of overload protection, and it should be fed from a power supply that provides current limiting. It will drive 12V d.c. motors, and a supply voltage of around 12 to 15 volts is needed. Results seem to be best with a 15V supply; the extra voltage compensating for the losses through TR2 when it is in the "on" state.

Listing .3

```
  5 REM MOTOR CONT PROG
 10 ?&FE6B = 16
 20 ?&FE68 = 255
 30 ?&FE6A = 255
 40 A=VAL (GET$):IF A=0 THEN 40
 50 ON A GOTO 60, 70, 80, 90, 100,
    110, 120, 130, 140
 60 V = 255: GOTO 150
 70 V = 127:GOTO 150
 80 V = 63: GOTO 150
 90 V = 31: GOTO 150
100 V = 15: GOTO 150
110 V = 7: GOTO 150
120 V = 3: GOTO 150
130 V = 1: GOTO 150
140 V = 0: GOTO 150
150 ?&FE6A=V
160 GOTO 40
```

Software

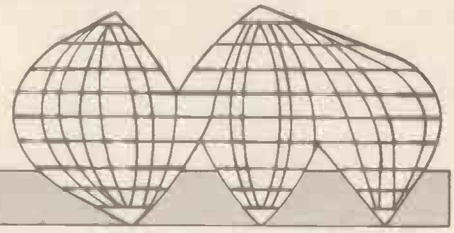
When writing software to drive the Port, bear in mind that the driver circuit inverts the signal, and values of 0 and 255 therefore provide "full on" and "off" respectively. The accompanying Listing .3 above is for a basic controller program.

Line 10 sets the shift register to the correct mode, and then the next line sets the output frequency. A value of 255 written to Timer 2 gives the lowest possible output frequency of about 245Hz. This should give good results with any small d.c. motor.

Line 30 sets the motor to the "off" state initially. The rest of the program monitors the keyboard and sends values to the shift register. It is designed so that keys from "1" to "9" (the number keys not the function keys) provide speeds from "off" to "full on".

With further development the system could make a very nice model train controller.

SIMPLE SHORT WAVE RADIO



MARK STUART

A three band 1·6 to 30MHz radio providing excellent results plus loud-speaker output

OVER the last ten years or so a number of good short-wave radio designs have been published. Nearly all of them have used expensive coils and air-spaced tuning capacitors, and have outputs suitable only for crystal earpieces, or high impedance headphones.

The design described here was produced to combine the advantages of these previously published circuits whilst using modern miniature coils and capacitors and having the benefit of a built-in loudspeaker. It is a TRF (tuned radio frequency) design covering approximately 1.6 to 30MHz in three bands. The audio output is provided by a single i.c. amplifier capable of supplying over one watt when operated from a nine volt supply.

CIRCUIT

The complete circuit diagram of the Simple Shortwave Radio, showing the r.f. tuner and the audio amplifier sections, is shown in Fig. 1. The five transistors in the tuner circuit are not discrete devices but are all contained in the "transistor array" chip IC1.

This approach has been taken mainly because of the close matching, and excellent thermal tracking of the transistors, which solve a lot of biasing problems. Another advantage of the transistors in IC1 is their excellent high frequency performance and low noise characteristics. Fig. 2 shows the schematic and connection diagram of IC1.

The "active" part of the tuner circuit consists of transistors TR1, TR2, and TR5. TR1 and TR2 are connected in what is known as a long-tailed pair configuration. This arrangement has several advantages. One is that the input of the circuit (TR1 base) is very well isolated from the output (TR2 collector). This allows a good amount of gain to be produced as there is very little negative or positive feedback from the output to the input.

Negative feedback is undesirable because it reduces the gain of the circuit. Positive feedback is undesirable because it reduces the stability of the circuit and can lead to oscillation problems. The input to TR1 base is obtained from a tapping on the main tuning coil L2.

Variable capacitors C3 and C4 form a parallel tuned circuit with L2 providing the circuit with its initial selectivity. A tapping is necessary on L2 so that the coil is

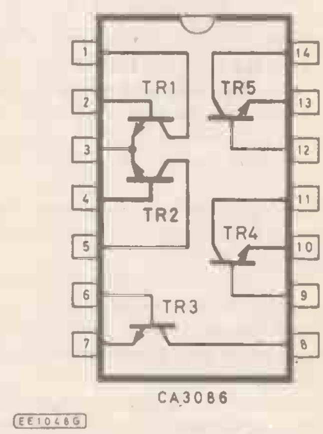
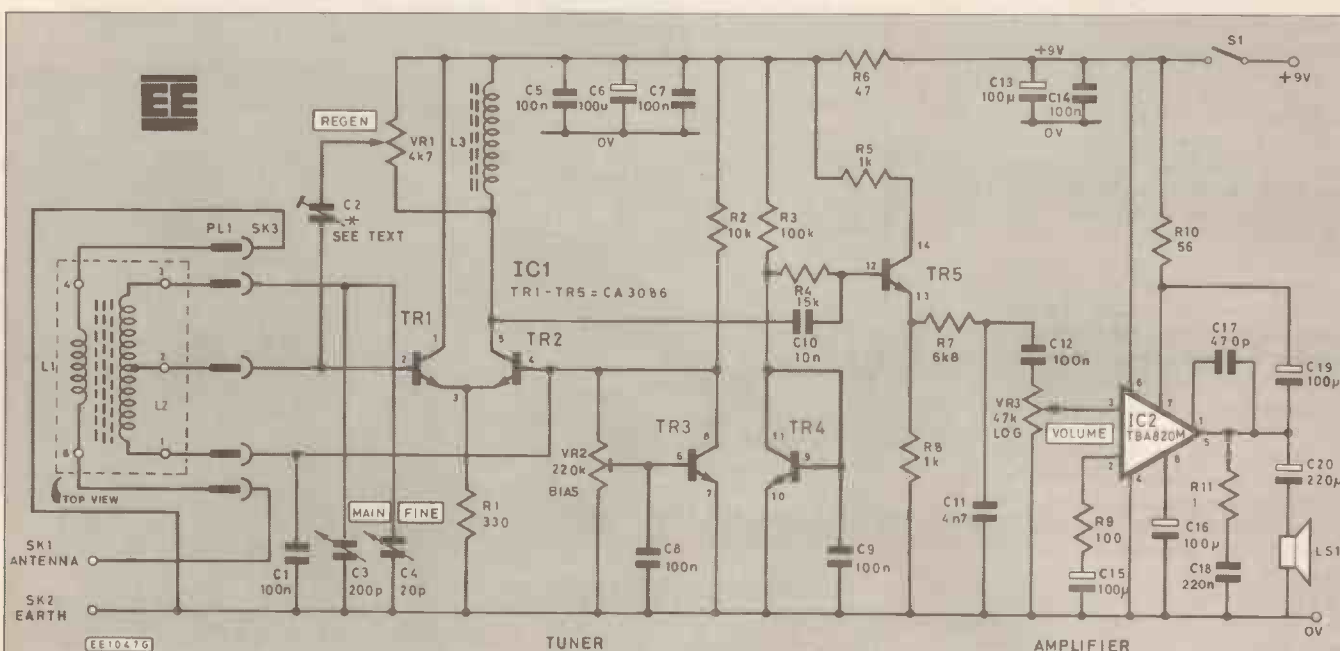


Fig. 2. Internal structure of IC1 (CA3086).

Fig. 1. Complete circuit diagram for the Simple Shortwave Radio



properly matched to the relatively low input impedance of TR1 base. If the base of TR1 was to be connected straight to the top of L2 the result would be much lower selectivity and a loss of gain. The exact position of the tap is not critical and on the coils used has been pre-set by the manufacturer to give a reasonable match in transistor circuits.

The aerial coupling winding L1 is a small winding on the same core as L2 to which the aerial is connected. The number of turns on this coil again have been chosen by the manufacturers to suit most commonly used aerials. It is worth noting however that accurate matching of the aerial to the coil is extremely unlikely especially over the wide frequency range involved. This is one of the compromises necessary with such a simple circuit. Aerial matching over such a wide frequency is extremely difficult and it is unusual for even good quality communication receivers to be particularly clever in this respect.

REACTION—REGENERATION

The signal at the collector of TR2 is an amplified version of the input signal. By coupling a small amount of this signal back to the input an effect known as reaction or regeneration comes into action.

As previously mentioned the presence of feedback is generally undesirable. If a controlled amount of positive feedback is applied however the effect is that the circuit "boosts" itself. The gain and selectivity of the circuit increase as more feedback is applied until at a certain level the circuit provides its own input and begins to oscillate.

At a point just before oscillation the performance of the circuit is dramatically improved. It is the function of the reaction of regeneration control to allow the feedback to be adjusted so that operation at this point can be achieved over the whole tuning range (see *Regenerative Receivers* EE June and July 1987).

Potentiometer VR1 is used to "tap-off" some of the output signal from TR2 which is coupled via C2 to the input. Advancing VR1 provides a higher level of feedback eventually leading to oscillation. The effect of the onset of oscillation can be quite violent in some circuits as the whole input stage "bursts" into oscillation.

In this circuit the onset of oscillation is very well controlled because of another very useful characteristic of the "long-tailed pair" connection of TR1 and TR2. This characteristic is that the gain of the stage decreases as the signal level increases. Thus any increase of signal level as the circuit approaches oscillation is opposed by a gradual fall in gain so that the circuit cannot "burst" into oscillation at all.

Instead as the reaction control is advanced gentle oscillation begins and the level of oscillation increases in a controlled way as the control is further advanced. It is therefore relatively easy to set the circuit to its most sensitive operating point by use of the reaction control.

The bases of TR1 and TR2 are biased to approximately two volts produced by R2, VR2 and TR3. This circuit uses the base-emitter voltage of TR3 as a reference voltage (0.6 volts) which is boosted by TR3 to a pre-set level adjustable by the setting of VR2. The gain of TR1 and TR2 is dependent on the setting of the bias control and increases with increasing bias voltage. A good initial setting of VR2 is two thirds of a turn clockwise which gives a bias voltage of 2V. Increasing the setting further increases the gain, but beyond a certain point this becomes excessive and good control of regeneration becomes difficult.

DETECTOR

From the collector of TR2 the amplified r.f. signal is coupled via C10 to the detector stage TR5. The job of the detector circuit is to remove the modulating audio signal from the unwanted high frequency carrier signal. The principle of detection will not be discussed here as it has been covered in previous articles. Usually a diode is used as a form of half wave rectifier to remove the modulation. The old "cats whisker" was a form of diode, nowadays usually replaced by an OA90 or similar germanium point contact device.

