EVERYDAY

ELECTRONICS

and ELECTRONICS MONTHLY

APRIL 1986 £1·10

SPECIAL OFFER!

HOME SECURITY SYSTEM

STEREO REVERB

FREELOADER

VERSATILE PSU

Newcomers Magazine for Electronic & Computer Projects

£1 BAKERS DOZEN PACKS

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

1. 5 – 13 amp ring main junction boxes
2. 5 – 13 amp ring main spur boxes
3. 25 – 13 amp fuses for ring mains
4. 5 – surface mounting switches suitably insulated for mains voltage
5. 3 – electrical switches intermediate type, will also replace 1 or 2 way 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 – ultra transmitters and 2 receivers with circuit
19. 2 – light dependent resistors
25. 4 – wafer switches – 6p 2 way, 4p 3 way, 2p 6 way, 2p 5 way, 1p 12 way small one hold fixing and good length ¼ spindle your choice
27. 1 – 6 digit counter 12V
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.)
46. 1 – hour clock work time switch
48. 2 – 6V operated reed switch relays
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
53. 2 – mains operated relays 3 × 8 amp changeover (s.h.)
54. 10 – rows of 32 gold plated IC sockets (total 320 sockets)
55. 1 – locking mechanism with 2 keys
56. 1 – miniature uniselector with circuit for electric jigsaw puzzle
60. 5 – ferrite rods 4" × 5/16" diameter aerials
61. 4 – ferrite slab aerials with L & M wave coils
63. 1 – Mullard thyristor trigger module
64. 10 – assorted knobs ¼ spindles
65. 5 – different thermostats, mainly bi-metal types
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
72. 1 – 1250 watt dimmer Ultra ref SE20
77. 1 – time reminder adjustable 1-60 mins clockwork
80. 2 – 10A bridge rectifiers 30V
81. 2 – 30A panel mounting slyslok fuses
85. 1 – mains shaded pole motor ¾" stack – ¼ shaft
89. 1 – mains motor with gear box 1 rev per 24 hours
91. 2 – mains motors with gear box 16 rpm
96. 1 – thermostat for fridge
97. 1 – infra red fire element 1000 watts
98. 1 – motorised stud switch (s.h.)
101. 1 – 2½ hours delay switch
102. 1 – mains power supply unit – 9V DC
103. 1 – mains power supply unit – 6V DC
104. 1 – mains power supply unit – 4½V DC
105. 1 – 5 pin flex plug and panel socket
107. 1 – 5" speaker size radio cabinet with handle
110. 10 – slider type volume controls
111. 2 – musical boxes (less keys)
112. 1 – heating pad 200 watts mains
113. 1 – FM front end with tuning condenser and data
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
123. 100 – staples for thin flex
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
130. 2 – centre zero panel meters 100-0-100 UA
132. 2 – plastic boxes with windows, ideal for interrupted beam switch
134. 10 – model aircraft motor – require no on/off switch, just spin to start
136. 2 – car radio speakers 5" round 4 ohm made for Radiomobile
137. 1 – 6½" 4 ohm 10 watt speaker and 3" tweeter
142. 10 – 4 BA spanners 1 end open, other end closed
145. 2 – 4 reed relay kits 3V coil normally open or c/o if magnets added
146. 20 – pilot bulbs 6.5V.3A Philips
147. 1 – secret switch kit with data
148. 1 – printed circuit kit with 100 circuits
149. 4 – socket covers (protect inquisitive little fingers) for twin 13A
152. 1 – air or gas shut off valve – clockwork operated
153. 1 – air or gas shut off valve – thermostat operated
154. 1 – 12V drip proof relay – ideal for car jobs
155. 3 – varicap push button tuners with knobs
156. 5 – 12 way connector blocks 2A 250V
159. 3 – 12 way connector blocks 25A 250V
162. 1 – 13A fused and switched spur for surface mounting or can be removed from box for flush mounting
163. 3 – 13A sockets good British make but brown
169. 4 – short wave air spaced trimmers 2-30f
171. 1 – shocking coi kit with data – have fun with this
172. 10 – 12V 6W bulbs Philips m.e.s.
178. 3 – oblong amber indicators with lilliputs 12V
180. 6 – round amber indicators with neons 240V
181. 100 – p.v.c. grommets ⅜ hole size
182. 1 – short wave tuning condenser 50 pf with ¼" spindle
184. 1 – three gang tuning condenser each section 500 pf with trimmers and good length ¼" spindle
188. 1 – plastic box sloping metal front, 16 × 95mm average depth 45mm
   2 – double pole 20 amp 250V flush mounting switch – white
191. 6 – B.C. lamp holder adaptors white
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.
198. 1 – rod thermostat for water heater etc. 11" rod
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
218. 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 for water heater
266. 2 – mains transformers 9V ½A secondary split primary so ok also for 115V
267. 1 – mains transformers 15V 1A secondary p.c.b. mounting
289. 50 3.5V torch bulbs
290. 3 7" reel to reel tape spools
291. 1 ten turns 3 watt pot ¼ spindle 100 ohm
292. 5 two plate brown bakelite ceiling roses
293. 50 silicon diodes mixed unmarked
294. 50 Germanium transistors mixed and unmarked
295. 10 round pointer knobs ¼ spindle
296. 3 car cigar lighter socket plugs
297. 1 cover for 24hr time switch ref 8045
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
304. 1 stereo amp 1 watt per channel
305. 1 tubular dynamic microphone with desk rest
306. 1 module, speaker & battery to make musical card
307. 5 thermal fuses 15 amp woods metal

MULLARD UNILEX AMPLIFIERS

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

CAR STARTER/CHARGER KIT

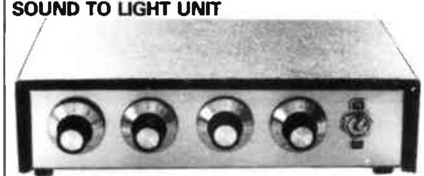
Flat Battery! Don't worry you will start your car in a few minutes with this unit – 250 watt transformer 20 amp rectifiers, case and all parts with data £16.50 or without case £15.00 post paid.

Ex-Electricity Board. Guaranteed 12 months.

VENNER TIME SWITCH

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

SOUND TO LIGHT UNIT

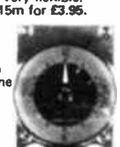


Complete kit of parts for a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two tone metal case and has controls for each channel, and a master on/off. The audio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

FROZEN PIPES

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

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. Independent 60 minute memory jogger. A beautiful unit at £2.50

THE AMSTRAD STEREO TUNER

This ready assembled unit is the ideal tuner for a music centre or an amplifier, it can also be quickly made into a personal stereo radio – easy to carry about and which will give you superb reception.

Other uses are a "get you to sleep radio", you could even take it with you to use in the lounge when the rest of the family want to view programmes in which you are not interested. You can listen to some music instead.

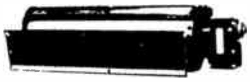
Some of the features are: long wave band 115 – 170KHz, medium wave band 525 – 1650KHz, FM band 87 – 108 MHz, mono, stereo & AFC switchable, fully assembled and fully aligned. Full wiring up data showing you how to connect to amplifier or headphones and details of suitable FM aerial (note ferrite rod aerial is included for medium and long wave bands). All made up on very compact board.

Offered at a fraction of its cost **only £4.95**

GOODS ARE ON APPROVAL

these notes are often hastily written and technical information sheets are seldom available about the items we have to describe, also advertisements sometimes go to press without our having a chance to correct any mistakes, however, everything we sell is supplied on the understanding that if it is not suitable for your project you may return it within 7 days for credit. If there was a definite error of description in our copy then we will pay postage. If not, then you pay the postage. Note this offer applies to kits, but only if construction is **not started**.

TANGENTIAL BLOW HEATER



by British Solartron, as used in best blow heaters. 3Kw £6.95 complete with 'cold' 'half' and 'full' heat switch, safety cut out and connection diagram.

Please add post £1.50 for 1 or 3 for £20 post paid 2.5 Kw KIT Still available: £4.95 + £1.50 post or have 3 for £16 post paid.

CORDLESS TELEPHONES

"IT'S FOR YOU-OU" even if you are in the bath, its an infinite extension any room and even in the garden – have one on approval or come and try one here. BT approved.

SOCKETS PLUGS ETC for BT phones

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**

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

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

J & N BULL ELECTRICAL
128 PORTLAND ROAD, HOVE, BRIGHTON, SUSSEX BN3 5QL

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 day or night. Haywards Heath (0444) 454563. **Bulk orders: phone for quote.**

308. 1 T.V. turret tuner (black & white T.V.)
309. 12 adaptable legended knobs ¼" spindle
310. 2 oven thermostats
311. 1 Clare Elliot sealed relay
312. 1 pressure pad switch 24 × 18 (Trigger Mat)
313. 5 sub miniature micro switches
314. 1 12" 8 watt min fluorescent tube white
315. 1 6" 4 watt min fluorescent tube white
316. 1 round pin kettle plug with moulded on lead

TWO POUNDERS*

- 2P1 –24 hour time switch with 2 on/offs, an ideal heating programmer
- 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 Amplifiers
- 2P6 –100W mains to 115V auto-transformer with voltage tappings
- 2P7 –Mini key, 16 button membrane keyboard, list price over £12, as used on PRESTEL
- 2P8 –Mains motor with gear box and variable speed selector. Series wound so suitable for further speed control
- 2P9 –Time and set switch. Boxed, glass fronted and with knobs. Controls up to 15 amps. Ideal to program electric heaters
- 2P10 –12 volt 5 amp mains transformer – low volt winding on separate bobbin and easy to remove to convert to lower voltages for higher currents
- 2P11 –Power amp module Mullard Unilex EP9000 (note stereo pre-amp module Unilex 9001 is BD216
- 2P12 –Disk or Tape precision motor – has balanced rotor and is reversible 230v mains operated 1500 rpm
- 2P13 –Sun Lamp switch stays on for ½ hr or 1 hr depending on setting of grub screw
- 2P14 –Mug Stop kit – when thrown emits piercing squawk
- 2P15 –Interrupted Beam kit for burgler alarms, counters, etc.
- 2P17 –2 rev pr minute mains driven motor with gear box, ideal to operate mirror ball
- 2P18 –Liquid/gas shut off valve mains solenoid operated
- 2P19 –Disco switch-motor drives 6 or more 10 amp change over micro switches supplied ready for mains operation sh
- 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
- 2P24 –Clockwork operated 12 hour switch 15A 250V with clutch
- 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
- 2P29 –24 position Yaxley switch contacts rated 5A – ¼ spindle
- 2P31 –4 metres 98 way interconnecting wire easy to strip
- 2P32 –Hot Wire amp meter – 4½ round surface mounting – old but working and definitely a bit of history
- 2P34 –Solenoid Air Valve mains operated
- 2P35 –Battery charger kit comprising mains transformer, full wave rectifier and meter, suitable for charging 6v or 12v
- 2P36 –20 Amp meter, with shunt unused but ex-equipment
- 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.
- 2P41 –Liquid crystal display, 8 digit 13mm black on silver.
- 2P42 –Tubular heater, 60 watts per ft, unusued but slightly storage soiled, made by G.E.C. Perfect order (must be collected by appointment as 12ft long)
- 2P43 –Small type blower or extractor fan, motor inset so very compact, 230V
- 2P44 –Inverter to operate 21" 13 watt fluorescent tube off 12 volts.
- 2P46 –Our famous drill control kit complete and with prepared case.
- 2P47 –Joy switch kit complete as previously sold.
- 2P48 –Telephone ringing unit reduces mains to 50 volts and changes frequency from 50 hz to 25 hz to give right ringing tone.
- 2P49 –Fire Alarm break glass switch in heavy cast case
- 2P51 –Stereo Headphone amplifier, with pre-amp
- 2P54 –2½kw. blow heater section of coal or log effect fire, this is a sheet metal assembly which holds the elements, the motor with fan, and the lamp holders and bits which give the flickering flame effect. Collect or add £3 to cover p&p
- 2P55 –Mains motor, extra powerful has 1½" stack and good length of spindle both ends
- 2P62 –1 pair Goodmans 15 ohm speakers for Unilox
- 2P63 –1 5Kv 20 ma mains transformer
- 2P64 –1 five bladed fan 6½" with mains motor
- 2P65 –2 resettable trips 4.5A mains
- 2P66 –1 2Kw tangential heater 115v
- 2P67 –1 12v–0–12v 2 amp mains transformer
- 2P68 –1 15v–0–12v 2 amp mains transformer
- 2P69 –1 250v–0–250v 60 mA & 66.3v 5A mains transformer
- 2P70 –1 E.M.I. tape motor two speed and reversible
- 2P71 –1 PAPST 240 5 hz motor
- 2P72 –1 115v Muffin fan 4" × 4" approx.
- 2P74 –1 pocket audio component tester
- 2P75 –1 6 hour timer, plugs into 13A socket
- 2P76 –1 audax tweeter partner to 5P26 speaker
- 2P77 –1 instrument box with key size 12" × 4½" wide 6" deep
- 2P81 –ORACLE VB100 instrument panel, is a MODEM with extras, it is the heart of many viewdata systems including the Prestel unit we recently stocked. It uses 25 I.C's, 2 crystals, u.h.f. modifier Aztex UM1233 etc. etc. You receive this, new, unused and complete except for 7 of the plug in I.C's.

£5 POUNDERS*

1. 12 volt submersible pump complete with a tap which when brought over the basin switches on the pump and when pushed back switches off, an ideal caravan unit.
2. Sound to light kit complete in case suitable for up to 750 watts.
3. Silent sentinel ultra sonic transmitter and receive kit, complete.
4. Dial indicator, measures accurately down to .01mm, "John Bull" or equally first-class make, a must for toolmaker or lathe worker.
5. 250 watt isolating transformer to make your service bench safe, has voltage adj. taps, also as it has a 115V tapping it can be used to safely operate American or other 115V equipment which is often only insulated to 115V. Please add £3 postage if you can't collect as this is a heavy item.
6. 12V alarm bell with heavy 8" gong, suitable for outside if protected from direct rainfall. Ex GPO but in perfect order and guaranteed.
7. Tape punch and matching tape reader, not new but believed in perfect working order if not so we would repair or replace within 12 months. Please add £2.50 postage.
8. Sensitive voltmeter relay, this consists of a 4½" dia moving coil meter with electronics (we will supply cct. dig.) over £120 each, they are new and still in maker's boxes.
9. Box of 25 fluorescent tubes 40 watt daylight or warm white ideal window pelmets, signs, etc. Please collect or add £2 postage.
10. Box of 25 18" fluorescent tubes assorted colours, please collect or add £2 postage.
11. 24 × 8 ft 85-120 watt warm white tubes. Ideal plant growing. Collect or send open cheque to cover carriage.
12. Equipment cooling fan – minin snail type mains operated.
13. Ping pong ball blower – or for any job that requires a powerful stream of air – ex computer. Collect or add £21 post.
14. Uniselector 360 degrees rotation, 5 poles, 50 ways, 50V coil.
15. Washing machine water pump, main motor driven so suitable for many applications.
16. Control panel case, conventional design with hinged front and finished metallic silver, easily arranged as lockable size approx. 15" × 10" × 5½", wall mounting.
17. Two kits: matchbox size surveillance transmitter and 2 FM receivers.

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EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY

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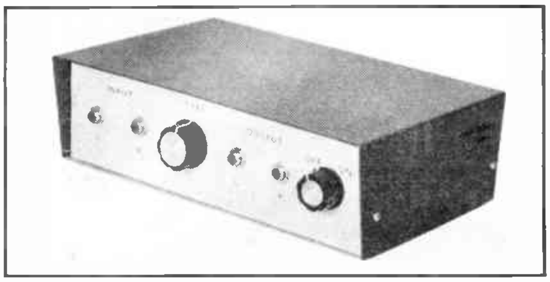
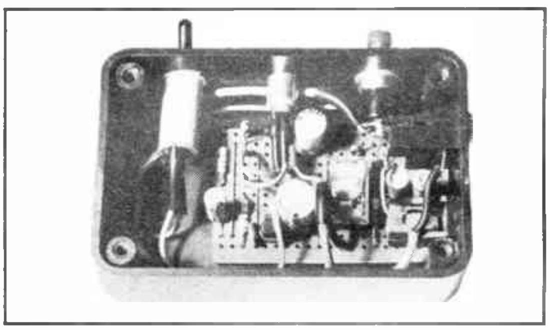
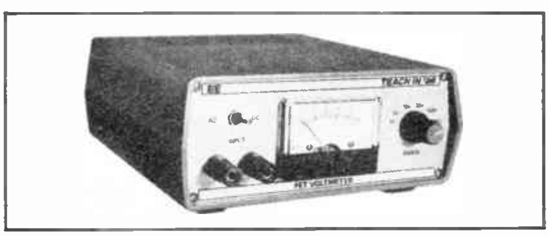
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .







FREE! READERS' BUY & SELL SPOT
EE MARKET PLACE
SEE PAGE 193

Projects

Series

Features

Our May 1986 issue will be published on Friday, 18 April. See page 189 for details.

E.E. PROJECT KITS — MAGENTA

Full Kits inc. PCBs, or veroboard, hardware, electronics, cases (unless stated). Less batteries.
If you do not have the issue of E.E. which includes the project – you will need to order the instruction reprint as an extra – 70p each. Reprints available separately 70p each + p&p 60p.

THIS MONTH'S KITS
SAE or 'phone for prices

BBC MIDI INTERFACE Mar 86	£25.34
INTERVAL TIMER Mar 86	£17.11
STEREO HI-FI PRE-AMP	£44.62
MAINS TESTER & FUSE FINDER Mar 86	£7.98
FUNCTION GENERATOR Feb 86	£22.53
POWER SUPPLY FOR ABOVE	£7.26
TOUCH CONTROLLER Feb 86	£11.67
pH TRANSDUCER (less Probe) Feb 86	£22.01
LIGHT EFFECTS/GAMES UNIT Feb 86	£10.37
SPECTRUM OUTPUT PORT Feb 86	£10.21
HEADLIGHT ONE SHOT Feb 86	£10.69
DPORT Jan 86	£6.80
TACHOMETER Jan 86	£23.40
MAIN DELAY SWITCH left case Jan 86	£17.93
ONE CHIP ALARM Jan 86	£7.90
MUSICAL DOOR BELL Jan 86	£16.98
TTL LOGIC PROBE Dec 85	£8.59
OPTICAL INTENSER TRANSDUCERS Dec 85	£16.34
DIGITAL CAPACITANCE METER Dec 85	£35.98
DIODE/TRANSISTOR TESTER Dec 85	£15.98
UNIVERSAL LCR BRIDGE Nov 85	£23.49
FLUX DENSITY TRANSDUCER Nov 85	£26.15
FLASHING PUMPKIN less case Nov 85	£3.82
SQUEAKING BAT less case Nov 85	£8.63
SCREAMING MASK less case Nov 85	£9.98
STRAIN GAUGE AMPLIFIER Oct 85	£25.46
SIMPLE AUDIO GENERATOR Oct 85	£2.59
SOLDERING IRON POWER CONTROLLER Oct 85	£4.72
VOLTAGE REGULATOR Sept 85	£6.78
PERSONAL STEREO P.S.U. Sept 85	£8.99
R.I.A.A. PRE-AMP Sept 85	£14.49
CARAVAN ALARM Sept 85	£9.37
FRIDGE ALARM Sept 85	£6.82
SEMI-CONDUCTOR TEMP. SENSOR Sept 85	£18.93
RESISTANCE THERMOMETER Sept 85 Less Probe	£18.83
PLATINUM PROBE Extra	£22.00
LOW COST POWER SUPPLY UNIT Aug 85	£16.72
TRI-STATE THERMOMETER (Batt) Aug 85	£6.05
TREMOLO/VIBRATO Aug 85	£34.48
STEPPER MOTOR INTERFACE FOR THE BBC COMPUTER less case Aug 85	£13.99
1D35 STEPPER MOTOR EXTRA	£14.50
OPTIONAL POWER SUPPLY PARTS	£4.67
EMERGENCY LIGHTS FLASHER less lamps July 85	£6.39
CONTINUITY TESTER July 85	£5.37
TRAIN SIGNAL CONTROLLER July 85	£8.78
AMSTRAD USER PORT July 85	£15.33
ACROSS THE RIVER June 85	£17.97
ELECTRONIC DOORBELL June 85	£6.55
COMPUTERISED SHUTTER TIMER June 85	£10.61
GRAPHIC EQUALISER June 85	£23.33
AMSTRAD CPC 464 May 85	£15.34
MAINS VERSION	£22.48
AUTO PHASE May 85	£16.39
INSULATION TESTER Apr 85	£16.96
LOAD SIMPLIFIER Feb 85	£16.98
SOLID STATE REVERB Feb 85	£39.98
GAMES TIMER Jan 85	£7.63
SPECTRUM AMPLIFIER Jan 85	£5.98
TV AERIAL PRE-AMP Dec 84	£12.36
Optional PSU 12V £2.03	240V £9.86
MINI WORKSHOP POWER SUPPLY Dec 84	£34.98
DOOR CHIME Dec 84	£14.91
BBC MICRO AUDIO STORAGE SCOPE INTERFACE Nov 84	£28.77
PROXIMITY ALARM Nov 84	£17.98
MAINS CABLE DETECTOR Oct 84	£4.39
MICRO MEMORY SYNTHESISER Oct 84	£47.98
DRILL SPEED CONTROLLER Oct 84	£6.89
GUITAR HEAD PHONE AMPLIFIER Sept 84	£6.38
SOUND OPERATED FLASH less lead Sept 84	£5.91
TEMPERATURE INTERFACE FOR BBC MICRO Aug 84	£19.70
CAR RADIO BOOSTER Aug 84	£13.87
CAR LIGHTS WARNING July 84	£7.99
VARICAP AM RADIO May 84	£10.43
EXPERIMENTAL POWER SUPPLY May 84	£18.72
SIMPLE LOOP BURGLAR ALARM May 84	£13.62
MASTERMIND TIMER May 84	£5.44
FUSE/DIODE CHECKER Apr 84	£3.45
QUASI STEREO ADAPTOR Apr 84	£10.90
DIGITAL MULTIMETER add on for BBC Micro Mar 84	£24.98
NI-CAD BATTERY CHARGER Mar 84	£9.85
REVERSING BLEEPER Mar 84	£6.78
PIPE FINDER Mar 84	£3.60
IONISER Feb 84	£23.98
ZX81 EPROM PROGRAMMER Feb 84	£14.48
SIGNAL TRACER Feb 84	£14.89
CAR LIGHT WARNING Feb 84	£3.76
GUITAR TUNER Jan 84	£17.73
BIOLOGICAL AMPLIFIER Jan 84	£19.16
CONTINUITY TESTER Dec 83	£9.99
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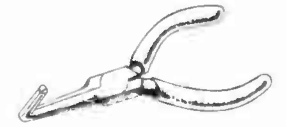

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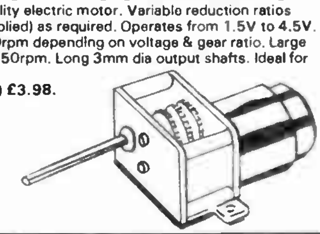

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PLANNING FOR THE FUTURE

ONE of the items we take seriously is the planning of issues of EE. We plan our editorial content for each issue well in advance and try to make sure each issue has a well balanced content and that particular projects appear at the right time of the year. Just as an example we like to have at least one item of test gear in each issue since test gear projects are always well received, however through the summer months projects like portable radios or camping/caravanning items are more popular and so we reduce the level of test gear in the mid-summer issues.

Such planning is based on our experience of readers' requirements and a "feel" for what might go down particularly well at any one time. We hope that we please most of the readers most of the time but please bear in mind that if you have a particular interest in one section of our hobby we may not be able to deal with it in every issue.

By the way please do not just ignore a certain project because, on the face of it, it has little relevance to your particular interest. Take for instance the *Stereo Reverb* in this issue; it would be very easy to think "I have no interest in playing or singing pop music, so this is not for me". Just take a closer look at the article and you will find a project that can be used as a stereo enhancer or quadraphonic synthesiser in addition to more straightforward musical effects. A similar situation occurs on other projects where a certain section of the circuit could easily be employed to meet your special requirements, maybe a simple timer could be adapted to control a particular item or process you have. While we try to give a full circuit description with each project, and this will help you to make minor modifications to meet your requirements, we are not able to advise on how to modify our projects.

The more you understand electronics the easier you will find it is, not only to modify circuits, but also to design your own projects. Follow *Teach In* or buy some books (see our book service) and get to grips with basic theory so you can understand how each circuit works. This month's *Teach In* is a good example of how a little knowledge can be very useful. It deals with the very popular 741 op-amp and is well worth reading even if you are not following the series.

Mike Kenward

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STEREO REVERB

R.A.PENFOLD

Stereo simulator, headphone enhancer or quadraphonic synthesiser plus musical effects—all these applications from this simple design

PROBABLY most readers will be familiar with reverberation units which give the so called "big hall" sound to the processed signal. Although most people seem to think of reverberation devices solely as musical effects units, reverberation units, especially the stereo type, can in fact be used in other applications.

The stereo reverberation unit described here is a simple type which is built around a single springline, but despite its simplicity it has a creditable level of performance. Apart from use as a musical effects unit, the main applications for a unit of this type are as a stereo simulator, headphone enhancer, or quadraphonic synthesiser.

SYSTEM OPERATION

Before considering these applications it would probably be as well to consider the way in which the unit functions, and the block diagram of Fig. 1 helps in this respect.

The left and right hand channel input signals are combined in a mixer stage. The output of the mixer drives an equalisation amplifier, and this provides treble boost to counteract the rather bass heavy response of a springline unit. This eliminates the "boominess" that plagues many springline reverberation unit designs and gives a much more realistic effect.

The springline consists of two transducers mechanically linked by (usually) two springs. The input signal is fed to one transducer where the electrical signals are converted into corresponding sound waves. These travel along the springs to the second transducer where they are converted back to electrical signals again.

The sound waves travel down the springs considerably less than instantly as the springs are specifically designed to have characteristics that give a significant delay. The delay time is typically about 35ms, and in the case of the springline used in this design it is 25 to 35ms.

The springline does not give a straightforward delay as the soundwaves tend to be reflected by the transducers, so that they travel backwards and forwards along the springs, gradually decaying to an insignificant level. The time taken for the signal to decay is normally between about 2 and 7 seconds, and is 2·5 to 3 seconds for the springline specified for this project.

This is the time taken for the output signal from the springline to decay by 60dB after the input signal has been cut off. In practice the reverberation signal may only be mixed into the main signal at a fairly low level, and the reverberation will then decay to an inaudible level in substantially less than 2·5 to 3 seconds.

This system of delayed and reflected sounds gives a good analogy to sounds being bounced around the walls and ceiling of a large hall, and produces an effect which closely resembles the real reverberation that is generated by this process.

Some of the output from the springline is fed to a mixer where it is combined with the right hand channel input signal. The output from the springline is not very large as there are inevitably substantial losses through the unit, but the mixer circuit is designed to provide amplification that boosts the reverberation signal to a suitable level. A variable attenuator enables the strength of the reverberation signal to be varied from zero up to a maximum level that is almost equal to the main signal.

The left hand channel is treated in a similar manner to the right hand one, but the output from the springline unit is inverted prior to being mixed with the left hand input signal. The unit therefore provides an output signal that consists of the two stereo input signals, plus a controlled amount of reverberation signal that appears out-of-phase at the two outputs.

APPLICATIONS

Obviously the unit can be used as a mono reverberation effects unit by using just one channel, and although only a single springline is incorporated in the circuit it can still be used as a stereo reverberation effects unit by using both channels. The reverberation content on each output signal is the same, but as the reverberation signals are out-of-phase they do not produce a strong central stereo image.

Instead the reverberation signal tends to spread out across the sound stage, and this gives quite a good effect. There is, in fact, little to be gained by using a separate springline for each channel, bearing in mind that with the real reverberation, sounds produced at various points in the hall tend to bounce around the walls and ceiling, merging into a hubbub that has no single point of origin.

A unit of this type can be very effective in an audio system to give a synthesised quadraphonic effect. The front channels are merely the ordinary stereo channels, and these are processed by the reverberation unit to generate the rear channel signals. In this application a fairly high reverberation level is likely to give the best results.

The obvious drawback with any system of this type is that an extra amplifier and set of loudspeakers are required, and could be quite costly. On the other hand, when upgrading the amplifier and loudspeakers of a system it is well worthwhile retaining the old units and trying them as the rear channels in a four channel set-up. Results can be quite spectacular with many programme sources.

When used as a stereo simulator the input signal is applied to both inputs of the

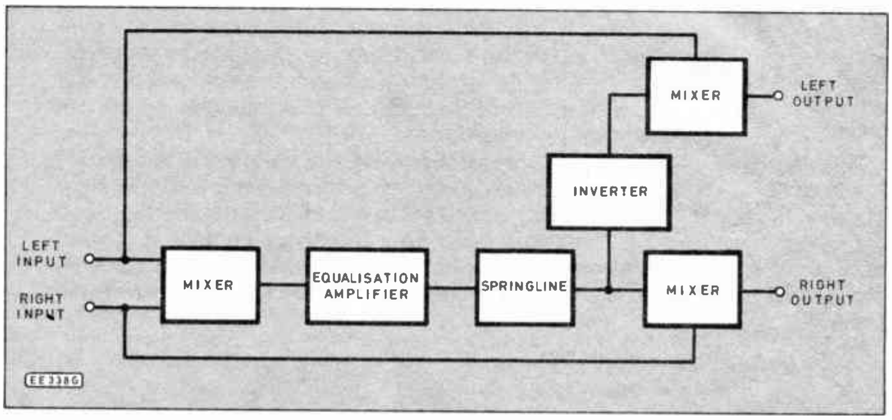


Fig. 1. Block diagram of the Stereo Reverb.

reverberation unit, and the two outputs of the unit provide a form of pseudo stereo signal. The main signal appears in-phase at both outputs and consequently gives a strong central stereo image. The reverberation signal is out-of-phase at the outputs and therefore tends to spread out across the sound stage, giving a better spatial effect. In this application it is usually best to opt for only a modest amount of reverberation signal on the output.

A problem that occurs when using stereo headphones with a normal stereo signal is that the sound stage tends to extend from one ear to the other, through the listener's head. This obviously gives an unrealistic effect, and one that some people find positively unpleasant.

By processing the stereo signal using a reverberation unit greater ambience and a more spatial effect is obtained, with the reverberation signal seeming to emanate from outside the normal and congested stereo sound stage. This can be quite effective but, again, it is advisable to use only a moderate amount of reverberation signal.

