EVERYDAY ELECTRONICS

JUNE 1987

INCORPORATING ELECTRONICS MONTHLY

£1·20

VISUAL Guitar/ Instrument TUNER

RS232 BREAKOUT BOX

Door Chime · Mini Disco Light

EXPLORING ELECTRONICS...SIMPLE TOUCH SWITCH

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 ⅜" 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 reed relay kits 3V coil normally open or c/o if magnets added
146. 20 – pilot bulbs 6.5V.3A Philips
154. 1 – 12V drip proof relay – ideal for car jobs
155. 3 – varicap push button tuners with knobs
169. 4 – short wave air spaced trimmers 2-30f
172. 10 – 12V 6W bulbs Philips m.e.s.
178. 3 – oblong amber indicators with lilliputs 12V
180. 6 – round amber indicators with neons 240V
181. 100 – p.v.c. grommets ⅜ hole size
182. 1 – short wave tuning condenser 50 pf with ¼" spindle
186. 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

POWERFUL MOTOR (2 in. stack) fitted with gearbox with final speed 60 r.p.m. Mains operated. Suitable to operate garage doors etc. Price £4.00. Our ref. 4P15.

CAR STARTER/CHARGER KIT

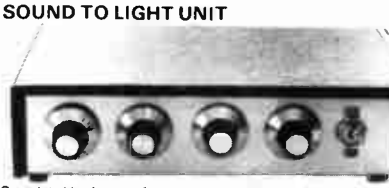
Flat Battery! Don't worry you will start your car in a few minutes with this unit – 250 watt transformer 20 amp rectifiers, case and all parts with data £17.50 post £2.

Ex-Electricity Board. Guaranteed 12 months.

VENNER TIME SWITCH

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

SOUND TO LIGHT UNIT



Complete kit of parts of a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two tone metal case and has controls for each channel, and a master on/off. The audio input and output are by 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.

12 volt MOTOR BY SMITHS

Made for use in cars, etc. these are very powerful and easily reversible. Size 3½" long by 3" dia. They have a good length of ¼" spindle –
1/10 hp £3.45
1/8 hp £5.75. 1/6 hp £7.50

25A ELECTRICAL PROGRAMMER

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

THIS MONTH'S SNIP

3" floppy disc drive unit plug in and with all electronics. Japanese made, brand new. We are told that this is suitable for use with the BBC, Commodore, Amstrad and most other popular computers, and we supply with technical information. Special snip price £29.50 including post and VAT.

12V BATTERY OPERATED SIREN

(Or you can work this off a 24V transformer). Makes a shocking noise, will frighten away any intruder. Japanese made one 50p each, 2 for £1, ref RD106. American, storage soiled but unused and guaranteed perfect, only 20p each, 5 for £1, ref BD221.

WONDERFUL BREAKDOWN VALUE – HAND HELD STEREO UNIT

Contains two beautiful miniature moving coil loud speakers. These could also be used as microphones, also contains many other useful parts including mini stereo amp, transistors, condensors, rocker switches etc. etc. To use this as a personal amplifier simply add a stethoset, only £1, ref BD29.

SPIT MOTOR

Powerful mains operated induction motor with gearbox attached. Shaft has square hole which gives very easy coupling and quick release if required. Shaft speed 5rpm. Price £5, ref 5P54.

NICKEL CADMIUM RECHARGEABLE BATTERY

The high capacity (4 Amp-hour) 'D'-size. £2 each. Our ref 2P141.

20V–0–20V 1A MAINS TRANSFORMER

Upright mounting. Primary thermal cutout to interrupt the supply if transformer overheats. Price £2, ref 2P138.

4 BOOKS FOR £1

Book 1 describes the Mullard Unilex amplifier and gives details of a suitable cabinet. Book 2 describes several useful pieces of test equipment which could be quite easily constructed. Book 3 is electronic projects. Book 4 describes short wave receivers which can be easily constructed and is intended for mainly beginners. Our ref BD400.

TRANSFORMER IN WATERPROOF METAL CASE

24V 5A output. Ideal for garden lighting or to operate pond pump etc. Case has cable glands for mains in and low voltage output leads. Price £5 plus £1 post, ref 5P88.

MAINS RELAY

With transparent plastic cover. Could be pcb or clip mounted, has single 8–10A c/o contact. Real bargain 2 for £1, ref BD486.

PANEL METERS

Engraved vu, approximately 1¾" square. Luminate these from behind and you will have a really super looking panel. Real bargain 2 for £1, ref BD366.

TRANSMITTER TUNING CONDENSOR

160pf made for a very famous RAF transmitter, only £1 each. Unused but mounting brackets will need a bit of cleaning up due to storage. Our ref BD424.

MAGNETIC READ/WRITE UNIT

A read/write head mounted on a thumb operated lever is made to traverse magnetisable paper. The paper is held between top and bottom rollers which can be spun for localisation of the written message – new and unused only £1 each, BD381.

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
- 2P94 –Telephone handset for EE home telephone circuit
- 2P95 –13A socket on satin chrome plate
- 2P97 –mains transformer 24V 2A upright mounting
- 2P98 –20m 4 core telephone cable, white outer
- 2P99 –500 hardened pin type staples for telephone cable
- 2P101 –15V mains transformer 4A upright mounting
- 2P105 –capillary type thermostat for air temperature with c/o switch
- 2P108 –mains motor with gear box giving 110rpm
- 2P109 –5" wide black adhesive pvc tape 33m, add £1 post if not collecting

OVER 400 GIFTS YOU CAN CHOOSE FROM

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

£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 –⅛hp motor, ex computer, 230V, mains operation 1450rpm. If not collect add £3 post
- 5P25 –special effects lighting switch. Up to 6 channels of lamps can be on or off for varying time periods
- 5P27 –cartridge player 12V, has high quality stereo amplifier
- 5P34 –24V 5A toroidal mains transformer
- 5P35 –modem board from telephone auto dialler, complete with keypad and all ICs
- 5P37 –24 hour time switch, 2 on/offs and clockwork reserve, ex Elec. Board loading up to 50A. Add £1 post
- 5P41 –5" extractor fan, very quiet runner (s.h.), gntd 12 mths.
- 5P48 –telephone extension bell in black case, ex-GPO
- 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
- 5P60 –DC Muffin type fan 18 to 27V, only 3W. Brushless.
- 5P61 –drill pump mounted on frame, coupled to mains motor
- 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
- 5P74 6rpm 60W mains motor and gearbox with instant stop
- 5P79 30rpm 80 watt mains driven motor with gearbox
- 5P82 1 25rpm mains 60w motor with gearbox
- 5P84 1 delay time switch, adjust 0–20 seconds
- 5P69 1 light box size 14" × 12" for circuit tracing pcb's. Add £3 for postage and packing
- 5P72 1 turntable for vdu or scope
- 5P81 1 stepper motor bi-directional, 7.5° steps 12–14V coil
- 5P86 1 mains transformer with 2 × 100V 1A secondaries. Add £1.50 post
- 5P88 1 24V 5A mains transformer in waterproof case, ideal for garden lighting, pond pump etc.

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

VOL 16 No.6 JUNE '87

EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

ABC

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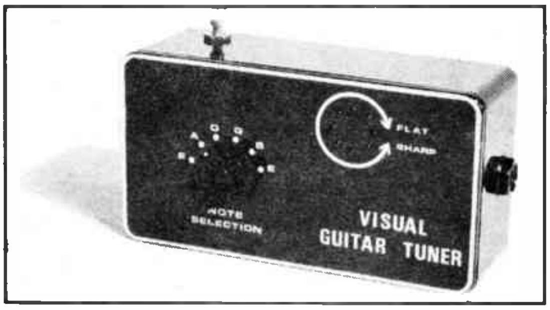
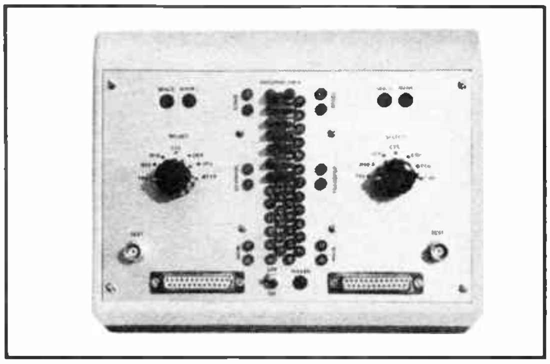
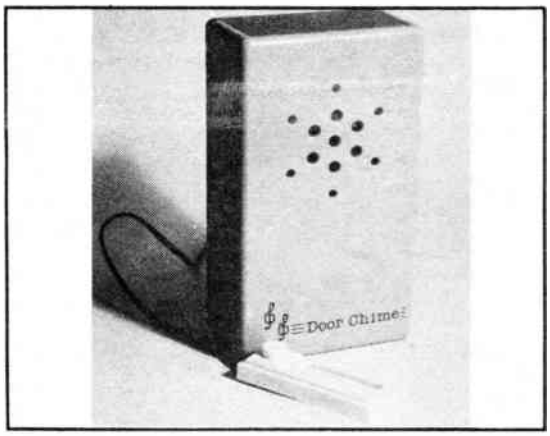
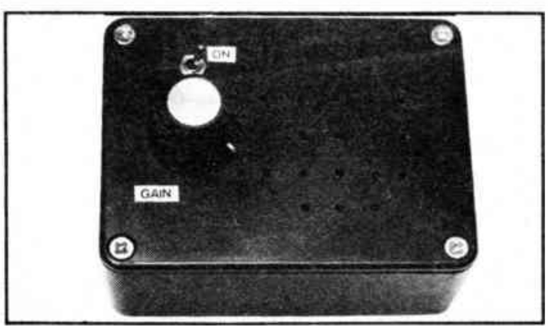
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .









Projects

Series

Features

Our July 1987 issue will be published on Friday, 19 June 1987. See page 307 for details.

BI-PAK BARGAINS

RESISTORS

Pak No	Qty	Description	Price
VP1	300	Assorted Resistors mixed values & types	£1.00
VP2	300	Carbon Resistors $^1/_4$–$^1/_2$ watt pre-formed, mixed	£1.00
VP3	200	1/8 watt Min. Carbon Resistors mixed values	£1.00
VP4	200	$^1/_2$–1 watt Resistors mixed values & types	£1.00
VP16	50	Wirewound Resistors mixed watt values	£1.00
VP112	1	Sub Resistance Box. 36 values 5ohms – 1Kohm	£4.75
VP140	50	Precision Resistors 1% Tol	£1.00
VP181	100	1 and 2 watt Resistors, assorted values	£1.00

CAPACITORS

VP5	200	Assorted Capacitors, all types	£1.00
VP6	200	Ceramic Capacitors Min. mixed values	£1.00
VP8	100	Mixed Ceramic Disc 68pf–.015pf	£1.00
VP9	100	Assorted Polyester/Polystyrene Capacitors	£1.00
VP10	60	C280 Capacitors. Metal foil, mixed values	£1.00
VP11	50	Electrolytics, all sorts	£1.00
VP12	40	Electrolytics 47mf–150mf mixed volts	£1.00
VP13	30	Electrolytics, 150mf–1000mf mixed volts	£1.00
VP15	25	.01/250V Min. Layer Metal Caps	£1.00
VP146	25	Solid Tantalum Caps. mixed values	£1.00
VP180	25	Tantalum Bead Caps. assorted values	£1.00
VP182	4	1000uf 50v Electrolytics	£1.00
VP192	30	Min. Electrolytics mixed values .47mf–1000mf 6–16v	£1.00
VP193	6	Sub Min. Electrolytics. 2x1000/2200/3300mf 10–16v	£1.00

74 SERIES SALE "ROCK BOTTOM" PRICES

VP223	50	Asst 74 TTL IC's. "ALL GATES" new & coded our mix 7400–7453	£6.00
VP224	100	Asst 74 TTL IC's. "ALL GATES" new & coded our mix 7400–7453	£10.00
VP7413	4	7413 Dual Nand Schmitt Trigger. 4-Input	£1.00
VP7440	4	7440 Dual 4-Input. Positive-Nand Buffer	£1.00
VP7470	4	7470 And-gated Positive-edge-triggered Flip-Flop with preset	£1.00
VP7480	4	7480 Gated full Adder	£1.00
VP7481	4	7481 16-Bit Random Access memories	£1.00
VP7490	4	7490 Decade Counter	£1.00
VP7491	4	7491 8-Bit Shift Register	£1.00
VP7492	4	7492 Divide by 12 Counter	£1.00
VP7493	4	7493 4-Bit Binary Counter	£1.00
VP7494	4	7494 4-Bit Shift Register	£1.00
VP7495	4	7495 4-Bit Shift Register	£1.00
VP74111	4	74111 Dual J K Master Slave Flip-Flop	£1.00
VP74141	4	74141 BCD—Decimal Decoder/Driver	£1.00
VP74151	4	74151 1 of 8 Data Selectors/Multiplexers	£1.00
VP74153	4	74153 Dual 4 line to 1 line Data Selectors/Multiplexers	£1.00
VP74164	4	74164 8-Bit Parallel Output Serial Shift Registers	£1.00
VP74167	4	74167 Synchronous Decade Rate Multipliers	£1.00
VP74174	4	74174 Hex D Type Flip-Flops	£1.00
VP74181	4	74181 Arithmetic Logic Units/Function Generators	£1.00
VP74193	4	74193 Sync. Up/Down Dual Clock Counters Binary clear	£1.00
VP74279	4	74279 Quad S-R Latches	£1.00
BPX6	1	TTL Data Book 74 Series, including "LS". Complete with Pin out Diagrams 7400–74870. TTL Interchangeability Guide. Function Selection Guide and Explanation of Function Tables. "NO VAT"	£1.00

TOOLS

VP246	1	25 watt High Quality Low Cost Soldering Iron 240v AC Long life Element. 1.7m lead	£3.50
VP247	1	15 watt "Lightweight" High Quality Low Cost Soldering Iron 240v AC. 1.7m lead	£3.50
VP248	1	High Suction Desoldering Pump, teflon nozzle. Auto Eject. Heavy duty return spring	£4.00
VP249	1	High Quality Soldering Iron Stand. Cast iron base. Tip cleaning sponge	£4.00
VP250	1	Long Finger Grip, soldering aid. Heavy metal base. Serrated jaws with rev. tweezer action. Ideal for holding small components. Fully adjustable	£3.00
VP251	1	Multi-tester. Pocket size. 18 ranges. 10000 ohms/VDC–4000 ohms-/VAC. Fuse and diode protection. Mirrored scale. Leads with 2mm plugs. Batt. & instructions inc.	£8.50
VP252	1	Multi-tester & Transistor Tester. 20000 ohms/V. 19 ranges Audio output. Test term. Fuse & Diode protection. Test leads & Transistor test leads. Batt. & Instructions. Mirrored scale. Size 147 × 97 × 45 mm	£18.50
VP253	1	Digital Multi-tester. 3½ digit. Side switches for single-hand operation. High quality construction tough ABS body. Fully guaranteed. Overload protection. Input imped. 10Mohms. 19 ranges Incl. 10ADC plus diode & transistor test. Accuracy 0.8%. Complete with leads. Batt. and manual. Size 145 × 70 × 31 mm	£35.00
VP254	1	250 grams Etchant Granules (Ferric chloride) makes ½ pint	£1.00
VP255	1	Etching Pen. Etch resistant. Spare tip. Blue	£1.00
VP256	1	PCB Mini Drill. Operating voltage 5–14V DC + 1mm twist drill and collet for .8 to 1.2mm drills and tommy bar inc	£6.00
VP257	1	Pack of 3 Twist Drills. 1, 1.5, 2mm for PCB Mini Drill	£1.00
VP258	1	Multicore Solder. 5m total. 18 and 22 S.W.G.	£1.00
VP259	1	PCB Holder. Fully adjustable from 0–320mm wide and to any angle. Complete with iron stand and sponge. Strong metal construction with rubber feet. Very High Quality	£15.00

MISC

VP223A	6	Tag Boards. 36 way Paxaline	£1.00
VP225	20	DIN Plugs, plastic 2–8 pin 180°/240°/360° mixed	£2.50
VP226	20	DIN Chassis Skts, metal 2–8 pin 180°/240°/360° mixed	£2.50
VP227	18	DIN In-line Skts, plastic 2–8 pin 180°/240°/360° mixed	£2.50
VP228	10	C15 Computer Cassette Tape, leadless	£3.00
VP229	10	C60 Cassette Tape, 2 × 30 min, low noise	£5.00
VP230	10	C90 Cassette Tape, 2 × 45 min, low noise	£6.00
VP231	1	Cassette Head Cleaner Tape, non abrasive, in case	£1.00
VP232	1	Cassette Head Cleaner/Demagnetizer, in case	£2.00
VP233	1	Revolving Cassette Rack, holds 32, smokey perspex	£2.50
VP234	1	Demagnetizer Curved Probe, 240v AC	£3.00
VP235	1	VHS Video Head Cleaner Cassette. Wet type	£4.00
VP236	1	Betamax Video Head Cleaner Cassette. Wet type	£4.00
VP237	1	Universal Ni-Cad Battery Charger. AA-HP11-HP2-PP3	£6.00
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- 3 levels of discrimination against false alarms
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- Built in delays
- 12V operation

This advanced module uses digital signal processing to provide the highest level of sensitivity whilst discriminating against potential false alarm conditions

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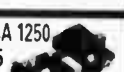
Suitable metal enclosure for housing the ultrasonic module type US 5063. Supplied with the necessary mounting pillars and screws etc

Control Unit CA 1250
Price £19.95 + VAT



This tried and tested control unit represents the finest value for money in control systems providing the following features

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- Provides exit and entrance delays together with fixed alarm time
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- Operates with magnetic switches, pressure pads, ultrasonic or I.R. units
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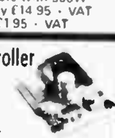
Lighting Controller DP 3570



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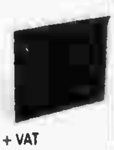
This versatile module provides timed switching of loads up to 3A for pre set times between 10 secs and 5 mins, the timed period being triggered by the opening or closing of an external loop or switch. The built in 12V 250mA power supply is available for operating external sensors. Priced only £13.95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

HW 1250 – Enclosure & fixings for CA 1250



only £9.50 + VAT

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

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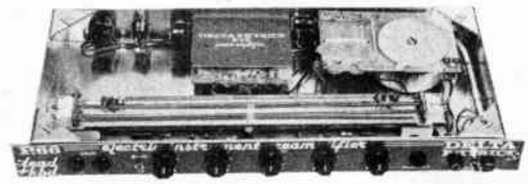

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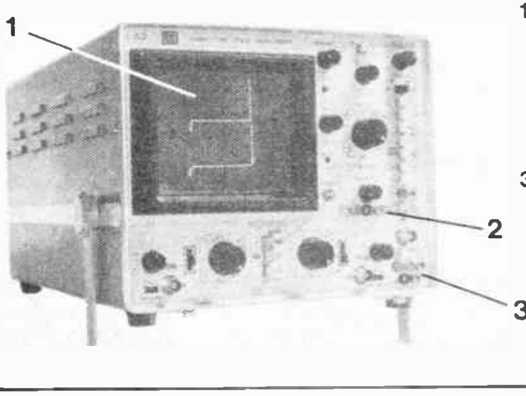

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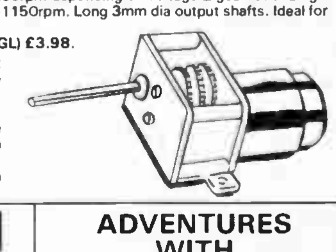

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EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

The Magazine for Electronic & Computer Projects

VOL 16 Nº6 **JUNE '87**

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RISING FIGURES

IT MAY seem a little late to be talking about 1986 but at the time of writing we have just had our 1986 circulation figures confirmed by ABC (Audit Bureau of Circulations)—the figures were a little late due to the change of publisher early in 1986. We are pleased to say that for the second year running EE has had the highest certified UK circulation of any monthly hobby electronics publication sold in this country.

During 1986 our UK circulation rose and is continuing to do so in 1987. This of course is thanks to you our loyal readers. The result is a better audience for our advertisers, every month over 400 more UK readers buy EE than take our nearest competitor. As this trend continues it leads to more adverts which eventually allow us to provide more editorial pages, more articles and more interest for you. This in turn helps sell more copies and so it goes on.

For some years, up to the end of '85, UK sales of the hobby electronics magazines were falling. I'm very pleased to say there is now a continuing strong upward trend on EE's circulation.

SUMMER

To keep up this trend we are always trying to give good value for money. The summer is coming and we start to think of suitable projects for the months when there may be some sunshine. Next month we will publish an excellent metal locator project which should help to provide some interest on the beach and on other outside sites through the summer.

We also have a couple of car and caravan projects coming up—to go with the *Fridge Alarm* we published last month. Of course there are many other projects which are equally useful in the summer and some that are perhaps not obviously so. Take for instance an Immersion Heater Timer—coming soon, at first sight it might be considered a winter project, but when the central heating is turned off a timed immersion heater may prove to be the most economical means of obtaining hot water.

We will of course continue to publish all the regular features plus our usual sample of test gear and computer items.

Mike Kenward

BACK ISSUES & BINDERS

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

Binders to hold one volume (12 issues) are available from the above address for £4.95 (£9.00 overseas surface mail) inclusive of p&p. *Please allow 28 days for delivery.*

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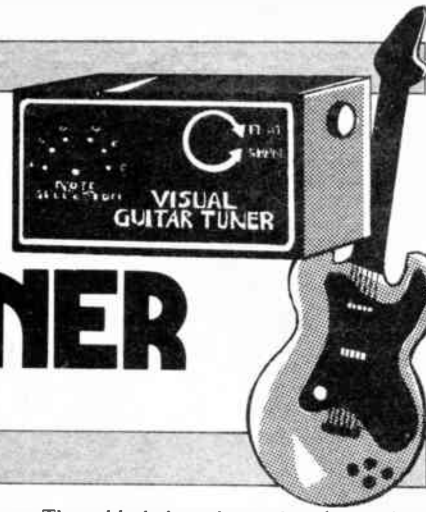
VISUAL GUITAR/ INSTRUMENT TUNER



MARK STUART

Keep in tune with this crystal controlled musical instrument tuner

THIS circuit was designed as a multi-purpose musical instrument tuner that could be pre-set to cover a wide range of crystal controlled reference frequencies. Tuning the instrument to the reference frequency is achieved by a novel and very effective display using a ring of l.e.d.s which light in a pattern that indicates relative phase and frequency.

The display also indicates whether the incoming frequency is above or below the reference frequency by the direction in which the pattern appears to rotate. As tuning becomes nearer, the apparent speed of rotation reduces, until the pattern is stationary when the tuning is exact. The display thus combines the benefits of a meter and an l.e.d.-type beat in indicator and is better than both.

The tuner is quick and easy to use, has a clear unambiguous display and is not over sensitive to input signal waveform or amplitude. Being a solid state display means that the tuner is robust and compact. The tuner requires a low level signal from either a microphone or an instrument pick-up (input impedance 47k).

A built-in acoustic resonator allows the reference frequency to be heard if required by pressing a button. This facility is useful when a suitable microphone or pick-up signal is not available as it enables simple tuning to be achieved by ear.

CIRCUIT

The circuit diagram of the tuner is shown in Fig. 1. The switch connections shown are set to produce the standard guitar string frequencies E, A, D, G, B, E through two octaves. The production of other notes and octaves for other instruments is achieved by the use of alternative pin connections to IC2 and IC3.

The crystal reference frequency is produced by X1 which is connected in a standard i.c. oscillator circuit using a single inverting gate from IC1. Capacitors C1 and C2 provide the correct loading for the crystal and R1 provides a d.c. bias path which ensures that IC1 is operating in its "linear" range. The output from IC1 is a square wave at 4MHz. This is too high for some of the notes required so it is divided in two stages in IC2 to produce alternative outputs of 2MHz and 1MHz. These outputs are on pins 9 and 6 of IC2 respectively. A third output from IC2 on pin 11 provides a buffered, undivided output at 4MHz.

Switch S1 is a two-pole six-way switch which is used to select the required note in two stages. For the two lower notes a 1MHz clock is required, the next three notes require a 2MHz clock and the top note uses the full 4MHz. The first section of S1 (S1c) selects the appropriate clock frequency which passes to the input of a "top octave divider" IC3.

IC3 is a chip designed to generate 13 output frequencies at the correct musical intervals over one octave from C to C. Only five of the outputs are used in this application—the difference between top and bottom E being determined by the selection of 1MHz or 4MHz for the input clock frequency. All of the other outputs are available of course and may be used if required by arranging suitable switching.

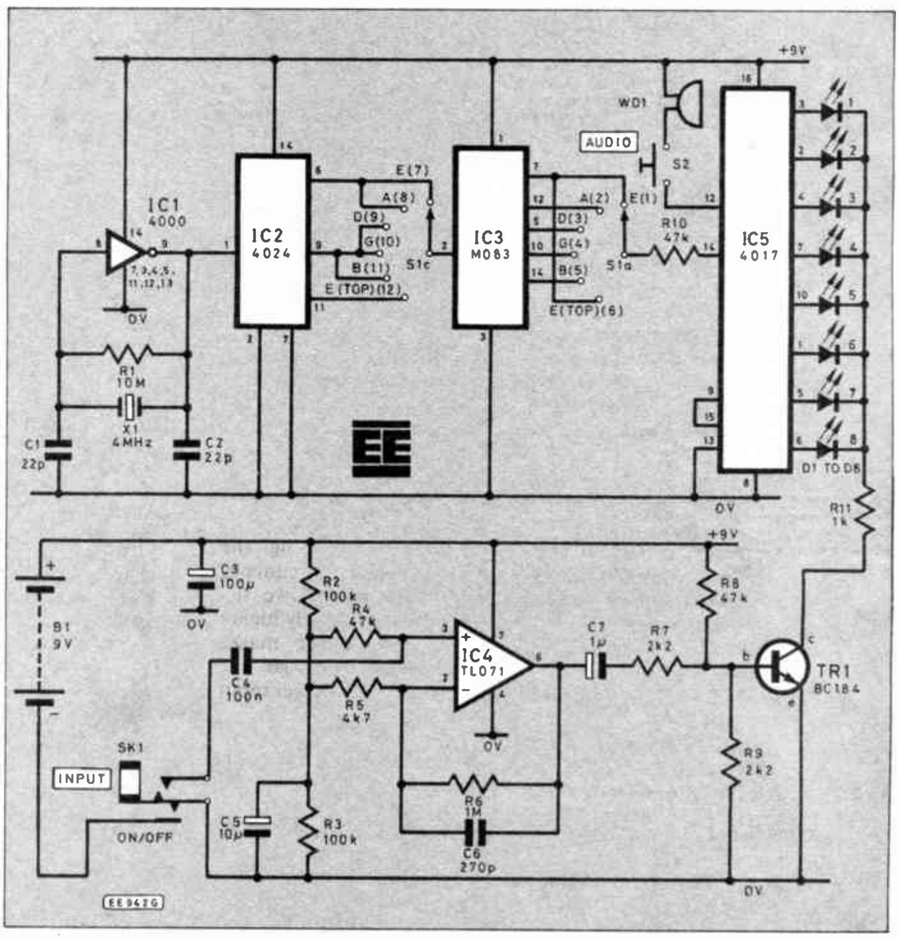
The table below shows the pins and the notes available from IC3

Available notes

Pin	Note
4	C sharp
5	D
6	D sharp
7	E
8	F
9	F sharp
10	G
11	G sharp
12	A
13	A sharp
14	B
15	top C
16	low C

The frequencies at the output of IC3 are exactly eight times the frequency of the note being tuned. This factor is required to give the correct display action. The selected output of IC3 is passed on to the "clock"

Fig. 1. Complete circuit diagram for the Visual Guitar/Instrument Tuner.



input IC5 which is a 4017 decode counter. The extensively used i.c. has ten outputs which switch from low to high and back again in turn on each clock pulse. Only one output can be high at any time so that a ripple effect is provided with a sequence of ten outputs each going high and then low again one by one in turn. For this circuit a sequence of only eight outputs is required not ten. This is achieved by connecting the ninth output to the "reset" pin on the i.c. (pins 9 and 15). This ensures that as soon as the ninth output attempts to go high the counter is automatically reset and assumes the starting state with the first output high.

The effect of this arrangement on the l.e.d.s (D1 to D8) is to scan through them one by one, taking the anode of each one in turn up to the positive supply voltage. If the cathodes of all of the l.e.d.s were held at 0V each l.e.d. would be lit when its turn came and all l.e.d.s would appear equally bright. This would be the case if transistor TR1 were to be turned on all the time. If TR1 were turned off all the time all l.e.d.s would be off.

In this circuit the state of TR1 is determined by the input signal to the tuner. The signal, from a microphone or pickup, passes via C4 to IC4 which is a standard non-inverting i.c. op-amp circuit. D.C. bias for the two inputs at half of the supply voltage is produced by potential divider resistors R2 and R3. C5 decouples this bias voltage which is then passed to the inputs via R4 and R5. Feedback around the amplifier is provided by R6 and C6, which in conjunction with R5 set the gain of the stage to 200. From IC4 the amplified signal is coupled to the base of TR1 via C7 and R7. Resistors R8 and R9 set the standing bias on TR1 so that in the absence of any input it is turned off.

COMPONENTS

Resistors

R1	10M
R2,R3	100k (2 off)
R4,R8,R10	47k (3 off)
R5	4k7
R6	1M
R7,R9	2k2 (2 off)
R11	1k

All 5% carbon film 0.25Watt

See Shop Talk page 206

Capacitors

C1,C2	22p ceramic plate (2 off)
C3	100μ radial elect. 16V
C4	100n polyester
C5	10μ axial elect. 16V
C6	270p ceramic plate
C7	1μ axial elect. 16V

Semiconductors

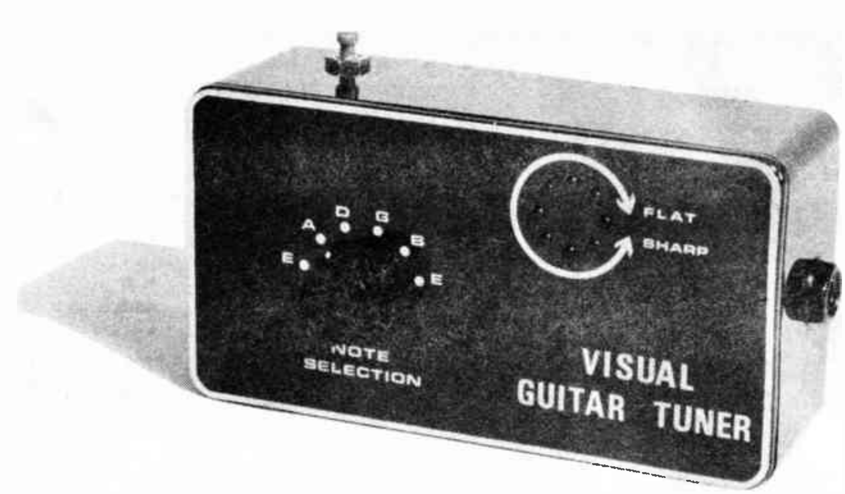
IC1	4000B CMOS
IC2	4024B CMOS
IC3	MO83 top octave generator
IC4	TL071 op-amp
IC5	4017B CMOS
TR1	BC184 (see text)
D1 to D8	KLMP1700 high efficiency low current red l.e.d.s (8 off)

Miscellaneous

S1	2-pole 6-way rotary switch
S2	Push to make switch
SK1	¼in. mono jack socket with 1 make contact and 1 break
X1	4MHz crystal HC18U wire-ended
WD1	PB2720 ceramic resonator

Knob; connecting wire; p.c.b. available from the *EE PCB Service*, order code EE568; case; PP3 battery clips; d.i.l. i.c. holders 8-pin, 14-pin (2 off), 16-pin (2 off).

Approx. cost Guidance only £23.50



SCANNING

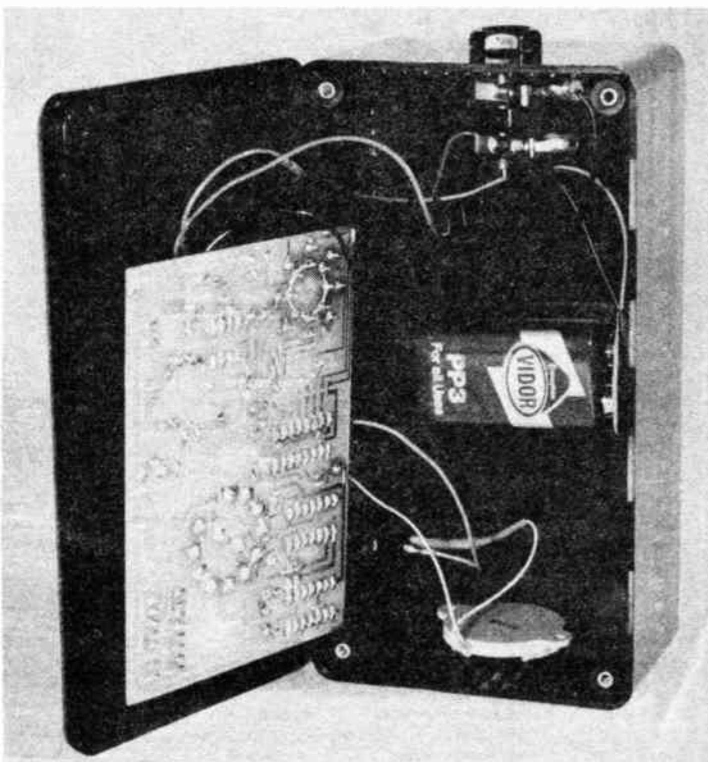
When a note of the correct frequency is applied to the input, TR1 will be turned on during the positive half cycle and off during the negative half cycle. During this time all eight l.e.d. anodes will have been scanned by IC5. Those l.e.d.s enabled during the positive half cycle of the input will be turned on and those during the negative half cycle turned off. This process repeats rapidly for each cycle of the incoming signal and provided the input is exactly one eighth of the scan frequency a stationary pattern of four l.e.d.s on and four l.e.d.s off will result.