In this circuit a more sophisticated approach has been used which results in better sensitivity and lower distortion than a simple diode detector. It is known as an "infinite impedance" detector and operates by using the action of a transistor which is biased so that it is just at the point of conduction. Positive signals increase the bias on the transistor and so are amplified, whilst negative signals reduce the bias, turn off the transistor, and produce no output.

The output at the emitter of TR5 thus consists of just the positive half of the modulated r.f. signal. R7 and C11 form a low pass network which removes the r.f. carrier frequency leaving the low (audio) frequency modulation to be passed to the audio amplifier section of the circuit.

Transistor TR4 provides the correct amount of d.c. bias voltage to keep TR5 at

COMPONENTS

Resistors

R1	330	R4	15k	R7	6k8
R2	10k	R5,R8	1k	R9	100
R3	100k	R6	47	R10	56
				R11	1

All 5% ¼ watt carbon film

See Shop Talk page 434

Potentiometers

VR1	4k7 lin.
VR2	220k min preset (horiz)
VR3	47k log.

COMPONENTS approximate cost £26

Capacitors

C1,C5,C7,C8,C9,C14	100n ceramic disc 50V
C2	preset (see text)
C3	200-300p variable
C4	20-30p variable
C6,C13,C15,C16,C19	100µ radial elect. 16V
C10	10n ceramic disc 50V
C11	4n7 ceramic plate
C12	100n polyester
C17	470p polystyrene/ceramic
C18	220n polyester 100V
C20	220µ radial elect. 16V

Inductors

L1/L2 A	KAN3333 miniature low range 1 r.f. coil
L1/L2 B	KAN3334 miniature med range 2
L1/L2 C	KAN3335 miniature high range 3
L3	1mH radial r.f. choke

Semiconductors

TR1 to TR5	CA3086 (IC1 transistor array)
IC2	TBA820M

Switch

S1	s.p.s.t. min toggle

Miscellaneous

LS1 8ohm 50mm loudspeaker
SK1, SK2 4mm banana sockets; SK3 DIN socket 5 pin 180 deg. (3 off—see text). DIN plugs 5 pin 180 deg. (3 off—see text); p.c.b.s available from the *EE PCB Service*, order codes EE575 and EE576; knobs (4 off); battery holder; 6 × HP7; wire; fixings etc. 8 pin d.i.l. i.c. socket; aluminium case 200 × 150 × 75mm.

the optimum point for maximum sensitivity. As TR4 and TR5 are on the same piece of silicon inside IC1, and have matched characteristics, the bias voltage from TR4 will vary in exactly the correct way to match the needs of TR5 as ambient temperature varies.

DECOUPLING

Most of the capacitors in the circuit are for decoupling purposes, C1, C5, C7, C8 and C9 are all used to keep high frequency from interfering with circuit stability. C6 and resistor R6 are there to remove audio signals present in the supply rail from the audio amplifier section.

The layout and wiring of circuits operating at high frequencies can be quite critical. It is recommended that the p.c.b. and wiring shown should be followed to ensure good results, although this circuit is quite well behaved.

AUDIO AMPLIFIER

From the tuner section a signal ranging from 10mV to about one volt is passed to the volume control VR3 via coupling capacitor C12. There is little to say about the amplifier circuit as it is all contained in a single i.c. (IC2).

The TBA820M can produce over one Watt into an eight ohm speaker providing a very good loud signal. The output could be connected to an external speaker (a larger one would give even better volume) or to any type of headphones from eight ohms upwards. Of the components surrounding IC2, C13, C14, and C16 are supply decoupling capacitors. C20 is the output coupling capacitor. R10 and C19 provide a type of feedback known as "bootstrapping" which temporarily boosts the positive supply voltage to the i.c. internal circuits during positive half cycles of the output. The benefit of this is higher power and lower distortion. R11 and C18 provide a controlled load at high frequencies and ensure that the circuit is stable. C17 sets the high frequency response of the circuit. Its value can be increased to reduce adjacent signal whistles if required. The remaining components R9 and C15 set the maximum gain of the circuit.

CONSTRUCTION

The radio is built on two printed circuit boards. These boards are available from the EE PCB Service, order codes EE575 and EE576. Construction of the audio amplifier board should be undertaken first as this is the simplest and can be tested on its own. Fig. 4 shows the component layout for the amplifier board. Take care to put the electrolytic capacitors in the right way and to fit the two wire links as shown. A socket can be used for the i.c. if required.

If the correct p.c.b. mounting potentiometer is not available, VR3 can be wired to the board using short lengths of stiff tinned wire. It is important to use stiff wire as the board is mounted solely by the bush and nut on VR3.

Attach a twisted pair of wires approximately 120mm long for the loudspeaker connections, and three other single wires for the positive, negative, and audio input connections.

When the loudspeaker and a battery are connected to the circuit, it should be possible to hear the familiar "mains hum" sound when the input wire is touched (with VR3 set to maximum). If an audio signal source is available the circuit can be tested more thoroughly. Once this section is complete proceed to the assembly of the tuner board.

TUNER P.C.B.

The assembly of the tuner board shown in Fig. 3 is only slightly more complicated than the audio board. Begin by inserting the four wire links followed by the resistors, ceramic capacitors, VR2, C6, L3, and VR1. IC1 should be soldered directly to the board to minimise stray capacitances which could reduce stability.

When the board is complete the wires should be attached for the battery clip, S1, SK1, C3, and C4. These connections should all be made using solid core wire which is soldered directly to the board in the same way as component leads. This method has the advantage that no loose strands of wire can cause short circuits and that the relatively stiff wire will stay in position. Capacitor C2 is made by twisting two 40mm lengths of wire together as shown in Fig. 6. Initially a single twist should be made so that the final adjustment can be done when the radio is tested.

ASSEMBLY

The main components should be assembled into the case approximately as shown in Fig. 6. The case used for the prototype had a wrap-over lid into which all of the components were fitted. This useful arrangement means that there are no wires trailing between the top and bottom of the case, and that there is plenty of room to work.

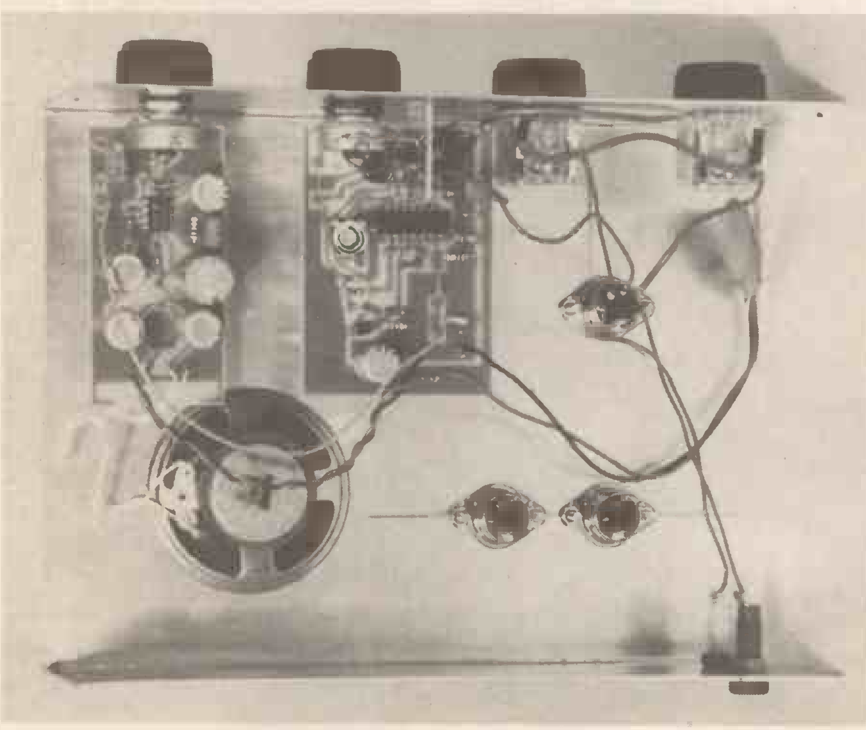
If the specified case is used the full size drawing of Fig. 5 can be photocopied and stuck onto the case front as a drilling guide (a second photocopy can be covered with transparent plastic and used as a proper case label when construction is complete).

The two tuning capacitors are each fixed to the case by means of two small M2.5 screws. Make sure that these are not too long as they will otherwise damage the vanes inside the capacitor.

Socket SK3 can be mounted inside or outside the case as preferred. In the prototype two further (unwired) sockets were added as parking places for the unused coils. To keep the front panel simple the on/off switch S1 was mounted on the rear of the case. If this is not convenient it can be re-positioned as required.

The connections to SK3 are simply made as shown in Fig. 6. The earth tag of SK3 is used to link the earth socket and one end of L1 to the chassis. Connections to the Main and Fine tuning capacitors C3 and C4 are as

Internal layout and interwiring of the prototype radio. The transistor buffer stage shown on the tuner board was found to be unnecessary.



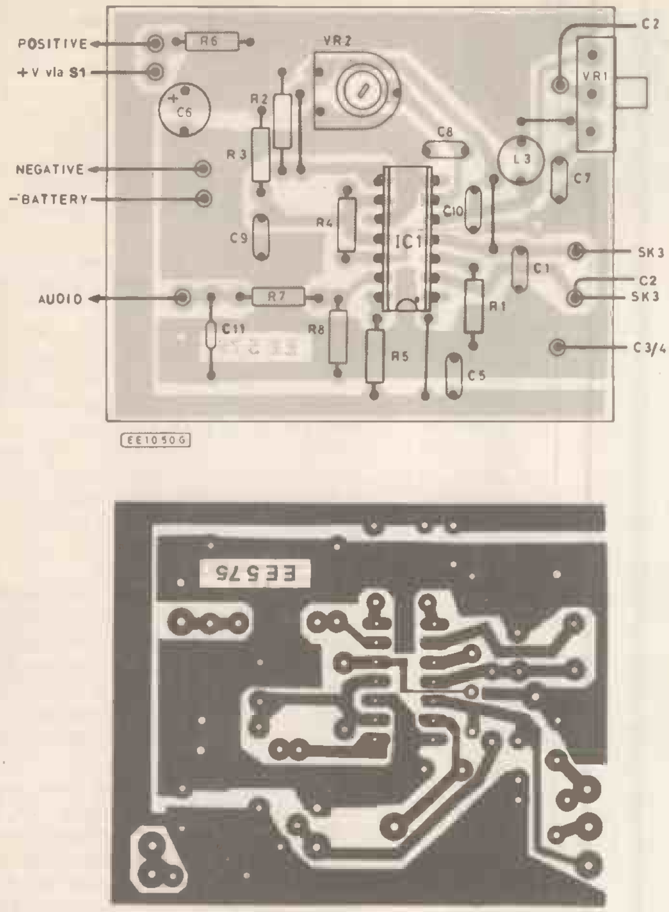
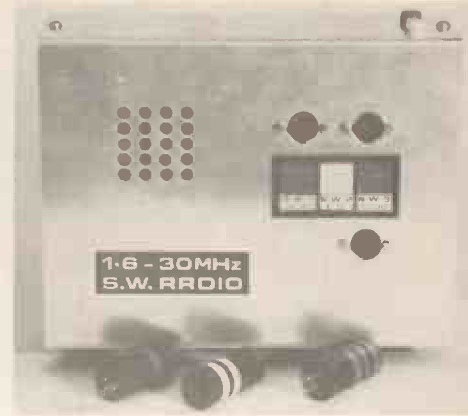


Fig. 3. Component layout and full-size printed circuit board foil master pattern for the tuner stage. Note than an i.c. holder is NOT required here.



