EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY

OCTOBER 1986 £1·10

10W AUDIO AMPLIFIER

LIGHT RIDER

Special Feature
THE DIFFERENTIAL AMPLIFIER

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
4. 5 – surface mounting
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
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
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
66. 1 – magnetic brake – stops rotation instantly
67. 1 – low pressure 3 level switch can be mouth operated
69. 2 – 25 watt pots 8 ohm
70. 2 – 25 watt pots 1000 ohm
71. 4 – wire wound pots – 18, 33, 50 and 100 ohm your choice
77. 1 – time reminder adjustable 1-60 mins clockwork
85. 1 – mains shaded pole motor ⅝" stack – ¼ shaft
89. 1 – mains motor with gear box 1 rev per 24 hours
91. 2 – mains motors with gear box 16 rpm
96. 1 – thermostat for fridge
98. 1 – motorised stud switch (s.h.)
101. 1 – 2½ hours delay switch
102. 1 – mains P.S.U. 9V DC
103. 1 – mains power supply unit – 6V DC
104. 1 – mains power supply unit – 4½V DC
107. 1 – 5" speaker size radio cabinet with handle
111. 2 – musical boxes (less keys)
112. 1 – heating pad 200 watts mains
114. 1 – 1W amplifier Mullard 1172
115. 1 – wall mounting thermostat 24V
118. 1 – teak effect extension 5" speaker cabinet
120. 2 – p.c. boards with 2 amp full wave and 17 other recs
121. 4 – push push switches for table lamps etc.
122. 10 – mtrs twin screened flex white p.v.c. outer
124. 25 – clear plastic lenses 1½ diameter
127. 4 – pilot bulb lamp metal clip on type
128. 10 – very fine drills for pcbs etc.
129. 4 – extra thin screw drivers for instruments
132. 2 – plastic boxes with windows, ideal for interrupted beam switch
134. 10 – model aircraft motor – require no on/off switch, just spin to start
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
154. 1 – 12V drip proof relay – ideal for car jobs
155. 3 – varicap push button tuners with knobs
169. 4 – short wave air spaced trimmers 2-30f
171. 1 – shocking coil 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
193. 6 – 5 amp 3 pin flush sockets brown
195. 5 – B.C. lampholders brown bakelite threaded entry
196. 1 – in flex simmerstat for electric blanket soldering iron etc.
197. 2 – thermostats, spindle setting – adjustable range for ovens etc.
199. 1 – mains operated solenoid with plunger 1" travel
200. 1 – 10 digit switch pad for telephones etc.
201. 8 – computer keyboard switches with knobs, pcb or vero mounting
206. 20 – mtres 80 ohm, standard type co-ax off white
211. 1 – electric clock mains driven, always right time – not cased
216. 1 – stereo pre-amp Mullard EP9001
232. 2 – 12V solenoids, small with plunger
236. 1 – mains transformer 9V 1 amp secondary C core construction
241. 1 – car door speaker (very flat) 6½" 15 ohm made for Radiomobile
241. 2 – speakers 6" × 4" 4 ohm 5 watt made for Radiomobile
243. 2 – speakers 6" × 4" 16 ohm 5 watt made for Radiomobile
244. 1 – mains motor with gear-box very small, toothed output 1 rpm
245. 4 – standard size pots, ½ meg with dp switch
249. 1 – 13A switched socket on double plate with fused spur 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
291. 1 ten turns 3 watt pot ¼ spindle 100 ohm
296. 3 car cigar lighter socket plugs
298. 2 15 amp round pin plugs brown bakelite
300. 1 mains solenoid with plunger compact type
301. 10 ceramic magnets Mullard 1" × 3/8 × 5/16
303. 1 12 pole 3 way ceramic wave charge switch
304. 1 stereo amp 1 watt per channel
305. 1 tubular dynamic microphone with desk rest
308. 1 T.V. turret tuner (black & white T.V.)
310. 2 oven thermostats
311. 1 Clare Elliot sealed relay 12V
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

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

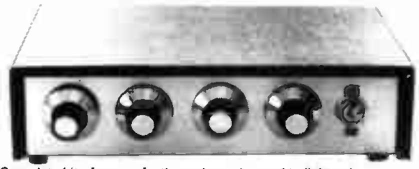
Flat Battery! Don't worry you will start your car in a few minutes with this unit – 250 watt transformer 20 amp rectifiers, case and all parts with data **£16.50** or without case **£15.00** post paid.

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

12 volt MOTOR BY SMITHS

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

25A ELECTRICAL PROGRAMMER

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

THIS MONTH'S SNIP

is a 13·5V DC power supply unit, plugs into a 13A socket and its output is OK to work 12V portable TVs, car radios etc., etc. Offered at £2 each, or 13 for £24 post paid. Our reference 2P110.

MAKING SUNBEDS?

CHOKE AND STARTER for 6' 100uva tube £2, post £1 for 1 or 50p each in quantity.
TUBE HOLDERS. Canopy type spring loaded, 4 pairs for £1, 100 pairs £20, 1,000 pairs £150, post paid.

TANGENTIAL HEATERS?

We again have very good stocks of these quiet running instant heat units. They require only a simple case, or could easily be fitted into the bottom of a kitchen unit or book case etc. At present we have stocks of 1·2kw, 2kw, 2·5kw, and 3kw. Prices are £5 each for the first 3, and £6.95 for the 3k. Add post £1.50 per heater if not collecting.
CONTROL SWITCH enabling full heat, half heat or cold blow, with connection diagram. 50p for 2kw, 75p for 3kw.

FANS & BLOWERS

Woods extractors
5" £5 + £1.25 post. 6" £6 + £1.50 post
4" × 4" Muffin equipment cooling fan 115V £2.00
4" × 4" Muffin equipment cooling fan 230/240V £5.95
5" Plannair extractor £5.50
9" Extractor or blower 115V supplied with 230 to 115V adaptor £9.50 + £2 post.
All above are ex computers but guaranteed 12 months.
10" × 3" Tangential Blower. New. Very quiet – supplied with 230 to 115V adaptor on use two in series to give long blow £2.00 + £1.50 post or £4.00 + £2.00 post for two.

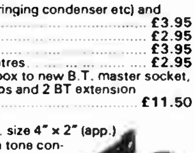
IONISER KIT

Refresh your home, office, shop, work room, etc. with a negative ION generator. Makes you feel better and work harder – a complete mains operated kit, case included.
£11.95 plus **£2.00** post.

TELEPHONE BITS

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

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



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

J & N BULL ELECTRICAL

Dept. E.E., 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. Brighton 0273 734648. **Bulk orders:** write for quote.

OVER 400 GIFTS YOU CAN CHOOSE FROM

There is a total of over 400 packs in our Baker's dozen range and you become entitled to a free gift with each dozen pounds you spend on these packs. A classified list of these packs and our latest "News Letter" will be enclosed with your goods, and you will automatically receive our next news letters.

TWO POUNDERS*

- 2P2 – Wall mounting thermostat, high precision with mercury switch and thermometer
- 2P3 – Variable and reversible 8-12v psu for model control
- 2P4 – 24 volt psu with separate channels for stereo made for Mullard UNILEX
- 2P6 – 100W mains to 115V auto-transformer with voltage tappings
- 2P8 – Mains motor with gear box and variable speed selector. Series wound so suitable for further speed control
- 2P9 – Time and set switch. Boxed, glass fronted and with knobs. Controls up to 15 amps. Ideal to program electric heaters
- 2P10 – 12 volt 5 amp mains transformer – low volt winding on separate bobbin and easy to remove to convert to lower voltages for higher currents
- 2P12 – Disk or Tape precision motor – has balanced rotor and is reversible 230v mains operated 1500 rpm
- 2P14 – Mug Stop kit – when thrown emits piercing squawk
- 2P15 – Interrupted Beam kit for burglar alarms, counters, etc.
- 2P17 – 2 rev pr minute mains driven motor 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
- 2P20 – 20 metres extension lead, 2 core – ideal most Black and Decker garden tools etc.
- 2P21 – 10 watt amplifier, Mullard module reference 1173
- 2P22 – Motor driven switch 20 secs on or off after push
- 2P26 – Counter resettable mains operated 3 digit
- 2P27 – Goodmans Speaker 6 inch round 8ohm 12 watt
- 2P28 – Drill Pump – always useful couples to any make portable drill
- 2P31 – 4 metres 98 way interconnecting wire easy to strip
- 2P32 – Hot Wire amp meter – 4½ round surface mounting 0–10A – old but working and definitely a bit of history
- 2P34 – Solenoid Air Valve mains operated
- 2P35 – Battery charger kit comprising mains transformer, full wave rectifier and meter, suitable for charging 6v or 12v
- 2P38 – 200 R.P.M. Geared Mains Motor 1" stack quite powerful, definitely large enough to drive a rotating aerial or a tumbler for polishing stones etc.
- 2P43 – Small type blower or extractor fan, motor inset so very compact, 230V
- 2P46 – Our famous drill control kit complete and with prepared case.
- 2P49 – Fire Alarm break glass switch in heavy cast case
- 2P51 – Stereo Headphone amplifier, with pre-amp
- 2P55 – Mains motor, extra powerful has 1½" stack and good length of spindle
- 2P62 – 1 pair Goodmans 15 ohm speakers for Unilex
- 2P64 – 1 five bladed fan 6½" with mains motor
- 2P66 – 1 2Kw tangential heater 115v easily convertible for 230V
- 2P67 – 1 12v–0–12v 2 amp mains transformer
- 2P68 – 1 15v–0–15v 2 amp mains transformer
- 2P69 – 1 250v–0–250v 60 mA & 86.3v 5A mains transformer + 50p post
- 2P70 – 1 E.M.I. tape motor two speed and reversible
- 2P72 – 1 115v Muffin fan 4" × 4" approx. (s.h.)
- 2P75 – 1 2 hour timer, plugs into 13A socket
- 2P82 – 9v–0–9v 2 amp mains transformer
- 2P84 – Modem board with press keys for telephone redialler
- 2P85 – 20v–0–20v ½A Mains transformer
- 2P88 – Sangamo 24 hr time switch 20 amp (s.h.)
- 2P89 – 120 min. time switch with knob
- 2P90 – 90 min. time switch with edgewise engraved controller
- 2P94 – Telephone handset for EE home telephone circuit
- 2P95 – 13A socket on satin chrome plate
- 2P97 – mains transformer 24V 2A upright mounting
- 2P98 – 20m 4 core telephone cable, white outer
- 2P99 – 500 hardened pin type staples for telephone cable
- 2P101 – 15V mains transformer 4A upright mounting
- 2P105 – capillary type thermostat for air temperature with c/o switch
- 2P107 – membrane keyboard, telephone type
- 2P108 – mains motor with gear box giving 110rpm
- 2P109 – 5" wide black adhesive pvc tape 33m, add £1 post if not collecting

£5 POUNDERS*

- 5P1. 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.
- 5P2. Sound to light kit complete in case suitable for up to 750 watts.
- 5P3. Silent sentinel ultra sonic transmitter and receive kit, complete.
- 5P5. 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.
- 5P6. 12V alarm bell with heavy 6" gong, suitable for outside if protected from direct rainfall. Ex GPO but in perfect order and guaranteed.
- 5P12. Equipment cooling fan – minin snail type mains operated.
- 5P13. Ping pong ball blower – or for any job that requires a powerful stream of air – ex computer. Collect or add £2 post.
- 5P15 – Uniselector 5 pole, 25 way 50 volt coil
- 5P18 – motor driven water pump as fitted to many washing machines
- 5P20 – 2 kits, matchbox size, surveillance transmitter and FM receiver
- 5P23 – miniature (appr. 2½" wide) tangential blow heater, 1-2kw
- 5P24 – ⅛ hp motor, ex computer, 230V, mains operation 1450rpm. If not collect add £3 post
- 5P25 – special effects lighting switch. Up to 6 channels of lamps can be on or off for varying time periods
- 5P26 – Audax woofer 8" 8ohm 35 watt
- 5P27 – cartridge player 12V, has high quality stereo amplifier
- 5P28 – gear pump, mains motor driven with inlet and outlet pipe connectors
- 5P32 – large mains operated push or pull solenoid. Heavy so add £1.50 post
- 5P34 – 24V 5A toroidal mains transformer
- 5P35 – modem board from telephone auto dialler, complete with keypad and all ICs
- 5P37 – 24 hour time switch, 2 on/offs and clockwork reserve, ex Elec. Board loading up to 50A. Add £1 post
- 5P41 – 5" extractor fan, very quiet runner (s.h.), gntd 12 mths.
- 5P45 – pack of 6 cooker clock switches
- 5P48 – telephone extension bell in black case, ex-GPO
- 5P50 – box of 20 infra red quartz glass enclosed 360W heating elements
- 5P51 – 200W auto transformer 230V to 115V torroidal
- 5P52 – mains transformer 26V 10A upright mounting, add £2 post
- 5P54 – mains motor with gear box. final speed 5rpm
- 5P58 – Amstrad stereo tuner FM and LM and S. AM
- 5P60 – DC Muffin type fan 18 to 27V, only 3W
- 5P61 – drill pump mounted on frame, coupled to mains motor
- 5P62 – 2½kw tangential blow heater, add £1.50 post if not collecting

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

VALVE PRE AMP described in the Aug E.T.I. it's a very interesting circuit if you intend trying it, we can supply many of the parts

mains transformer 250–0–250 + 6·3V our ref	2P69 + £1 post
B9A valve bases 4 for £1	BD95
Double tag strips 3 lengths £2	2P100
Toggle switches dpst and 4p 4 way rotary switch	BD394
1 meg single gang pot 4 for £1	BD391
100 + 100µf 320V electrolytic 2 for £1	BD392
4µf 300V 4 for £1	BD393

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EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY

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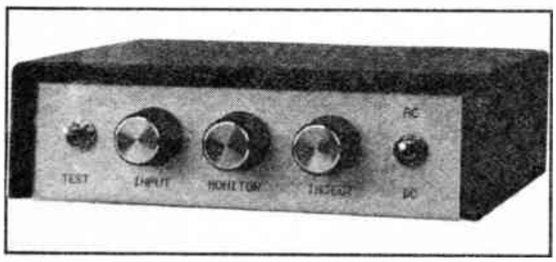
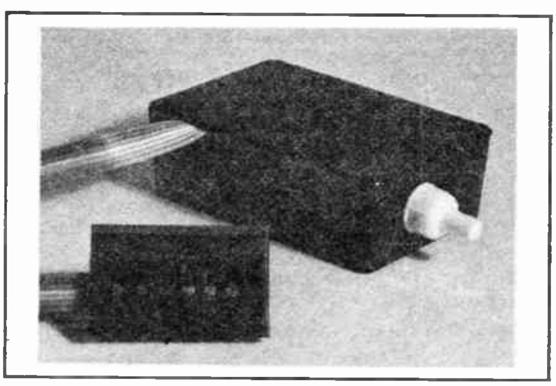
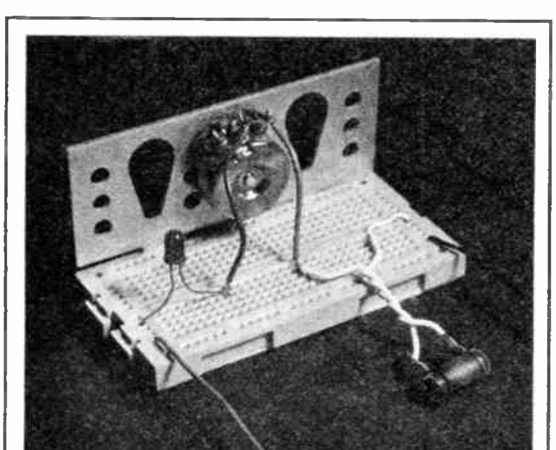
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .







Projects

Series

Features

Our November 1986 issue will be published on Friday, 17 October. See page 553 for details.

For KITS & COMPONENTS Choose the easy way – with TK

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VERSATILE REMOTE CONTROL KIT

This kit includes all components (+ transformer) to make a sensitive IR receiver with 16 logic outputs (0–15V) which with suitable interface circuitry (relays, triacs, etc—details supplied) can be used to switch up to 16 items of equipment on or off remotely. The outputs may be latched (to the last received code) or momentary (on during transmission) by specifying the decoder IC and a 15V stabilised supply is available to power external circuits.

Supply: 240V AC or 15–24V DC at 10mA. Size (excluding transformer) 9 × 4 × 2cms.

The companion transmitter is the MK18 which operates from a 9V PP3 battery and gives a range of up to 60ft. Two keyboards are available MK9 (4-way) and MK10 (16-way), depending on the number of outputs to be used.

MK12 IR Receiver (incl. transformer)	£14.85
MK18 Transmitter	£7.50
MK9 4-way Keyboard	£2.00
MK10 16-way Keyboard	£5.95
601 133 Box for Transmitter	£2.60

XK 102 3-NOTE DOOR CHIME

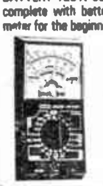
Based on the SAB0600 1C the kit is supplied with all components, including loudspeaker, printed circuit board, a pre-drilled box (95 × 71 × 35mm) and full instructions. Requires only a PP3 9V battery and push-switch to complete.
AN IDEAL PROJECT FOR BEGINNERS **£6.00**

XK 113 MW RADIO KIT

Based on ZN414 IC, kit includes PCB, wound aerial and crystal earpiece and all components to make a sensitive miniature radio. Size: 5·5 × 2·7 × 2cms.
Requires PP3 9V battery
IDEAL FOR BEGINNERS **£6.00**

LOW COST MULTIMETER

A versatile meter with 19 ranges including 10A DC & BATTERY TEST. Case is tilted for easy reading. Supplied complete with batteries, test leads and a manual. Ideal meter for the beginner. Input impedance 20K ohm per volt.



AC Volts: 0-10-25-1000V 5%
DC Volts: 0-2·5-10-25-250+1000V +5%
DC Current: 0-2·5m-25m-250mA-10A +4%
Resistance: 0-10K-100K-10M
Battery test: 9V-1·5V AA-1·5VC&D
Protection: Fuse
Dimensions: 154 × 77 × 43mm
405 103 **£8.62**

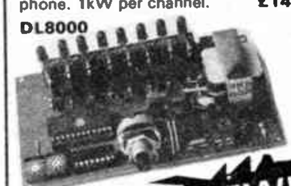
DVM/ULTRA SENSITIVE THERMOMETER KIT

Based on the ICL 7126 and a 3½ digit liquid crystal display, this kit will form the basis of a digital multimeter (only a few additional resistors and switches are required – details supplied), or a sensitive digital thermometer (−50°C to +150°C) reading 0·1°. The kit has a sensitivity of 200mV for a full-scale reading, automatic polarity and overload indication. Typical battery life of 2 years (PP3). **£17.00**

DISCO LIGHTING KITS

DL1000K – This value-for-money 4-way chaser features bi-directional sequence and dimming. 1kW per channel. **£17.50**
DLZ1000K – A lower cost uni-directional version of the above. Zero switching to reduce interference. **£9.85**
DLA1 – Optional opto input allowing audio 'beat'/light response. **70p**
DL3000K – 3-channel sound to light kit features zero voltage switching, automatic level control and built-in microphone. 1kW per channel. **£14.25**

DL8000



NEW!

The DL8000K is an 8-way sequencer kit with built in opto-isolated sound to light input which comes complete with a pre-programmed EPROM containing EIGHTY—YES 80! different sequences including standard flashing and chase routines. The KIT includes full instructions and all components (even the PCB connectors) and requires only a box and a control knob to complete. Other features include manual sequence speed adjustment, zero voltage switching, LED mimic lamps and sound to light LED and a 300W output per channel.
And the best thing about it is the price: ONLY **£28.50**

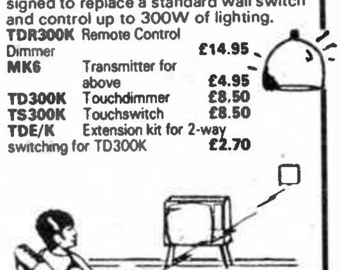
ELECTRONIC LOCK KIT

With hundreds of uses in doors, garages, car anti-theft devices, electronic equipment, etc. Only the correct easily changed four-digit code will open it! Requires a 5V to 15V DC supply. Output 750mA. Fits into standard electrical wall box. Complete kit (excl. front panel)
XK101 **£12.50**
701 150 Electronic lock mechanism for use with the above kit **£16.50**

HOME LIGHTING KITS

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

TDR300K	Remote Control Dimmer	**£14.95**
MK6	Transmitter for above	**£4.95**
TD300K	Touchdimmer	**£8.50**
TS300K	Touchswitch	**£8.50**
TDE/K	Extension kit for 2-way switching for TD300K	**£2.70**



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LONDON W7 3SJ
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SATURDAY 10–4pm

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ALL PRICES EXCLUDE VAT

FREE P&P on orders over £20 (UK only), otherwise add 75p + VAT. Overseas P&P: Europe £2.75. Elsewhere £6.50. Send cheque/PO/Barclaycard/Access No. with order. Giro No. 529314002.