CIRCUIT DESCRIPTION

The full circuit diagram of the Stereo Reverberation Unit appears in Fig. 2.

IC1a acts as the input mixer stage, and this is a conventional operational amplifier summing mode mixer circuit. The circuit is powered from a single 9V supply rail, rather than the normal (for operational amplifier circuits) dual balanced supplies.

However, R1, R2 and C1 provide a centre tapping on the supply which effectively gives dual balanced 4·5V supplies. All the stages in the circuit are based on operational amplifiers and they all make use of the centre tap on the supply lines for biasing purposes.

The equalisation amplifier uses IC1b in the non-inverting mode. R6 and R8 set the voltage gain of this amplifier at 6dB (two times), but at high frequencies C5 and R7 provide a boost in gain of up to about 20dB (ten times). It must be emphasised that this is not designed to give a perfectly flat overall frequency response from springline circuitry, but is merely intended to overcome the excessive low frequency response and to give a subjectively much improved effect from the unit.

The drive level applied to the springline has to be something of a compromise. The input transducer is capable of handling power levels of up to a few hundred milliwatts, and it is actually a low impedance electromagnetic type which provides a load that is similar to a loudspeaker.

A small power amplifier is therefore the obvious choice as the driver circuit, but in practice driving the input transducer at something approaching its maximum power level seems to provide relatively poor audio quality. A low drive level gives a much better quality output signal, but one which is at a very low level.

This necessitates the use of a high level of amplification at the output of the springline, and increases the likelihood of problems with vibration producing unwanted output signals. The risk of problems with acoustic feedback is also increased.

In this circuit a medium drive level is used, with IC1b being used to drive the springline. Resistor R9 prevents the springline's input transducer from excessively loading the output stage of IC1b.

The level control VR1 controls the reverberation level for both channels. IC2 mixes the reverberation signal with the right hand channel input, and this is another summing mode mixer circuit.

Resistors R11 and R12 have been made equal in value so that there is unity voltage gain from the right hand input to the right hand output. Resistor R10 has been given a relatively low value so that the output from VR1 is boosted by a little over 20dB to compensate for losses in the springline.

The inverter stage, IC3a, is a simple unity voltage gain inverting mode amplifier. The inverted signal is mixed with the left hand channel input signal by IC3b. As for the right hand channel, the main signal receives unity voltage gain, but the reverberation signal is boosted by over 20dB.

As the circuit has a current consumption of only about 8 milliamps it can be powered from a small (PP3 size) 9V battery. However, if it is likely to be used a great deal it would probably be more economic to use a larger battery such as a PP7 or PP9 size.

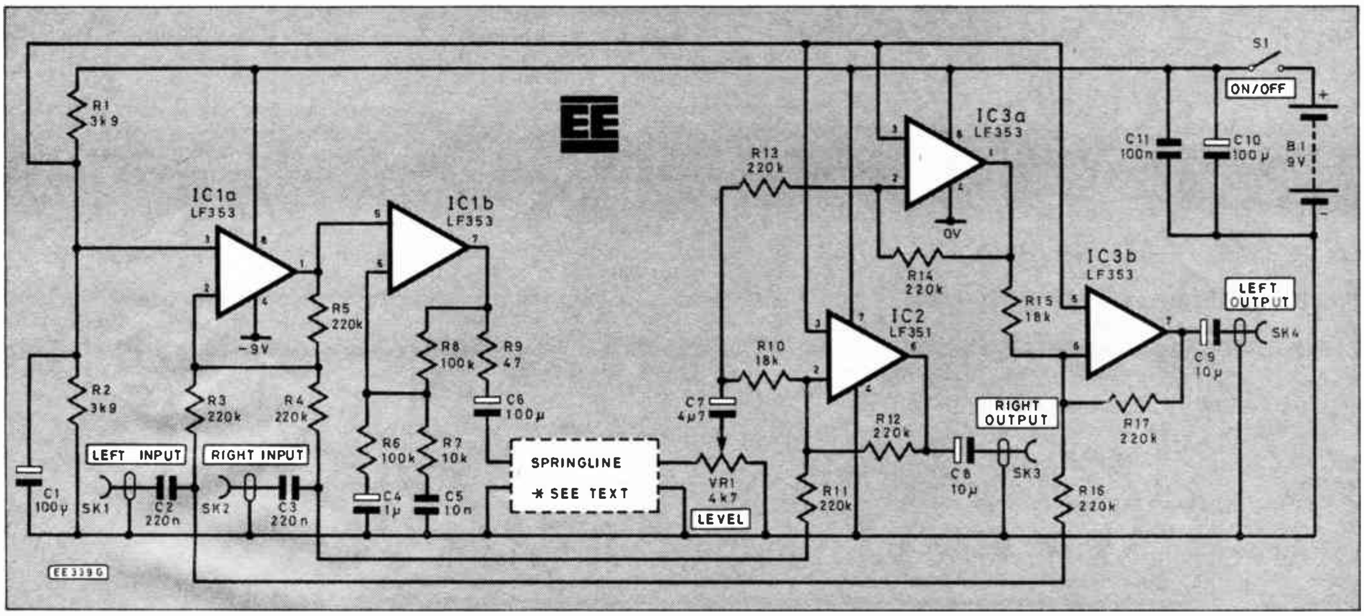


Fig. 2. Full circuit diagram of the Stereo Springline Reverberation Unit.

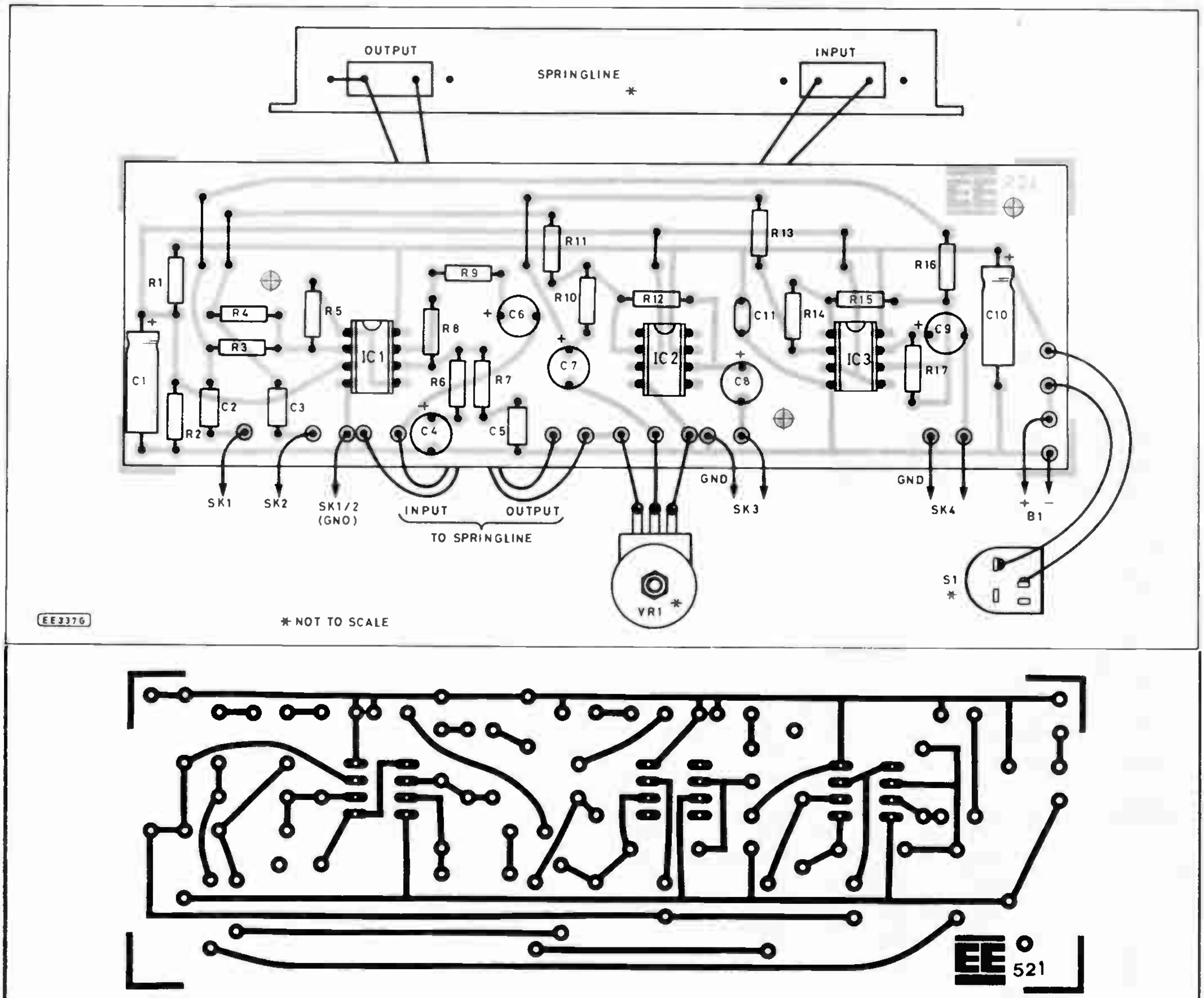
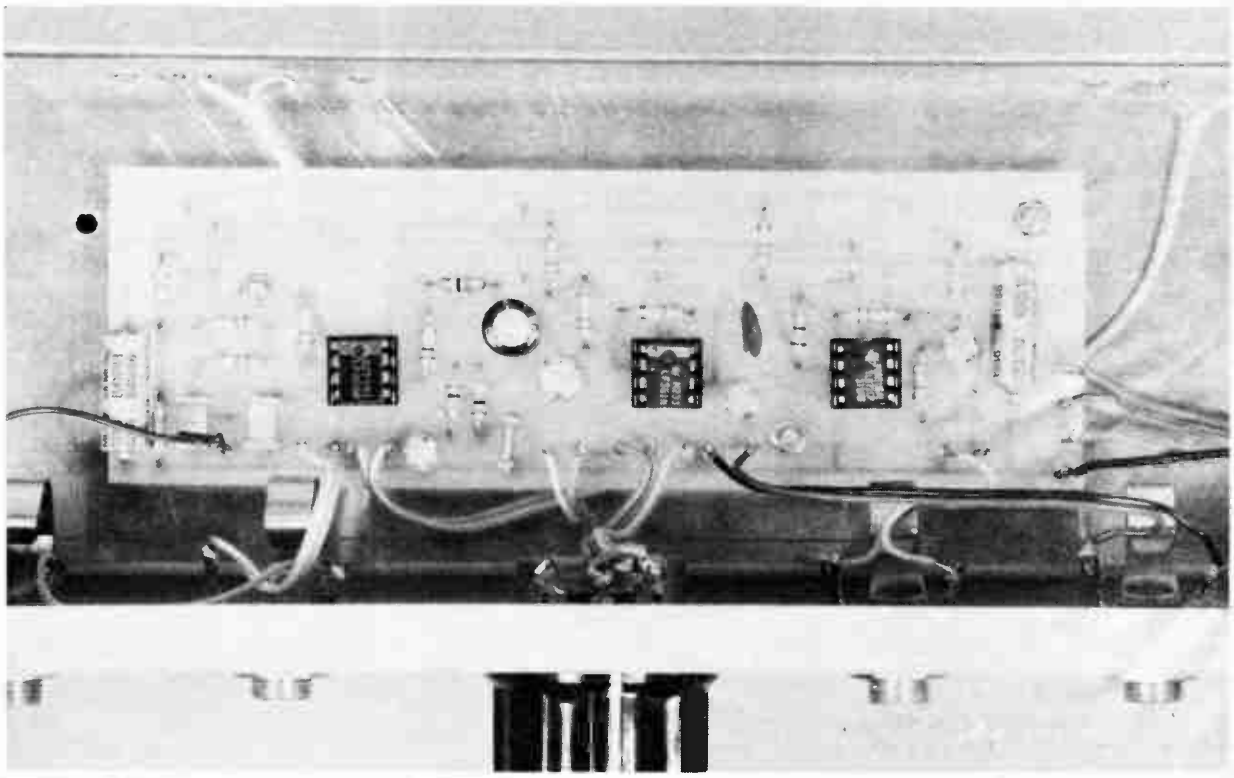


Fig. 3. Layout of components on the printed circuit board and interwiring details. (Above) Full size printed circuit master. This board is available from *EE PCB Service:* code EE521. (Below) Close-up photo of the wiring to the p.c.b.



CONSTRUCTION starts here

CIRCUIT BOARD

Most of the components are fitted onto a printed circuit board, as detailed in Fig. 3. This board is available from the *EE PCB Service*, order code EE521.

COMPONENTS

Resistors

R1,R2	3k9 (2 off)
R3,R4,R5, R11,R12, R13,R14, R16,R17	220k (9 off)
R6,R8	100k (2 off)
R7	10k
R9	47
R10,R15	18k (2 off)

All ¼W 5% carbon film

Potentiometer

VR1	4k7 log.

See Shop Talk page 208

Capacitors

C1,C10	100µ 10V axial elec. (2 off)
C2,C3	220n carbonate (2 off)
C4	1µF radial elec. 63V
C5	10n carbonate
C6	100µ radial elec. 10V
C7	4µ7 radial elec. 63V
C8,C9	10µ radial elec. 25V (2 off)
C11	100n ceramic

Semiconductors

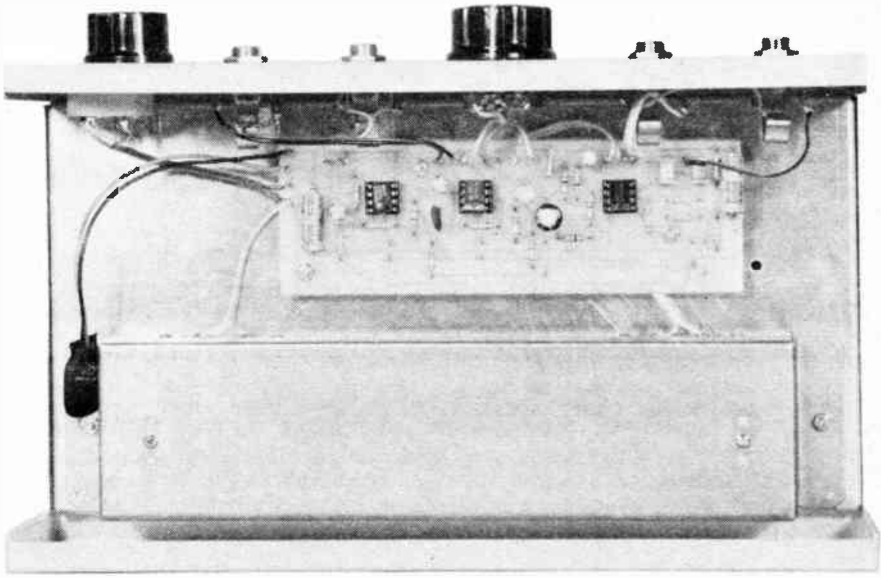
IC1,IC3	LF353 or TL072 dual op-amp (2 off)
IC2	LF351 or TL071 op-amp

Miscellaneous

SK1,SK2, SK3,SK4	Standard jacks (4 off)
S1	Rotary on/off switch
B1	9V battery (PP3 size)

Short springline (Maplin); printed circuit board, available from the *EE PCB Service:* order code EE521; two control knobs; battery connector; three 8-pin DIL i.c. holders; case about 250mm × 150mm × 75mm, wire, solder, etc.

Approx. cost Guidance only £18 plus case



Completed Stereo Reverb showing positioning of printed circuit board, springline and wiring to front panel components.

Provided the specified types of capacitor are used all the components should fit onto the board without difficulty and construction should not give any real problems. Do not overlook the five link-wires.

None of the integrated circuits are MOS input types, but the use of holders is still recommended, especially if you are new to electronics construction. Fit pins to the board at the points where connections to the springline, VR1, and the other off-board components will eventually be made.

CASE

A fairly large case is needed in order to accommodate the length of the springline. The prototype is housed in a case which measures approximately 250mm by 150mm by 75mm, and this is about the minimum size that is likely to be satisfactory.

The springline is mounted on the base panel or chassis, well towards the rear of the unit, using two short M3 or 6BA bolts and fixing nuts. Make sure that the connections are facing towards the front of the case so that they are easily accessible

The printed circuit board is mounted in front of the springline, leaving sufficient space for the battery to the right of the board. M3 or 6BA fixings are used, and these must include spacers about 6mm long to hold the connections on the underside of the board away from the metal chassis or case.

Potentiometer VR1, switch S1, and the four sockets are mounted on the front panel. Although standard jack sockets are specified in the components list, these can in fact be phono, DIN, or any other type that matches the equipment with which the unit will be used.

The complete interwiring between the springline, front panel components and the printed circuit board is shown in Fig. 3. Use ordinary multistrand insulated connecting wire here.

One output terminal of the springline unit is connected to the metal case of this component and therefore to the case of the whole unit. Make sure that this is the terminal that is connected to the negative supply rail of the printed circuit board. The leads to the input transducer can be connected either way around.

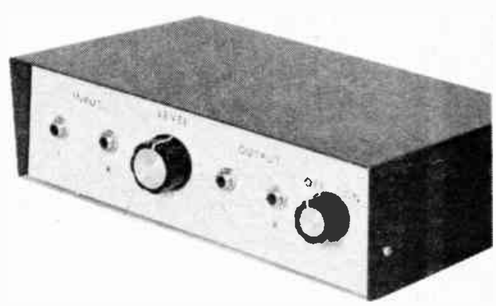
IN USE

There should be no difficulty in connecting the unit into an audio or electronic music system using ordinary screened audio leads. In order to avoid problems with acoustic feedback do not position the unit close to loudspeakers. In fact, it is a good idea to keep the unit at least half a metre or so away from any other item of equipment if possible, and this is particularly important with items of equipment that incorporate a transformer.

The input impedance at each input is about 100k and input levels of up to about 1V r.m.s. can be accommodated. The unit is therefore compatible with a wide range of equipment.

Problems with noise and acoustic feedback would almost certainly arise if the unit was to be used with a very low input signal level, such as the output from a microphone or a low output guitar pick-up. A preamplifier to boost the input signal to a higher level is required if it is to be used with equipment of this type. It is advisable to use a peak signal level of no less than about 100 millivolts.

The Level control VR1 is adjustable to any setting you judge to provide the best effect. When used as a headphone enhancer or stereo simulator VR1 needs to be adjusted very carefully in order to obtain a good effect. Slightly too little reverberation and the unit will have no significant effect; slightly too much and the reverberation signal can become dominant, producing a very unrealistic and unconvincing effect. □



TEACH-IN 86

PART 7 · Michael Tooley BA David Whitfield MA MSc C Eng MIEE

THE whole of this month's instalment of "Teach-in" is devoted to just one topic; the operational amplifier. The operational amplifier usually takes the form of nothing more than an 8-pin dual-in-line i.c.; nevertheless its range of applications is immense. These devices are now found in such apparently diverse applications as d.c. power supplies, automotive instrumentation, alarm systems, computers, and hi-fi equipment. In fact, it is hard to think of an area of electronics which has remained untouched by the humble operational amplifier.

THE OPERATIONAL AMPLIFIER

An operational amplifier is essentially a multi-stage direct coupled amplifier which acts as what might aptly be described as a "universal gain block".

Operational amplifiers were originally employed in the field of analogue computing and control systems, the first generation of such devices being based purely on discrete components. Due to various factors including the need to reduce the noise and drift inherent in high-gain direct coupled amplifiers to an acceptable level, these devices were extremely costly.

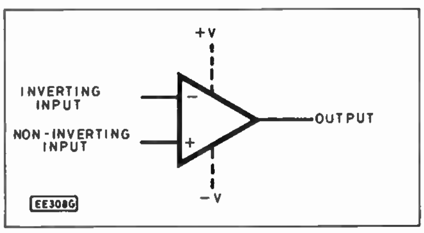


Fig. 7.1. Symbol used for an operational amplifier.

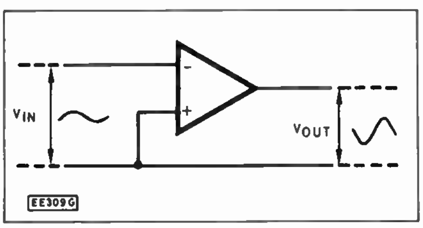


Fig. 7.2(a). Basic configuration for an inverting amplifier.

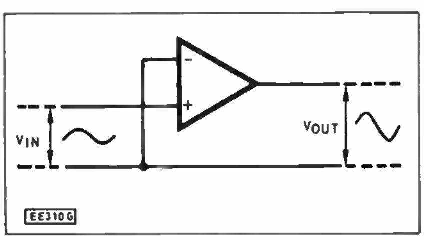


Fig. 7.2(b). Basic configuration for a non-inverting amplifier.

Now, with the advent of mass produced i.c. technology, prices have fallen to an absolute minimum (20p, or less, for a typical "industry standard" device!). A further effect of the falling price has been that industry at large has found a host of new applications which, in turn, has increased demand and further reduced the cost.

The symbol used for an operational amplifier is shown in Fig. 1. It should be noted that the device has two signal inputs (labelled "+" and "−") and one output. Operational amplifiers generally require both positive and negative supplies, often between ±9V, and ±15V. Furthermore, these supply connections are sometimes omitted from circuit diagrams and it is simply assumed that all devices are connected to the requisite common positive and negative supply rails!

The two signal inputs are distinguished by the internal phase shift produced using the output as a reference. The input marked "−" is also known as the "inverting input" (i.e. the output voltage is 180° out of phase with this input) whereas the input marked "+" is called the "non-inverting input" (i.e. the output voltage is in-phase with this input). This idea leads to the two basic amplifier configurations shown in Fig. 7.2.

Fig. 7.2a shows the basic configuration of an inverting amplifier in which the signal is applied to the inverting input and the non-inverting input is returned to the common rail. Fig. 7.2b shows the basic configuration of a non-inverting amplifier in which the signal is applied to the non-inverting input and the inverting input is returned to the common rail.

Readers should note that neither of the circuit arrangements of Fig. 7.2 is complete. The reason is that, since the open loop voltage gain of the device is so large (typically 100,000 or more) the stage would almost certainly be unusable in this form. What is required, of course, is some form of negative feedback to reduce the stage gain to a sensible value and make the operation of the stage both predictable and repeatable.

IDEAL CHARACTERISTICS AND INTERNAL CIRCUITRY

The ideal characteristics of an operational amplifier are shown below with typical values shown in brackets:

Open loop voltage gain: Infinite (200,000)
Input resistance: Infinite (2M)
Full-power bandwidth: Infinite (100kHz)
Output resistance: Zero (20 ohm)

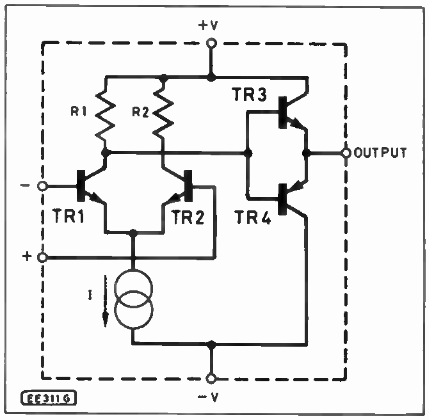


Fig. 7.3. Simplified internal circuitry of an operational amplifier.

Fig. 7.3 shows the internal circuitry of an operational amplifier in much simplified form. The input consists of a symmetrical arrangement of balanced transistors. This circuit is sometimes called a "Differential Amplifier" or "Long Tailed Pair". (The "tail" simply refers to the constant current source connected in the emitter circuit.)

There is nothing particularly special about a constant current source; it can be very easily realised by just one transistor with its base voltage held constant by means of one or more forward biased diodes.

The constant current source simply ensures that the *total* emitter current remains constant. If the emitter current of one transistor increases (by virtue of an applied signal) the emitter current of the other transistor *must* decrease by the same amount.

In practical operational amplifiers, the differential input stage can be augmented by one, or more, emitter followers which effectively raise the input impedance. Alternatively, where exceptionally high values of input resistance are required, f.e.t. devices can be used.

To produce the low value of output resistance (and to ensure a symmetrical output voltage swing) the device should incorporate some form of low-power output stage. This can be achieved using nothing more than a complementary symmetrical output stage (like those described in Part Four).

PRACTICAL AMPLIFIER STAGES

Three basic practical operational amplifier circuits are shown in Figs. 7.4 to 7.6. Each of these circuits employs negative feedback which is instrumental in reducing the voltage gain. Fig. 7.4 shows an inverting amplifier using input and feedback

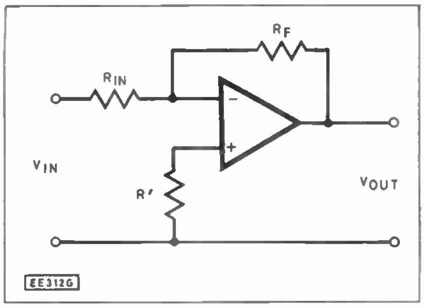


Fig. 7.4. A practical inverting amplifier.

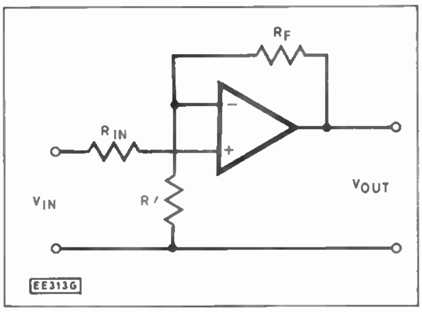


Fig. 7.5. A practical non-inverting amplifier.

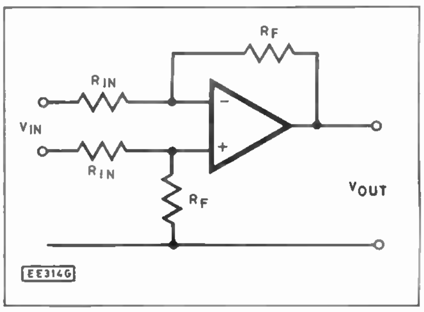


Fig. 7.6. A differential amplifier.

resistances, R_{in} and R_f respectively. In order to improve the symmetry of the arrangement, rather than return the non-inverting input directly to the common rail we have included a resistance R^1. This resistance is equivalent to the parallel combination of R_{in} and R_f and ensures that both the inverting and non-inverting inputs "see" the same resistance externally. In practice R_f is usually much greater than R_{in} thus, in a practical case, R^1 is often made equal to R_{in}.

Provided that the open-loop voltage gain is large, the voltage gain of the inverting amplifier is dependent purely on the amount of negative feedback applied. This, in turn, simply depends upon the ratio of R_f to R_{in}, hence:

Closed loop voltage gain, $A_v = -\frac{R_f}{R_{in}}$

Readers should not worry overmuch about the minus sign (−) it merely indicates that the output and input act in the opposite sense (i.e. the output is 180° out of phase with the input). It does *not* indicate a loss!

Since the open-loop voltage gain is very large, the voltage appearing at the inverting input is very small (typically no more than a few millivolts). Hence the inverting input is sometimes called a "virtual earth" (i.e. it is only a few millivolts above true earth potential). The true resistance seen looking into the input terminals of the amplifier stage must therefore be very nearly equal to R_{in}.

All of this makes the operational amplifier very easy to use. Suppose, for example, we wish to make an inverting amplifier with a voltage gain of 100 to match an input resistance of one kilohm. We simply make R_f equal to 100k and R_{in} equal to 1k. What could be more simple!

Fig. 7.5 shows a practical non-inverting amplifier, whilst Fig. 7.6 shows a true differential amplifier (neither of the inputs are earthed). This latter arrangement is possible by virtue of the balanced symmetrical internal arrangement of the operational amplifier.

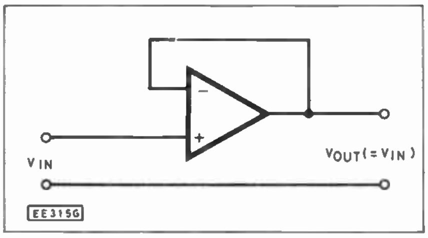


Fig. 7.7. A voltage follower.

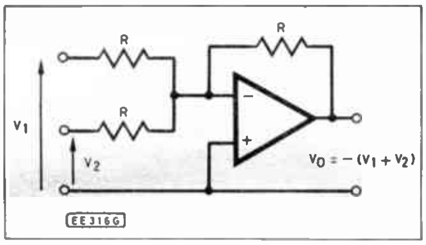


Fig. 7.8. A summing amplifier.

A voltage follower stage is shown in Fig. 7.7. The operation of this stage is somewhat analogous to that of an emitter follower; 100% voltage negative feedback is applied so that the overall closed-loop voltage gain falls to unity. The input impedance of the stage is, however, raised to an exceptionally high value.

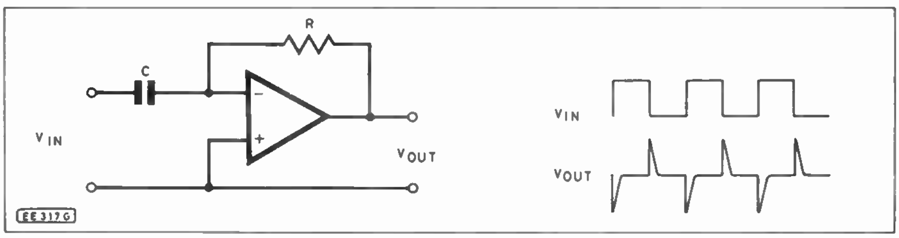
MATHEMATICAL OPERATIONS

As mentioned previously, operational amplifiers have their origins in analogue computers. In this application they were used to perform mathematical operations such as summation, integration, and differentiation.

Fig. 7.8 shows a simple summing amplifier. If all resistors are made equal, the output voltage is the inverse of the sum of the two input voltages. A typical practical application of such an arrangement (away from the world of analogue computers) would be a simple audio mixer in which each signal input is fed to its own input resistor. We could easily extend the circuit to incorporate as many additional inputs as required with, perhaps, a variable "gain" control fitted in place of the fixed input resistor.

Fig. 7.9 shows an operational differentiator. If this sounds a bit of a mouthful, it simply means that, provided the time constant (C x R) is very much less than the periodic time of

Fig. 7.9. An operational differentiator.