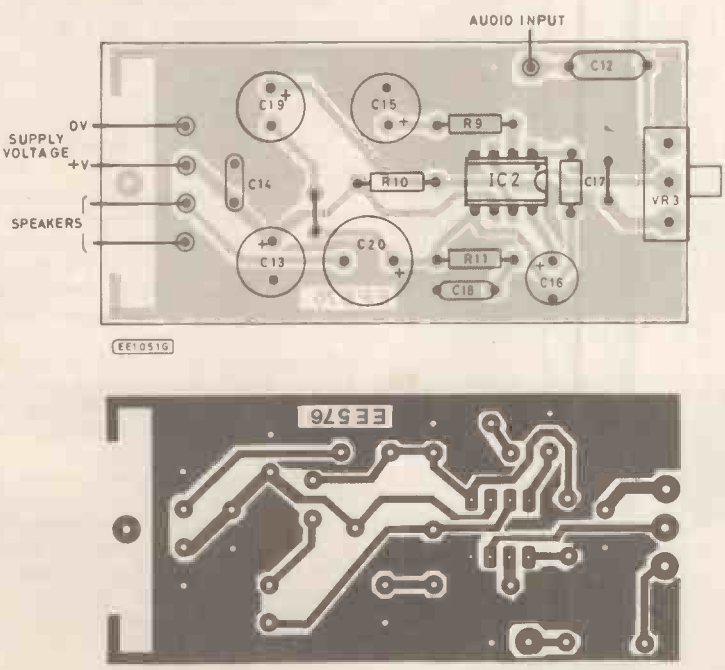
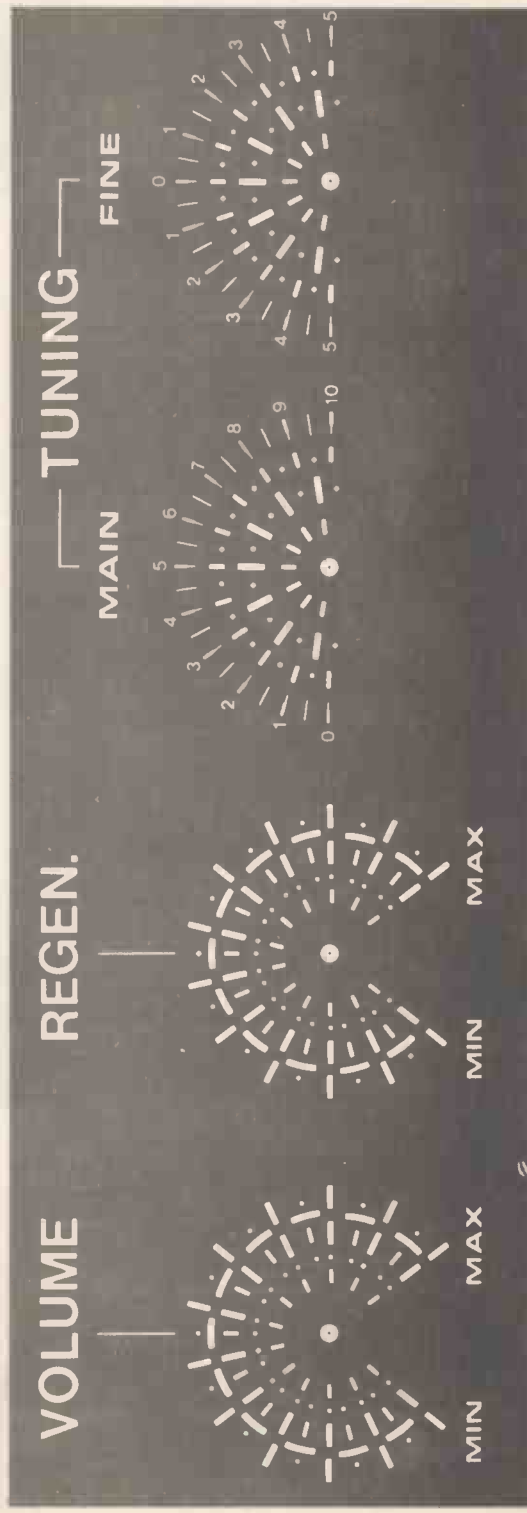
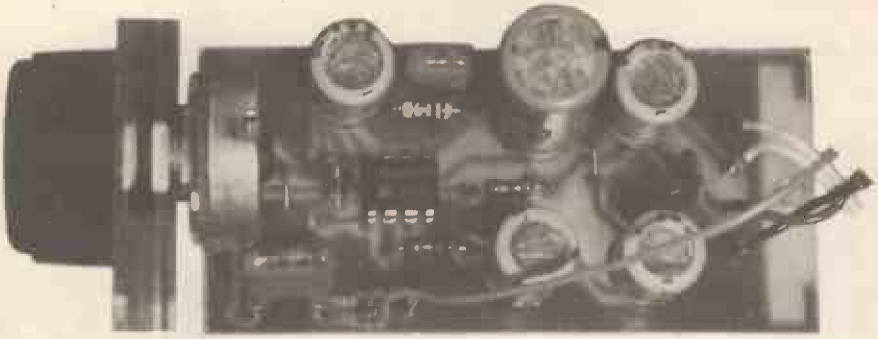


Fig. 4. Component layout and full-size printed circuit board foil master pattern for the amplifer stage.

Fig. 5 (right). The full-size front panel labelling can be cut out or photocopied and fixed to the case as shown in the photographs.





shown if the specified components are used. Other capacitors may have totally different connections and so should be wired accordingly. The specified capacitor is of the type that has two a.m. sections of approximately 250p each and two f.m. sections of 30p each. One section of each type is used on the prototype, but it may be better to use both a.m. sections in parallel to extend the low frequency coverage of each band.

Other tuning arrangements can be used instead of the ones shown, for example, an air-spaced capacitor with a reduction drive attached should give very good results, but would be quite a lot more expensive. As the "common" terminal of the tuning capacitors are connected to the chassis there is no difficulty in using standard metal types.

The antenna socket is wired directly to one pin of SK3 using the same solid core wire formed to run along close to the chassis.

COIL ASSEMBLY

The miniature tuning coils used in the circuit have been chosen for their excellent performance and low price. The penalty of using them is that a special socket arrangement must be adopted for them as shown in Fig. 7. This has been done by using "standard" 5 pin DIN audio plugs and sockets. The type of plug must be the one that has a removable plastic "insert" into which the pins are moulded. Apart from the insert, the rest of the plug is discarded.

Each coil should be fitted with a 50mm length of thin (28s.w.g.) tinned wire soldered to each pin. The wires should then be carefully formed so that they will pass easily into the rear of the DIN plugs and cut so that 5mm of each wire will be inside each hollow pin of the plug. At this point the assembly is quite rigid and the wire to each socket pin can be soldered into place. An additional small link from the screening can to the earth pin should be made as shown in Fig. 7.

In the prototype the coils were protected by lengths of insulating tubing pushed over the plug inserts which had been thickened by wrapping them with p.v.c. tape. This gives the coils excellent appearance but is not strictly necessary.

OPERATION

Once the coils are complete the circuit can be tested by plugging in the middle range coil, attaching about 30 feet of aerial wire and switching on. Set VR1 to minimum and VR3 mid-way. VR2 should be set two thirds of a turn clockwise as mentioned earlier.

If all is well it should be possible to pick up a few strong stations somewhere within the range of C3. Once a station is heard, advance the setting of VR1. The signal should become louder as VR1 is advanced until at a certain point distortion begins to occur and a whistle becomes audible. Reduce the setting of VR1 so that the best possible position is obtained and then rotate C4 to see if other stations can be heard.

With a good aerial and provided there are not too many interference sources (lamp dimmers, TV sets, fluorescent lights) dozens of stations will be heard.

Each time the Main tuning control is rotated the Regeneration control will have to be re-adjusted for the optimum position. It would be nice if a single setting for regeneration would cover the whole band, however this is impossible because of the varying impedance of the coil, the aerial, and the tuning capacitors themselves. If there is insufficient regeneration an extra twist on C2 may be required.

Once the circuit is operating with one coil try plugging in the other coils and tuning through the range. Note that because of propagation effects some parts of the shortwave bands will be completely silent at some times of the day and extremely busy during others.

When all ranges are working the effect of advancing VR2 can be tried. There will be an optimum position for C2, VR2 and VR1 for each station but as this is impractical it is best to set VR2 and C2 for good all round performance and do the fine adjustments with VR1. On some ranges adding a 470 ohm resistor in series with the aerial was found to improve reception of weaker stations.

The calibration of the radio is left to the user. The "log" scales on the tuning knobs enable dial setting to be repeated so that known stations can be found again. A chart of scale settings, station names, times of day, and frequencies will soon be built up as time is spent listening. The author was quite fascinated by the number of interesting stations that can be heard throughout the day. It is very interesting to compare the Russian news programmes (in English) with the American ones.

Whilst testing the prototype the author was rather intrigued when a telephone dialling sound was heard at about 4MHz. It soon became apparent that this was the cordless telephone of someone living about 200 metres away. Both sides of the conversation could be heard very clearly. So much for privacy!