In fact the four l.e.d.s that appear to be on are flickering at the input frequency as they are scanned. This is too fast for the eye to follow and so a steady pattern is perceived. When the input frequency is slightly different from the reference frequency the relative phase of the two signals changes progressively through successive scans. This has the effect of making the l.e.d. pattern appear to rotate slowly, the frequency of rotation being the difference frequency between the two signals. A slightly higher input signal makes the rotation go one way and a lower input signal reverses the rotation. This is an extremely useful feature as it shows which way tuning is required.

At higher difference frequencies the pattern rotates faster and when the difference is very large all that can be seen is a general flickering effect. By the time this occurs the difference is so great that it is usually obvious which way to start tuning, if not, a quick process of trial and error soon results in a rotating pattern.

So far a perfect input signal waveform has been assumed which turns on exactly four l.e.d.s. A waveform which is rich in harmonics may result in a larger or smaller number of l.e.d.s, being lit. The rotational effects are still exactly the same however, and so practically nothing is lost. As the combined gain of IC4 and TR1 is very high the input signal can decay a long way before any effect is noticed on the brightness of the l.e.d.s. Use of the special high efficiency low current l.e.d.s specified is not essential but does produce a far superior display than ordinary "cooking" l.e.d.s. As the signal dies away it eventually falls below the level necessary to turn on TR1 and the l.e.d.s all go out.

The circuit is switched on and off by means of the input jack socket which is of the make/break type. Piezo-electric transducer WD1 allows the unit to be used as a pitch-pipe for tuning instruments by ear. It allows the tuner to be used when a microphone or pick-up is not available.



Positioning of components inside the case. The p.c.b. is mounted on the lid of the case so that the ring of l.e.d.s can protrude through the top of the case.

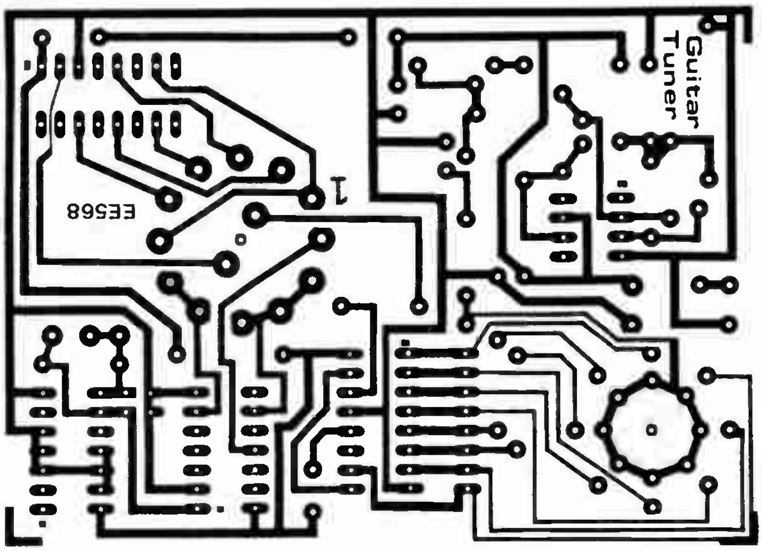


Fig. 2. Printed circuit board foil master pattern. This board is available through the *EE PCB Service*, order code EE 568.

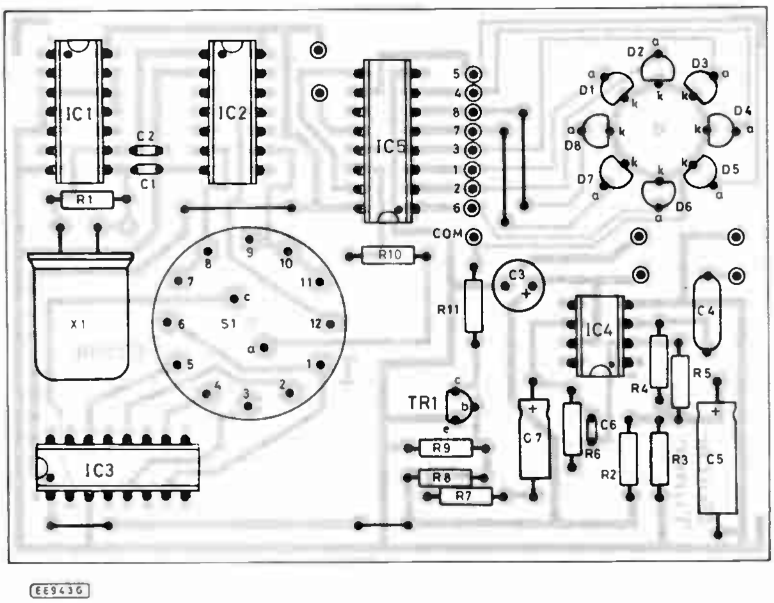
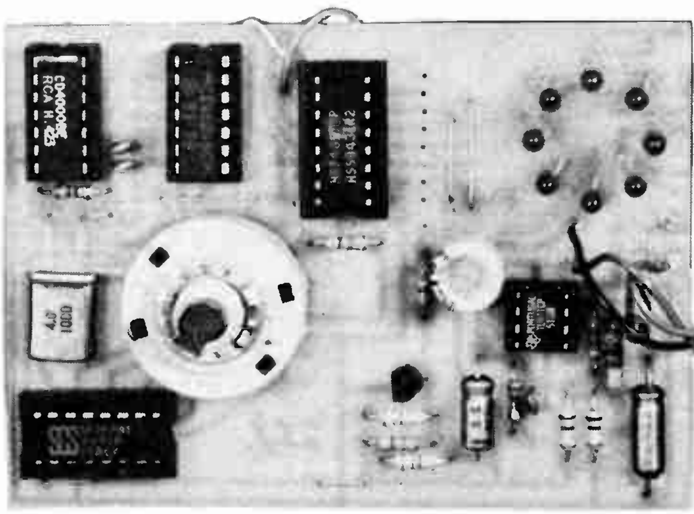


Fig. 3. Printed circuit board component layout. The numbers to the side of IC5 are the order of the outputs if the l.e.d.s are mounted off the p.c.b.



The completed board with the display l.e.d.s forming a circle.

CONSTRUCTION

The circuit is built on a single printed circuit board. Fig. 2 shows the p.c.b. track patterns and Fig. 3 the component layout. This board is available from the *EE PCB Service*, code EE568. See page 340.

S1 and the l.e.d.s can be mounted on the board as shown or may be mounted remotely if a different style of case layout is preferred. A set of connection points are provided for remotely mounted components.

Assemble the circuit in the usual order: small components, wire links and i.c. sockets first followed by larger components and wiring. TR1 must be the standard BC184 type and **not a BC184L** (which has the collector connected to the middle lead). Capacitors C3, C5 and C7 must be fitted with the correct polarity as shown. The l.e.d.s have a small flat at the point where the leads are attached which identifies the cathode.

In the prototype the l.e.d.s were all mounted directly on the board and the case front drilled appropriately. It is easier to do this if the l.e.d.s are first pushed into close fitting holes drilled for them in the case front and the printed circuit board fitted over the leads so that they all pass through the correct holes. The leads can then all be soldered and the board removed complete with the l.e.d.s, which will be in perfect alignment.

If a standard switch is used for S1 the letters and numbers shown are moulded on the switch body. The board is designed so that the switch can be mounted directly on it. Alternatively it can be mounted elsewhere and connected by wiring. The type of switch specified will need its tag ends removed for p.c.b. mounting.

CRYSTAL

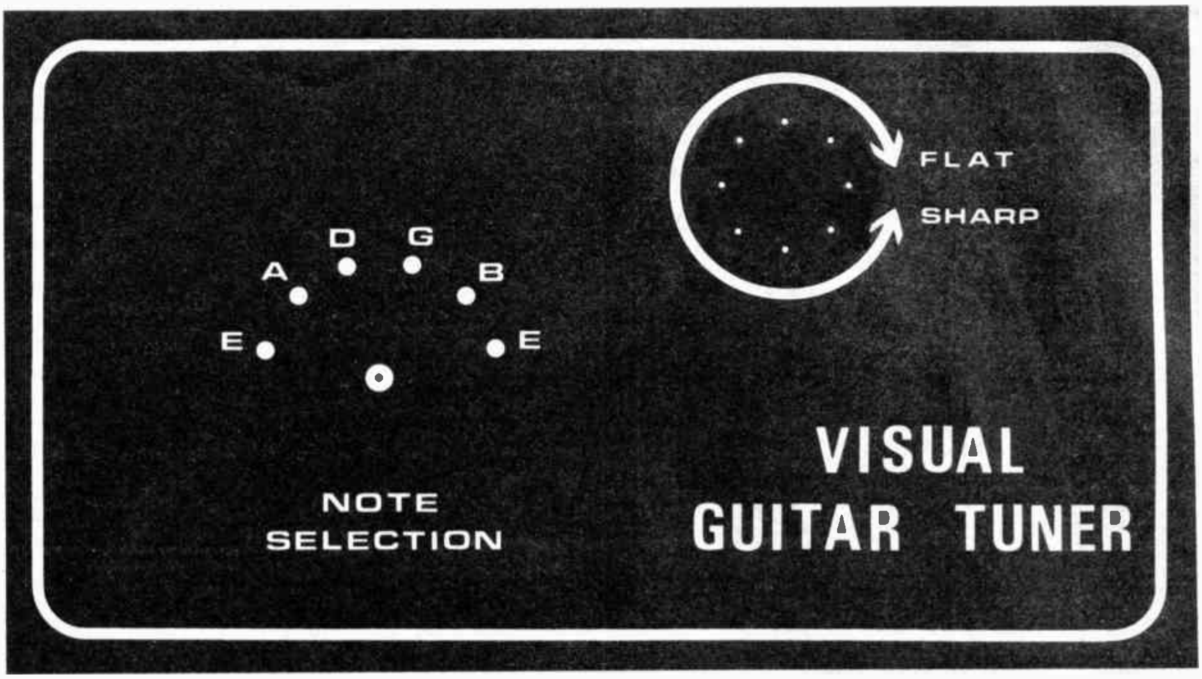
The crystal X1 should have its leads supported whilst they are bent, so that the glass seal is not broken. A small double-sided sticky pad can be used to hold the crystal firmly down on the board. Wiring simply involves the connection of S2 and WD1, a battery clip and the input socket SK1. Use flexible connecting wire and take care to connect SK1 exactly as shown in Fig. 4 so that the switch section works correctly. Other types of switched socket can be used if they have the correct switching arrangement.

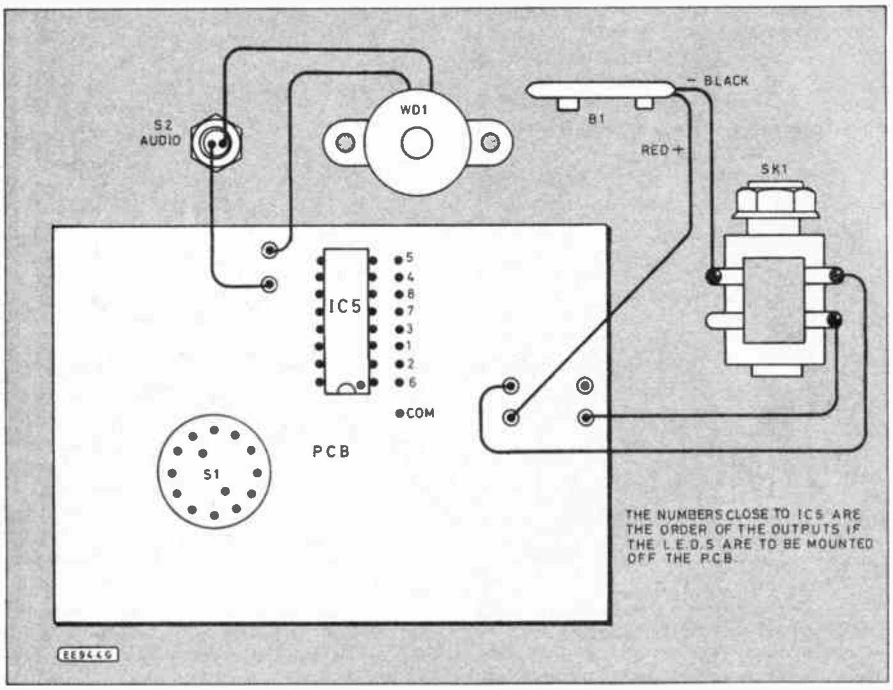
The board can be mounted by means of the fixing nut of S1 if this is fitted to the board. If S1 is mounted off the board it will be necessary to drill some fixing holes and mount the board using spacers or long screws fitted with extra nuts. The front panel of the prototype was marked as shown in Fig. 5. If the specified case and layout are used this panel layout can be photocopied, covered with plastic film, and used as a label. Details for drilling the front panel are shown in Fig. 6.

TESTING AND USE

Insert all i.c.s, switch on and check that the l.e.d.s do not light. Press S2 and check that a rough sounding note is produced. Keep S2 pressed and rotate S1 to obtain all six of the set notes. If everything is correct so far it remains only to inject a signal and see if the lights behave as described. A signal generator can be used as the source to simplify fault finding (if any is required).

If none of the l.e.d.s light there could be a fault in the signal path or IC5. Short circuit





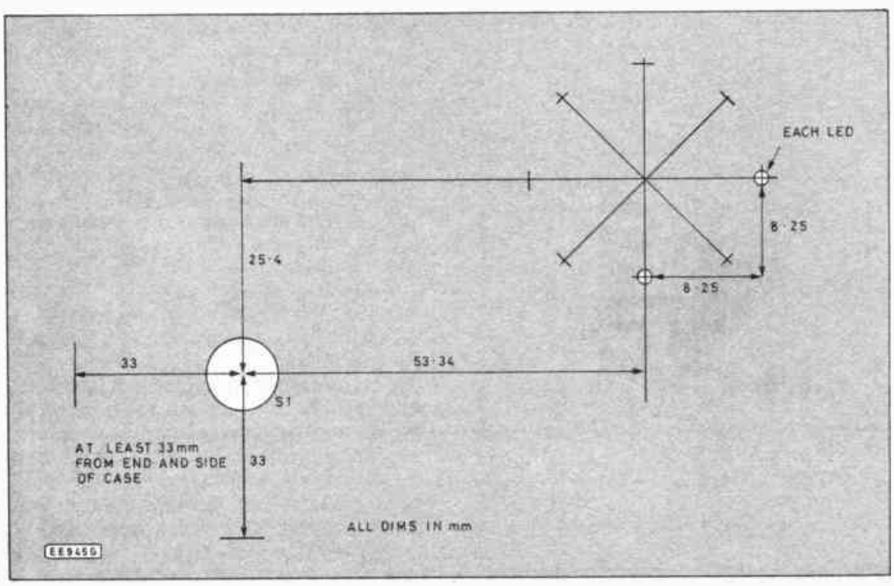


Fig. 5 (above). Full size front panel legend for the tuner. This diagram may be photocopied and fixed on the case to give a neat finish.

Fig. 4 (left). Interwiring details to the off-board components.

Fig. 6 (bottom left). Front panel drilling details for the note selection switch and the display l.e.d.s.

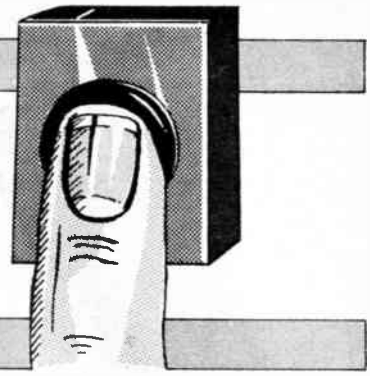
collector-emitter of TR1 and all l.e.d.s will light if IC5 is working and is receiving the correct signals. If only one l.e.d. lights, check that S1a is correctly wired.

If all l.e.d.s light when TR1 is shorted out but refuse to light when a signal is connected it is likely that either IC4 or TR1 is at fault. Check that both are inserted the right way round and that C7 and C5 are also the right way round. If a multimeter is available check that the output of IC4 (pin 6) is at exactly half of the supply voltage.

If these checks are correct but the circuit still refuses to work there could be a fault in the wiring of SK1 or in one of the capacitors C4, C5, C6, and C7 which would prevent the signal from getting through to TR1. As there is very little wiring it is likely that the circuit will work first time. Remember that 99 per cent of faults are due to poor soldering—dry joints, bridges, short-circuits—or incorrectly fitted components. If you cannot see anything wrong, ask a friend to look. It's surprising how easy it is not to see one's own errors!

As the circuit is crystal controlled, temperature stability and accuracy are excellent and no setting up is required at all. Battery drain is about 30mA when operating, most of this being used by IC3 and the l.e.d.s. A PP3 should have a good life provided the jack plug is removed when tuning is complete. A failing battery will be shown by the display getting dimmer but accuracy will not be affected.

The type of display used is a very effective way of comparing two frequencies and probably has a wide range of other applications where a clear simple indication of frequency difference is needed. The author would be delighted to hear of readers' suggestions which could possibly be used as the basis of other projects. □



DOOR CHIME

A. R. WINSTANLEY

No gimmicks, low cost "traditional" three-tone chime with decay

MANY designs have been published in the past for electronic door bells which generate a twin-tone chime, and some of them incorporate further circuitry in order to imitate more accurately the "ding dong" of a classical Friedland chime.

Other more elaborate microprocessor-based systems incorporate a custom chip which generates musical tunes, although there is always the danger that the integrated circuits utilised can become obsolete almost overnight, so that if the chip in a particular unit fails, there is no alternative but to scrap the unit altogether.

Electromechanical chimes themselves rely on the action of a solenoid-driven hammer striking a chime bar and then hitting another lower-frequency chime bar upon returning to its original position. The bars are suspended on rubber bushes to aid reverberation and clarity, and this results in a pleasant tone which decays over a period of several seconds.

TONE GENERATION

It is possible to emulate this effect electronically and it is a simple matter to generate uncomplicated tones over a loudspeaker: the trick however is to modify this by modulating the tones to introduce the reverberation and decay characteristics of a Friedland. This can involve some fairly extensive circuitry.

The Door Chime to be described here utilises a single eight-pin integrated circuit which requires very little additional circuitry indeed to construct a complete chime. It incorporates an integral audio amplifier stage and will drive an eight ohm speaker directly.

The output is a little restricted—something to be expected in such a simple circuit as this—and is claimed to be about 160mW or so. This is obviously not quite as loud as a conventional chime but will prove quite adequate for use in smaller apartments; alternatively it could easily be employed in a larger household if the main Door Chime unit could be mounted within earshot of the occupants.

The Door Chime can actually generate a single, twin or treble chime, depending on which type of integrated circuit the user employs in his model. The author recommends the three-tone chime for its novelty value and pleasing effect.

If the twin or three-tone chime is constructed, the Door Chime will generate each tone successively, each tone overlapping the previous one which then decays away "naturally". After the last tone has died away, the Door Chime switches off automatically. The device operates from a 9V battery, and since the quiescent or "standby" current is tiny—less than 1µA—battery life should be exceptional.

Ease of construction is a keynote of this design, which has been kept deliberately simple, and the author recommends this project to beginners who will be able to assemble the Door Chime without any difficulty.

More experienced readers will also find this unit of value since it forms a quickly and economically assembled gift for a friend or relation.

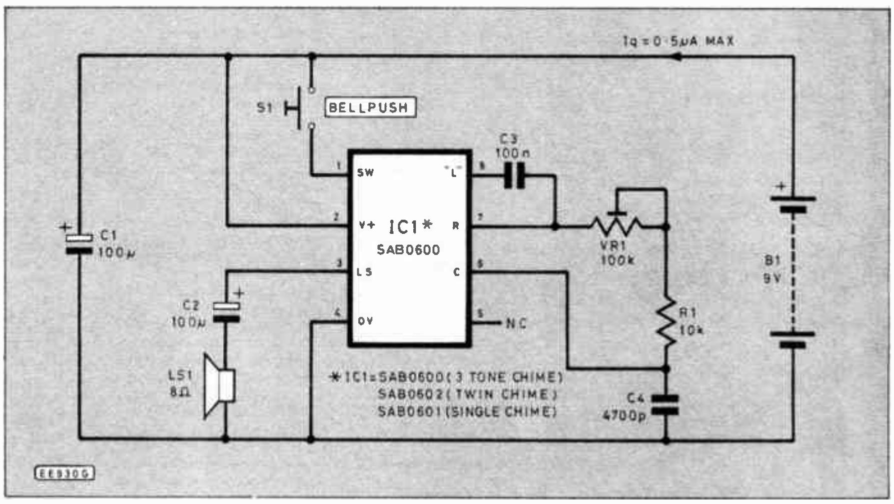


Fig. 1. Complete circuit diagram for the Door Chime. The i.c. used in this circuit is for the three-tone version.

CIRCUIT DESCRIPTION

The circuit diagram is shown in Fig. 1. It will be seen that the Door Chime is of very simple design. IC1 does all the work and the user should select at the outset which chip he requires to produce the desired effect:

I.C. TYPE	EFFECT
SAB 0600	Three-tone Chime
SAB 0602	Twin-tone Chime
SAB 0601	Single Chime.

Any of the above chips can be employed in the circuit without any modification being necessary.

Switch S1 is the bell-push switch and this is a normally-open push to make switch which, when closed, will activate the chime sequence by connecting pin 1 to the positive rail. Pin 1 includes a 2mS time delay: triggering pulses of less than this duration are disregarded by the chip, and this provides some protection against false triggering caused by the switch wiring picking up interference from, for example, mains-borne glitches.

FREQUENCY SELECTION

The basic frequency of the chimes, together with the overall period for which the chime sequence plays, is determined by an external RC network—the resistance comprises VR1 and R1, and C4 is the timing capacitor. Adjusting VR1 produces effects ranging from a high-pitch tinkle at one extreme, to an effect similar to a grandfather clock striking, at the other!

The three-chime effect itself consists of three tuned frequencies which are switched successively to a summing point. Three internal digital-to-analogue converters then generate the envelope decay waveforms which attenuate each chime individually so that each tone is heard to diminish in a manner similar to a traditional doorbell.

The single and twin-tone derivatives are all based on the three-tone chip, but with the relevant number of tones being suppressed from the end of the sequence.

The audio output is observed at pin three of IC1 and the chip will drive a speaker directly through a decoupling capacitor C2. When the last tone has decayed, the chip will automatically switch off. The quiescent current is typically less than 1µA. A PP3-type battery is used to power the circuit (B1) and should remain serviceable for at least one year. An alkaline type is preferred for its leakproof properties as well as the extended life that these batteries offer.

TONE QUALITY

The tone quality itself, together with output volume, will depend not only on the power output of the chip, but also the following major factors:

1. The resonant frequency of the loudspeaker—the larger the speaker, the lower the resonant frequency. Maximum volume is achieved when the speaker is driven at its resonant frequency.
2. The operating frequencies of the chime circuit, as determined by VR1.
3. The resonant characteristics of the enclosure housing the loudspeaker.

A large speaker will improve the tone colour. A small 200mW speaker, for example, produces a "tinny" effect which is not particularly pleasant to listen to, nor is it particularly audible.

In practice, a compromise will have to be attained whereby volume is traded off to a certain extent for a more melodious tone, and this is achieved by setting VR1 to a fairly low resistance—generating higher frequency chimes—and reproducing the tones over a larger speaker than would theoretically be necessary to handle the power. The prototype utilised an eight ohm, one Watt loudspeaker and the resultant effect was quite acceptable.

Finally, C1 decouples the power supply rail and is essential to maintain stability when the i.c. is generating the chimes. Some pretty weird effects may be heard without it! C1 also smoothes out to a certain extent any fluctuations on the power rails which will occur during operation once the battery starts to age.

CONSTRUCTION

With such a simple circuit as this, the author considered it unnecessary to design a printed circuit board, and so in the interests of keeping construction simple, the circuit was assembled on a piece of 0.1 inch matrix stripboard size 24 holes × 10 strips—see Fig. 2.

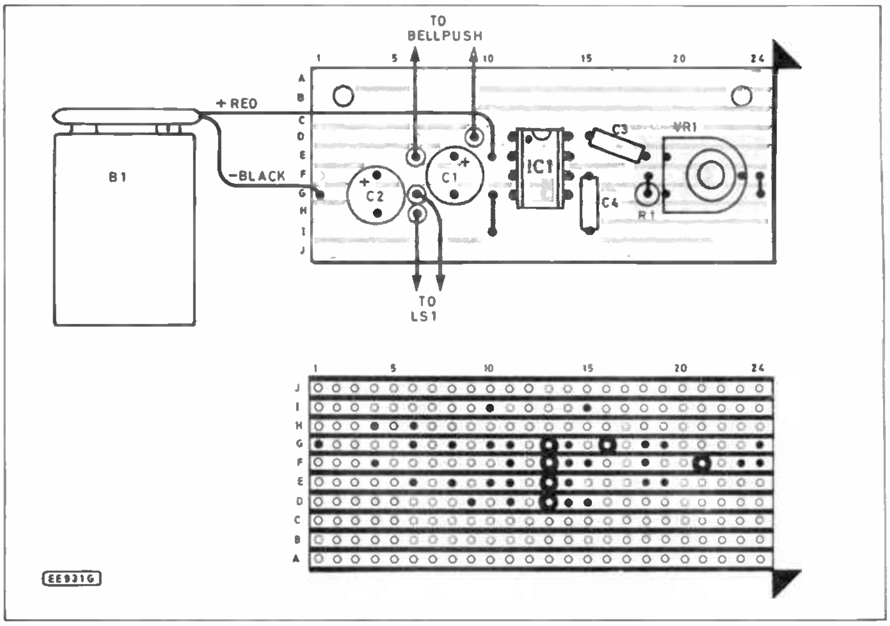


Fig. 2. Circuit board component layout, details of breaks to be made in the underside copper tracks and wiring details to the speaker LS1 and bellpush S1. An i.c. holder should be used to mount IC1 on the board.

Assembly of the components upon the stripboard is a straight-forward matter and should present no problems. An eight-pin d.i.l. socket is recommended to carry IC1. This will prevent any thermal damage being caused to the chip during the soldering process. It will also permit the constructor to change the chip at a later date for an alternative SAB type—so you can convert to a twin or single chime if desired.

Two holes are necessary in the stripboard at the positions indicated, to accommodate standard circuit-board mounting hardware, e.g. M3 or 6BA nuts, bolts and spacers.

CASE

Since the completed Door Chime may well be displayed prominently in the home, it is desirable to house the circuit in a cabinet which is aesthetically pleasing. For the prototype an all-plastic Verobox type 65 40767F was employed. This measures 188 × 110 × 60 mm and is moulded in beige and

COMPONENTS

Resistor
R1 10k 0.25W carbon 5%

Potentiometer
VR1 100k lin. min horizontal preset

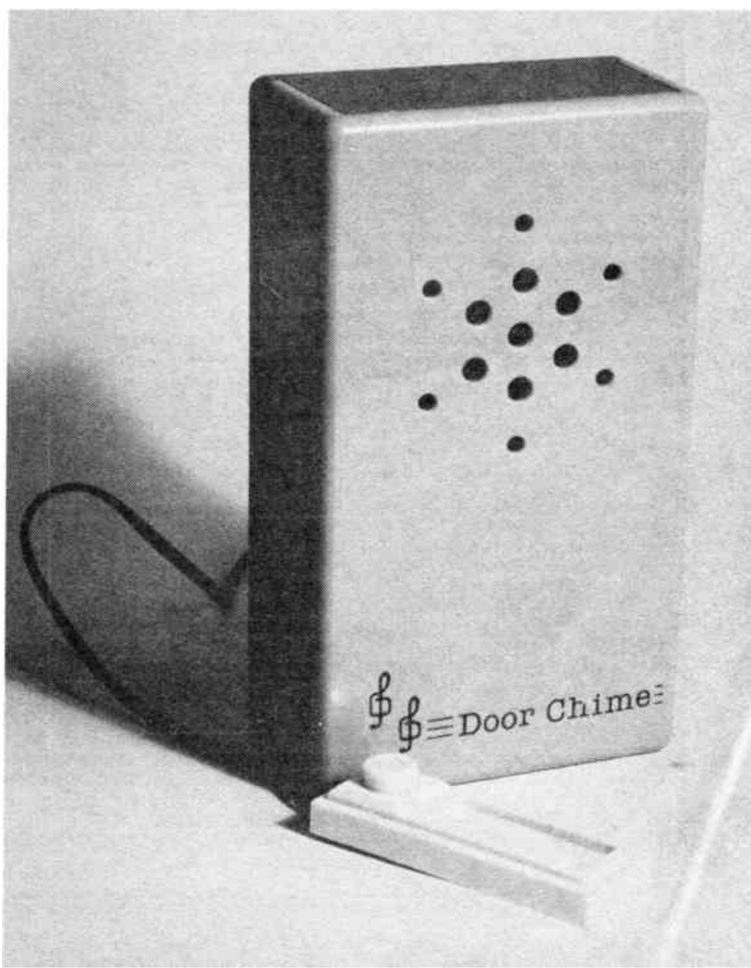
Capacitors
C1,2 100µ radial elect. 16V (2 off)
C3 100n polyester layer
C4 4700p polyester layer

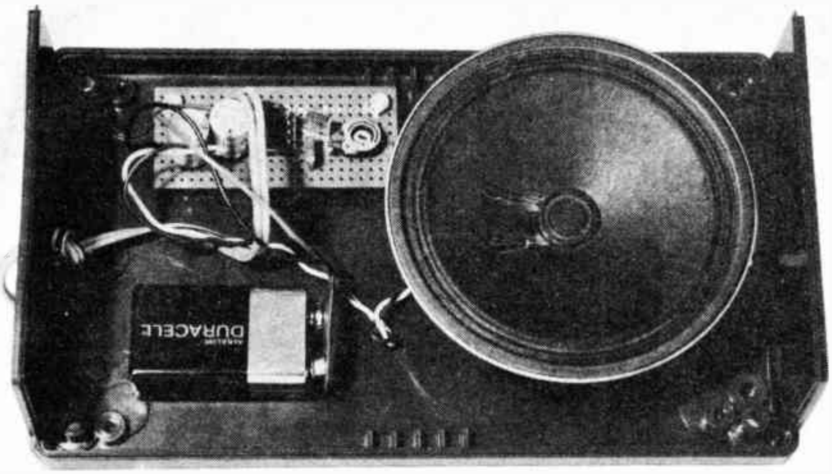
Semiconductors
IC1 SAB0600 (three tone chime), or SAB0602 (twin tone chime), or SAB0601 (single tone chime)

See Shop Talk page 306

Miscellaneous
B1 PP3 alkaline 9V, with battery clip
S1 single pole push to make bell push
LS1 8 ohm loudspeaker—see text
Verobox 65-40767F size 188 × 110 × 60mm; 0.1inch matrix stripboard, 24 holes × 10 strips; twin-core interconnecting wire to suit; wire; solder; 8 pin d.i.l. socket; circuit board mounting hardware, etc.

Approx. cost Guidance only £7 (Plus case)





the appearance by gently applying a countersinking bit: a couple of revolutions of the hand-held drill are all that are required.

The bell-push switch can be connected by a length of twin core "zip" wire and this passes through a hole in the base of the cabinet and is soldered to the stripboard inside. The wire was approximately five metres long on the protoype and the indications are that a much greater length could be used effectively (but see "Installation").

Finally a battery is clipped onto the battery connection clip and it can then be stuck down inside the case with a small piece of double-sided adhesive foam strip.

With assembly completed, the unit can be tested by operating the bell push to generate the chimes, and VR1 can be adjusted to achieve the best effect. The cabinet can then be installed in the home.

brown plastic. It proves to be the most expensive component in the design, and you could of course use a different type if you wish, or perhaps make your own out of wood. Preferably acquire the loudspeaker first and then select a cabinet of appropriate dimensions to fit it.

The recommended case is prepared in the following manner. The base of the housing has knock-out keyhole slots which can be drilled out to permit the box to be positioned on the wall. Two further countersunk holes are required for the circuit board mounting hardware. Countersinking will prevent damage arising to wallpaper or paintwork.

On the prototype, the loudspeaker was merely glued down by applying a drop of cyanoacrylate adhesive gel ("Superglue Xtra") to the rear of the speaker and then sticking into position on the base. It should never be dislodged, and apart from simplifying construction, also means that no unsightly loudspeaker mounting screws are visible anywhere.

An alternative means of affixing the speaker is to apply cement around the "gasket" or rim of the speaker and then sticking it to the lid of the case. However experience has shown that eventually the gasket—being made of cardboard—will separate into layers and the loudspeaker will simply fall off.

Obviously a loudspeaker grille is necessary in the removable lid to permit the chimes to be heard. The holes are best effected by careful use of a hand drill. Great care should be exercised when marking out the location of each hole prior to drilling. Afterwards, chamfer each hole to "soften"

INSTALLATION NOTES

The main unit should naturally be installed in a location where it has most chance of being heard by the occupants of the house, though like most doorbells, the Door Chime may be drowned out by a loud T.V. or hi-fi.

When routing the twin-core wire it is desirable to keep the wires away from any mains cable or apparatus. In spite of the 2mS delay built into the trigger pin of IC1, it has been found that the Door Chime will upon occasion still sound if any adjacent mains equipment is switched on or off. This is especially true if the equipment incorporates a large mains transformer.