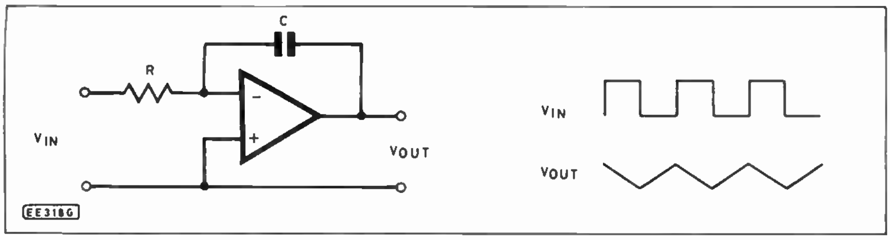


Fig. 7.10. An operational integrator.

the applied signal input, the output voltage will be proportional to the rate of change of the input voltage. If the input voltage changes very rapidly from one voltage level to another (e.g. on the rising or falling edge of a square wave) a large output voltage will be produced. If the input voltage remains constant for a relatively long period of time (i.e. it remains at a fixed level) no output voltage will be produced. A typical application of such an arrangement is in the synchronisation of oscillator stages.

Fig. 7.10 shows an operational integrator. This, effectively, provides the opposite function to that of the differentiator. Provided the time constant (C x R) is very much greater than the periodic time of the input, this arrangement produces an output voltage which is proportional to the area under the input voltage curve. A typical application of such an arrangement is in a waveform generator where, for example, we might wish to convert a square wave input into a triangular wave output.

TERMS USED

Before we take a look at a typical operational amplifier, it is worth introducing some of the terms which are frequently used in conjunction with such devices.

Common mode rejection ratio

Common mode rejection ratio is the ratio of differential voltage gain to common mode voltage gain (i.e. the voltage gain that would be produced if the inverting and non-inverting inputs were to be shorted together and the signal applied between them and common 0V). Common mode rejection ratio is normally expressed in dB.

Differential voltage gain

Differential voltage gain is the ratio of peak-peak output voltage to the peak-peak input voltage applied differentially (i.e. between the inverting and non-inverting inputs).

Input offset voltage

Input offset voltage is the d.c. voltage which must be applied at the input terminals in order to make the d.c. output voltage exactly 0V.

Input resistance

Input resistance is simply the resistance "seen" between the input terminals of the operational amplifier.

Maximum pk-pk output voltage

Maximum peak-peak output voltage is the maximum voltage swing that can be obtained at the output before clipping occurs. (For obvious reasons it is very much dependent upon the supply rail voltages).

Output resistance

Output resistance is simply the resistance "seen" between the output terminal and common 0V.

Short-circuit output current

Short-circuit output current is the current produced at the output terminal when it is directly shorted to the common 0V rail.

Slew rate

Slew rate is the rate of change of output voltage with time when the input is supplied with a step voltage change. It is normally expressed in volts per microsecond.

Total power dissipation

The total d.c. power dissipation is the total d.c. power supplied to the device less any power delivered to a load. (Under no-load conditions this is simply equal to the product of the voltage and current in each rail.)

THE 741 OPERATIONAL AMPLIFIER

The 741 is the most common operational amplifier and it is available in a variety of packages including the ubiquitous 8-pin d.i.l. encapsulation, the pin connections for which are depicted in Fig. 7.11.

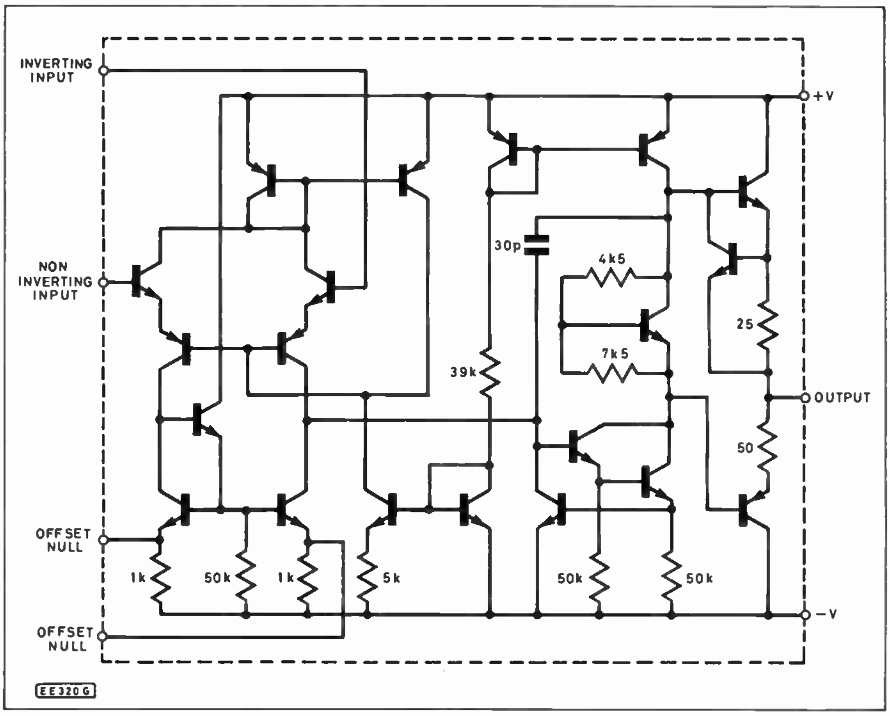
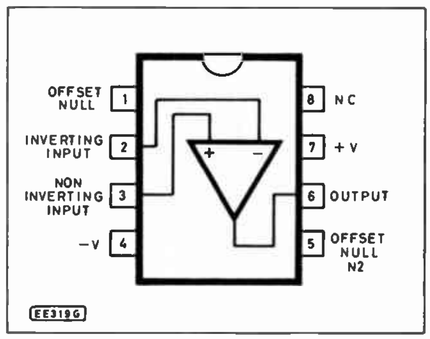


Fig. 7.12. Internal circuit of a 741.

Fig. 7.11. 741 8-pin d.i.l. pin connections.



The internal circuit of the 741 operational amplifier is shown in Fig. 7.12. Readers may like to compare this with that shown in Fig. 7.3—hopefully some similarity will be detected!

The characteristics of the ubiquitous 741 operational amplifier (when operating from ±15V supply rails at 25°C) are summarised below:

Input offset voltage	1mV
Max output voltage (10k ohm load)	28V pk-pk
Differential voltage gain	200,000
Input resistance	2M
Output resistance	75
Input capacitance	1·4p
Common mode rejection ratio	90dB
Short-circuit output current	±25mA
Supply current (no signal)	1·7mA
Total power dissipation (no signal)	50mW
Slew rate	1V/µs

Like many operational amplifiers, the 741 is provided with two inputs which can be used to set the d.c. output voltage exactly to zero. This facility is known as "offset null" and it simply uses an external potentiometer to balance the internal differential stage, as shown in Fig. 7.13.

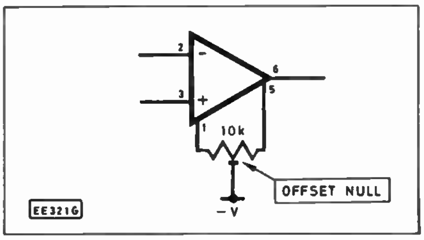


Fig. 7.13. Offset null provision for the 741.

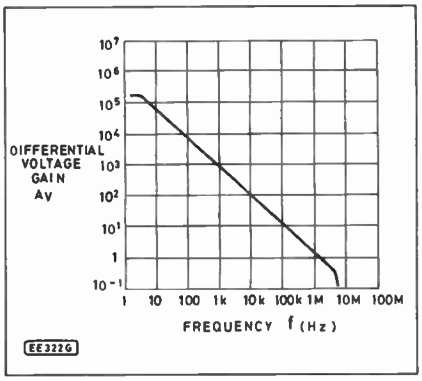


Fig. 7.14. Typical frequency response of a 741.

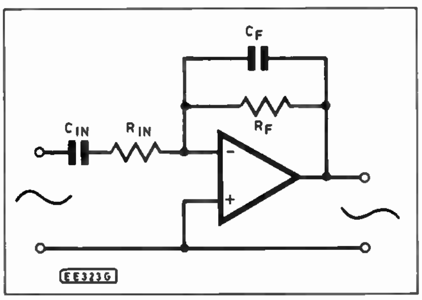


Fig. 7.15. Bandwidth limited amplifier.

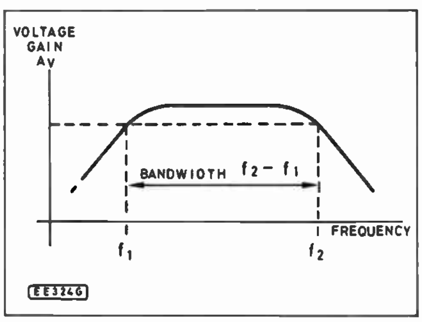


Fig. 7.16. Frequency response for the arrangement shown in Fig. 7.15.

FREQUENCY RESPONSE AND BANDWIDTH

The typical frequency response of a 741 operational amplifier is shown in Fig. 7.14. Readers should note from this that unity gain is achieved at a frequency of approximately 1MHz.

The product of closed-loop voltage gain and bandwidth of any particular operational amplifier is a constant. This means that there is a trade-off between closed-loop voltage gain and frequency response. Taking a typical 741 for example, we could have the following options:

Closed loop voltage gain	Bandwidth
1	1MHz
10	100kHz
100	10kHz
1,000	1kHz
10,000	100Hz

Clearly we should not be too greedy when it comes to selecting a closed-loop voltage gain or an unacceptable loss of bandwidth may result!

Despite this, there will be numerous applications in which it is desirable to limit the frequency response of an amplifier to within precise limits. This can be achieved using the arrangement depicted in Fig. 7.15.

The frequency response of the arrangement of Fig. 7.15 is shown in Fig. 7.16. The upper and lower cut-off frequencies are respectively given by:

$$f_2 = \frac{1}{2\pi C_f R_f} \quad \text{and} \quad f_1 = \frac{1}{2\pi C_{in} R_{in}}$$

The bandwidth of the stage is simply given by: $B/W = f_2 - f_1$

COMPARATORS

One important application of the operational amplifier is that of comparing two voltages. A simple comparator based on an operational amplifier is shown in Fig. 7.17. In this arrangement the stage is operated without any negative feedback and thus it exhibits a very high value of voltage gain. Whenever the voltage present at the non-inverting input exceeds that present at the inverting input, the output voltage will rise to just less than that of the positive supply. Alternatively, when the voltage present at the non-inverting input is less than that at the inverting input, the output voltage will fall to slightly more than that of the negative supply. The voltage present at the inverting input is thus effectively a "reference voltage" (V_{ref}) against which we are comparing the input. The transfer characteristic of this circuit arrangement is shown in Fig. 7.18.

An extension of the comparator arrangement is shown in Fig. 7.19. Here the reference voltage is 0V and hence any input signal of more than a few millivolts in amplitude is converted to a square wave output regardless of its actual waveform. This circuit can be useful in a variety of applications including intruder alarms, motion detectors and digital counters.

OSCILLATORS

Whilst operational amplifiers can be used to replace the transistor(s) used in most of the oscillator circuits described in Part Five, there is just time to introduce a useful square wave oscillator circuit. This oscillator is shown in Fig. 7.20 and uses just five components, including the operational amplifier itself.

To understand how the circuit operates assume that the output of the operational amplifier initially goes high to just less than the positive supply. The capacitor will initially be uncharged and will thus commence charging with current supplied by R. The voltage at the inverting input will

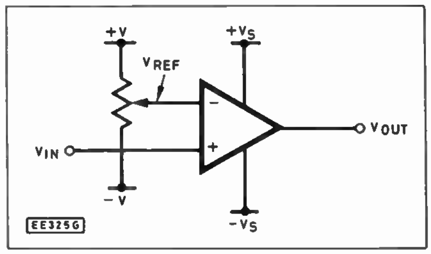


Fig. 7.17. An operational comparator.

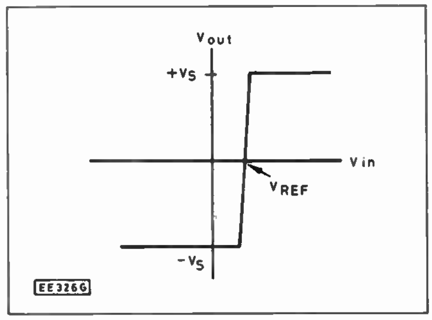


Fig. 7.18. Transfer characteristic of the arrangement shown in Fig. 7.17.

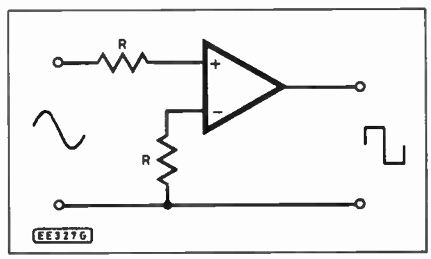


Fig. 7.19. Square wave converter.

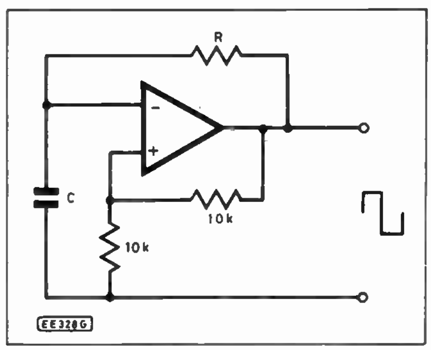


Fig. 7.20. Simple square wave oscillator.

therefore rise steadily until, at some later time, it will exceed the voltage at the non-inverting input (which will be approximately half that of the positive supply by virtue of the resistive potential divider formed by the two 10k resistors).

At this point the output voltage will rapidly fall to a level which is just less than the negative supply. C will then discharge through R until the voltage at the inverting input falls to less than that present at the non-inverting input (which will be approximately half that of the negative supply). At this point the circuit reverts to its original state and the cycle repeats continuously.

NEXT MONTH

Next month we shall be taking a look at digital circuits.

PROBLEMS

Difficulty rating: (e) easy; (d) difficult; (m) moderate.

7.1 An operational amplifier is to be used in an inverting configuration to provide a voltage gain of 20. If the input resistance is to be 5k determine the value of feedback resistance required. (e)

7.2 Two inverting operational amplifiers are used in tandem. If each amplifier has a voltage gain of 50 determine the overall voltage gain and phase shift. (e)

7.3 An operational amplifier has a gain x bandwidth product of 4MHz. If the device is to be used in a single stage amplifier with a bandwidth of 20kHz determine the maximum value of closed-loop voltage gain that can be allowed. (m)

7.4 A pre-amplifier is to be built using an operational amplifier. If the unit is to have the following specifications, produce a complete circuit design and include all component values (specify the nearest preferred value in each case): (d)

Mid-band voltage gain: 40
Input resistance: 5k
Frequency response: 400Hz to 10kHz

ANSWERS TO LAST MONTH'S PROBLEMS

6.1 Between 3·833V and 4V (approx.)
6.2 200 ohm
6.3 500m
6.4 150MHz
6.5 Maximum capacitance, 253p
Minimum capacitance, 28p

Practical Assignments

COMPONENTS

Beside the items specified for earlier parts you will need two 741 operational amplifier i.c.s in order to complete this month's assignments.

ASSIGNMENT 7.1

This assignment is designed not only to demonstrate the operation of a single stage inverting amplifier but also to allow readers to confirm the equation (quoted earlier in the text) for the voltage gain of a closed loop inverting amplifier.

PROCEDURE

Connect the circuit shown in Fig. 7.21 on your breadboard using the wiring diagram shown in Fig. 7.22. Carefully check that the i.c. has been correctly oriented before connecting the supply which consists of four 4·5V batteries wired in series and having a centre common 0V connection.

Initially set VR1 to mid-position and connect the multimeter (switched to the 10V d.c. range) to read V_{in}. Adjust VR1 for exactly 0V input then transfer the multimeter to read V_{out} (this should be exactly 0V).

Transfer the meter back to the V_{in} position and adjust VR1 for an input of exactly +1V. Transfer the meter to the output and measure V_{out} (this should be −2V).

Repeat the procedure measuring V_{out} for each of the following input voltages; +2V, +3V, −1V, −2V, −3V. Confirm, in each case, that the voltage gain is −2.

If desired, add an extra 10k resistor in series with R4. Repeat the previous measurements and confirm that the closed loop voltage gain is now −3.

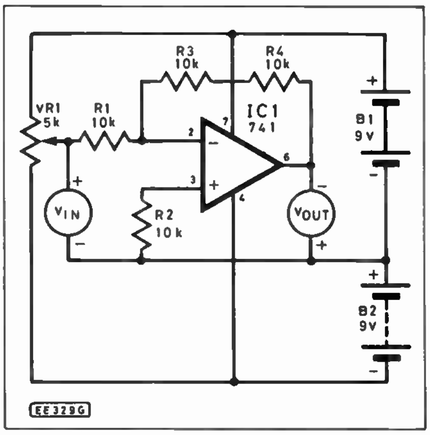
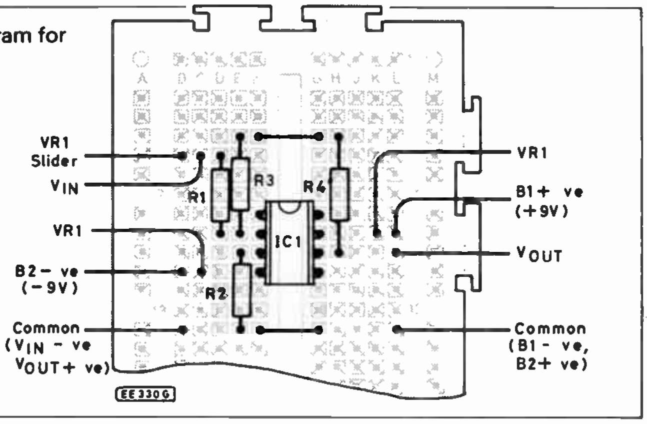


Fig. 7.21. Circuit for Assignment 7.1.

Fig. 7.22. Wiring diagram for Assignment 7.1.

COMPONENTS	
R1	10k
R2	10k
R3	10k
R4	10k
VR1	5k
IC1	741



ASSIGNMENT 7.2

This assignment demonstrates the operation of a bandwidth limited amplifier. In order to complete this, and the next assignment, readers should have access to an audio amplifier or tape recorder having an "auxiliary" input.

PROCEDURE

Connect the circuit shown in Fig. 7.23 on your breadboard, using the wiring diagram given in Fig. 7.24. As before, take care to ensure that the i.c. is correctly connected.

Connect the output of Fig. 7.23 to

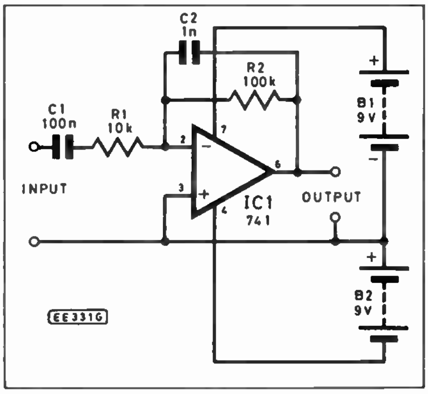
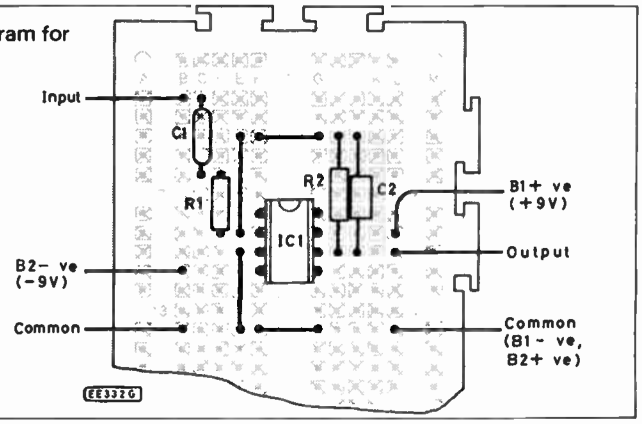


Fig. 7.23. Circuit diagram for Assignment 7.2.

Fig. 7.24. Wiring diagram for Assignment 7.2.

COMPONENTS	
R1	10k
R2	100k
C1	100n
C2	1n
IC1	741



the input of the audio amplifier or tape recorder taking care to ensure that the common 0V line is taken to earth or chassis. The input of Fig. 7.23 can be derived from a microphone, radio tuner, record or cassette deck.

Readers should compare the signal quality with, and without, the bandwidth limited amplifier connected. The frequency response of the amplifier is approximately 159Hz to 1·59kHz.

Readers having access to a variable frequency audio signal generator may like to plot the frequency response of the stage. The multimeter (switched to the 10V a.c. range) can be used to measure the output voltage resulting from a constant input voltage of, say, 250mV r.m.s. from the generator. Results should be compared with the frequency response curve shown in Fig. 7.16.

ASSIGNMENT 7.3

This assignment demonstrates the action of a simple square wave oscillator using an operational amplifier.

PROCEDURE

Connect the circuit of Fig. 7.25 using the wiring diagram shown in Fig. 7.26. Set VR1 to maximum resistance (corresponding to a minimum output frequency) and connect the output of the oscillator to the "auxiliary" input of an audio amplifier or tape recorder.

Monitor the signal using the amplifier and investigate the effect of varying VR1. Change C1 first to 1μ and then to 100n, and repeat the experiment. Typical output frequency ranges are shown.

C1	Minimum frequency	Maximum frequency
10μ	9Hz	90Hz
1μ	90Hz	900Hz
100n	900Hz	7kHz

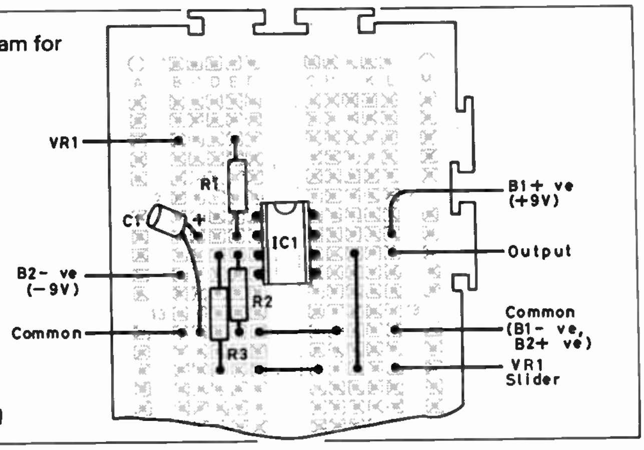


Fig. 7.26. Wiring diagram for Assignment 7.3.

COMPONENTS	
R1	470
R2	10k
R3	10k
VR1	5k
C1	10μ
IC1	741

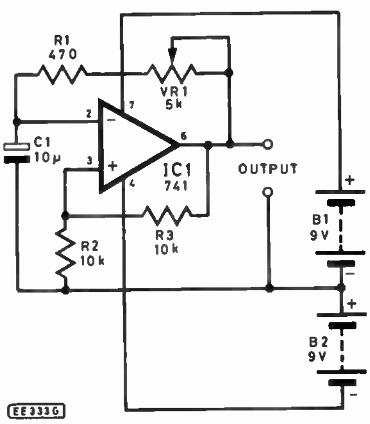


Fig. 7.25. Circuit for Assignment 7.3.

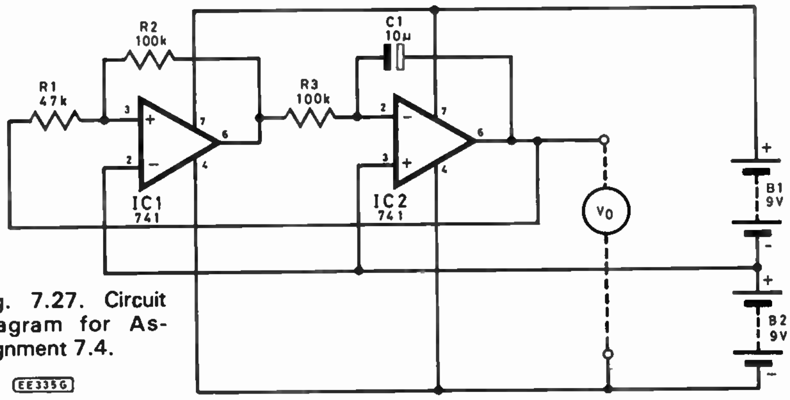


Fig. 7.27. Circuit diagram for Assignment 7.4.

ASSIGNMENT 7.4

This assignment demonstrates a linear ramp generator comprising an operational integrator with positive feedback applied.

PROCEDURE

Construct the circuit diagram of Fig. 7.27 using the wiring diagram shown in Fig. 7.28. Switch the meter to the 50V d.c. range and connect it between the output (meter positive) and the –ve rail (meter negative).

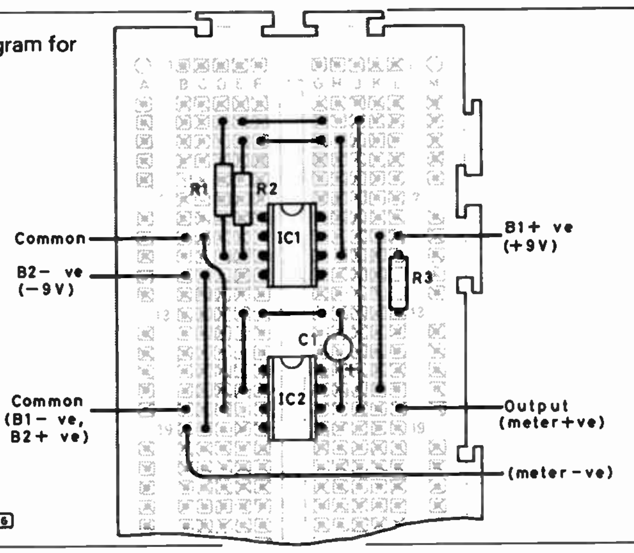


Fig. 7.28. Wiring diagram for Assignment 7.4.

COMPONENTS	
R1	47k
R2	100k
R3	100k
C1	10μ
IC1	741
IC2	741

The output consists of a triangular waveform of approximately 9V pk-pk and frequency 0·5Hz. At the low operating frequency, the nature of this waveform can readily be recognised by simply observing the meter deflection. If time permits, readers may like to experiment with a range of values for C1 (say, 1μ, 100n, 10n and 1n). If a square, rather than triangular, output is required this may be obtained simply by taking the output from the first stage (i.e. pin-6 of IC1).

NEXT MONTH

You will need the following additional components in order to carry out the practical assignments in next month's instalment of Teach-In:

Resistor 270 ¼W 5% carbon (1 off)
Semiconductors 7400, 7402, 7408, 7432 i.c.s. Red light emitting diode (LED)

FREELOADER

IAN REES

Allows programs to be located and loaded easily. Can control most types of recorder

THE FREELOADER prevents faulty loading caused on some computers when the program is loaded from cassette after its Header Tone. This occurs on several computers, including the Dragon 32/64 and the Tandy CoCo.

Freeloader is connected inline between the computer and recorder and ensures that no signal is present from the ear socket at the instant loading starts. If a signal is present, the unit holds off the loading until a silent period between programs is detected. The unit then drops out and the next program is loaded.

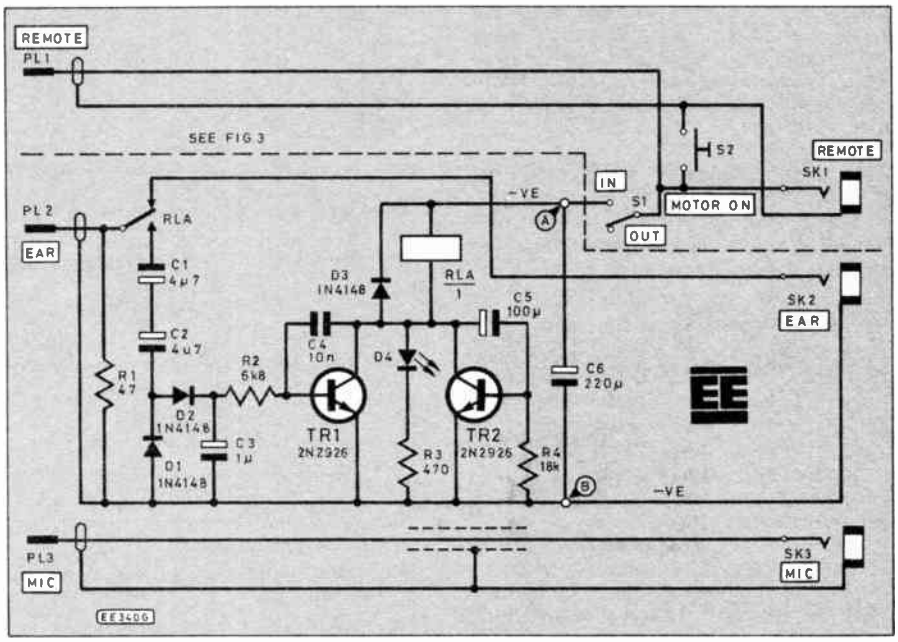


Fig. 1. Complete circuit diagram of the Freeloader when powered by the cassette recorder.

STACKED PROGRAMS

The main advantage of the unit comes when programs are stacked one behind the other on the same tape. The need to accurately position the tape using the counter is no longer required.

Indeed it is desirable to start loading on the tail of the previous recording. "Fast forwarding" timed menu directories will not have as large a gap between programs now that the gap need not be landed on.

Incorporated in the design is a "Motor On" press button which enables the cassette to be switched on without either calling it from BASIC or pulling out the "Remote" plug. The l.e.d. indicates loading status.

CIRCUIT

The circuit for the unit is shown in Fig. 1. With the Freeloader S1 in the "OUT" position, the data signal is routed directly from the cassette recorder ear jack through RLA to the computer as normal.

The unit draws its supply from the recorder. The positive voltage comes via the "Remote" socket, the negative is returned through the "EAR" socket chassis return.

If S1 is switched to the "IN" position, the positive supply comes on immediately the computer turns on the cassette's motor supply. Transistor TR2 operates RLA as C5 slowly charges. The output from the ear jack (if present) is directed by RLA through C1 and C2, to be rectified by D1 and D2, then smoothed by C3 before turning on TR1. TR2 turns off after approximately 5 seconds but RLA will be held by TR1 until the input ceases. The green l.e.d. is illuminated when the supply comes on but is dimmed or extinguished if the Freeloader detects a signal.

The majority of "Computer compatible" cassette recorders currently available have their supply lines configured as Fig. 2. When operated from the mains, around 7V will be available from the "Remote" socket (battery operation is not satisfactory with this attachment). I have used Morphy Richards C440, Murphy 2022 and a Bush 3160 without problems.

In the real world there are bound to be machines which do not conform. Fig. 3 shows how to add extra circuitry to make the Freeloader compatible with all recorders.