EXPERIMENTS

Finally, for those who become really keen on radio, there is no reason why home-made coils should not be used with the radio. Varying the numbers of turns, the aerial coupling, and the position of the coil tapping can be very interesting and produce rewarding results. □

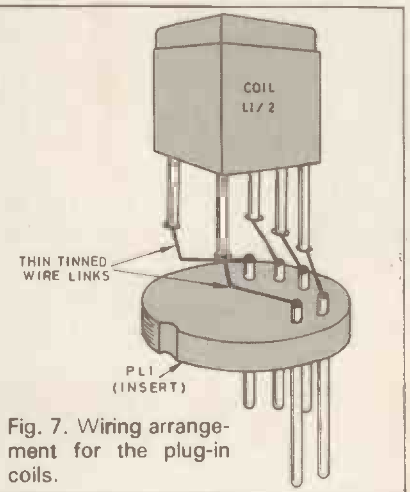
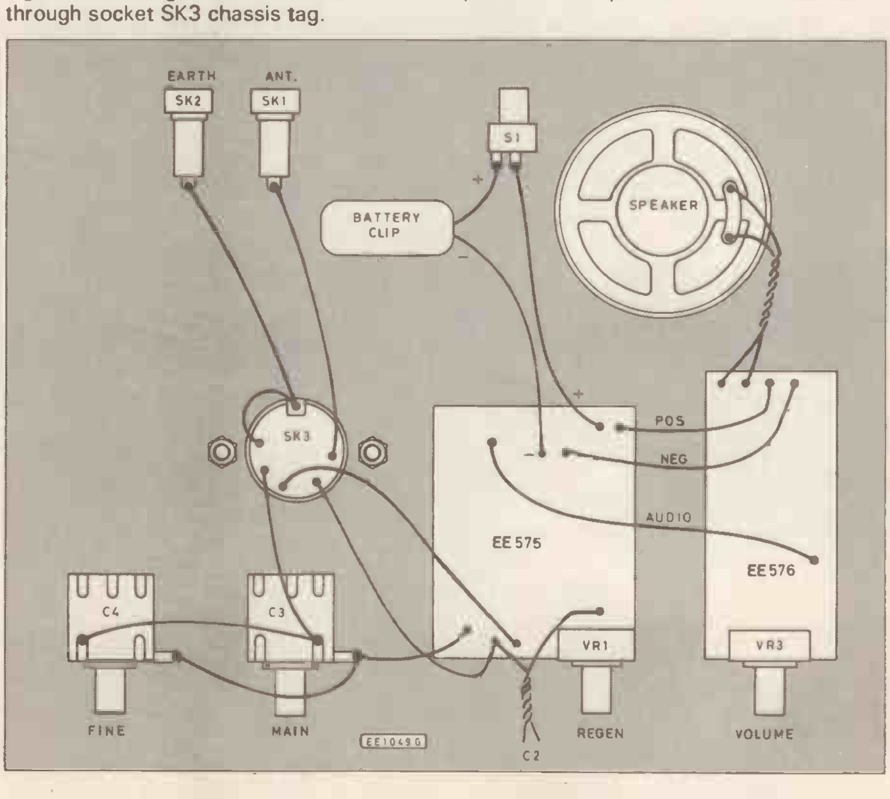


Fig. 7. Wiring arrangement for the plug-in coils.

Fig. 6. Interwiring details for the off-board components. Note pin 4 of coil L1 is "earthed" through socket SK3 chassis tag.



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33µF16V	0.05
47µF35V	0.10
100µF25V	0.07
100µF50V	0.17
330µF16V	0.12
470µF10V-A	0.30
470µF50V	0.30
1000µF10V	0.15
2200µF16V	0.30
4700µF25V	1.58

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470µF250V	5.70
470µF385V	9.42
4700µF63V	6.27
*5500µF40V	5.25
10000µF40V	3.12
DISC CERAMIC	
47pF63V	0.03
120pF63V	0.05
100pF50V	0.03
1000pF63V	0.02
2200pF63V	0.03
4700pF63V	0.04
0.047µF50V	0.04
0.1µF25V	0.05
0.1µF63V	0.14
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47pF-2700pF	0.10
TANTALUM	
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6.8µF10V	0.12
10µF10V	0.10
10µF16V	0.13
22µF16V	0.21
33µF16V	0.32
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Actually Doing it!!

THE HOBBY of electronics perhaps tends to conjure up visions of workbenches covered with high technology equipment and "state of the art" components. This is certainly one aspect of the hobby, but there is also the so called "nuts and bolts" side of things, where the hobbyist is literally dealing with nuts and bolts, plus other quite mundane mechanical components and tools. If you wish to become proficient at electronics construction the ability to undertake the mechanical side of construction is just as important as being competent at dealing with the electronics.

It would be easy to become condescending about the mechanical aspect of construction, and the low technology tools involved. Unless you are particularly skilled at this type of thing it would be a mistake though, and unless due care and attention is paid to this part of construction the result is likely to be a very shabby looking project which will almost certainly be awkward to use.

A great deal of thought and effort goes into the mechanical design of commercially produced electronic devices so that they are pleasant to use and can be serviced easily if necessary. The home constructor needs to take this aspect of construction equally seriously.

LAYOUTS

If you are building a project featured in *Everyday Electronics* you should be able to see from the photographs and diagrams the general layout used on the prototype, and it is generally best not to use a layout which is radically different to this. The layout used for the prototype will generally be one which is neat looking, but is also practical as far as constructing and using the project are concerned.

It is not normal practice these days for constructional details to include precise details of front panel layouts etc. There are exceptions, but in most cases there would be no point as few constructors use exactly the same case and components as those used in the prototype project. For example, two mains transformers with the same ratings can be quite different sizes and shapes, and a layout that is suitable for one might be completely useless for another. With something like a front panel layout, a design which looks neat with one set of control knobs could look decidedly odd with knobs of a different style.

When designing the general layout of a project it is necessary to arrange the components so that the controls and sockets are sensibly positioned, and (say) when a plug is fitted into a socket it will not make it virtually impossible to adjust one of the control knobs. On the other hand, the layout should be such that there is not a lot of "spaghetti" wiring trailing all over the place. The layout should be such that the wiring is, as far as possible, short and direct with as little crossing over as possible. This is not just a matter of making the finished construction look as neat as possible.

Wires running all over the project makes error-free construction relatively difficult, and corrections almost impossible. It is easy to end up correcting mistakes that are not there, and missing those that are.

Another factor to bear in mind is that this type of wiring tends to encourage stray coupling from one part of the circuit to another. This is not an important factor with many types of project, especially most digital types. However, with the more critical types of linear circuit it can be sufficient to prevent what is otherwise a perfectly satisfactory project from functioning correctly.

When deciding the positioning of components and space is at a premium, it is a good practice to put the components in position on the base panel or front panel to make sure that there is room for everything to fit together properly. Failing that, very careful measurements should be made.

Many modern cases helpfully have moulded-in mounting pillars for circuit boards, but in most instances they will not be used, and may well get in the way. They can usually be drilled out without too much difficulty, but be very careful not to penetrate the case too deeply.

FRONT PANEL LAYOUTS

With front panel layouts it is a good idea to position the control knobs on the panel so that you can get a good idea of exactly what the finished unit will look like. It also makes it easier to determine whether or not the intended layout enables the controls to be easily adjusted or if there is excessive cramping of the controls. With components such as switches and sockets the fixing nuts can be removed and positioned on the front panel to give a rough idea of what the final unit will look like.

Do not fall into the trap of working out a neat layout and then finding that there is insufficient space for all the components. The fact that there is enough space for the knobs and fixing nuts does not mean that there is enough space for the components themselves.

Once you have manoeuvred everything into the right position and you are satisfied with the layout, carefully measure the positions of everything and draw out a diagram showing their positions. This does not have to be very neat and a rough sketch is fine, but make sure that all the information you need is included, and check that none of the components have been accidentally omitted from the layout. Mistakes have to be sorted out at this stage—it will almost certainly be too late to make corrections once you have started drilling.

MARKING

With anodised aluminium front panels it is generally quite easy to mark the layout. Any pencil will do the job, and once the drilling has been completed any remaining marks are easily removed using an eraser.

Untreated aluminium panels and plastic panels are much more difficult, and certain types of fibre-tipped pen are about the only means of marking onto these clearly. This is not necessarily a good way of doing things though, since the lines may be quite broad which tends to limit the accuracy with which holes can be drilled. Also, there may be difficulty in removing any lines left once the drilling has been completed.

The use of fibre-tip pens with plastic cases is particularly dubious, as the spirit based inks used in some pens can actually attack the plastic. Pens with water based inks are safe, but are usually ineffective at marking onto plastic.

What is probably the best approach to the problem is to fix a piece of paper on the panel using double-sided adhesive tape. The panel layout can then be marked using a fine pencil, and once the drilling has been completed the paper and tape are easily removed. Once you have marked the layout it should be carefully checked before proceeding to drill the panel.

DRILLING

Most projects these days are quite small, and this tends to make any lack of accuracy in the positioning of front panel components quite conspicuous. In particular, with a row of control knobs it will be pretty obvious if they are not all at the same height or are unevenly spaced. Great care is therefore needed with the positioning and drilling of the components.

With a steel or aluminium front panel a centre punch should be used to make indentations which can be used to guide the point of the drill precisely into position. You may already have a suitable punch and a small hammer, but if not they are available from most do-it-yourself stores and even some of the larger electronic component retailers, and are quite inexpensive.

A centre punch can also be used quite successfully with plastic cases that are made from one of the softer, tougher plastics, or you might find the alternative of a bradawl easier. There used to be a large number of plastic cases available that were constructed from a fairly hard and brittle plastic, and these were quite difficult to deal with.

These seem to be something of a rarity these days, but with cases that are constructed from the harder plastics great care has to be taken when working on them. The centre punch method of making the indentations is out of the question as the most likely result would be the shattering of the panel. A bradawl used with moderate pressure is a more realistic way of doing things. The holes should be drilled carefully, again using only moderate pressure.

Ideally you should have a full range of drill sizes available, but for most purposes only four sizes are needed. A small drill of around 3·3 millimetres is needed for M3 or 6BA mounting bolts, a five millimetre type is needed for sub-miniature toggle switches, and a 6·3 millimetre drill bit is required for 3·5 millimetre jack sockets, certain other types of socket, and miniature toggle switches. Last but by no means least, a 10 millimetre diameter drill is needed for potentiometers, rotary switches, some variable capacitors, and some other components. You will certainly need other drill sizes, but you should make sure that you

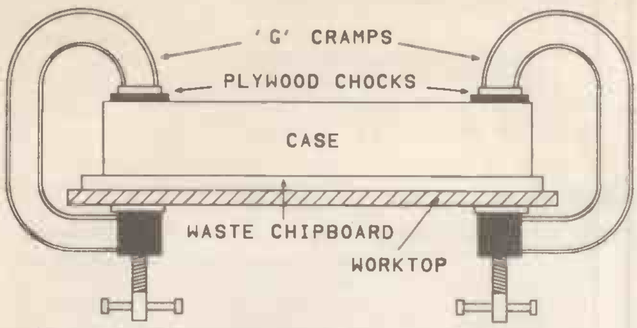

Fig. 1. Clamp the workpiece firmly before drilling.