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LOCAL AUTHORITY AND EXPORT ORDERS WELCOME
GOODS BY RETURN SUBJECT TO AVAILABILITY

OSCILLOSCOPES

TELEQUIPMENT D75 Dual Trace 50MHz Delay Sweep £350
COSSOR CDU150. Dual Trace 35MHz Solid State Portable 8 × 10cm display with manual £200
GOULD OS255 Dual Trace 15MHz £200
TELEQUIPMENT D81 Dual Trace 10MHz with Manual £150
S.E. LABS SM111. Dual Trace 18MHz Solid State Portable AC or External DC operation 8 × 10cm display with manual £150
TELEQUIPMENT D43. Dual Trace 15MHz. With manual £100
TELEQUIPMENT S54A. Single Trace 10MHz .... Solid State. With manual £110

MULTIMETERS

AVO 9 Mk4 (identical to AVO 8 Mk4 but scaled differently). Complete with Batteries & Leads. £55
AVO 8 Mk2 Complete with Batteries & Leads £45
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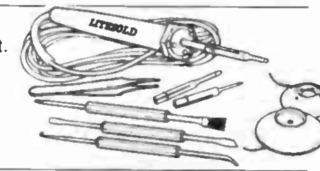

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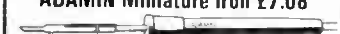

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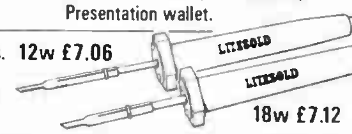

High efficiency irons for all electronic hobby work. Non-roll handles with finger guards. Stainless steel element shafts. Screw-connected elements. Slip-on bits available from 1.6 to 4.7mm. LA12 model, 12w, 2.4mm bit. LC 18 Model, 18w, 3.2mm bit. 240v Std – 12v available. Presentation wallet.

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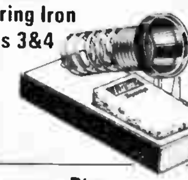

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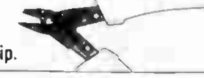

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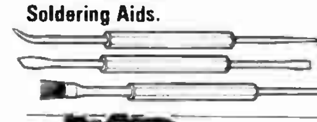

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VOL 15 Nº10 **OCTOBER '86**

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Incidentally with one voucher readers can get a five per cent reduction on any of the books advertised in our book service—so we are taking part in our own scheme.

In addition to the voucher, the yellow card carries a subscription order form and a newsagents order form. Sadly we find many readers miss issues during the year as they do not have a regular order. While we can supply back numbers of most recent copies, some isues are particularly popular and therefore sell out quickly. To avoid missing issues either fill in the newsagent order and hand it to your local newsagent, he will then reserve your copy each month, or send in the subscription form with the appropriate payment (bank draft, in £ sterling only please overseas readers). Once you have done this we will post each issue to you for a year.

FAME

EE and its readers could be even more famous soon. We have had some preliminary conversations with BBC TV about the use of our *EE Geiger Counter* project (August issue) in a science series they are planning. It is just possible that if you have built one of these counters you will be asked to participate in some nationwide experiments in the new year—watch this space for further details. Perhaps it's a sad reflection on the times we live in but the Geiger Counter has proved to be a very popular project!

ADDRESS

Some readers are still using old addresses for EE services. All correspondence should now be sent to Everyday Electronics, 6 Church Street, Wimborne, Dorset BH21 1JG. This address is also correct for back numbers, binders, p.c.b.s, subscriptions, press releases and our book service as well as all editorial correspondence. Only display advertisers need to deal with our Advertisement Manager at his separate address.

Please note and use the Wimborne address—it will speed up your orders and correspondence. We did actually move last March!

Mike Kenward

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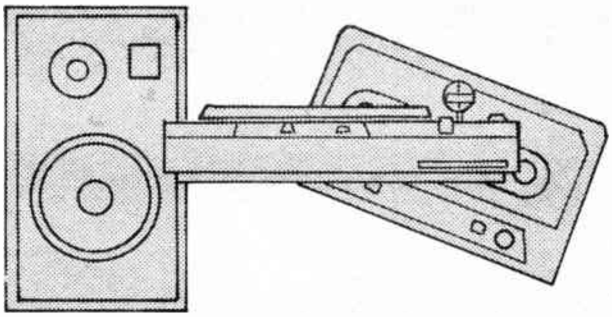
10W AUDIO AMPLIFIER



MARK STUART

A versatile design which will accept a wide variety of inputs and provides mixing facilities

THIS AMPLIFIER was designed to be extremely versatile and useful. It provides 10 watts r.m.s. sine wave output power (20 watts PEAK) into 8 ohms and will accept a wide variety of inputs.

There are two "flat" inputs; one with 47k input impedance is for dynamic and electret microphones, guitar pick-ups and other low signal sources. The other input has a 1 megohm impedance and accepts signals at standard "line" levels between 100mV and 1 volt.

Another completely independent input is provided with full disc RIAA equalisation for use with moving magnet pick-up cartridges. This channel has a separate level control from the "flat" channel and so signals from the two can be mixed without interaction to blend announcements with music for example. A master volume control allows the overall output level to be adjusted without affecting the relative levels of the two channels.

HOW IT WORKS

A block diagram of the amplifier is shown in Fig. 1. Two input sockets wired in parallel are provided on the disc input so that stereo signals will automatically be combined for mono reproduction. The mixer stage incorporates a "soft limiter" action which can be used to provide overdrive effects when used with electric guitars or to improve the intelligibility of speech from those individuals who insist on shouting into the microphone regardless of the fact that the amplifier is giving its all.

The beauty of soft limiting is that the behaviour of the amplifier under overload is smooth and controlled. In fact a degree of soft limiting adds a compression effect which improves the effective "speech power" without introducing harshness.

Soft limiting is introduced by reducing the master volume setting and increasing the flat channel input volume setting to compensate. The relative levels of these two controls affect the degree of limiting that is applied. At "normal' control settings limiting does not occur until the full power output is being delivered and the power amplifier begins to clip.

The power supply to the amplifier incorporates an i.c. voltage regulator. This component is often omitted in audio amplifier designs to keep down the cost. Its inclusion in this design gives two very worthwhile benefits. The first is that the output hum level is practically inaudible even at maximum settings of all controls. The second benefit is that the power supply transformer and rectifiers are fully protected from output short-circuit conditions. The ability to withstand abuse without problems is essential for an amplifier which will be used as a "workhorse" in a wide variety of situations.

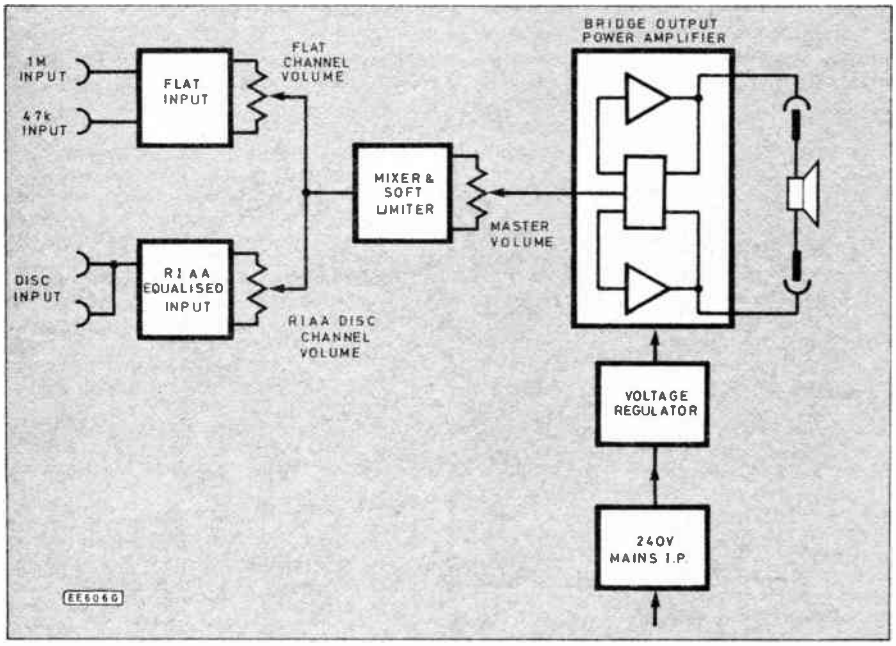


Fig. 1. Block diagram of the 10W Audio Amplifier.

POWER AMPLIFIER

The circuit of the amplifier is shown in Fig. 2. The power amplifier section appears

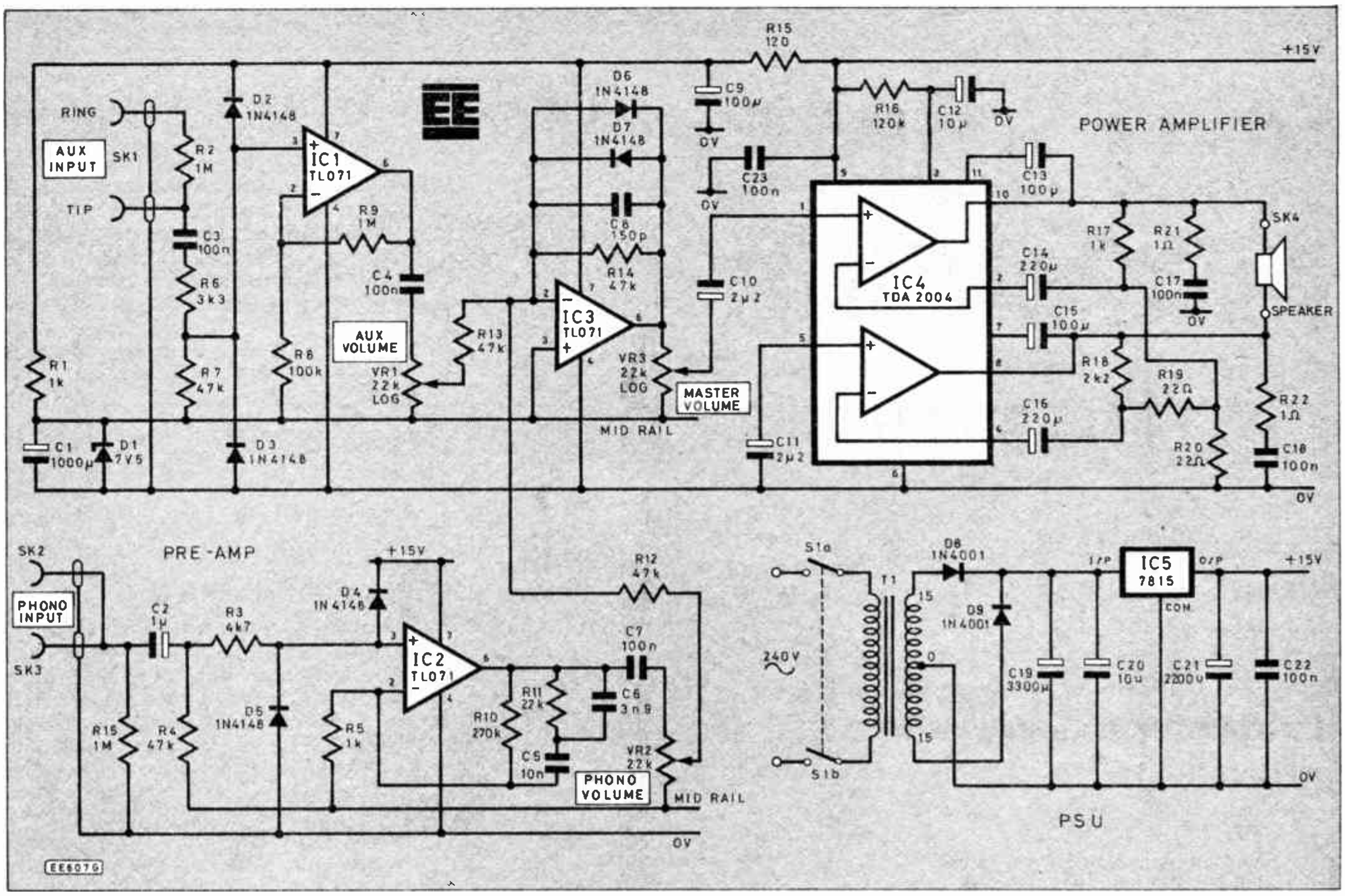


Fig. 2. Complete circuit diagram of the 10W Audio Amplifier.

very simple because all of the work is done by a single TDA2004 class B dual audio power amplifier i.c. This i.c. contains two identical power amplifier stages which have been connected in this circuit as a full bridge amplifier.

The feedback network of resistors R17, R18, R19, R20, and capacitors C14, C16 is arranged so that the output of the lower amplifier is exactly the opposite to that of the upper amplifier. The loudspeaker is connected between the two outputs so that the maximum voltage swing across it is twice that of each single stage.

At maximum output each stage can deliver 13V peak-to-peak giving 26V across the loudspeaker. With a sine wave output this corresponds to 9V r.m.s. which gives just over 10 watts into 8 ohms or 20 watts peak.

The supply to IC4 is decoupled by C23, R16 and C12. Other components around IC4 are: R21, C17, R22 and C18, which prevent high frequency instability; C13 and C15, which provide bootstrapping to increase the available output voltage swing and the input coupling capacitors C10 and C11. One big advantage of the full bridge amplifier is that the two outputs are at the same d.c. voltage and so a large output coupling capacitor is not required.

POWER SUPPLY

The power supply is based on a good quality mains transformer with separate primary and secondary bobbins; this is used to reduce mains borne interference to an absolute minimum.

A standard centre tapped transformer arrangement with two diodes (D8, D9) and a smoothing capacitor (C19) provides the rough d.c. supply which feeds the 15V regulator IC5. From IC5 the stable 15V rail is decoupled by C21 before passing to the power amplifier circuit.

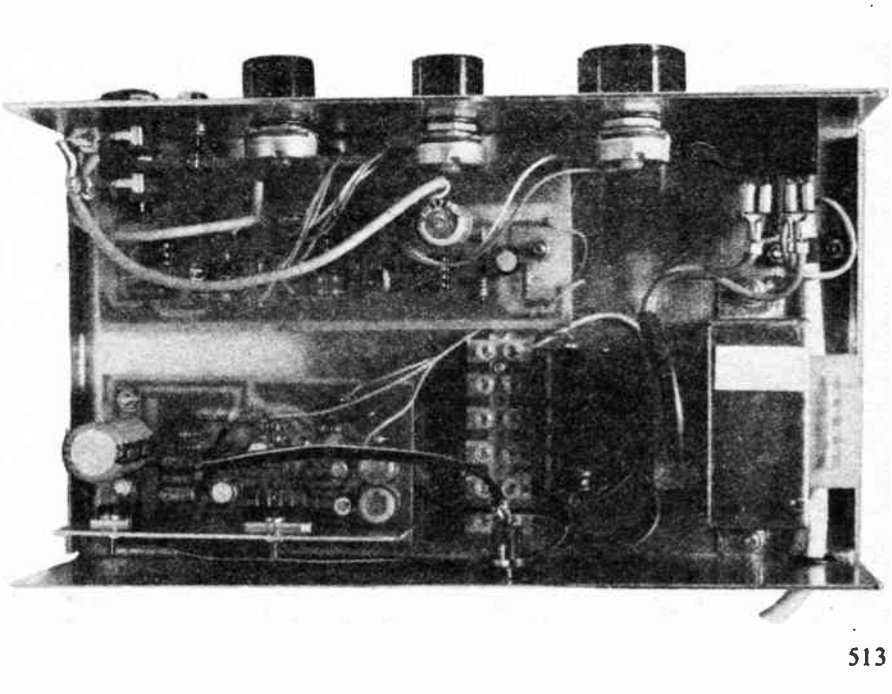
Capacitors C20 and C22 are connected close to IC5 and prevent high frequency instability due to lead inductances. The output ripple voltage from IC5 is less than 10mV even when the amplifier is delivering its full output.

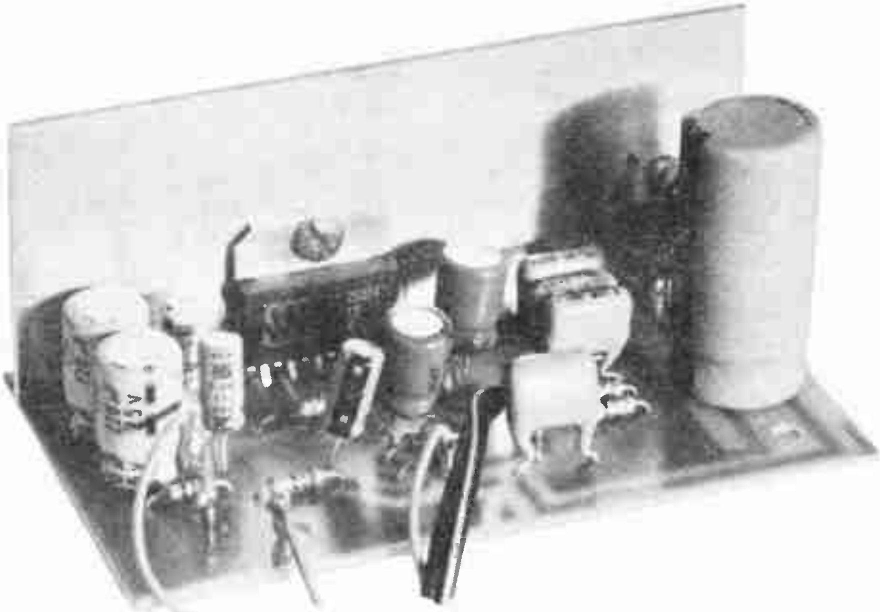
PREAMPLIFIER

In the preamplifier section three low noise op-amps are used to provide the two input channels and mixer amplifier. The mid-rail voltage of 7·5V which is required for correct biasing of these stages is provided from the main 15V supply by resistor R1 and Zener diode D1 and decoupled by capacitor C1.

The "flat" frequency response channel gain is provided by IC1, which is configured as a non-inverting amplifier. Two input levels are obtained by means of resistors R2 and R7 which also define the input impedances.

Inputs are connected via a stereo jack socket SK1 which is wired so that the high sensitivity 47k input is connected to the plug *tip*, and the low sensitivity one megohm input is connected to the plug *ring*. The





sleeve of the jack plug is the common ground connection.

When a mono jack plug is inserted it automatically connects to the 47k high sensitivity input, which is the one required by guitars, microphones, etc. Diodes D2 and D3 along with series resistor R6 have been added to protect the amplifier from excessive input signals.

Static charges, mains pick-up, and the output signals from other amplifiers are all potential hazards to P.A. systems of this type. The combination of a series resistor to limit the current and shunt diodes which direct excess voltages safely into the supply rails should eliminate the danger from all but lightning strikes!

The output from IC1 passes to the flat channel volume control VR1 via C4. From the slider of VR1 the signal passes to the mixer amplifier stage where it is combined with the signal from the RIAA equalised phono channel.

RIAA INPUT STAGE

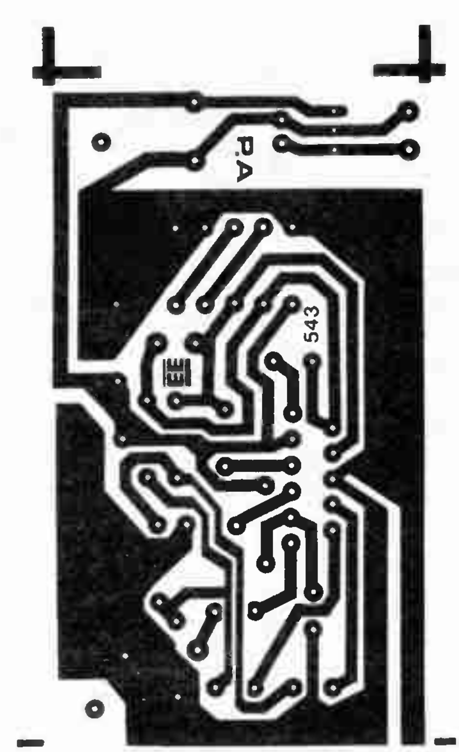
The RIAA disc equalising section of the circuit is built around the TL071 low-noise BI-FET op-amp IC2, see Fig. 2. It is connected in a similar arrangement to IC1 but the feedback network which consists of R5, R10, R11, C6 and C5 is calculated to give the necessary equalisation for a standard moving magnet disc pick-up.