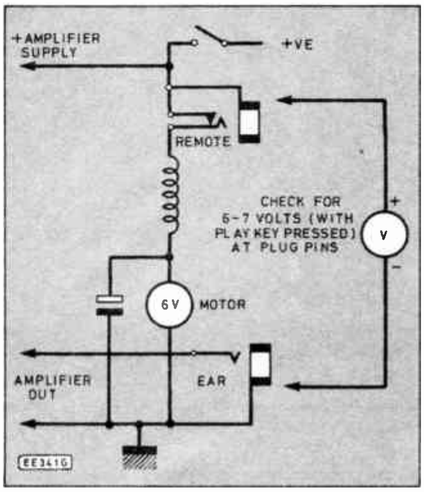


Fig. 2. Remote wiring connections on most recorders.

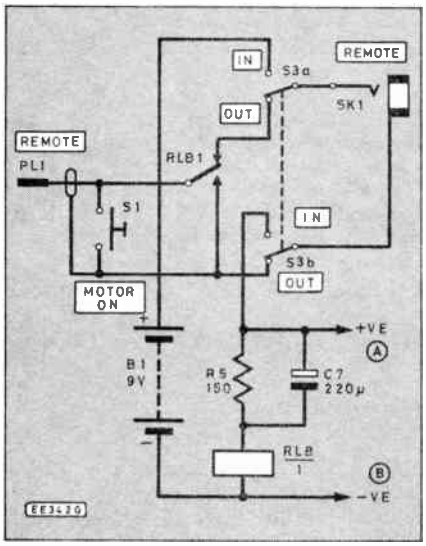


Fig. 3 (Right). Universal circuit which replaces that above the dotted line in Fig. 1 and joins at points A and B. C7 reduces battery drain by allowing a smaller relay holding current—current is only drawn during loading.

COMPONENTS

See Shop Talk page 208

Resistors

R1	47
R2	6k8
R3	470
R4	18k
R5	150 (if required)

All ¼W ±5%

Capacitors

C1,C2	4µ7 10V p.c. elect. (2 off)
C3	1µ 10V p.c. elect.
C4	10n 30V disc ceramic
C5	100µ 10V p.c. elect.
C6,C7	220µ 10V p.c. elect. (2 off) (C7 may not be required—see text)

Semiconductors

D1,D2,D3	1N4148 (3 off)
D4	5mm green l.e.d. (with mounting clip)
TR1,TR2	2N2926 (2 off)

Miscellaneous

RLA,RLB	s.p. changeover relay, 5V 56 ohm coil (2 off) (RLB may not be required—see text)
S1	s.p.s.t. min. toggle switch
S2	s.p.n.o. press-switch
S3	d.p.d.t. min. toggle switch (if required)
SK1	2·5mm o.c. jack socket
SK2,SK3	3·5mm o.c. jack socket (2 off)

Case—dimensions approx. 82 × 54 × 28mm (see text); 0·1 inch matrix stripboard 12 strips by 21 holes; 2·5mm jack plug; 3·5mm jack plug (2 off); screened leads.

Approx. cost Guidance only £7.50

CONSTRUCTION

The universal version will require a larger case than the standard described to house the extra relay and PP3 battery.

The simpler unit was built on a piece of Veroboard (Fig. 4) and mounted in an inexpensive Tandy Experimenter's Box.

The "REMOTE" (SK1) and "EAR" (SK2) jacks are mounted directly onto the board after enlarging the holes. The circuit board can then be secured by the jack nuts after suitable size holes have been drilled in the end of the case.

The "MIC" feed could obviously go direct to the computer. After an early prototype, I found the lead dressing looked much neater when all were terminated at the Freeloader. S1, S2, SK3 and the l.e.d. are mounted and interwired on the side of the case. The "MIC" lead to the cassette should be screened. On the Prototype I used 30cm screened fly leads with their braids in separate PVC sheaths—(jack plugs should be marked).

RLA and RLB (if used) must be able to operate at 5 volts. TR1 and TR2 can be any *npn* general purpose a.f. transistors with a gain of at least 50.

OPERATION

No setting up is required other than to connect the Freeloader to the "EAR", "MIC" and "REM" sockets on the cassette recorder. The lead from the computer is connected to the same connectors on the Freeloader.

With a program tape in the recorder and

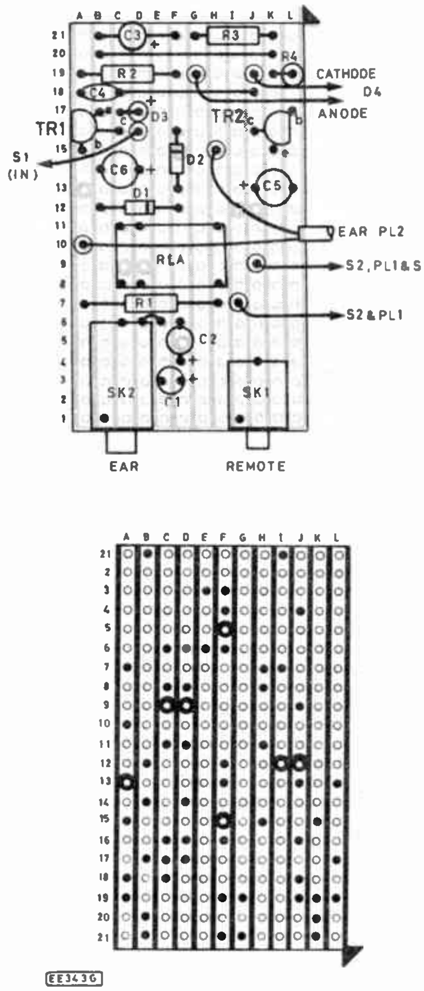


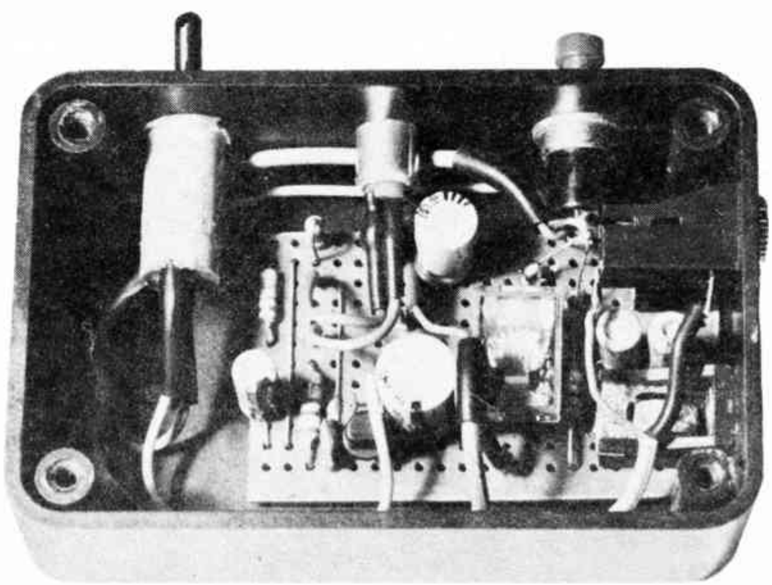
Fig. 4. Veroboard layout and wiring for the Freeloader. The board is mounted by SK1 and SK2.

S1 set to "OUT" loading should be as normal.

Rewind the tape by pressing the "Motor On" button. Dump the program and load again. Note that this time the l.e.d. will light, going out when the program has loaded.

Finally, rewind as before, but stop somewhere before the start. Commence loading. This time the l.e.d. will flicker or dim, signifying a hold of data from the computer. Nothing should load.

There are circumstances when you will need to switch "OUT" the Freeloader: for example, if data is being loaded which rapidly cycles the control relay (files, etc.). Otherwise it can be left "IN". □



The Man Behind the Symbol

No8 Michael Faraday

by Morgan Bradshaw

IN THIS, the first half of a two part article, we meet the man once described as the "Columbus of Electricity"—Michael Faraday—who discovered how to make electricity by mechanical means, and gave his name to the unit of electric capacitance (see Table 1).

Michael Faraday was born at Newington Butts, Walworth, on the Surrey side of the Thames, on 22 September 1791, the third son of a Yorkshire blacksmith who had migrated to London.

At the age of fourteen Michael was apprenticed to George Riebau, a bookbinder, who gave young Michael time to study the many learned books they were binding. Michael was a good worker, with an aptitude for learning and in April 1812 as a reward Mr. Riebau took him to a series of four lectures, on chemistry given by Sir Humphrey Davy of Miner's Safety Lamp fame.

GREATEST DISCOVERY

The young Faraday was spellbound not only by Davy but by the content of the lectures, so much so that he made notes, bound and illustrated them, and sent them to Davy requesting an interview as an assistant. Although impressed, Dave wrote to Faraday saying that he should stick to his trade of bookbinding, "Science is too precarious for a young man".

Then fate took a hand, Davy's assistant was dismissed for fighting and Faraday was offered a job, and Davy made what he later described as "My greatest discovery". The man who in later years was to succeed him as Director of the Royal Institute.

Photo: Courtesy Science Museum

ROYAL INSTITUTE

Faraday started work at the Royal Institute on 1 March 1813, in a humble capacity assisting lecturers and keeping the apparatus polished for a weekly salary of twenty five shillings. Soon he became Davy's experimental assistant, and together from October 1813 to April 1815, they toured Europe lecturing.

On 12 June 1821 Faraday married Sarah Barnard and they moved to apartments at the Royal Institute where he had been promoted to Superintendent, at a salary of £100 a year.

Photo: Courtesy Science Museum

Diorama showing Faraday in his laboratory.

Taking up original work in chemistry Faraday made a number of discoveries, among them benzol, and two new chlorides of carbon. He was also much in demand as a lecturer.

BIRTH OF THE DYNAMO

Gradually his work in chemistry was eclipsed by his electrical discoveries.

Faraday proved that a conductor carrying a current also induced currents in neighbouring conductors. On a wooden core he wound two coils of insulated wire, and sent electricity through one, while the other was connected to a meter which measured current. He noticed that while the battery current flowed steadily through one coil, the meter connected to the other coil did not move, but when the current was started or stopped, the needle jerked back and forth.

Picking up where Ampere left off, Faraday concluded that since electricity produced magnetism, so magnetism might produce electriciy. He discovered that if a magnet is thrust into a coil of wire an electric current is "generated" in the coil, when the magnet is withdrawn the current direction is reversed proving that movement can produce electricity. This great discovery—that electricity could be produced by magnetism—was dated in Faraday's notebook as 29 August 1831.

Table 1: FARAD (*F*)

The farad is the unit of electric capacitance. A capacitor has a capacitance of one farad when a charge of one coulomb raises the potential between its plates to one volt, hence

$$\text{farads} = \frac{\text{coulombs}}{\text{volts}}$$

For everyday use the farad is too large a unit, and smaller units called microfarads (symbol $\mu F = 10^{-6} F$), nanofarads (symbol $nF = 10^{-9} F$) and picofarads (sometimes called "puffs"—symbol $pF = 10^{-12} F$) are used.

The unit was first suggested in 1867 by Latimer Clark, the English engineer and electrician, who besides inventing the Clark standard cell took a leading part in the movement for the systemisation of electrical standards. The farad was adopted as the unit of electric capacitance, at the first meeting of the International Electrotechnical Conference in 1881.

Faraday then set about making a small dynamo in which a current was produced by rotating a loop of wire between the two poles of a magnet. At each half turn of the wire loop the direction of the current was reversed so that it flowed back and forth (a.c.). Faraday eventually fitted a commutator to turn the a.c. into d.c. He demonstrated his dynamo and reported his two discoveries of electrodynamic induction and magnetoelectric induction to the Royal Society on November 24th 1831.

This is generally regarded as the birth of the modern dynamo and transformer, and lead to the development of the electric motor.

But Faraday had not finished yet as we shall be seeing in Part 2, next month.

MAY FEATURES...

PA AMPLIFIER

Twenty watts r.m.s. for around £20. Designed for the home constructor using just three i.c.s and a handful of discrete components. This unit is capable of a respectable performance while still being inexpensive to build.

MINI STROBE

Recently a range of "ultra bright" l.e.d.s have become available, this feature together with their ability to be flashed at a very high speed has enabled us to present a versatile project.
Freeze rotating objects, time the car or use the Mini Strobe as a tachometer.

AUTOMATIC FIRING JOYSTICK ADAPTOR

Add automatic fire to your joystick. This unit uprates your scores with a variable preset fire rate of between 3 and 30 times a second. This unit is inexpensive and easy to build.

EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY

MAY ISSUE ON SALE FRIDAY, APRIL 18

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NEWS ...from the world of electronics

TOP AWARD FOR WOMEN

A DEVELOPMENT engineer with Hoover plc has been voted the 1985 Girl Technician of the Year.

At a ceremony in London recently, Mr. T. P. Jones, CB, Chairman of the Electricity Council presented Sharon Howes, age 28, with the prize of £250 and an inscribed rose bowl. Sponsored by The Caroline Haslett Memorial Trust and The Institution of Electrical and Electronics Incorporated Engineers, this award is intended to focus attention on electrical and electronic engineering as a worthwhile professional career for women.

In addition to the main award, The Mary George Memorial Prize for the most promising young woman technician engineer went to Michelle Richmond, age 20, from Plessey Radar, Isle of Wight.

As a Development Engineer, Sharon's duties include the testing and assessment of Hoover domestic electrical appliances and evaluating new design models with a view to improving product performance, manufacturability and cost.

Michelle is currently involved in computer programming for analysis of microwave patterns. At present she is busy setting up a test system for monitoring detection pulses in an air surveillance radar system.

In 1984 she gained public acclaim in local newspapers, TV and radio for her part in the design and construction of a baby alarm system to prevent cot deaths.

APPOINTMENTS

Roger Graham, Group Managing Director of the Business Intelligence Services (BIS) Group of Companies, has been elected President of the European Computing Services Association (ECSA) at a recent council meeting in Istanbul, Turkey. He is the first British President of ECSA in its eleven-year history, although the ECSA Secretariat has always been based in London.

ECSA was formally established in 1975 as the voice of the European Computing Services Industry. It brings together the national industry associations of sixteen European countries.

British Telecom has appointed Mr John McMonigall as Deputy Managing Director of British Telecom Enterprises.

He has executive responsibility initially for consumer products where he will be conducting an operational review of BTE's consumer electronics factory in South Wales.

The world's first all-digital public telephone link spanning the world's oceans has been set up by British Telecom International (BTI) and its Japanese counterpart KDD.

A new satellite link interconnects modern digital exchanges in London and Tokyo by using a new satellite transmission technique known as TDMA—time division multiple access—via an *Intelsat* satellite over the Indian Ocean and BT's earth station at Madley in Herefordshire.

SPACE STUDY

The British National Space Centre has announced that it will support proof-of-concept studies on Hotol, the horizontal take-off and landing space plane being investigated by British Aerospace and Rolls-Royce.

Hotol is an advanced concept for a horizontal take-off and landing launch vehicle for satellites. It is based on Swallow, a new power plant, proposed by Rolls-Royce.

The novel propulsion system reduces the need for Hotol to carry large quantities of liquid fuel by utilising a hybrid engine arrangement which combines air-breathing and rocket propulsion. Details of the engine are at present confidential. Hotol will be developed as an unmanned automatic vehicle capable of being adapted for manned operations at a later date.

Studies of Hotol and its propulsion system will last for up to two years and cost £3 million. The contracts placed with the two companies contain a break point after the first six months when the position will be reviewed. The cost of studies up to that point will be about £750,000 which will be shared equally by the BNSC and industry.

FIBRE RECORD

A new world record for optical fibre transmission set by British Telecom promises to help contain the cost of expanding the network. A team of engineers have succeeded in transmitting data over 32km of singlemode fibre at a rate of 2·4 Gbit/s, the fastest rate yet achieved over an installed cable.

Unlike previous laboratory demonstrations this feat was achieved over an existing cable. It illustrates the feasibility of upgrading existing optical systems without the need to replace cables.

The data rate achieved, 2,400 million bits of information per second, represents a 16-fold capacity increase over the existing 140 Mbit/s systems. It is equivalent to passing 30,720 separate speech channels, or 32 full-bandwidth colour television pictures, down the same single optical fibre.

Rapid Silicon now have a Bonded Store and Military Standard components which complies with BS9000.

Amstrad has announced that 0277 230222 has been designated as the Customer Service number at the company's Brentwood headquarters.

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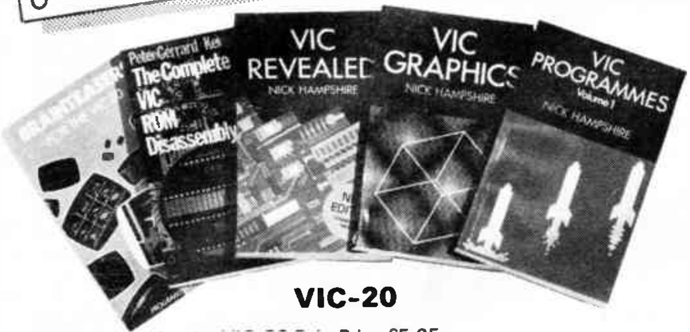

VIC-20

Brainteasers for the VIC-20 Pub. Price £5.95
G. Ludinski. Size 215 × 134mm 133pp
Book of programs built around a competition element—logic, general knowledge, maths, whodunnits, etc. Graphics fully exploited.

The Complete Vic ROM Dissassembly Pub. Price £6.95
Peter Gerrard & Kevin Bergin. Size 215 × 134mm 157pp
For the serious programmer, complete dissassembly of all ROM routines, also complete 6502 m/c instruction set, etc.

Vic Revealed Pub. Price £9.95
Nick Hampshire. Size 215 × 134mm 267pp
How and why the Vic works. 5 sections in the book covering functional blocks—6502, 6561, 6522, software and I/O functions plus appendices of codes and circuit diagram.

Vic Graphics Pub. Price £6.95
Nick Hampshire. Size 215 × 134mm 185pp
How to generate graphic displays—graph and colour plotting, Hi-res graphics, scaling, rotating and 3D displays, all fully explained.

Vic Programmes Vol. 1 Pub. Price £6.95
Nick Hampshire. Size 215 × 134mm 184pp
Useful and interesting collection including music, games, utilities, graphics and functional programs, 36 altogether.

A Pocket Handbook for the VIC Pub. Price £2.95
Peter Gerrard & Danny Doyle. Size 215 × 135mm 95pp
A must for all serious VIC-20 users—tables, disk commands, memory, maps, m/c inst. set, details of all sockets, sound, etc., etc. Cover design similar to Dragon version.

SPECTRUM MSX & ATARI

Introducing MSX Basic Pub. Price £6.95
Paul Kuzora & Christine King. Size 210 ×150mm 242pp
First steps in MSX BASIC, sound and graphics, sprites + 5 programming projects. Essential guide for all MSX owners.

Getting Started with the Atari 600XL Pub. Price £5.95
Peter Goode. Size 215 × 134mm 141pp
Aimed at first time users, this book guides you through BASIC, graphics, designing progs and filing data on cassette. Example progs shown.

Spectrum Graphics Pub. Price £6.95
Nick Hampshire. Size 215 × 135mm 192pp
Hi-res graphics, graph plotting, using the video memory, 3D and rotating displays are all included. Many progs with full explanations.

Spectrum Programmes Vol. 1 Pub. Price £6.95
Nick Hampshire. Size 315 × 134mm 182pp
A wide range of interesting and useful progs: music, games, utilities, graphics, functional progs, etc.—26 altogether.

My Atari XL & Me Pub. Price £2.95
Jack Walker. Size 196 ×125mm 89pp
For children, this book starts at the beginning. Nicely illustrated, well written, finishing with complete game.

My Spectrum Computer & Me Pub. Price £2.95
Meyer Solomon. Size 196 × 125mm 83pp
For children, this book starts at the beginning. Nicely illustrated, well written, finishing with a complete game. Cover design similar to Atari version.

Spectrum Crib Card Pub. Price £1.99
Everything needed on a fold-out, double-sided, glossy card. 12 panels. Size 210 × 98mm. Similar style to the CBM 64 version.

CBM 64

The Sensible 64 Pub. Price £5.95
David Highmore & Liz Page. 208 × 150mm 122pp
Covers what the manual doesn't!—keyboard, user defined graphics, displays, sprites, sound and music, disk drives and printers.

Commodore 64 Games Pub. Price £6.95
Kevin Bergin. Size 215 × 134mm 190pp
21 exciting games—making full use of graphics and soundcar dodge, air attack, hangman, etc. All are accompanied by notes.

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Richard Franklin & Nick Hampshire. Size 215 × 134mm 191pp. 20+ progs covering a wide variety of interests. Includes Hi-res graphics, music, games, utilities, sprites etc. plus full length adventures.

C64 Crib Card Pub. Price £1.99
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A Pocket Handbook for the Commodore 64 Pub. Price £2,95
Peter Gerrard & Danny Doyle. Size 215 × 135mm 95pp. Essential for all serious C64 users—Tables, memory, maps, m/c inst. set, cartridge and joystick connexions RS232/Centronics data, sound chip registers, sprites, etc., etc. Cover design similar to Dragon version.

DRAGON

Brainteasers for the Dragon 32 Pub. Price £5.95
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Book of programs built around a competition element—logic, general knowledge, maths, whodunnits, etc. Graphics fully exploited.

Dragon Programs Pub. Price £6.95
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20 exciting and interesting programs—Star Trek, Breakout, Logic games, sound effects, graph plotting, etc.

A Pocket Handbook for the Dragon Pub. Price £2.95
Peter Gerrard & Danny Doyle. Size 215 × 135mm 91pp. For machine code enthusiasts, it contains ASC11 codes, tables, assembly/dissassembly, BASIC keywords/errors, etc. plus useful hints and tips.

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Exploring Adventures with the BBC/Electron Pub. Price £6.95
Peter Gerrard. Size 215 × 135mm 244pp
Starting with an introduction to adventures and their early history, this book takes you through the steps necessary to write your own games. Highly readable. **Versions for BBC and Electron available—state which is required.**

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...Beeb...Beeb...Beeb...Be

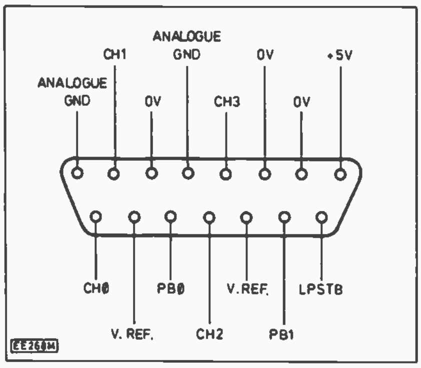
ANYONE involved with home computers professionally tends to get asked the dreaded question; "which is the best computer to buy?" This is very much a "how long is a piece of string?" type question, and the right answer depends entirely on the intended applications of the machine. However, for someone who is interested in connecting home constructed gadgets to a computer the BBC model B remains the obvious choice. It is not so much that it has greater add-on potential than the competition, but is more a case of its range of ports making it easier to add practically any type of add-on to this machine than any other. Its fast version of BASIC and built-in assembler are also plus points which must be taken into account.

With around 400,000 BBC computers in circulation, and many of these in the hands of electronics enthusiasts and educational establishments, no excuse is made for this new series which will deal with interfacing to the BBC machine. Do not worry about this series being devoted to masses of software; we will be primarily concerned with circuits that you can build, and any software will be applications or demonstration programs to accompany these devices. The circuits will in the main be quite simple types, and it is surprising how much can be achieved using the BBC machine in conjunction with a few very simple add-ons. None of the circuits will involve delving into the interior of the machine and making modifications. All will connect to one or more of the computer's many externally accessible ports.

Analogue Port

For someone who is just starting at computer interfacing, especially if they are more familiar with linear circuits than digital types, the analogue port of the BBC computer probably represents the easiest introduction to the subject. This is one of the ports at the rear of the machine, and it uses a 15-way "D" type socket. Connections to it are accordingly made by way of a matching 15-way "D" type plug, although I have found it possible to use one millimetre plugs as a cheaper solution in cases where only two or three connections are to be made. Fig. 1 gives connection details for the analogue port.

Fig. 1. Connection details for the BBC micro analogue port.

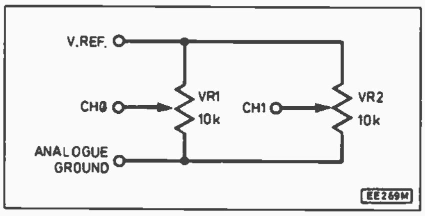


The main purpose of this port is to enable two joysticks to be connected to the machine. The joysticks must be of the type which contain potentiometers, rather than the Commodore/Atari switch type. One potentiometer is operated by vertical movement of the stick—the other is controlled by horizontal movement. With this type of joystick the idea is to have the position of some on-screen character related to the position of the joystick (e.g. placing the stick over to the extreme right hand side and centrally top to bottom would place the character on the extreme right hand side and half way up the screen). This is unlike the more common switch type joystick where the stick is used to indicate movement in a particular direction rather than to directly indicate a precise screen position.

A joystick connects to the port in the manner shown in Fig. 2. The V.Ref outputs provide a reference potential of 1·8V, which is equal to the full scale value of the analogue inputs (CH0 to CH3). The two potentiometers are connected between analogue ground and V.Ref, and can each therefore supply any voltage between zero and the full scale value of the port. The potentiometers of the second joystick have the same method of connection, but their outputs feed into the CH2 and CH3 inputs. Most joysticks have a "firebutton", and PB0 and PB1 are used to monitor these. The pushbuttons are wired so that they take these inputs to ground when operated. Incidentally, the analogue ground inputs are used instead of the 0V supply rail as the analogue ground inputs, in theory at any rate, give less severe noise problems.

The converter in the BBC machine is a µPD7002 12-bit type. It includes an analogue multiplexer which provides the four inputs, but it is not a high speed type and only about 100 readings per second are taken, or 25 per channel with all four in use. From BASIC the analogue inputs are read using the ADVAL function, with ADVAL(1) to ADVAL(4) somewhat confusingly corresponding to CH0 to CH3 respectively. The values returned are in the range 0 to 65520, but increment in 16s. Returned values must be divided by 16 to give a 0 to 4095 range with increments of 1. In practice noise prevents the full 12-bit accuracy from being obtained, and a true accuracy of no better than 10-bit resolution is likely to be obtained. This is not too important as most applications require only 7 or 8-bit resolution, and as we shall see in later articles the analogue inputs can be used very successfully in a wide range of measurement applications.

Fig. 2. Joystick connection to the analogue port.



We will consider the analogue port in more detail in next month's article, which will include a touch controller circuit.

REVIEW

BBC Diagnostics

Has your Beeb ever coughed or sneezed? If so, to the rescue come Watford Electronics with a disc-based program to tell you what the trouble is. Well, perhaps not quite, but the Diagnostics Disc is an effective way of checking most of the main components and systems of the BBC micro.

As the well-written and comprehensive instruction book rightly says, to fully check all the Beeb's bits would take a very large program several years. This program makes a good effort, however, checking the RAM, OS ROM (the program is for OS 1·20 only), the keyboard, the video components and RAM, the user port, RS432 interface, analogue port, cassette system, the sound system, and the printer port.

The program can also be used to check some add-ons, such as sideways RAM, joysticks, the disc system, speech system, and second processors (6502 and Z80) if these are fitted. However, the "TUBE" circuitry cannot be checked if a second processor is not fitted.

There is also a means of testing sideways ROMs. The program will perform a Cyclic Redundancy Check on these, and report the checksum, which you can record on a special page in the instruction book. The idea is that you check ROMs as soon as possible after you obtain them, when presumably they are working correctly.

If at some later date, a ROM appears to go faulty, you can perform the test again, and if the checksum has changed, a ROM fault is indicated.

Certain tests on some of the ports require connections to be made, and leads are supplied with the disc for this purpose.

The instruction book contains a lot of general advice about how to treat the components of a computer (static sensitivity, etc.) and though some of this will be old hat to readers of this magazine it is nice to see it included. In fact, much praise could be heaped on the documentation. It is very readable, and includes clear diagrams where necessary.

As well as taking you through all the stages of the program, the instructions include suggestions for further tests when a fault is located, and also advice on possible cures.

This program is, perhaps, of limited interest to individual owners of BBC computers (though it has considerable "play value" for the technically minded) but it could be invaluable to schools and institutions using many computers. In particular, it will be of value where BBC computers are being used for data acquistion in laboratories, as it will allow both RAM and ports to be checked before and after experiments. If an unexpected result should then occur, the possibility of malfunction can be eliminated.

In any case, this is certainly an interesting and unusual addition to the wide range of software available for the BBC micro. It is available direct from Watford Electronics, for £24.15, including VAT, postage and packing. (Please mention this EE review when ordering.) Watford Electronics, Dept EE, 250 High St., Watford WD1 2AN. Tel. 0923 37774.

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Wanted: oscilloscopes type 3031. Good picture and working inc. probes. £100 or under. Mr. P. S. Boult, 25 Tudor Road, Intake, Doncaster, S. Yorks DN2 6EN.

Oscilloscope, Cossor 339A. Dual trace, uncalibrated. Quite old. £25 o.n.o. or swap for multimeter/other test gear. Mr. Walls. Tel: 0371 2900.

YAESU FRG 7700 comms. receiver. 0–30MHz boxed with manuals. Little used. £270 o.n.o. Tel: Bradford 594880.

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Aquarius computer new, unused £40 o.n.o. Rhythm ACE drums unit £50 o.n.o. Excellent professional keyboard £15. J. Howells, 118 Heritage Park, St. Mellons, Cardiff, S. Glam. Tel: 0222 797956.

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EE MARKET PLACE APRIL '86

...REPORTING AMATEUR RADIO...

TONY SMITH G4FAI

AMONG radio amateurs there are a number of operators regarded as slightly mad by their colleagues. These are the QRP (low power) enthusiasts, and I admit to being one myself. They make contact over the air with a fraction of the power used by everyone else. In the face of ever increasing noise and interference on the bands, they persist in this practice even when, sometimes, it is almost impossible to hear each other's signals!

Why do they do it? Because of the challenge in completing a contact under such conditions; because the equipment required is so simple it can all be home-made and need cost very little; because it brings back something of the atmosphere of early amateur radio.

I mention this because I had the pleasure of attending the Yeovil Amateur Radio Club's annual QRP Convention recently. Well over a hundrd keen QRPer's from many parts of the UK converged for an enjoyable day out. This included lectures, an exhibition of home-constructed equipment, and the opportunity to buy components for further construction.

Three stations were on the air, using less than three watts output, including a B2 spy set originally carried in a small suitcase by SOE operators during WW2. Visitors could operate these stations, and contacts were made with other QRPer's unable to attend the convention.

A fascinating lecture by Rob Micklewright, G3MYM, posed the question, "Can we work VK (Australia) on QRP?" Most of his audience knew the answer already, but he analysed the various factors involved, i.e. propagation path, noise level, optimum frequency, station site, antenna, losses in signal hops, time of year, time of day, and the sunspot count.