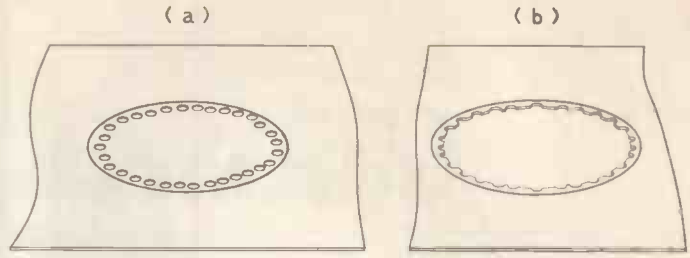

Fig. 2. A simple method of producing large cutouts by drilling a series of holes and breaking out the centre.

have these sizes from the outset as life is likely to be difficult without them.

It is best to start by drilling small guide holes about two millimetres in diameter, and to then drill out the holes full-size. Hand-held power drills are fine for the smaller holes, but they can be difficult to control properly when drilling the larger sizes (about six millimetres and upwards). The problem is caused by the relatively soft materials that are normally involved, especially some of the plastics. The drill bits tend to cut into them much too coarsely and this can give rather rough results. Power tools used in a proper stand are much better, but I find it easier to do most of the drilling using large hand-drill.

The case or panel must be firmly held in position, and there is a strong risk of damaging the panel and (or) yourself if it is not. The easiest solution to the problem is to enlist the help of someone to hold the case or panel steady while it is drilled, but there may not always be a willing helper available, and this can be a little impractical with small workpieces anyway. A large vice or a vice-type workbench can be used to hold the workpiece in position, but take care not to clamp it in place so tightly that it sustains damage.

"G" clamps (or the modern equivalent of "crab" clamps) are useful for fixing the workpiece to a worktop, with a set-up of the type shown in Fig. 1. The two small pieces of plywood help to spread the load and prevent damage to the workpiece. The use of two clamps rather than a single one is preferable, as a single clamp is unlikely to keep things firmly in place. The workpiece would tend to pivot around the point at which it was clamped. It is important to use a piece of scrap chipboard or plywood under the workpiece to protect the worktop. Where possible, this piece of board should be immediately underneath the panel being drilled. This supports the panel and reduces the risk of it being seriously distorted, and it also helps to give good clean holes. A certain amount of deburring will still be needed, and this can be done using the appropriate tool, or a twist drill bit somewhat larger than the hole being deburred.

CUTOUTS

Large cutouts, as required for panel meters for example, represent one of the more awkward aspects of electronic construction. In the absence of any special tools for making these, probably the easiest method is to drill a series of small holes (around four millimetres in diameter) just inside the periphery of the required cutout, spacing the holes as closely as possible (Fig. 2a). Clearly mark the required cutout, and then use a centre punch to go around and mark the positions of the holes by eye. If the holes are drilled close enough together it might be possible to break out the central piece of metal, but if not the holes must be joined up using a miniature round file. This leaves a very rough looking cutout of the type shown in Fig. 2b. This may look beyond hope, but using a large round or half round file it takes surprisingly little time to smooth the rough edges and enlarge the hole to precisely the right size.

Although a circular cutout is shown in Fig. 2, this general method works well on any shape within reason. However, for good results to be obtained it is essential to take care not to stray over the wrong side of the line when drilling the holes, and to be meticulous with the final filing to shape.

Robert Penfold

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a regular feature for the Spectrum Owner...

by Mike Tooley BA

SEVERAL regular readers of this column have written to say that they would like to see more constructional projects suitable for beginners and those working on a restricted budget. This month, to redress the balance in favour of the more complex projects which we have been featuring lately, we have a very simple project for you in the form of a Five Channel Optically-Isolated Input Interface.

This versatile interface makes use of a Sinclair standard joystick port and thus requires an absolute minimum of circuitry. So if you have not tried one of our projects before, this one will get you started with minimal outlay and furthermore requires very little technical and programming knowledge to get going!

Before we start, and for the benefit of newcomers to *On Spec*, it is worth spending a few moments discussing the operation of the Sinclair joystick port.

Joystick Interface

The standard Spectrum joystick interface (and that fitted to Interface II and the Plus Two machine) corresponds to the so-called "Sinclair Interface II standard". This maps the joystick to a decimal input port address of 61438 (EFFE hexadecimal).

The joystick functions (left, right, up, down and fire) are made to correspond to the upper right section of the Spectrum's keyboard on the following basis:

Joystick Function	Corresponding Key
Left	6
Right	7
Down	8
Up	9
Fire	0

In terms of the data byte read from port address 61438, bits 0 to 4 correspond to *"fire", "up", "down", "right",* and *"left"* respectively. Readers who do not possess a Sinclair standard joystick interface and would like to construct their own, may like to know that we featured the construction of such a device in the August 1985 instalment of *On Spec*.

FIVE-BIT INPUT INTERFACE

Besides its obvious application as a games controller, the standard joystick interface may also be used to provide a digital input; the switch contacts of a joystick are simply replaced by suitable electronic switching devices. It is thus possible to have up to five one-bit digital inputs connected to the port.

The ideal switching device for this application is an opto-isolator; such a device will not only provide electrical isolation between the sensing transducers and the Spectrum but will also interface very neatly with the keyboard circuitry.

The complete circuit of our Five-bit Input Interface is shown in Fig. 1. Each input is connected via a standard single-transistor opto-isolator (Fig. 2) which provides electrical isolation of each input from every other and from the Spectrum's own circuitry. This is a useful facility particularly where input sensors are connected to items of equipment which may operate from different supply rails (it is not necessary to have any "common" connection between the input circuitry and the Spectrum).

The inputs to IC1 to IC5 can range from between 3V and 24V depending upon the value of series current limiting resistor, R1 to R5, which can be selected from the table below:

Input voltage	Resistance value
3V to 5V	270 ohm
5V to 8V	560 ohm
8V to 12V	1 kohm
12V to 17V	1·5 kohm
17V to 24V	2·2 kohm

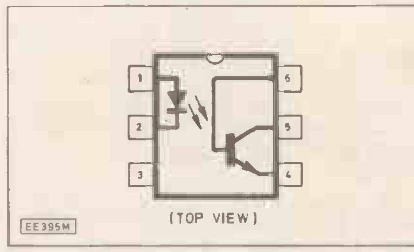


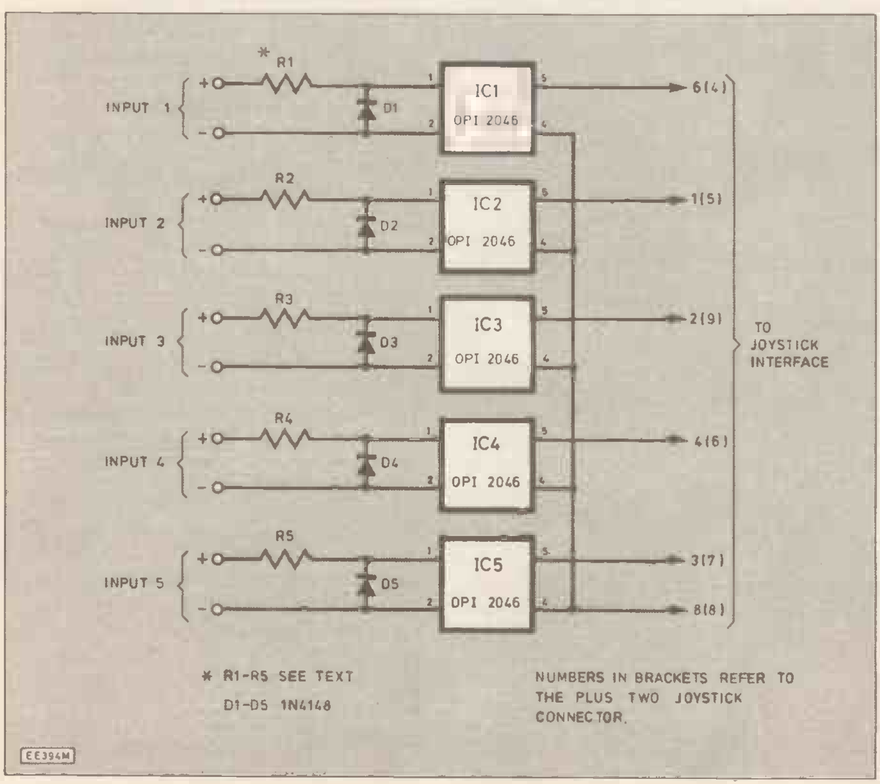
Fig. 2. Pin-out details for the single transistor opto-isolators.

Construction

The Five-bit Input Interface may be assembled on a piece of Veroboard measuring approximately 50mm × 100mm. The precise dimensions of the board are unimportant as long as it can accommodate five 8-pin DIL sockets and associated wiring.

Component layout is not critical though readers may wish to carry out the exercise on paper first (using, if desired, the layout sheet provided with our *On Spec Update*). Note that, even though the integrated circuits are 6-pin DIL devices, 8-pin sockets have been specified as these are inexpensive and readily available.

Fig. 1. Complete circuit diagram of the Five-bit Input Interface.



COMPONENTS

Resistors

R1 to R5 (see text)

Semiconductors

IC1 to IC5 OPI 2046 single transistor opto-isolator

Miscellaneous

9-way D-type female connector; 8-way low profile DIL sockets (5 off); terminal pins or connectors; 0.1in matrix stripboard approx. 50mm × 100mm; connecting wire and solder etc.