There should be no problem if the user steers clear of such equipment when installing the bell-push wiring. □

Robot Roundup

NIGEL CLARK

ON THE QT

A few years ago when people began to realise that there was a market for small robot arms, particularly in education and training, one of the first machines to appear in Britain was the Armdroid I. It was a conventional articulated arm with five axes plus a gripper driven by stepper motors. Transmission was provided by nylon cords and it cost about £500.

With a reach of 430mm and an accuracy of ±4mm it could lift 300gm. It could be interfaced with most of the popular micros of the time and operated either direct from the keyboard or could be given a series of moves by moving it from point to point and then, having remembered each point in the sequence, it would retrace its steps when ordered.

It was bought by schools and colleges throughout the country and proved popular despite a tendency for the nylon cords to slip on the pulleys, making long-term repeatability difficult.

Other arms, both cheaper and more efficient entered the market but the Armdroid continued until last year when Colne Robotics, its maker, went into voluntary liquidation, hit by a variety of problems. The major factor being blamed was financial difficulties experienced by its US agent.

Now a new company has bought the assets of Colne and, trading as Qti Colne Robotics from Merthyr Tydfil, is continuing all the old Colne lines. As well as Armdroid I there will be Armdroid II, the long-awaited upgrade which was being worked on when the company closed.

The new model is said to be more robust and stronger than the original with stronger stepper motors, a toothed-belt drive and optical encoders to provide a more accurate check on movement than is possible with steppers alone. The lifting capacity is increased to 400gm and the accuracy is greatly improved and is now claimed to ±1mm. It is being priced at about £700.

The new owners are also trying to build on the foundations laid down by Colne. Chris Magee, managing director of Qti, said that he did not think sales of the arms would match previous levels. The section of the market which they serve had been well covered but he expected steady sales.

LOOKING AHEAD

As well as upgrading Armdroid, on which some work was still needed when Qti took over, Magee said he was looking to change the concept of robotic software. In the past the software had been seen as subordinate to the robot and was developed to allow people to learn about the machine. The software to be provided with the Armdroids would help people learn about programming as well as find out what the software was doing; this would enable the users to write their own control programs.

However, at the moment the company's main attention is being focussed on the Colvis Vision System. This had been sold for some time by Colne and was one of the few vision systems for which software had been developed to allow it to be used with an arm. The Armdroid, with a small camera attached, was often to be seen at exhibitions sorting different shapes on a turntable.

Although costing more than the inexpensive Snap system, developed by Microbotic Systems, Colvis has still proved popular. Magee now plans to increase the resolution from 32 × 32 to 256 × 256 and increase the power of the processor by switching from the original Z80 to the 68000 series. "That should make it accurate enough for industrial uses," he said.

But it will still be possible to use the Colvis system in conjunction with the Armdroid. Qti is pressing ahead with plans made by Colne to link the two in a special package with a software system called Coordinator 32. For about £1,300 the company is supplying the vision system plus software which can control two Armdroids acting in synchronisation. For an extra £400 an Armdroid will be included.

The Coordinator has 32K of control software on EPROM and another 24K on RAM allowing the storage of up to 2,255 steps for pick and place operations.

CONNECT

Another new name has entered the robot arm market. Shesto Tech is marketing the Connect RL1 arm, developed by Richmond Logic which has taken on some former Colne Robotics employees. Based loosely on the Armdroid it has five axes plus a three-fingered gripper as standard with the option of a two-fingered gripper. Powered by stepper motors on an open loop, transmission is by a belt drive.

Interfaces are available for the BBC, IBM PC, Amstrad and Apple 8-bit machines. The software allows the input of sequences from the keyboard, which will then be repeated at differing speeds, or the development of a sequence off-line using cartesian coordinates to define points in the sequence.

Maximum reach is 380mm and it can lift up tc 5ozs. The base can move through 360 degrees, the shoulder through 270 degrees, elbow 180 degrees, the wrist has continuous rotation with a pitch of 180 degrees. It is priced at £575 plus VAT.

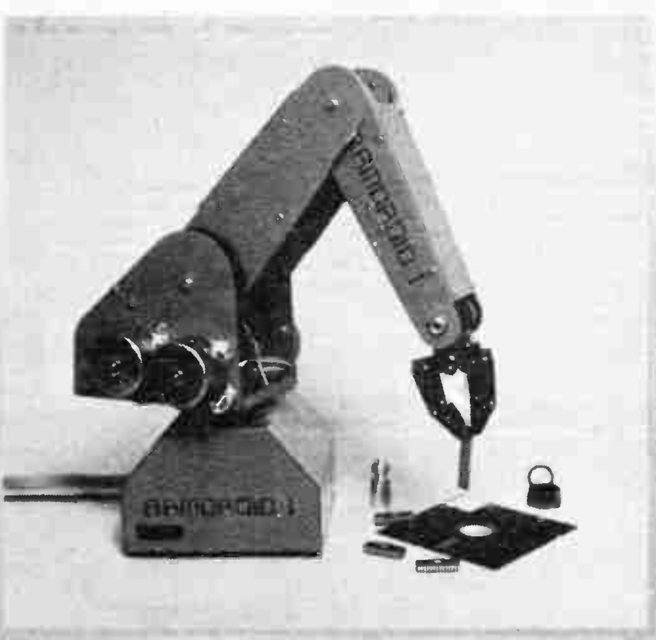
Richmond is also working on a bigger version driven by d.c. motors to be ready later in the year and priced provisionally at £1,400.

NO REPLACEMENT

One of the few Japanese companies to produce a small arm was Mitsubishi with its bottom of the range RM101. The company however has ceased production of this 5-axis stepper-motor driven machine, which has lead to E & L Instruments of Wrexham leaving the arm market.

E & L had included the machine as part of an educational package with a detailed manual and control provided by the company's Fox micro. Reg Jones, UK sales and marketing manager said at the moment the company was not actively seeking a replacement. They were concentrating on their other products but might return if an upturn in demand was seen, however Jones added that there were already a lot of suppliers involved in selling arms.

It is thought that an American company had taken over the rights to make the RM101. The other Mitsubishi arm, the RM 501, which is more robust and suitable for small industrial uses, is still being made.



Marketing of the Armdroid I articulated arm, with five axes plus a gripper driven by stepper motors, is now being undertaken by Qti Colne Robotics of Merthyr Tydfil.

REGENERATIVE RADIOS Part 1

JOE PRITCHARD (G1UQW)

"WHEN I were a lad . . ." (well, about 12 years ago actually), I was very interested in simple radio sets. I built a simple crystal set which tuned the 49, 41 and 31 metre broadcast bands on short wave with a decent aerial and earth. This led onto other homebrew sets, culminating in a two transistor regenerative receiver for the 80m amateur band, based on a design published in a 1973 edition *Everyday Electronics*. The original was for medium waves, but I found that excellent results on short wave could also be obtained, and I soon logged my first US amateurs.

Well, that's how I got interested in the regenerative receiver, a set that's just about the oldest of all the useful amateur designs, but which is still effective today and is cheap to build. In these two articles I'll explore the theory and practice of regenerative radio sets, their operation, some practical ideas, and the results you can expect to get.

WHAT IS A REGENERATIVE RECEIVER?

The simplest of all radio sets is a crystal set; Fig. 1 shows a simple short wave set that you might like to try out. The crystal set allows us to take in stations and hear them with no battery or power supply. All the energy needed comes from the received radio waves. For this reason a good aerial—the larger and higher the better—and an earth—usually a metal object buried in the ground—are normally necessary. Don't use the mains earth. This won't give such good results and could be dangerous.

L1 is the aerial coil—this induces a voltage in L2, the tuning coil, and voltages of a single frequency, that tuned by L2 and VC1, a variable capacitor, are passed on to the diode, D1. This extracts the sound signals being carried on the radio waves tuned in by VC1 and L2, and the earphone or amplifier allows the sounds to be heard. C1 provides a bypass for any radio frequency signals that may have got this far, and R1 provides a discharge path for C1 when a crystal earphone is used. If this were omitted then it's possible that audio quality would suffer.

PROBLEMS

After that whistle-stop tour of the crystal set, why isn't it more commonly used? Well, build one and see! Seriously though, it has a number of shortcomings:

1. Low volume sound output—no audio amplifier.
2. Needs large aerial and good earth.
3. Can only give good results with strong signals.
4. Often you hear two or more stations at once.

Problem 2 is due to the lack of amplification of the radio signals before the audio is extracted by diode D1. D1 acts as a detector and requires that a fairly strong signal be presented to it before the audio can be detected. The response of any radio set to weak signals is called its sensitivity. A set with good sensitivity will receive and make audible very faint signals. The crystal set has poor sensitivity.

Problem 4 is a more serious one; even when we can hear the strong signals, we may be able to hear two or more at once! The set needs to be able to pick out or select one signal at a time for detection. The selectivity of a radio is a measure of this ability, and our crystal set has very poor selectivity. (Fig. 2).

So, what can we do to get around these problems? The solution is in replacing the simple diode detector with an amplifier which will also detect the audio signal. This would clearly solve our sensitivity problem by amplifying the incoming signals.

Fig. 3 shows a simple amplifier and its effect on an incoming radio wave. The signal is made bigger, but its *phase* is reversed. That is, the signal is turned "upside down" by the single stage f.e.t. amplifier. This phase reversal is a common side effect in single stage amplifiers.

POSITIVE FEEDBACK

If we want the most efficiency from just a single stage of amplification, then we can use a technique called *positive feedback* to take a small portion of the output signal and apply it again to the input of the amplifier. The signal is thus amplified again. For this to work, though, the signal fed back to the input must be the same phase as the input; taking a fraction of the out-of-phase output at B and re-applying it at A would actually cancel out the input, thus reducing gain and sensitivity! However, if we have a circuit that will

Fig. 1 The crystal set.

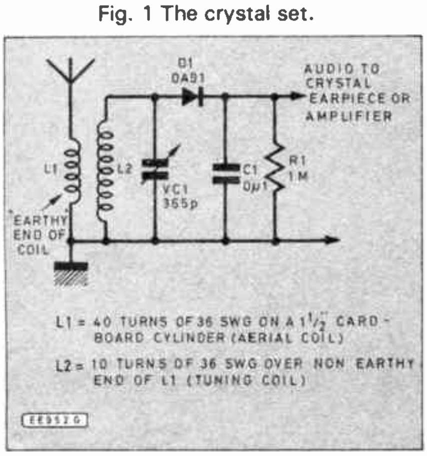


Fig. 2 Crystal set selectivity.

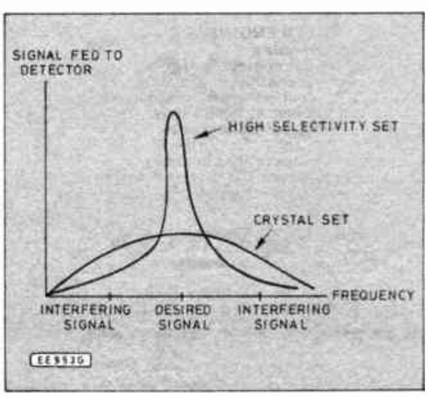
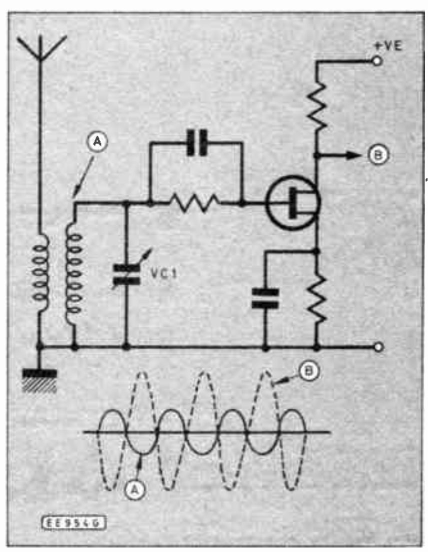


Fig. 3 An amplifier added to a simple receiver.



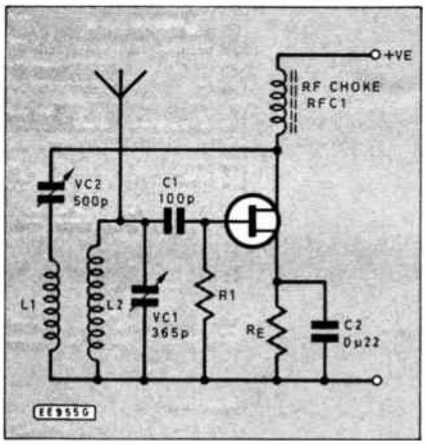


Fig. 4. Simple regenerative receiver.

make the phase of the output like that of the input, the feedback will be effective. Fig. 4 shows such a circuit, with VC2 acting as a control to limit the amount of positive feedback.

Resistor R1, RFC1 and R_E set up the load and bias condition of the f.e.t. L1 does the phase change, and the currents flowing in this induce voltages in L2 which are in phase with the radio signals picked up by the aerial. Thus the gain is increased. If too much positive feedback is applied, then the circuit turns into an oscillator, creating r.f. signals at the frequency set by VC1 and L2.

In order for the signals fed back by VC2/L1 to be in phase with those in L2, coil L1 must be connected the "right way around". One way will not give positive feedback, thus dropping the gain of the amplifier. In practice, if one way of connecting up the feedback coil doesn't give positive feedback, simply try the coil the other way round.

REGENERATIVE

This *regenerative amplifier* gives maximum gain when the positive feedback is at a point just below the level needed to sustain oscillation. This is different for each frequency selected by L2/VC1, hence the use of VC2 to adjust the amount of feedback. You'll probably have realised by now that Fig. 4 is a very simple, almost "classical" regenerative receiver. VC1 is a tuning control and VC2 is the regeneration control, setting the gain of the receiver.

Detection is carried out by virtue of the fact that one half cycle of the input is amplified more than the other half by the amplifier. This is basically distortion of the signal, but it serves the purpose of producing an audio signal.

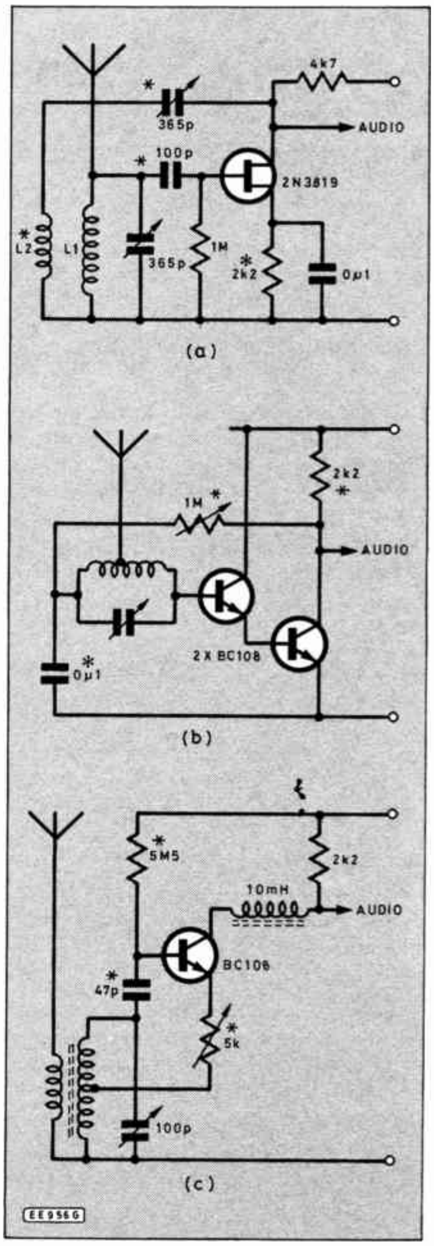
What about the selectivity? Well, poor selectivity is often due to signal losses in L2/VC1. Positive feedback makes up these losses, and this causes the selectivity to increase. The selectivity is highest at a point just below that at which oscillation starts. If positive feedback exceeds this the selectivity will decrease.

And there we have it! The regenerative receiver shown in Fig. 4 is just about as simple as you can get. The main requirements are thus:

1. A tuned circuit.
2. An amplifier.
3. A means of achieving positive feedback.
4. An audio amplifier.
5. An aerial and earth.

For the rest of these two articles I will adopt the following design principles. Items 1, 2 and 3 are found in r.f. oscillator circuits, so I have designed a couple of regenerative receivers by selecting an r.f. oscillator circuit and then reduced its positive feedback to give a regenerative amplifier. This is the "other way around" to the description just given, but it gets the same results. In addition, it's often easier to "calm down" an r.f. oscillator than it is to "beef up" an r.f. amplifier to the point of oscillation.

Fig. 5. Various regenerative receivers.



RF CIRCUITS

The RF stage of these simple sets will be a "calmed down" r.f. oscillator. Some circuits are better than others in this respect, and you may need to experiment to get the best results. However, I've used sets based on the r.f. oscillators shown in Fig. 5. The components used to control positive feedback are shown marked with a * In each case, selection of the "*" parts will have an impact on the performance of the set. You may have to experiment for best results. The coil/capacitor combination is selected to tune the frequency of interest and you may find that a circuit will work well on some frequencies but not others.

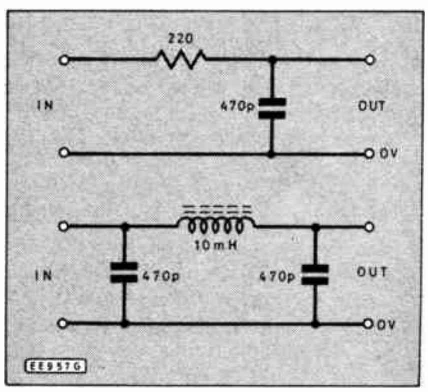
Fig. 5a uses a variable capacitor to control feedback. The others use a variable resistor. The circuits with variable resistors will give as good results and are cheaper, but often need more care in use. In each case, the amount of positive feedback applied is limited, either directly or by limiting the gain of the amplifier. Alternative designs apply sufficient positive feedback to get the circuit into oscillation then apply a small amount of negative feedback to reduce the gain until oscillation no longer occurs.

AUDIO AMPLIFICATION

The audio output provided is usually small, so some sort of amplification is desirable. However, it's also necessary to get rid of any remaining r.f. that might get to the audio amplifier. If this were to happen, the audio amplifier might easily oscillate at r.f., thus generating signals that could interfere with those being received. The cause of this is that many devices used in audio circuits will also work at radio frequencies as well. This isn't very desirable, so we usually include an r.f. filter to short any r.f. signals to earth and prevent them getting to the amplifer. A couple of simple filters are shown in Fig. 6.

The final stage of any regenerative receiver is the audio amplifier stage, usually capable of providing adequate output to headphones. Loudspeakers

Fig. 6. Two simple r.f. filters.



aren't a good idea; some of the squawks and whistles produced by regenerative receivers could tend to strain family relationships if audible to all! Fig. 7a shows a small audio amplifier using the popular LM380 integrated circuit. Alternatively, a simple two transistor amplifier, as shown in Figure 7b, could be used. Both provide output to an 8 ohm pair of headphones.

Well, that completes the outline of the theory of regenerative receivers and the circuit "building bricks" out of which they're made. Next month, I'll give you a couple of practical circuits to experiment with, and explore how to use these sets to get the best results.

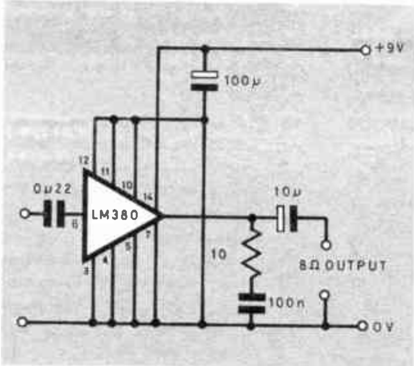


Fig. 7a. Integrated circuit amplifier.

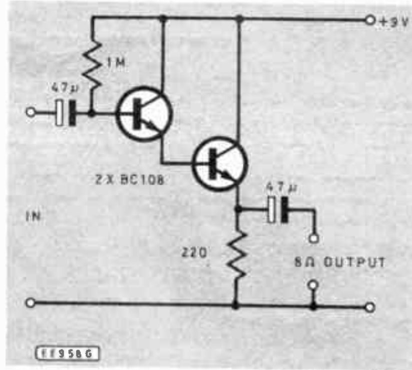


Fig. 7b. Two transistor amplifier.

SHOP TALK

BY DAVID BARRINGTON

Whoof Whoof!

If you do not have or are unable to take advantage of a local "neighbourhood watch" group, the problem of safe guarding your home from unwanted intruders is always an added worry when you want to take your annual holidays. If you have a pet/guard dog it usually travels with you or is boarded out during this period, leaving the home unattended.

A novel approach to this problem from **TK Electronics** would appear to offer an ideal solution to this problem. With the holiday season approaching, they have produced an "Electronic Dog" kit, whose bark is definitely worse than its bite!

The "dog" may be connected to a doorbell, pressure mat or to any other intruder device, such as an infra-red beam alarm.The only food required is an 18V d.c. or 12V a.c. supply, which it consumes at only 4mA, when not barking!

A re-entrant loudspeaker is provided, which, it is claimed, is essential to generate the loud barks required to deter the intruder. The "guard dog" can be adjusted to give a random sequence of barks and can be "tuned" to mimic a range of voices from a terrier to an alsatian.

The kit comes complete with p.c.b., mains transformer and full instructions, and costs £21.95 plus VAT. For details, contact **TK Electronics, Dept EE, 13 Boston Road, London W7 3SJ.**

Next month: We hope to offer the first "litter" of Electronic Dogs to readers of EE at a special price!

Enterprise

Last month we advised readers of the "bargain price" offered by Greenweld Electronics for the Enterprise 64 home computer. We must report that within the first few days of publication of EE, the entire stock of *complete* Enterprises had been sold.

CONSTRUCTIONAL PROJECTS

Visual Guitar/Instrument Tuner

Most of the parts required for the *Visual Guitar/Instrument Tuner* appear to be standard components and should be available from most component suppliers. However, for those readers who experience difficulties, a complete kit (£21.99, including p.c.b.) is available from **Magenta Electronics, Dept EE, 135 Hunter Street, Burton on Trent, Staffs DE14 2ST.** Add £1 for p&p per order.

The printed circuit board is obtainable through the EE PCB Service—see page 340.

When ordering components, it is important to specify the standard BC184 for transistor TR1 and **not the BC184L**. The leadouts for the L are different (centre lead being collector) and can cause confusion.

RS232C Breakout Box

The chassis mounting 25-way D-sockets called for in the *RS232C Breakout Box* "comp list" are now fairly common items and should not cause local sourcing problems. The sloping front instrument case was purchased from Electromail, stock code 509-276 (£11.25). However, it is not essential to use the same case as the prototype model and any case that will accommodate the circuit board and "patching" matrix will suffice.

As a total of 62 1mm chassis mounting sockets are required for this project, it might be worth while asking for a "bulk" discount. Alternatively, one of our "bargain packs" advertisers, such as **Bi-Pak** or **MJR Wholesale,** should be willing to help.

The only source we have been able to locate for the insulated 0.4in p.c.b. jumper plugs is from **Electromail**. These are available in packs of ten, with red and black mouldings, and are listed under p.c.b. selector plugs, stock codes: red—435 428 and black—435 412.

EE Apex Hi Fi Amplifier

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

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

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

Mini Disco Light

We have only been able to find two suppliers who list the specified triac opto-isolator used in the *Mini Disco Light*. The MOC3020 device is currently listed by **TK Electronics and Electromail**.

The input current to trigger the triac is a typical 15mA and a maximum 30mA. The triac output is capable of switching 240V a.c. supplies. As these characteristics appear to be fairly standard, most component suppliers should be able to supply an equivalent device.

It is most important to use 3A three-core mains wire when specified. Please remember that since mains voltages exist inside the case, extreme care must be taken whenever it becomes necessary to inspect the circuit for faults. If possible, always unplug from the mains when testing the unit.

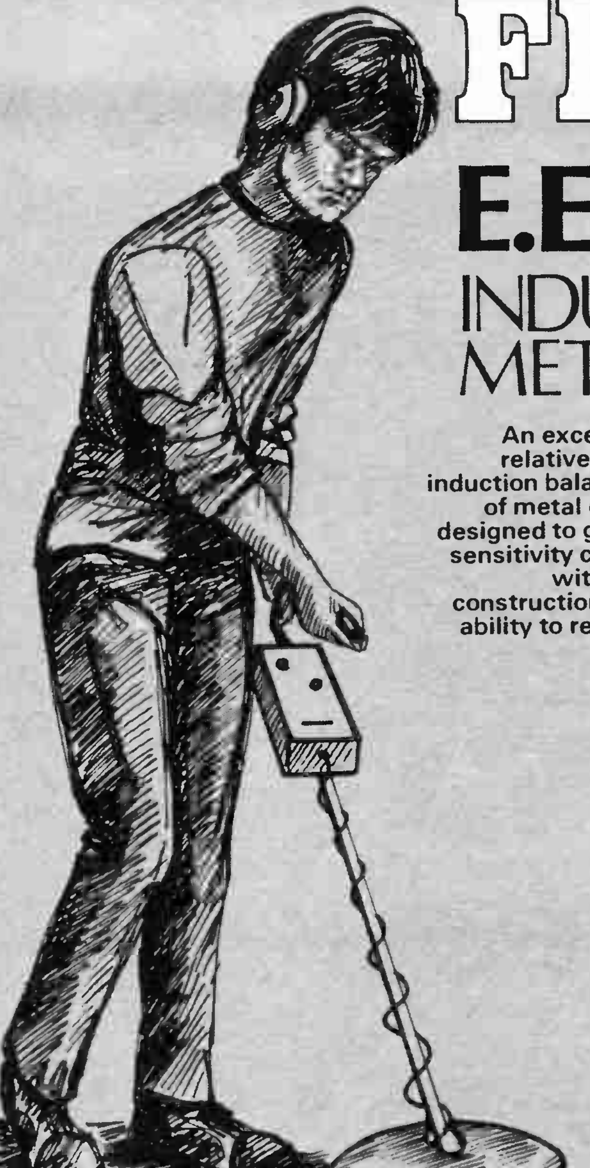
Door Chime

The specified instrument case for the *Door Chime* is available from **Verospeed**, code 65-40767F (£6.41). The beige/brown type made a change to the usual standard grey Verobox.

The choice of "chime" is left to the constructor and is governed by the chip used. The only sources for the three-note chime i.c., type SAB0600, we have been able to locate are **TK Electronics** and **Electrovalue.**

We cannot foresee any component buying problems for the *Simple Touch Switch —Exploring Electronics project. Several of our advertisers are prepared to make up complete kits of parts.*

JULY FEATURES



E.E.Buccaneer
INDUCTION BALANCE METAL DETECTOR

An excellent but relatively simple induction balance type of metal detector, designed to give good sensitivity combined with ease of construction and the ability to reject iron.

FERMOSTAT

A simple unit for controlling the temperature of fermenting wine. The Fermostat can also be used to control virtually any form of mains heating, holding the temperature constant.

MONOMIX

A simple four channel monophonic mixer designed primarily with the video enthusiast in mind. One input is for a microphone and the other three are line level inputs for sources such as cassette decks, tuners, etc.

MIDI THRU BOX

MIDI means Musical Instrument Digital Interface. MIDI THRU is a buffered duplication of the MIDI IN signal. Unfortunately, many manufacturers do not include this socket. However, at its best it cannot match a MIDI THRU box, which allows any of the devices to be used as the Master and provides several MIDI THRU outputs.

EVERYDAY ELECTRONICS

OUR JULY ISSUE IS ON SALE ON FRIDAY JUNE 19.

...RPM and Frequency Meter...

IN THE previous article the subjects of event timing and frequency counting using the BBC Micro were covered, but the frequency meter circuit was rather crude in that it would only operate with signals at logic levels, and it provided a maximum input frequency of 65.535kHz. Both these limitations can be overcome by adding suitable input circuits, with no modifications being required to the basic gating circuit described last month. In this article we will conclude our look at use of the timer counters with some input circuits for the digital frequency meter unit that enable it to be used as an audio frequency measurement, radio frequency measurement, or as a revolutions per minute (r.p.m.) meter.

Audio Use

For audio frequency applications the basic 0 to 65.535kHz range of the frequency meter should be perfectly adequate, as should the 1Hz resolution. Its shortcoming in this application is that most audio sources will not reliably drive the unit. Even those signals that do provide a high enough drive level may not have sufficiently short rise and fall times to give reliable operation, and there is a danger of high level signals actually damaging at least the input device. Thus, really all that is required is some signal conditioning circuitry ahead of the main frequency meter circuit.

A suitable circuit appears in Fig. 1, and this consists basically of an input protection circuit, a high input impedance buffer stage, a voltage amplifier, and a Schmitt trigger. The input impedance is just under one megohm and an input level of only about four millivolts r.m.s. is required to drive the circuit properly.

Resistor R1, D1, and D2 provide a simple clipping action that limits the input signal to about 1.3V peak to peak and prevents high signal levels from damaging any subsequent circuitry. Of course, there is a limit to the input level that can be applied to the unit without damaging the protection circuit, but this should be over 100V peak to peak, and very much higher than the signal level from any likely audio signal source.

IC1 acts as the buffer stage, and this is a simple operational amplifier voltage follower circuit. TR1 provides the voltage amplification, and this is a common emitter stage which provides around 40dB of voltage gain. Finally, IC2 is connected as a conventional operational amplifier Schmitt trigger. VR1 is adjusted to optimise sensitivity.

The circuit is quite simple, but when constructing it bear in mind that the unit is quite sensitive and has a high input impedance. Due care must be taken to avoid problems with stray feedback and pick up of electrical noise, and the test leads should be the screened variety (the types used for oscilloscopes being equally suitable for this application).

RPM Interface

In some cases r.p.m. measurement can be achieved by tapping off a signal from the equipment being monitored, and then using some signal conditioning to give an output at logic levels to drive the basic frequency meter unit. The circuit of Fig. 1 will often be suitable as the signal conditioner in applications where this approach is usable. It is obviously not applicable in all cases, since not all machinery is electrical in nature, and there may be no easy and safe way of tapping off a signal anyway.

There are two common approaches to monitoring shaft rotation without actually building some form of pulse generator into the machinery. One is to fix small magnets onto the shaft and then detect the passing magnetic poles using a Hall effect device or some other form of magnetic sensor. The other is to use a method of optical detection, and this is generallly the type which can be most easily implemented in practice. There is more than one approach to this problem, but the method which seems to be the most simple, and which will normally give excellent results, is to use reflective optical detection.

The basic idea is to shine a light onto the shaft, with a photocell to detect the reflected light level. Alternate light and dark bands are marked around the shaft so that as it rotates it alternately reflects large and small amounts of light onto the photocell. The signal from the photocell is amplified and used to drive the frequency meter circuit. Calibration of r.p.m. meters can often be a problem, but in this case it is just a matter of applying some simple mathematics in the software in order to get a direct reading in r.p.m., with no adjustments being needed.

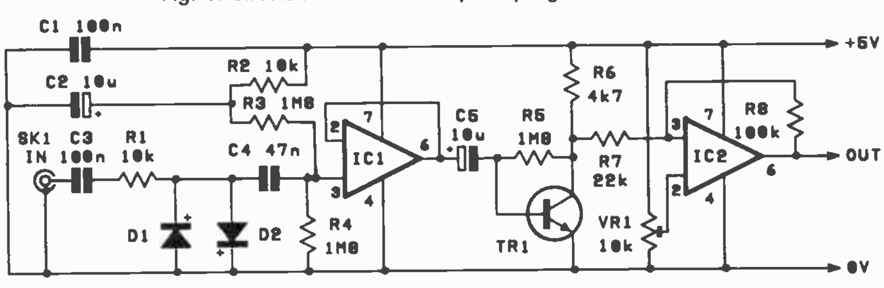
The exact mathematics required depends on the number of bands marked around the shaft. In general, the more bands that are used the better as this helps to give good resolution. On the other hand, making the bands too narrow would make the system unreliable, or could even prevent it from working at all. This is really a matter of experimenting to find the best compromise. For the sake of this example we will assume that there are six dark bands and six light ones. Each pair of bands produces one pulse per revolution, giving a total of six pulses per revolution. The frequency meter has a one second gate period and normally gives readings direct in Hertz, but in this case a gate period of one minute is required in order to give a direct reading in r.p.m. Such a long gate period could be achieved by modifying the divider circuit, but it is inconveniently long for most purposes. It is normally necessary to settle for a relatively short gate period and to accept the reduced resolution that this provides.

In this case, sixty r.p.m. are needed in order to produce one pulse per gate period, but with six pulses per revolution this conveniently gives ten r.p.m. per measured pulse. In other words, simply dividing the frequency reading by ten gives an answer in r.p.m., and the resolution is ten r.p.m. This should be adequate for most applications. The frequency meter program provided in last month's article could obviously be very easily modified to suit this application. Using other than six sets of bands around the shaft might make the mathematics work out less conveniently than this, and it is probably best to only use three, six, or twelve sets of bands. These represent resolutions of twenty, ten, and five r.p.m. respectively.

Optical RPM Interface

A suitable optical r.p.m. interface appears in Fig. 2. D1 is the light source, and it should ideally be a five millimetre, high brightness l.e.d., or better still an ultra-high brightness type. TR1 is the photocell, and this is a silicon photo-transistor having a built-in lens. Virtually any silicon n.p.n. photo-transistor will work in this circuit, but for good results it is best to use a type which has a built-in lens. The fluctuations in received light level result in small changes in TR1's collector current, which in turn give variations in the collector voltage. These are then amplified by TR2 to bring them to a suitable level to drive the Schmitt

Fig. 1. Circuit of the audio frequency signal conditioner.