Overload protection is provided by resistor R3 and diodes D4, D5. The output passes to the phono volume control VR2 and then on via resistor R12 to the mixer stage.

MIXER STAGE

Signals from VR1 and VR2 pass via R13 and R12 respectively to the inverting inputs of IC3, the mixer stage. Feedback around this stage is provided by R14 and C8 for low and medium level signals. At higher levels diodes D6 and D7 begin to conduct and provide progressively higher amounts of feedback as the signal level increases.

This progressive feedback gives the stage



Main amplifier p.c.b. master.

COMPONENTS

Approx. cost Guidance only £35

Resistors

R1,R5,R17	1k (3 off)	R11	22k
R2,R9	1M (2 off)	R15	120
R3	4k7	R16	120k
R4,R7,R12, R13,R14	47k (5 off)	R18	2k2
R6	3k3	R19, R20	22
R8	100k	R21,R22	1
R10	270k		

See Shop Talk page 537

Potentiometers

VR1,VR2,VR3	22k log. (3 off)

Capacitors

C1	1000µ radial elect. 16V
C2	1µ radial elec. 16V
C3,C4,C7,C17, C18,C22,C23	100n polyester (7 off)
C5	10n polyester
C6	3n9 polyester
C8	150p ceramic
C9,C13,C15	100µ radial elect. 25V (3 off)
C10,C11	2µ2 radial elect. 63V (2 off)
C12,C20	10µ radial elec. 16V (2 off)
C14,C16	220µ radial elec. 25V (2 off)
C19	3300µ or 2200µ axial elc. 35V
C21	2200µ radial elec. 16V

Semiconductors

IC1,IC2,IC3	TL071 low-noise BI-FET op-amp (3 off)
IC4	TDA2004 dual audio power amp
IC5	7815 +15V voltage regulator
D1	BZY88C7V5 Zener
D2-D7	IN4148 (6 off)
D8,D9	IN4001 (2 off)

Miscellaneous

T1	18V/A transformer, 240V primary, 15V-0V-15V secondary (see text)
S1	d.p.s.t. mains rocker switch
SK1	¼in stereo jack socket
SK2,SK3	metal panel mounting phono sockets (2 off)
SK4	DIN loudspeaker socket

Metal case, 230mm x 130mm x 60mm; 8-pin i.c. sockets (3 off); 6-way 2A terminal block; aluminium heatsink, approx. 102mm x 38mm; mains cable "saddle" clamp; connecting wire and soldering pins, etc.; printed circuit boards, available from *EE PCB Service*, order code: EE543 and EE544; knobs.

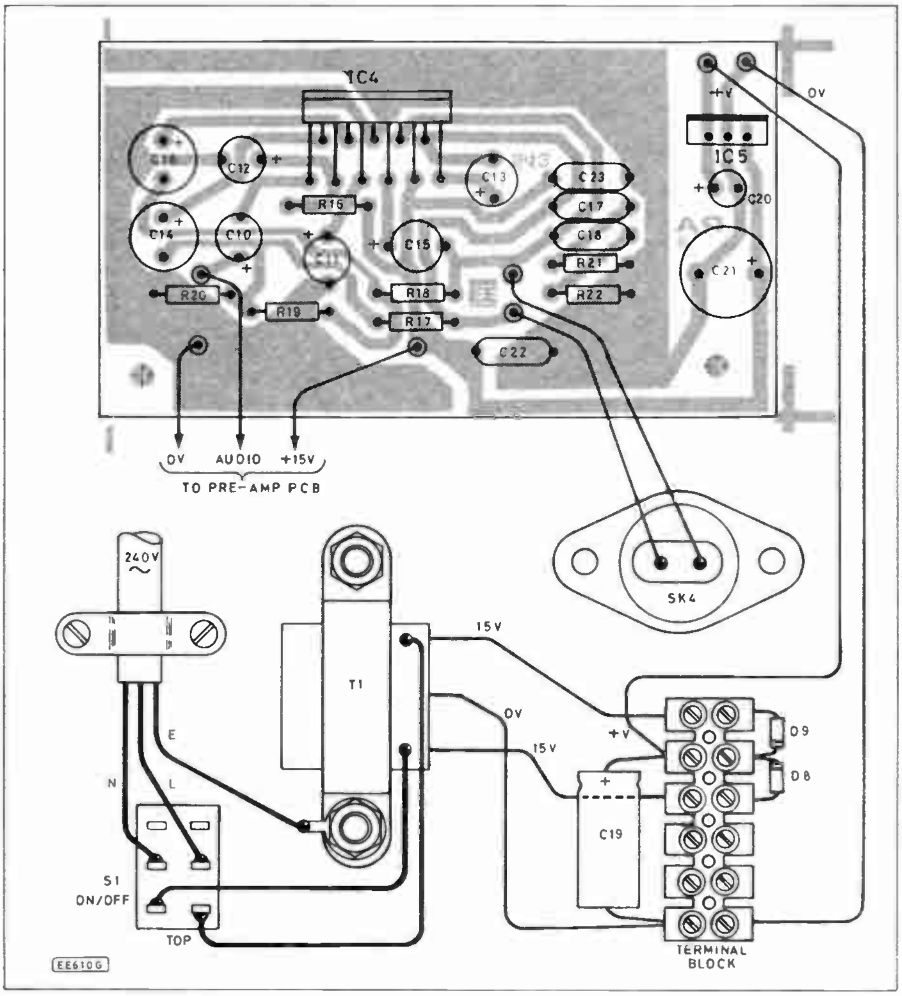
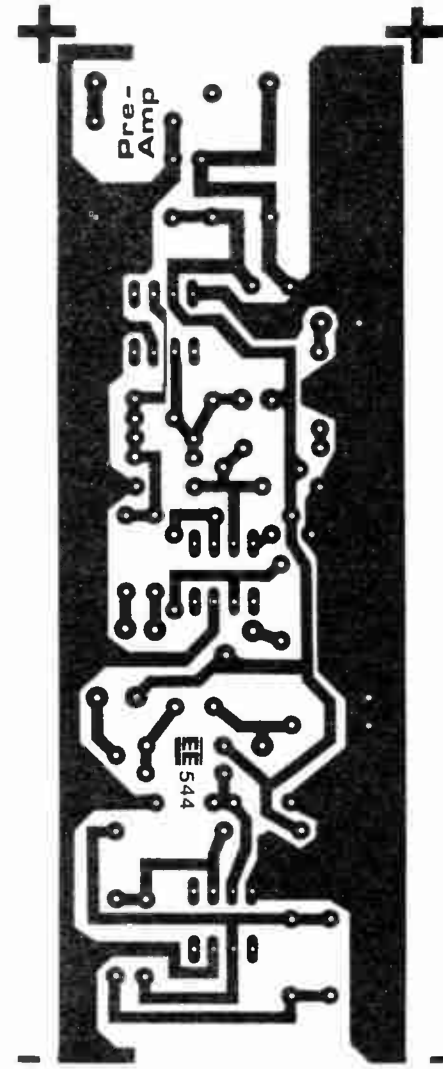
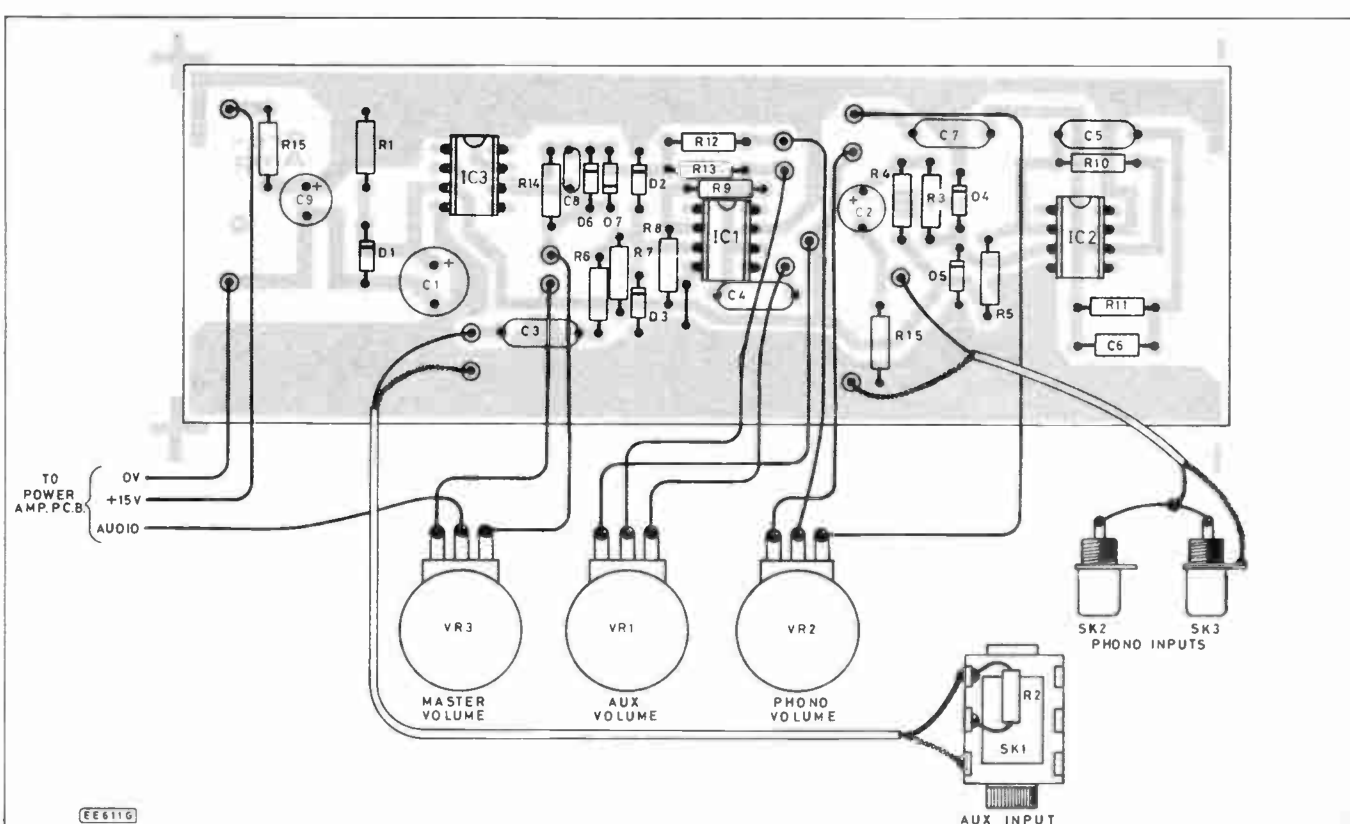


Fig. 3. Power amplifier p.c.b. and power supply component wiring.



Pre-amplifier p.c.b. master.

Fig. 4. Pre-amplifier p.c.b. plus control and input socket wiring.



the soft limiting characteristic which has been discussed earlier. Capacitor C8 gives the mixer response a gentle high frequency roll off.

The use of an inverting amplifier as a mixer stage ensures that interaction between the settings of VR1 and VR2 is completely eliminated. From the mixer stage the signal passes via the master volume control to the power amplifier.

CONSTRUCTION

Individual printed circuit boards are used for the power amplifier and the preamplifier. Figs. 3 and 4 show the printed circuit master patterns (full size) and component layout of the two boards. These boards are available from the *EE PCB Service*, order code EE543 and EE544.

Before inserting any components into the boards it is suggested that the case is drilled and the sockets, potentiometers, mains switch, mains transformer, power supply terminal block and mains cable are fitted. The printed boards can be used as templates to mark out their fixing holes and can be temporarily fitted to ensure that the layout of the components in the case is correct.

It is advised that the layout used in the prototype is adhered to as this gives the best routeing of signal wires and ensures that the mains wiring is safely separated from all other connections. The transformer recommended is one with fully insulated wire leads. This means that the mains connections can be made by insulated spade connectors to the on-off switch.

It is also essential that there is a good mains earth connection to the case for reasons of safety and to eliminate mains hum. A solder tag fitted tightly under one of the transformer mounting bolts makes the best mains earthing point.

Also important for safety is the use of a suitable grommet where the mains cable enters the case and a saddle clamp or similar device near to the switch to ensure that the mains lead cannot work loose and make dangerous contact with other parts of the circuit. ***Attention to these safety aspects is vital to the construction of all types of mains powered projects.***

To simplify the cutting of the front panel a dimensional drawing of the case specified is given in Fig. 5. The speaker output socket SK4 is fitted to the rear panel of the case.

Diodes D8 and D9 and the smoothing capacitor C19 have been deliberately kept away from the rest of the circuit and are mounted on a screw terminal block fitted to the bottom of the case. A small double-sided adhesive pad should be used to secure C19 to the case.

CIRCUIT BOARDS

Begin assembling the boards by fitting wiring pins in all of the appropriate places. The pins must be pressed into the board material from the track side so that they are a tight fit and then soldered. Considerable force may be needed to push the pins fully home, a vice or small hammer may be used (with care) if necessary.

Construction of the boards is straight forward. Observe polarity of the diodes and electrolytic capacitors and fit i.c. sockets for the three pre-amp i.c.s.

A small piece of aluminium is used as a heatsink for IC4 and IC5. This heatsink does not need insulating from either of the i.c. tabs, but it MUST NOT contact the

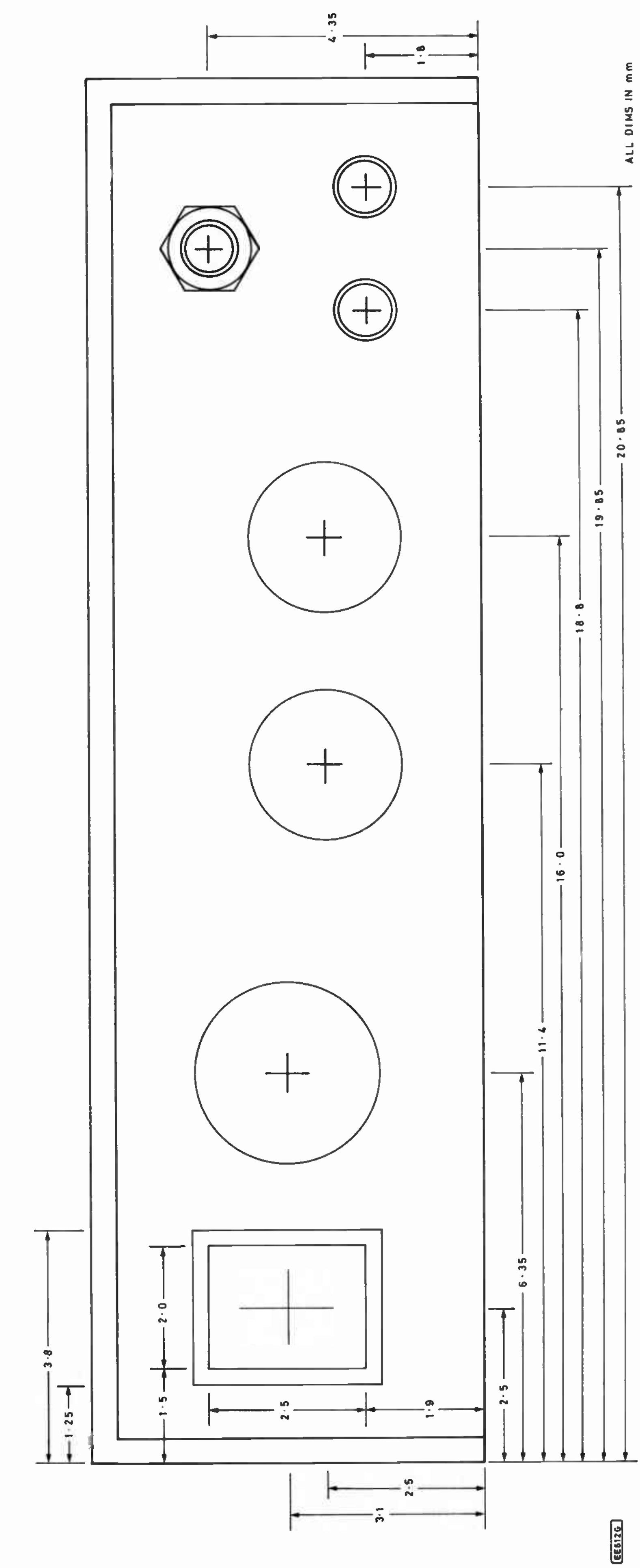
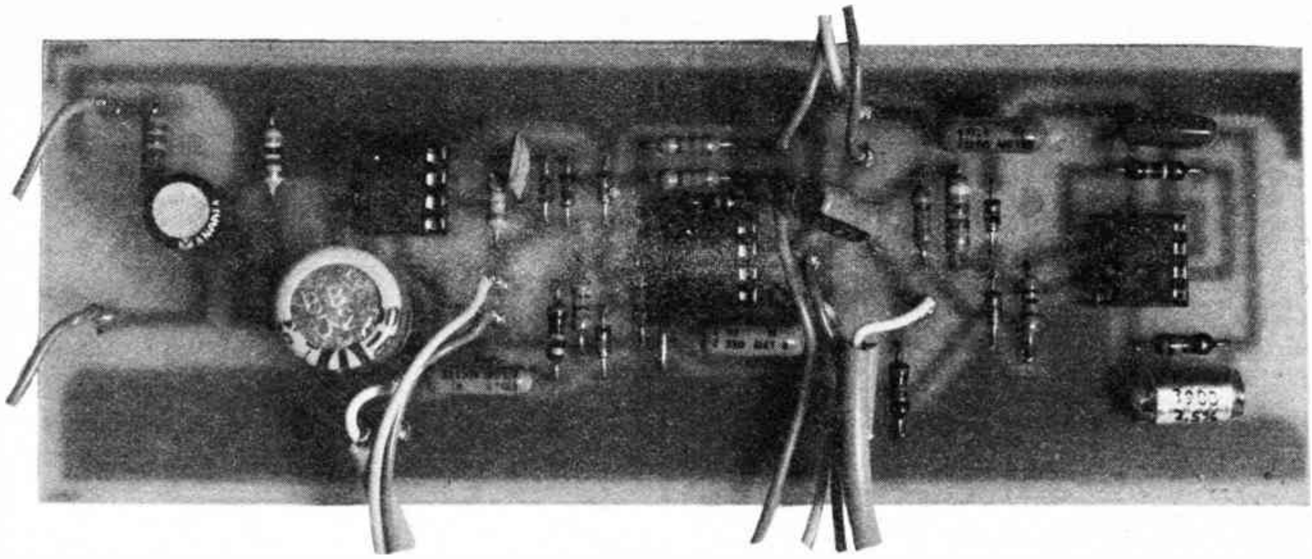


Fig. 5. Hole positions for drilling the specified case front panel.



case. The reason for this is that power supply currents flowing in the case can appear as input signals by means of so called "earth loops", resulting in severe distortion and instability.

Earth loops are completely overcome by ensuring that the power supply is connected to the case at just one point. In this amplifier a single connection is made to the case via a solder tag on the input socket SK3.

When the two boards have been assembled they can be mounted in the case ready for wiring.

WIRING

Wiring details to the boards and case mounted components are given in Figs. 3 and 4. The wiring between the pre-amp board and the three controls and input sockets should be carried out first. Use 7/0·2 or similar stranded wire and keep the three wires to each control separate from the other wires. Leave sufficient wire to enable the board to be lifted and turned over for testing.

The connections to the input sockets are made using single screened cable. Note that R2 is fitted directly on to the tags of SK1. Complete the wiring by making the connection between the two boards, and to the speaker socket and power supply.

When everything is complete check that the mains wiring is secure and well separated from the other wiring and that the power amplifier heatsink cannot touch the case. The amplifier is now complete and ready for testing.

TESTING

To test the amplifier it is necessary to have the power connected whilst the case lid is removed. Provided the mains connections have all been carefully insulated this should be possible with complete safety. Before applying power look over the mains wiring and ensure that there are no bare connections.

Begin testing by using an ohmmeter to check for continuity between the mains lead, earth wire and the case. Next, disconnect the positive supply wire (+V) from the power supply terminal block, and switch on the amplifier. Check that the voltage across capacitor C19 is about 28V and of the correct polarity. Switch off again and discharge C19 using a resistor (between 100 ohms and 1k).

If a multimeter with a current range of 250mA or greater is available connect this between the positive terminal of C19 and the +V wire to the power amplifier. Switch on and check that after an initial surge the current steadies at between 80mA and 120mA.