Approx. cost Guidance only £4.00

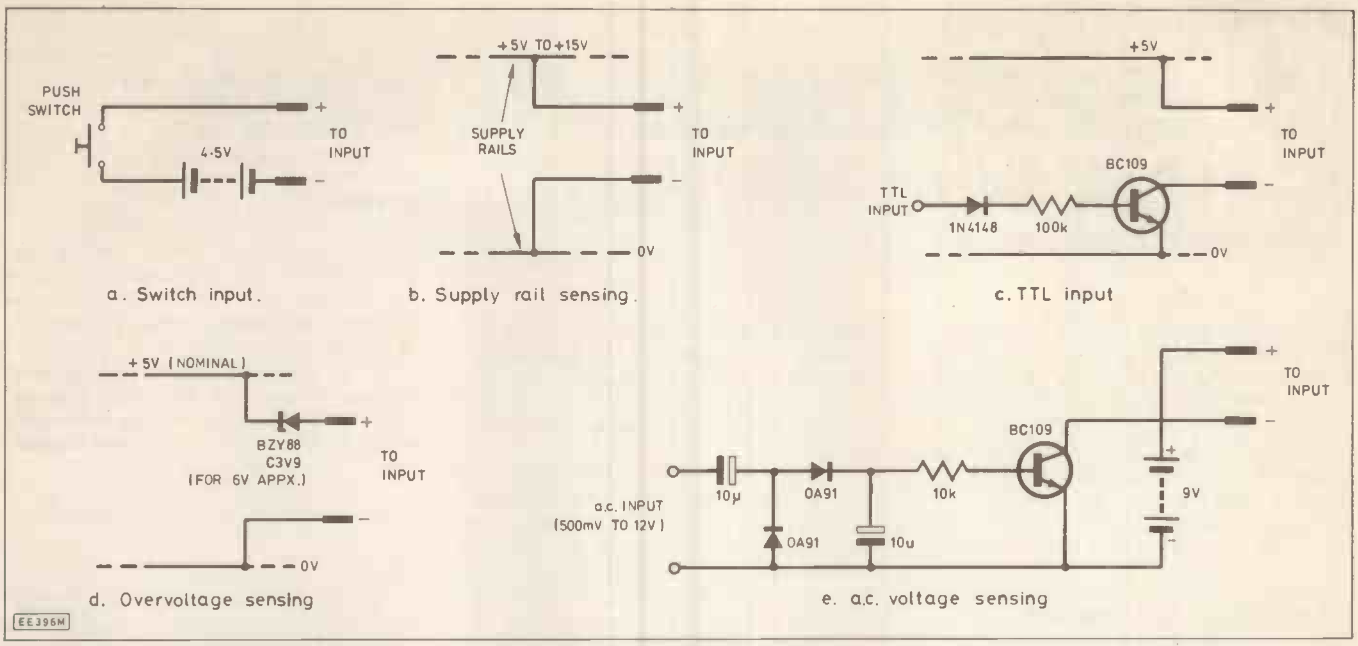


Fig. 3. Some suggested applications for the Five-bit Input Interface, including supply rail and switch state sensing.

After mounting the five i.c. sockets care must be taken to ensure that all copper tracks on the underside of the board are cut as required. A purpose designed "spot-face" cutter is ideal for this purpose or, if such a tool is not obtainable, a small sharp drill bit may be used.

The resistors and terminal pins or connectors should then be fitted to the board. When the stripboard wiring has been completed, the opto-isolators should be inserted into their sockets (taking care to ensure correct orientation of each device) and the five output lines (plus common) connected to a female 9-way D-type joystick connector using a short length of multi-core or ribbon cable (see last month's *On Spec* for further details of the joystick connector).

Finally, the entire board and wiring should be very carefully checked before attempting to connect it to the Spectrum or connecting any of the input transducers. Various applications for the interface, including sensing the state of switches and supply rails are shown in Fig. 3.

Testing the Interface

The following BASIC program can be used for testing the simple input interface:

```
10 LET x = IN 61438
20 PRINT AT 0,0; x
30 GO TO 10
```

The values returned by the program and printed in the top left hand corner of the screen reflect the state of the five inputs as shown below (note that keys "6" to "0" may be used to simulate inputs):

Input Active	Binary Weight	Corresponding Key	Value returned
none	0	none	191
1	1	0	190
2	2	9	189
3	4	8	187
4	8	7	183
5	16	6	175

When more than one input is active at a time, it is possible to determine the data returned from IN 61438 by adding together the respective binary weightings and subtracting the result from 191. Let's suppose that inputs 1, 3 and 5 are all active simultaneously. Adding their respective binary weightings gives 21 (1 + 4 + 16). The data returned will thus be 170. This condition may be simulated by simply holding down the "6", "8" and "0" keys—try it and see!

The state of the inputs can be more easily recognised using a binary representation of the data present at port 61438. The following program allows readers to display the individual data bits:

```
10 LET x = IN 61438
20 GOSUB 900
30 PRINT AT 0,0; a$
40 GO TO 10
900 REM Decimal to binary conversion
910 LET a$=""
920 IF INT(x/2)= x/2 THEN GO TO 970
930 LET a$="1" + a$
940 LET x = x - 1
950 IF x=0 THEN RETURN
960 GO TO 980
970 LET a$="0" + a$
980 LET x= x/2
990 GO TO 920
```

If the method of determining which inputs are active seems rather cumbersome don't panic. With the aid of a little machine code, there are some much more elegant solutions as we shall show next month!

Points from the Post

Finally, there's just time to mention two letters from readers. Ian Jones writes from Tyne and Wear to say that he is trying to establish a "User Domain Resource Centre" for the *Jupiter Ace* computer. He hopes to be able to distribute ideas for software and hardware projects and generally promote continued use of the Ace. Ian can be contacted at: ***21 Dene Street, Pallion, Sunderland, Tyne and Wear, SR4 6JB.***

William Ogilvie writes from Maidstone to issue a timely warning for those constructing interface circuits using stripboard. He suggests that readers check that they are using a sufficiently large drill when making track cuts—if the drill is not large enough a small copper link can remain in place with fatal results!

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.

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

Next month: We shall be dealing with software for use with the Five-bit Optically Isolated input interface together with some signal conditioning circuits for light level and temperature sensing applications.

SPECDRUM REVIEW

By K. Lenton-Smith

KEYBOARD players owning a Spectrum which is gathering dust because the endless succession of space games has palled might consider using the computer as a drum machine. Cheetah Marketing are distributors for SpecDrum, which was briefly demonstrated on the BBC's Microlive program, and they describe it as the most exciting peripheral ever developed. For those interested in music, I would certainly agree.

In case SpecDrum is thought to be simply another rhythm unit, let me assure you that it is a very good drum machine for amateur or professional use. At this point it may be useful to define the essential differences between the two devices.

RHYTHM UNIT

Rhythm units are usually based on a ROM which triggers damped oscillators and white noise generators in a two-bar pattern according to a particular rhythm selected. Because the sequence is relatively short in musical terms, the repetitive nature of a rhythm unit is only too apparent to the listener. More advanced units allow the user to lengthen the sequence, possibly to 4 two-bar patterns, to relieve the montony.

The nature of the sounds from the individual instrument generators is often unrealistic. Also, I have the distinct impression that the designers of the chip that triggers the generators have greater electronic ability than musical experience. It would be better not to select any specific manufacturers device for the booby prize in this respect but I leave readers with practical experience to name their own pet hate! There is no doubt in my mind that many rhythm chips are distinctly boring after the first few minutes of use.

DRUM MACHINE

Drum machine systems are totally programmable, so the sequence of instrument sounds may be infinitely varied and chosen to fit a given piece of music precisely. The length of the composition written into the drum machine is limited only by the available memory. Boredom should not be a factor for these reasons and, if the end result is repetitive, the user only has himself to blame!

The quality of the various instruments is vastly improved as computer methods allow an alternative to damped oscillators. Sounds of acoustic (or electronic) percussion instruments can be stored in digital form and recreated through D to A conversion systems to produce a high degree of realism.

There is practically no limit to the patterns available and the way they can be sequenced. Indeed, it is possible to take a percussion score and write this into the drum machine, given appropriate instruments. Voices can usually be separated for multi-tracking and edited to suit the user.

SPECDRUM SYSTEM

The boxed SpecDrum kit contains a unit which fits to the expansion port at the back of the Spectrum computer, software for the programs and a comprehensive instruction manual.

The program itself is excellent and user-friendly. Quite obviously written by musical authors, it emanates from Wales—the Land of Song. Cost of the outfit is £29·95 and is considerably cheaper than a typical drum machine with far less memory available.

Software comprises the System program, Voice Kit, demonstration songs and two extra voices. Additional tapes which can be obtained for SpecDrum are the Latin Kit & Editor (a highly recommended extra) and Electro Kit & Editor. The Editor allows voices to be changed from one Kit to another and for the sound to be reversed.

Over 1000 programmed patterns can be stored and up to 64 of these can be sequenced in any order with repeating loops for each of the 16 songs the machine can hold, copy, save and load. Instrument sounds are digital and percussion parts may be written either in real time or into a screen display of bar lines. There is also a sync. tape facility.

Summarising its use, patterns are written into the machine (consisting of any desired number of bars), these are then filed and edited into a sequence to form one of the songs in the system.

VOICES

Eight digital voices are available at any time, though these may be changed and edited at will. They are indicated in the displayed bar lines in three channels:

	BASIC KIT	LATIN KIT
Channel 1	1 Kick Drum	1 Kick Drum
	2 Snare Drum	2 High Snare
Channel 2	3 High Tom	3 High Timbale
	4 Low Tom	4 Low Timbale
Channel 3	5 Cowbell	5 Hand Cowbell
	6 Hi Hat closed	6 Stick
	7 Hi Hat open	7 Cabasa
	8 Claps	8 Tambourine

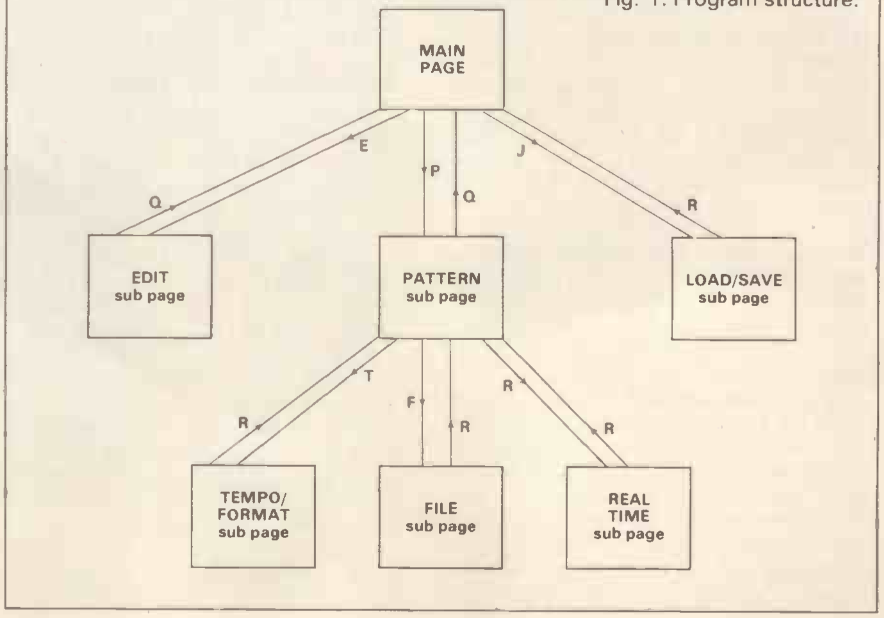
IN USE

The black box is fitted to the expansion port (before applying power) and its flying audio lead connected to an amplifier or keyboard instrument input. The System program is loaded, which in turn loads a Voice Kit, the MAIN PAGE finally appearing on screen. This offers various options—Choice of Song, Play, Tempo, Pattern, Load/Save, Edit, Copy, Delete and Synchro.