D1, 2 1N4148 TR1 = BC549 IC1 = CA3140E IC2 = CA3130E

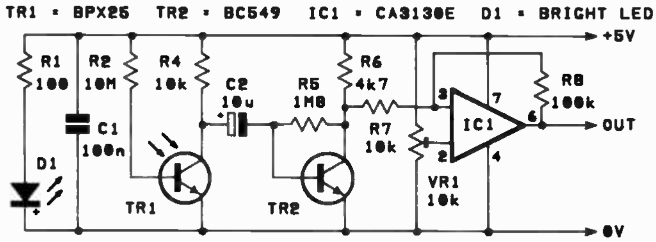


Fig. 2. The r.p.m. interface circuit.

trigger circuit based on IC1. This provides a suitable output signal for the frequency meter circuit.

In Use

In use TR1 and D1 are mounted side by side and aimed in the same direction. I did not experience any difficulty in obtaining good results from this set up, but for optimum results it is a good idea to shield TR1 from any light it might otherwise receive direct from D1, and it seems to be necessary to have the two cells about 10 millimetres or more away from the shaft. The maximum usable distance is very much dependent on the strength of the light output from D1, and the reflectivity of the light bands around the shaft. I found that good results could be obtained by marking black bands onto a metal shaft using a marker pen. Presumably even better results would be obtained using mat black paint though. Of course, the system can only work well if the shaft is shielded from strong light sources other than D1 (especially mains lighting which carries 100Hz modulation that could prevent correct operation of the system).

R.F. Frequency Meter

There is no difficulty in extending the maximum operating frequency of the basic frequency meter circuit, and it merely requires the addition of a prescaler. This is just a frequency divider circuit, and with a division rate of one hundred for example, the full scale reading would be increased to 6.5535MHz. There is a disadvantage in the prescaler method in that it reduces the resolution of the system, with 100Hz resolution being obtained in this case. However, there is no easy solution to this problem, and for a radio frequency d.f.m. a resolution of 100Hz or even 1kHz is sufficient for most purposes.

The circuit diagram for a simple three stage prescaler and input amplifier is shown in Fig. 3. The input amplifier consists of a source follower input stage (TR1), a common emitter voltage amplifier (TR2), and an emitter follower output stage (TR3). The input sensitivity is about 20 millivolts into one megohm, but the gain falls away somewhat at high frequencies, and the input impedance also reduces substantially at high frequencies.

The prescaler is a three stage divide by ten type, with each stage consisting of a 74LS90 decade counter in the standard divide by ten configuration. S1b selects either the divided by ten, divided by one hundred, or the divided by one thousand signal, and it therefore operates as the range switch. The three ranges are 65.535MHz, 6.5535MHz, and 655.35kHz respectively, giving resolutions of 1kHz, 100Hz, and 10Hz respectively. Note that on the highest frequency range it might not be possible to obtain operation right up to the 65.535MHz maximum frequency. The input amplifier might not operate properly right up to this frequency, and the 74LS90 is only guaranteed to operate up to 42MHz. The unit should certainly work well at frequencies up to the 30MHz upper limit of the short wave range.

```
  10 REM DFM PROGRAM
  20 REM FOR BBC MICRO JWP 3/87
  30 MODE 7
  40 PRINTTAB(12,3)CHR$(141);"DFM READOUT"
  50 PRINTTAB(12,4)CHR$(141);"DFM READOUT"
  60 ?&FE6B=224
  70 ?&FE64=80
  80 ?&FE65=195
  90
 100 REPEAT
 110 ?&FE68=255
 120 ?&FE69=255
 130 IF (?&FE60 AND 32)=0 THEN 130
 140 IF (?&FE60 AND 32)=32 THEN 140
 150 PRINTTAB(15,14)CHR$(141);FNread
 160 PRINTTAB(15,15)CHR$(141);FNread
 170 PRINTTAB(15,8)CHR$(141);R$
 180 PRINTTAB(15,9)CHR$(141);R$
 190 UNTIL FALSE
 200 END
 210
 220
1000 DEF FNread
1010 R=FNrange
1020 V=FNval
1030 IF R=1 THEN V=V/100:R$=" kHZ":@%=&
2020A
1040 IF R=2 THEN V=V/10000:R$=" MHZ":@%
=&2040A
1050 IF R=3 THEN V=V/1000:R$=" MHZ":@%=
&2030A
1060 =V
1070
1080
2000 DEF FNrange
2010 N=?&FE60 AND 14
2020 IF N=12 THEN R=1
2030 IF N=10 THEN R=2
2040 IF N=6 THEN R=3
2050 =R
2060
2070
3000 DEF FNval
3010 LB=?&FE68
3020 HB=?&FE69*256
3030 val=LB+HB
3040 val=65535-val
3050 =val
```

Switch S1a is used to indicate to the computer which range is in use so that the software can adjust the display to have the decimal point in the right place, and show the units of measurement as 'kHz' or 'MHz', as appropriate. This is achieved by pulling one of lines PB2 to PB4 low, and reading these lines on each loop of the software. Suitable software for use with this unit is provided in the above listing.

An alternative which might be worth pursuing would be to use spare lines of the user port as outputs to drive a data selector which would be used to select the appropriate output of the prescaler. The required range would then be selected using the computer's keyboard and suitable software routines.

It is certainly well worth gaining an understanding of the BBC machine's timer/ counters, and they can be useful in a variety of applications. They are a subject to which we will probably return at some later date.

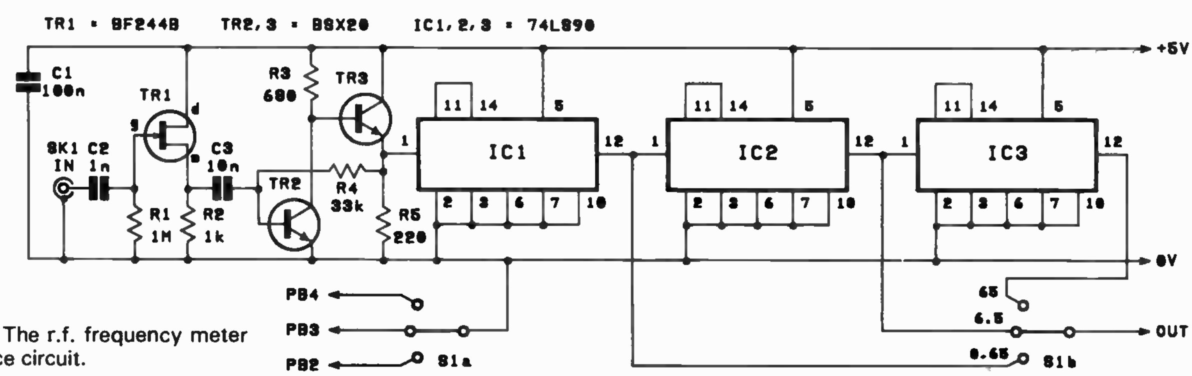
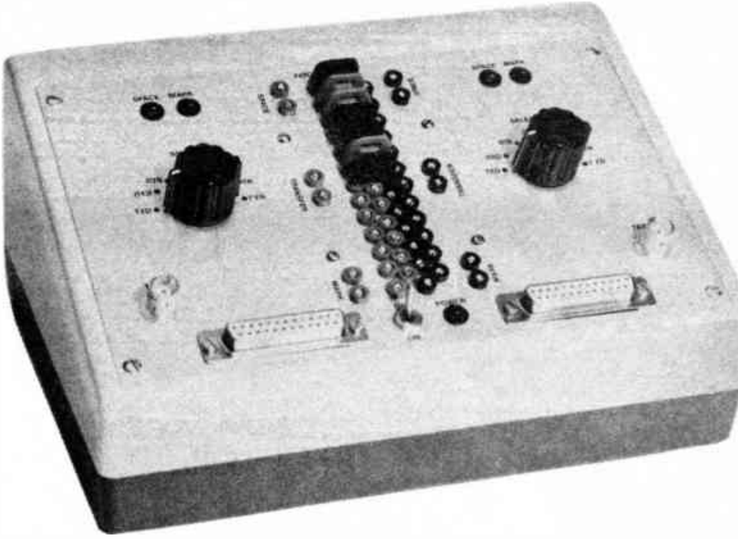


Fig. 3. The r.f. frequency meter interface circuit.

Digital Trouble Shooting
Part Eight



MIKE TOOLEY BA

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

IN LAST month's instalment of *Digital Troubleshooting* we dealt with programmable I/O devices. This month we shall continue this theme by taking a look at two important methods of interconnecting microprocessor based systems and peripheral devices.

The first of these makes use of the well known (but often misunderstood!) RS-232C serial interface whilst the second, somewhat lesser known system, is the IEEE-488 General Purpose Instrument Bus (GPIB). Our companion Digital Test Gear Project is dedicated to the construction of an *RS-232C Break-out Box.*

RS-232C

The RS-232C/CCITT V24 interface undoubtedly reigns supreme as the most widely used standard for serial communication between microcomputers and peripheral devices. The interface, defined by the Electronic Industries Association (EIA) standard, relates essentially to two types of equipment. The first of these is known as Data Terminal Equipment (DTE) whilst the second is referred to as Data Communications Equipment (DCE).

To avoid one of the most problematic pitfalls of the RS-232C system, it is important to make a clear distinction between these two forms of equipment. Data Terminal Equipment (e.g. a microcomputer) is capable of sending and/or receiving data via the serial interface. It is thus said to "terminate" a serial link.

Data Communications Equipment, on the other hand, is generally thought of as a device which can facilitate serial data communications in conjunction with a DTE. A prime example is that of a modem (modulator-demodulator). This device forms a link in the serial chain between a microcomputer and a telephone line (as shown in Fig. 8.1).

Unfortunately the distinction between DTE and DCE is somewhat blurred and this gives rise to a number of problems. Consider,

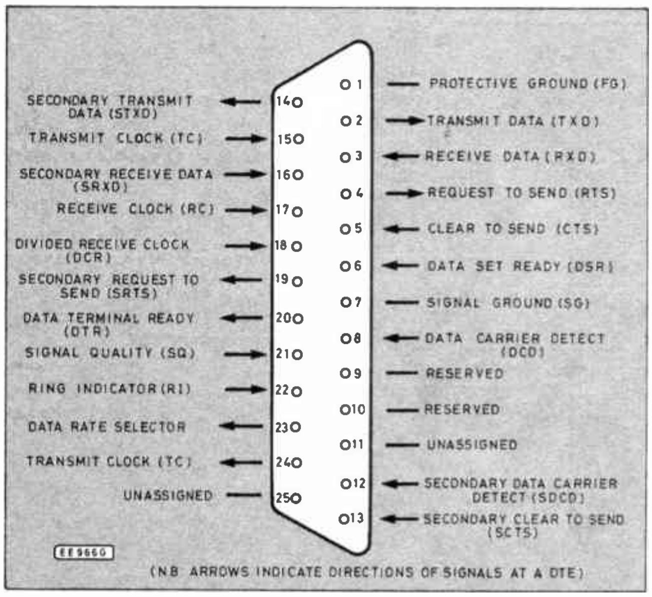
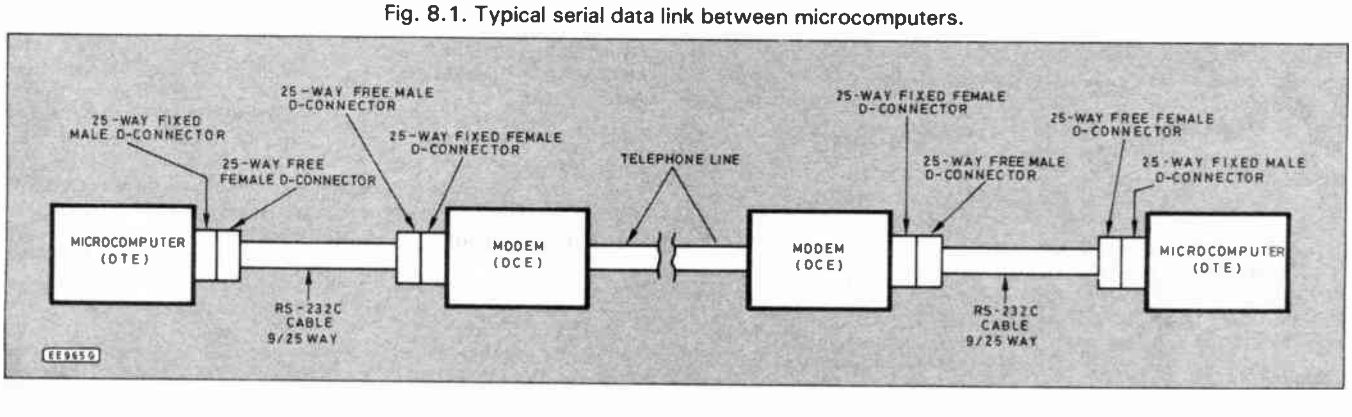


Fig. 8.2. Pin assignment of the 25-way D-connector used with RS-232C.

for example, the case of a printer. Is this a DTE or DCE? Alternatively, suppose we need to link together two microcomputers when both machines are configured as DTE. How can this be achieved?

The key to both of these problems lies in the physical interconnection of the devices. With only a few changes to the wiring of the

Fig. 8.1. Typical serial data link between microcomputers.



RS-232C system, it is quite possible to make a DCE behave as a DTE, and vice versa. To understand how this can be achieved it is necessary to have some idea of the function of each of the RS-232C signals.

RS-232C SIGNALS

Readers will almost certainly be familiar with the appearance of a "standard" RS-232C serial port which invariably takes the shape of a 25-way D connector. DTE equipment is normally fitted with a male connector whilst DCE equipment uses a female connector (*note that this is not a hard and fast rule and there are a few exceptions!*).

The pin assignment for the RS-232C connector is shown in Fig. 8.2 and the function of each of the lines is listed in the table shown below:

Pin No.	Abbreviation	Direction	Full name
1	FG	—	Frame or protective ground
2	TD (TXD)	To DCE	Transmitted data
3	RD(RXD)	To DTE	Received data
4	RTS	To DCE	Request to send
5	CTS	To DTE	Clear to send
6	DSR	To DTE	Data set ready
7	SG	—	Signal ground
8	DCD	To DTE	Data carrier detect
9		To DTE	(positive test voltage)
10		To DTE	(negative test voltage)
11	QM	To DTE	Equaliser mode
12	SDCD	To DTE	Secondary data carrier detect
13	SCTS	To DTE	Secondary clear to send
14	STD	To DCE	Secondary transmitted data
15	TC	To DTE	Transmit clock
16	SRD	To DTE	Secondary received data
17	RC	To DTE	Receive clock
18	DCR	To DTE	Divided receive clock
19	SRTS	To DCE	Secondary request to send
20	DTR	To DCE	Data terminal ready
21	SQ	To DTE	Signal quality
22	RI	To DTE	Ring indicator
23		To DCE	(data rate selector)
24	TC	To DCE	External transmit clock
25		To DCE	(busy)

Notes:

1. Lines 11, 18 and 25 are normally referred to as "unassigned". The functions given above relate to the Bell 113B and 208A specifications.
2. Lines 9 and 10 are often referred to as "reserved". A typical use for these lines is testing of the positive and negative voltage levels used to represent the MARK and SPACE levels.
3. To avoid any confusion which may exist between RD (Read) and RD (Received data), we shall refer to RXD and TXD (rather than RD and TD) throughout. We shall similarly refer to SRXD and STXD for the secondary channel (rather than SRD and STD).
4. Some manufacturers use "spare" RS-232C lines for testing or for special functions peculiar to particular hardware (some equipment even feeds power and analogue signals along "unused" RS-232C lines—so beware!).

Signal categories

RS-232C signals fall into one of three categories which may be briefly summarised as follows:

Serial data (e.g. TXD, RXD)

RS-232C provides for two independent serial data channels (described as "primary" and "secondary"). Both of these channels provide for full duplex operation (i.e. simultaneous transmission and reception).

Handshake control signals (e.g. RTS, CTS)

The handshake signals provide the means by which the interchange of signals is controlled allowing, for example, a DTE to open a dialogue with the DCE prior to actually transmitting or receiving data over the serial data path.

Timing signals (e.g. TC, RC)

For synchronous (rather than the more usual asynchronous) mode of operation, it is necessary to pass clock signals between the devices. These timing signals facilitate synchronism of the received signal for decoding purposes.

In practice, few RS-232C implementations make use of the secondary channel and, since asynchronous (non-clocked) operation is the norm, only eight or nine of the 25 are regularly used. The function of these lines are listed below:

Pin No.	Signal	Function
1	FG	Earth connection to the equipment frame or chassis.
2	TXD	Serial data transmitted from DTE to DCE.
3	RXD	Serial data received by the DTE from the DCE.
4	RTS	When active, the DTE is signalling that it wishes to send data to the DCE.
5	CTS	When active, the DCE is signalling that it is ready to accept data from the DTE.
6	DSR	When active, the DCE is signalling that a communications path has been properly established.
7	SG	Common signal return path.
8	DTR	When active, the DTE is signalling that it is operational and that the DCE may be connected to the communications channel.

RS-232C WAVEFORMS

In most RS-232C systems, data is transmitted asynchronously. This simply means that it is transmitted as a series of "data packets". Each data packet contains sufficient information for it to be decoded without the need for a separate clock signal. Each packet contains a single ASCII character.

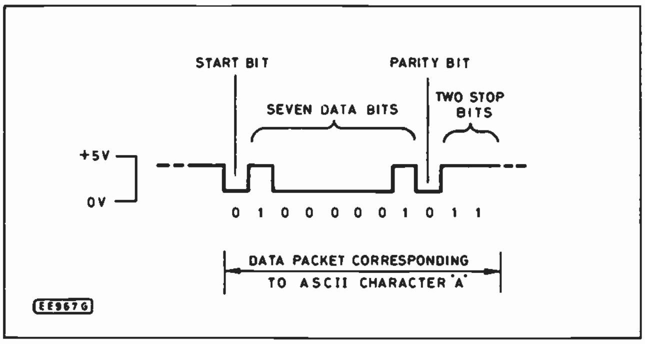


Fig. 8.3. Typical representation of the ASCII character 'A' using TTL signal levels

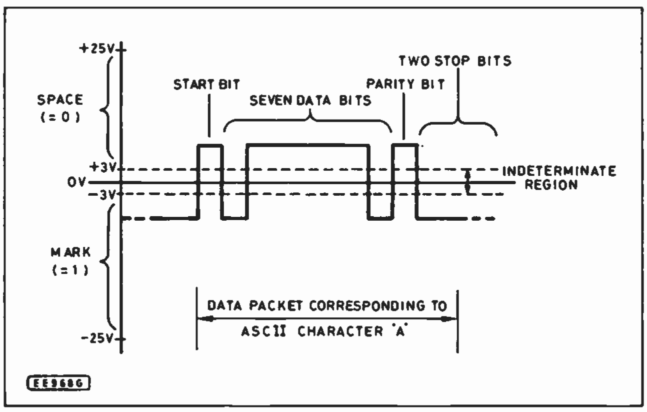


Fig. 8.4. ASCII character 'A' as it would appear on the TXD or RXD signal lines.

Readers will probably be aware that ASCII characters are represented by seven binary digits (bits). The upper case letter 'A', for example, is represented by the seven-bit binary word: 1000001. In order to send a letter 'A' via an RS-232C system, we need to add extra bits to signal the start and end of the data packet. In addition, we may wish to add an extra bit to provide a simple parity error detecting facility.

One of the most commonly used schemes involves the use of one start bit, one parity bit, and two stop bits. The equivalent TTL signal for an ASCII character 'A' has been shown in Fig. 8.3. The commencement of the data packet is signalled by the low start bit. This bit is always low irrespective of the contents of the packet.

The start bit is followed by the seven data bits representing the ASCII character concerned. A parity bit is added to make the resulting number of 1's in the group either odd ("odd parity") or even ("even parity"). Finally, two stop bits are added. These are both high.

The complete asynchronously transmitted data word thus has eleven bits (note that only seven of these actually contain data!). In

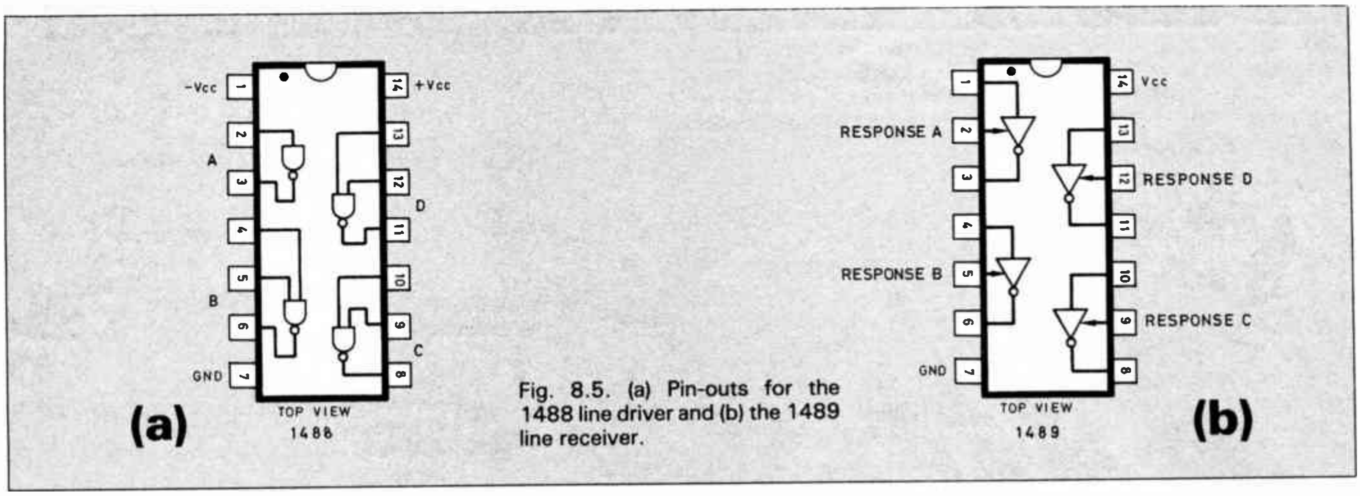


Fig. 8.5. (a) Pin-outs for the 1488 line driver and (b) the 1489 line receiver.

binary terms the word can be represented as: 01000001011. In this case, even parity has been used and thus the ninth (parity bit) is a 0.

Unfortunately, the voltage levels employed in an RS-232C system are quite different from those used within a microcomputer. A postive voltage (of between +3V and +25V) is used to represent a logic 0 (or *SPACE*) whilst a negative voltage (of between −3V and −25V) is used to represent a logic 1 (or *MARK*). Fig. 8.4 shows the waveform of a data packet corresponding to the ASCII character 'A' as it would appear on the RS-232C TXD or RXD lines.

The level shifting (from TTL to RS-232C signal levels and vice versa) is accomplished using special "line driver" and "line receiver" chips. The most commonly used devices are the 1488 and 1489 devices, the pinouts for which are shown in Fig. 8.5.

A typical microcomputer RS-232C interface is shown in Fig. 8.6. IC1 is a programmable serial I/O device which provides the necessary parallel-to-serial and serial-to-parallel data conversion. IC2 and IC3 provide level shifting for the three output signals (TXD, RTS and DTR) whilst IC4 provides level shifting for the three input signals (RXD, CTS and DSR). Readers should note that IC2 and IC3 both require ± 12V supplies.

ENHANCEMENTS

Several further standards have been introduced in order to overcome some of the shortcomings of the original RS-232C specification. These generally provide for better line matching, increased distance capability, and faster data rates.

Notable amongst these systems are the RS-422, a balanced system which caters for a line impedance as low as 50 ohm and the RS-432, an unbalanced system which will tolerate a line impedance of 450 ohm minimum. There is also the RS-449, a very fast serial data standard which uses a number of changed circuit functions and a 37-way D-connector.

RS-232C TEST EQUIPMENT

Where one is engaged in regularly testing or commissioning systems which use an RS-232C (or equivalent) serial interface, a number of specialised accessories and test instruments will be required. The following items are commonly available:

Patch Boxes

Patch boxes are low-cost devices which facilitate the cross connection of RS-232C signal lines. The equipment is usually fitted with two D-type connectors (or ribbon cables fitted with a plug and socket) and all lines are brought out to a patching area into which links may be plugged. In use, these devices are connected in series with the RS-232C serial data link and various patching combinations are tested.

Gender Changers

Gender changers normally comprise an extended RS-232C connector which has a male connector at one end and a female connector at the other.

Fig. 8.6. Typical RS-232C interface circuitry.

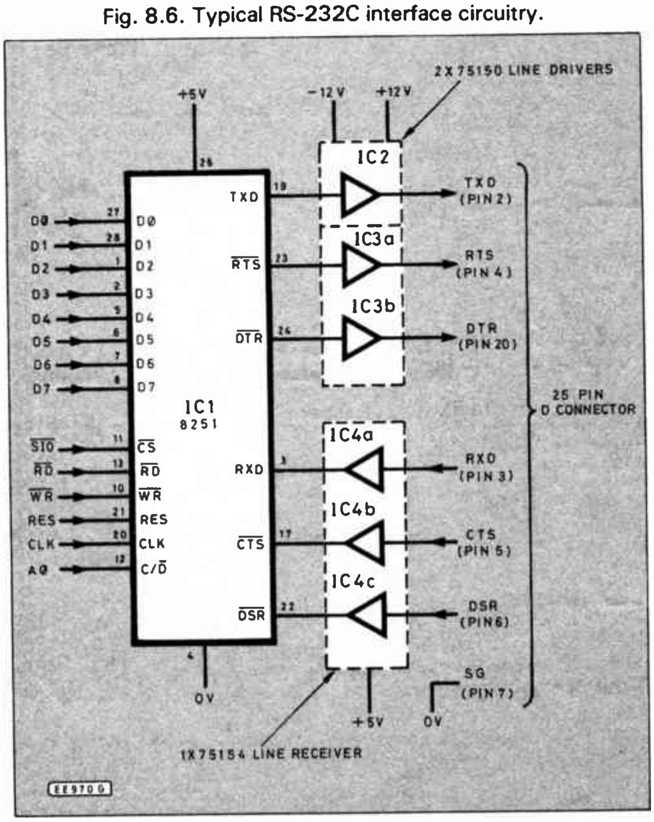
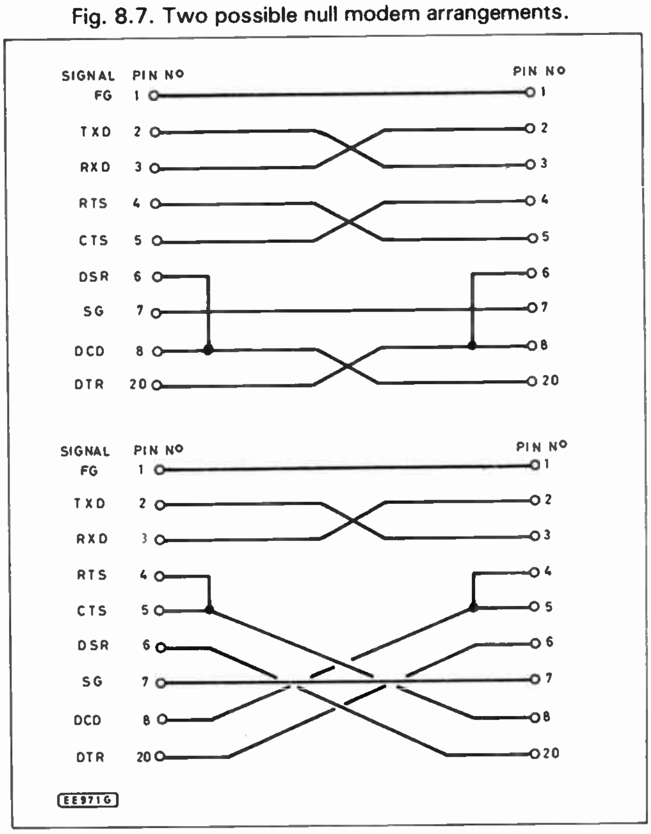


Fig. 8.7. Two possible null modem arrangements.



Null Modems
Like gender changers, null modems are connected in series with the RS-232C serial data path. Their function is simply that of changing the signal lines so that a DTE is effectively configured as a DCE. Null modems can easily be set up using a patch box or manufactured as required. Fig. 8.7 shows two possible null modem configurations.

Line Monitors
Line monitors display the logical state (in terms of MARK or SPACE) present on the most commonly used data and handshaking signal lines. They thus give the user a rapid indication of which signals are present and active within the system.

Breakout Boxes
Breakout boxes provide access to the signal lines and usually combine the features of patch boxes and line monitors. In addition, switches or jumpers are usually provided for linking lines on either side of the box. Connection is almost invariably via two 25-way ribbon cables terminated with connectors.

Interface testers
Interface testers are somewhat more complex than simple breakout boxes and may incorporate facilities for forcing lines into MARK or SPACE states, detecting "glitches", measuring baud rates, and even displaying the data word structure in use. Such instruments are, not surprisingly, rather expensive and a fully fledged interface tester will usually cost in excess of £250.

FAULT FINDING ON RS-232C SYSTEMS

Fault finding on RS-232C systems usually involves the following basic steps:

(a) Ascertain which device is the DTE and which is the DCE. This can usually be accomplished by simply looking at the connectors (remember that DTE equipment is normally fitted with a *male* connector whilst DCE equipment invariably uses a *female* connector). Where both devices are configured as DTE (as is often the case) a null modem will have to be inserted for correct operation.

(b) Check that the correct cable has been used. Note that RS-232C cables are provided in a variety of forms; 4-way (for "dumb" terminals), 9-way (for normal asynchronous data communications), 15-way (for synchronous communications), and 25-way (for "universal" applications). Fig. 8.8 shows the various possibilities which exist. If in doubt, use a full 25-way cable.

(c) Check that the correct word format and baud rate has been selected at each end of the serial link.

(d) Activate the link and investigate the logical state of the data (TXD and RXD) and handshaking (RTS, CTS etc) signal lines using a line monitor, breakout box, or interface tester.

(e) If in any doubt, refer to the equipment manufacturer's data in order to ascertain whether any special connections are required and to ensure that the interfaces are truly compatible. Note especially that some manufacturers have implemented quasi-RS-232C interfaces which make use of TTL signals. These are clearly *NOT* electrically compatible with the normal RS-232C system even though they may use identical protocols!

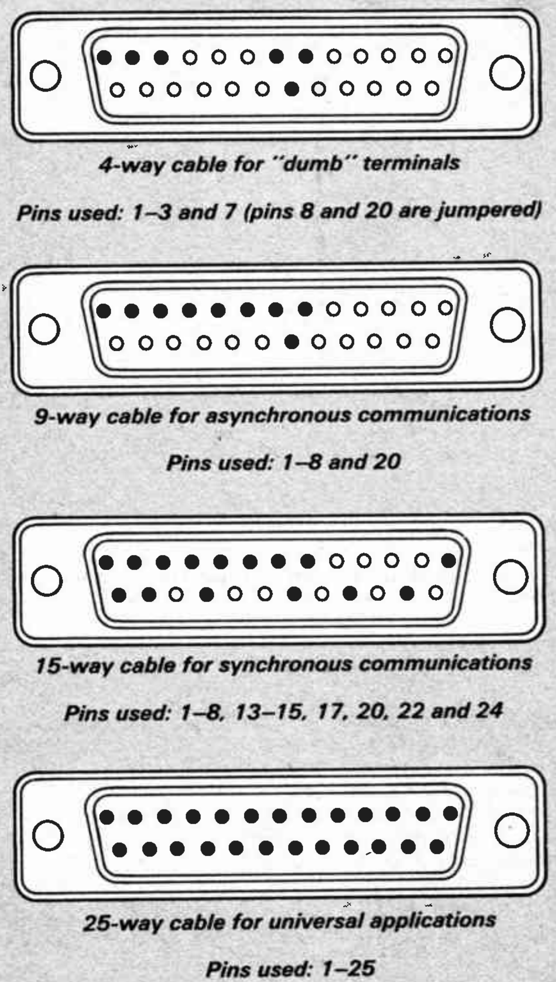


Fig. 8.8. Various possibilities for RS-232C data cables.

THE IEEE-488 GENERAL PURPOSE INSTRUMENT BUS

The IEEE-488 bus (also known as the Hewlett Packard Instrument Bus or General Purpose Instrument Bus) is popularly used as a means of interconnecting microcomputer controllers in automatic test equipment (ATE) configurations. Many of the more powerful items of modern electronic test equipment (including digital voltmeters and signal generators) are fitted with the necessary IEEE-488 interface to allow them to be connected to a microcomputer controller which can be used to both supervise their operation and process data which they may collect.

The IEEE-488 standard provides for the following categories of device:

Listeners
Listeners can receive data and control signals from other devices connected to the bus but are not capable of generating data. An obvious example of a listener is a signal generator.

Talkers
Talkers are only capable of placing data on the bus and cannot receive data. A typical example of a talker is a tape reader. Note that, whilst only one talker can be active at a given time, it is possible for a number of listeners to be active and receiving data at the same time!

Talkers/listeners
Talkers/listeners can both send and receive data to/from the bus. A digital multimeter is a typical example of a talker/listener. Data is sent to it in order to change ranges and returned to the bus in the form of digitised readings of voltage, current, and resistance.

Controllers
Controllers are used to supervise the flow of data on the bus and provide processing facilities. The controller within an IEEE-488 system is invariably a microcomputer and, whilst many systems make use of the ubiquitous IBM PC, some test equipment manufacturers provide their own dedicated microprocessor based controllers.

The IEEE-488 bus uses 8 multi-purpose bi-directional data lines. These are used to transfer data, addresses, commands and status bytes. In addition, five bus management and three handshake lines are provided.