A higher current reading indicates possible reversed capacitors or diodes or faulty wiring. In this event the best policy is a thorough check of everything. The use of an i.c. voltage regulator (IC5) means that the fault current will be limited automatically and so damage is unlikely to occur even if a fault is present.

When the current reading is correct take the meter out of circuit and reconnect the +V wire directly to the power supply terminal block. A set of voltage checks can now be made and will reveal any obvious errors.

All voltages should be measured with respect to the negative supply rail (case) and be within 0·5V of the value given. First check that the output of IC5 is delivering 15V. The two terminals of the speaker socket should both be at half supply (7·5V).

Next check that the pre-amp board midrail voltage on the cathode of D1 is 7·5V. The same voltage should appear on pin 6 of all three pre-amp i.c.s. If all the voltages are correct it is likely that the whole circuit is functioning correctly and all that remains is to do a few audio signal tests.

The simplest audio signal test is to connect a speaker, turn up all three controls to mid setting and touch each input terminal in turn. There should be the familiar loud mains buzz, adjustable in volume by the appropriate controls. The RIAA equalised channel should give a deeper sounding buzz because of the built-in low frequency emphasis.

If all of these tests are satisfactory, switch off, fit the case lid and try using a few appropriate audio signal sources. The effect of the soft limiter is brought in by turning up the input control and turning down the master volume control. Using an electric guitar as a source it should be possible to get a smooth overdrive and sustain effect.

For use with sources where soft limiting is not required use lower settings of the input controls and turn up the master control to compensate. A few minutes experimenting will show how controllable the effect is and how it can be eliminated completely if required.

VARIATIONS

Although the amplifier as it stands can cope with most input signals, by changing a few component values its gain can be changed to suit other applications.

The soft limiting effect can be eliminated completely by removing diodes D6 and D7 and the overall gain of the mixer stage can be increased by increasing the value of resistor R14. A value of 470k will give a ten fold increase in gain.

Similarly the gain of the "flat" channel amplifier IC1 can be increased by reducing the value of resistor R8. A 10k resistor will give a ten fold increase in gain. Changing the values the other way will give gain reductions.

The input impedances of the "flat" channel are set by resistors R7 and R2. These may be changed to anything between zero and 2M2 without altering the gain of IC1. The value of resistor R6 will need to be reduced, if very low (below 4k7) input impedances are required, the potential divider effect of R2 and R7 must be taken into account when the input is connected via R2. There is plenty of room for experiment with these values for specific applications without any problems of stability or noise, so the user is encouraged to make what adjustments seem desirable.

No matter what the final use is, the amplifier will soon become an indispensible piece of equipment, much sought after by friends. So take good care of it! □

Robot Roundup

NIGEL CLARK

GCSE ROBOTICS

AS THE autumn term began a group of fourth year pupils at a North Wales secondary school began a course which will lead them to their taking the only GCSE examination in robotics in this country. They are the third group to begin the course but the first to be working with the experience of a two-year course at the school having been completed.

Two years ago children at St Richard Gwyn High School, Fflint, Clwyd, began a pilot course for the examination. Last summer saw 26 children receiving the results of their efforts.

The course was judged a success and will be continued. However, it had already been hailed as a worthwhile addition to the curriculum by the many schools which took an interest in its development, with one school having started its own course this year and others about to follow. Local industrialists who took children on placement were impressed by their development and abilities.

And it may have contributed to the person behind the course, Alex Whittaker, the school's director of microtechnology, being appointed adviser for microelectronics, information technology and computer education for Cheshire County Education Authority.

Whittaker also thought it had been successful in being able to remain close to his original intentions. He said soon after the pilot had begun that he wanted it to be, what he called, a real robotics syllabus which would allow the maintenance of intellectual honesty while giving valuable instruction which would enhance the pupils' employment prospects.

"I think we achieved that. What was particularly pleasing for me was that the results covered the whole range of ability, and didn't concentrate on the elite, and that when they went on their placements the children had the confidence to tackle all sorts of tasks," said Whittaker.

In writing the original syllabus these intentions led to the setting down of a number of criteria. These were the development of personal skills, work experience, project management, counselling and guidance, profiling a way of assessing a pupil's performance, tied to continuous assessment, and recognised certification at national level.

In practice that means the pupils research, specify, design, prototype, manufacture, document, test, modify, program and market various robotic devices. In addition they learn about the history and development of robots, with emphasis on the social and ethical impact on society. The economics are also examined.

The practical section is broken down into three, making a piece of hardware, a piece of software and their documentation. Each child has to make an interface and has to write the accompanying software but after that it is a matter of personal choice.

INITIATIVE

The projects completed this year included a flexible robot distribution system which sorted components and transported them by a monorail system to a variety of locations and, on a simpler scale, a shaft encoder system.

However, where the children were said to have shown the greatest initiative was in the documentation.

"They had to word process all their information and some of the results have been absolutely superb," said Whittaker. "One pupil even generated computer graphics to illustrate the work, which takes a lot of effort."

He added that the robotics pupils were getting more keyboard work experience than the children doing computer studies and that the effect on their use of English was far greater than would normally be expected from a technical course.

The result of following these aims was a lot of hard work for both the children and the staff and an approach which allowed total flexibility to allow the children to work in ways which suited them best.

"We did not just set the tasks and expect these children to produce the work. We encouraged them to go through the course themselves with us so that adjustments might be made."

The staff, in association with the examining board, were constantly looking for ways in which the course could be improved. Mostly it was fine tuning but one major change was made in the marking system, giving more value to the quality of the final presentation of the documentation.

MONEY

Although his school does have some facilities not available to others Whittacker does not think that a great deal of money would have to be spent to provide a similar course. "Most schools would already have much of the necessary expertise and equipment, which is why they write to us and visit us, not because they want to spend vast amounts of money."

He based his view on the realisation that robotics was not so much a new subject as a collection of old ideas put together in a different way. When he was setting up the course he looked at the existing staff and found, in common with many comprehensive schools, that there were people with skills in design technology, computing, hydraulics, pneumatics and microelectronics, all of which are needed in robotics.

However, he is missing out a few advantages of St Richard Gwyn school which others do not have readily available. It is a school which encourages the development of technological subjects and was receptive to Whittaker's ideas. It is also part of the Government's Technical and Vocational Educational Initiative giving it sufficient funds to equip fully a purpose-built laboratory with generous support from robotics suppliers such as Commotion and Greenweld.

TURTLE

The facilities allowed an interest to develop among the pupils who were soon designing and building their own turtles, even doing their own printing and etching of circuit boards. This was done out of school hours, during lunchtimes and after school. They became so proficient that other schools were demanding their products, including a turtle called Gwynbach which can now be found in every Clwyd secondary school.

The turtle has since been developed into the successful Trekker which is now built by Clwyd Technics and with which the school has a close relationship.

A further factor was the local examination board, the Welsh Joint Education Committee which was willing to consider being the examining body and took a keen interest in the initial development of the course and how it worked in practice.

Finally there is Whittaker himself. As he said when the course was being set up, he had often been encouraged to do something about the teaching of new technology and he had always been able to blame lack of resources. At St Richard Gwyn he had the resources and no more excuses. He tackled the challenge with enthusiasm, an enthusiasm which has not waned.

FUTURE

For the future there is much to be done which has grown out of the course. The school has a number of research projects with industry. Trekker, which at present is available for the BBC B is being adapted for Commodore machines and into Danish, and Whittaker is working on an 'A' level in information technology and business management.

The Differential Amplifier

Joe Pritchard

As an inveterate experimenter, I occasionally come across some circuit configuration that, while simple, is very useful indeed. In this article, I want to take a look at one such circuit—the differential, or difference amplifier. Let's begin with what such a circuit does. For once, the name is very descriptive; it is an amplifier that amplifies the difference in the voltage applied to its two inputs. This is shown in Fig. 1.

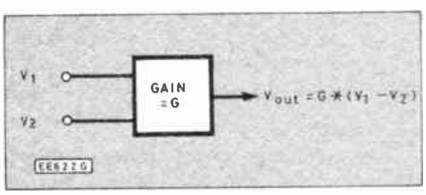


Fig. 1. Basis of the differential amplifier.

The circuit is thus useful for detecting small changes in voltage that may be superimposed on a larger voltage that is common to both input terminals. Well, what is in this black box? In the past, it would have been a fairly messy arrangement involving several transistors. But today, with operational amplifiers, we can put a difference amplifier together with one chip and four resistors! Fig. 2 shows the basic configuration for a differential amplifier.

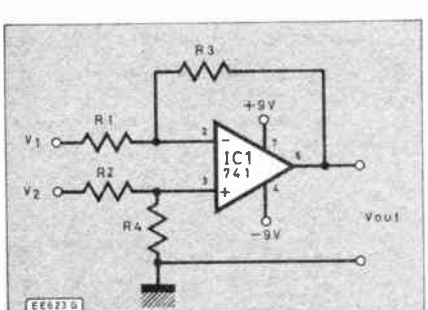


Fig. 2. Basic configuration.

The output voltage would ideally be related to the two input voltages by the relationship:

$$V_{out} = \frac{-R3}{R1} * (V_1 - V_2)$$

(where R1 = R2 and R3 = R4).

Note that I said ideally. However, reality takes over and there is a further parameter that describes the behaviour of a differential amplifier. This is called, wait for it, the common mode rejection ratio, or CMRR for short.

CMRR

From the above equation, it follows that V_1 = 0V and V_2 = 0·001, and V_1 = 10·0V and V_2 = 10·001V should both give the same output voltage. After all, the differences between each pair of voltages are the same, 0·001 volts. In a real amplifier, this isn't so. The two "common mode" voltages, 0V and 10V, are never totally ignored in real difference amplifiers. The common mode voltage affects the output by different amounts for different amplifiers. Part of this problem is caused by mismatches in the values of R1 and R2 and R3 and R4, but other causes include the manufacturing tolerances of the amplifier.

The better the amplifier, of course, the less effect the common mode voltages will have on the output. A measure of this is the CMRR, which measures how much the circuit "ignores" the common mode voltages. This is quoted in dB, the higher the figure the better the CMRR. CMRR varies with both the size of the common mode voltage and its frequency.

PRACTICAL DEMONSTRATION

For a practical demonstration, try the circuit in Fig. 3. This allows us to

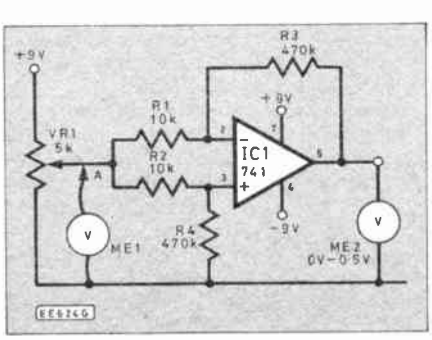


Fig. 3. Practical circuit.

measure the output voltage from a difference amplifier whose input terminals are at the same voltage. You will see that the effect on the output voltage is not very high, but it can be annoying in some situations. The gain of the circuit shown is 47. I measured output voltages of between 0·2 and 0·4 for different 741 op. amps. in the same circuit. The output voltage also increased with increasing input voltage.

Such a circuit is very useful in that it allows you to choose values of R1, R2, R3 and R4 that are accurately matched. The experiments that I carried out were done with five per cent tolerance resistors; for accurate work, 0·1 per cent devices are often used. But as we haven't got big budgets, a trial and error matching process with a circuit like this will often produce closely matched components. The aim, of course, is for as low an output voltage as possible.

In some circuits, R4 often has a trimmer in series with it so that a fine adjustment of the CMRR of the amplifier as a whole can be made. The fact that good CMRR from such a circuit relies on R4 and R3 being closely matched in value means that the usual method of varying the gain of an op. amp. based amplifier, altering the value of the feedback resistor between inverting input and output, cannot be used here. If it were, varying the gain would vary the CMRR of the circuit unless we also varied the value of R4. Not exactly convenient, so the usual trick is to make the differential amplifier with a fixed gain, and follow it with a conventional inverting amplifier with variable gain. Such a circuit is shown in Fig. 4. Here, the following relationship exists between input and output voltages.

$$V_{out} = -V_{in} * \frac{(VR1 + R2)}{R1}$$

In fact, in some situations, where a high CMRR is more important than gain, the differential amplifier is made with four resistors of the same value. This gives a gain of one, but it is easier to match all the resistors from a single large batch. In this situation, an amplifier such as that in Fig. 4 might well provide all the gain.

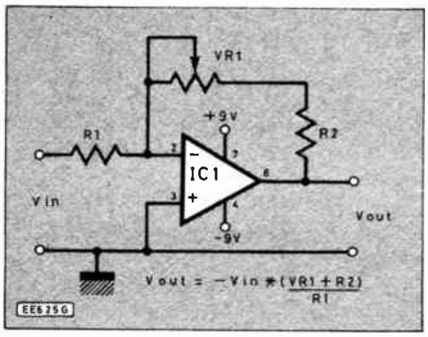


Fig. 4. Inverting amplifier with variable gain.

As to actually selecting values for the resistors, select R1 and R2 so that they are higher than the impedance of the voltage sources providing the inputs. Once this has been done, R3 can be selected to set the gain, and R4 = R3. Having said that, though, R1 and R2 can be chosen to be as high as possible so as to provide a high input impedance for the amplifier. If you do this, then the chances are that the gain of the differential amplifier will not be all that high, as you will then have to find a correspondingly large pair of resistors for R3 and R4. However, further gain can be easily provided, as we've already seen.

As to a choice of operational amplifier, the 741 is as good as any for starting your experiments. One reason for this is that it is "well behaved"; high gain amplifiers of any type will occasionally "take off" into spontaneous oscillation. This is still possible with the 741 but less likely. If I get this problem, I often limit the gain of that particular amplifier to a level at which stability can be maintained. If you want to try other operational amplifiers, the TL072 is quite nice, as is the LM324. As to practical applications, well . . . use your imagination. But to start you off, here are some simple circuits.

SOUND OPERATED SWITCH

A simple sound operated switch circuit is shown in Fig. 5. This will respond to claps, telephone ringing, etc. It is especially sensitive in the range 3–4kHz. The input device is a piezoelectric insert from Tandy (Part Number 273–069) which was originally intended to be an output "bleeper" driven by a 3–4kHz square wave. However, when sound impinges on it a voltage is developed across its terminals, which we can then amplify. The input voltage is fairly large, so I haven't bothered with accurately matching the input impedance of the amplifier to that of the insert. Any sound will cause the l.e.d. to flicker, and the addition of a Schmitt Trigger device will allow a logic signal suitable for TTL or CMOS logic circuitry to be obtained.

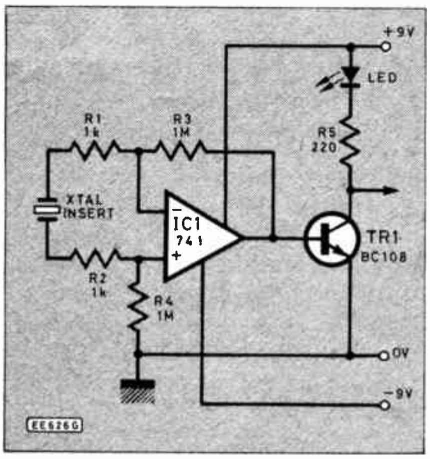


Fig. 5. Simple sound operated switch.

The insert could be mounted at the end of a long run of cable, any mains hum being rejected by the CMRR of the amplifier. One subtle point to note here is that the voltage must be identical in both input leads for it to be rejected. If you run the leads to the insert by different routes, then each lead will be subject to different amounts of mains interference which will cause different amounts of voltage to be induced in each lead. This will lead to some mains interference getting through. Thus the cables to the insert should follow the same route.

PHOTODIODE AMPLIFIER

There are a variety of devices, such as the photodiode, that are voltage sources capable of producing a very small current. Fig. 6 shows a circuit with a gain of 1 that allows the voltage produced by the photodiode to be measured on a meter. The voltage output depends upon the incident light, but will be in the 0 to 0·25V range.

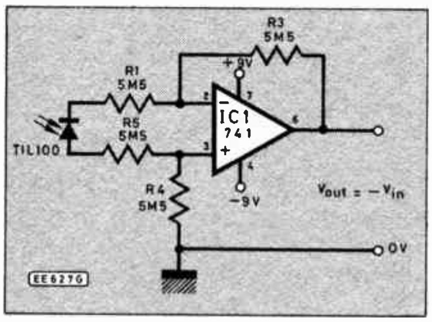


Fig. 6. Measuring photodiode voltage.

INSTRUMENTATION AMPLIFIER

We have already said that the input impedance of the differential amplifier should be higher than the impedance of the voltage source that is driving the inputs. So, if we want a general purpose differential amplifier, we should try and get as high an input impedance as possible. Such a circuit is often used in scientific instruments, and so is often called the instrumentation amplifier. Fig. 7 shows two possible arrangements of this circuit.

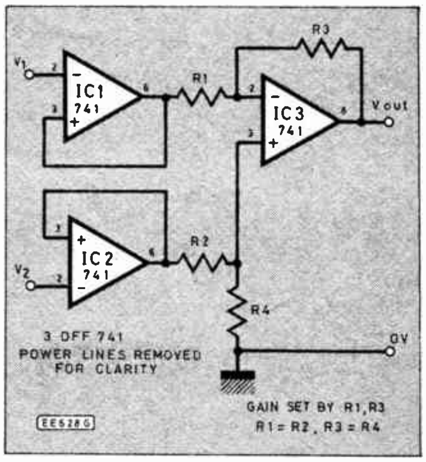


Fig. 7(a). Instrumentation amplifier.

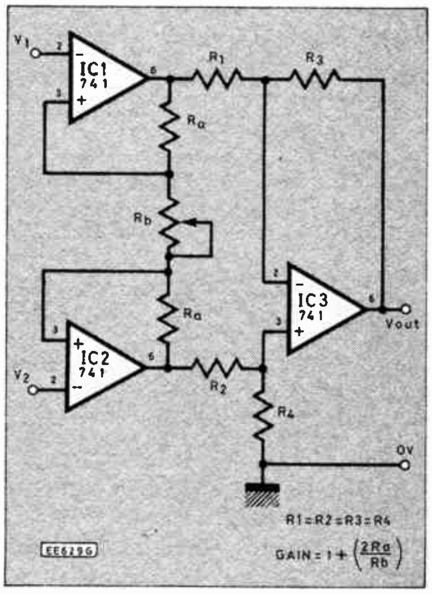


Fig. 7(b). Instrumentation amplifier with variable gain.

Of these two circuits, Figure 7(b) is the best, offering variable gain and requiring no great matching of R_a and R_b. In these circuits, the CMRR of the amplifier is provided by IC1 and IC2. These two amplifiers also provide a very high input impedance, making the circuit useful with a variety of voltage sources. In each of these circuits, R4 can be replaced with an arrangement like that in Fig. 8. Assume that R4 is to

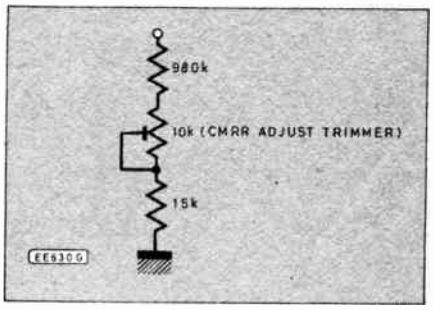


Fig. 8. Arrangement to replace R4 in Figs. 7(a) and 7(b).

be a 1M resistor. The trimmer allows the value of "R4" to be varied between 995k and 1005k, thus allowing adjustment of the CMRR of the circuit.

The measurements made with instrumentation amplifiers are often in the low frequency part of the spectrum. For this reason, capacitors are often used to provide what is called "high frequency roll off", which is a reduction in the gain of an amplifier with increasing frequency. Fig. 9 shows a typical arrangement of capacitors to limit the high frequency response of the circuit. The values of C1, C2, C3 and C4 are chosen to suit the maximum frequency that the amplifier is designed to be used with. The value of these capacitors should decrease with increasing frequency. The capacitors are especially valuable in limiting the response of instrumentation amplifiers to low frequency radio signals, such as Radio 4 on 200kHz.

If you want an instrumentation amplifier with a very high input impedance, then FET operational amplifiers can be used, such as the TL072.

AC DIFFERENTIAL AMPLIFIER

It's possible that the signal of interest might be superimposed on a fixed difference voltage. For example, a fixed difference of 100mV on top of which there is a 2-3mV a.c. signal that we are interested in. The simple way around this is to "block" the d.c. signal with capacitors. This gives us the circuit in Fig. 10.