Before the program will accept any instruction, one of the 16 songs must be chosen from the displayed list and subdivision of each beat selected. The user can then move to the sub-pages—LOAD/SAVE, EDIT and PATTERN. The last of these has three further sub pages—TEMPO/FORMAT, FILE and REAL TIME. Fig. 1 shows the program structure.

Let us assume that a Samba song is needed for general rhythm or perhaps specifically to accompany a certain piece of music (the Latin Kit of voices is the obvious choice here). Having selected one of the (empty) songs from the list the number of subdivisions to each beat is chosen. A good starting point is 4 (semiquavers if each beat is assumed to be a crotchet) but, if triplets and semiquavers are required in this song, 12 will be the required figure (the lowest

Fig. 1. Program structure.



common multiple of 3 and 4). At this point the song can be given a name in the list.

The PATTERN page is selected next, and from there the TEMPO/FORMAT sub-page to allow the user to choose the number of beats in the bar and number of bars per pattern. Dave Brubeck fans will note that awkward time signatures such as 5/4 are no problem! Key K will automatically insert the Kick Drum on the first beat of the bar and key H the Hi Hat on each beat—as an aid to programming, if necessary.

After returning to the PATTERN page, lines of bar patterns are displayed with Kick Drum and Hi-Hat already present and the drum sounds (numbered 1–8) can now be inserted/deleted with the cursor at appropriate places in the bar. Extra beat divisions can be added or deleted if required: three lines of bars are shown and the user can scroll up or down through the bar sections. Pressing D will start the pattern playing (and space stops it), enabling the user to experiment until exactly the required rhythm has been found. A downbeat lamp appears on the screen at the start of each sequence of bars. Fig. 2 gives some idea of the screen display at this point:

The FILE sub-page allows each pattern created to be stored, retrieved or erased; there may be up to 64 of these for each song. Thus there are a number of possible variations on a main theme and, when a few patterns have been filed, returning to the MAIN PAGE allows the user to edit them.

EDIT is simply fitting the stored patterns, each of which may be looped up to 255 times, into a sequence. Of course, it helps to know something of percussion as the patterns can include drum breaks for insertion at given points in the sequence to simulate a live sideman. Indeed, it is possible to produce realistic side drum rolls, flams and paradiddles on this drum machine.

Having written the first song, there is still space for a further 15 to be added. Individual songs may be COPIED to another position in the list or DELETED completely. LOAD/SAVE allows any one or the complete set of songs to be taped. SAVE DUMP and LOAD DUMP handle their functions automatically for all 16 Songs. The LOAD/SAVE page also caters for loading voices, individually or as a kit of eight.

REAL TIME

Setting up rhythm patterns with the cursor is ideal for an experienced musician as, with headphones on and score alongside the monitor, music can be played mentally and the percussion part precisely arranged.

Alternatively, the REAL TIME sub-page allows the user to tap patterns into the keyboard. In this case, one of the instruments is selected and that particular sound written into the bar sections by pressing key 0 as the existing pattern is played; key 9 will erase any instrument in this mode. For those grappling with music, this may well be a better method but it will probably be necessary to tidy up the PATTERN page afterwards. It is not easy to be sufficiently accurate when hitting keys in real time, especially bearing in mind that each beat may have up to 32 subdivisions.

Used in the simplest way possible, an eight bar pattern can be set up and looped 255 times to form a song for each rhythm. By this method one could have something akin to a 16 pattern rhythm unit. At least the patterns are of your choosing, eight bars is long enough for the repetition to be unnoticeable and the sound is lifelike.

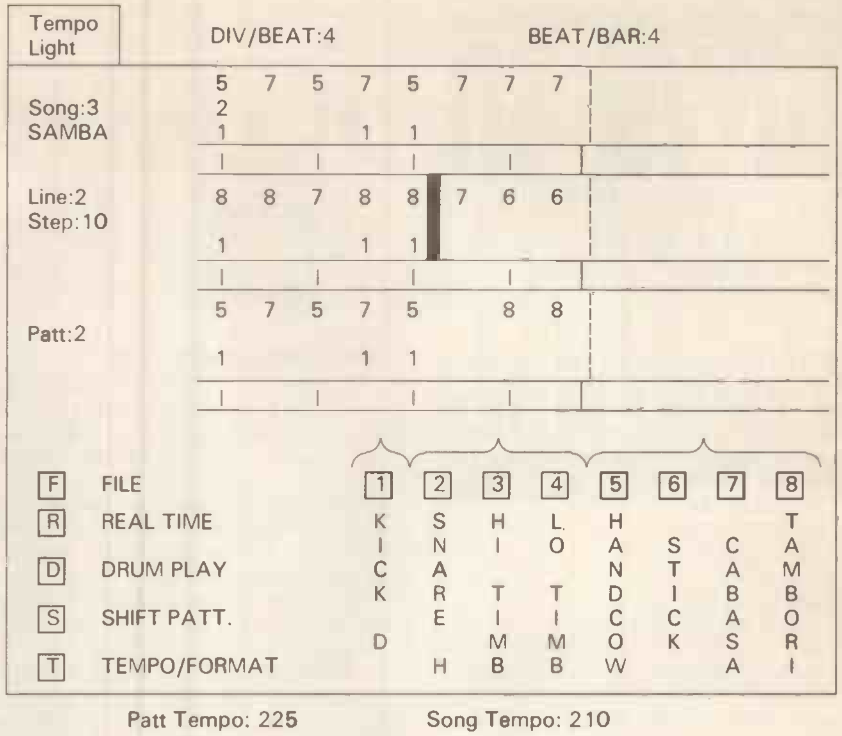


Fig. 2. Pattern page, showing first three bars of Song 3, a Samba. The central line is currently being entered, with cursor across all three channels at the tenth beat division (step) of that bar. Instruments are indicated in the lower part of the display according to the Kit loaded.

Of course, the drum machine is capable of very much more than this; a little patient experiment will pay handsomely—to the point that it is difficult to tell if a machine or human drummer is performing (either way, the drummer is human when you think about it!).

PROGRAMMING POINTS

The SpecDrum does not have separate outputs for each voice but they can be recorded individually using SYNCHRO if multi-tracking is envisaged. This puts sync. pulses onto tape: by copying a song several times and deleting all but one voice, various tracks can be brought together accurately.

If SpecDrum ties up a Spectrum that has other current uses, individual songs could be put onto a well logged audio tape and played through the amplification system instead of the original digital sounds. If a small amount of reverberation can be added to the percussion it often helps but this point is debatable.

Specdrum has a SHIFT facility which allows the complete pattern to be shifted to the left. This is worth mastering as it saves times when inserting Kick Drum and Hi-Hat in multi-bar sequences.

CONCLUSIONS

Are there any snags? A slight limitation is that the eight voices are written into the bars in three channels and no two instruments in the same channel can be sounded simultaneously. This problem can be surmounted by subdividing each beat into 16, say, and placing two same-channel sounds next to each other.

There is no brush sound among the voices available, which is a point that Cheetah is considering. There may be technical reasons for this as, although an Open Hi-Hat can be reproduced, I know that a crash cymbal voice is not possible on grounds of memory usage.

The authors of this program, P. Hennig and A. Pateman, have produced something quite absorbing for Spectrum owners with a musical inclination. It is not only useful in the practical sense but will teach even the most experienced musician to think again about timing.

SPECDRUM

The Specdrum is distributed by Cheetah Marketing Ltd., 1 Willowbrook Science Park, Crickhowell Road, St. Mellons, Cardiff. Tel: 0222 555525 (Telex: 497455). The program is stocked or available from computer stores.

Cheetah have also produced a similar version for the Amstrad 464, 664 and 6128 machines. This costs £34.95 and is called Amdrum.

DOWN TO EARTH

BY GEORGE HYLTON

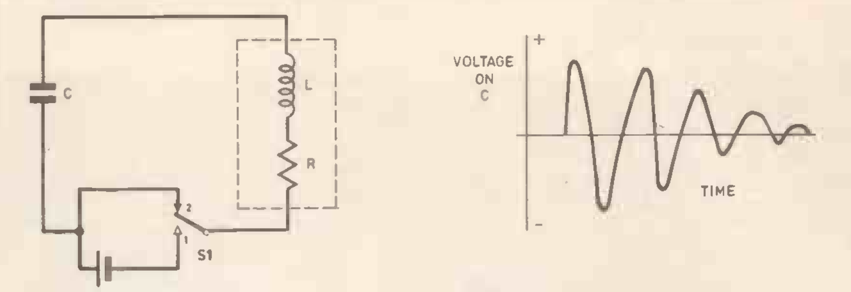


Fig. 1 Shock-exciting a tuned circuit.

TUNED CIRCUITS

ONE of the most important inventions in electronics is nowadays so familiar and ordinary that we don't often think of it as an invention. Tuning in a radio or TV is just something we do. It's a chore, a nuisance that we want to avoid doing, if possible, by making it automatic or push-button controlled. Yet tuning had to be invented. The very earliest transmitters sent out, not specific frequencies but broad-band noise, often made by sparks. The early receivers were likewise broad-band devices.

INTERFERENCE

So long as radio transmitters were few and far between this didn't much matter. But when two broad-band transmitters were operated close together the risk of interference was obvious. Tuning provided a means of sharing out the radio spectrum so that interference was reduced. It also turned out that tuning can increase efficiency at the transmitter.

The Marconi company, in its pioneering days, exploited this new technology. A famous cartoon in Punch, drawn to honour Marconi as the provider of life-saving marine radio, depicts an installation with several tuning devices.

THE PENDULUM ANALOGY

If you make a pendulum by hanging a weight by a thread you find that the number of to-and-fro swings per minute is constant. It's the same whether the swing is large or small. To change the rate you must alter the length of the string.

I fancy that the pioneers of tuning were familiar with the behaviour of pendulums and saw that the combinations of inductance and capacitance in what we know now as tuned circuits acted as the electrical equivalents of pendulums. Capacitance and inductance, when turned into their physical counterparts, capacitors and inductors (condensers and coils, in Marconi's day) are energy-storage devices. A capacitor stores energy as an electric charge. An inductor stores it as a magnetic field, the field created when a current flows through the coil wire.

These are two quite different ways of storing energy. The analogy with the pendulum arises because it, too, stores energy—it goes on swinging after the initial push—and it stores it in two ways. When the weight is at its highest point and about to swing back it must be static for an instant. At such moments stored energy is potential energy. This potential energy is expended in the down-swing, which accelerates the weight. Maximum speed is reached at the bottom of the swing. At this point the energy has all been converted into a different sort of energy, kinetic energy, the energy of motion. This enables the weight to climb up, against gravity, until it reaches the other end of its swing, at which point the energy is all potential again. And so on, for ever and ever, if there were no friction or air resistance to absorb some of the energy of movement. The swings, because of this loss of energy, get progressively smaller, unless you give the weight another push.