The connector used for the IEEE-488 bus is invariably a 24-pin type (as shown in Fig. 8.9) having the following pin assignment:

Pin No.	Abbreviation	Function
1	D101	Data line 1
2	D102	Data line 2
3	D103	Data line 3
4	D104	Data line 4
5	EOI	End or identify. This signal is generated by a talker to indicate that transfer of data is complete.
6	DAV	Data valid. This signal is asserted by a talker to indicate that valid data has been placed on the bus.
7	NRFD	Not ready for data. This signal is asserted by a listener to indicate that it is not yet ready to accept data.
8	NDAC	Not data accepted. This signal is asserted by a listener whilst data is being accepted.

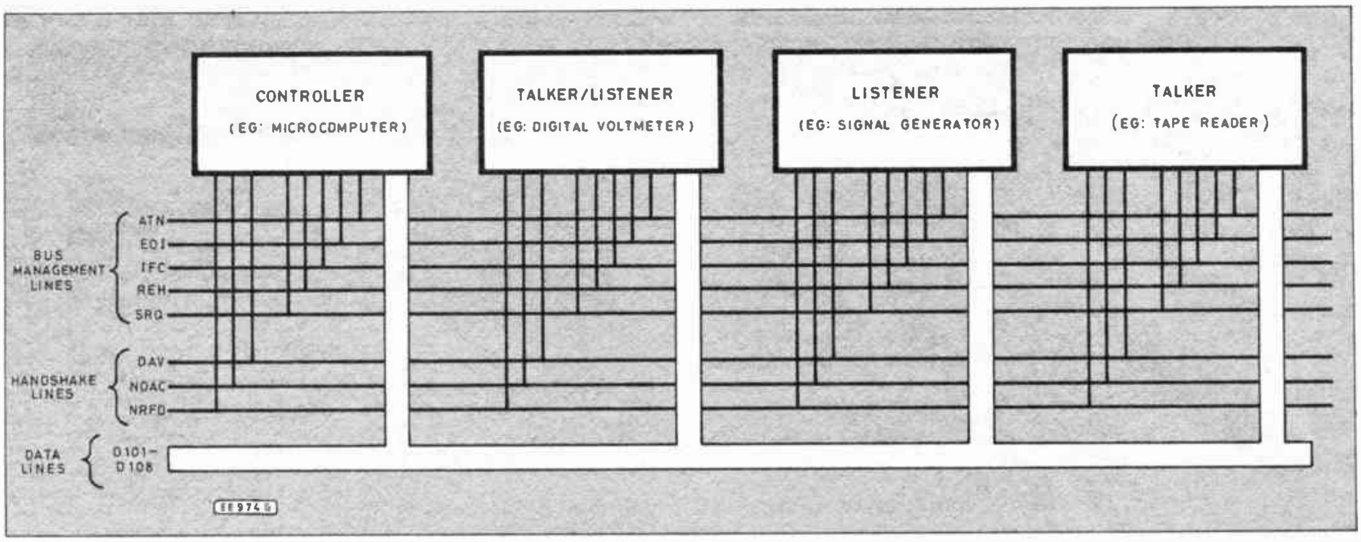


Fig. 8.10. Typical IEE-488 bus arrangement.

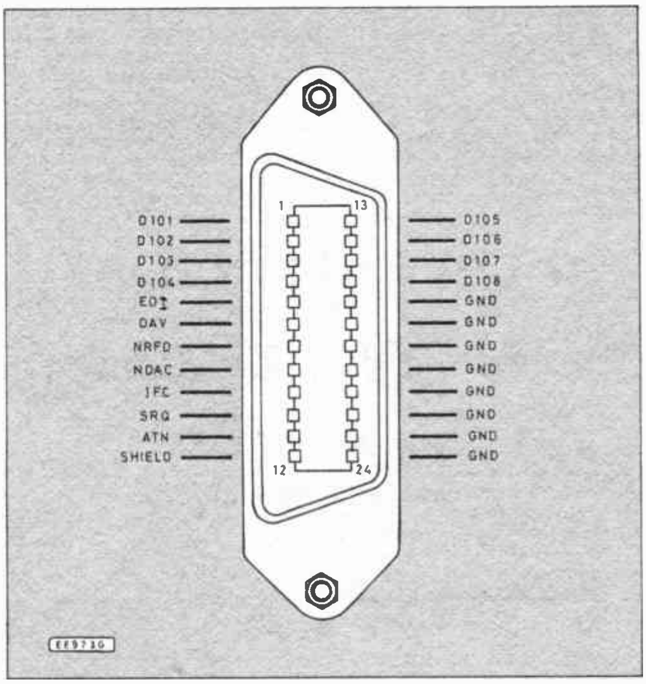


Fig. 8.9. Pin assignment for the 24-way connector used with IEEE-488.

9	IFC	Interface clear. Asserted by the controller in order to initialise the system in a known state.
10	SRQ	Service request. This signal is asserted by a device wishing to gain the attention of the controller.
11	ATN	Attention. Asserted by the controller when placing a command on to the bus.
12	SHIELD	Shield.
13	D105	Data line 5.
14	D106	Data line 6.
15	D107	Data line 7.
16	D108	Date line 8.
17	REN	Remote enable. This line is used to enable or disable bus control (thus permitting an instrument to be controlled from its own front panel rather than from the bus).
18–24	GND	Ground/common signal return.

Notes:

1. Handshake signals (DAV, NRFD and NDAC) employ active low open-collector outputs which may be used in a wired-OR configuration.
2. All remaining signals are fully TTL compatible and are active low.

Bus commands are signalled by taking the ATN line low. Commands are then placed on the bus by the controller and directed to individual devices by placing a unique address on the lower five data bus lines. Alternatively, universal commands may be issued to all of the participating devices.

Since the physical distance between devices is usually quite small, data rates may be relatively fast. Data rates of between 50Kbyte/second and 250Kbyte/second are typical, however, to cater for variations in speed of response, the slowest listener governs the speed at which data transfer takes place. Fig. 8.10 shows a typical IEEE-488 bus arrangement in which a microcomputer is used as the controlling device.

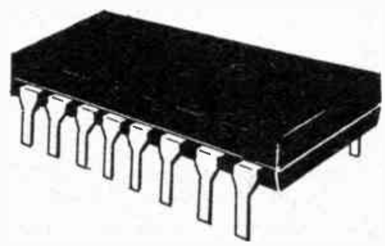
FAULT FINDING ON IEE-488 BUS SYSTEMS

Fault finding on the IEEE-488 bus is usually very much simpler than that associated with RS-232C systems. There are two main reasons for this; firstly, the IEEE-488 bus standard is open to much less variation in implementation and secondly, all signals use standard TTL voltage levels.

This latter fact permits the use of conventional digital instruments (such as logic probes and pulsers). Furthermore, the controlling software often contains its own diagnostic routines and will warn the user if, for example, an external device is not responding to commands placed on the bus.

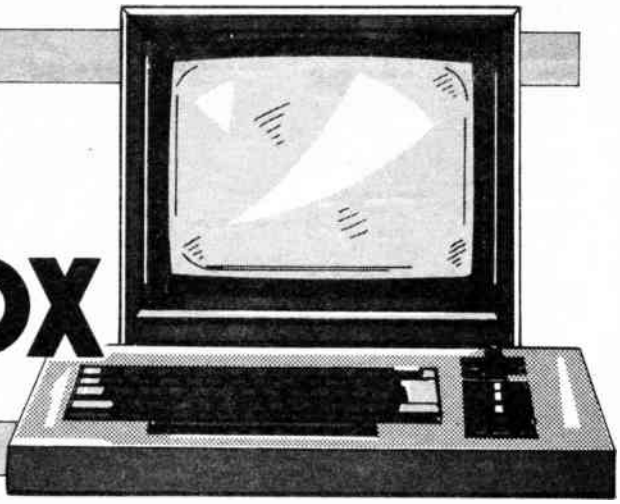
Where troubles are encountered, it is worth checking the configuration of the software and the assignment of addresses to the various devices employed within the system. If it is necessary to check the state of the various signal lines, a common or garden logic probe can be used to check for activity (remember that lines are active low).

Next month: we shall be rounding off the series by taking a look at some complete digital systems and describing several study programmes for readers who wish to progress further. Our Digital Test Gear Project features a highly versatile Digital Counter/Frequency Meter.



ORDER YOUR COPY NOW!

RS232C BREAKOUT BOX



MIKE TOOLEY B.A.

Make all the right connections with this versatile unit

THIS MONTH'S Digital test Gear Project deals with the construction of an RS-232C Breakout Box. This indispensable device allows the user not only to alter the configuration of an RS-232C system but also provides a means of examining the various signals present and diagnosing the more common faults which can arise.

In the last few years, a wide variety of breakout boxes has appeared. Some provide only basic patching and line monitoring facilities whilst others can display baud rates and automatically detect the RS-232C system configuration (in terms of DCE and DTE).

Our own Breakout Box has been designed with home construction in mind and offers the following facilities:

Ability to simultaneously display the logical state (i.e. MARK or SPACE) present on any two lines.

Ability to patch any line to any other line (on either side of the interface).

Ability to force any line into either a MARK or SPACE condition.

Ability to connect external equipment (e.g. oscilloscope, digital counter, pulse generator etc) to any line.

Self contained and operates from internal batteries.

CIRCUIT DESCRIPTION

The simplified circuit of the RS-232C Breakout Box is shown in Fig. 1. Circuitry is duplicated on either side of a "patching area" which allows any line to be patched to any other line (on either side of the interface).

Connections within the patching area may be made using PCB jumpers or using short link wires terminated with 1mm plugs. The patching area also has 1mm connecting points fed with d.c. levels to represent the MARK and SPACE states.

The six most important signal lines (TXD, RXD, RTS, CTS, DSR, and DTR) are taken to a selector switch on each side of the interface. The output of this switch is taken to the mark/space detecting circuitry and also to an input/output socket for external test equipment. A seventh position on the switch is used for transferring the remaining signals from the patching area to the mark/space detecting circuitry as and when necessary.

The circuit of the RS-232C Breakout Box is shown in Fig. 2. Circuitry duplicated on the other side of the interface has not been included (duplicate components have numbers separated by 100).

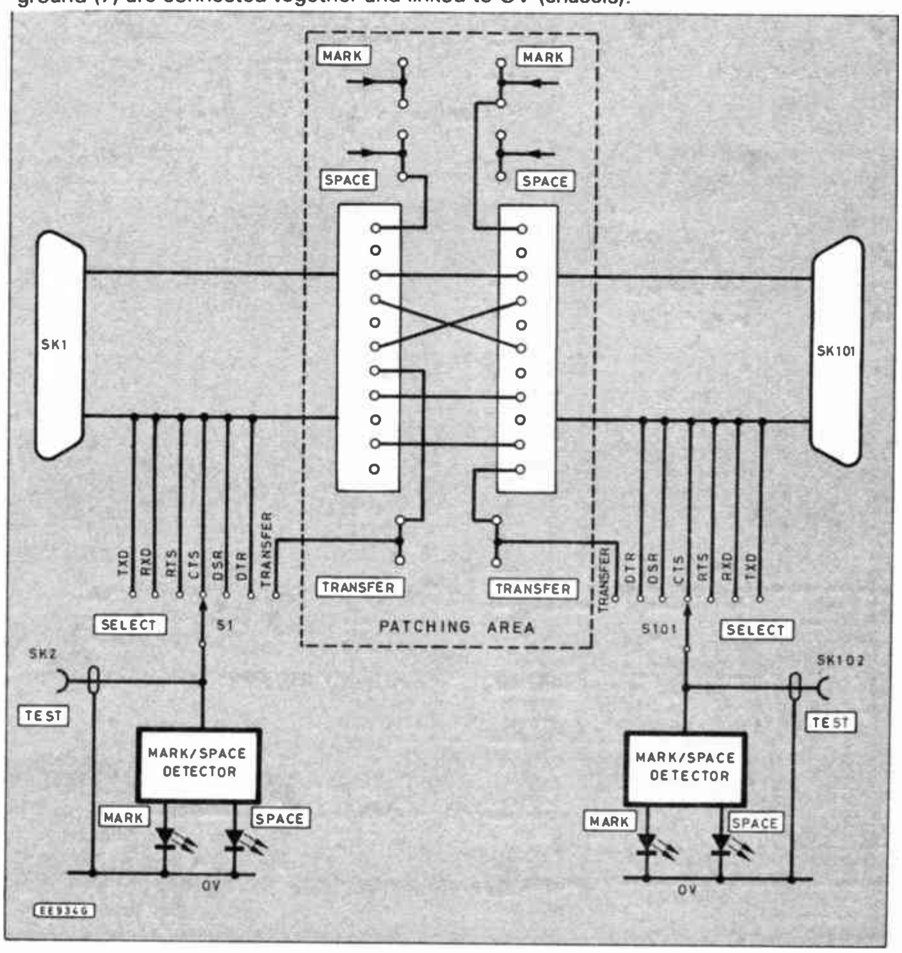
Signals from the patching area are selected by means of Select switch S1 and S101. IC1a and IC1b operates as comparators whose outputs go "high" when the input voltage exceeds +3V or falls below −3V respectively. Diodes D1 to D4 provide protection for input voltages in excess of the positive and negative voltage rails (the maximum voltage allowed in the RS-232C system is ±25V).

Zener diodes D7 and D8 establish the comparator reference voltages (the minimum voltage for SPACE and maximum voltage for MARK respectively). D5 and D6 help to overcome a limitation of the operational amplifier employed when presented with an input voltage close to the negative supply rail. The supply for the RS-232C Breakout Box is derived from two 9V dry batteries and the red light emitting diode D11 provides an indication that the supply is switched "on".

CONSTRUCTION

The two mark/space detecting circuits are mounted on a piece of 0.1in matrix stripboard measuring 60mm × 64mm approx and having 24 tracks each with 23 holes. This may be cut from a standard size Veroboard.

Fig. 1. Simplified circuit of the RS232C Breakout Box. Note: Frame ground(1) and signal ground (7) are connected together and linked to OV (chassis).



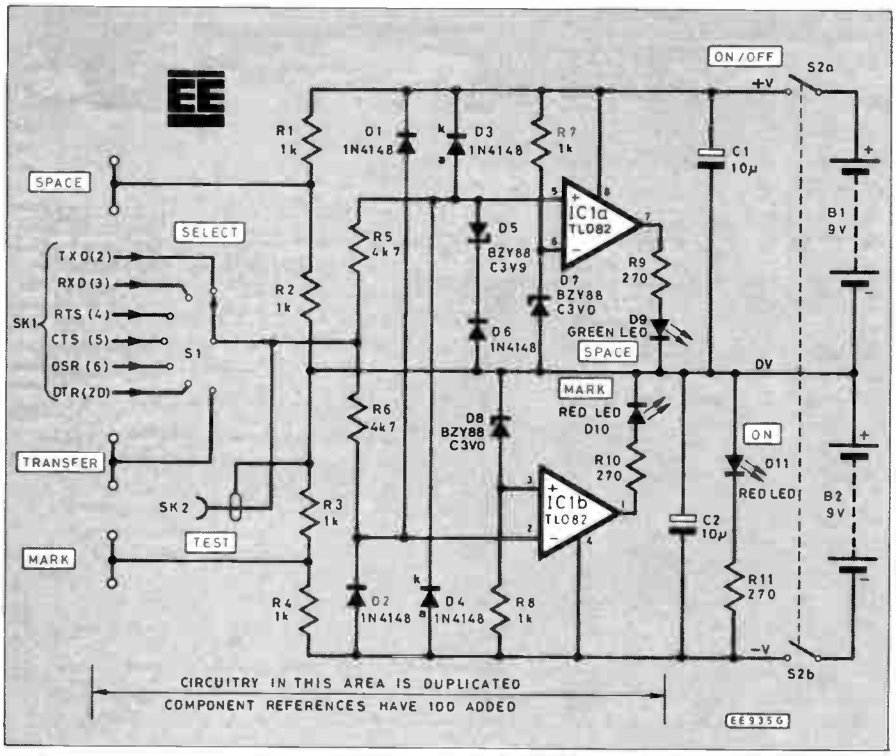


Fig. 2. Circuit diagram of the RS232C Breakout Box.

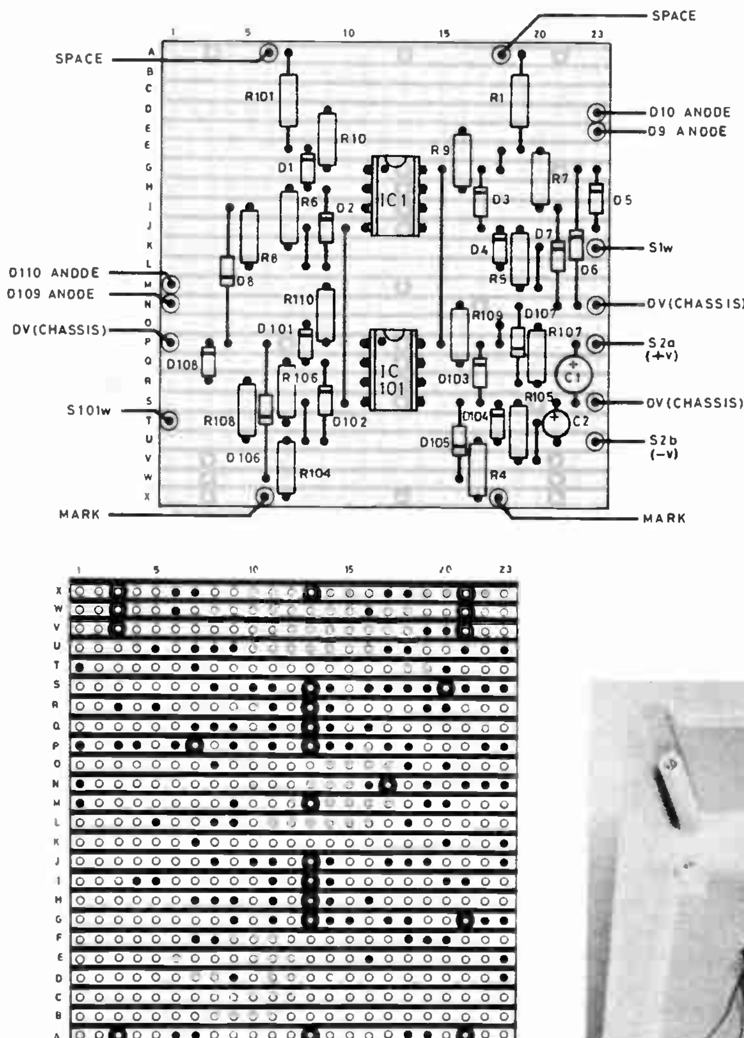


Fig. 3. Circuit board component layout and details of breaks to be made in the underside copper tracks.

COMPONENTS

Resistors

R1	R101	1k
R2	R102	1k
R3	R103	1k
R4	R104	1k
R5	R105	4k7
R6	R106	4k7
R7	R107	1k
R8	R108	1k
R9	R109	270
R10	R110	270
R11		270

All 0.25W 5% carbon

See **Shop Talk** page 306

Capacitors

C1	10µ tant. 25V
C2	10µ tant. 25V

Semiconductors

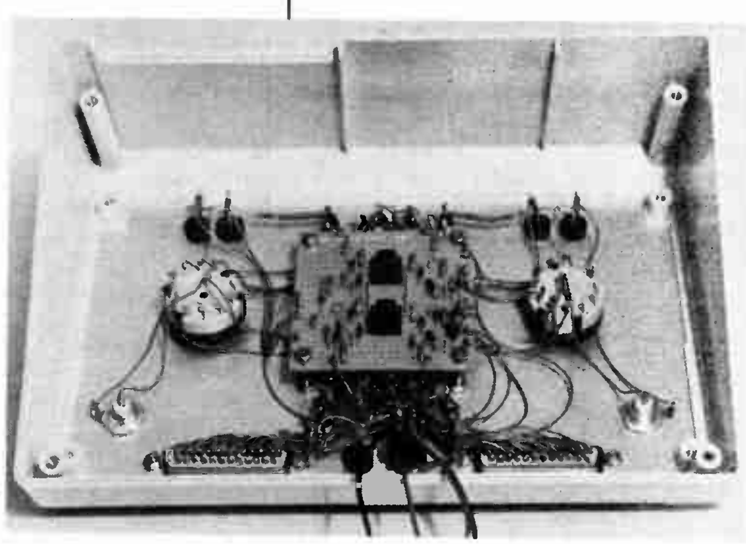
IC1	IC101 TL082 Dual op-amp
D1	D101 1N4148
D2	D102 1N4148
D3	D103 1N4148
D4	D104 1N4148
D5	D105 BZY88 C3V9 Zener
D6	D106 1N4148
D7	D107 BZY88 C3V0 Zener
D8	D108 BZY88 C3V0 Zener
D9	D109 Green l.e.d.
D10	D110 Red l.e.d.
D11	Red l.e.d.

Miscellaneous

S1	S101 1-pole 12-way rotary switch (with rotation stop adjusted for 1-pole 7-way operation)
S2	miniature DPDT toggle switch

LED mounting clips (5 sets); 8-pin low profile i.c. socket (2 off); 25-way chassis mounting type D-socket (2-off); sloping front instrument case, measuring 220mm x 156mm x 100mm approx; single-sided 1mm terminal pins (15 required); 0.1in matrix stripboard measuring 60mm x 64mm approx; nuts, bolts, and mounting pillars (4 sets); BNC chassis mounting sockets (2 off); 1mm chassis mounting sockets (31 black and 31 red); insulated 0.4in. p.c.b. jumpers; knobs (2 off); PP3 snap-fit battery connectors (2 off).

Approx. cost Guidance only £20 (excluding case)



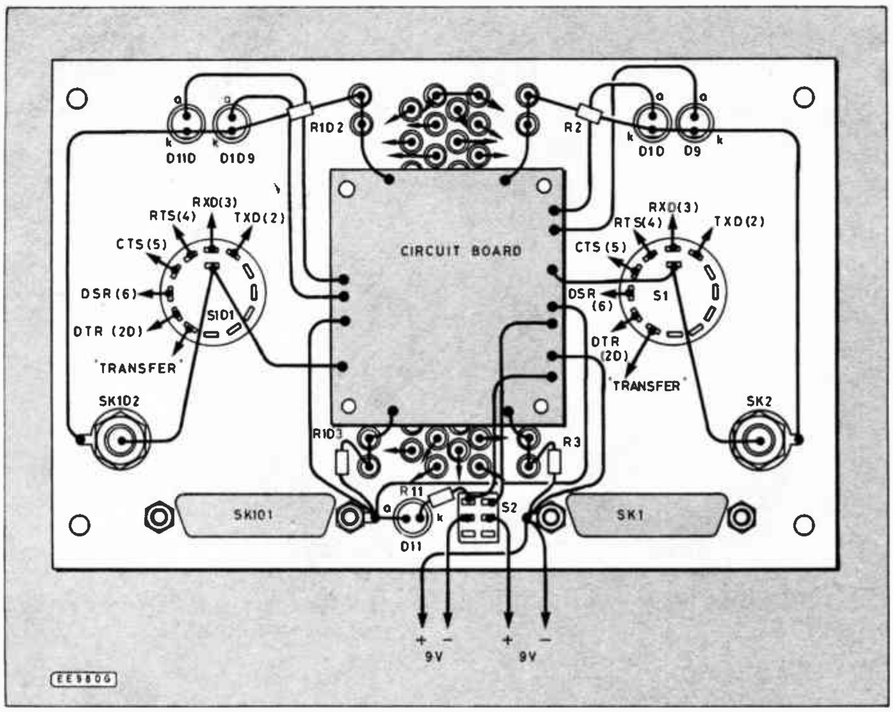
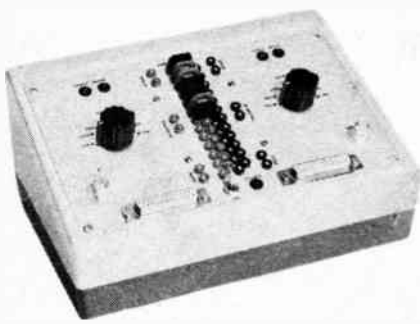


Fig. 4. Interwiring of front panel mounted components. The sockets in the patching area are linked to correspondingly numbered connections on SK1 and SK101. Patching area sockets for pins 1 and 7 (on both sides) are connected together and linked to 0V (chassis)

The stripboard component layout of the RS-232C Breakout Box is shown in Fig. 3. Readers should note that a total of 23 track breaks are required and these should be made using a spot face cutter. If such a tool is unavailable, a sharp drill bit of appropriate size may be substituted.

The following sequence of component assembly is recommended; i.c. sockets, terminal pins, links, resistors, diodes, and capacitors. Before inserting the two integrated sockets into their holders and mounting the stripboard in its final position, constructors should very carefully check the components, links, and track breaks.

It is also worth checking that all of the polarised components (including l.e.d.s, diodes and electrolytic capacitors) have been correctly oriented. Constructors should carefully examine the underside of the board for dry joints, solder splashes, and bridges between adjacent tracks. When the board has been thoroughly checked, the two integrated circuits should be inserted into their holders (taking care to ensure correct orientation).



The interwiring to the front panel mounted components is shown in Fig. 4. The patching area consists of a matrix of 1mm sockets (a total of 62 sockets will be required). These sockets are laid out in the same format as the two 25-pin D-connectors (SK1 and SK101) and are wired to correspondingly numbered pins. When drilling the front panel, constructors should ensure that the horizontal spacing between alternate rows is 0.4in. (to permit the use of 0.4in. p.c.b. jumpers) while the vertical spacing should be 0.3in.

The two sockets corresponding to pin-1 (protective ground) should be linked together as should the two sockets corresponding to pin-7 (signal ground). Furthermore, both ground sockets (pin-1 and pin-7) should be connected to the front panel (common 0V) at a suitable point using an earth tag.

The six links from the selector switches (S1 and S101) to the patching sockets should be connected as follows:

RS-232C signal	Switch position	Patch socket
TXD	1	2
RXD	2	3
RTS	3	4
CTS	4	5
DSR	5	6
DTR	6	20

(NB: Position 7 on each switch should be linked to its respective Transfer socket.)

Once wiring of the patching area has been completed, the stripboard should be mounted above the patching area using four pillars of suitable length. The remainder of the front panel wiring can then be completed as shown in Fig. 4.

Finally, a bracket should be made for retaining the batteries and attached to the rear base of the case. The batteries should then be connected to the front panel by means of two sets of battery connecting leads fitted with snap-fit clips.

TESTING

Initial testing of the RS-232C Breakout Box should be carried out without connection to a microcomputer system. Connect two fresh PP3 batteries to the unit and switch "on" (Diode D11 should become illuminated indicating that power is available).

Switches S1 and S101 should both be switched to the "Transfer" position, neither MARK nor SPACE l.e.d.s should be illuminated. The Transfer sockets on each side of the patching area should then be linked in turn to the MARK and SPACE connecting points. The respective l.e.d.s should become illuminated but, if this is not the case, constructors should carefully recheck the internal wiring; including that associated with the stripboard mounted components.

The RS-232C Breakout Box should now be tested using a known operational computer system. The unit should be connected in series with the RS-232C signal path using short lengths of ribbon cable terminated with appropriate 25-way D-connectors. The Breakout Box should be configured for normal operation (it will usually only be necessary to place jumpers in positions 2, 3, 4, 5, 6 and 20).

Initially, the slowest available baud rate should be selected (e.g. 50 baud) and the system set up to send a file of reasonable length to the peripheral. The signal present on each line should be examined and the effect of breaking various lines (in particular RTS and CTS) noted.

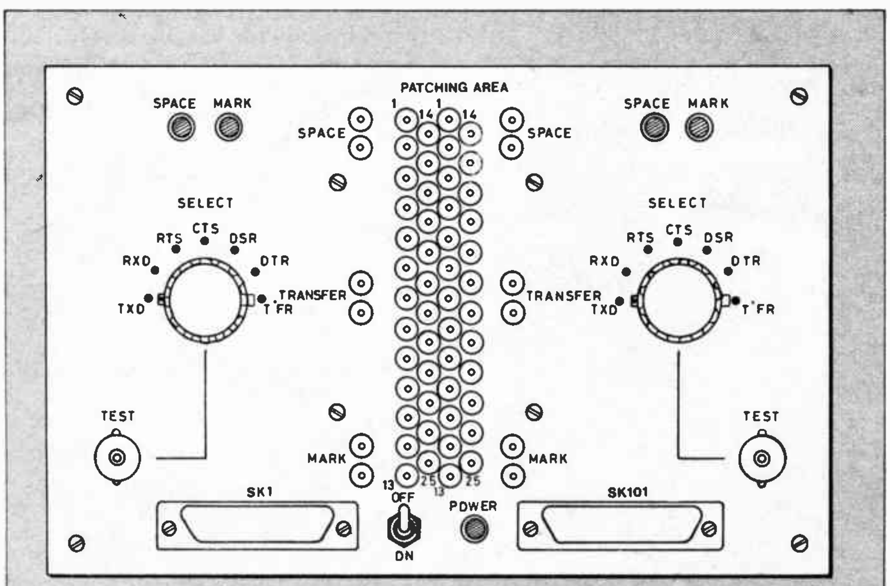


Fig. 5. Front panel labelling of the RS232C Breakout Box.

Next month: Digital Counter/Frequency Meter.

MINI DISCO LIGHT

T.R. de VAUX-BALBIRNIE

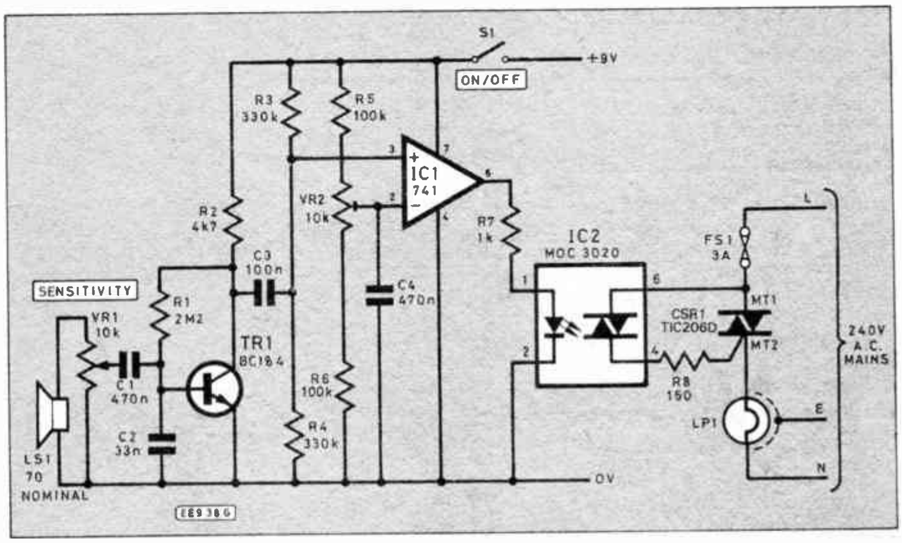


Fig. 1. Circuit diagram of the Mini Disco Light

Simple unit to provide 240W of mains powered flashing lights without audio connections to amplifiers etc.

OF ALL the disco effects available, lights which flash to the beat of the music continue to enjoy greatest popularity. This circuit fills the gap between simple low-voltage circuits (for example, *Children's Disco Lights,* EE, December, 1983) and high-power multi-channel systems. The low constructional cost makes this ideal for parties or for use in teenagers' bedrooms. Note that this is a *single channel* system so all bulbs connected to it will flash in unison, unlike more sophisticated circuits.

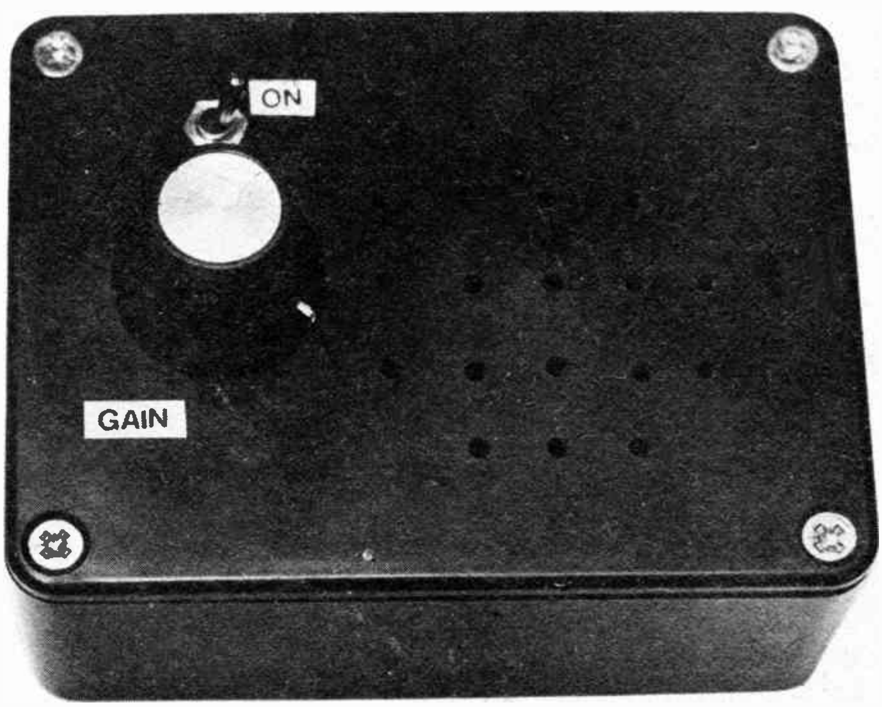
The Mini Disco Light will operate mains filament lamps to a maximum total loading of 240W on 240V a.c. mains. The prototype unit was used with four 60W coloured spotlights. The circuit itself is battery operated which reduces costs and simplifies construction—the battery will provide excellent service. An inbuilt microphone picks up the music so avoiding direct connections with the amplifier. This has the benefit of causing the lights to flash with other sounds in the room. A gain control, which matches the response of the unit to the volume of sound and a supply on-off switch are provided on the front panel.