The gain of such a circuit is now dependant upon the values of input capacitor, input resistor and feedback resistor R3. At a given frequency, the input capacitor will have a certain impedance, or "a.c. resistance". Thus the output voltage of the circuit is related to the input voltage by the expression.

$$V_{out} = -V_{in} * \frac{R3}{R1 + (1/2*\pi*f*C1)}$$

where f is the frequency of operation. The gain of the amplifier will thus fluctuate with frequency, and the input capacitors can thus also be used to limit the frequency response of the amplifier.

If you experiment with these circuits, whether differential amplifiers or instrumentation amplifiers, then the following points may be useful to you.

PRACTICAL POINTERS

1. Choose a "well behaved" amplifier, such as the 741 when you start experimenting.
2. For accurate work, matched resistors are needed.
3. For high gain amplifiers, clean circuit boards are next to godliness! Don't leave soldering flux, pencil lines or finger prints around the wiring side of the p.c.b. or Veroboard. Also, ensure good soldered connections. Any of these problems could lead to radical alterations in the gain of the amplifier.
4. There is no point in introducing hum into the circuit via the power lines if you've gone to the trouble of producing a circuit that has low CMRR. Batteries are thus preferable in situations with noisy mains.
5. If batteries are used, take care when they run down. Low batteries can lead to rather mysterious problems, such as violent oscillation.
6. For a.c. differential amplifiers, the input capacitors should have matched values of capacitance, but remember that the tolerance of capacitors is often quite large.
7. Fig. 11 shows the pinouts of some suitable op.amps. for experimenting. □

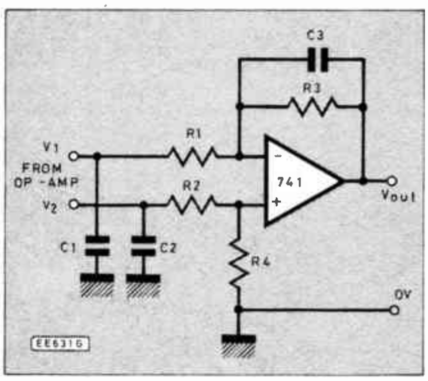


Fig. 9. Circuit with high frequency roll off.

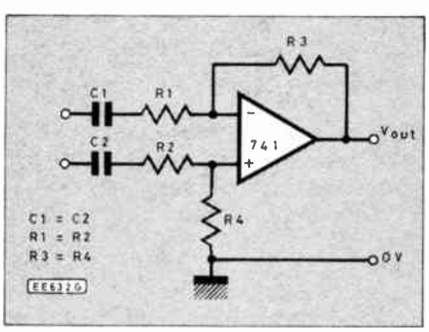


Fig. 10. D.C. blocking circuit.

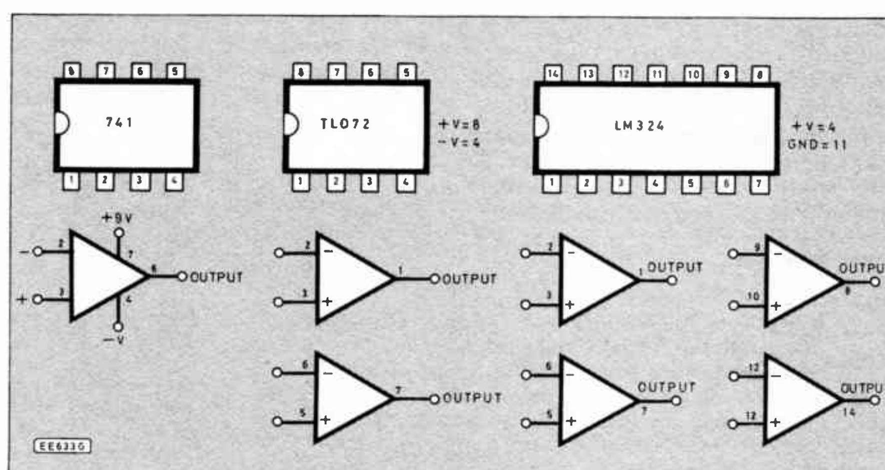


Fig. 11. Pin outs of some amplifiers suitable for experimenting.

NEWS
...from the world of electronics

WINNING IDEAS

Finalists in BT's annual "New Ideas Competition" produced ideas to improve service and maintenance. A special award went to the designer of a telephone aid which allows customers with a speech impairment to make calls.

The New Ideas Competition is the culmination of British Telecom's continuing Awards for Suggestions Scheme. Ideas adopted through the scheme during the year automatically go forward for consideration in the annual competition. Of several hundred original entries, nine reached the final.

First place and £2000 went to a team from Nottingham who devised an automatic network analyser (ANA) which generates test calls, plots the path of each call and alerts staff to potential faults developing. The team was made up of Geoff Wesson, an assistant executive engineer, and technical officers Tom Henson, Joe Oskiewicz and Ian Rollinson.

Second place in the competition went to Jim Harrison, a technical officer from Bristol, for his idea to modify an exchange processor programme resulting in speedier testing and allowing more lines to be tested. He won £1000.

Keith Beddoe, a technical officer from Southampton, won third place for a microprocessor-based monitoring system for the tariff pulses generated within a telephone exchange. He won £500.

A special award of £1500 was made to Ernie Huggins, winner of last year's competition, for his invention *"Claudivs Converse"*. This is an aid which allows speech impaired customers to use the telephone.

The winning team, from left to right, Joe Oskiewiez, Tom Henson, Ian Rollinson and Geoff Wesson. Their idea for an automatic network analyser won them £500 each.

Automatic Network Analyser

The Automatic Network Analyser (ANA) is a centralised callsending unit which uses the latest technology to make a balanced programme of test calls. When a deterioration is detected, the local exchange maintenance staff are allerted. They then investigate the situation, using hold and trace callsenders, thus taking the fault out of service as soon as possible.

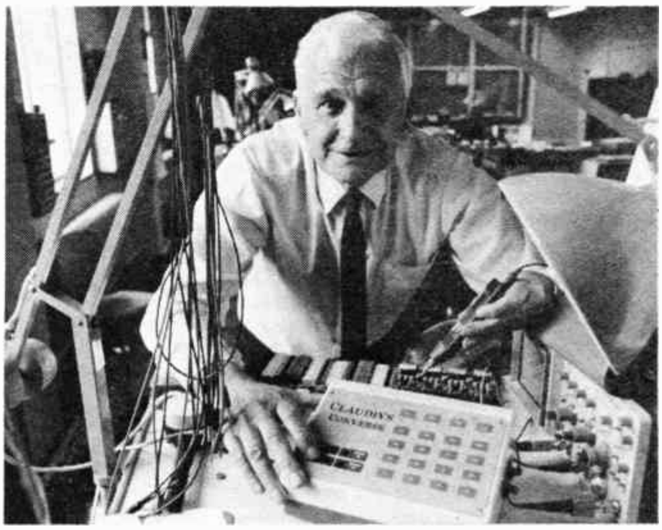
The system has 17 processor-controlled callsenders each with 2 channels. Each of the 32 channels have a callsending programme and produce a set of results. It allows one man, familiar with the area and its local routes, to monitor 32 exchanges.

Claudivs Converse

Ernie's invention, called Claudivs Converse, can either be connected to a telephone line or used on its own to broadcast words, sentences, or mesages through its loudspeaker.

It offers a combination of words giving access to a total of 64 possible phrases. In addition, there are four red emergency buttons to enable the user quickly to telephone the fire, police or ambulance services, automatically giving the caller's home address.

Phrases are recorded for the customer and then transferred digitally on to a speech synthesis microchip which is later installed into the unit. Male or female voices can be reproduced, in any language.



A special award of £1,500 went to Ernie Huggins, the designer of an aid which enables speech impaired people to communicate over the phone.

Thanks to Claudivs Converse, Beattie Brooks can speak to friends again for the first time since having an operation to remove her larynx two years ago.

"This machine is a bit of a miracle, it has given me a 'voice' again," Beattie scribbles on the notepad she keeps beside her machine.

SUPERCHANNEL

Superchannel and Music Box have finally agreed the terms under which they will jointly operate a European satellite TV service. The service is expected to be operational in the autumn and will be called Superchannel.

One of the hurdles the new satellite station will have to overcome is the question of transmitting the service within the UK on cable networks. IBA permission is needed for this and Superchannel are fairly confident that this will be granted.

The company will be owned by a consortium made up of ITV contractors and The Virgin Group. Thames TV has taken an option to join the group by the end of the year.

a regular feature for the Spectrum Owner...

by Mike Tooley BA

Plan your own escape from the limitations of the Spectrum

LAST month we looked briefly at the two types of RAM device used in the Spectrum and dealt with the construction of a "custom designed" joystick. This month we show how it is possible to overcome one of the Spectrum's most severe limitations—the lack of an effective "escape" key! First, however, we start with something for all you budding programmers . . .

BASIC

Long suffering users of the Spectrum fall into two quite distinct camps; they either love the Spectrum's BASIC interpreter or they hate it! Regular users of other computers, in particular, generally find the Spectrum's tokenised keyword system extremely cumbersome.

If, like me, you fall into the "hate" rather than the "love" camp, there's no need to despair any longer since help is at hand in the form of several BASIC extensions, which not only provide a host of extra commands but also free the user from the awkward keyword system.

In the next three months we shall be taking a look at three of the best of these programs; BETA BASIC, MEGA BASIC and LASER BASIC.

BETA BASIC

BETA BASIC is produced by Beta Soft and comprises an 18K extension to Spectrum BASIC. RAMTOP is lowered to 47270 and this leaves the user with approximately 23K of memory. The program is supplied on tape and takes approximately 2 minutes to load. Transfer to microdrive is, however, extremely straightforward and, following the instructions supplied, only requires a few minor changes to the program.

Surprisingly, and unlike some other enhanced BASIC interpreters, there is little outward difference when BETA BASIC is initially loaded. The user is confronted with the same screen layout complete with flashing cursor in the bottom left hand corner of the screen. This, however, belies the underlying power of the program which, to gladden the hearts of all those advocates of "structured programming", provides a very comprehensive range of control structures. These include procedures (using DEF PROC and END PROC), DO WHILE, LOOP WHILE, DO UNTIL, and LOOP UNTIL.

BETA BASIC allows the user to choose between the normal Sinclair BASIC keyword entry system and conventional key entry (i.e. spelling everything out in full). If that is not enough, you even have the option of mixing the two systems! If, for example, you can remember where a particular keyword is, simply force "K-mode" and use a single keypress. If, on the other hand, you cannot immediately locate the keyword, just spell it out in full. Nothing could be neater nor more elegant than this!

Neat Line

Another nice feature of BETA BASIC is that it is possible to produce very much neater listings. Lines that are longer than one screen width are indented so that only line numbers occupy the first four columns on the left hand side of the screen. This vastly aids program readability! However, not content with this, BETA BASIC goes even further and provides no less than six variations of list format, including options which indent FOR NEXT loops and omit line numbers.

It also provides a WINDOW command which allows users to set up separate areas of the screen to which it is possible to LIST and PRINT. Furthermore, each window has its own print position, attributes, INK and PAPER colours, and character size. This makes for some very interesting and impressive effects which are more akin to machines like the Macintosh, QL, and Atari ST.

The character size command, CSIZE, permits the user of a large range of character sizes limited only by the resolution of the video display. On test, 85 characters per line was found to be a reasonable limit for a good quality colour monitor whilst the limit for a normal colour TV was found to be 64 characters per line. The smallest number of characters per line is just 1; i.e. a single character occupying the entire screen!

The enhanced editing, automatic line number generation, trace, search and change, and re-numbering facilities all help to simplify the programmer's task. However, unlike the two other BASIC enhancements tested, BETA BASIC does not incorporate a sprite facility. Whilst this might not handicap those who are developing applications in the engineering/scientific fields, it may represent a severe limitation to the aspiring games programmer.

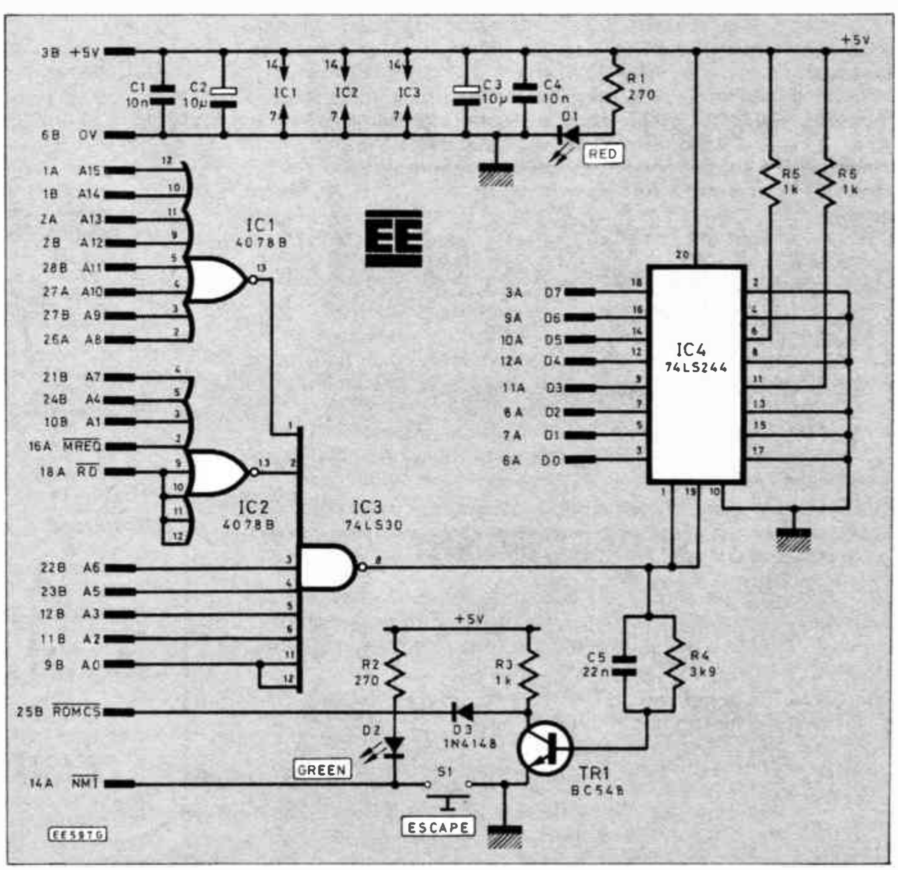
A 90-page A5 size manual is included in the BETA BASIC package. This is logically presented and contains numerous example routines. The manual also describes the 26 new functions which BETA BASIC adds to ZX-BASIC by means of an invisible BASIC line 0.

Overall, BETA BASIC is so powerful that it is hard to do justice to it in just a few words. It is arguably the best general purpose ZX-BASIC enhancement to have become generally available and it can be thoroughly recommended. BETA .BASIC costs £14.95 and is available from **Beta Soft at Dept EE, 92 Oxford Road, Moseley, Birmingham, B13 9SQ.**

Basically Speaking

Finally, if you are a beginner to BASIC and require an effective tutorial, you could

Fig. 1. Complete circuit diagram of the Escape Interface.



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R2	270
R3	1k
R4	3k9
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C2	10μ 16V p.c.b. elec.
C3	10μ 16V p.c.b. elec.
C4	10n polyester
C5	22n polyester

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D1	Red l.e.d.
D2	Green l.e.d.
D3	1N4148
IC1	4078B
IC2	4078B
IC3	74LS30
IC4	74LS244
TR1	BC548

See Shop Talk page 537

Miscellaneous

S1 miniature p.c.b. mounting normally open push switch.
14-pin d.i.l. sockets (3 required); 20-pin d.i.l. socket; 0·1" matrix Veroboard (or similar) measuring approximately 80mm × 80mm; 28-way open end double-sided 2·54mm pitch edge connector (e.g. Vero part number 838-24826A).

Approx. cost Guidance only £6.50

do a lot worse than take a look at Jim Maitland's *Basically Speaking*. This package, comprising a book of around 100 pages and a cassette tape, provides an informative and entertaining introduction to the language.

Divided into twelve sections, *Basically Speaking* deals with such topics as loops, string handling, decisions, and random numbers and contains five useful appendices (including one devoted to correct use of the keyboard). The book claims to "bring programming within everyone's reach" and its friendly and informative approach is ideal for the newcomer.

Exercises (together with answers) are provided for the reader and the accompanying cassette tape not only saves a great deal of typing but also gives a useful starting point for further program development. *Basically Speaking* can be obtained from **Computer Publications at Dept EE, 5 Western Drive, Shepperton, Middlesex, TW17 8HJ.**

Escape Interface

Regular readers of this column will know that, in recent months, we have taken the lid off several of the Spectrum's more useful system variables. The addresses of these variables (there are over sixty of them!) are published in several reference books including the original (and much maligned!) *Spectrum Handbook*.

These lists of system variables invariably refer to a two byte variable located at address 23728 as simply "not used". What is not apparent, however, and the reason behind this variable's disuse, is that there is a fundamental error in the Spectrum's operating system code. A tiny (just one byte) error is responsible for what is arguably one of the Spectrum's worst failings —the lack of an "escape" key.

If you are still wondering what this is all about, consider what happens when a program crashes and the Spectrum just sits there ignoring your keyboard input. What do you do? The answer, of course, is either press the "reset" switch on your Spectrum Plus or remove the power connector if you have an older Spectrum.

Either way, in order to render the machine once more usable, you have had to erase your program and data from the Spectrum's memory. Wouldn't it be nice if the Spectrum had an "escape" key which would allow you to regain control and drop you back into BASIC or wherever, without paying such an awesome penalty? Fear not, now you can recover from all those annoying and time wasting crashes using, guess what, our "not used" system variable at 23728!

NMIADD

The Spectrum, like most microcomputers, incorporates a "non-maskable interrupt" routine. This allows for interruption of the CPU, regardless of what it is doing, whenever the active-low non-maskable interrupt (NMI) line is activated. If the Spectrum's operating system had been written properly, the user would have been provided with the means of inserting the start address of his own NMI code by means of a vector in RAM using a system variable called, not surprisingly, NMIADD. This, of course, is the function of the bytes at 23728 and 23729.

The programmer unfortunately miscoded part of the Spectrum's NMI routine, which starts at 66H, with a relative jump on non-zero rather than a jump on zero to address 70H. The net result of this disastrous error is that the Spectrum resets itself whenever the NMI line is activated regardless of whether, or not, NMIADD actually contains a valid address. The solution to this problem involves changing a JR NZ instruction into a JR Z instruction—the difficulty, of course, is that the code is in ROM and therefore unalterable as far as the user is concerned!

The circuit diagram shown in Fig. 1, shows a hardware solution to the problem which pages out the ROM whenever the CPU attempts to read the memory at the offending address. The "escape" interface then provides the correct byte whilst the offending one remains out of harm's way inside the ROM.

If you have any comments or suggestions, please send them 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'!

Next month: We shall be taking a look at MEGA BASIC and describing the construction, testing, and use of the *Escape Interface*. See you then!

PLEASE TAKE NOTE

Infra-Red Beam Alarm *(September 1986)*
Pages 455 and 457. The diode D5 should be reversed, i.e. the cathode k (marked with a bar) should be connected to TR5 base.

Flat TV Aerial *(August 1986)*
Page 427, Fig. 1. Note that the 90cm foil "element" is continuous and should NOT be broken as shown, see photo.

Geiger Counter *(August 1986)*
A number of readers have queried the occurence of random clicks emitted by the Geiger Counter.

These are quite normal and are the natural background events detected by the GM tube. With the ZP1310 tube, an average occurence of around 2 clicks per minute is to be expected. This is an average taken over several hours.

Since they are random events, several clicks may sometimes occur close together, others may be spaced by a minute or two. Other types of tube, having different sensitivities, will produce a different average background detection rate.

The occurence of these random clicks also serves as another way in which the functioning of the unit can be checked.

Fig. 7, page 405, there should be a link between the two inner tags of the "SEC" windings of T1. (Lead marked 7 and the lead which goes to S1.)

DOWN TO EARTH

BY GEORGE HYLTON

QUANTIZING

"Quantizing noise" is a term which crops up from time to time in articles on digital systems. In particular, it is used in connection with systems such as digital recording and digital speech transmission.

In these and similar systems, what begins as an analogue signal is converted into digital form. Later—after transmission, or during playback—it is converted back again to analogue form. Quantizing noise is the term for the distortions to the analogue waveform which result from this process.

VANISHING QUANTITIES

In view of the frequent claims that digital systems eliminate noise and distortion it may be surprising to learn that waveform distortion is an inevitable consequence of the analogue to digital, digital to analogue conversion-reconversion process. The claim, despite this, is a reasonable one, because it is possible to engineer the process so that the distortion has no perceptible effect. In mathematical terminology, by good engineering the distortion can be made vanishingly small.