TUNED CIRCUIT

In a circuit like Fig. 1, the energy source is the battery. When the switch S1 is moved to position 1, current flows to charge the capacitor C. It has to pass through the coil L and in the process some energy is absorbed by the coil's resistance, R. But eventually C becomes charged to the battery voltage. If S1 is now put to position 2, the battery is disconnected and the charge stored in C as potential energy is enabled to be expended in driving current through L and R.

Inductance in a circuit always tries to oppose any change in current. In this case it tries to oppose the discharge of C. The effect is to prevent the maximum possible current from flowing immediately. Instead, the current rises gradually, and so of course does the magnetic field of the coil. In time, as C discharges, it can no longer sustain the supply of current. But by now, L has built up its magnetic field to a maximum. As the field collapses it induces a voltage in L. This voltage drives a current round the circuit but in the opposite direction, charging C with a reverse voltage. In time, the energy in L can no longer sustain this current and C discharges again, and so on. The current oscillates this way and that, diminishing a little each time as some of the energy is converted by R into heat and lost.

When the charge on C is maximum the field of L is minimum, and vice versa. In terms of the pendulum, the charge represents potential energy and the field kinetic energy. The frequency of the oscillations in current depends on the energy storing abilities of both L and C, hence if either is made larger the frequency diminishes.

RESONANT FREQUENCIES

The rate of current oscillation in Fig. 1 is called the *natural frequency*, because it's the frequency produced when the circuit is allowed to behave as it wants to. If instead of a battery the circuit were energised by the sparks of a spark transmitter each one would kick it into oscillation and the frequency would be the frequency of the transmission.

At the receiver, however, a tuned circuit is energised by incoming signals whose frequencies are set at the transmitter. So we are interested not just in the natural frequency but in what happens at other frequencies besides. To explore this, in a modern laboratory, you can use a signal generator to make signals of constant amplitude but variable frequency, apply these to a tuned circuit and see how it responds.

However, the pendulum analogy tells what to expect. I find it easier, in this case, to think of a special form of pendulum—a swing. If you are the passenger on a swing, and there's nobody to push, so you have to keep it going by your own efforts, then you have to make the appropriate movements—kick your legs, say—at just the right instants. Then, if your timing is exactly right, you can build up the amplitude of the swinging. Or, if you are swinging high enough for your taste, you can keep the movement going by working just hard enough to compensate for the frictional losses. On the other hand, if your timing is less accurate you have to work harder to keep the swing going. If the timing is very bad you may even stop it.

Evidently the oscillation of the swing is sustained most by timing your movements to assist its natural oscillation frequency. This suggests that when a tuned circuit is forced into oscillation by applying a signal, the amplitude will be greatest when the signal is at the natural frequency. Let's get out a signal generator and see.

When you do this, you discover two things. First, the impedance of the circuit varies strongly with frequency. And secondly, the way in which it varies depends on how the coil and capacitor are connected together. When connected in series the impedance, Z, varies with frequency as shown in Fig. 2. At one frequency, which is often called f_o, the impedance falls to a minimum. It turns out that this impedance is a resistance, and that this resistance is R, the coil resistance. This frequency is sometimes referred to as the Resonant Frequency and called f_r.

With parallel connection of coil and capacitor, the impedance varies as in Fig. 3. Here there is a maximum at f_o. This is the opposite from the series case and for this reason the parallel connection variety of f_o is sometimes called the anti-resonant frequency and labelled f_a. These labels, f_a and f_r are often used to describe quartz crystals, which exhibit both series and parallel resonance.

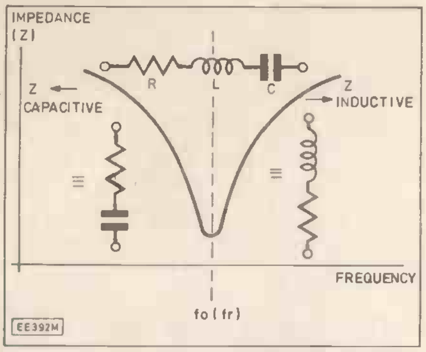


Fig. 2 Impedance (Z) versus frequency for a series-tuned circuit.

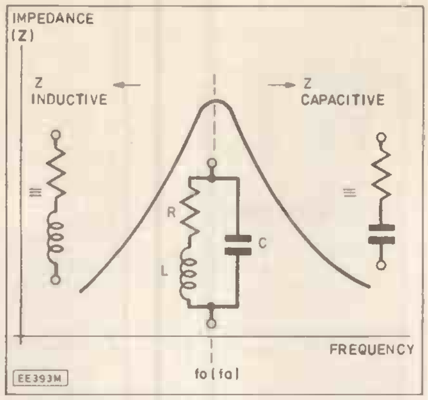


Fig. 3 Impedance (Z) versus frequency for a parallel-tuned circuit.

It turns out that for the same coil and capacitor f_o is nearly the same for either connection, with coils whose resistance R is low. One odd feature of the parallel tuned circuit (odd at first sight, anyway) is that as R is increased the peak impedance is reduced. The pendulum analogy helps here, by comparing R with friction and air drag (which is a form of friction anyway). The lower the friction, or R, the greater the ability to free-run at the natural frequency.

This ability is often expressed as a number which is the ratio of the energy stored to the energy lost in R or friction, averaged over a whole number of cycles of oscillation. This number is labelled by the letter, Q.

For the sort of circuits used for tuning radios, Q is typically of the order of 100. For a good pendulum it's much higher, and for quartz crystal resonators it may be as high as a million. Q is short for Quality factor.

At f_o, the tuned circuit behaves like a pure resistance. At other frequencies it behaves like a combination of resistance and capacitance or resistance and inductance. Which? That depends on which side of f_o you are, and on whether the tuned circuit is made by series or parallel connection of coil and capacitor.

In radios, parallel-tuned circuits are the norm because they are easier to use, but series tuning is employed in some other kinds of equipment.

FOR YOUR ENTERTAINMENT

BY BARRY FOX

On ICE

Surely the best, or more accurately worst, example of non-standardisation in the electronics industry is to be found in the field of in-car entertainment (ICE). Anyone who has tried to fit a stereo system to a car, or replace one of the crutty systems which car manufacturers insist on supplying, will know what I mean.

Business is now so bad for some of the big names in Japanese hi fi and video, that they are quite literally surviving on sales of ICE gear. To increase those sales, they go to quite extraordinary lengths to ensure that equipment for one manufacturer will not work with equipment from another. They want you to buy *their* radio/cassette player, *their* amplifier and *their* equaliser.

This isn't just a case of deliberate physical miss-match between leads, plugs and sockets; ICE equipment from different manufacturers will often miss-match electrically—and, with a bit of bad luck for the DIY fitter, self destruct.

One small British company Kob Audio of Burnham, Bucks, is now making a healthy living out of selling connector leads and interface boxes (under the brand name Audiolinx) which bridge the artificial gaps created by the manufacturers—for instance so that a Pioneer radio will work with a Trio-Kenwood amplifier or a Panasonic will work with an Alpine or a Blaupunkt with a Kenwood and so on. For the uninitiated, here are a few basic ground rules.

Budget or "regular" ICE systems centre on a combined amplifier, radio and cassette player. Power output is less than 10 watts per channel.

Recently, there has been a trend towards so-called "high power" units. These also combine an amplifier with radio tuner and cassette player, but use BTL output stages to give up to 25W per channel. BTL stands for Balanced TransformerLess.

Both halves of the audio sine wave are amplified in opposite phase. This doubles the effective power available from a 12V supply. Distortion goes up to 10 per cent at 25W but it's a cheap compromise.

At the top end of the price and power scale, a "component" system has a radio tuner and cassette deck (perhaps with compact disc player), feeding a low level line output to a separate amplifier, often via a separate equaliser. Buying separate components from separate manufacturers is a nightmare because of their deliberate miss-matching tricks. It's usually better to admit defeat and stick with one brand. But if you end up with different brands, try Audiolinx for a tailored interface.

Most new cars are sold with a low power "regular" system and budget loudspeakers already installed. Power can be increased by feeding the loudspeaker outputs to a booster amplifier, sometimes combined with a graphic equaliser. This works like a very flexible tone control, to boost some frequency bands more than others.

Adding a booster amp will crank up the power, but this can burn out the speakers. Replacing the speakers with something better is thus essential if you use a booster.

Conversely, using a booster is essential if you upgrade the speakers. This is because better loudspeakers will usually be less efficient at converting electrical energy into sound. So you will also need to increase the power supplied from the amplifier.

Pitfalls

So, on the face of things, buying a booster amp sounds like a neat idea. But be warned, there are very real electrical pitfalls.

Most low cost boosters are designed to work only with a budget amp which has a common negative on the loudspeaker outputs. But there may be no warning of this. If you connect one of these boosters to a car stereo which has a BTL output stage, which by virtue of its design cannot have a common negative, then you will short the amp outputs down to chassis and risk burning out its output i.c.s.

As if to confuse the issue, the booster may well have a quite different warning; don't connect its outputs to a loudspeaker system which has a common or grounded negative return. The booster is liable to self destruct if you do.

In short, many low cost boosters will only work with a car stereo amplifier which has a common negative for its loudspeaker outputs and with a loudspeaker system which does not have a common negative. The instruction books don't seem capable of saying this clearly.

Beware the temptation to create an artificial common negative at the amplifier output, by joining the two negatives of a BTL amp output. This will "ground" the amp's output i.c.s and blow them.

Some higher priced booster-equalisers, for instance the Clarion 280 EQB, have an adjustment which can be set for use with either a common negative or separate negative amplifier. But what do you do if you have been sold a booster which works only with a common negative amp, and your amp does not have a common negative?

There is one possible way out. Try connecting only the positive output wires of the amplifier to the booster, thereby letting the negative circuits find their own return path through the vehicle chassis. Just leave the negative output wires dangling free (be sure to cover any bare wires, of course). The booster will now be taking 6V d.c. as well as the audio signal at its inputs, but the decoupling capacitors at the booster input will *probably* be able to cope.

Expensive Smoke

Finally, as a general tip, don't be tempted to run two pairs of loudspeakers in parallel off an amplifier designed to serve only one pair. Paralleling the pair will reduce impedance from 4 ohms to 2 ohms and this may well overheat and destroy the output i.c.s.

So it goes on, and on, and on. Unless you really know what you are doing, beware the mix and match approach for ICE. Or take advice from a specialist firm like Audiolinx. Trial and error is likely to generate what the trade cheerfully calls "expensive smoke".

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