CIRCUIT DESCRIPTION

The circuit for the Mini Disco Light is shown in Fig. 1. LS1 is a miniature loudspeaker but in this application it is used as a microphone. When sound waves impinge on its cone, a small a.c. voltage is developed between its terminals. VR1 "taps off" a proportion of this voltage and a weak a.c. current passes via C1 to TR1 base. VR1 thus provides a means of adjusting the sensitivity of the circuit. R1 and R2 bias TR1 which amplifies the signal and delivers larger voltage changes through C3 to the operational amplifier non-inverting input, IC1 pin 3. In the absence of detected sound, the potential divider action of R3 and R4 apply a fixed voltage to pin 3 while the inverting input (pin 2) receives a voltage which depends on the adjustment of VR2. R5 and R6 narrow the range of VR2 adjustment making it easier to obtain the correct setting. With this adjustment correct, the voltage at pin 2 will *just* exceed that at pin 3 so IC1 is off with pin 6 (the output) low. This has no effect on the rest of the circuit.

When LS1 detects sound, the voltage variations passed to IC1 pin 3 modulate the existing voltage which rises and falls in sympathy. On rising excursions, the voltage at pin 3 exceeds that at pin 2 and the op-amp switches on with pin 6 going high (battery positive voltage). This operates the light-emitting diode contained within IC2. (Resistor R7 limits the l.e.d. operating current to the correct working value.)

IC2 is an optically-coupled triac and operating the l.e.d. in this way establishes a



COMPONENTS

See **Shop Talk** page 306

Resistors
R1 2M2
R2 4k7
R3,R4 330k (2 off)
R5,R6 100k (2 off)
R7 1k
R8 470 0.5W (3 off) or single 150 2W
All (except R8) 0.25W ± 5%

Potentiometers
VR1 10k lin.
VR2 10k miniature vertical preset

Capacitors
C1,C4 470n (2 off)
C2 33n
C3 100n

Semiconductors
IC1 741 op. amp.
IC2 MOC3020 triac opto-isolator
TR1 BC184
CSR1 TIC206D triac

Miscellaneous
LS1 miniature loudspeaker 60 to 80 ohms. 60mm diameter maximum.
S1 sub-miniature s.p.s.t. toggle switch.
B1 PP3 battery and connector.
6-pin d.i.l. socket; 8-pin d.i.l. socket (or 2 off 8-pin sockets—see text); plastic box 95 × 71 × 35mm internal minimum; 3A terminal block—4 sections required; control knob for VR1; self-adhesive feet (4 off); adhesive fixing pad; stranded connecting wire; 3A, 3-core mains wire; TO66 mounting kit; mains plugs and sockets; 3A fuses as necessary; aluminium for heat sink—see text; printed circuit board, available from the *EE* PCB Service, order code *EE*567.

Approx. cost Guidance only **£8.50**

conducting path between pins 4 and 6. Such optical coupling totally isolates the mains from the battery-powered section of the circuit. The inbuilt triac is rated at mains voltage but its current carrying capability is insufficient for the present purpose, it therefore feeds a small gate current through R8 to the external triac, CSR1, of higher rating. This switches the lamp load connected in series with the triac. It is assumed that the unit will be plugged into a standard mains socket using a fused plug—no internal fuse or separate mains switch are therefore provided.

CONSTRUCTION

Construction is based on the printed circuit layout shown in Fig. 2. Solder all components into position including the i.c. sockets. Do not insert the i.c's themselves until last, however. IC2 requires a six-pin d.i.l. socket—these are uncommon so it will probably be necessary to gently file an eight-pin socket to size. CSR1 should be mounted perpendicular to the circuit panel with the full length of its pins used. Do not bend them at this stage. R8 may be a single component or, as in the prototype, three resistors connected in parallel—provision for this is made on the p.c.b. Solder 10cm pieces of light-duty stranded connecting wire to the points marked "S1", "VR1" and "battery negative". Solder 10cm pieces of 3A mains wire to CSR1 main terminals on the copper strip side of the panel.

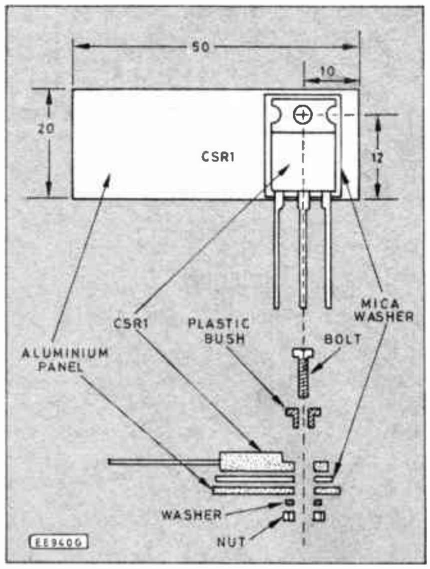
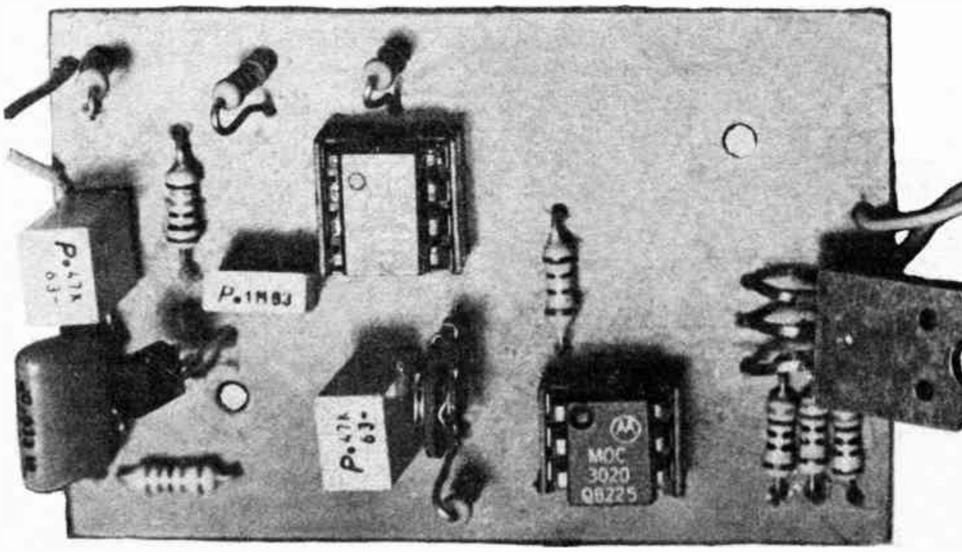


Fig. 3. Heat sink size and fitting details.



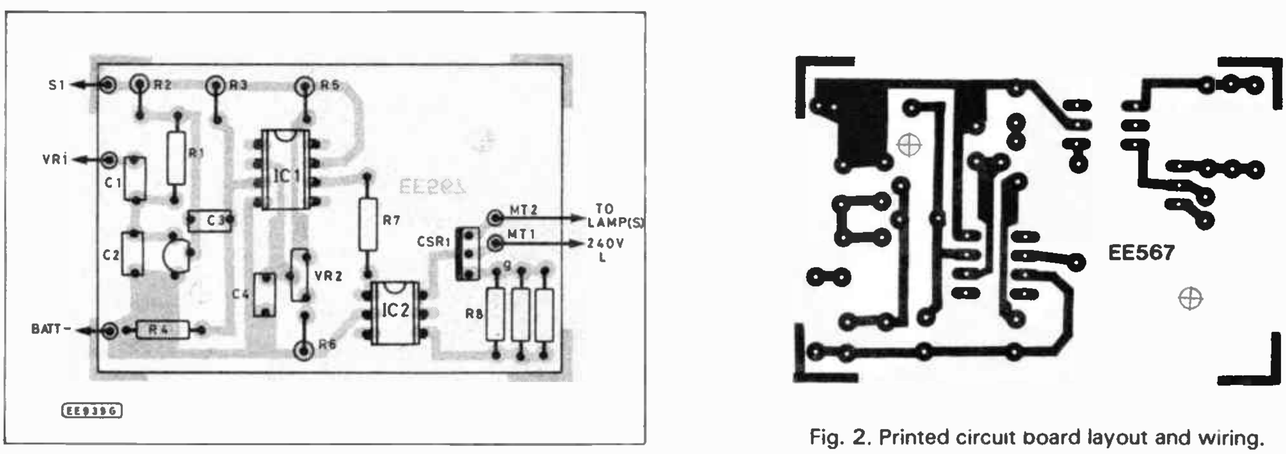


Fig. 2. Printed circuit board layout and wiring.

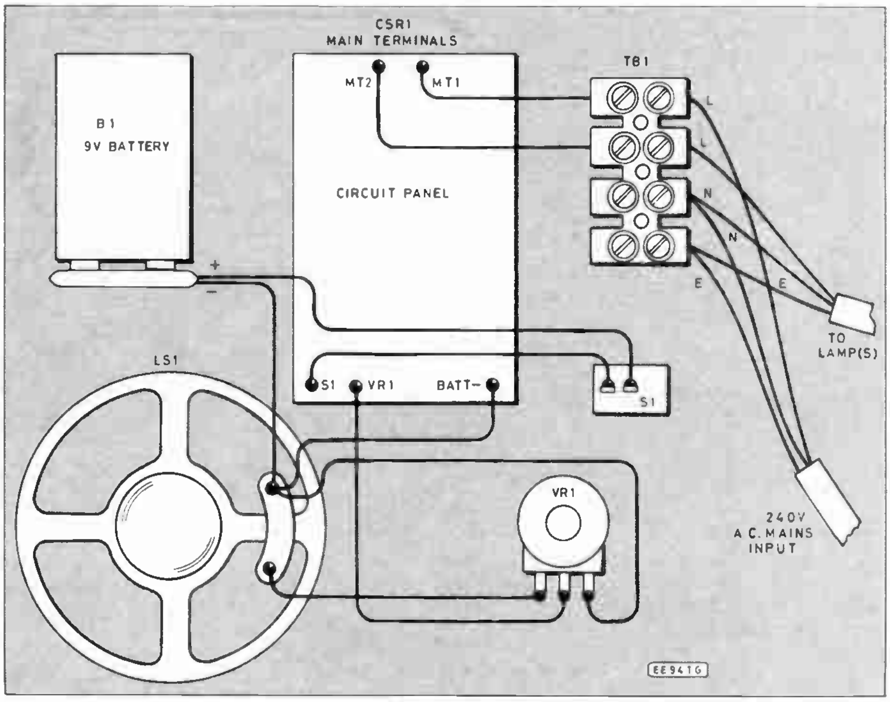


Fig. 4. Wiring of the Mini Disco Light. The mains plug must be fused at 3A.

Refer to Fig. 3 and make the triac heat sink using thin sheet aluminium—mount this as shown (see photograph). Note that a mounting kit consisting of a thin mica washer and a plastic bush must be used to isolate the heat sink from the mains. Mount the p.c.b. and TB1 to the base of the case using small fixings. Prepare the lid by drilling holes for S1 and VR1. Drill a matrix of small holes for the sound to pass to LS1. Mount S1 and VR1 then secure LS1 using quick-setting adhesive sparingly around the rim, make sure the adhesive does not touch the paper cone. When the adhesive is fully hardened, check LS1 for security.

Refer to Fig. 4 and complete the internal connections shortening any wires as necessary. Note that one LS1 terminal is used as a common anchorage for the battery negative connections. Make a mains input lead of suitable length. Use 3A three-core mains wire for this and **fit a plug carrying a 3A fuse**. Use similar wire for the output lead—fit a mains line socket or multi-socket. A block of four in-line sockets will be found most useful. If the output socket requires a fuse, fit one of 3A rating. Fit suitable strain relief clamps inside the case to both mains input and output leads.

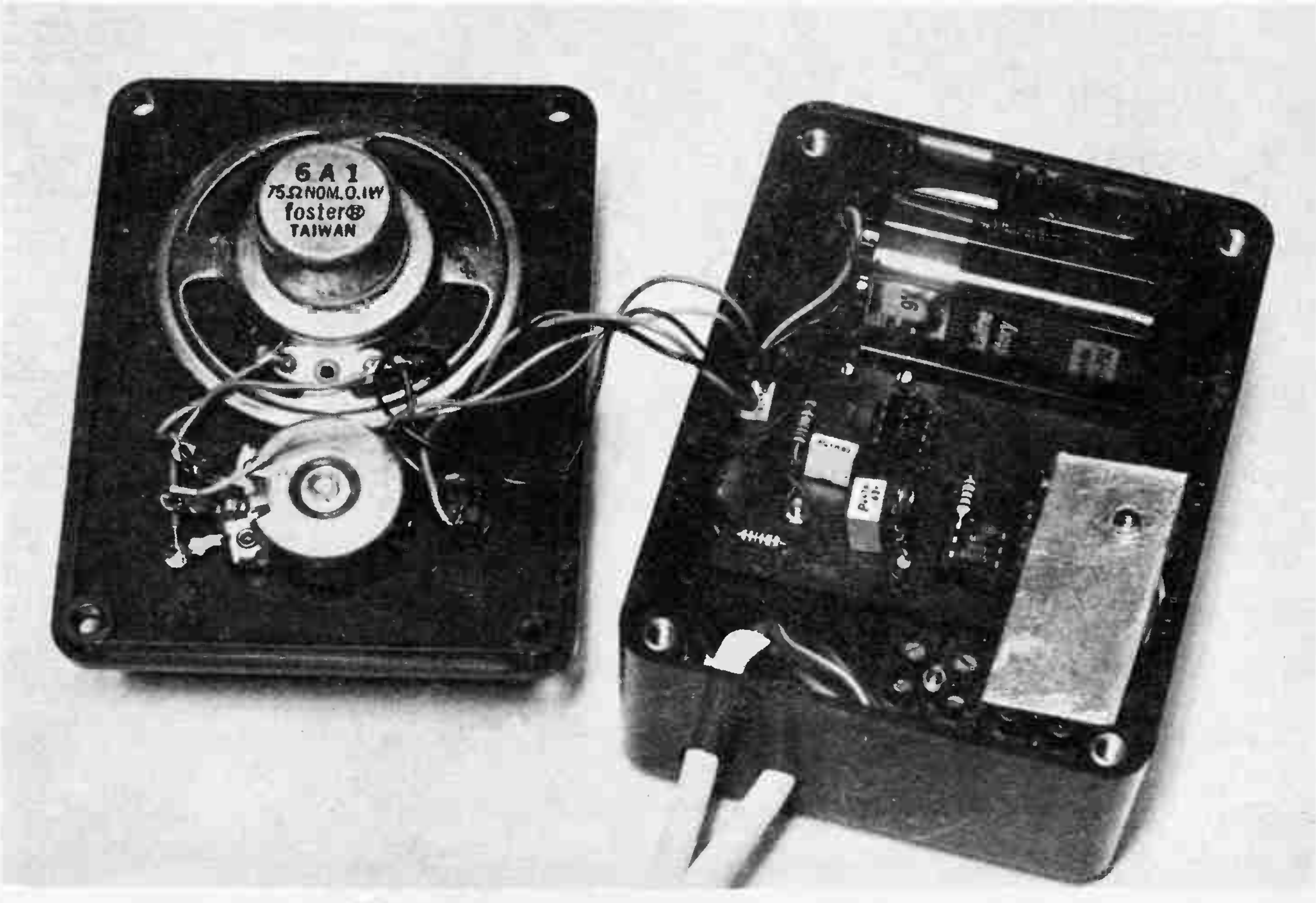
Gently bend CSR1 pins so that the heat sink rests horizontally (see photograph). Slowly offer the lid to the rest of the case and check for trapped wires. Check also that all internal components remain clear of the heat sink. Connect the battery and secure it to the side of the case using an adhesive fixing pad. Finally, fit the case with self-adhesive plastic feet. This will prevent scratched table tops when the unit is in use.

TESTING AND OPERATION

Safety warning: Since mains voltage exists inside the case, the unit must be unplugged from the supply whenever the lid is removed. Adjustment to VR2 must therefore be made in a series of small steps with the lid replaced before testing.

Potentiometer VR2 sliding contact should be adjusted so that IC1 *just* remains off when no sound is detected. Plug a reading lamp into the output socket. Adjust VR1 fully anti-clockwise (least sensitive position). adjust VR2 sliding contact fully clockwise (as viewed from IC2). Replace the lid and plug the unit into the mains. Switch on S1. The lamp may flash briefly but should then remain off. Make small anti-clockwise adjustments to VR2 to find the position where the lamp remains on. It should then be adjusted slightly so that it stays off. If this operation is carried out *too* critically, there will be a tendency for the lamp to "lock on" and fail to respond as it should. If it is not done carefully enough, the circuit will lack sensitivity. Test for correct adjustment by increasing the gain with VR1 then speak into LS1. The lamp should flash with the sound.

If all is well, the unit may be put into use with, perhaps, further small adjustments to VR2 over a trial period for best effect. After use, do not forget to switch off at S1 or the battery will not last long! □



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 12 Operational amplifiers

THIS MONTH we introduce another inexpensive yet extremely versatile integrated circuit (i.c.) the 741 operational amplifier. This is but one of an ever increasing family of such devices, each with their own special features, but all doing more-or-less the same thing.

There are several ways in which operational amplifiers can be connected up and used, and we shall investigate one of these. The *op-amp*, as it is often called for short, has many transistors and resistors inside, connected as an amplifier that has very high gain. The i.c. has only seven external connections, two of which we are not concerned with here.

POWER SUPPLY

The power supply to the 741 i.c., is a little different from what we have met so far. It requires a voltage greater than zero at pin 7, and a voltage less than zero at pin 4. By splitting the battery into two sections as shown, we can arrange for +3V and −3V supplies. This is the minimum voltage on which the i.c. will work.

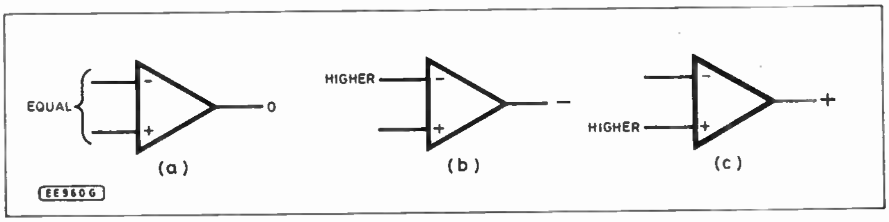


Fig. 12.2. Input and output voltage of an operational amplifier.

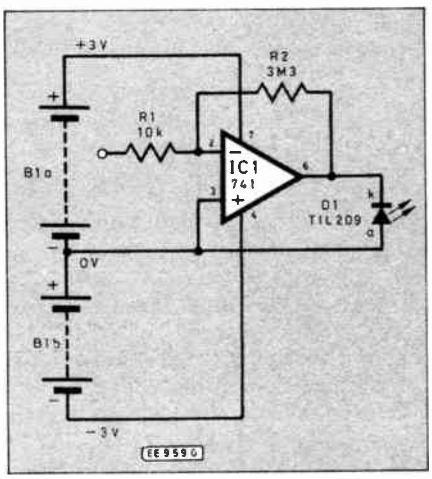
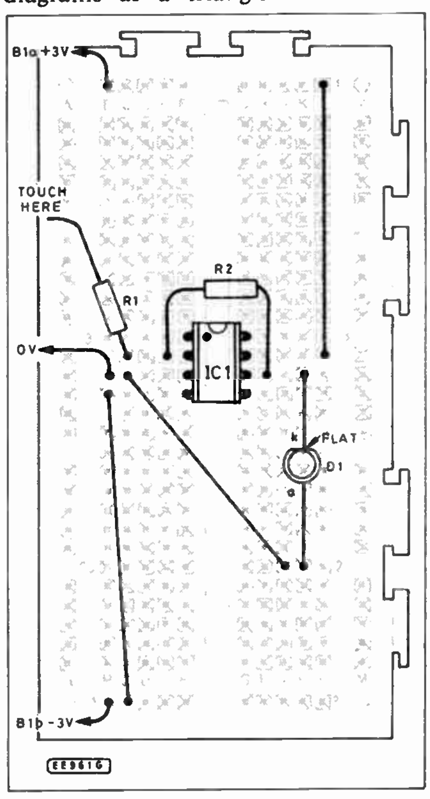


Fig. 12.1 (above). Circuit to demonstrate the action of an operational amplifier.

Fig. 12.3 (right). Component layout for the op-amp demonstration circuit.

The recommended voltage range is 5V to 8V and the i.c. will give its best performance within that range. However, 3V is easier to obtain, as only a standard battery-holder is required, and this is adequate for the purposes of this article, see Fig. 12.4.

The amplifier is represented in the diagrams as a triangle. It has two



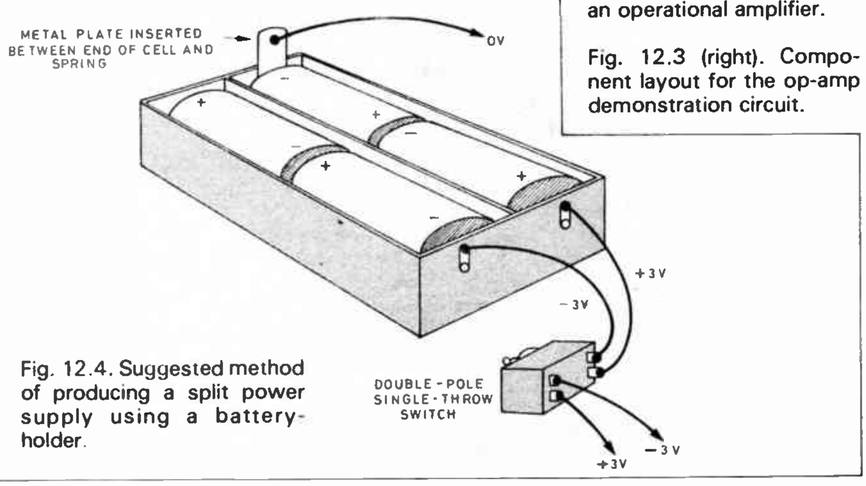
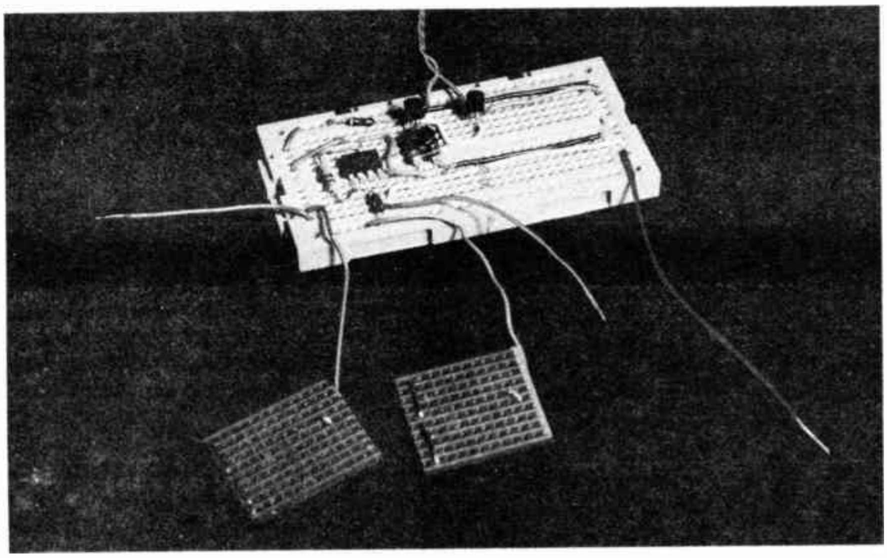
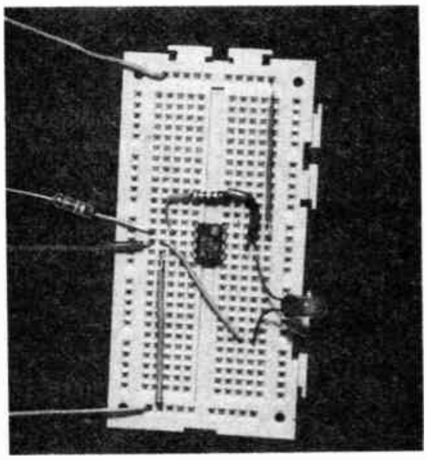


Fig. 12.4. Suggested method of producing a split power supply using a battery-holder.



inputs, labelled '–' and '+', and an output (at the point of the triangle).

The amplifier is very sensitive to a *difference* between the voltages applied to its inputs, as Fig 12.2 shows. Gain is high so, if there is a small difference in voltage at the inputs, the output voltage is very high or low, almost reaching that of one of the supply lines.



The completed op-amp "test-bed".

WHAT TO DO

The Op-Amp demonstration circuit is shown in Fig. 12.1. The non-inverting input ('+') is connected to the zero volt rail so, if the inverting input is also at zero volts (making both inputs equal), output is zero too.

The circuit shown in the diagram will be in that state because, if resistor R1 is unconnected and output is zero volts, then the inverting input must also be at zero. The amplifier is in a stable state. Now take hold of the free end of resistor R1 in one hand, then touch your finger against the other positive terminal of battery B1a. What happens?

The resistance of your body, from one hand to the other, is about 4MΩ (Megohm), so the current flowing through your body to the op-amp is well under 1µA, and the voltage at the hand touching resistor R1 is only about 7.5mV.

Yet with a difference of only 7.5mV between the inputs, the output of the op-amp swings low enough to make the l.e.d. light. Note that, with a *positive* voltage applied to the inverting input, the output swings *negative*.

In this circuit the l.e.d. has been connected so as to pass current when the output swings below 0V. We will learn more about operational amplifiers and look into their many applications next month.

TOUCH SWITCH

The circuit diagram for a Simple Touch Switch is shown in Fig. 12.5. This "switch" makes a buzzer sound when you place your finger against two small metal contacts so as to bridge the gap between them. It can also be used for lighting lamps, triggering a timer circuit and in many other ways.

COMPONENTS

DEMO-MODEL

Resistors

R1 10k
R2 3M3
All 0.25W 5% carbon

Semiconductors

D1 TIL209 light emitting diode
IC1 741 operational amplifier

Miscellaneous

Split power supply, four 1.5V cells and battery holder (see Fig. 12.4); breadboard (e.g. Verobloc); 8-pin d.i.l. i.c. socket and connecting wire.

TOUCH SWITCH

Resistors

R1 10k
R2 3M3
All 0.25W 5% carbon

See Shop Talk page 306

Potentiometer

VR1 1k miniature horizontal carbon preset

Capacitor

C1 47µ elec. (single touch-plate version)

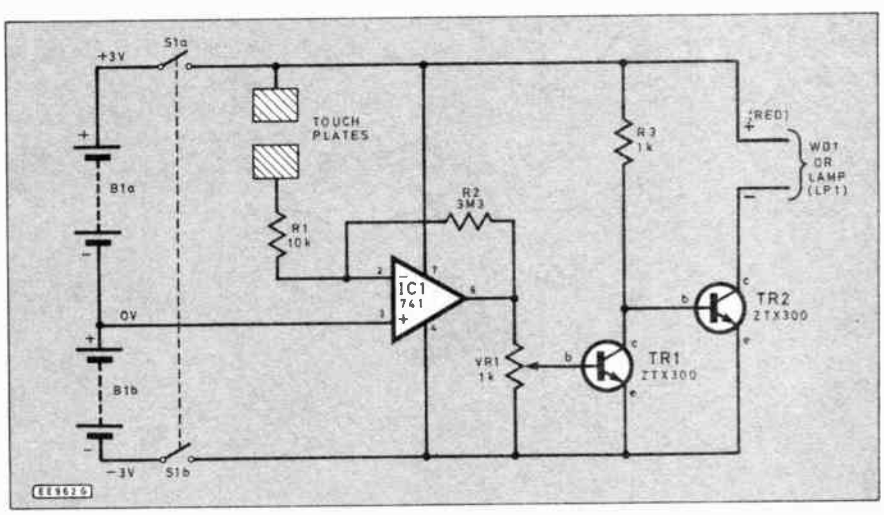
Semiconductors

TR1,TR2 ZTX 300 *npn* transistor (2 off)

Miscellaneous

S1 DPST toggle switch.
WD1 Solid state audible warning buzzer.
Split power supply; four 1.5V cells and battery holder (See Fig. 12.4); breadboard; 8-pin d.i.l. i.c. socket; touch-plate—see text; connecting wire.

Fig. 12.5. The complete circuit diagram of the Simple Touch Switch.



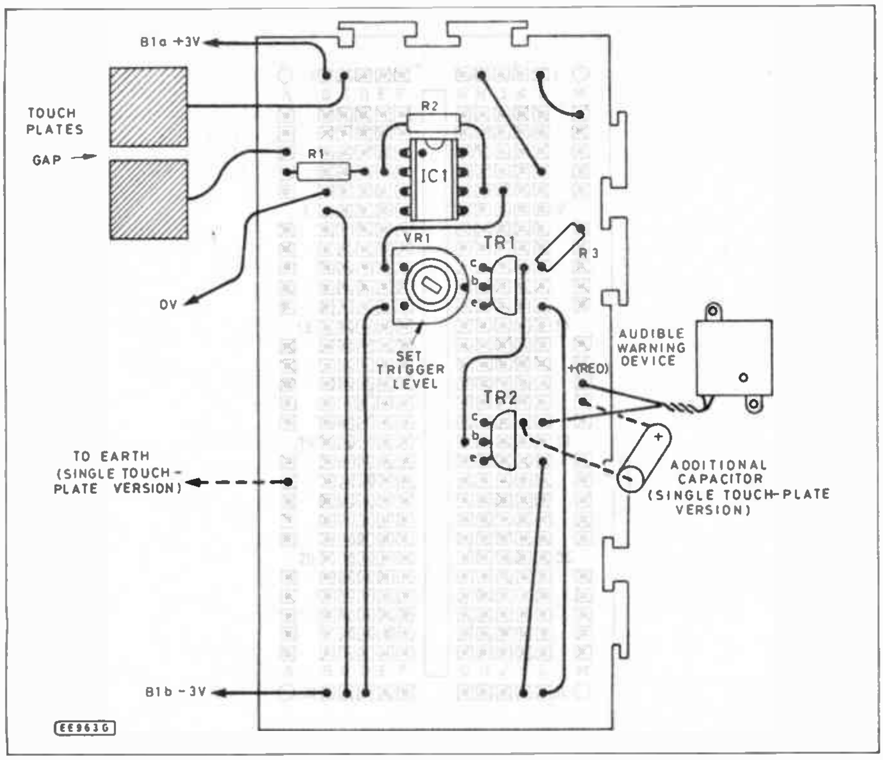


Fig. 12.6. Demonstration breadboard component layout for the Simple Touch Switch.

HOW IT WORKS

The touch-plates have a small gap between them so resistor R1 is unconnected (compare with Fig. 12.1) and the voltage at the inverting input of the op-amp is zero. Its output is also zero.

When a finger is placed across the gap a small current flows to the inverting input. The voltage at the inverting input becomes slightly higher than that of the non-inverting input. This makes the output voltage fall below zero (Fig 12.2b), almost to –3V.

The variable resistor (potentiometer) VR1 acts as a potential divider. It is adjusted so that when the output from the op-amp IC1 is zero (or +3V relative to the emitter of TR1) transistor TR1 is switched on, causing TR2 to be off and the buzzer to be silent.

When the circuit is triggered, by touching the plates, IC1 output goes low turning TR1 off, which causes TR2 to be turned on. A collector current flows through the buzzer to TR2, and the buzzer sounds.

CONSTRUCTION

The demonstration breadboard component layout for the Simple Touch Switch is shown in Fig. 12.6.

There are lots of ways of making the touch-plates. A simple method is to push two drawing-pins into a piece of wood or plastic, so that they have a gap of about 1mm between them. This can be mounted beside a doorway, or wherever else you wish the control switch to be.

Set VR1 so that the buzzer sounds then turn it back again to a position in which it *just* fails to sound.

Touching the plates should now make it sound.

VARIATIONS

We can carry the touch switch idea still further and use only one touch-plate. This circuit must be earthed and also needs a capacitor (47μ) across the terminals of the buzzer to obtain steady operation.

This version of the touch switch depends on the fact that your body is in a rapidly changing magnetic field due to all the many and changing electrical currents that are flowing in the mains wires in your home. The changing fields induce changing electrical currents in your body. These are exceedingly small, but are sufficient to trigger the circuit.

Instead of the buzzer, you can use a filament lamp (LP1) or an l.e.d. The capacitor is not then required.

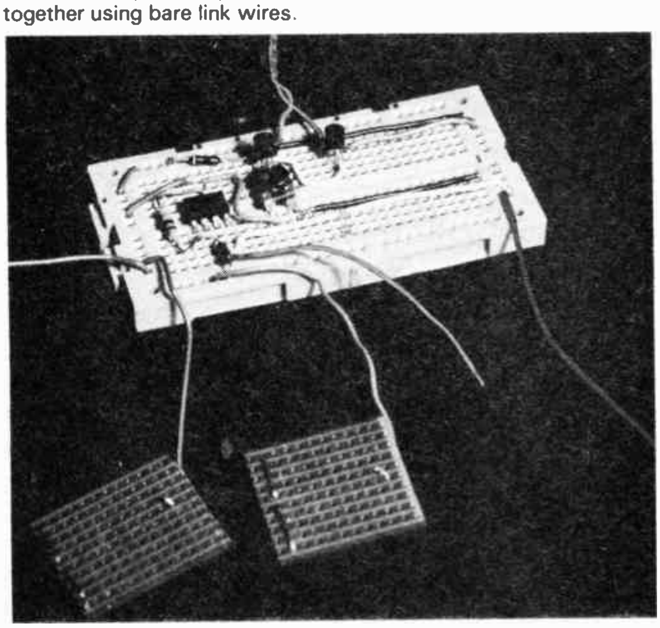
The touch-plate can take many forms. It can be a single drawing-pin, a square of stripboard, or disc of metal. It could be the metal number-plate on the front door, or a metal door-knob. It could be a length of bare wire tacked along the edge of a window-sill, so that the alarm sounds when someone tries to climb in.