Most of us just wait until we hear Australian stations. We call them using anything from three watts down, and just occasionally someone is successful. Rob showed us there was considerably more to it than that and how, with some forethought, we could increase our chance of success.

MEET THE CLUB

The convention is the only one of its kind in Britain, and the Yeovil Club are to be congratulated on organising it. Back in the fifties, they operated what may have been the first amateur transistor transmitter. Constructed around an experimental point-contact transistor, this made an historical transmission on the 80 metre band, over a distance of 90 miles, with an input power of just 30 milliwatts. The club celebrates its 40th anniversary in 1986, and still has four founder members going strong.

Amongst many activities, there is a radio amateur's examination course, where newcomers make a simple direct-conversion receiver as a practical introduction to both construction and short-wave listening. RSGB slow Morse practice transmissions are put out under the club callsign, G3CMH/A, and the club station can be heard at times on all amateur bands from 160m to 70cms.

They have built, and maintain, a 70cms repeater, GB3YS. This receives weak signals, amplifies, and re-transmits them over a wider area than would otherwise be possible, a facility particularly useful for mobile operators. Special event stations, where the public can see the club in action, are mounted at the Mid-Somerset Show, the Yeovil Festival of Transport, and at various other events.

There is much more. If you live in or around Yeovil, telephone Eric Godfrey, G3GC, on Yeovil 75533, for further information. There are similar clubs in most parts of the country, where newcomers to the hobby are always welcome.

50MHz ALLOCATED

The new 50MHz allocation became effective on 1st February. As anticipated, there are a number of restrictions to prevent interference with European broadcast stations. The power permitted is considerably less than that on other bands, and antenna heights are limited. Mobile, portable, temporary premises, or repeater operation is not allowed. Fortunately, the possibility of restricted operating times has not materialised, for the DTI has agreed to review the use of the band in a year's time.

Since the preliminary announcement last year, a number of magazine articles have anticipated the new allocation. These show how to get on the new band in various ways, and some commercial equipment has arrived on the market.

The sunspot minimum provides poor propagation conditions at present, however, and, with the restrictions imposed, it is difficult to see the amateur population at large getting too excited about the new band. When conditions begin to improve in the next two or three years, it may be a different story!

QUESTION CORNER

Q. What is an s.w.r. bridge, and what does it do?

A. This is a device inserted in a feeder line to indicate to the operator that there is (hopefully) a good match between a transmitter and an antenna. Assume that a simple dipole antenna is in use. This is a length of wire with a physical length calculated as a half-wavelength for the frequency to be used. For 7MHz—the 40 metre band—this would be approximately 20 metres long. If this wire is broken in the middle to provide a feed point, the impedance will be such that it will provide a reasonable match (50–70 ohms) to an amateur transmitter, and a satisfactory transfer of power for the antenna to radiate. To help in this, matching coaxial cable of, say, 50 ohms impedance is used as a feeder.

When there is not a satisfactory match at the feed point for any reason, a portion of the power is reflected back down the feeder in the form of "standing waves". The ratio between the "forward" and "reflected" power is the "standing wave ratio", and the function of an s.w.r. bridge is to indicate this ratio.

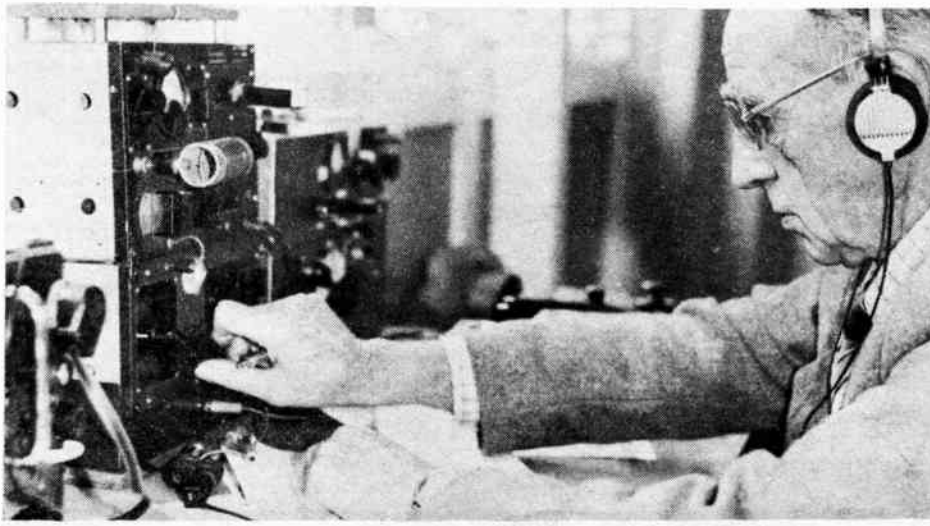
The actual instruments may have one or two meters. A single meter can be switched to show forward and reflected readings separately, while twin meters show them simultaneously. When a forward reading gives full-scale deflection of the meter, the reflected reading should never exceed 3:1, which is usually half-scale. An s.w.r. of 2:1 is better, and anything down to 1:1 is best of all, normally indicating that most of the power is being taken by the antenna.

Some transmitters automatically reduce output in the face of a mismatch, a situation the bridge will indicate immediately. It is invaluable in antenna experiments, and in the forward mode some versions can be calibrated to give an indication of actual power output. An s.w.r. bridge is an essential part of an amateur station, which can be either purchased or easily built. In the latter case it makes a very good introduction to amateur radio home construction.

QUESTIONS PLEASE!

If you have a question about amateur radio, write to me c/o the editor. I can, however, only reply through this column. 73 de G4FAI.

Nobby Clark, G3BEC, a founder member of the Yeovil club, operating a B2 spy set at the QRP convention.



TEACH-IN '86

PROJECT 7

FET VOLTMETER

Michael Tooley BA **David Whitfield** MA MSc CEng MIEE

MEASURING instruments are an essential aspect of almost every type of practical electronics. This month's project in the *Teach-In '86* project is a FET Voltmeter.

One of the important features of any measuring instrument is that it should not significantly disturb the circuit under investigation. It is, after all, little use having an ammeter in series with a 5V power supply rail if it introduces a 1V drop in the process.

VOLTAGE MEASUREMENT

With voltage measurements, the increasing use of low power technologies such as CMOS has made the situation even more extreme. A general purpose multimeter on the d.c. voltage ranges has an effective impedance which varies according to the range selected; typically this will be around 20kΩ per volt of the range selected. Such a voltmeter, if set to the 5V d.c. range, would thus impose a load of 100kΩ on the circuit under test.

In high power circuits, this would cause little problem, amounting as it does to an additional drain of 50μA on a 5V signal. However, in circuits which have very low operating currents and hence impedances which may run to many megohms, it is clear that the load imposed by such a voltmeter could significantly disturb the operation of the circuit.

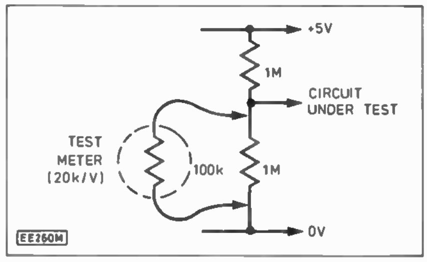


Fig. 1. Voltmeter impedance effects.

For example, referring to Fig. 1, if we try to measure the potential at the centre of a simple 1MΩ + 1MΩ resistive divider across a 5V rail using a 20kΩ per volt meter, the result would be a reading of 0·42V. This is a significant error when compared to the correct value of 2·5V!

The FET Voltmeter to be described is an electronic voltmeter which presents a constant input impedance of 10MΩ, irrespective of the range selected. It thus presents a very significantly higher impedance than is possible with a conventional multimeter for the measurement of d.c. and a.c. voltages. In addition, the load imposed on the circuit under test is not affected by the range selected.

COMPONENTS

Approx. cost Guidance only **£22**

Resistors

R1,R4,R5	1M (3 off)
R2	6M8
R3	200k
R6	680k
R7	20k
R8,R9	100k (2 off)
R10	68k
R11	2k
R12	30k
All 2% or better	
R13,R20	1M (2 off)
R14,R15	18k (2 off)
R16	6k8
R17,R18,R22	10M (3 off)
R19,R21	100k (2 off)
All ¼W ±5% carbon film	

Potentiometers

VR1	4k7 horizontal preset
VR2	1k horizontal preset

Capacitors

C1	47n polyester
C2,C3,C4	100n polyester (3 off)
C5,C7	10μ elec. 25V (2 off)
C6,C8	100n polyester (2 off)

See Shop Talk page 208

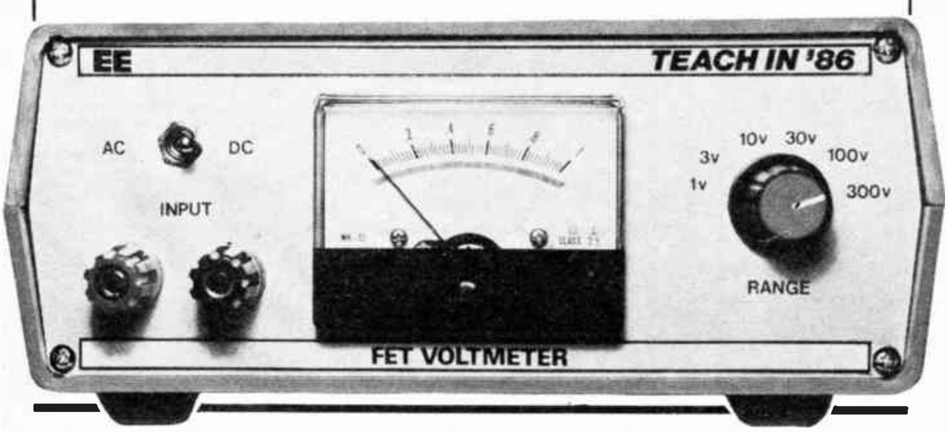
Semiconductors

D1,D2	1N4148 (2 off)
D3,D4	1N4001 (2 off)
IC1	TL072 BI-FET Operational Amplifier

Miscellaneous

ME1	1mA meter (e.g. 2in Panel Meter)
S1	2-pole 6-way rotary switch
S2	DPDT toggle switch
SK1	4mm terminal (red)
SK2	4mm terminal (black)
SK3	4mm socket (red)
SK4	4mm socket (black)
SK5	4mm socket (blue)

One knob, with pointer; 4 stick-on plastic feet; Veroboard 0·1" pitch 5in × 3·75in and mounting hardware; Vero terminal pins (7 off); Case: West Hyde Developments type TEK A22, available in black, grey or lobster red at £6.18 + VAT, inclusive of carriage.



CIRCUIT DESCRIPTION

A block diagram for the FET Voltmeter is shown in Fig. 2, with the corresponding circuit diagram in Fig. 3. The input attenuator formed by R1 to R12 presents an impedance of 10MΩ between SK1 and SK2.

The range selection is performed by S1, and the input impedance of the following stages is so high as not to impose any significant loading on the attenuator. At full-scale input on the selected range, the output from S1 is 900mV.

For d.c. measurements, the output from the attenuator is applied directly to the input of the meter buffer amplifier, IC1b. This stage uses a low noise BI-FET operational amplifier which has an input impedance of 10^{12}ohms.

The gain of the stage is set by R20 and R21 to produce a 1V output from a 900mV input. The output is arranged by suitable setting of VR2 to produce 1mA through the meter, ME1, for a full-scale input.

For a.c. measurements, the input signal is switched to the active rectifier circuit by S2. The rectifier uses the second amplifier in the IC1 package, IC1a. A capacitor, C1, is connected in series with the input to remove any d.c. component present on the signal.

The precision rectifier then uses D1 and D2 to rectify the alternating input cycles. The positive component of the signal is sampled by R19 and C4. The circuit is arranged to sense the mean value of the input, while the output is calibrated to indicate the r.m.s. value of a sine wave by suitable adjustment of VR1.

CONSTRUCTIONAL DETAILS

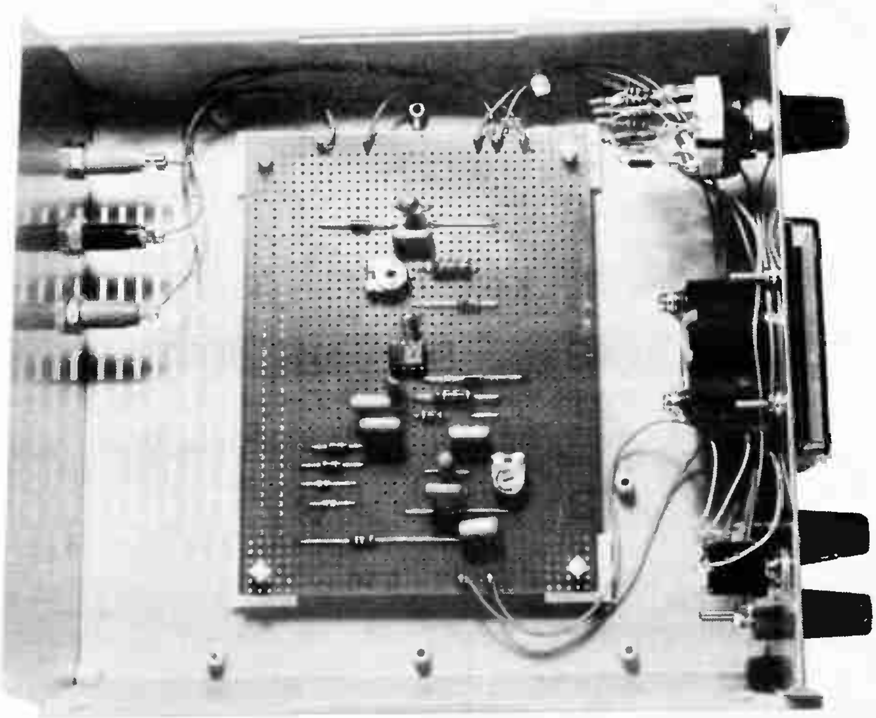
The meter is built in the standard project case, and uses a circuit board for mounting most of the small components. The layout for the main circuit board is shown in Fig. 4.

However, before soldering any components in place on this board, four mounting holes of suitable diameter need to be drilled, and 6 track cuts are required. These are best made using a proprietary track cutter, or a large diameter sharp drill rotated slowly by hand.

When the board has been prepared, the components may be fitted in the positions shown in Fig. 4. The order of assembly is not critical, but a methodical approach (e.g. left to right across the board) is to be recommended.

Care should be taken to correctly orientate the polarised components (the integrated circuit, electrolytic capacitors and the diodes). The use of terminal pins is recommended for all off-board connections, since this will simplify the later installation of the interconnection wiring.

Before moving on, it is well worth spending a few moments at this point making a careful visual inspection of the completed



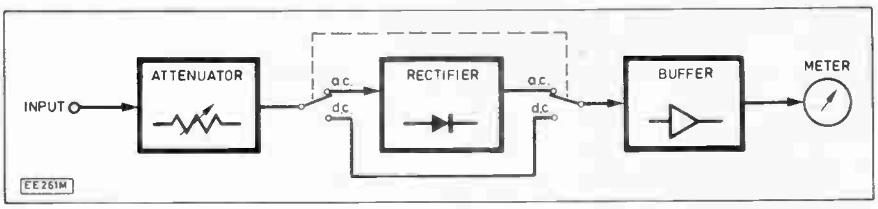
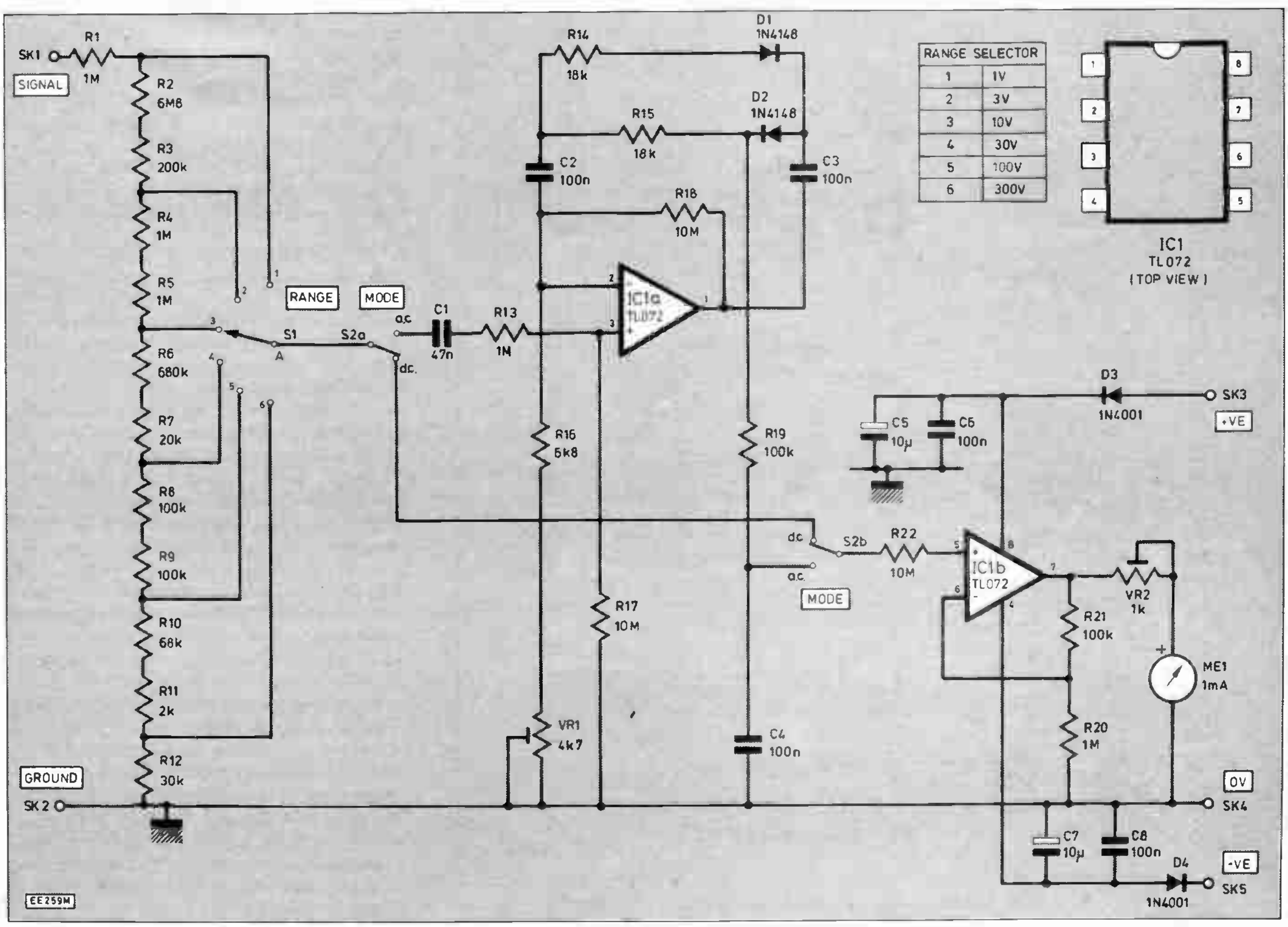


Fig. 2. Block diagram for the FET Voltmeter.

Fig. 3. Complete circuit diagram for the FET Voltmeter.



RANGE SELECTOR	
1	1V
2	3V
3	10V
4	30V
5	100V
6	300V

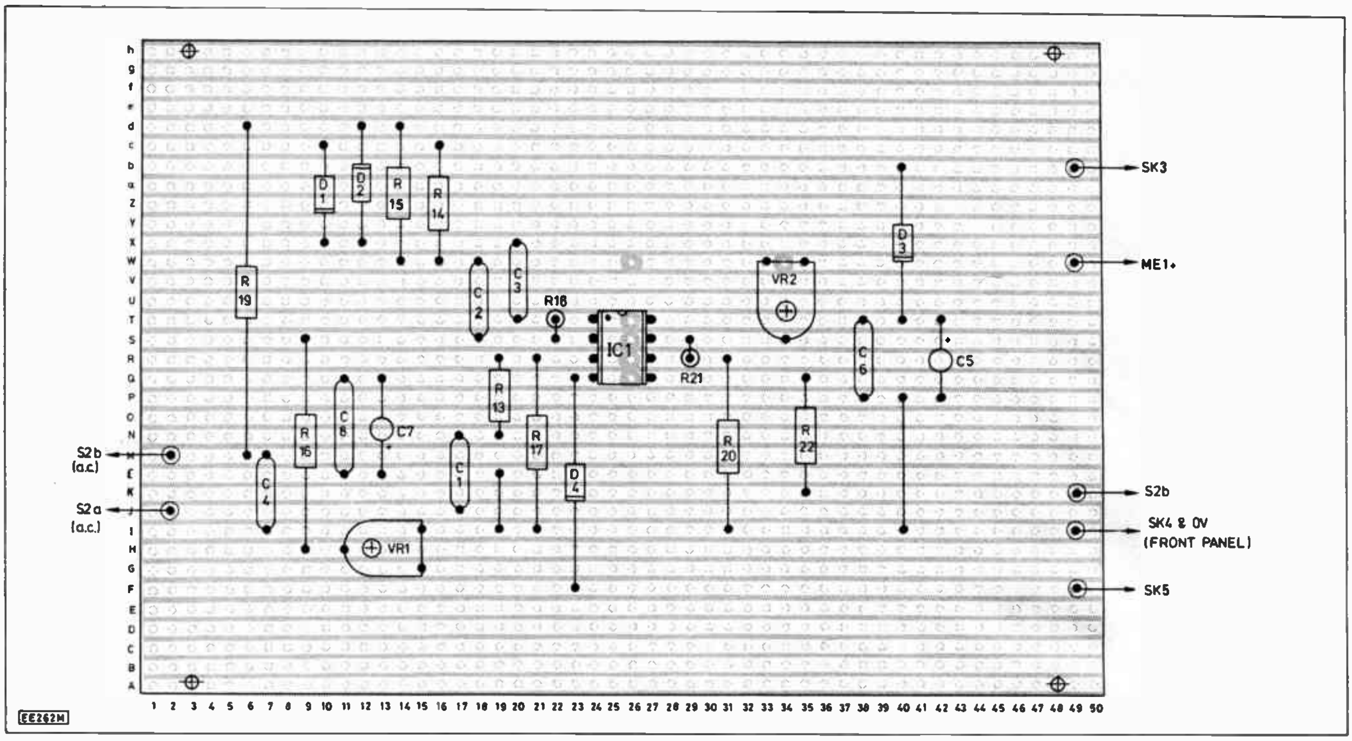


Fig. 4. Circuit board component layout and details of breaks to be made in the copper strips on the underside of the board. Breaks are required at *Q*26, *R*26, *S*26, *T*26, *W*26 and *W*34.

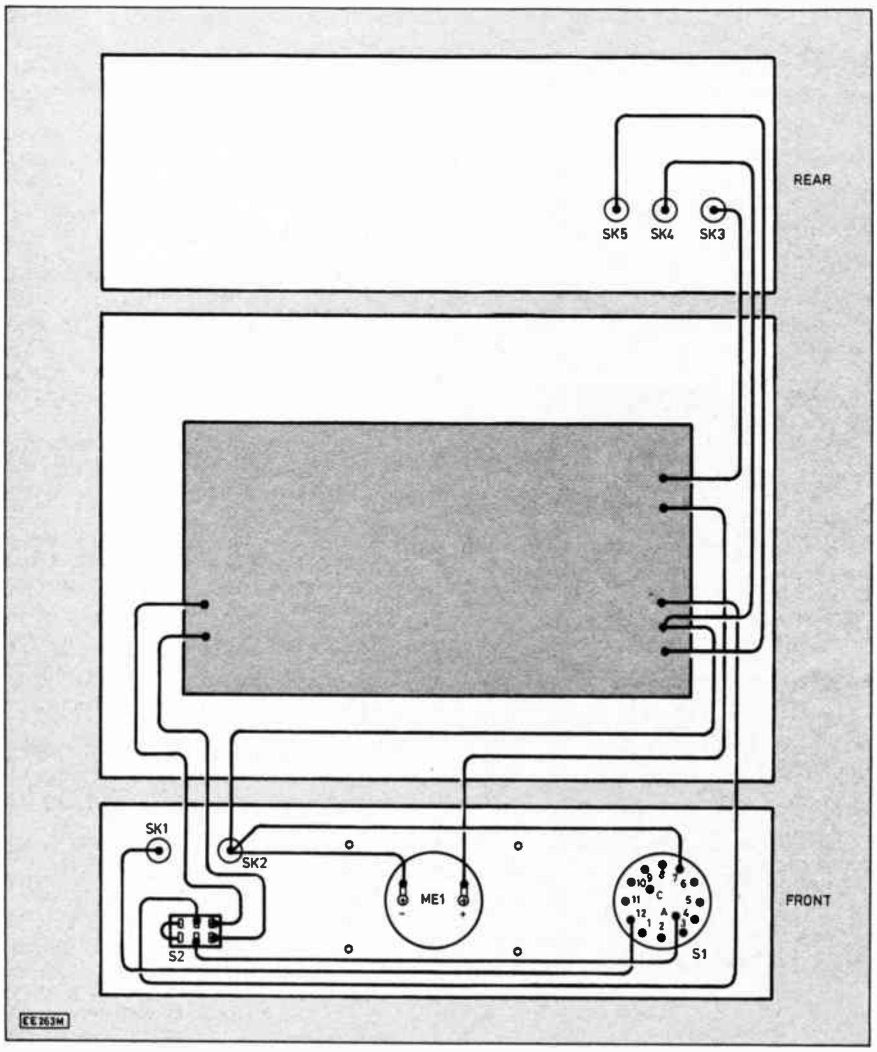


Fig. 6. Assembly and interwiring details.

board. Particular points to look for are: missing links, wrongly fitted components, solder splashes and short circuits caused by accidental solder bridges on the track side of the board. A little time spent in checking at this stage can save many hours of trouble-shooting later on.

After the check, the board should be mounted in the base of the case. Enough space should be left to ensure adequate clearance for all panel mounting components. Plastic feet on the base of the case will prevent the mounting hardware from scratching bench or table surfaces.

FRONT PANEL

The next step is to drill the front panel in accordance with the layout given in Fig. 5. The hole diameters required may vary a little from those shown, depending on the exact dimensions of the components used.

When cutting the large-diameter hole for the meter, a number of different approaches may be taken, depending on the tools available. Constructors may use a tank cutter or a proprietary sheet metal punch to cut the hole in a single operation. An alternative, used in the construction of the prototype, is to drill a series of intersecting holes just *inside* the outline of the cut-out to remove the bulk of the metal, and then clean up the rough edge with a half-round file.

Once the panel has been drilled, the overlay in Fig. 5 (or a photocopy) should be fixed to the panel; a layer of self-adhesive transparent library film can then be used for protection. The rear panel requires three holes in any convenient position to allow mounting of SK3, SK4 and SK5. The panel mounting components (i.e. the meter, sockets, and switches) can then be fitted as shown in Fig. 6.

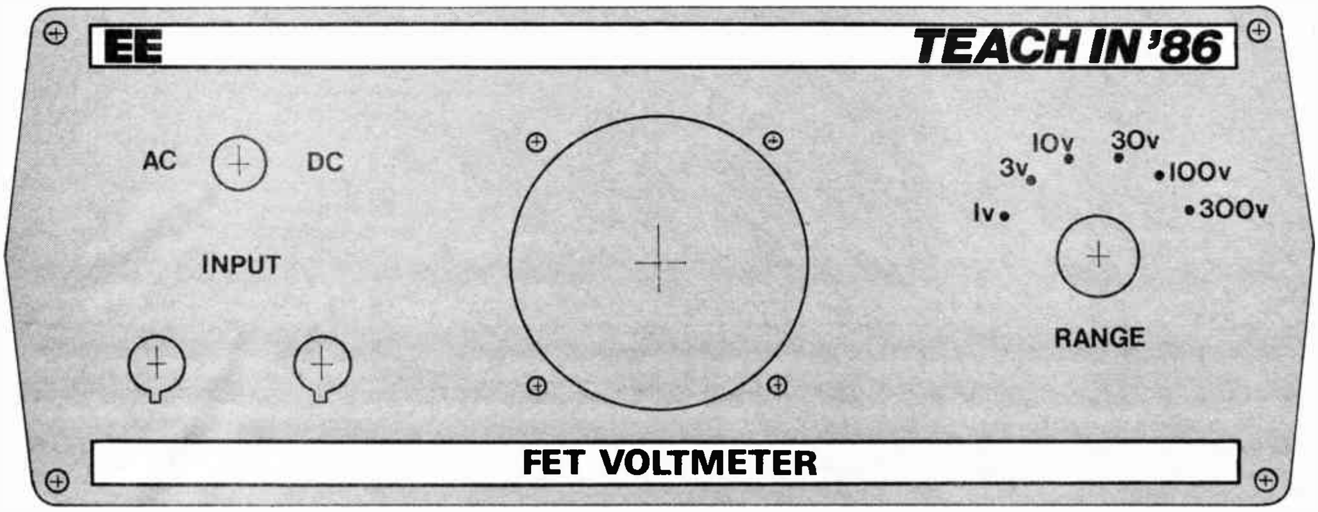


Fig. 5. Front panel layout (full size).