GRAININESS

The way in which waveform distortion arises can be seen by looking at a rather crude conversion-reconversion process (Fig. 1). Here the analogue voltage waveform (a) is a sine wave. The first step in the digitization or quantizing process is to sample it at regular and frequent intervals.

The sample amplitudes (b) which result are each made to generate a train of pulses which form a binary coded number. This number corresponds to the amplitude of the sample. Thus 00000000 may represent an amplitude of zero and 11111111 the maximum possible amplitude. (Real systems may use more than eight digits.)

The binary coded sample amplitudes are transmitted, or recorded, or manipulated electronically according to the needs of the system. Finally they are converted back into analogue voltages (d).

Each voltage level is held until the next arrives. The stepped waveform which results can be seen to contain the original sine wave, but also a lot of unwanted rapid fluctuations at the sampling frequency.

In drawing these waveforms I've chosen a rather low sampling rate, so that the irregularity or graininess of the recovered analogue waveform shows up clearly, see Fig. 1. If (a) were a 1kHz audio tone in a speech or music chain its decoded equivalent (d) would sound horribly distorted. But if the audio frequency were 15kHz the distortion would not be apparent to the ear because it consists of frequencies too high to be heard. The ear, in other words, would act as a low-pass filter to remove the quantizing noise.

To make the noise disappear from any frequency of interest, such as our 1kHz tone, all that needs to be done is to raise the sampling frequency. If (e) is a 1kHz tone recovered from a system with a high sampling rate it is obvious that a low-pass filter could remove all the noise.

A rule of thumb for digital systems like this is to make the sampling frequency at least twice the highest analogue frequency. Thus in a digital telephone system, where an audio band of 300–4000Hz is good enough, the sampling frequency could be 8kHz. For a hi-fi audio system it might be 40kHz. For a digital TV system it has to be many MHz.

Since each sample is encoded into many binary pulses the bandwidth needed to carry the encoded signal is much greater than the sampling frequency. If a digital TV signal samples at 12MHz and each sample contains 10 pulses then to transmit this calls for a bandwidth of the order of 120MHz. This is the reason why digital TV cannot be fitted into the existing TV broadcast bands, though it is just possible, in theory, to use digital audio for TV sound.

In digital audio systems it might seem as though a very modest low-pass filter would be good enough to eliminate quantizing noise, since the sampling frequency (for hi-fi sound) is ultrasonic anyway. In practice, digital audio systems usually contain a very good low-pass filter. This is needed because, after decoding (reconversion) the recovered audio signal will be passed through ordinary audio amplifiers.

No amplifier is perfect, and some degree of intermodulation between signals in it is inevitable. If significant amounts of the sampling frequency and its by-products are present they might intermodulate with the audio signals and produce audible noise. A good filter, placed immediately after the decoder, avoids this risk.

ZERO NOISE?

Readers may have deduced, from the way that the analogue to digital encoding system works, that noise might be reduced. There must be some level of voltage at the analogue input which is so small that it fails to change the output from 00000000 to 00000001.

In which case, if this very small voltage were noise, it would be eliminated. In practice, the weakest signals in an audio system may be so close to the noise voltages that little improvement is possible.

For a full orchestra, the range in level from pianissimo to fortissimo is enormous. If the system is designed to handle the fortisssimo passages without overloading then the pianissimo bits are likely to be only moderately over the level of the noises present in a record studio, whether these emanate from people breathing, the air conditioning, transistors in microphone amplifiers or whatever.

What is true of digital systems, however, is that once the signals are quantized it is easy to ensure that no noise is added

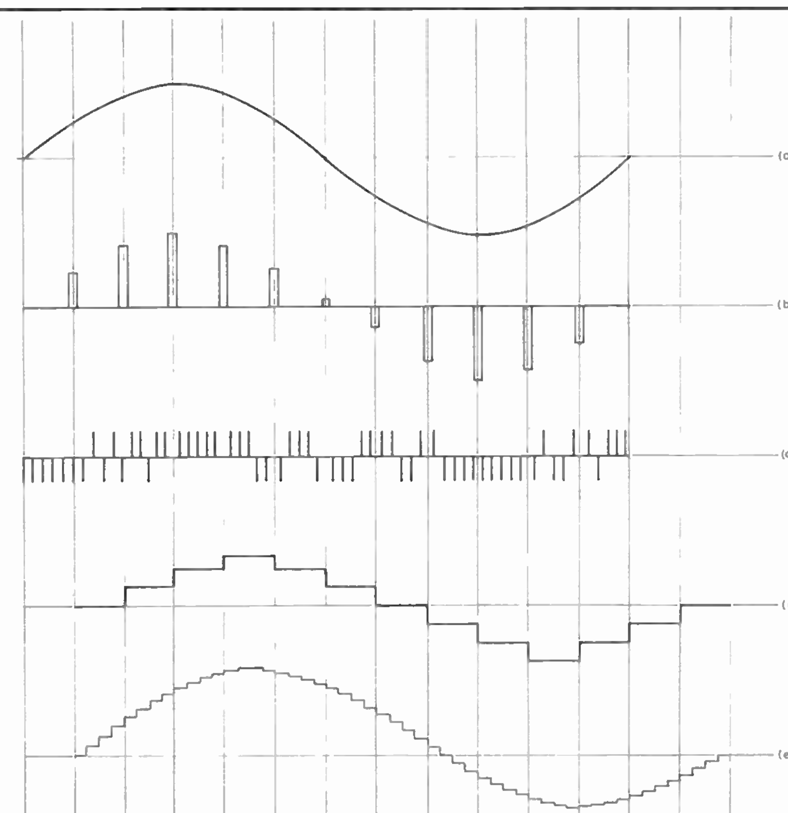

Fig. 1. Quantizing signals. (a) Analogue signal. (b) Sampled amplitudes. (c) Encoded samples. (d) Decoded signal with quantizing noise. (e) Decoded but higher sampling rate.

by whatever is done to them while in digital form. The ordinary noise of a transmission channel, for instance, should have no effect.

Of course, once reconverted to analogue form the signals are no longer protected and it behoves the designer to ensure that his analogue amplifiers are as good as possible.

MAGIC BY NUMBERS

Perhaps the most spectacular success of signal quantizing is to be seen on television. Many of the special effects used in "commercials" are produced by manipulating quantized signals.

Once a signal exists in the form of numbers (which is what quantization means), it can be manipulated like numbers. Geometrical transformations such as generating a mirror image of a TV picture are easy. With the right algorithms the picture can be wrapped around a cylinder or a sphere or distorted in almost any way imaginable.

To make manipulation easy the signals for a complete "frame" are stored, after encoding, in a "frame store". In this, every picture point is represented by a quantized signal. They can then be manipulated ad infinitum. Contrast can be enhanced or reduced. The picture can be expanded (by repeating picture-point numbers so that it swells beyond the screen) to produce zoom effects.

If entire frames are repeated the speed of a moving picture is reduced, giving a synthetic slow-motion effect. Carried too far this causes jerkiness, but in the latest gear each extra frame is the average of the preceding and following frames, so that the jerks are smoothed out. This facility is clearly a great boon to a cartoon animator who wants to minimise the number of frames which must be created "by hand" to make his characters move smoothly.

The effective noiselessness of quantized signals means that they can be recorded and re-recorded ad lib without degradation. A boon to the editor who wants to get every frame right before adding it to the sequence which forms, say, a ten-second commercial.

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This month's voucher is attached to the outside of the magazine

LETTERS

Impressions Update

Sir—I last wrote to you in October '85, concerning the contents of EE and my general impressions. I thought that you wouldn't mind an update.

I have been very pleased with the number of test equipment projects since then and in your own words "... those who have built them should have a very useful suite of test equipment ..." In the August '86 issue, running through the contents, the projects are OK, as usual, but there is still this leaning towards computers with *On Spec* being a regular feature.

Someone was behind me at the check-out of the bookshop where I bought EE and he said "Snap, I see you are buying EE too—what do you reckon on it this month?" When I told him that I thought there was too much abstract padding and waffle, also sections on computers—he agreed entirely!

To continue about the August issue, *Amateur Radio*, these enthusiasts are a race apart and have their own magazines. *BBC Micro*, another computer feature! *For your Entertainment*, just a load of waffle and not much to do with electronics. And then there's *News*—what's happening in the world of electronics—it's nothing of the kind is it?

I wouldn't mind seeing the letters boosted and encouraged as this could occupy several pages.

Isn't there an implied smugness about assuming that you are giving people the magazine that they want when in fact you do nothing to find out? What about using two pages as a questionnaire referendum which could be very illuminating?

Projects I would like to see are: a sound only TV Tuner; an ioniser air rejuvenator; a wobbulator and the Oscilloscope that I mentioned before. You mentioned in your reply last time "that it is far cheaper to buy a ready made scope than to construct one". You have to be joking!

The type of scope I have in mind uses a 3in. to 3½in. c.r.t., surplus stock, priced as low as £7 to £10 and the other parts are more or less "common or garden" in their availability.

However, despite all this I am a committed and regular purchaser and reader but I would still like you to consider my observations.

G. E. Glover,
Sheffield,
Yorks.

All points duly noted. Any further views would be appreciated; we are considering a readership questionnaire.

Intelligent View

Sir—I generally glance through your magazine so that I can take an intelligent (?) interest in my husband's hobby, but this time you've excelled yourself!

The *Flat TV Aerial* by M. James (August '86)—I made it, it works. Please may we have more of these so simple projects.

Betty Mardell (Mrs A.H.),
Brighton.

Astonished

Sir—I would not normally write a letter commenting upon or criticising any material published in EE—after all, who am I to pronounce upon fellow contributors—but I really must take Robert Penfold to task concerning his article *Actually Doing It* in EE&EM August '86 issue.

I was astonished to read the opening paragraphs of the article and really do think he is out of touch with the hobby when he says that *"he knows of no electronic law which states that more fun is derived from building a well finished project than from putting together one with a relatively crude appearance"*.

He further comments upon the current "trend" of assembling projects to emulate professionally-manufactured equipment, as though this is a bad thing.

Naturally there are hobbyists who are perfectly happy to throw together a project and build it in whatever is to hand—a tobacco tin for example—and they couldn't give a hoot what it looks like so long as it works. And jolly good luck to them. Others may not have all of the practical skills of building a neat unit but nonetheless the hobby has a lot to offer them.

However, it is the job of EE&EM to set an example to its readers, many of whom will be novices in the subject, by setting standards in constructional and educational articles it publishes, and to suggest that there is no more to gain in "fun" by making a project look professional is an opinion which I would not have associated with such a respected technical author.

What is NOT apparent in his article—indeed he seems to scoff at the idea—is that there *IS* indeed a good deal of *FUN* to be had by a constructor who, instead of throwing a project together, assembes his model with great care and workmanship, both when etching and soldering a p.c.b. and when working on the cabinet or housing. Such a constructor will take much longer to carefully build his unit bit by bit, taking a pride in his work at each and every stage, and perhaps spending a few pounds more on improving the appearance both inside and out.

He may even go to more elaborate lengths (like I do!) to embellish his project to set it apart from a mere home-made anonymous gadget which does a particular job.

I think that attempting to attain professional standards of assembly and appearance is a target which EE should be continuously promoting. It does not cost anything to take more care when building a unit; the main danger is that the constructor will rush a job in his enthusiasm to finish the gadget and get it up and running. The results of being more thorough and workmanlike will be evident in the end product, and if you can afford better-looking parts then so much the better.

If we were to liken Mr. Penfold's views with, say, d.i.y. woodworking, then he would be advocating that it's perfectly alright to build a rickety bookcase, it doesn't matter too much what it looks like providing it holds the books!

It simply isn't on these days to suggest that it is acceptable to build an eye-sore which will do the job. A magazine such as EE&EM should strive to promote the fact that the hobby has a great deal to offer in terms of the challenge of construction and the pride of owning a device which YOU built to a professional standard throughout. Readers should indeed be encouraged to "make it look good" almost as a matter of ethics!

If a reader hasn't the skills, time, patience or money to build a high quality unit, then fair enough: let's however continue to promote high standards of constructional workmanship in every aspect of our hobby, so that the novice can achieve maximum benefit and enjoyment from it in terms of pride in a job well done. Anyone making do with a "hammer and nails-job" prototype is missing out.

Incidentally the "Opto Repeater" unit illustrated in Mr. Penfold's article was constructed by myself.

A. R. Winstanley,
Ulceby,
South Humberside.

I seem to be accused of inciting constructors to throw their projects together in a haphazard way, paying no attention to the appearance of the finished unit. This was not my intention, and on reading through the opening of the article again I find it difficult to see how this interpretation could be put on it.

The point I was trying to make was simply that if you are the type of person who has difficulty getting a neat finish on things, or you are simply not interested in this aspect, then this does not matter in the least and don't bother—if this aspect does appeal to you then here are some useful tips. In other words, I was simply suggesting that readers should pursue whatever aspects of the hobby they most enjoy and should not feel that they are cheating if they largely ignore other aspects.

It was not my intention to "scoff at the idea" of there being more fun to be had from carefully finishing a project, and I would certainly encourage constructors to at least give things such as p.c.b. production and front panel finishing a try. Mr. Winstanley seems to suggest that everyone, like himself, will enjoy electronics as a hobby more if they finish every project in a careful and painstaking manner.

I would suggest that it is not true, and that there are plenty of people who enjoy putting projects together, seeing how they work and how well (or otherwise) they work, and then put them aside until they are eventually plundered for parts for the latest construction project. Technology and experimentation are surely valid aspects of hobby electronics, and I think that there are many constructors who would find some aspects of project construction a bit of a chore.

Mr. Winstanley suggests that EE&EM should always promote "professional standards", but I would not accept this except where safety is involved. We are amateurs not professionals, and can have the luxury of doing our own thing in our own way if we choose. Professionalism requires abilities and expense which go beyond what many of us can muster, and I can see no point in putting people off the hobby by trying to force on them a professionalism with which they will not be able to cope (which I believe has happened to some extent in the past).

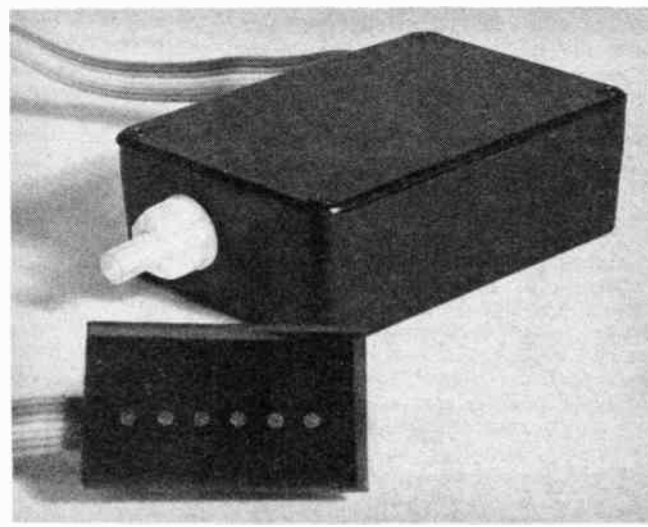
The d.i.y. woodworking analogy strikes me as a poor one since woodworking is almost totally concerned with practical skills, the quality of the finished product, and the production of a functional finished article. My point is that electronics can be in this category, but it need not be. This is up to the individual hobbyist.—Robert Penfold.

LIGHT RIDER

DISCO LIGHTS ... LAPEL BADGE ... CHASER LIGHT

Three projects that will certainly test the creative eye of the experimenter. You could even create your own version of "Kit" of *TV Knight Rider* fame.

LAPEL BADGE



MARK STUART

THE Lapel Badge project was started to give a 10 year old something different to amaze his friends at the school disco. A row of six red l.e.d.s are arranged to be lit in order from left to right and then back from right to left continually, completing two full cycles every second. Each l.e.d. in turn is switched on and then switched off followed by the next one along the line and so on.

If the l.e.d.s are switched on and off abruptly the display appears to flicker unpleasantly. This is completely eliminated by connecting capacitors across the l.e.d.s so that each one fades gradually. The result is a tail of three or four l.e.d.s of decreasing brightness which appears to follow the leading light.

Reasonable battery life is achieved by the use of a new breed of low current l.e.d.s designed to operate at 2mA with plenty of brightness. The badge is clearly visible in normal daylight and appears to be extremely bright at night.

CIRCUIT DESCRIPTION

The circuit diagram for the Lapel Badge is shown in Fig. 1. There are many ways of switching the l.e.d.s in the necessary manner but this circuit has a certain simplicity and cunning which may impress even the best engineers.

The dual 3-input NOR gate IC1a and IC1b form a simple two gate oscillator which runs at about 16Hz. The inverter section of the device is not used in this circuit design.

Very briefly capacitor C1 charges first in one direction and then in the other direction, via resistor R2, as the outputs of IC1a and IC1b change state. Oscillation is maintained by positive feedback through resistor R1 to the input of IC1a, which ensures that the output of IC1a switches over each time the capacitor charges.

The output from IC1b is a square wave which is used to clock the Decade Counter/Divider, IC2. Ten outputs are available from IC2 which change from low to high one by one in turn each time the i.c. receives a clock pulse. Only one output can be high at a time, so on each clock pulse the output that was high becomes low as the next output changes from low to high and so on.

If the light emitting diodes were connected to all ten outputs and the i.c. clocked, a single illuminated l.e.d. would appear to move along from left to right. After ten pulses the far right l.e.d. would go out and the display would appear to jump back to the left end as the cycle began to repeat.

Switching the l.e.d.s from left to right and then back from right to left is more complicated and is achieved by means of the diodes D1 to D10. These are connected so that the l.e.d.s light in the order shown in Table 1.

Table 1 shows that above six clock pulses the l.e.d.s (D12 to D15) are lit in reverse sequence via diodes D9, D7, D5 and D3. The two l.e.d.s at the ends of the display are lit once each cycle and all the others twice, once in one "direction" and then in the other. Resistors R4 to R9 limit the current

Fig. 1. Complete circuit diagram for the Lapel Badge.

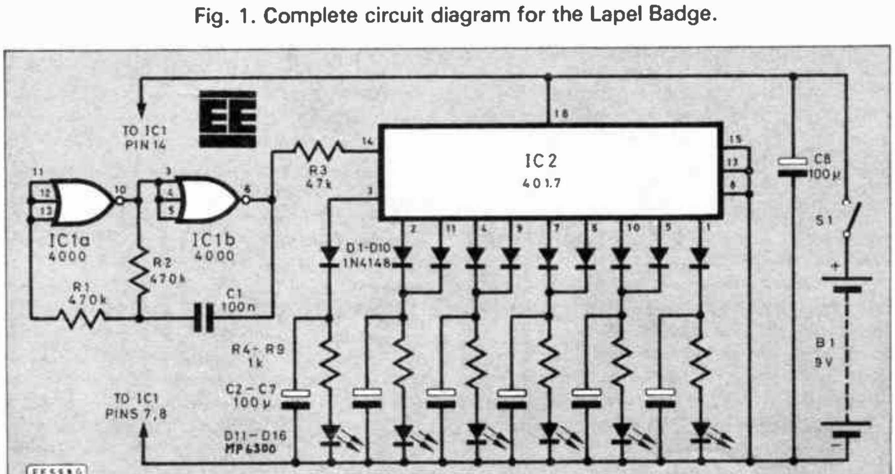


Table 1: Display Switching Sequence

IC count	IC pin high	Diode conducting	(D11–D16) l.e.d. lit
0	3	D1	D11
1	2	D2	D12
2	4	D4	D13
3	7	D6	D14
4	10	D8	D15
5	1	D10	D16
6	5	D9	D15
7	6	D7	D14
8	9	D5	D13
9	11	D3	D12
0	3	D1	D11

in each l.e.d. to about 5mA with a fresh battery.

The electrolytic capacitors C2 to C7 improve the visual effect enormously by discharging gradually through the l.e.d.s and resistors after the i.c. output has turned off. This gives a slow fade-out to each l.e.d. and produces the desired "tail" of decaying light which appears to follow the leading light. As the capacitors are charged directly from the outputs of IC2 their charge time is relatively short and so each l.e.d. appears to turn on instantaneously.

CONSTRUCTION

The circuit for the Lapel Badge is built on two printed circuit boards: the main board and the display board. These boards are available from the *EE PCB Service:* code EE540 and EE541.

The circuit is built in two parts. The small display board carries the six l.e.d.s and is connected by a short length of ribbon cable to the rest of the circuit which is housed in a small plastic box.