It could be a really large metal plate so that it can be easily found in the dark, or by a blind person. Even the slightest touch on it causes the buzzer to sound.

If transistor TR2 is replaced by a BD131 transistor, you can use the Touch Switch to control a low voltage electric motor. You could build a touch switch control panel for controlling model railways or other motor-powered models.

Next month: Telephone Alarm and Model Speed Control using an Op-Amp.

The finished Touch Switch. The "touch-plates" have been made from some spare stripboard, with the copper tracks soldered together using bare link wires.



PLEASE TAKE NOTE

Experimental Speech Recognition Unit ***(April 1987)***
Page 204, Components List. The numerical sequence of the capacitors is incorrect and should be as follows:

C8,C11,C14,C17	1μ radial elec. 63V (4 off)
C9,C10	4n7 miniature polyester layer (2 off)
C12,C3	2n2 miniature polyester layer (2 off)
C15,C16	1n miniature polyester layer (2 off)

Capacitors C1 to C7 are correct as listed.

SPECIAL OFFER...

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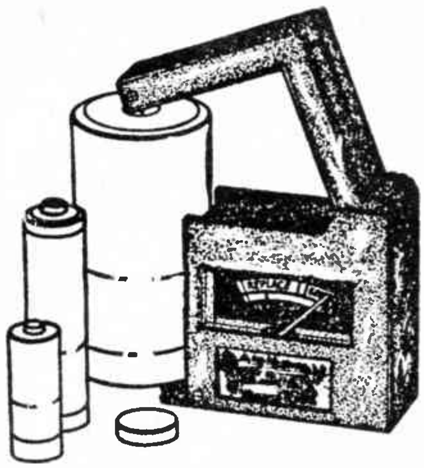

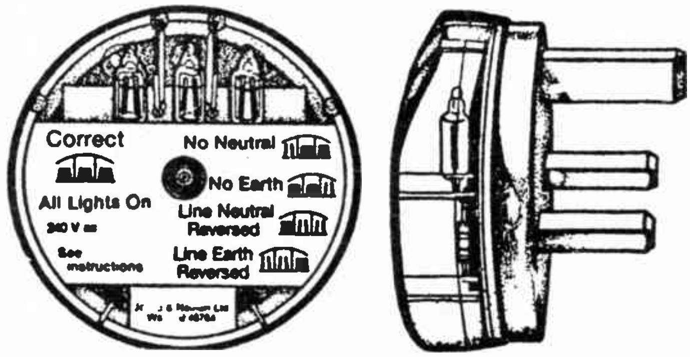

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FOR YOUR ENTERTAINMENT

BY BARRY FOX

Computer Show

To the eighth annual Which Computer? Show at the National Exhibition Centre in Birmingham . . .

Still crowded, like hi fi and video shows used to be, before their boom times passed. First and main impression was an almost total commitment now to the IBM standard, or more accurately range of IBM standards. Only Apple stay out of the IBM PC world with the Mac.

This puts some writing on the wall. It may well have been the uncertainty, and confusion of conflicting standards, which has fuelled public interest in the computer market. Now IBM compatibility has become the norm, the only source of real future interest will be price, features and bolt-on accessories.

The computer market will then emulate the audio and video market. People who have bought computers to use will be too busy using them to prowl round a show. People who haven't yet bought one, will go to a local dealer.

Within a few years anyone trying to stage a computer show will be up against the same difficulties that face anyone now trying to stage an audio or video show. The large consumer electronic shows in America, and the Berlin Radio Show, point to the future. At these exhibitions everything is under one roof; audio, video, computers, radio, TV, satellite systems, telephones and general electronic gadgetry. That is the path exhibitions must follow in Britain, or perish.

Accessory Market

At Birmingham the accessory market was clearly booming. I counted no less than twenty exhibitors showing equipment which is claimed to protect computers from the evil effects of mains-born interference and voltage drops and surges. All these systems doubtless work as claimed. There were some impressive demonstrations of how expensive circuitry can eliminate spikes, stabilise widely varying supply voltages and bridge gaps in the supply.

Repeatedly I asked the exhibitors what work they had done on analysing mains supply problems in Britain, and the ability of available computers to cope with the kind of problems likely to be encountered. I asked, because the British electricity supply is commendably stable and most computers made by respectable manufacturers have good smoothing and stabilisation circuits, with large enough capacitors in the power supply to bridge brief voltage dips.

I could not find one exhibitor with convincing evidence to show that respectable computers cannot cope with what they face from the mains. On the face of things, the boom in line conditioners looks like a sophisticated and expensive solution looking for a problem.

The technology is interesting, but is it necessary? It would be useful to hear readers' views on this, based on practical experience. We can then return to the technology in a later column.

Optical Illusion

There was still no sign of the optical storage revolution reaching the home or small business computer market. No-one was showing a CD-ROM system and no-one was showing a working optical disc recorder for a PC.

In the press room Maxell had posted a notice, inviting all present to come and see the company's new 5·25 inch optical disc. This sounded interesting, because the computer industry is currently trying to set a standard for optical discs which allow users to record their own data—either permanently or semi-permanently.

So far there has been only confusion, with different firms adopting different disc sizes (14, 12, 8, 5·25 and 3·5 inch) and different coding standards for the data. The only thing these systems have in common is that the blank disc is coated with a metal surface into which pits are burned by a laser in the recorder. Rotational speed is constant to give orderly sectoring. But there is no agreed standard for the fixed speed.

Sometimes the blank disc has a groove to guide the laser; sometimes it has a preformed spiral track of servo control pits. As a result it is a safe bet that data recorded on one manufacturer's optical disc system will not replay on another.

Philips and Sony have been trying to set a standard based on a 5·25 inch disc contained in a protective cassette. The disc drive would fit in a standard PC drive slot. The Maxell demonstration turned out to be a damp squib. Simply a 5·25 inch disc in a demonstrator's pocket. No working hardware and no working demonstration.

Quickdisk

Maxell was also talking about, but not demonstrating, an interesting system called Quickdisk. The Japanese company is offering this to firms in Europe which make budget computers.

Quickdisk is a low cost magnetic floppy disc which offers an alternative to cassette tapes for data storage. It was developed by Mitsumi and Maxell and is already used in Japan for toy computers made by Nintendo. Maxell now suggests that Quickdisks would make an ideal memory store for low cost office equipment, such as electronic computers.

Quickdisk looks like a conventional floppy disc, 2·75 inch in diameter, but requires much simpler and thus much cheaper read-write electronics to store and retrieve the data.

Conventional floppy disc systems divide the magnetic surface into evenly distributed pie-shaped sectors. Each sector is digitally labelled and a magnetic pick-up moves rapidly between sectors under servo control to record or retrieve labelled blocks of data. The head can find any sector and read its data in less than a second.

Data is recorded on Quickdisk as a spiral track, like a magnetic gramophone record, instead of sectors. The read-write head starts at one end of the sprial track and runs right through to the other end as the disc rotates at a fixed speed of 423rpm. So all the data to be stored is recorded as a serial stream.

The spiral track on one side of the disc can store 64 kilobytes, which is equivalent to around 64,000 text characters. It takes eight seconds to run through the complete track, either recording or retrieving the full data stream.

Although Quickdisk is a clumsy method of storing data when compared to conventional floppy disc, it is far cheaper because there is no need for complicated servo and search control of the head. It is also much faster to use than a tape cassette, which can take minutes rather than seconds to run through. Maxell reckons it could sell Quickdisks for around £1 each, which is as cheap as a data cassette tape.

I couldn't help thinking that Maxell would have more chance of selling the system to British manufacturers if it had staged a demonstration at the Birmingham show, rather than just putting out a pile of leaflets and leaving journalists like myself to try and find someone who knew what the leaflets meant.

Z88 Launch

The Birmingham show saw the official launch of Sir Clive Sinclair's new computer. Because Sir Clive literally sold his name to Amstrad for use on computers, he has had to start a new company called Cambridge Computers. Although he can still call himself Sir Clive Sinclair, he has to call the new computer simply the Z88. As usual with Sir Clive, the Z88 is available only by mail order.

The "no-compromise" Z88 is a portable and much improved version of the old Spectrum. Although the 'rubbery' keyboard is better than the Spectrum keyboard, it still fits the classic description—"like shaking hands with a dead man". The l.c.d. screen is reasonably clear, but the text characters are small, and could prove pretty wearing on the eyes. Working with the larger Tandy 100 screen is bad enough.

At Birmingham, the Sinclair (sorry Cambridge Computers) stand was small—quite a comedown from Sir Clive's days of past glory. But otherwise it was déja vu. Although there was a pile of cardboard boxes, there was only one working model on display.

A milling crowd were given a brochure with mail order form. The brochure promised a "special introductory price" of £199.95 but the form told potential customers to send £229.95 plus £7.50 postage. All very puzzling.

It will be interesting to see whether history repeats itself and there now follows the familiar saga of complaints from members of the public who send their money for a new Sinclair gadget, only to find that it is not yet available. It would be nice to think that Sir Clive, having lost his fortune, has finally learned his lesson. Time will tell.

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EE APEX HI FI AMPLIFIER

PART 4

GRAHAM NALTY

THIS month we look at the construction, wiring up and final testing of the power amplifier. Thus completing the four part series on the *EE Apex Hi Fi Amplifier.*

CONSTRUCTION

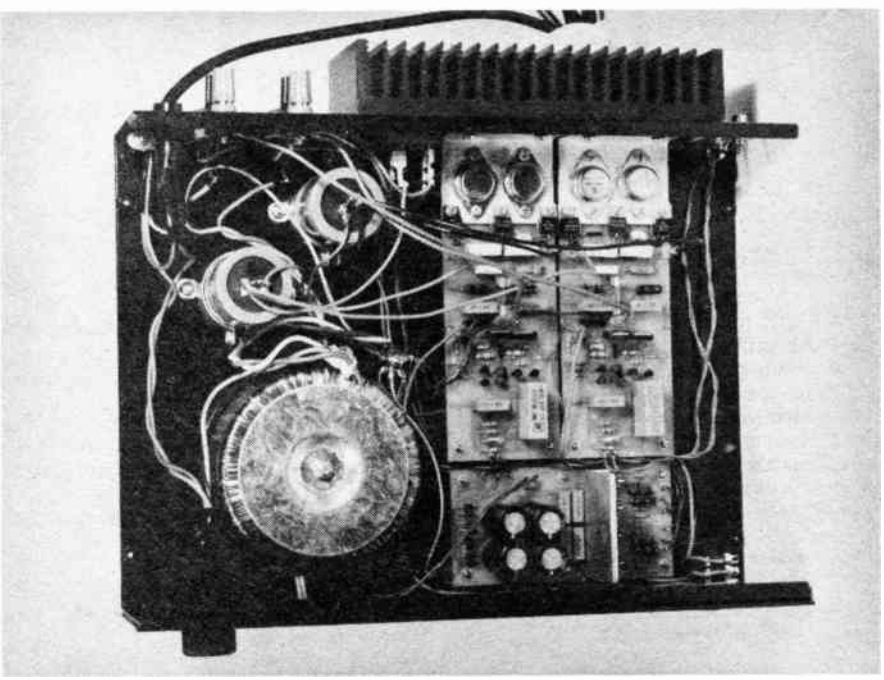
The input phono sockets are fixed to the fibreglass insulating boards. They should be tightly fixed to prevent them from working loose when the amplifier is completed. Next build the low current power supply boards. Construction is fairly straightforward apart from the i.c. regulators, but do check and double check the polarity of the diodes and electrolytic capacitors. The installation of the i.c. regulators should be undertaken with care—each regulator requires one 6 BA × 12mm bolt, nylon insulating bush (to insulate the i.c. from the bolt), a mica or silicone rubber TO220 insulator between the i.c. and bracket and a shakeproof washer and nut. Attach the board to the chassis with four sets of two 6BA × 6mm bolts, and a 6BA × 12mm spacer.

Two identical boards are used for each power amplifier.

The components should be attached to the board in order of ascending size, leaving TR8 and TR10 to TR15 to last. If Wondercaps are used for C1 and C3, they should be installed vertically. Three terminal pins should be fitted close to the end of R14. The fuseholder clips are best installed with a fuse placed inside them. Otherwise there is a tendency for the clips to twist and make it more difficult to install the fuse. TR8 and TR10 should be installed together with about 2mm of lead below the board. For better sound quality, a small heat sink should be attached to both TR8 and TR10, and one of the two transistors, should be insulated from the heatsink. Mounting the five transistors to the main heat sink bracket needs some care. If you are using mica washers, use heat sink compound on either side for better thermal contact. Place the two TO3 transistors in position and screw down gently. Each TO3 transistor requires two 6BA × 12mm bolts, two 6BA washers, one TO3 insulator between transistor and bracket, two insulating bushes, one 6BA soldertag and washer and two 6BA nuts. The insulating bush should insert all the way into the p.c.b. and part of the way into the bracket to insulate the bolt from the bracket.

The TO-220 transistors are best installed by inserting them into the p.c.b. and bending them over so that the hole in their tab lies above the hole in the bracket and p.c.b. Place the insulating washer between the transistor and bracket, and add heat sink compound on both sides if you are using mica washers. Place an insulating bush on a 6BA × 12mm bolt and insert. Because of the proximity of p.c.b. track a 6BA insulating washer should be placed immediately below the p.c.b. followed by a 6BA plain or shakeproof washer and 6BA nut. Before finally tightening the transistors, align the bracket so that its position is true to the p.c.b. This also can be done within the case. Attach the heatsink to the chassis via 6 × 4BA × 10mm bolts and 6 × 4BA washers. Next attach the stand off to the floor of the chassis. One 20mm or two 10m 6BA spacers are required. These are fixed using a 6BA ×12mm bolt. The boards can be fixed to the heat sink via two 4BA × 10mm bolts and washers to the chassis via two 6BA × 6mm bolts and washers. With the board firmly fixed, the seven bolts holding the power transistors can be tightened. For final tightening, remove the board, then check the insulation of the transistors with a meter. Solder the solder tags to the p.c.b. track for electrical connection to the supply. Remember that these bolts fix the power transistors to the heat sink and must be tight for good heat transmission. Check all the components and solder joints visually and screw into position.

The input socket board is attached to the rear of the chassis via two sets of 6BA × 6mm bolt, 6BA shakeproof washer and nut. The power supply capacitors are held by capacitor clips each using one 4BA × 12mm bolt, two 4BA washers and nut. These are attached to the chassis via four 4BA × 10mm bolts, 4BA washers and 4BA nuts. The mains transformer is attached using the hardware provided in the following order: bolt, chassis, neoprene pad, transformer neoprene pad, metal circular piece, washer and nut. It is important to ensure that none of the metal on the topside of the transformer touches any part of the chassis as it will create a short circuit single turn around the core of the transformer and pass a very high current. The mains switch and headphone socket are fixed to the front of the chassis and are used to hold the front panel in position. The mains switch may need to be shortened to accommodate the knob. It is best to do this before connecting any wires to it and remove it from the chassis to do so. This way you avoid scratching the front panel with a hacksaw blade.



CONNECTING WIRE

The quality of wiring you use will have a significant effect on the overall sound quality of the amplifier, far more than most people would expect. The best cable I have used to date for internal wiring is Kimber cable. It is flexible and its insulation is easy (with experience) to cut. The secret of stripping the insulation of Kimber cable is to cut the insulation with the strippers and move the cable round about a ¼ turn and cut the insulation again. The insulation is then removed much more easily than with a

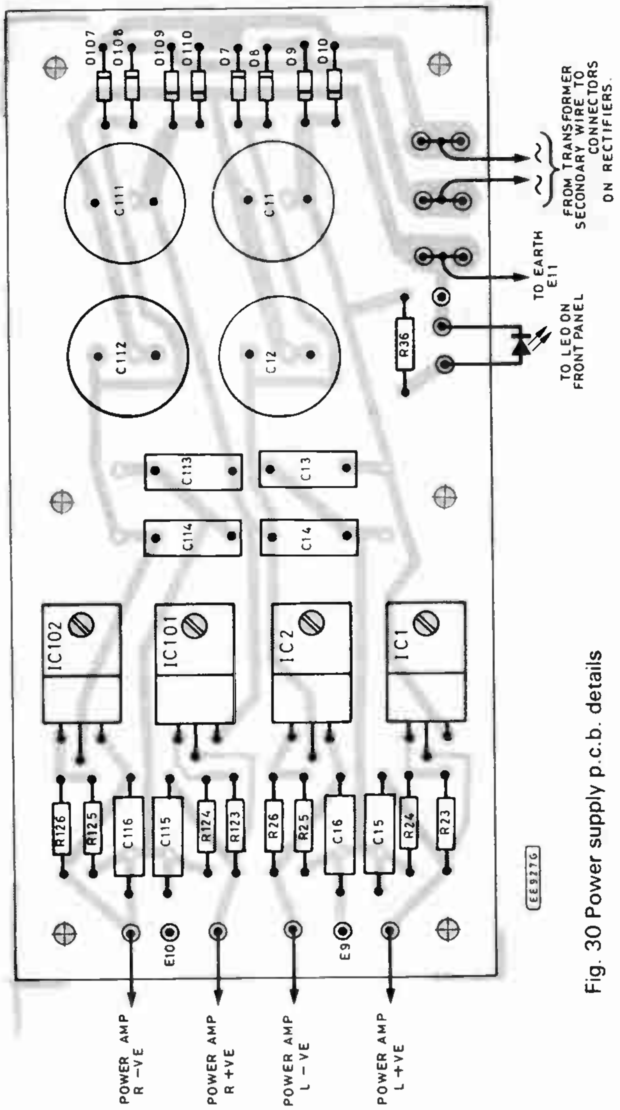


Fig. 30 Power supply p.c.b. details

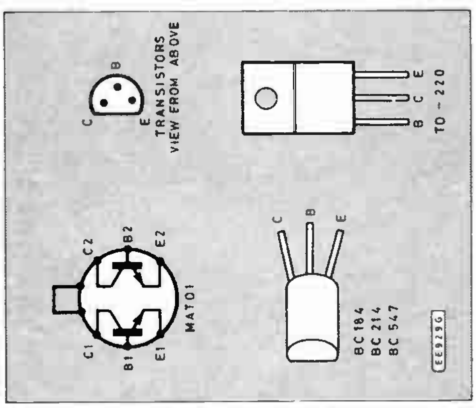


Fig. 32 (above) Transistor leadouts

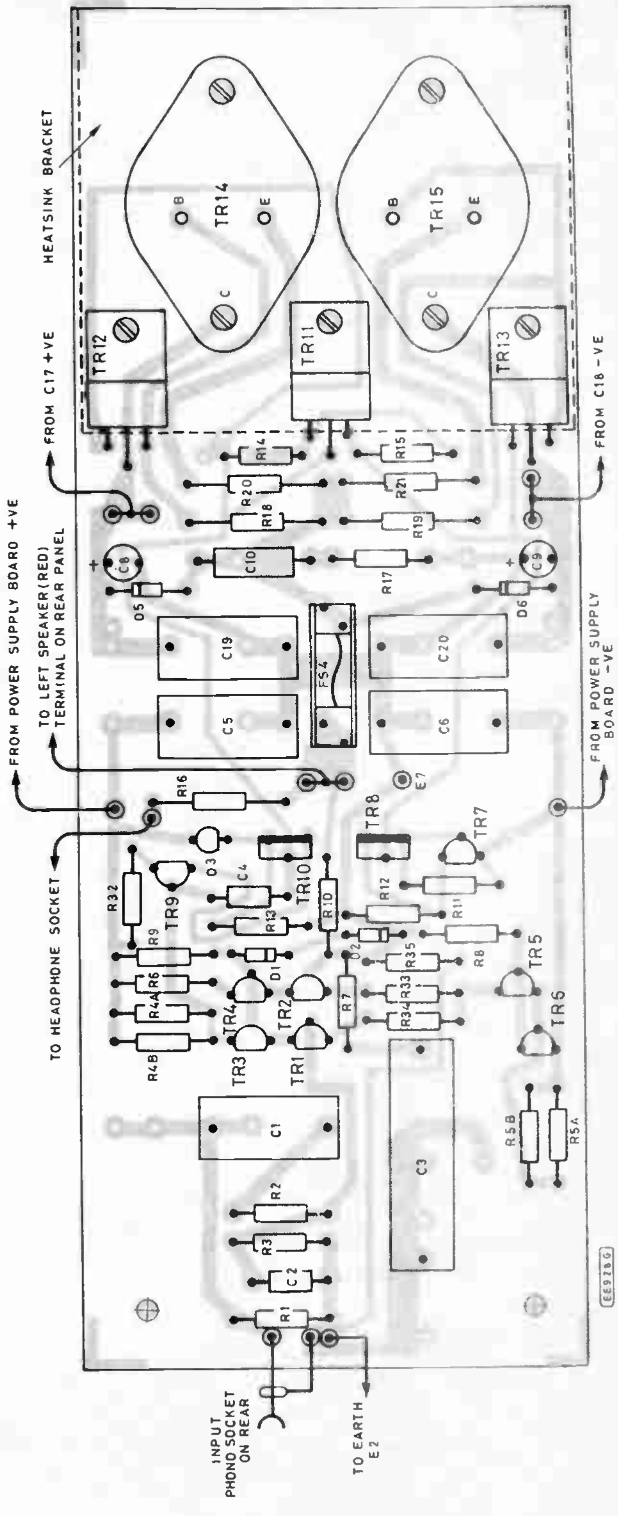


Fig. 31 Power amplifier p.c.b. Two identical boards are required. All transistors are electrically isolated from the heatsink bracket.

single cut. Sound quality from using Kimber cable is excellent, but there is perhaps less bass subjectively than you might expect or require. The disadvantage is the high cost. Single core cables are a fraction of this cost. Large single core cables are very good for high current connections but are inflexible. They are usually covered with p.v.c. and, surprising though it is, can sound better if the p.v.c. insulation can be removed.

Small single core cables can be obtained with high quality polythene insulation. They can look very neat in a finished amplifier as they can be bent into shape, but if you have to remove a board to test it, they tend to break off. Also it is difficult to remove the insulation without nicking the wire. One answer is to wire the amplifier with flexible cables until it has been completely tested and then change each cable to single core. Multistrand cables are easy to use, but the sound quality from using multistrand cables is generally inferior to single core cables. But for simplicity, I shall assume the use of multistrand cables for internal wiring, using cables rated four to six amps for mains and high current (output stage and speakers) and at one to three amps for low current wiring, heavier grade multistrand or single strand cable can be used to gain improved sound quality, but will be less easy to install.

MAINS WIRING

The mains wiring can be carried out first. The mains lead is stripped of its outer insulation for several inches. A few inches down the cable it is held in a nylon clamp by a 4BA × 12mm bolt, two washers and a 4BA nut. This prevents the cable from being pulled out of the amplifier. The earth core is attached to a 6BA solder tag (E1). The live end is placed into the insulating boot for the mains fuseholder and soldered to the fuseholder. A similar wire is soldered to the other tag on the fuseholder via the cover, then through the rectangular mains switch cover and soldered to the mains switch.

The neutral core is twisted around the live core from the fuseholder, inserted into the switch cover and soldered onto the switch. The primary leads from the mains transformer are pushed into the fuseholder cover (this will be getting rather tight now)

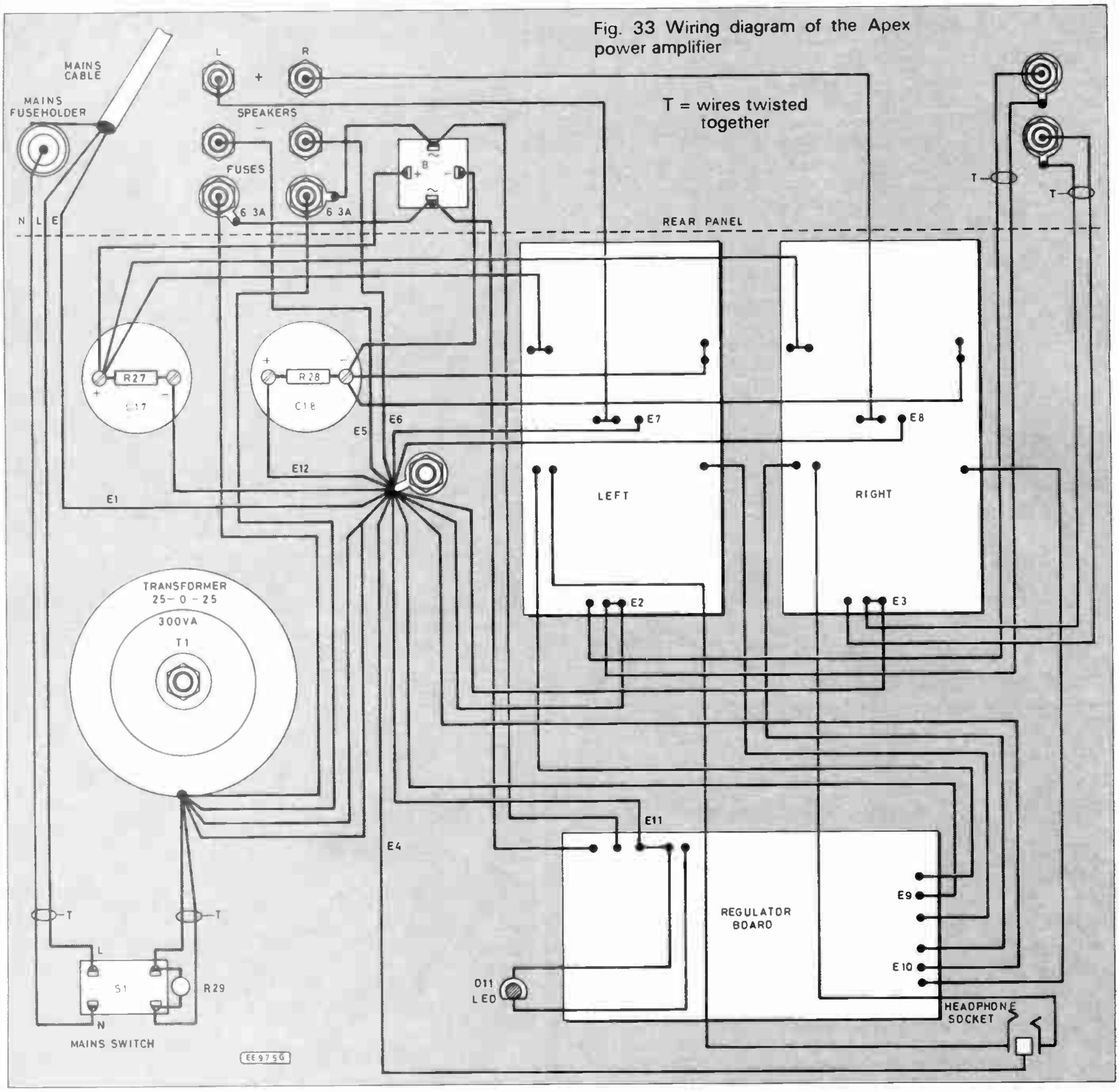
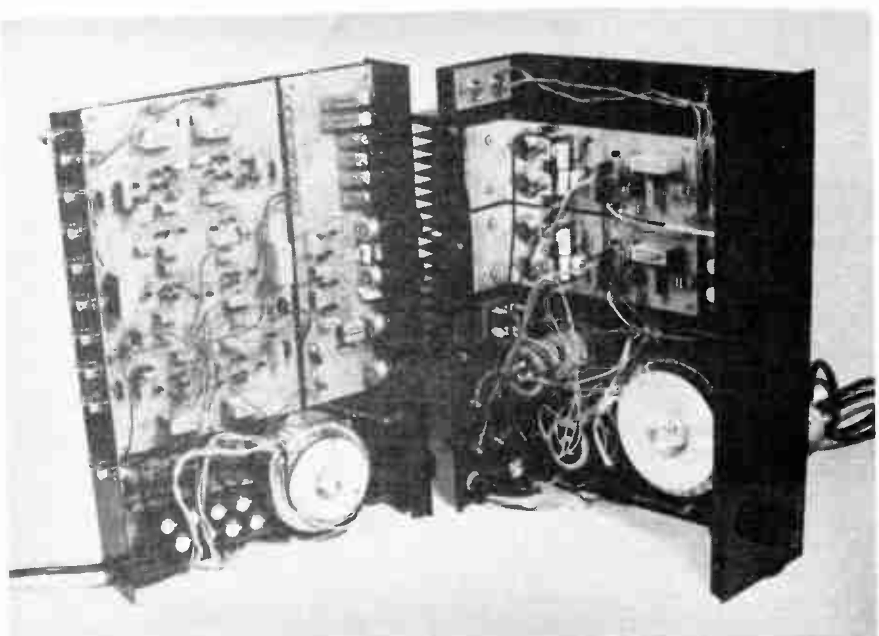


Fig. 33 Wiring diagram of the Apex power amplifier



and soldered to the other terminals of the switch. Make sure that the insulation goes right up to the switch tags. The VDR is also attached to the same terminals of the switch. A method I use is to wind the leads from the transformer around the VDR leads to 6mm and solder this to the switch. Place the fuseholder and switch covers in position, insert the mains fuse FS4 and the primary circuits are now complete.

Most transformers will have two separate windings. The two centre winding connections (typically blue and yellow) are twisted together and soldered to a solder tag (E13). Each outer winding connection (typically red and grey) is soldered to a fuseholder (FS2 and FS3). The mains rectifier is attached to the heatsink via a 4BA × 20mm bolt and three washers. A pair of $\frac{1}{4}$-inch push on connectors each have two wires soldered to them, are fitted and these are then attached to the a.c. (~) blades on the rectifier. One pair of leads is connected to FS2 and FS3 and the other pair is connected to the a.c. terminal on the low current power supply board.

CABLES

Pin No.	From	To	Lgth.	Colour Stdrd.	Colour Kimber (Direction)	
	Input signal	L. power amp.	32	Blue	Blue	→
	Input earth	L. power amp.	32	Green	Black	→
	Input signal	R. power amp.	25	Brown	Red	→
	Input earth	R. power amp.	25	Green	Black	→
E2	L. power amp.	Earth	12	Green	Black	→
E3	R. power amp.	Earth	18	Green	Black	→
	L + regulator	L. power amp.+	25	Brown	Red	→
E9	L. OV regulator	Earth	24	Green	Black	→
	L. – regulator	L. power amp.–	19	Blue	Blue	→
	R.+ regulator	R. power amp.+	19	Brown	Red	→
E10	R. OV regulator	Earth	27	Green	Black	→
	R – regulator	R. power amp.–	18	Blue	Blue	→
	Regulator board	l.e.d.+	18	Brown		
	Regulator board	l.e.d.–	18	Green		
E7	L. power amp.	Earth	9	Green	Black	→
E8	R. power amp.	Earth	15	Green	Black	→
	L. (h'dphone) amp.	H'dphone socket	38	Blue	Blue	→
	R. (h'dphone) amp.	H'dphone socket	24	Red	Red	→
E4	H'dphone socket	Earth	30	Green	Black	←
	L. power amp.	L. Speaker+	21	Brown	Blue	→
E5	Earth	L. Speaker–	20	Green	Black	→
	R. power amp.	R. Speaker+	24	Brown	Red	→
E6	Earth	R. Speaker–	17	Green	Black	→
	Rectifier a.c.	Regulator board	27	Brown	Red	→
	Rectifier a.c.	Regulator board	27	Brown	Red	→
	Rectifier+	C17+	12	Red	Red	→
	C17+	L. power amp.	19	Red	Red	→
	C17+	R. Power amp.	23	Red	Red	→
	Rectifier–	C18–	7	Black	Blue	→
	C18–	L. power amp.	13	Black	Blue	→
	C18–	R. power amp.	20	Black	Blue	→
	FS2	Rectifier a.c.	15	Brown	Red	→
	FS3	Rectifier a.c.	13	Brown	Red	→
	FS1	Mains switch	26	Red	Red	→
E11	Earth	Regulator board	12	Green	Black	→

Total lengths of Kimber cable: red 279; blue 168; black 241.

EARTH WIRING

Three earth leads (E9, E10, E11) can now be taken from the low current power supply board to the earth point. One solder tag is used for E9 and E10 and a second for E11. Now connect all other earth leads, using shared solder tags for E2 + E3 and E7 + E8. The purpose of the shared tags is to reduce the number of tags to a more manageable number. The earth tags can now be attached to the chassis via a 6BA × 12mm bolt and nut in correct order, with E1 closest to the chassis and E13 farthest away. Speaker earths E5 and E6 are connected to the black speaker terminals which are fixed to the rear of the chassis. The solder tags are fixed securely to the terminals with 4BA shakeproof washers.

TESTING

Now test the low current regulators. Connect to the mains, switch on and measure the voltage at the output of the regulators.