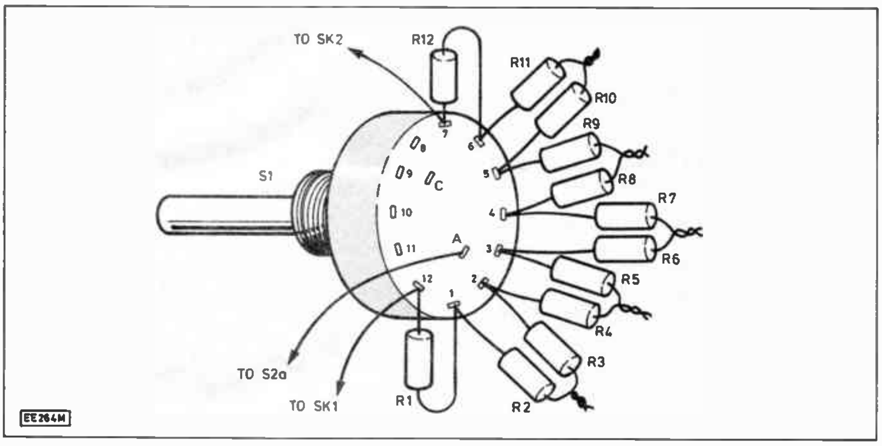
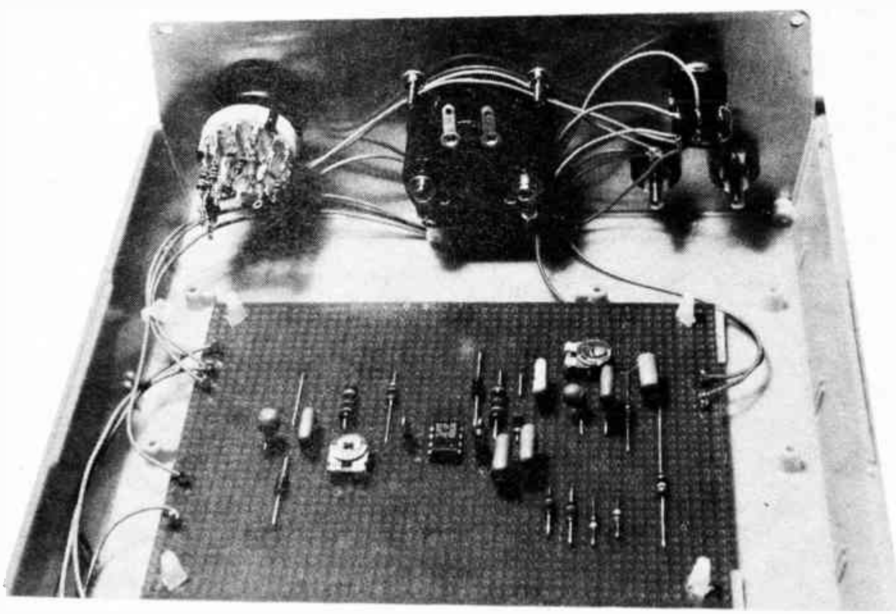


Fig. 7. Range selector switch S1 detailed assembly. The "free ends" of the resistors should be twisted together in pairs and soldered.



Wiring to the front panel range switch, meter, mode switch, input terminals and the solder pins on the circuit board.

RANGE SWITCH

The remaining components (which should comprise R1 to R12) are fitted directly to the tags of S1. The accuracy of the components will significantly affect the accuracy of the instrument, and 2 per cent tolerance or better is recommended.

The assembly of the resistors on the switch S1 is illustrated diagramatically for clarity in Fig. 7. The interconnection wiring should then be fitted as shown in Fig. 6.

The front and rear panels may now be attached to the top of the case using the screws provided, but the top cover should not be fitted as there are a number of adjustments to be made. The preset potentiometers VR1 and VR2 should finally be set to maximum resistance, and the unit is then ready for testing and use.

TESTING

The first step, when testing the meter, is to measure the supply current drawn by the unit. This should typically be in the range 1mA to 5mA for supply voltages of ±12V to ±15V, although the unit will operate quite satisfactorily from any d.c. supply in the range ±10V to ±18V.

Any significant deviation from the supply current figures given should be investigated before proceeding. Particular attention should be paid to the orientation of IC1, D3 and D4, and to the interconnection wiring.

The next step is to set the instrument to the d.c. mode and, using a known d.c. voltage source, adjust VR2 to give the correct indication on the meter. The meter used in the prototype had an internal resistance of 200 ohms, and so the correct position for VR2 is at around 80 per cent of maximum.

Checks should be made on a range of voltage sources to verify correct operation of the input attenuator. The final step is to set the unit to a.c. mode, and adjust VR1 to give the correct indication when being used to measure a known sine wave source.

The unit is now ready for use. It will be noticed in operation that the unit is very sensitive to capacitively stray coupled signals, e.g. by holding the test leads connected to the input terminals. This is a natural consequence of the very high input impedance of the unit.

NEXT MONTH: Project 8 is a Pulse Generator, the last in this series of test instruments.

Actually Doing it!!

IN THE previous article the subject of wiring up a project was commenced, and in the main we were concerned with how to connect the wires, rather than exactly where they should be connected. How difficult or otherwise the task of deciding exactly where wires must be added depends very much on the source of the project. A full constructional article in *Everyday Electronics And Electronics Monthly* will be accompanied by illustrations which will usually make it perfectly clear where every single wire must be connected. Problems are then only likely to arise if a component you are using is physically different to the one illustrated. It is important to realise that there are often marked physical differences between two components of the same type, and that both are probably perfectly suitable for a given application provided they are connected correctly.

If the source of the project is something like a circuit diagram in a book with no constructional details being provided, then the task of wiring up the unit can be an awkward one for a beginner. In fact it is advisable to only try projects for which constructional information is provided.

The connections to standard switched and unswitched jack sockets are shown in Fig. 1. If the socket is feeding into something like a pair of headphones it does not actually matter if the connections to the "earth" and "signal" tags are reversed. The same is not true if the equipment is something that will feed into an amplifier, mixer, or some similar piece of audio equipment. Reversing the connections to the plug or socket will at best result in a lot of "hum" and other electrical noise being picked up, and at worst no output at all will be obtained.

You may sometimes encounter the term "insulated" socket, particularly when dealing with jack types. The switched jack socket of Fig. 1 is an example of an insulated type. The socket has a plastic body, which consequently is not electrically in contact with the panel on which it is mounted (if this should be made of metal). Sockets such as the unswitched type of Fig. 1 have a metal mounting bush and fixing nut which do make electrical contact with a metal panel if they should be mounted on one.

In wiring diagrams there may be no connections shown going to the earth tags of non-insulated sockets, and this is where connections to these are made via the metal chassis and panels of the project. If insulated sockets are used then it is obviously necessary to add in the earth connections, since they will not be provided via the chassis. The same is also true if a plastic case is used where the project designer has assumed that the case will be a metal type. Sometimes insulated sockets are specified because it is important that connections between the sockets are not provided via the case. Just because a socket or control of some kind has a metal body, do not assume that one of the tags connects to the body. Many switches, potentiometers, and other components have metal bodies which are electrically isolated from any of the tags.

The popular 3·5 millimetre size of jack socket is a common cause of confusion. This occurs because many projects only require two of the three tags that most 3·5 millimetre sockets possess. The extra tag is included as most sockets of this type have a break contact. These sockets were originally used as earphone sockets in small transistor radios, and the break contact was required to automatically switch out the loudspeaker when the earphone was plugged in. This is still a common use for these sockets. The correct method of connection is shown in Fig. 2, but in applications where the break contact is not needed the two output leads are just omitted.

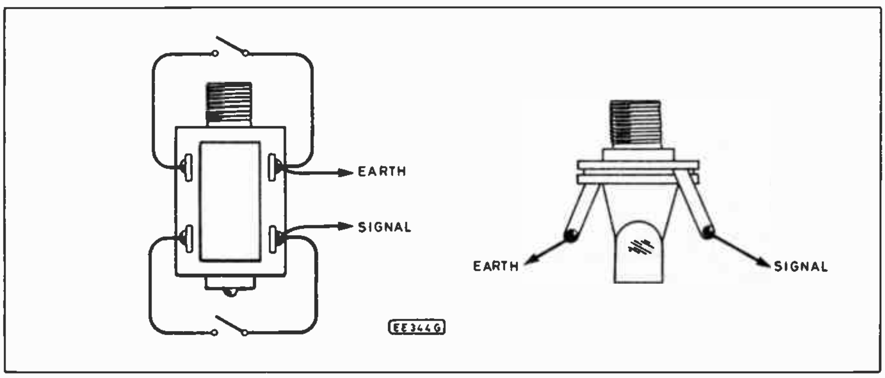


Fig. 1. These jack sockets differ in that one has d.p.s.t. contacts while the other has none. Both are suitable for most applications.

WHICH WAY ROUND

Jack sockets are a good example of components which vary physically and can cause confusion. Apart from the fact that there are three common sizes (2·5, 3·5 and 6·35mm), plus stereo and mono versions of the two larger sizes, there are physical variations on each type, and one component catalogue lists some thirty different jack sockets. Sometimes there may be electrical variations as well as physical differences, such as some sockets having built-in switch contacts while others do not. A socket which has integral switch contacts is electrically suitable for use where no switch contacts are required, and the additional tags are just ignored. Physical differences between components are not always unimportant, and in this case the larger size of a switched socket might make it unsuitable if there is little space to accommodate it.

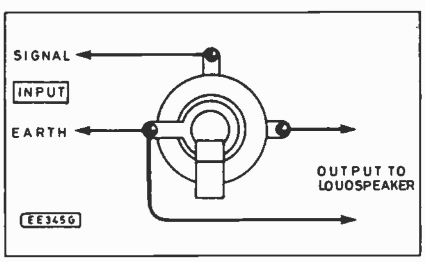


Fig. 2. The 3·5mm jack sockets normally have a break contact which can be used in this fasion. In many applications the switched output is not required, and the third tag is left unused.

EVERY TAG?

It is easy to assume that every tag of a component must connect to something, but this is far from true. Often components offer facilities that are not required for a particular project, leaving one or more of the tags unconnected. A few components (particularly transformers and coils) seem to have tags which are totally unnecessary. This is presumably where a number of similar components are built from the same basic parts, with some components requiring all the tags while others do not.

With some components a careful physical examination will reveal the correct method of connection, but sooner or later you are bound to encounter a socket, switch, or other component where there is no obvious way of telling which connection is which. A continuity tester of some kind is then invaluable as it usually enables any uncertainties to be resolved before you start wielding the soldering iron. For instance, with a rotary switch you can test to see which tags are connected together at each setting of the switch. With a plug and socket they can be fitted together, and connections from one to the other can be traced. By testing for continuity between tags with the plug inserted and removed it is possible to determine exactly how any switch contacts are organised. Any "dummy" tags should also be revealed by a lack of connection to anything else.

If at all possible you should always find the correct method of connection before connecting anything. This may be a little time consuming, but it is probably quicker in the long run. Simply trying all the possible methods of connection in an attempt to find the right one by trial and error should be regarded as a desperation measure. It is something which should never be tried in any part of a circuit where the mains supply is involved, or anywhere in the circuit that is handling high powers (at the output of a hi-fi amplifier for example). Apart from the fact that expensive components would almost certainly be destroyed, it could also be extremely dangerous.

When having difficulty with a component it is often worthwhile checking through some component catalogues. These often give useful information and connection details for transformers, switches, etc., and can sometimes prevent a great deal of time being wasted trying to figure out which tag is which.

POTENTIOMETERS

Potentiometers can cause problems as they can be used in two ways. Usually when used in volume control and similar applications all three tags are employed, and Fig. 3a shows the appropriate method of connection. A common and easy error to make is to accidentally swop over the track connections. This is pretty obvious when the finished project is tested, as the volume control (or whatever) operates in reverse (clockwise rotation giving reduced volume).

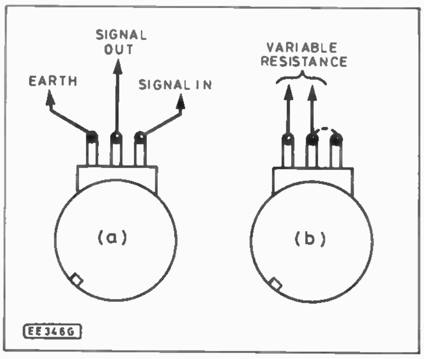


Fig. 3. Using a potentiometer as a volume control (a) and a variable resistance (b).

Potentiometers are often used as what are really variable resistances rather than true potentiometers, and then only two connections are needed, as shown in Fig. 3b. The third tag is often connected (as indicated by the broken line), and this can give better results with less noise during adjustment from a well worn component, but it is essentially the same method of connection. With the method of wiring shown in Fig. 3b the component gives increased resistance when it is adjusted in a clockwise direction, but some applications require the opposite of this. This can be accomplished by swopping the track connections. It will be obvious if you have the track terminals connected the wrong way round as the control will work "backwards".

Robert Penfold

NEW · NEW · NEW · NEW PRODUCTS NEW · NEW · NEW · NEW

ELECTRONIC MAIL KIT

EVERYTHING you need to get started in electronic mail is now available in a complete package, from **Brother**, for £399, plus VAT.

Of special benefit to anyone who needs to write and send copy, quickly, whilst on the move, the new Brother "start up" pack fits in a briefcase and can be used anywhere where there is a telephone. The package comprises a Brother EP-44 portable teleprocessor, an acoustic coupler, connecting leads, a mains unit, subscription for a One-to-One electronic mailbox and an electronic mail guide book.

The EP-44, which is the terminal used to prepare the written material, can also be used as a portable electronic typewriter or computer printer, operating at 16 characters per scecond. With 4Kbytes memory, it can hold and recall up to three full pages of text at any one time. There is also a 15-character display to facilitate simple and accurate inputting and editing of text.

Other features include 44 international characters, basic arithmetic calculation facilities, a letter quality typeface plus a variety of standard electronic typewriter functions. The RS232C interface enables the unit to be linked up as a computer printer.

Completing the package is the One-to-One electronic mailbox, with individual password and identity number, now subscribed to by over 6,000 users in the UK alone.

The Brother "start-up" pack is available from Brother dealers and distributors. For details of nearest stockists contact:

Brother Computer Peripherals Division, Dept EE, Shepley Street, Guide Bridge, Audenshaw, Manchester M34 5JD.

LOGIC PROBE

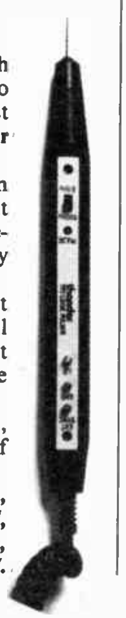
IDEAL for checking out both TTL and CMOS circuits, two useful logic probes have just been released by **Thandar Electronics.**

The TP1 Logic Probe can show up to fourteen different circuit conditions and can detect pulses down to typically 10ns.

The TP2 Logic Pulsar can, it is claimed, inject a signal directly into a circuit without damaging any sensitive components.

The two probes cost £23 each, plus VAT, and for details of local stockists contact:

Thandar Electronics Ltd., Dept EE, London Road, St. Ives, Huntingdon, Cambs, PE17 4HJ.



DIGITAL TRIP

A NEW digital residual current trip tester, complying with IEE wiring regulations, has just been marketed by **Harris Electronics (London).** The TEM1400B is designed to make safe and accurate measurements of the "trip time" of Residual Current Circuit Breakers (RCCB) at various required levels of fault current.

Sporting a 3½ digit l.c.d. display, with bright l.e.d. indication of P–E and P–N, trip times are measured from 0 to 200ms with a 1ms resolution to a ±5ms accuracy. Trip times can be held for up to 40s until the "test" button is released.

Seven measuring ranges of test current give 15, 30, 50, 100, 150, 250 and 300mA outputs and are accurate to ±3 per cent. A slide switch gives the choice of start readings on a negative going cycle or a positive going cycle. Ideal for most RCCB applications, the TEM1400B can be used for 3-pin plug testing, single-phase breaker tests, 3-phase breaker tests and can carry out half rated tests, full rated tests and fast trip tests as laid down by the IEE regulations.

For details of prices and suppliers readers should contact:

Harris Electronics (London) Ltd., Dept EE, 138 Grays Inn Road, London, WC1X 8AX.

CIRCLE CHASER

M. P. HORSEY

With a little ingenuity you can have your name in "lights"

THE PROJECT to be described comprises a self-contained unit, housing 30 l.e.d.s, arranged in a circle. Six l.e.d.s light up together, and these are spaced equally around the circle.

At a rate determined by a preset potentiometer, the illuminated l.e.d.s go out, and the ones next to them light up. Thus the circle appears to revolve, at a speed set by the preset. The unit may be connected to the line output (or speaker output) of a record player, radio, etc., in which case the apparent speed increases with the volume of sound.

The unit includes a mains power supply, or may be used with a battery. Relays may be used to power large bulbs if required.

CIRCUIT DESCRIPTION

The circuit diagram for the Circle Chaser is shown in Fig. 1.

Two CMOS i.c.s are used, to keep current consumption to a minimum. IC1 is a type 4007, and produces pulses, the frequency of which depends upon the voltage at pin 3. Each pulse is delivered to IC2, which is a 4017 decade counter/divider. Thus each pulse from IC1 causes the output from IC2 to increment by one. The display is connected to IC2, via transistors TR2 to TR6.

The input from an audio source, such as an amplifier, radio, tape, etc., is fed to the base of TR1 via d.c. blocking capacitor C1. Preset potentiometer VR1 provides control over the strength of signal received, and resistor R1 provides base bias.

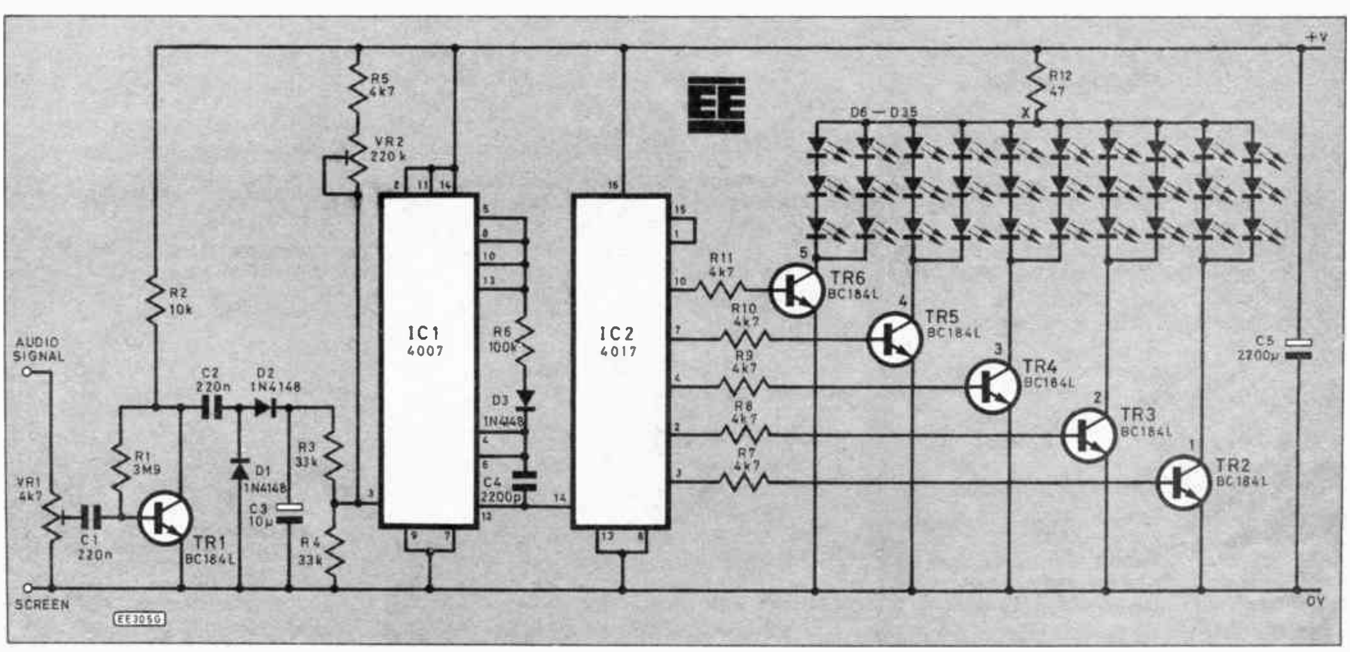
The output from TR1 passes via C2 and diode D2, to charge capacitor C3. The voltage on C3 is reduced by potential divider resistors R3 and R4, and the result is applied to pin 3 of IC1. Preset potentiometer VR2 also controls the voltage at pin 3, and allows the user to select the minimum desired frequency.

IC1, which contains pairs of complementary transistors, oscillates, the rate of which is determined by the value of C4, and the voltage at pin 3. The output from IC1 is connected to the input (pin 14) of IC2. This is a decade counter, and each of its outputs goes "high" in turn, as pulses are received at pin 14.

Thus, at switch on, IC2 output pin 3 is "high", and hence transistor TR2 is turned on. At the first pulse from IC1, the next output from IC2 (pin 2), goes "high", and TR3 turns on, as TR2 turns off. This continues, until the sixth pulse is received at pin 14, when the output from pin 1, is fed to the reset pin 15. IC2 now resets, and pin 3 goes "high" again.

A single resistor R12, controls the current drawn by the display, and is wired in series with each chain of l.e.d.s (D6 to D35). The l.e.d.s are arranged in three's—wired in series and parallel.

Fig. 1. Complete circuit diagram for the Circle Chaser, except the mains power supply.



Each transistor is connected to two of these groups, wired in parallel with each other. Thus with the value of R12 shown, a total of about 40mA is used by the six l.e.d.s lit at any one time.

The only external control on the prototype, is a sub-miniature mains on/off switch. Some constructors may prefer the spindle or control type potentiometers instead of presets VR1 and VR2. This is particularly useful if the unit is to be operated in a variety of situations, or if full manual control of the speed is required.

CONSTRUCTION

The circuit is constructed on a piece of 0·1in. matrix stripboard (14 strips × 60 holes), measuring 18cm by 5·2cm. The component layout and underside of the circuit board showing breaks in the copper strips is shown in Fig. 3.

Begin by drilling the four mounting holes in the stripboard and make the required breaks in the tracks (44 altogether). Next solder the i.c. holders and presets in position.

Solder the wire links, noting that one link is angled (*F*33–*B*35), so that the breaks may be made in a neat straight line. Next solder in the resistors, capacitors, diodes and transistors, noting the polarity of those components which must be fitted the correct way round. **Note that the transistors are BC184L types;** BC184 transistors have different connections.

The audio input should be a screened cable, with the screen connected to track *J*1. The miniature transformer will probably have wires fitted, and these may be soldered

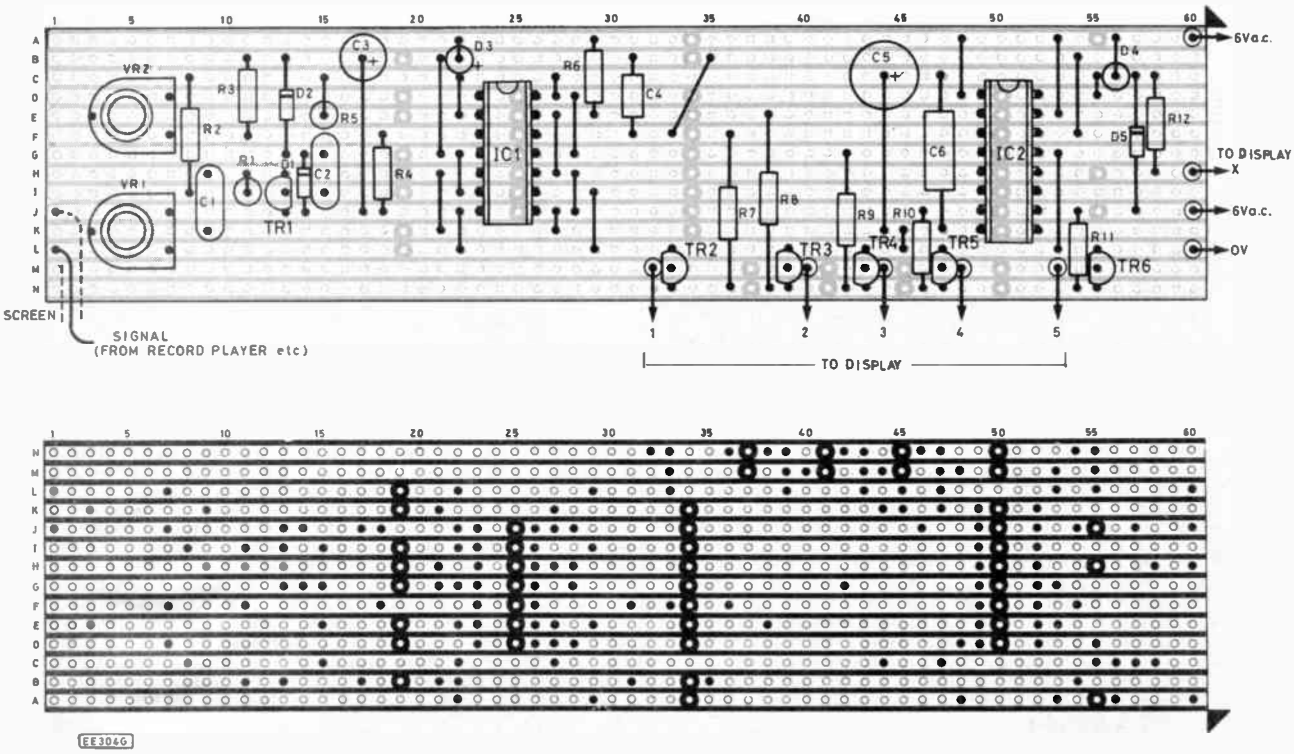


Fig. 3. Component layout, underside showing breaks (44 off) in the copper strips and interwiring details. Use screened cable for the input signal lead.

POWER SUPPLY

The project was originally designed for battery use, and if a battery is to be the only power supply, resistor R12 should be

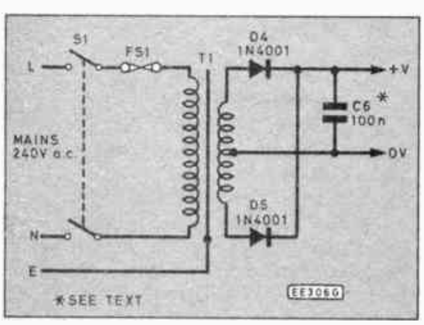


Fig. 2. Suggested mains power supply circuit. Capacitor C5 forms part of the power supply but is shown on the main circuit Fig. 1.

increased to 100 ohms, in order to prolong the battery life. Decoupling capacitor C5 may be reduced to 1000μ if desired, to save a few pence.

A mains transformer was included upon the discovery that it was actually cheaper than a PP9 battery. The transformer used is a miniature 6-0-6V type, supplying 100mA. Diodes D4 and D5 together with capacitors C5 and C6 provide a smooth d.c. supply.

COMPONENTS

Resistors

R1	3M9
R2	10k
R3,R4	33k (2 off)
R5	4k7
R6	100k
R7–R11	4k7 (5 off)
R12	47 (see text)

All ¼W ±5% carbon

See Shop Talk page 208

Potentiometers

VR1	4k7 sub min. preset, horizontal
VR2	220k sub min. preset, horizontal

Capacitors

C1,C2	220n polyester (2 off)
C3	10μ elec. 16V
C4	2200p polystyrene
C5	2200μ elec. 16V
C6*	0·1μ polyester

Semiconductors

IC1	4007 CMOS dual complementary pair + inverter
IC2	4017 CMOS decade counter/divider
TR1–TR6	BC184L *npn* silicon (6 off)
D1,D2,D3	1N4148 (3 off)
D4*,D5*	1N4001 (2 off)
D6–D35	5mm red l.e.d.s (30 off)

Miscellaneous

S1	Mains d.p.s.t. sub min. switch
T1*	240V primary, 6-0-6V sec. (100mA) trans
FS1*	100mA fuse and holder

Case 19cm × 11cm × 9cm, with transparent top; 0·1in. matrix stripboard, 14 strips × 60 holes; 14-pin i.c. holder; 16-pin i.c. holder; screws; screened cable; connecting wires; card; red acetate; grommets; etc.

** These items not required if Circle Chaser is battery powered.*

Approx. cost Guidance only **£14.50**

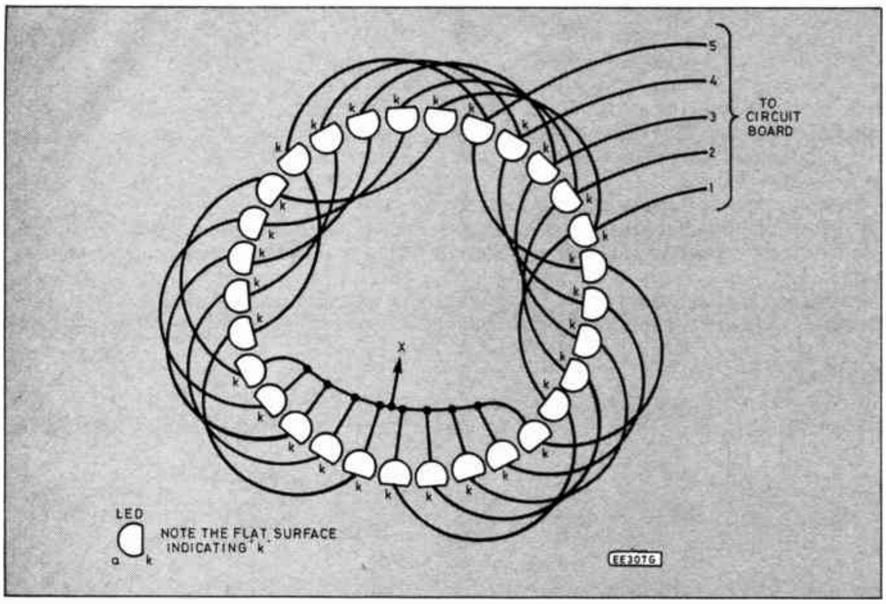


Fig. 4. Wiring to the display l.e.d.s D6 to D35. The polarity of the l.e.d.s can be ascertained by referring to the pinning diagram.

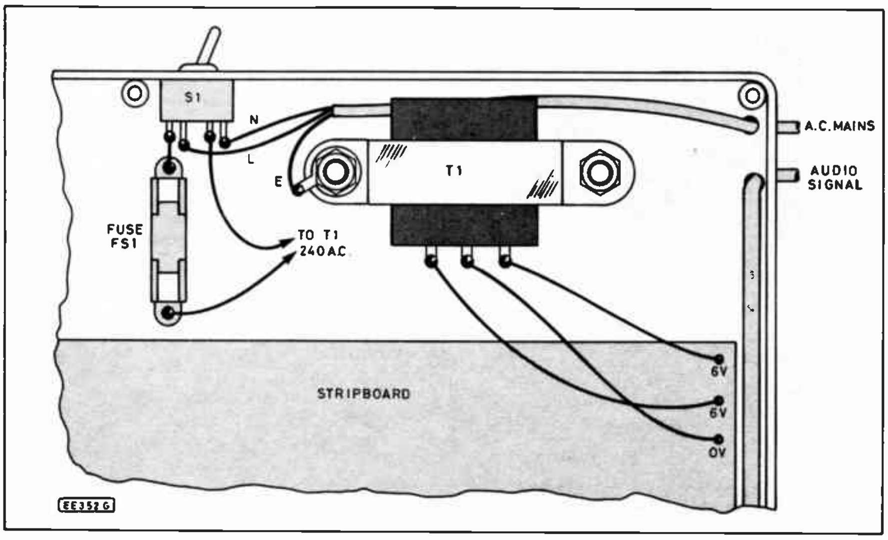


Fig. 5. Wiring details for the mains power supply. The mains lead should be held in position by a plastics P-clamp.

directly to the stripboard, ensuring that the centre (0V) tapping goes to track *L*60.