An area of track on the display board is provided so that a small safety pin can be soldered on to it to allow the badge to be attached to clothing. The plastic box is carried invisibly in a convenient pocket.

The component layout of the Main Board is shown in Fig. 2. To make sure that the battery will fit into the specified case it is essential to use modern miniature components in all positions and to mount them as close to the board as possible. A socket may be used for IC1 if required but not for IC2, as it fits underneath the battery.

Construction is quite straightforward. Ensure that the diodes, capacitors and i.c.s are all fitted the right way round. The leads from C8 should be protected with insulated sleeving and left as long as possible. Remember to fit IC1 before connecting C8.

When all components are in place turn over the board and crop all the leads as close as possible to the tracks to ensure that the board can sit as low down in the case as possible.

DISPLAY BOARD

Turning to the Display Board, the component layout is also given in Fig. 2. The six special low current l.e.d.s are fitted so that their domed lenses pass from the track side of the board into close fitting holes. Their two leads are soldered where they lie flat on the adjacent copper tracks. Note that the polarity is indicated by the thickness of the leads, the thick lead being the cathode (k). Also take care not to overheat the l.e.d.s whilst soldering as the plastic used for all l.e.d.s is particularly susceptible to melting and causing the leads to come adrift inside.

INTERWIRING

Interwiring between the main and display boards is also shown in Fig. 2. The necessary cross overs in the ribbon cable should be made close to the main board inside the case. The leads at the badge end are connected directly to the copper tracks on the rear of the board.

In the prototype a small saddle of sleeved wire was soldered over the ribbon cable to reduce the stress on the connections. Alternatively a good adhesive may be used. There is plenty of room for individual interpretation of the badge part of the project, but check that it works in standard form first before trying anything too clever.

The connections for the ribbon cable, battery and switch leads are made to the main board by passing a small stripped length of each wire through its hole in the top side of the board and soldering to the copper track on the underside.

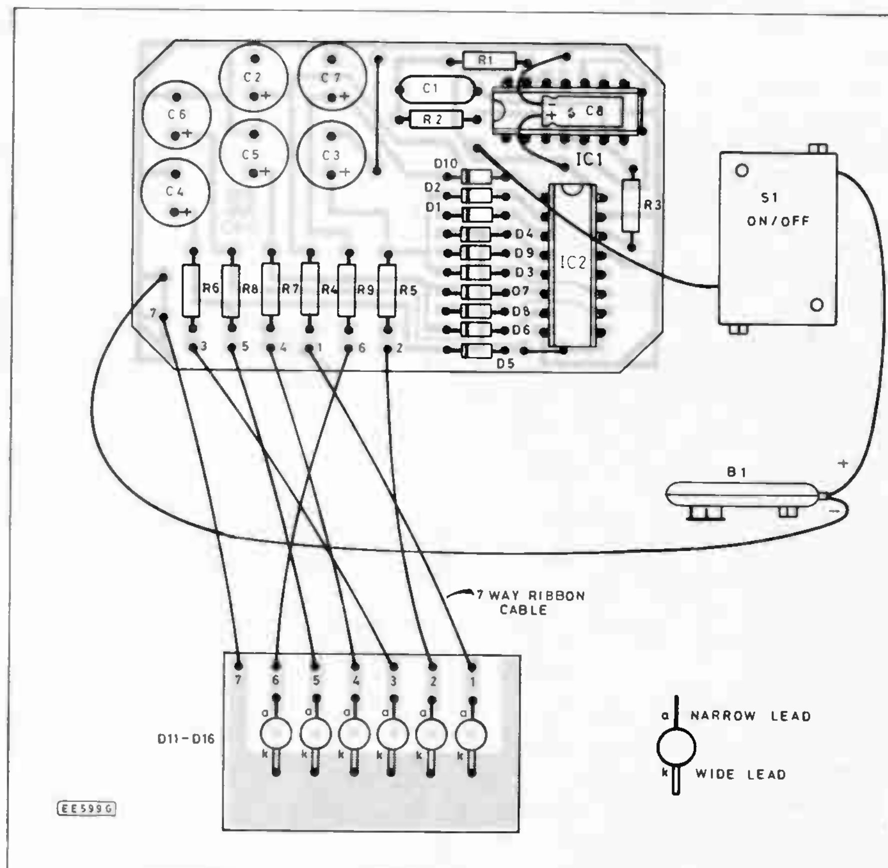


Fig. 2. Component layout for main board, display board and interwiring between the two boards. Full size p.c.b. masters are shown below. These boards are available from *EE PCB Service*, code EE540 and EE541.

COMPONENTS

LAPEL BADGE

Resistors
- R1,R2 — 470k (2 off)
- R3 — 47k
- R4–R9 — 1k (6 off)
- All ¼W carbon ± 10%

Capacitors
- C1 — 100n poly. C368
- C2–C8 — 100μ radial miniature elec. 10V (Size critical) (7 off)

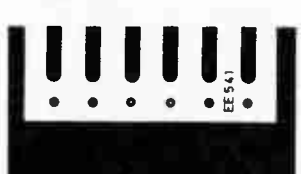
Semiconductors
- IC1 — CD4000 Dual 3-input NOR gate + inverter
- IC2 — CD4017 Decade Counter/Divider
- D1–D10 — 1N4148 (10 off)
- D11–D16 — MP 6300, high efficiency Red l.e.d.s (6 off)

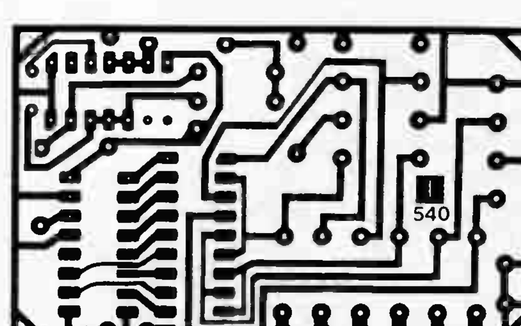
Miscellaneous
- S1 — s.p.s.t. push-on/push-off switch

PP3 battery and clips; 7-way ribbon cable; case, 71mm × 46mm × 22mm; 14-pin i.c. socket; red Perspex, 25mm × 38mm; small safety pin; printed circuit boards available from the *EE PCB Service*, order code: main board—EE540, display board—EE541.

Approx. cost Guidance only £9.75

See Shop Talk page 537





The layout of the parts in the plastic case is shown in Fig. 3. As everything is such a tight fit there is no need to fix the board or battery, but small sticky pads may be used if required. A hole must be drilled for S1 and a shallow notch cut in the edge of the case so that the ribbon cable can pass out under the lid.

TESTING

There is very little to be said about testing since the circuit is either on or off. The main things to check are that the component values and polarities are correct and that there are no errors in the wiring.

The current consumption is about 15mA with a fresh battery. As the battery voltage falls the brightness of the l.e.d.s will decrease but the circuit will continue to function correctly right down to about 5V. The current consumption will fall as the voltage drops, prolonging the life of the battery.

For special applications the values of resistors R4 to R9 can be increased or decreased to give a dimmer or brighter display. For a very bright display it is possible to use two 5mm "ultra-bright" l.e.d.s in series in each position, set the resistor values to 330 ohms, and use a 12V supply.

The circuit is quite happy up to 18V and so can be used in a car without problems. Ideally a small resistor (100 ohms) should be connected in series with each electrolytic capacitor to limit the peak current in IC2.

The stepping speed is set by R2 and C1 either or both of which can be changed as required. If a variable speed control is required this can be achieved by replacing R2 with a 470k "reverse" log potentiometer. □

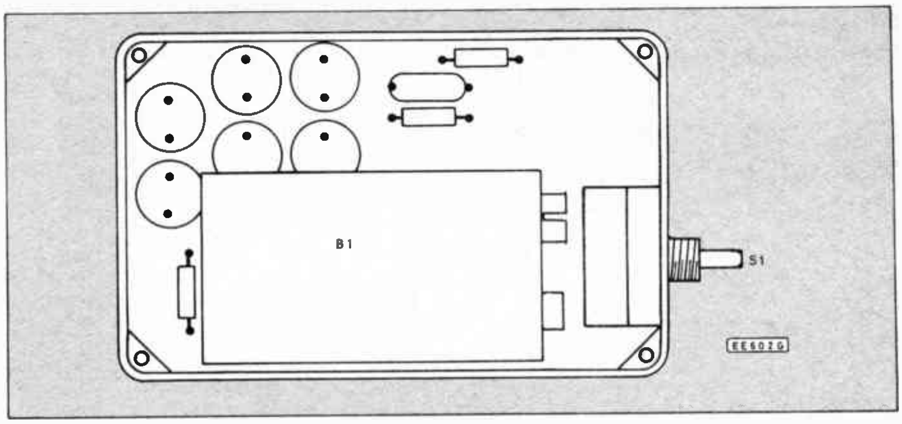
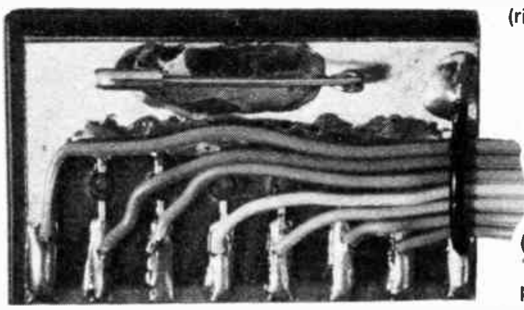
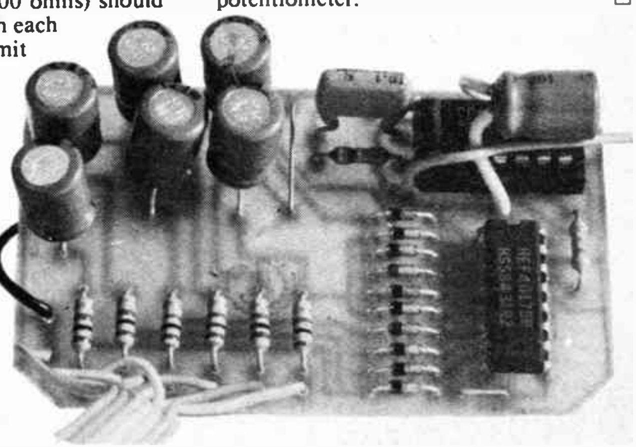


Fig. 3. Layout of components inside the small plastic case.



(left) The completed "badge", with safety pin.



(right) The completed main driver and switching board.

DISCO LIGHTS

MARK STUART

THE EXTENSION of the Lapel Badge circuit to give a high power mains voltage display is a simple idea. The result when, connected to a bank of bulbs arranged in rows, crosses, stars or concentric circles is very effective indeed.

Each of the 6 original l.e.d. outputs has been adapted to drive a 5A special sensitive gate triac. Without heatsinking each triac will be able to switch banks of small lamps totalling over 500 watts. As only one bank is switched on at any time the mains supply current is not excessive. To enhance the range of effects a variable Speed Control has been added.

CIRCUIT DESCRIPTION

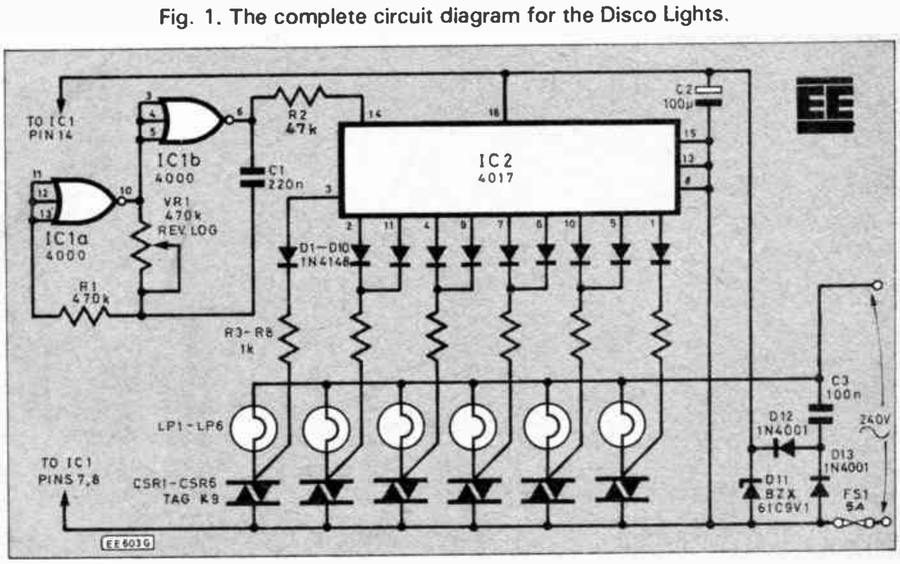
The circuit diagram for the Disco Light Rider is shown in Fig. 1. Each of the outputs of IC2 is fed to the gate terminal of a triac which switches mains voltage. Special sensitive gate triacs, CSR1 to CSR6, are required so that they can be driven directly from IC2 without problems.

The power for IC1 and IC2 is derived directly from the mains via a series capacitor dropper C3. This method is very effective for small currents (10mA in this case) and is very efficient as there is negligible power dissipation in the capacitor. In contrast a resistor carrying 10mA would be dissipating 2·5W.

The operation of this type of circuit is quite simple to understand. The capacitor C3 passes the a.c. mains voltage signal to diodes D11, D12 and D13. During negative half cycles of the mains, current flows via D13 into C3 and during positive half cycles current flows via D11 and D12. As D11 is a Zener diode the voltage across it must exceed its rating (in this case 9·1V) before it can conduct. The result is a series of half-wave 9·1V positive pulses which are smoothed by capacitor C2 to drive the rest of the circuit.

The main disadvantage of this type of circuit is that a short circuit fault in the capacitor C3 will apply the full mains supply voltage with catastrophic results. For this reason a special mains suppressor

Fig. 1. The complete circuit diagram for the Disco Lights.



COMPONENTS

DISCO LIGHTS

Resistors

R1	470k
R2	47k
R3–R8	1k (6 off)

All ¼W carbon ± 10%

Potentiometer

VR1	470k reverse log.

Capacitors

C1	220n miniature polyester C368
C2	100µ 25V radial electrolytic
C3	100n 250V a.c. suppressor type

Semiconductors

IC1	4000 Dual 3-input NOR gate + inverter
IC2	4017 Decade Counter/Divider
D1 to D10	1N4148 (10 off)
D11	BZX61C 9V1 Zener
D12,D13	1N4001 (2 off)
CSR1–CSR6	TAG K9 Triacs (sensitive gate) (6 off)

Miscellaneous

TB1	10-way 2A terminal block
FS1	5A 20mm quick-blow fuse
LP1–LP6	Mains lamps, colours and shape to choice (see text) (6 off)

14-pin i.c. socket; 16-pin i.c. socket; p.c.b. mounting fuseholder; case, Plastic 145mm x 95mm x 55mm minimum; screw fit knob; wire; printed circuit board available from the *EE PCB Service*, order code EE542.

Approx. cost Guidance only £18.50

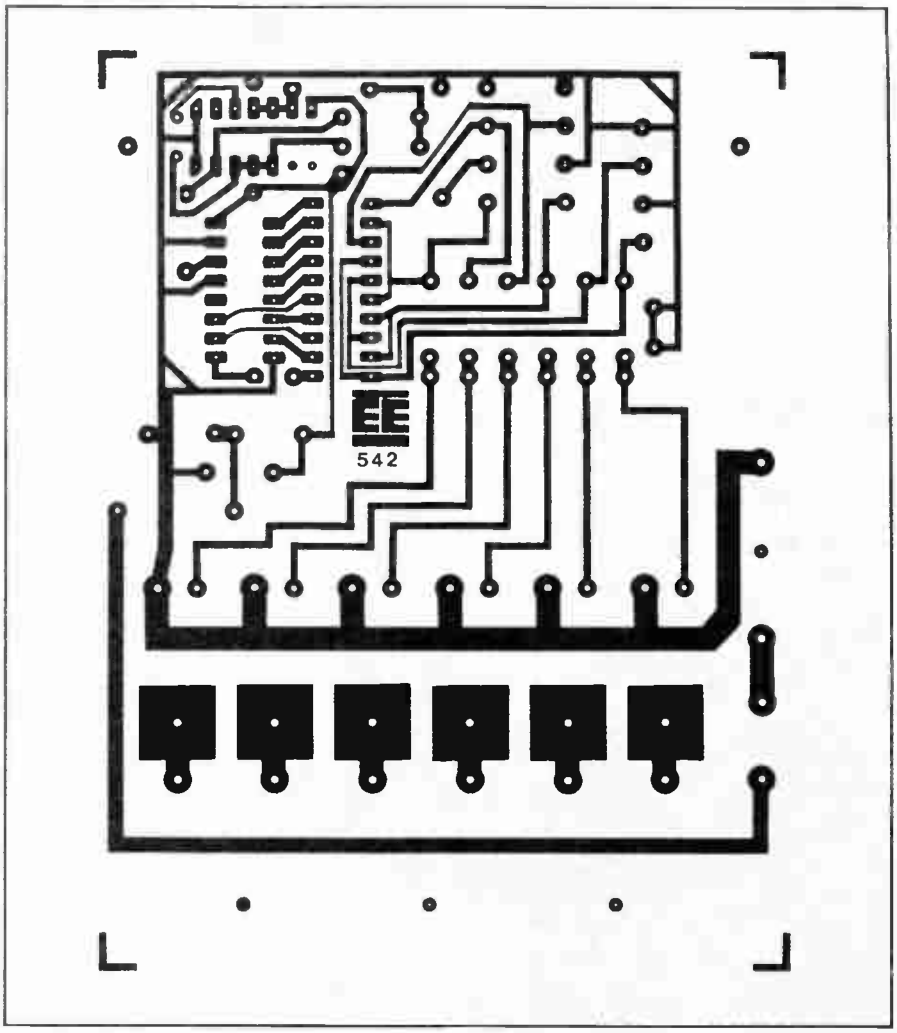


Fig. 2. Full size printed circuit master pattern for the Disco Lights. This board is available from the *EE PCB Service*, code EE542.

See Shop Talk page 537

capacitor is specified. Provided this is used the chances of a breakdown are very small indeed.

A second disadvantage is that the whole of the circuit is connected directly to the mains supply. This is not a problem in sound-to-light effects and similar circuits which are already connected to the mains in any case.

The big advantage is that a bulky heavy and expensive mains transformer is not needed.

CONSTRUCTION

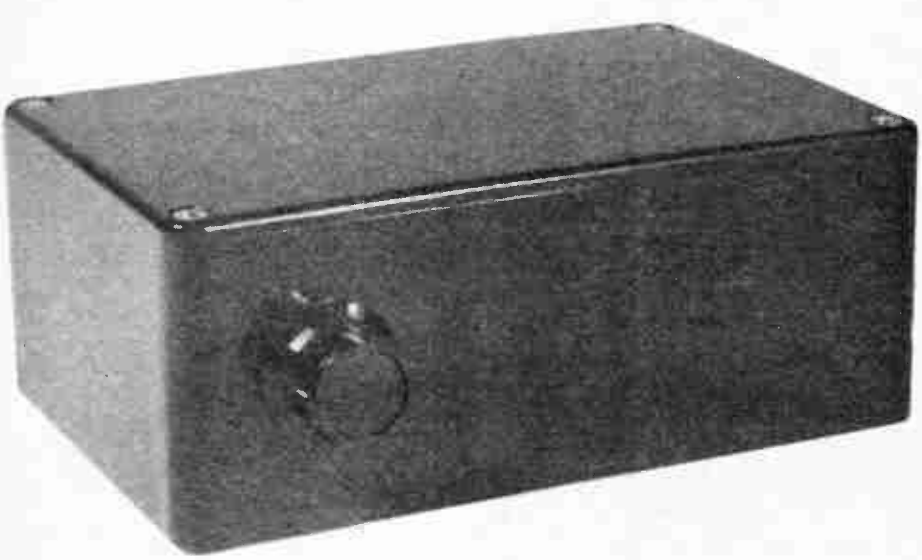
Because of the mains voltages present in the Disco "Light Rider", constructors should be very careful when building this unit. It is advised that only persons experienced in mains circuits should tackle this project and extra care should be exercised when testing and checking the circuit.

To keep cost to a minimum the circuit is built on a single printed circuit board housed in a plain plastic box. This board is available from the *EE PCB Service:* order code EE542.

The component layout and p.c.b. master pattern (full size) is shown in Figs. 2 and 3. As the tabs on the triacs are connected to the MT2 terminal the mounting screws have been used to make the connection to the board and the MT2 leads removed.

A standard 2A terminal block is used to make all of the connections from the mains and to the lamps. All six banks of lamps share a common mains neutral connection. To keep the board layout simple the connections for the lamp do not follow in a strict order and so a little wire-crossing is needed when the connections are made.