If there are no faults, the output voltage of the regulator should read close to + or - 30V. Now connect from the low current regulators to terminals on the amplfier boards. The output stage is not powered, but you can test the operation of the circuit as follows:

The offset voltage at FS4 should be quite a bit less than 300mV (the final output offset after completion should read lower than 100mV). The voltage across each transistor base/emitter junction or across each diode should read close to 600mV, except for D3 which should read 1.6V. If these tests are O.K. disconnect the mains, and wire up the output stages. First attach R27 and R28 to the capacitor terminals. If you are using capacitors with screw terminals, you will need an additional set of 2BA solder tags for them and crimp tags for the cables.

You will need to attach three wires to the positive tag of C17 and three wires to the negative tag of C18. The other ends of each wire are soldered to ¼-inch blade connectors. One wire from the positive tag of C17 is connected to the +ve output of BR1. One wire from the negative tag of C18 is connected to the –ve output of BR1. (Make sure these are correct by using different colour wires). The other wires are connected to the ¼-inch blades on the amplifier boards, but you will need first to insert 4 × 47ohm 5W w/w resistors between the leads and the board to test.

Check—have you soldered the solder tags below TR14 and TR15, TR114 and TR115 to the p.c.b. Place one ¼-inch blade and one ¼-inch push-on connector at each end of the 47ohm 5W resistors (cut the leads so that the connectors are close to the body of the resistor). Connect one resistor to each of the four power supply leads at one end, and to the amplifier board (correctly!) at the other ends.

Connect to the mains and switch on. R30 and R31 should get warm, but you should be able to measure about 0·3V to 0·4V across R18 and R19 each. If not or you notice R30 and R31 getting red hot, switch off and examine for faults. When you are certain that both power amplifiers are functioning correctly switch off and remove the resistors (allow five minutes for C17 and C18 to discharge). Switch on; the amplifier should run warm and the transistors TR12 and TR13 hot to touch.

Check the d.c. offset voltage. If this is greater than 100mV you can reduce it by altering the value of R3 by up to a factor of two. If this adjustment is not enough you can adjust by placing a resistor (typically about 10 times the value) across R5 (if offset is negative) or across R4 (if offset is positive). The positions on the board marked R4B and R5B are provided for this purpose.

FINAL CONNECTIONS

The final connections are output signal connections to the speaker terminals and headphone socket. Remember to use shakeproof washers in fixing to the speaker terminals. If you have used a heatsink bracket on TR8 and TR10, TR108 and TR110, you should cover the ¼-inch push on connector for the speakers with an insulator.

The mains transformer may induce a very small amount of hum into the circuitry of the power amplifier. This can be virtually eliminated by turning the transformer around until a null point is reached (in one prototype this was about 20 degrees clockwise from the position shown in the photographs). The ideal way to do this is with the amplifier on and loudspeakers connected but **you must be very careful and wear rubber gloves whilst turning the transformer** as your hand is close to the mains connections—the rubber cover on the mains switch can easily be dislodged! The safe way is to switch off, disconnect the mains plug, rotate the transformer a little and try again.

Your amplifier should now be complete. To get the best performance from the amplifier mount it on a vibration free surface. Accessories such as the RATA Torlyte platform or Mission Isoplat will improve the sound quality if placed under the amplifier.

Use a new mains plug, preferably one of high quality by a recognised manufacturer (e.g. Crabtree, MK etc.). Also use a high quality interconnect between the preamp and power amp and between the power amp and loudspeakers. Such measures will ensure that you get the very best performance from your amplifier. □

NOTE

EE Apex Additions/Corrections
Preamp March page 148

C17, 18, 117, 118
improved version *47n* 1½% LCR EXFS/RP

C29–32,129–132
10µ *35V* (35V capacitors can be used)

page 149
C3, 10, *25*
470n polyester (3 off) 470n polypropylene

Higher current versions of the Apex power amp can be built by using alternative devices

	10A	20A	30A
TR14	2N3716	MJ15003	MJ802
TR15	2N37392	MJ15004	MJ4502

Some components used in the improved versions have very limited distribution outlets and may be subject to fairly long delivery times if suppliers' stocks become exhausted.

Actually Doing it!!

IN LAST month's article we considered the subject of resistors, and this month we make the natural progression to the subject of capacitors. Capacitors are amongst the most simple and inexpensive of electronic components, but from the readers' letters that I receive they are obviously a continuing source of minor problems. The fact that there are a number of types available does not help, and the availability of variations on most types exacerbates the problems. Like other components, they are subject to continuing development and consequent changes which can lead to confusion.

DIELECTRICS

The main difficulty seems to be in obtaining components having the right dielectric. A capacitor is basically just two metal electrodes with a thin insulating layer in between. Practical components generally consist of two thin strips of metal foil rolled up into a tube, with two thin strips of insulating material interleaved with them so as to provide the electrical isolation. This enables reasonably high values to be easily condensed into a small and convenient size. The dielectric is the insulating material.

There are several common dielectric materials. High quality low value types use mica, and low through to highish value types sometimes use a ceramic material. The latter are generally only specified for high freqency decoupling applications. With both these types of component it is not advisable to substitute a different type of capacitor, or for that matter, to use components of these types where they are not specified.

The most common dielectric these days is probably the plastic foil type. In fact this is a generic term for a variety of materials, the most common of which are mylar, polystyrene, polycarbonate and polyester. Polystyrene is normally only used for capacitors up to a few nanofarads in value, whereas the other three are mostly used for values of about one nanofarad and above. Confusion sometimes seems to result if a component list merely specifies something like "plastic foil" rather than a specific material. If plastic foil or something similar is quoted, then mylar, polystyrene, polycarbonate and polyester (or poly anything) are all suitable from the electrical point of view. It is always unwise to ignore the physical characteristics of components though, and it might be possible to obtain (say) a polystyrene capacitor of the required value, but it would not be a good choice if it was far too big to be easily accommodated on the printed circuit board.

Polycarbonate capacitors are often just referred to as "carbonate" types, and these seem to have largely disappeared from component catalogues with miniature polyester types now taking their place. If you come across a design which specifies polycarbonate capacitors, there will probably be no alternative but to substitute polyester capacitors. Although the polycarbonate type is generally superior in certain respects, it is unlikely that using polyester types instead would give any problems.

High value capacitors are mostly of the electrolytic type, and these should not provide any major difficulties. Remember that these are almost invariably "polarised", and must be connected the right way round. Also, components lists do not usually specify the voltage rating for non-electrolytic capacitors, since most circuits operate at potentials of a few volts, and virtually all capacitors of this type will operate at around 100V or more. The voltage rating is therefore unimportant. The same is not true of electrolytic types where the maximum voltage rating can be as low as 6V, and you therefore need to be careful to obtain components with an adequate voltage rating.

For low value types (about 470n to 4μ7) components lists often stipulate a fairly high voltage of around 50 to 63 volts. This does not necessarily mean that a voltage rating as high as this is required, and it is often just because low value electrolytic capacitors are only widely available in these relatively high voltage ratings. It is often quite acceptable to use components which have a much lower voltage rating if your supplier stocks them, but unless you are sure you know what you are doing it is advisable to play safe and use types having the specified rating. Many of the low value low voltage electrolytic capacitors I have encountered have proved to be of mediocre quality, and I tend to avoid these anyway.

There should be no difficulty in using an electrolytic capacitor which has a maximum working voltage that is much higher than the one specified in that such a component should work perfectly. On the other hand, a capacitor such as a 100μ 63V type could easily be double the length and diameter of a 100μ 10V type, and the small size of most modern circuit boards does not provide enough space for components that are more than marginally bigger than the ones for which they were designed to accept. Most component catalogues specify a maximum size for electrolytic capacitors, and so this is something that can usually be checked before ordering.

AXIAL AND RADIAL

You will often encounter terms which refer to the physical characteristics of a capacitor rather than any electrical properties. The most vague of these is "printed circuit mounting", or just "PCM". This just means a component which has both leadout wires protruding from the same end, and which is intended for vertical mounting on the circuit board. All the ceramic capacitors I have come across have been of the PCM variety, either in the form of "disc" ceramic capacitors (Fig. 1a) or the ceramic "plate" type (Fig. 1b). Some of the disc ceramic capacitors currently on sale seem to be quite large and are difficult to fit into many component layouts. I would recommend that miniature types are obtained whenever possible, even if they cost a little more.

Plastic foil capacitors are often of the PCM type, and they generally have the box type appearance depicted in Fig. 1c. Ceramic types normally have quite long and flexible leadout wires, and can be manoeuvred into most component layouts without too much difficulty. PCM plastic foil capacitors are a very different proposition, and almost invariably have short, stiff leadouts that are intended to fit mounting holes a certain distance apart. The standard pitches are 2·5, 5, 7·5 and 10 milimetres, which in imperial measure corresponds to almost exactly 0·1, 0·2, 0·3 and 0·4 inches. In previous articles I have warned about the difficulties of using a capacitor of the wrong pitch, but it is one that is well worth repeating here. It is sometimes possible to gently persuade one of these capacitors to fit into mounting holes of the incorrect pitch, but the necessary bending of the leadout wires can easily result in one of them being broken away from the body of the component.

"Axial" is a term that is applied to any component, including electrolytic and non-electrolytic capacitors, which take the general form shown in Fig. 2a. Printed circuit mounting electrolytic capacitors normally take the form shown in Fig. 2b. These are more usually referred to as "radial" rather than printed circuit types.

COLOUR CODES

Colour codes are less common with capacitors than they are with resistors, and most capacitors have the value, volt-

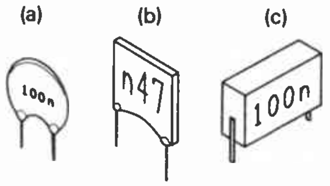


Fig. 1. Three popular types of PCM capacitor; (a) disc ceramic, (b) ceramic plate, (c) miniature polyester/carbonate.

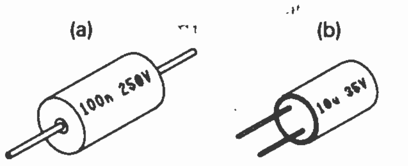


Fig. 2. Two common styles of capacitor; (a) is axial and (b) is radial. Both styles are only common in electrolytic capacitors though.

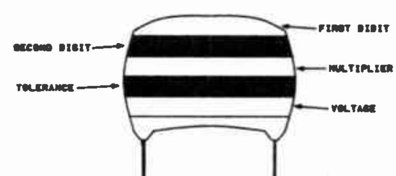


Fig. 3. The C280 capacitor style of colour coding.

age, and polarity (where appropriate) simply written on the body of the component. There are still a few tantalum bead types which use colour coding, but as this coding was covered in the "Actually Doing It" which appeared in the December 1986 issue this will not be described again here.

Polyester capacitors of the Mullard C280 variety (and some similar types) used to have colour coded value markings, but many of the capacitors of this type that I have obtained over the last few years seem to have the values etc. just written on. However, you are still likely to come across colour coded versions of these capacitors quite frequently, and will need to understand the system of coding.

Fig. 3 helps to explain this coding system which has some similarities to resistor types. It is a five band system which indicates value, maximum operating voltage and tolerance.

The first three bands indicate the value in exactly the same way as the standard four band resistor colour code which was described last month. However, in this case the value is in picofarads instead of ohms. Divide the value by 1,000 to give an answer in nanofarads, or by 1,000,000 to give an answer in microfarads. The fourth band shows the tolerance, but not using the standard resistor colour codes this time. Instead this band will either be black to indicate 20 per cent tolerance, or white to signify 10 per cent tolerance. The fifth band indicates the maximum working voltage, and will either be red (250V) or yellow (400V).

MARKINGS

When capacitors have the value written on it is not always in a form that makes the value immediately obvious. In particular, with ceramic and mylar capacitors the value is often indicated by a simple three digit code. The first two numbers are the first two digits of the value, and the third number is the number of zeros to be added in order to give the full value. This has obvious similarities to the standard resistor colour coding. As an example of this system, "332" would indicate 33 as the first two digits plus two zeros giving a total value of 3,300. This is picofarads, and dividing by 1,000 to give an answer in nanofarads produces a result of 3·3 nanofarads (or 3n3 if you prefer).

It is quite common for low value ceramic capacitors to have the value marked in nanofarads rather than picofarads, which can be a little confusing. For instance, a 100 picofarad component might be marked n10. There may well be other markings apart from the value, but these are not normally of any significance and can be ignored. Many ceramic capacitors have the top part of the body a different colour to the rest of the component, and this is not to make them look pretty. It indicates the temperature coefficient of the component, but unless you build sophisticated pieces of radio equipment you are unlikely to come across a components list that specifies a particular temperature coefficient.

Robert Penfold

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...REPORTING AMATEUR RADIO...

TONY SMITH G4FAI

MORSE TELEGRAPHY

Samuel F. B. Morse invented his electric telegraph and associated code in America in the 1830's, and introduced an improved code, known as American Morse, about 1844. The code used today is *International* Morse, devised in Europe in 1851, retaining 16 of the symbols from American Morse. The telegraph was the wonder of the age in Victorian times. Its single wire and earth return circuits circled the globe, providing instant communication more often than not by means of the Morse code.

Marconi introduced to the world the means of sending those same Morse signals *without* wires and that was the sole purpose of wireless at that time. Since then, of course, radio technology has advanced by leaps and bounds, and Morse code communication has become increasingly redundant.

Ships at sea were the first to benefit from the new invention and eventually every ship was required by international law to carry one or more wireless operators able to signal in Morse code. With the advent of satellite communications and other advanced techniques, maritime communications from the 1990's will no longer require ships' wireless officers of any kind, and all communications will be conducted from the bridge, with no sign of Morse on the maritime airwaves anywhere. These are the proposals of the Future Global Maritime Distress and Safety System due to be finalised at a meeting of members of the International Maritime Organisation, and others, next year.

AMATEUR MORSE

But if Morse is so old-fashioned and out-of-date, how is it that radio amateurs take it up with enthusiasm, and a good many operate only with code and nothing else?

Morse radio transmission in its basic form is known as c.w., signifying continuous wave transmission, which is simply the radiation of radio waves maintaining a constant amplitude and constant frequency. It is a somewhat confusing title since the Morse signals are obtained by interrupting the transmitted carrier wave so that it is, in fact, not continuous!

As a mode of communication c.w. offers advantages over all others. It takes up far less space on the crowded radio bands (at least ten c.w. stations could operate in the space taken up by an amateur station using speech); c.w. signals can often get through when other signals cannot; and the use of international abbreviations and code groups permits communication between operators having little or no knowledge of the other's language.

It might be thought that having to spell out words, etc, letter by letter is a tedious way of communication, but it doesn't really work out like that. C.W. operating is a combination of qualities. **Skill**, in using transmitter, receiver, antenna, and Morse key to the best advantage. **Knowledge** of, and fluency in, the Morse code and its abbreviations. **Technique**, in knowing how to conduct a contact to ensure effective communication with the minimum of time and effort. And **patience**, because sometimes signals are blotted out by adjacent stronger stations. Sometimes they become weaker and more difficult to copy. Then, the successful completion of a contact may call for personal qualities of patience and perseverance as much as anything else.

HOME-MADE EQUIPMENT

Another advantage of c.w. communication is that it is relatively easy to make your own transmitter and receiver. Unfortunately, modern equipment for speech operation is fairly complex to build and beginners are reluctant to attempt home-construction. With c.w. the position is entirely different. Simple circuits operate extremely well and it is possible for beginners to make equipment which can put them on the air with low cost and high satisfaction.

Morse operating is a compelling, absorbing, world, but one which is difficult to demonstrate to an outsider. It is an entirely personal thing as far as the individual operator is concerned, who is concentrating on what he is doing to the total exclusion of everything else at that moment in time. He is also enjoying himself immensely. Incidentally, for "he" always read "he or she" since there are also a good number of YL ("young lady") amateur Morse operators.

It is necessary to pass a Morse test to obtain a class A amateur licence to operate on the international h.f. (high frequency) bands. At one time amateurs had to use Morse exclusively for a year before they could transmit speech. Nowadays this is not required and, regrettably, some pick up their microphones as soon as they get their class A licence and forget about Morse code from that moment on. This is a great pity, because they are giving up a major aspect of amateur radio, capable of giving great satisfaction and pleasure, without ever having tried it.

LEARNING MORSE

There are a number of ways to learn Morse for the amateur test. There are home-study courses available, using tapes or records. There are "how-to-do-it" books; evening classes; and there are electronic devices which send random Morse at the speed of your choice, including one which speaks and tells you what it has just sent. There are also a number of excellent Morse learning programs for home computers. Radio clubs run courses for their members, and the Radio Society of Great Britain puts out slow Morse transmissions for learners on the amateur bands daily.

A recent concession for class B licensees (v.h.f. bands only) permits them to send and receive Morse on the bands for which they are licenced, to help prepare themselves for the amateur Morse test. In doing this, however, they must give their call-sign by telephony at the beginning and end of each over.

Morse telegraphy was the first kind of amateur radio, and among the various modes available to today's operator it is the one which relates most to "original" wireless operating, including some of the "olde-worlde" virtues such as courtesy and consideration for others. The many thousands of operators, worldwide, who remain faithful to the mode bear witness to its continuing attraction! There is even an international magazine, *Morsum Magnificat*, devoted entirely to Morse telegraphy, past, present, and future.

NOVICE LICENCE?

C.W. operating is ideal for beginners to amateur radio, since it is so easy to get on the air at low cost. Many countries have graduated licensing systems starting at "Novice" level with simple examinations and slow Morse requirements, progressing later to more demanding examinations to qualify for full licence privileges.

There is a movement to obtain a no-age-limit Novice licence in the UK which would permit Morse-only operation on the 10 metre band with a transmitter output of 5 watts, preferably using inexpensive home-made equipment. It is suggested that an eight week study course, covering theoretical and technical matters, at an appropriate level, could be followed by a two hour examination set by the RSGB, and a Morse test at 5 wpm conducted by local amateurs.

The Secretary of the Amateur Radio Novice Licence Campaign is Ian Abel, G3ZHI, who says, "The idea has the support of the G-QRP (low power) Club, the Scouts, Sea Cadets, the RSGB, and a number of radio amateurs. The Novice Licence could find its way into schools, etc; it is learning with a purpose and a use.

"The system is proven in the States, as I have seen for myself. Morse is the 'key' to its success—it is a code to learn and then communicate with, like learning a foreign language. Youngsters will love it because to them it is like a 'secret code', and the practical emphasis on construction and Morse operating skills should make the Novice approach a more attractive proposition/challenge than the present system of entry for any age of candidate. Ian will gladly provide further information on these proposals. His address is 52 Hollytree Avenue, Maltby, Rotherham, S66 8DY, tel: 0709 814911.

a regular feature for the Spectrum Owner...

by Mike Tooley BA

THIS month, as promised, we shall be describing the programming of the Versatile Sound Synthesiser described last month. We shall also be taking a look at some handy routines for manipulating the Spectrum's screen.

Before we get started, there's just time to deal with one or two important points from the post . . .

Free Memory Revisited

Several readers have written to say that M. Tucker's free memory routine (see March *On Spec*) fails to provide a sensible indication of the amount of RAM remaining. In fairness to Mr Tucker, his machine code routine is quite correct. The problem is, however, nothing more than a missing "USR" in the calling routine! To put the record straight, the line of BASIC in our mythical program which makes use of the free memory routine should read:

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

On the same topic, John Wall writes from Tyne and Wear with a much more elegant solution to the problem. John points out that the Spectrum already has a routine in ROM which determines the extent of free memory.

This routine starts at a decimal address of 7962. In order to find how much free memory exists it is thus only necessary to incorporate a line of the form:

9999 PRINT 65536 — USR 7962

Whilst on the subject of ROM routines, Andrew Wilson writes from Basildon to enquire about the availability of a disassembled and commented listing of the Spectrum's ROM code. For the benefit of anyone out there needing this information, *The Complete Spectrum ROM Disassembly* by Dr Ian Logan and Dr Frank O'Hara (published by Melbourne House, ISBN 0-86161-116-0) is the definitive text which can be recommended to serious Spectrum programmers as well as those wishing to exploit the occasional ROM routine in their own programs!

Spectrum Screen Manipulation

Anyone who has delved into the inner workings of the Spectrum will be aware that the Spectrum screen memory occupies the 6K RAM block extending from 16384 decimal (4000 hex.) to 22527 decimal (57FF hex.). A further 1K block of RAM extending from 22528 decimal (5800 hex.) to 23295 (5AFF hex.) is used to store the attributes of the 1024 screen character cells. The total memory devoted to the Spectrum's screen is thus 7K (extending from 4000 hex. to 5AFF hex.).

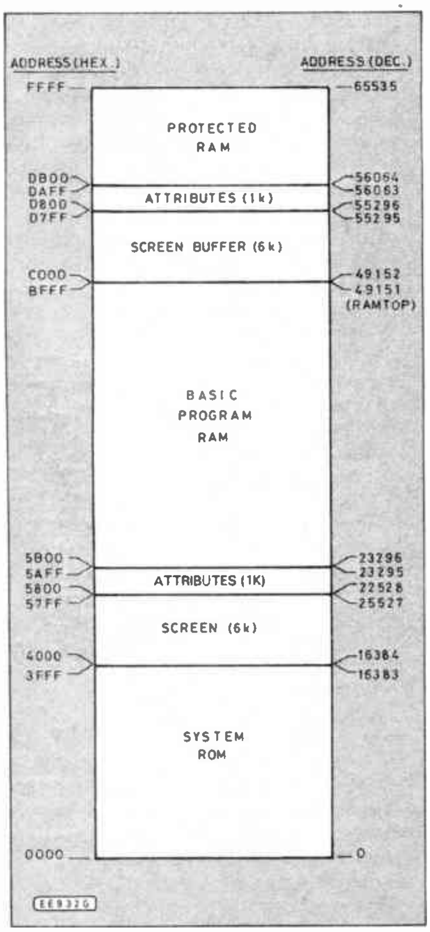

Fig. 1. Memory map for the screen swapping routines.

Let's assume that we wish to implement an "alternative" screen by setting up a screen buffer starting at C000 hex. This would extend to DAFF hex. (including the 1K attribute file).

The memory map for this arrangement is shown in Fig. 1. To ensure that any program does not attempt to use the screen buffer it would be prudent to lower RAMTOP to 49151 before attempting to run software which uses the "alternative" screen.

Fortunately, when it comes to manipulating large areas of memory, the Z80 instruction set provides the programmer with some very easy to use block move instructions. Of these, the "load increment and repeat" (LDIR) instruction is perhaps the most useful.

LDIR takes the contents of the HL and BC register pairs as the source and destination addresses for the block move. The number of bytes to be moved is taken from the BC register pair.

To take the existing screen memory (a 7K block comprising video RAM and attributes) and copy it to the block starting at hexadecimal address C000 it is necessary to:

(a) load the HL register pair with the start address of video RAM (4000 hex.)
(b) load the DE register pair with the start address of the RAM into which the block is to be moved (C000 hex.)
(c) load the BC register pair with the length of the screen memory (1B00 hex.)

The routine thus becomes:

```
LD   HL,4000H   ; HL points to the
                  start of the source
                  block
LD   DE,C000H   ; DE points to the
                  start of the destina-
                  tion block
LD   BC,1B00H   ; BC contains the
                  number of bytes to
                  be moved
LDIR            ; perform the block
                  move
```

We now have a routine which can transfer (copy) the video RAM (complete with attribute file) to another block of RAM (we shall call this the "screen buffer"). We could easily modify the routine to copy the block back (from the screen buffer into the video RAM) by simply changing the contents of HL (to C000 hex.) and DE (to 4000 hex.). In practice, both routines could be extremely useful. The only remaining question is where to put them!

Most of the machine code routines introduced in *On Spec* have been safely tucked away above RAMTOP in protected memory. Another alternative is that of making use of the "printer buffer". This small block of memory starts immediately above the screen attributes file and extends from 23296 decimal (5B00 hex.) to 23551 decimal (5BFF hex.). Provided one is not making use of the original ZX-printer, this area is quite safe to use and is quite large enough to accept the short routines used for screen manipulation.

The following code is required:

```
5B00  21 00 40   LD HL,4000H    ; Where it starts
5B03  11 00 C0   LD DE,C000H    ; Where we want it
5B06  01 00 1B   LD BC,1B00H    ; How much to move
5B09  ED B0      LDIR           ; Move it!
5B0B  C9         RET            ; Back to BASIC
5B0C  21 00 C0   LD, HL,C000H   ; Where it starts
5B0F  11 00 40   LD DE,4000H    ; Where we want it
5B12  01 00 1B   LD BC,1B00H    ; How much to move
5B15  ED B0      LDIR           ; Move it!
5B17  C9         RET            ; Back to BASIC
```

The following BASIC loader sets up the two screen swapping routines within the printer buffer:

```
1 RESTORE
2 FOR x=23296 TO 23319
3 READ z: POKE x,z
4 NEXT x
5 DATA 33,0,64,17,0,192,1,0
6 DATA 27,237,176,201,33,0
7 DATA 192, 17,0,64,1,0,27,237
8 DATA 176, 201
```

Thereafter the screen swapping code can be called from BASIC by a statement of the form RANDOMIZE USR nnnnn (where nnnn is the decimal start address of the required routing). Furthermore, it is possible to load and save screen images to the screen buffer in much the same way as it is to load and save the screen directly.

The following BASIC statements should thus cope with most requirements:

(a) Copy screen to buffer:	RANDOMIZE USR 23296
(b) Copy buffer to screen:	RANDOMIZE USR 23308
(c) Load screen from tape:	LOAD "pic" SCREEN$
(d) Load buffer from tape:	LOAD "pic" 49152,6912
(e) Save screen to tape:	SAVE "pic" SCREEN$
(f) Save buffer to tape:	SAVE "pic" 49152,6912

Finally, here is a little BASIC program which can be used to test the screen swapping routines (make sure that you have previously installed the machine code with our earlier program!):

```
10 INK 0: PAPER 7: CLS
20 PRINT AT 10,12; "SCREEN 1"
30 INPUT "Press <ENTER> to store";r$
40 RANDOMIZE USR 23296
50 INK 7: PAPER 0: CLS
60 PRINT AT 10,12; "SCREEN 2"
70 INPUT "Press <ENTER> to
restore";r$
80 RANDOMIZE USR 23308
90 GO TO 10
```

When the program is run and the prompts are followed, the change from "SCREEN 1" to "SCREEN 2" should be virtually instantaneous. It now remains for the reader to make good use of the screen swapping routine. The possibilities are endless—drop me a line if you come up with something that may be worthy of a wider audience!

PROGRAMMING THE SOUND SYNTHESISER

Last month we glibly mentioned that individual bits stored in the control register array of the AY-3-8913 are responsible for determining such things as the frequency and amplitude of the outputs of the three tone generators. In addition, bits are used to determine the envelope of the waveform and the amount and period of noise mixed into the output.

The function and organisation of the AY-3-8913's internal registers can be made a whole lot clearer by studying Table 1. Registers 0 and 1 determine the frequency of the signal produced by the oscillator assigned to channel A.

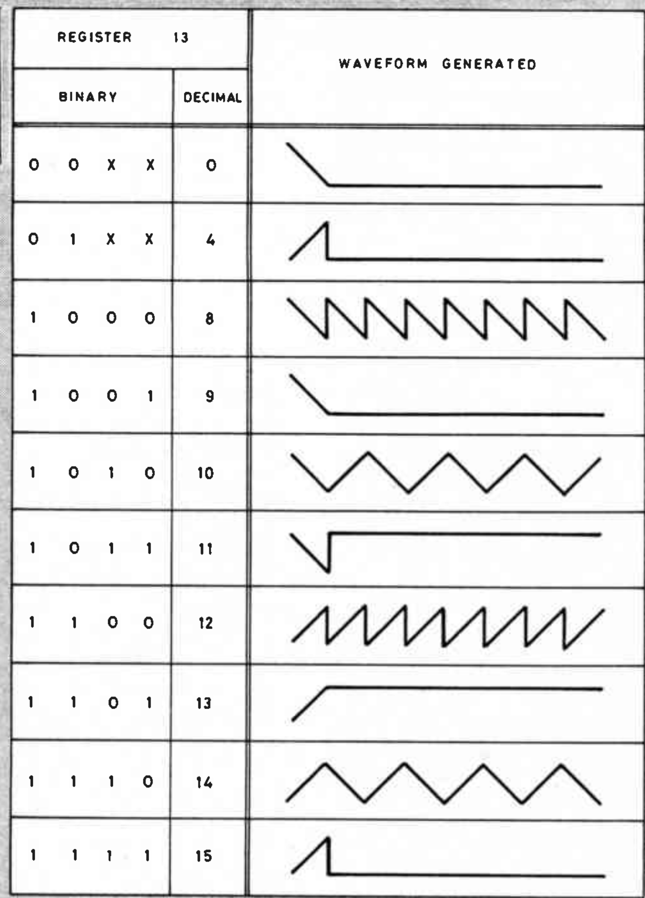

Fig. 2. Envelope waveforms produced by the AY-3-8913.

Register 0 provides "fine tuning" of the oscillator whilst register 1 provides "coarse tuning". Readers should note that, whereas all 8-bits of register 0 are used, only the four least significant bits of register 1 have any effect on the tone produced.

The same arrangement is used to tune the oscillators assigned to channels B and C. Registers 2 and 3 are respectively used for fine and coarse tuning of channel B whilst registers 4 and 5 are respectively used for fine and coarse tuning of channel C.

Table 1. AY-3-8913 register functions

Register Number	Register Function	Bit Number 7	6	5	4	3	2	1	0
0	Channel A	8-Bit Fine Tune							
1	Tone Period					4-Bit Coarse Tune			
2	Channel B	8-Bit Fine Tune							
3	Tone Period					4-Bit Coarse Tune			
4	Channel C	8-Bit Fine Tune							
5	Tone Period					4-Bit Coarse Tune			
6	Noise Period				5-Bit Noise Period				
7	Enable			Noise C	Noise B	Noise A	Tone C	Tone B	Tone A
8	Channel A Amplitude				Envelope Control	4-Bit Amplitude Control			
9	Channel B Amplitude				Envelope Control	4-Bit Amplitude Control			
10	Channel C Amplitude				Envelope Control	4-Bit Amplitude Control			
11	Envelope Period	8-Bit Fine Period							
12		8-Bit Coarse Period							
13	Envelope Waveform					Continue	Attack	Alternate	Hold
14 15	Not Used On AY-3-8913								

The five least significant bits of register 6 are used to determine the period of the noise signal whilst register 7 is used to enable the internal oscillators and noise generators. The six least significant bits are used and they act as active-low control signals.

To put this into context, suppose that we only wish to make use of the tone generator of channel A. We would have to ensure that bit-0 of register 7 was taken low whilst all other bits were high. The binary pattern required is thus:

Bit Number						Decimal Value
5	4	3	2	1	0	
1	1	1	1	1	0	62

We would thus have to output a data value of 62 to register 7. Alternatively, suppose that we wished to enable the tone generators of all three channels (A to C) and mix some noise into the signal produced by the tone generator of channel A. The following bit pattern would be required:

Bit Number						Decimal Value
5	4	3	2	1	0	
1	1	0	0	0	0	48

The four least significant bits of registers 8, 9 and 10 control the amplitude of the signals produced by channels A, B and C respectively. The output amplitude increases in fifteen logarithmic steps (corresponding to increasing data values of 1 to 15 decimal) whereas a data value of 0 results in no output at all.

Envelope Control

Bit 4 of registers 8 to 10 is used to enable envelope control of the outputs and is active when high. When envelope control is employed, the characteristics of the output waveform (in terms of amplitude versus time) are determined by the contents of registers 11 to 13.

Registers 11 and 12 are used to determine the period of the envelope (register 11 is the least significant) whilst register 13 allows selection of a particular envelope waveform (see Fig. 2). Since it is difficult to describe the effects of the various bits in register 13 (the nomenclature used by G.I. is not particularly helpful either!) it is best to experiment a little.

Readers should make use of the simple program described last month and make the following entries in response to the prompts:

Register Number	Data Value	Comment
0	28	Set channel A to produce
1	1	an output at approx. 440Hz
7	62	Enable channel A
8	16	Select envelope control
11	255	Set longest possible
12	255	envelope period
13	0	Single falling ramp (see Fig. 2.)

Having confirmed that the output is a tone of constant frequency but steadily falling amplitude (over a period of about 5 seconds), experiment by placing different data values in register 13 (values should be selected from Fig. 2). Finally, change the envelope period (by placing, say, 0 in register 12) and repeat the exercise. You should very quickly get some idea of the sort of effects that can be produced!

The following entries can be made to investigate the output of the noise generator (we shall assume that data from the previous example is still resident and, in particular, that envelope control has been selected):

Register Number	Data Value	Comment
6	31	Set noise period
7	247	Mix noise into channel A
12	255	Restore longest envelope period
13	8	Produce a repetitive negative going ramp waveform

Again it is worth experimenting by changing the contents of the various registers and keeping a note of the effects produced for future reference!

Sound Routine

Having demonstrated some of the effects that can be produced, we shall conclude this month's *On Spec* with a few clues for those of you ready to incorporate sound routines into your own programs. Readers should recall that port address 191 decimal (BF hex.) is used for selecting particular internal registers and that data may be written to the synthesiser chip using port address 63 decimal (3F hex.).

A BASIC statement of the form OUT 191,rn (where rn is a decimal register number in the range 0 to 15) can be used to select one of the AY-3-8913's internal registers. A statement of the form OUT 63,val (where val is the data to send in the range 0 to 255) can then be used to send data to the register previously selected.

A series of OUT may be used to produce the desired sound effects at particular points in a program. An arguably better solution would be that of making use of one, or more, sound generating subroutines to be called as, and when, desired.

If you would like a copy of our "On Spec Update", please drop me a line enclosing a large (A4 size) stamped addressed envelope.

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

Next month: We shall be taking a look at one of the latest Spectrum software development systems in the form of Ocean's "Laser Genius".

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