Of the two transformer output wires left, either may be connected to tracks *A*60 and *J*60 respectively. **Do ensure that proper breaks have been made in the tracks to prevent a.c. reaching the chip.**

A 9 volt battery may still be used if desired, in which case it should be connected to track *C*60 (positive) and *L*60 (negative). The display will be a little brighter than intended, and although not a problem in itself, the battery will have a shortened life. Thus resistor R12 should be increased to 100 ohms if substantial battery use is contemplated.

If a battery is never likely to be used, R12 could be reduced to increase the display brightness. However, a value of less than 39 ohms is not recommended.

The transformer need not be disconnected from the circuit if a battery is used, but **DO NOT CONNECT THE UNIT TO THE MAINS, WHILST THE BATTERY IS CONNECTED.**

DISPLAY WIRING AND CONSTRUCTION

All the outputs from the circuit, are taken at points along track *M*, with the common source from track *H*60. If possible, use a variety of colours, to avoid confusion at the display end.

The display consists of 30 round 5mm l.e.d.s. Whilst a variety of colours may be used, red only was chosen, to allow a red filter to be fitted in front of the display.

The l.e.d.s may be fitted on a piece of board, or thick cardboard, which must be cut for an exact fit in the case.

Begin by drawing a circle of 7cm diameter, on the board. The 30 l.e.d.s should be spaced at 12 degree intervals, and some care is required at this stage, to achieve a pleasing effect.

Small holes must be drilled in the cardboard for the l.e.d. leads. A small circuit board drill is ideal for this purpose. The l.e.d.s may be glued into place, but this is quite difficult, and in the prototype it was found sufficient to secure them by bending their leads.

The wiring to the display l.e.d.s, D6–D35, is shown in Fig. 4. Take great care to connect the leads in the correct way, with special regard to the polarity of D6 to D35. The series/parallel arrangement can be very confusing.

CASE DETAILS

A plastic case measuring 19cm by 11cm by 9cm with a transparent top, was used. The depth of 9cm is larger than necessary, and only about 6cm is really needed. However, cases with transparent tops are not available in a wide variety of sizes.

Begin by drilling the required holes in the case, to mount the stripboard, transformer (if required), fuse holder (if required), and switch. Two additional holes are required for the mains cable, and audio cable. These two holes should be fitted with grommets.

The position of the transformer or battery should be chosen carefully, in order to increase stability when the unit stands vertically. If potentiometers are used instead of presets, additional holes will be required. Do not mount them too close to the mains section of the unit.

MOUNTING THE DISPLAY

The lower half of the transparent top, together with its sides, were covered with plain blue card on the inside. Any similar material is suitable, according to taste. The card should be cut exactly to size, in order to ensure a good fit, as parts which show from the front, cannot be glued. Small pieces of double sided sticky tape, or glue may be used to secure the card mounted at the sides, where it crosses the supports.

A sheet of red acetate material may be cut exactly to size, and placed inside the transparent top. It need not be glued, as the display will hold it in position.

Finally, the circle of l.e.d.s may be eased into position, and secured with small pieces of sticky tape.

TESTING

The Circle Chaser may be tested without an audio signal, in the first instance. Set preset VR2 fully clockwise (slowest speed). Switch on, **taking care not to touch the "live" parts.** Alternatively, use a battery for testing.

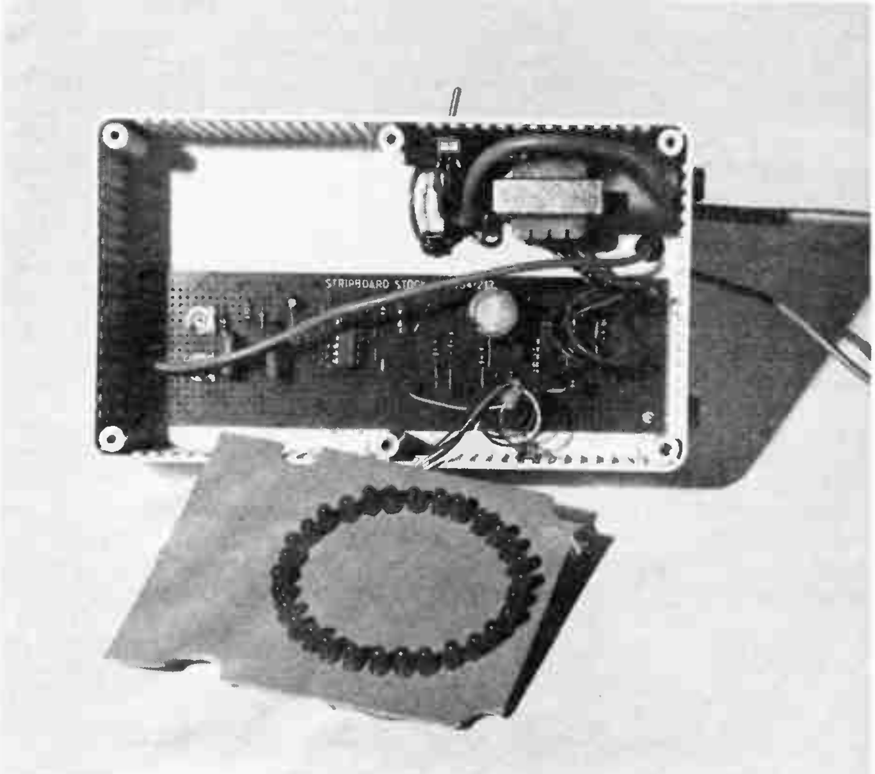
The display should light at six points, which appear to revolve slowly. Move VR2 anti-clockwise. The speed of the display should increase, to a point where all the l.e.d.s appear to be on. Set VR2 to a point about midway along its track.

Connect an audio signal to the screened lead, either from a speaker output, or line output. Adjust preset VR1 fully anti-clockwise (full gain). The speed of the display should increase with the volume of the sound. High frequencies have more effect than low frequencies, and very rapid changes of volume will have less effect than slower changes. Classical music works particularly well.

Preset VR1 may be reduced in gain if required, in order to achieve the correct effect. Preset VR2 may then be adjusted to achieve the desired speed for the quietest sounds.

FINAL ASSEMBLY

When the adjustments are finalised, switch off, and secure the lid of the unit,



The completed Circle Chaser with the display card removed.

checking that no display wires accidently touch metal parts inside the case. Note that the lid must be placed so that the display is away from the transformer, i.e. the transformer must be in the lower section, when the unit stands upright. Ensure that the display cannot make contact with the live mains parts inside the case.

FAULT FINDING

If the display fails to light, the most common mistake is incorrect polarity on one or more l.e.d.s. Connect a voltmeter between point *X*, and display line 1. Set VR2 fully clockwise (slow), and switch on. The voltmeter should indicate a reading of 4V or more, for a short time. This reading should then pulse, as display line 1 switches on.

If this test does not work, the fault lies elsewhere. The obvious checks to make include voltage checks across pins 7 and 14 of IC1, and across pins 8 and 16 of IC2. The readings should be between 7V and 9V.

The circuit divides into two sections, with an angled wired link joining pin 12 of IC1, to pin 14 of IC2. The voltage on this link should appear to be 7V to 9V.

A check with an oscilloscope at this point should reveal very short negative pulses, at a rate determined by the voltage at pin 3 (about 2V with VR2 midway) of IC1. The presence or absence of these pulses will reveal which half of the circuit is at fault.

ADDITIONS

The Circle Chaser can form the heart of any chaser system, and the outputs from transistors TR2 to TR6 can be used to drive power transistors which in turn can drive larger bulbs. Alternatively, relays may be driven directly from transistors TR2 to TR6, in which case protection diodes must be connected across the relay coils to prevent high voltage spikes (e.m.f.) damaging the transistors. □

a regular feature for the Spectrum Owner...

by Mike Tooley BA

LAST month we provided some guidance for programming the "Programmable I/O Interface" described in February's *On Spec* page. This month we take our first look at the computer language known as FORTH. We also feature a Stepper Motor Interface for the Spectrum

FORTH

FORTH stands for "Forth Generation Language" and it was invented by Charles Moore as a means of controlling an astronomical telescope at the Kitt Peak Observatory. It is fair to say that no other high level language is as comfortable and versatile in real-time control applications as FORTH. The breadth and scope of its applications are enormous and anyone wishing to use a microcomputer in a control situation would be well advised to use FORTH rather than either BASIC or assembly language.

Fortunately, the Spectrum is well catered for as several excellent implementations of the language are available. Abersoft's FORTH, in particular, conforms with the "FIG" (Forth Interest Group) standard and yet contains a number of additional Spectrum goodies!

Having loaded FORTH from cassette or microdrive (FORTH requires an interpreter), the user is greeted with FORTH's somewhat cryptic "ok" prompt. Regular FORTH users have to come to terms with this—it merely indicates that FORTH has understood your last command and is awaiting further input.

One other peculiarity of FORTH is that it employs "Reverse Polish Notation" (remember the first generation of pocket calculators?) when performing arithmetic. This means that, for example, instead of writing 2 + 3 we will need to enter 2 3 + .

The Stack

The most crucial structure in FORTH programming is the "stack". Whenever a numerical input is received from the keyboard (as opposed to a FORTH "word" such as +, –, *, /, and .), FORTH places it in a temporary storage location which forms part of the stack. When further numerical values are input, they too are placed in the stack. Numbers are, in effect, "pushed" onto the stack, operations are carried out on the contents of the stack, and then values are "pulled" or "popped" off the stack. The last input value occupies the top of the stack *(we shall refer to this as "TOS")*, the previous value occupies the second place on the stack *(hereafter referred to as "2OS")*, and so on. It should now be apparent that the stack operates on a last-in first-out *(LIFO)* basis.

When executed, the FORTH word . ("dot") removes TOS and sends it to the display. The remainder of the stack (i.e. that which exists from 2OS downwards) moves up one place such that 2OS becomes TOS, 3OS becomes 2OS, and so on.

Now suppose that we wish to determine the average of three numbers; 2, 4, and 6. The following keyboard entry could be used:

2 4 6 + + 3 / .(ENTER)

FORTH's integer arithmetic operators have the following actions:

+ adds TOS to 2OS and places the result in TOS.

– subtracts TOS from 2OS and places the result in TOS.

* multiplies TOS and 2OS and places the result in TOS.

/ Divides 2OS by TOS and places the result in TOS.

After all four of these operations, TOS and 2OS are destroyed and the remainder of the stack (i.e. that which exists from 3OS downwards) moves up one place. Hence 3OS becomes 2OS, 4OS becomes 3OS, and so on.

FORTH Words

In FORTH, a word is a string of characters which may include punctuation but which should not contain blank characters (i.e. spaces). We have already made use of simple FORTH words like+, /, and ..

Unfortunately not all FORTH words have such obvious actions. Words like DO, FORGET, and REPEAT will provide us with some pretty good clues to their action whereas ., .S, !, C!, @, and C@ (which all qualify as FORTH words) may be somewhat obscure.

Words can be either typed in at the keyboard for immediate execution or can form part of a definition of another word. In the latter case it is, of course, essential that the word contained within the definition has already been defined. Most FORTHs provide between 150 and 200 ready defined words contained in what is appropriately known as the "resident FORTH dictionary".

A powerful property of FORTH (and one which makes it a most attractive language for many applications) is the ability to extend the dictionary. This is done whenever the programmer defines a new word. This must, as we mentioned earlier, be in terms of existing words since otherwise the new word cannot be compiled into the dictionary.

The FORTH word VLIST can be used to display the entire dictionary contents. When typed at the keyboard, VLIST displays the resident dictionary (together with those words relating to any current application) starting with the most recently defined word.

Colon Definitions

To add a word to the resident FORTH dictionary, it is merely necessary to define the word in terms which are acceptable to the FORTH compiler. A definition is valid if it uses existing FORTH words and is entered in the correct form.

When the more recently defined word is executed, the words contained in its definition are also executed. If the words contained in the definition have not been previously defined the new word will make no sense to the compiler and hence an error message is generated.

The rules for making a colon definition of a new FORTH word are as follows:

(a) Start the definition with a colon. This tells the FORTH compiler that the next character string is the name of a new word. The colon *must* be followed by a space which acts as a delimiter.

(b) The new word name should then follow. The name can consist of a string of alphanumeric characters (including punctuation) but should not contain any blank characters (which would otherwise be taken as delimiters). As far as possible the word name should be meaningful.

(c) Follow the word name with a space and then enter the definition of the word. This may consist of numbers (which will be placed in the stack), text strings (which will be sent to the output device) and, of course, previously defined FORTH words.

(d) Close the definition with a semi-colon preceded, of course, by a space. This tells the compiler that the definition is complete.

Here is a simple colon definition of a word which simply divides the value at the top of the stack by 100, multiplies it by 15, and then prints the result. For obvious reasons we shall call the word "VAT":

: VAT 100 / 15 * . ;

Now, supposing that we wished to find the VAT payable on an item costing say, £4500 we would simply key:

4500 VAT

The value 675 should then appear on the screen. This is obviously a rather trivial example but should at least serve to illustrate some of the features of FORTH.

Your comments and suggestions should be sent, as usual, to:
Mike Tooley,
Department of Technology,
Brooklands Technical College,
Heath Road, WEYBRIDGE,
Surrey KT13 8TT
P.S. Don't forget to include a large (A4 size) stamped addressed envelope if you would like to receive a copy of our "Update"!

STEPPER MOTOR DRIVER

This month's constructional project features a Stepper Motor Driver for use with the Programmable I/O Interface described in the February 1986 issue. The interface can also be used with the simple Four-Channel Output Interface described in June 1985.

The complete circuit of the Stepper Motor Driver is shown in Fig. 1. The circuit is based on a purpose designed driver i.c. (SAA1027) and uses only a handful of other components.

The stepper motor should be a 12V 4-phase (47ohm/400mH per phase) two stator type providing 7·5 degrees rotation per step. Such motors are readily available at reasonable cost from a number of suppliers and are capable of producing a maximum working torque in excess of 50mNm.

Due to the relatively large power consumption of the stepper motor, a separate power supply of 12V ±5% at 500mA (max) will be required. **Under no circumstances should the stepper motor power be derived from the Spectrum's own power unit!**

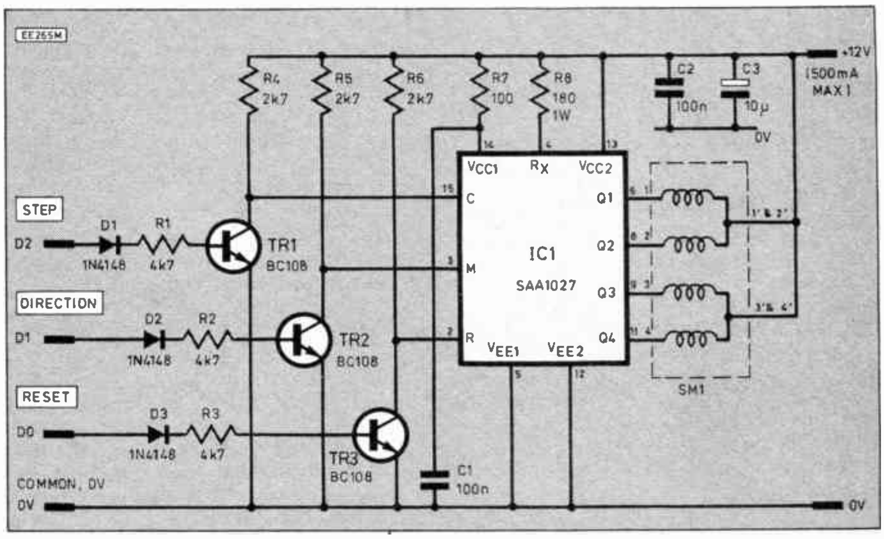


Fig. 1. Complete circuit diagram for the Stepper Motor Driver.

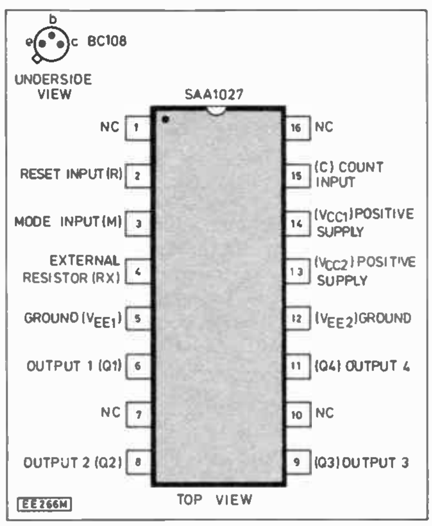


Fig. 2. Pinning details for the BC108 and SAA1027.

Construction

The stepper motor driver may be assembled on a piece of Veroboard measuring approximately 100mm × 80mm. The precise dimensions of the board are uncritical and those quoted leave plenty of room for the necessary input, output, and power connectors. The use of a low-profile 16-way d.i.l. socket is recommended.

Component layout is uncritical though care should be taken to ensure that the decoupling capacitors, C1 to C3, are distributed around the p.c.b. Links can be made, as necessary, between the components using short lengths of tinned copper wire on the upper surface of the matrix board.

Readers should give some careful consideration to the choice of connectors used. The input connector should be a four-way type whilst the output should have at least five, and preferably six, ways. This latter connector should be rated at currents of at least 1A.

Connections to the stepper motor are depicted in Fig. 3. The power connector should be a polarised two-way type and this again should be rated for currents of up to 1A. If desired, this latter connection can be replaced with suitably coloured flying leads.

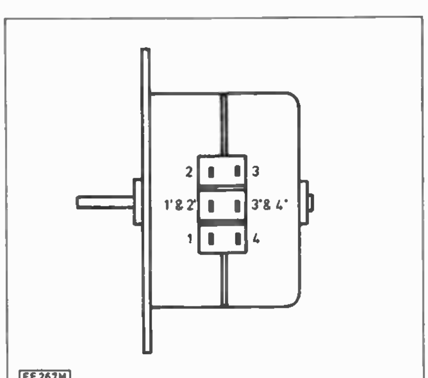


Fig. 3. Stepper motor connection details.

NEXT MONTH: Some routines for driving the Stepper Motor Interface will be described and we shall be taking a further look at FORTH.

COMPONENTS

Resistors

R1 to R3	4k7 (3 off)
R4 to R6	2k7 (3 off)
R7	100
R8	180 1W

Unless otherwise stated all resistors are 0·25W 5% carbon

See Shop Talk page 208

Capacitors

C1 and C2	100n polyester
C3	10µ elec. 16V p.c.

Semiconductors

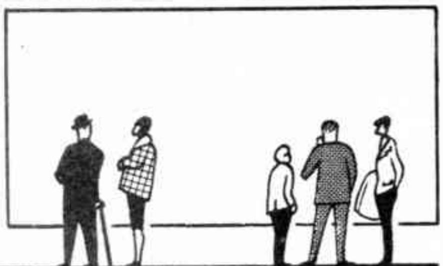
D1 to D3	1N4148 (3 off)
TR1 to TR3	BC108 (3 off)
IC1	SAA1027

Miscellaneous

Stepper motor SM1 (see text), 16-pin d.i.l. socket, connectors (see text), 0·1in. matrix Veroboard (or similar) measuring approximately 100mm × 80mm.

Approx. cost Guidance only **£16**

SHOP TALK



BY DAVID BARRINGTON

CATALOGUES RECEIVED

This month we have received two first class catalogues form **Marco Trading** and **Cirkit.**

Containing over 130 pages, with most containing illustrations, the Marco 1986 Catalogue list is very impressive and carries items ranging from a musical buzzer to high speed pen recorders and test equipment to telecom equipment, including the latest press-button phones.

Also there are 30 pages devoted to popular, and not so popular, i.c.s, semiconductor and opto devices. I like the idea of the inclusion of two pages devoted to Sony equipment spares, as finding a source of replacement parts for Japanese equipment can be very difficult in the UK.

Our copy of the catalogue was accompanied by a 15-page inset of "bargain buys". Items listed included dynamic mics, component packs, portable gas soldering iron and a range of low voltage miniature d.c. motors.

The catalogue costs £1, but includes a 50p credit note. They claim that orders received by 4 p.m.—post, phone or telex—will be despatched same day (subject to availability). Copies of the Marco 1986 catalogue may be obtained from: **Marco Trading, Dept EE, The Maltings, High Street, Wem, Shropshire SY4 5EN.**

Every year when the new edition of the **Cirkit** Components Catalogue is released, they usually augment the event with an announcement of a new "exclusive" franchise or component range. This year they have gone one better and announced a new "first" and a special educational phone-in desk.

Coinciding with the latest Spring '86 edition, they have just launched, what they claim, is the first 6m transverter kit to be offered by a UK company. The kit, designed by G3 WPO, is just one of the many new items listed in the 144-page catalogue which should now be arriving on the bookstalls. The catalogue can also be purchased at the cover price of £1.15 direct from Cirkit at their Broxbourne headquarters. The catalogue contains redeemable £1 vouchers for use with each single order of £15 and over, excluding VAT.

For the first time the new issue features a special section containing pinouts for linear i.c.s plus an enlarged section on computer communication peripherals for the Amstrad, including modems, text dumps, RS232 interface, parallel/centronics interface and ROM card. Additions to the kit range are low power h.f. amps and h.f. pre amps, plus a car windscreen wiper delay.

By contacting the Cirkit "hot line" on 0992 445736, educational Science and Technology departments can receive a complimentary copy of the catalogue and regular updates.

Service with a smile from Sonia, Marco's Internal sales rep.

CONSTRUCTIONAL PROJECTS

Stereo Reverb

The dimensions of the case for the *Stereo Reverb* will be determined by the size of springline module used. The one in our prototype was obtained from **Maplin** and is their "short" version. This should be ordered as: XL08J (Short Spring Line).

If the reverb is to receive fairly rough treatment, it may be a good idea to mount the springline on "rubber couplers". These are also available from Maplin (code FB98G) and are claimed to reduce transmission of acoustic shocks and vibrations to the springs.

Freeloader

The case used in the *Freeloader* project is entirely optional and, in view of the tight density of components, readers may prefer to use a larger case.

If constructors do follow the circuit board layout and use a case of the type listed, the choice of relay may cause problems. Also, if the "universal" modification is built the extra relay and battery will not fit in the case.

The relay used in the author's model was a low-profile, sub-miniature printed circuit mounting type. The relay used must be able to operate down to 5V.

The sub-miniature relay is listed by **Electrovalue.** An alternative would be one of the microminiature range from **Rapid Electronics.** These have two sets of contacts and only one set need be used.

FET Voltmeter—Teach In '86 Project

Components for the *FET Voltmeter*, this month's Teach In '86 Project 7, seem to be readily available and no purchasing problems should be encountered.

Kits for the Teach In '86 Project Series have been specially prepared by some of our advertisers. Readers should browse through the advertisements in this issue to locate a stockist nearest to their town.

Versatile Power Supply

When ordering components for the *Versatile Power Supply* it is important to quote the ***L*** when specifying the transistor type BC184L. The BC184 has a different pinning arrangement and will cause confusion when mounting on the stripboard.

Stepper Motor Driver

Readers contemplating building this month's suggested *On Spec* project may encounter a couple of component purchasing problems.

We can only find the 16-pin stepper motor i.c. type SAA1027 listed in the Maplin catalogue at £3.75.

Suitable stepper motors for the *Stepper Motor Driver* should be available from Greenweld, or Maplin Electronics Supplies. Maplin can supply a stepper motor kit consisting of motor and motor driver i.c. (SAA1027) for the sum of £12.95: code LK76H (Stppr Mtr + Drvr Kit).

Circle Chaser

We do not expect any component buying problems when ordering parts for the *Circle Chaser.*

The mains transformer used in the prototype was one of the miniature types rated at 100mA. These have a C-clamp type construction with flying leads and are listed by **Rapid, Dziubas, TK Electronics** and **Marco Trading.**

VERSATILE PSU

M.P. HORSEY

Cheap constant current for charging cells and boosting batteries—a useful PSU to boot

THE RATHER high cost of a power unit is due mainly to the transformer and the need for mains safety in the form of fuses, switches, neon indicator, and a substantial case. It is helpful, therefore, to make any power unit as versatile as possible. The unit to be described provides: a regulated variable voltage output from 1·2V to 15V and a constant current output, suitable for charging a wide range of nickel-cadmium cells.

CONTROL

The voltage is controlled with a variable resistor linked with an integrated circuit, and regulation is sufficiently accurate to allow a scale to be marked, without the need for a built-in voltmeter.

The constant current required is set via a rotary switch. The settings are as follows:

Setting 1. Regulated voltage output.

Setting 2. Constant current 8mA (for charging PP3 batteries & AAA cells).

Setting 3. Constant current 45mA (for charging AA cells).

Setting 4. Constant current 80mA (for charging PP9 batteries).

Setting 5. Constant current 150mA (for charging C cells).

Setting 6. Constant current 320mA (for charging D cells).

AUTOMATIC VOLTAGE REGULATION

Regulator circuits can be designed which automatically compensate for a changing current, and thus provide a true regulated voltage. Such circuits can now be obtained in the form of miniature integrated circuits, such as the chip which forms the heart of this project, the LM317T.

This i.c. provides a possible regulated voltage range from 1·2V to 37V, at up to 1·2A. It is fully protected from short circuits, and includes thermal shutdown—which automatically reduces the current if the i.c. becomes too hot. The basic regulated voltage circuit is shown in Fig. 1.

AUTOMATIC CURRENT REGULATION

The same i.c. may also be wired to produce a constant current which is determined by a single resistor. The following formula may be used to calculate the size of the resistor required:

$$\text{Output current} = \frac{1{\cdot}25}{R}$$

(where R is the value of the resistor)

Thus, if a current of 45mA is required, the resistor needed will have a value of 27Ω as shown in Fig. 2.

The figures quoted for voltage and current regulation assume ideal conditions but actual values will depend on the type of heat sink used, and the voltage drop across the i.c.

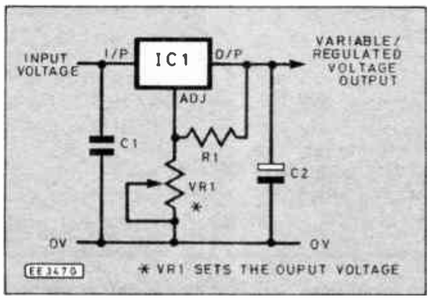


Fig. 1. Basic regulated voltage circuit.

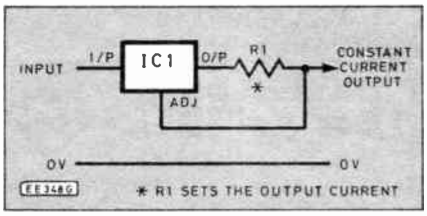


Fig. 2. Constant current regulation is determined by resistor R1.

CIRCUIT DESCRIPTION

In this project a conventional transformer circuit is employed, with transformer T1 stepping down the mains 240V a.c. to 12V a.c. Four silicon diodes (contained in a bridge rectifier), are used to rectify the a.c. into d.c., and capacitors C1 and C2 provide smoothing of the supply. The positive supply is fed into the i.c., the output of which is fed via switch S2, either into one of the current control resistors, or to the regulated voltage output. This allows VR1 to control the voltage when S2 is in position 1.

Voltage regulation is sufficiently accurate to allow calibration of VR1, which removes the need for a built-in voltmeter. However, without a voltmeter, there is no indication if a short circuit is connected across the output. An l.e.d. indicator is therefore included, with components R3, R4, TR1 and R1.

Under normal conditions, enough current will flow into the base of transistor TR1 to turn it on, and hence the l.e.d. will light, as current flows through limiting resistor R1 to ground via the transistor. If a short circuit occurs the voltage at the junction between R3 and R4 will fall, causing the l.e.d. to switch off.

Such a short circuit will not harm the i.c., or any other part of the power unit. However, it is essential to know of this condition, in case damage is caused to whatever is connected to the power unit. Note that the l.e.d. does not function when the unit is set to constant current, since a virtual short circuit is normal in this application.

If switch S2 is set to position 2, the adjust pin is connected directly to the constant current output. The i.c. output is also connected to the constant current output, but via resistor R5. Thus a circuit similar to that shown in Fig. 2 is created, the 150Ω

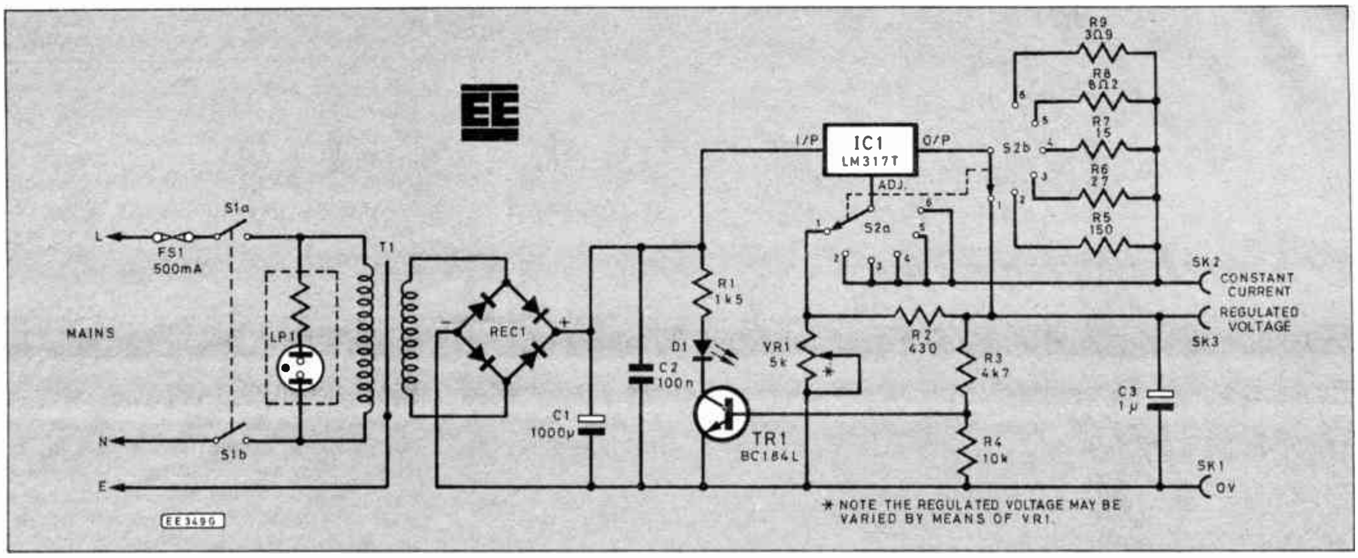


Fig. 3. Complete circuit diagram for the Versatile Power Supply Unit.

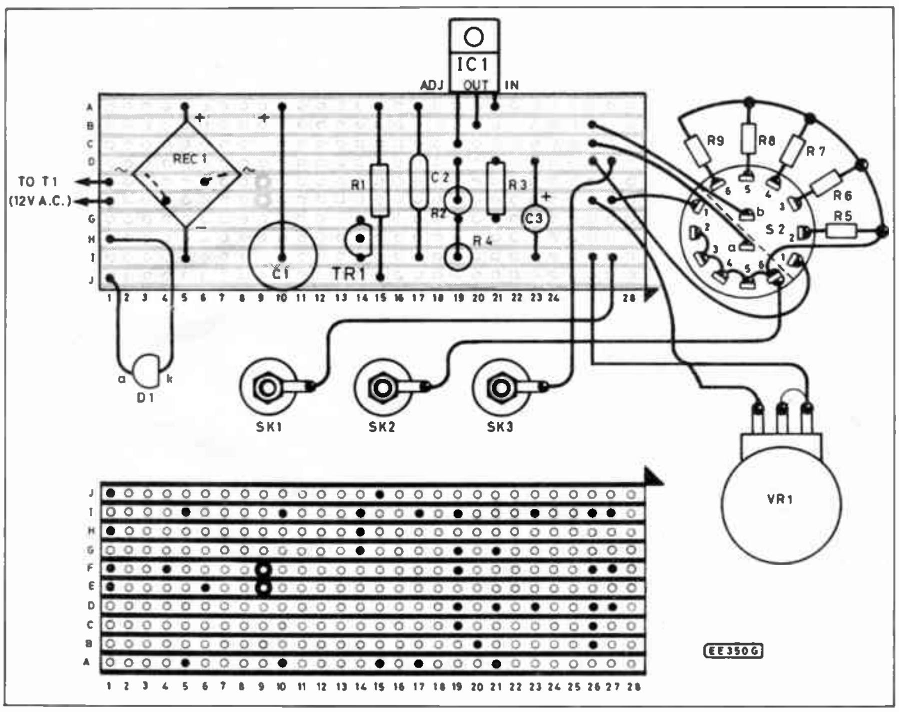


Fig. 4. Component layout, details of breaks in copper strips (2 off) and interwiring to the front panel mounted components. The wires from S2 to the stripboard should be kept as short as possible and reasonably thick.

value of R5 fixing the output current to 8·3 mA.

The other positions of switch S2 work in a similar manner thus providing a variety of output current options.

CONSTRUCTION

The majority of components are housed on a piece of stripboard measuring 70mm by 40mm. This is large enough to allow four holes to be drilled for mounting purposes.

Begin by marking out the stripboard, shown in Fig. 4, including the positions of the breaks. Strictly speaking, only one break is necessary on track F. It was considered prudent, however, to isolate the a.c. supply as much as possible; hence the other break. If the stripboard is to be mounted with metal screws, make additional breaks to isolate them from the circuit.

Assemble the components, starting with the smallest. Note carefully the polarity of the bridge rectifier, and place transistor TR1 the correct way round, noting it is a BC184L (not a BC184, which has different connections). Note also the polarity of the electrolytic capacitors.

The regulator i.c. (IC1) is positioned in order to allow a heatsink to be fitted. The heatsink may be made from aluminium, copper or steel. The prototype used a strip of aluminium measuring 19 cm by 5cm, and shaped in order to avoid other components. Alternatively, IC1 may be bolted to the case of the power unit, if made of metal. Note, however, that the metal tag on the i.c. is connected internally to the output pin. It is essential to electrically isolate the tag, if it is bolted to the power unit case.

The l.e.d. is connected via flexible wires. Be sure to use wires capable of carrying up to 2A for the a.c. input. The wires linking the rotary switch with the stripboard must have the lowest possible resistance, if good load regulation is to be achieved. Therefore, keep the wires as short as possible, and reasonably thick.

COMPONENTS

See Shop Talk page 208

Resistors

R1	1k5
R2	430
R3	4k7k
R4	10k
R5	150
R6	27
R7	15
R8	8·2 (0·5 watt)
R9	3·9 (0·5 watt)

All resistors 5% ¼W unless stated otherwise

Potentiometers

VR1	5k linear

Capacitors

C1	1000µ 25V electrolytic
C2	100n polyester
C3	1µ 50V electrolytic

Semiconductors

REC1	bridge rectifier 2A 50V (or more)
TR1	BC184L *npn* silicon
IC1	LM317T variable regulator i.c.
D1	0·2" l.e.d.

Miscellaneous

LP1 mains neon with integral resistor; T1 mains transformer (20VA) with 12V, 1·6A output; S1 toggle switch d.p.s.t.; S2 rotary switch 2 pole, 6 way; FS1 fuse holder and 500mA fuse; push-on knobs (2 off); terminals (2 red, 1 black); case (see text); heatsink (see text); 13A plug; stripboard (0·1 inch) 70mm × 40mm; mains cable; screws, etc.

Approx. cost Guidance only **£14**

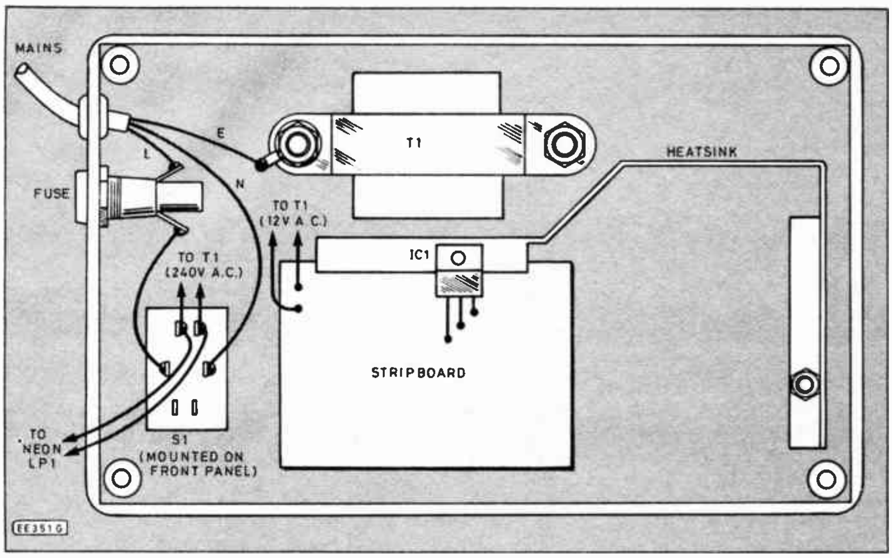


Fig. 5. Layout of components inside the case and wiring to the power supply section.

Resistors R5 and R9 are soldered to the rotary switch contacts. A piece of flexible wire is used to join their opposite ends together with the other tags of the switch as shown. The constant current output is also taken from this connection. Finally, link variable resistor VR1 with the stripboard, and solder in the regulated voltage output, and zero output wires. Carefully check the stripboard for bridged tracks, dry joints, etc. Check also that the a.c. supply is fully isolated from the d.c. side of the circuit.

It may be easier to test the circuit before the stripboard is mounted in the case. (See "Testing").

Almost any sturdy case may be used. Ensure that there is sufficient space for the transformer, and allow enough clearance for the potentiometer, switches, etc. The prototype unit was housed in a case with sloping front.

If ventilation holes are not provided, begin by drilling some, especially near the heatsink. However, ensure that small children are not able to make contact with mains connections inside. Any metal parts of the case must be properly earthed (i.e. connected to the mains earth), as must the transformer.

HEAT SINK

A fairly substantial heat sink is required, especially if the unit is expected to supply 1A at low voltages. At lower currents, or higher voltages, less heat is produced. The strip of aluminium (described earlier), must be shaped and positioned to avoid touching other components or wires. One end is fixed to the i.c., and the other end bolted to the plastic case. A small piece of stripboard may be fixed between the aluminium and plastic, to prevent heat damage.

A smaller heatsink may be used, but the output current may be automatically reduced to below 1A (especially at low output voltages), as the i.c. becomes hot. If a metal case is used, the i.c. may be bolted to it, ensuring that it is electrically isolated with a suitable washer.

When the internal arrangement is finalised, drill the necessary holes, and secure the components. Take special care with the mains connections, ensuring that they cannot make contact with the low voltage connections. Fit a 1A or 3A fuse in the mains plug, and a 500mA fuse in the power unit. The power unit should give many years of service, and will almost certainly earn its keep, many times over.

TESTING

The circuit may be tested at this stage, if a suitable a.c. or d.c. supply is available (a 9V battery will suffice). Alternatively testing may be carried out when the transformer and associated circuitry is installed and working.

Connect the a.c. (on the stripboard) to the supply (either way round, whether an a.c. or d.c. supply is used). Set the rotary switch S2 to position 1 (fully counter-clockwise—if wired correctly).

The l.e.d. should light. If it does not, use a voltmeter to find out if there is a voltage across it. If a reading of several volts is obtained, the l.e.d. is probably connected the wrong way round.

Use the voltmeter to test the regulated output voltage. It should be possible to vary this voltage, using VR1, from 1·2V to a little less than the input voltage. If no reading is obtained, connect the voltmeter across tracks A and I, and establish that the rectifier is working properly. Check the voltage on the output (centre) pin of IC1. If this is satisfactory, there may be a wiring fault at switch S2. Note that for a regulated voltage output, the rotary switch should connect track B to track D, and track C to track F.

FINAL CHECKS

WARNING: These checks will quickly run down a battery, if in use as a temporary power supply.

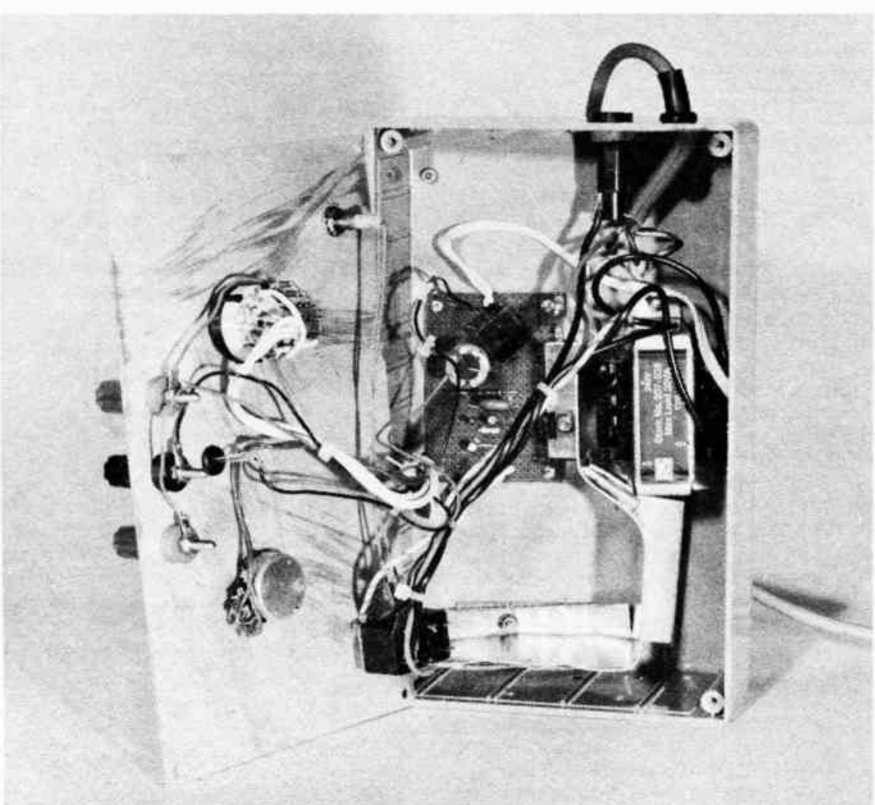
If all is well, short circuit the regulated voltage output. The l.e.d. should go out. The short circuit current should range from 2A to 3A, quickly falling to about 1A. This may be tested if an ammeter with a f.s.d. of about 5A is available.

Finally, connect an ammeter set to 1A f.s.d. to the constant current output. Turn the rotary switch to position 2. The l.e.d. should turn off, and the ammeter should show a small reading, which when set to a smaller scale, indicates about 8mA. Check that the other positions of S2 produce the correct current readings.

CALIBRATION

Calibration of VR1 must be accomplished with the aid of a voltmeter. The scale must be marked by hand, at 1V or 5V intervals. Switch S2 may be marked with the current options outlined earlier, not forgetting that setting 1 is reserved for regulated voltage operation. □

The completed Versatile Power Supply Unit showing shaping of the heatsink for IC1. This heatsink must NOT touch any of the other components or wires. The mains input cable should be fixed by a strain relief clamp.



DOWN TO EARTH

BY GEORGE HYLTON

CREATING trick audio effects is a well-known use for the ring modulator. In communications, however, it has other uses and a long history.

TRADITIONAL RING MODULATORS

In its traditional form (Fig. 1), a ring modulator comprises two transformers with centre-tapped windings and four diodes. Its function is to generate amplitude-modulation sidebands.

Although it isn't very obvious from Fig. 1 that the diodes are connected in a ring, nose to tail, they are (compare Figs. 1 and 2) and this is the origin of its name.

Long ago, before silicon and germanium diodes were invented, the ring modulator used copper-oxide diodes and was sometimes referred to as a copper-oxide modulator.

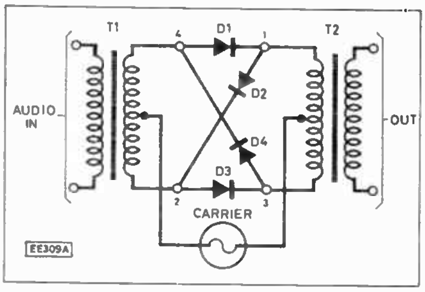


Fig. 1. Traditional ring modulator.

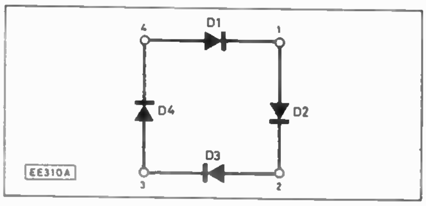


Fig. 2. The "ring" arrangement of the diodes in Fig. 1.

SWITCHING

The diodes are used as switches. They are switched on and off by the carrier, that is by a steady oscillation which normally runs at a much higher frequency than the audio signal.

The carrier is much stronger than the audio: this means that the state of any diode at a particular moment is governed by the carrier, not the audio. The carrier either makes the diode conduct strongly or reverse biases it so that it doesn't conduct at all.

All the audio can do is to flow through whichever diodes are conducting, adding a little more or a little less to the current created by the carrier, but not changing the state of a diode. The job done by the carrier is in effect to steer the audio through whatever diodes are required at any instant.

The diodes conduct in pairs. One half-cycle (Fig. 3) of the carrier makes D1 and D3 conduct while reverse-biasing D2 and D4. On the next half-cycle (Fig. 4) D2 and D4 conduct while D1 and D3 are off. The single arrows indicate the direction of the carrier current.

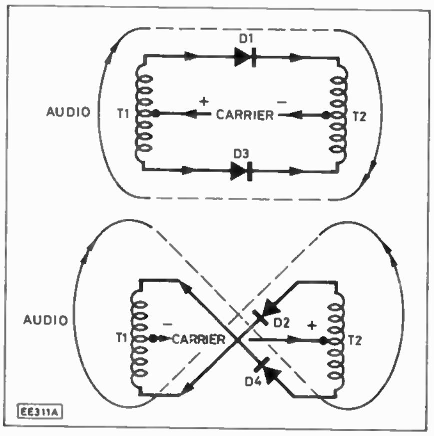


Fig. 3 (top). The diodes conduct in pairs. One half cycle of the carrier makes D1 and D3 conduct. On the other half cycle (Fig. 4 above) D2 and D4 conduct.

A conducting diode behaves like a low resistance. Audio signals (double arrows) at the secondary of transformer T1 flow through the diodes and the primary of T2. Because the audio is feeble compared with the carrier, audio currents can in effect flow in any direction through the low resistance of a conducting diode, mixed up with the much stronger carrier current.

If an audio half-cycle drives currents as shown then on one carrier half cycle (Fig. 3) the audio current goes downward through T2 (double arrow) and on the next, upward. Thus the direction of the audio current is reversed every time the carrier's polarity reverses.

The audio, as shown in Fig. 4, is steered first one way then the other at a rate governed by the carrier. This converts the audio to a high frequency whose amplitude is governed by the audio wave, but whose frequency is governed by the carrier.

SIDEBANDS

This converted "audio" wave in fact contains no audio, only high frequencies. It contains no carrier, either. Equal and opposite carrier currents flow through the two halves of T2's primary. The result is that they create equal and opposite magnetic fields which cancel, producing no carrier voltage in T2's secondary.

Because neither audio nor carrier appears at the output a ring modulator is said to be double-balanced. That is, both carrier and audio are "balanced out". This leaves only the sideband frequencies, plus harmonics. If the carrier is at 100kHz and the audio 2kHz then the output contains 98kHz (lower sideband) and 102kHz (upper sideband) and some harmonics of no practical importance.

APPLICATIONS

Ring modulators were first widely used in carrier telephone systems. In these, a number of different telephone channels were created and sent over the same line, on different frequencies. One sideband of each channel was filtered out. This halved the bandwidth, enabling more channels to be carried by the same line.

Nowadays, ring modulators are also used in high-performance radio receivers, where they act as frequency changers. For example, an incoming signal on 4MHz might be mixed, in a ring modulator, with a local oscillation of 5MHz to give an intermediate frequency (i.f.) of 1MHz. The other sideband, on 9MHz would be eliminated by the i.f. filters.

The big attraction of the ring modulator, in its diode form, is that it produces less intermodulation of unwanted signals hence less spurious signals and noise. (This may not always be true of i.c. versions incorporating transistors.)

TRICK EFFECTS

It's quite possible (in Fig. 1) to replace the carrier with a second audio signal. If the first signal is a musical instrument and the second a human voice, then the instrument emerges controlled by the voice.

But because the ring modulator is balanced, the voice as such does not emerge. The result is an output consisting of the instrument modulated by a ghostly voice. This is how effects like the "talking piano" are made.

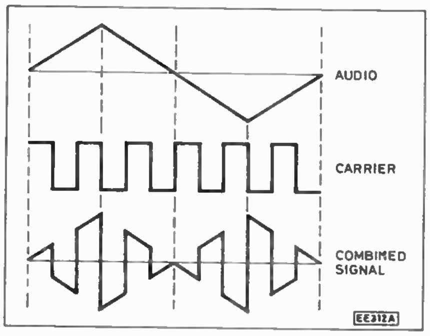


Fig. 4. The effect of combining the audio and carrier waves.

I.C. MODULATORS

It's possible to use transistors instead of diodes and to use transistor phase-splitters instead of centre-tapped transformers.

The way is then clear to making a sort of ring modulator on a chip. These are now finding their way into consumer equipment (often as parts of more complex i.c.s). Because of the mathematics of their operation they are sometimes called multipliers or product modulators.

The classic diode-ring modulator, with transformers, is now available as a miniature encapsulated assembly. It is likely to use Schottky diodes and windings on ferrite toroids but in all essentials is a direct descendant of the copper-oxide modulator of fifty years ago.

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Just send in your idea to our editorial offices, together with a declaration to the affect that it has been tried and tested, is the original work of the undersigned and that it has not been offered or accepted for publication elsewhere. It should be emphasised that these designs have not been proved by us, but are included to stimulate further thought.

STEPPER MOTOR CONTROLLER

THIS circuit is designed for use with any computer with an eight line TTL compatible output port, e.g. VIC20, BBC, Commodore 64. It is ideal for controlling a turtle as it operates two stepper motors.

Some recommended dimensions for this turtle are 61·1mm diameter wheels and 229mm between the wheels. These dimensions mean that with both motors running in the same direction, the turtle will move 2mm forwards/step. (The motor's step is 7·5 degrees). If the motors are stepped in opposite directions, the turtle will turn through 1 degree/step.

To make motor ME 1 step forwards, the output port should be poked with 255–(1,5,4,6,2,10,8,9). To make the other motor step forwards, the port should be poked with 255–16(1,5,4,6,2,10,8,9).

The 255– compensates for the inverters in the circuit. The inverters are NOR gates with one input grounded. They are present to ensure that the ULN 2803A, which is a Darlington amplifier, receives 5V whatever the inverter's input voltage.

The power supply must be 10–15V and capable of supplying 2A.

S. A. Baker,
Hampstead,
Glos.

SIMPLE PUSHBUTTON CODELOCK

IT HAS come to my notice there are two kinds of codelock systems. They are either the sort where you may push each button one at a time to release the lock, but require complicated logic; or they are the simple type that are just several switches in an "AND" type form where you have to press all the coded buttons at once. The circuit presented here is a code lock of both simple use and construction.

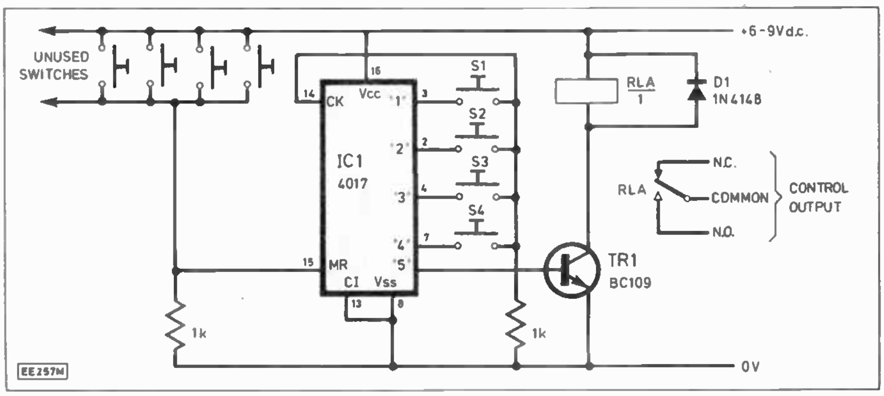
The circuit below operates around just one chip, a 4017 counter. When power is first supplied, the first output of IC1 goes high.

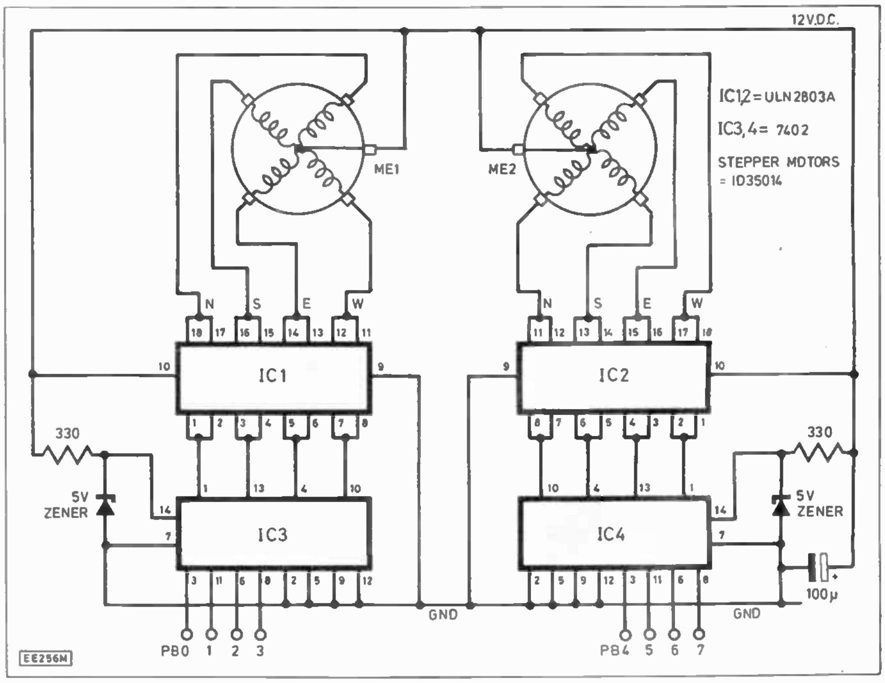
If the first coded switch S1 is pressed, the counter would be allowed to clock on one count. If any other switch is pressed, nothing would happen. Now that the i.c.s second output is high, the second button may be pressed, allowing the counter to clock one again.

Now if one of the unused switches is pressed, the counter will be reset. This goes on until the counter reaches the fifth output. At this point, the output is carried to the base of TR1, allowing the relay to operate. The resistance of the relay coil should be greater than 100 ohms in order to avoid damage to the transistor.

Up to nine switches may be used in the code. If more than the four shown here are required, simply connect the extra switches between the next output and the clock input pin. The base of TR1 should be connected to the output after the last switch. Any extra "unused" switches should be wired in parallel with those already shown.

David Cox,
Cardiff.





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

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

NOTE: Please allow 28 days for delivery. We can only supply boards listed in the latest issue.

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FOR YOUR ENTERTAINMENT

BY BARRY FOX

Computer Problems

The computer industry continues to decline. This can only be good news for the people who try to use computers as a working tool, rather than a hobby toy.

For too long the computer companies have been in such a mad rush to beat their rivals onto the market with new equipment, that they have sold it long before it is ready. In this, and a string of other respects, the computer industry has shown surprisingly little interest in lessons learned over the last twenty years by other consumer electronics industries.

I went to the press conference held by Apricot to explain the company's financial problems and tell how they will be tackling the future. Roger Foster, Group Chief Executive, kicked off with the disarmingly frank admission that his company "got it wrong".

Apricot has written off £6 million against lower priced and unsuccessful products, like the mains-powered Portable and peglegged F1. They are now dumping these machines at very low prices, around £500 for the Portable which originally cost three times as much. After that, says Foster, Apricot will sell only higher priced hardware from selected dealers.

On the face of things the Apricot flog-offs (mainly through Dixons) look like a very good bargain. But what happens, I asked, if they go wrong and need repair?

If only one thing in life is certain it is that everything goes wrong in the end. And there is plenty to go wrong in a computer. A monitor is a modified TV set, and thus as likely to develop a fault as a TV.

Magnetic disc storage drives rely on precision mechanical technology and magnetic record and replay heads which can clog or wear. There is already a bandwaggon industry of cleaning gadgets which can do more harm than good. The video industry learned ten years ago about the problems of head cleaners.

Hot Spot

The large number of chips in a computer body draw heavy power and give off a considerable amount of waste heat. This can damage other components.

The latest Apricot computer, the Xen, has its transformers and rectifiers in a separate metal cage which sits on the floor by the computer and doubles as a footwarmer. Previous machines had the power supply on board.

Apricot PCs can overheat and loosen components on the printed circuit board which in turn causes distortion of the picture on screen. Until today I thought the cure was a cheap kitchen fan at the back of the machine to create some turbulence and help the internal fan do a better job. It's not! My Apricot PC picture is distorting again!

The hifi industry learned years ago about the value of separate power supplies and the problems of overheating. Japanese audio and video factories put all products on soak test for long enough to find out if there is any overheating. They do this *before* launching a product for sale.

In a Spin

The video industry has been through a nightmare of battles on standardisation. The public has been the main casualty, often left with cassettes which can't be played and recorders for which blank tapes are hard to find.

Spare a thought for why the Amstrad PCW 8256 is so cheap, at £458.85 inc VAT (not £399 as the large print suggests—that's plus VAT). One reason is that the package uses a 3 inch floppy disc drive, not 3·5 inch.

The 3in. compact floppy disc system (CFD) was first announced in 1981 by Matsushita, Maxell and Hitachi. CFD came a year after Sony's 3·5in. MFD or micro floppy disc.

In both types of disc, the spinning flimsy magnetic sheet is protected by a hard case with a window shutter which opens only when the disc is being read. The large style older floppies are protected by only a flimsy sleeve with open window.

In 1984 ANSI (American National Standards Institute), ECMA (the European Computer Manufacturers' Association) and ISO (the International Standards Organisation) blessed Sony's MFD format. Hewlett Packard, Apple, Apricot, Atari and the MSX group started to use MFD drives and IBM is expected soon to follow with a second generation PC.

In February 1984 Matsushita proudly announced that it had begun making 30,000 CFD drives a month. This can only have produced one heck of stockpile. Amstrad struck a hard bargain and took 450,000 at a price which helped make the budget 8256 possible.

Amstrad admits that blank discs are in short supply. The comment came after I found that Dixons' store in London's Oxford Street was selling the Amstrad computer but telling customers that they had no discs and could not get any from Amstrad.

Dixons was telling people to try rival specialist computer shops. Amstrad says plenty of blank discs are coming in from the Far East and 8256 users should "phone round stores looking for stocks". Users, says Amstrad, are buying so many discs that there is a shortage.

It follows then that 8256 owners are storing data. Read on to find out why this is important.

After-Sales Service

Amstrad was previously best known in the consumer electronics industry for budget audio systems. The company then moved into Citizens Band radio, car cassette players, video recorders and TV sets. These are seldom now seen in the shops. They are now moving into compact disc digital audio.

The company says it has been in computers for two years and they are a "long term product". The company also says it has a commitment to spares even if it quits the wordprocessor business. Only time will tell how easy it is to get blank CFDs in five years' time and how easy current users find it to access the disc libraries of data which they are now building up.

The audio and video industries found long ago that "after-sales service" does not mean fixing equipment free under guarantee. That's the easy part. At worst you just give the customer another new one. The hard part is offering service-for-a fee years after guarantees have run out.

I fear many people who are building up libraries of data on systems which go to the wall are going to find it as inaccessible as the Crown Jewels in just a few years. The firms which survive in the computer business will be those who get their long term service right, and thus don't attract bad publicity from disgruntled customers who go public with their complaints.

I hope Apricot get it right for two reasons. Apricot is the only serious rival to IBM which is true-blue British; and I'm a user who already needs repairs.

I asked Roger Foster about this. Anyone buying the £500 portable from Dixons can buy a service contract from Apricot. But it costs £405 plus VAT for four years —which is almost the machine cost.

Foster says the Birmingham-based company has "many times" thought about opening a repair depot in London, where people can take equipment if their dealer is unhelpful. But Apricot is still only thinking about this.

Rental

The biggest lesson the computer firms could learn from the consumer electronics industry is on rental. Britain has the highest penetration of video recorders in Europe, with over a third of UK homes now using one.

This is the direct result of Britain's unique rental system. It began with colour TV. Ten years ago three-quarters of all colour TVs in Britain were rented, because people were scared of the high price of repairs.

When the rental companies switched to video, customers jumped at the chance of hiring rather than buying. They feared expensive repairs.

In the early 80s well over half the video recorders in Britain were rented. Even now, when colour TV and video recorders are cheap, very easy to use and proven to be reliable, one out of three colour sets and four out of ten video recorders are on hire.

Although personal computers cost more than video recorders or colour TV sets, are more difficult to set up and more likely to go wrong, there has been no serious attempt at renting out computers.—*Why not?*

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