The Speed Control potentiometer VR1 (which should have a plastic insulated spindle) must be mounted on a bracket from the board so that its insulated spindle



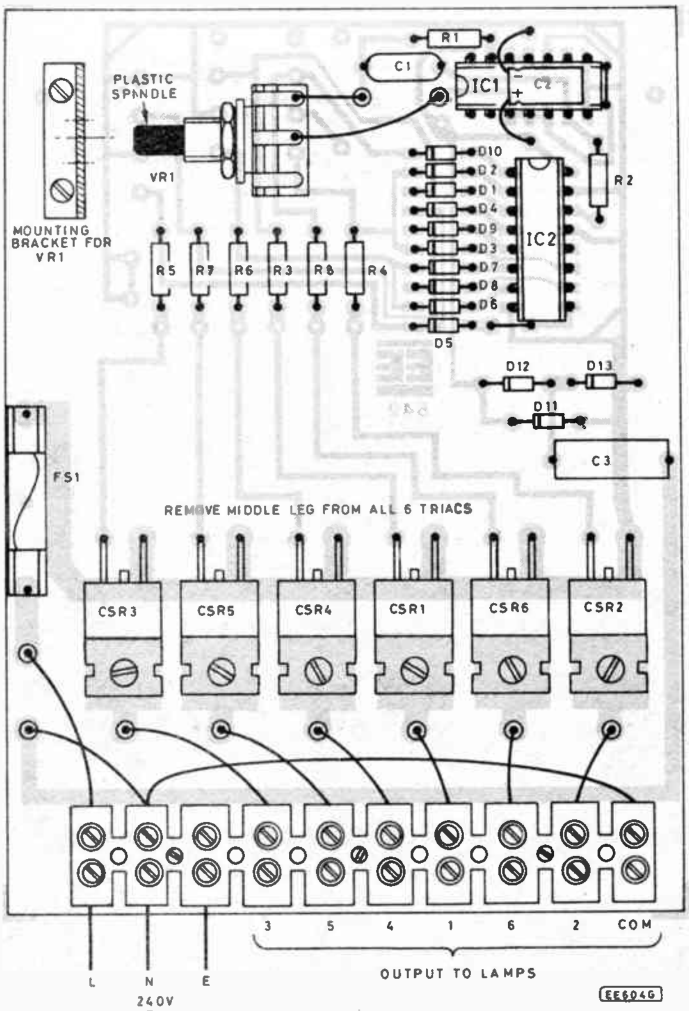


Fig. 3. Component layout and interwiring for the Disco Lights. Note that this board must be housed in a PLASTIC case.

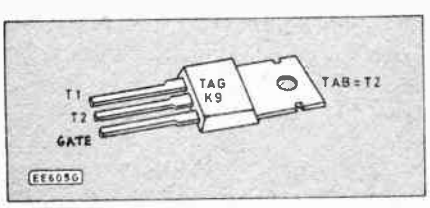
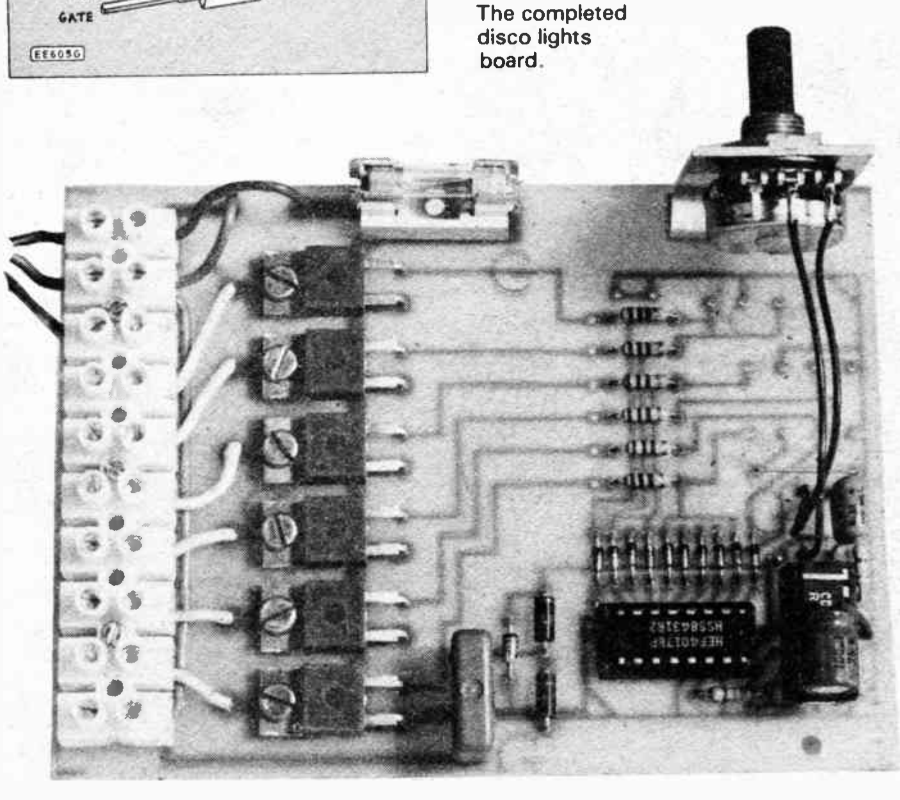


Fig. 4. Pinning details for the thyristors CSR1–CSR6. Note the T2 lead is cut short and the "tab" used for this connection.

The completed disco lights board.



passes through a close fitting hole in the case. This is to ensure that even with the control knob removed it is impossible to touch any part of the circuit that may be live. A "reverse log" potentiometer is specified because this gives a very smooth control of speed over a wide range.

Only two connections are made to the board as shown in Fig. 3 and the assembly of the rest of the board is straightforward. Take particular care with the three diodes D11 to D13 to ensure their correct polarity.

Once the board is complete it should be tested at low voltage and then fitted into a plastic case before testing at mains voltage. The incoming and outgoing leads should be fed through close fitting grommets and should have strain relief clamps fitted just inside the case to restrain them and prevent them from being pulled out accidentally. The board should be mounted on sticky pads or with nylon nuts and screws so that there are no exposed metal parts to become live.

TESTING

Ideally the circuit should be tested first at *low* voltage. This can be done by applying 9V d.c. across diode D13 with the negative side connected to its anode. With the Speed Control set at minimum it should be possible to see the triac gates pulsing in turn by using a multimeter set to a low d.c. voltage range. The voltage on each gate should pulse up to 1·2V approximately.

A separate 6–12V a.c. source and a number of low voltage bulbs can be used to check full operation of the triacs. Keep the 9V d.c. supply connected and connect the a.c. supply to the *L* and *N* terminals. Connect the bulbs to each output and they should be turned on and off in the correct order. Check that the Speed Control works, and the circuit is ready for testing at mains voltage.

Before testing at mains voltage the board must be fitted into a suitable all plastic case. Disconnect the low voltage supply and take ***extreme care*** when making measurements. With the mains connected *all* parts of the circuit should be considered to be *"live"*. Use a good multimeter with insulated test probes. Apply the mains to the circuit; if the power supply section is producing 9V across diode D11 all is well and all that remains to be done is a quick test with six mains lamps.

IN USE

Once the unit is working satisfactorily it can be connected to whatever type of display is required. Remember to use cable rated at mains voltage for the interconnections. Combinations of shapes, colours and lamp types can be arranged to produce exactly the effect required.

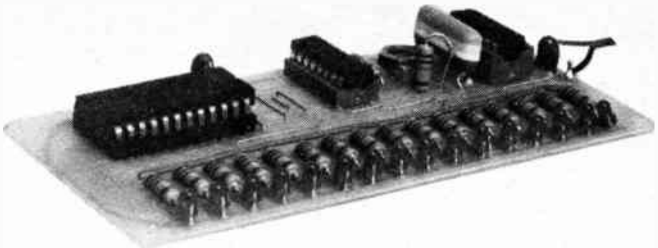
Unlike l.e.d.s it is not possible to turn the triacs off slowly simply by using capacitors. Instead the thermal inertia of the lamp filaments is relied upon to produce a gradual fade out. At slow speed setting the fade is relatively fast and so the lamps will appear to switch abruptly but at higher speeds the fade becomes significant and a very pleasant smooth effect is achieved.

At very high speed settings the frequency of the oscillator approaches mains frequency. This gives rise to a number of very strange effects. Some of which are quite interesting. If preferred the upper range of speed can be limited by connecting a 22k resistor in series with VR1.

□

CHASER LIGHT

G.R. HAYNES



THIS project simulates the red light which sweeps to and fro on the front of "Kit" the computerised car in the TV series *Knight Rider.*

Although designed primarily with novelty in mind and not for mounting on car bonnets, there are useful applications for this circuit.

It could, for example, be used to add that little bit extra to home-made robots, be they kit or self-designed. Or, the l.e.d.s could be arranged in different patterns using different colours to produce interesting displays.

The circuit is not limited to driving l.e.d.s however. If a suitable interface is used any type of lamp can be driven, making the circuit suitable for "disco lights" etc.

The number of outputs required is selectable up to a maximum of 16 by a single wire link. The prototype used all 16 outputs. The speed of the display is adjustable from dead slow to a blur by an on-board preset potentiometer.

A feature of the circuit is the ability to disable the display without removing the power to it. For instance, when a robot is "idle" preventing unnecessary drain on the battery.

Since the circuit uses CMOS i.c.s it will operate over a wide supply range (3V–15V) and is very economical on battery power.

PRINCIPLE OF OPERATION

A simplified block diagram of the circuit is shown in Fig. 1. For normal operation Disable is low. When high however the oscillator is stopped and all l.e.d.s are turned off.

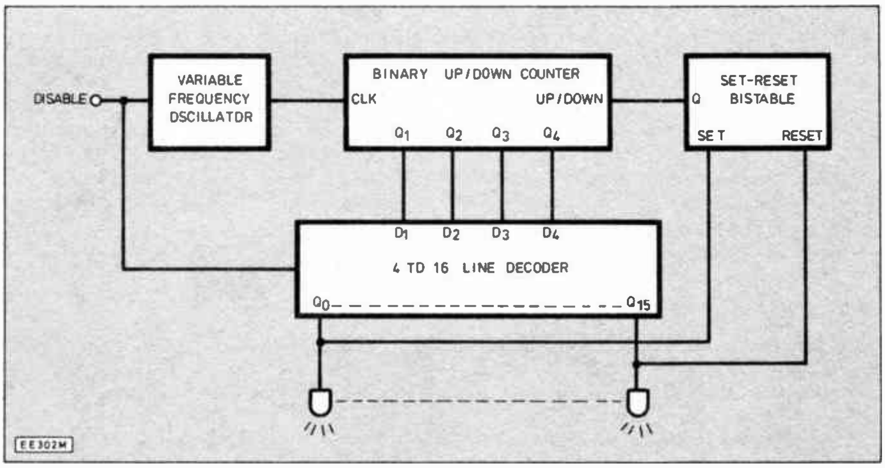


Fig. 1. Block diagram of the Chaser Light system.

The Variable Frequency Oscillator produces pulses which are counted by a Binary Up/Down counter. The direction in which the pulses are counted is controlled by the logic level applied to the counters Up/Down input. When "high" it counts up, when "low" it counts down. The Up/Down input is fed from the output Q of a Set-Reset Bistable. Q goes high when the Set input is pulsed high and low when the Reset input is pulsed high.

The counters output appears as a binary code weighted Q1 = 1, Q2 = 2, Q3 = 4, Q4 = 8 and is fed to the inputs of a 4 to 16 Line Decoder which selects one of its 16 possible outputs according to the binary code at its input e.g., code 0101 will select Q5 and code 1111 will select Q15. The selected output goes high causing the l.e.d. connected to it to light. All other outputs remain low and therefore all other l.e.d.s are off.

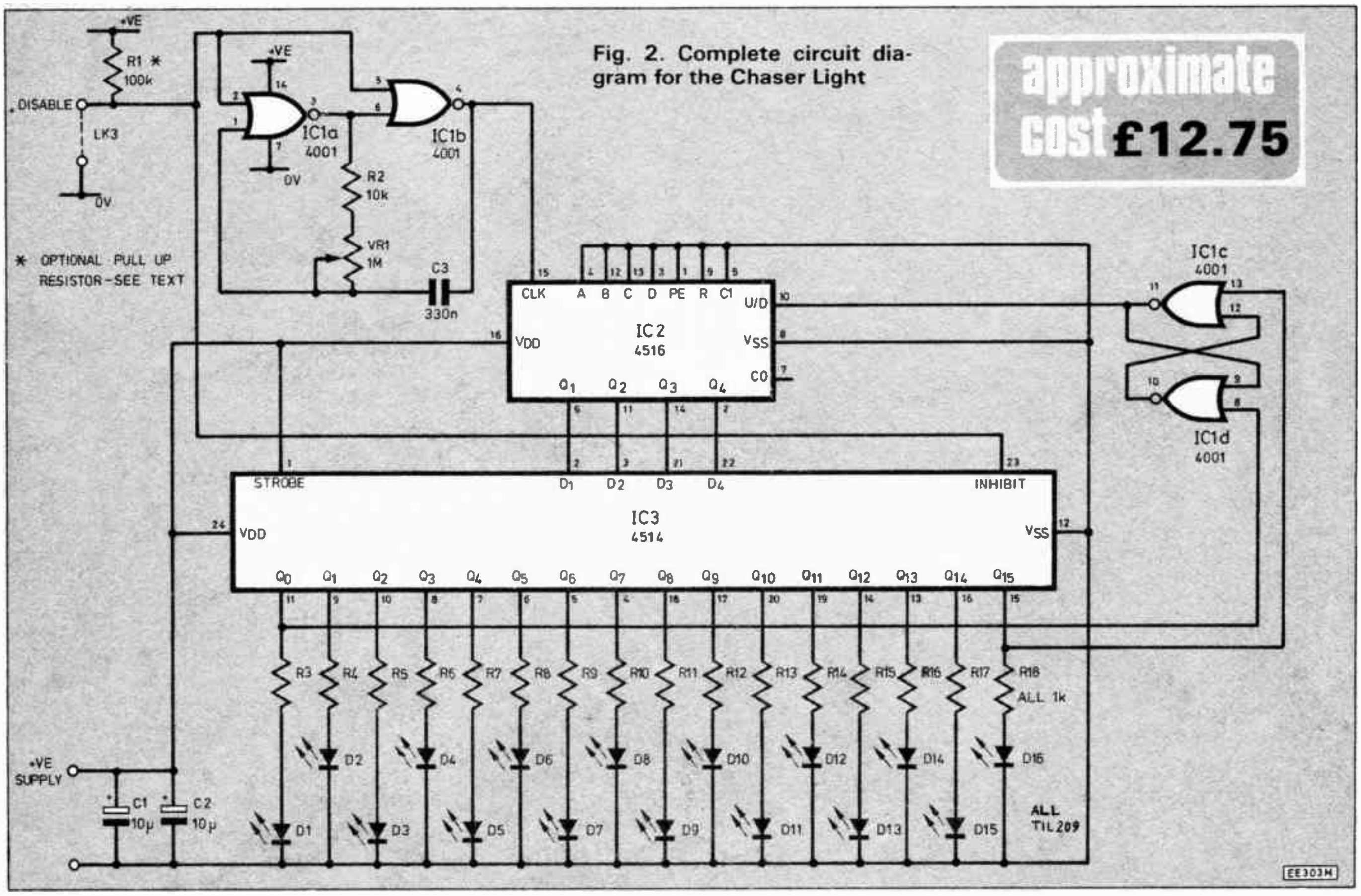


Fig. 2. Complete circuit diagram for the Chaser Light

approximate cost £12.75

Consider that the bistable is in the Set state, i.e. Q is high and the counter is counting up. Each time it receives a clock pulse from the oscillator it adds one to its count, the count is decoded and the selected output goes high lighting the l.e.d. connected to it. This continues until eventually Q15 goes high, at this point the bistable is reset and its output Q goes low.

The counter now begins to subtract one from its count each time it receives a clock pulse. As before the count is decoded and the selected output lights an l.e.d. This continues until eventually Q0 goes high, the bistable is set and the counter begins to count up once more. The result is a display that produces a light that sweeps to and fro.

By altering the point at which the bistable is reset the number of lights required can be changed e.g. if ten lights are required Q9 is used to reset the bistable.

CIRCUIT DESCRIPTION

The complete circuit diagram for the Chaser Light is shown in Fig. 2. Having discussed the circuit's operation all that remains is to describe its finer details.

The prototype was powered from a 9V PP3 battery but the circuit will work equally well in the range 3V to 15V. If a different supply voltage is to be used then the value of l.e.d. current limit resistors R3 to R18 will have to be changed.

The current required by an l.e.d. for satisfactory illumination is usually in the range 5mA to 10mA and the forward voltage is about 2V. On the prototype an l.e.d. current of 7mA was used.

The value of the current limit resistors can be calculated by the following formula:

$$R\text{ limit} = \frac{V\text{supply} - V_F}{I\text{ l.e.d.}}$$

e.g.. for the prototype

$$R\text{ limit} = \frac{9V - 2V}{7mA} = 1k\text{ ohms}$$

The supply is decoupled by capacitors C1 and C2.

The Variable Frequency Oscillator is formed by two NOR gates IC1a and IC1b C3, R2 and VR1 set the oscillator frequency. Preset potentiometer VR1 allows adjustment of the frequency and hence the speed of the display. The oscillator output is fed to the CLK input (pin 15) of IC2, a Binary Up/Down Counter which counts the pulses the oscillator produces.

Preset inputs A, B, C, D, Preset Enable (PE), Reset and Carry In (pins 4, 12, 13, 3, 1 9, 5) of IC2 are all unused and are tied permanently low. Carry Out (pin 7) is not required and is left unconnected.

The UP/DOWN input (pin 10) of IC2 determines the direction of count and is controlled by a bistable formed by two NOR gates IC1c and IC1d. Pin 11 of IC1c acts as the Bistable output, pin 13 of IC1c acts as the Reset input and pin 8 of IC1d as the Set input.

The counters binary output appears at Q1 to Q4 (pins 6, 11, 14, 2) and is fed to the inputs D1 to D4 (pins 2, 3, 21, 22) of IC3, a 4 to 16 Line Decoder. As explained previously IC3 decodes the binary input to select one of its 16 possible outputs. The selected output goes high and drives an l.e.d. (D1 to D16) via a current limiting resistor R3–R18).

Output Q0 (pin 11) is also connected to the Set input of the bistable such that when the count is at 0000, i.e. at its minimum, the bistable is set, its output is forced high and the counter is made to count up. Q15 (pin 15) of IC3 is conencted to the Reset input of the bistable such that when the count is at its maximum, i.e. 1111, the bistable is reset and the counter is forced to count down.

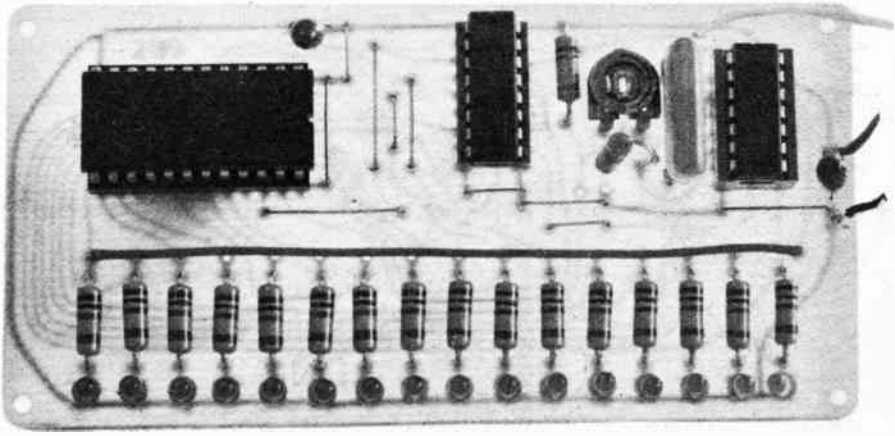
The data latching facility of IC3 is not required and so Strobe (pin 1) is tied permanently high. The Inhibit, pin 23, is connected to the Disable input as are the NOR gates IC1a and IC1b which form the oscillator. When the Disable is taken low the circuit works normally. However, when left unconnected the Disable input is pulled high by resistor R1 stopping the oscillator and forcing the outputs of IC3 low switching off all l.e.d.s.

The Disable input was designed to be driven by an external transistor which when turned on pulls Disable low and when turned off allows Disable to be pulled high by R1.

CONSTRUCTION

All the components are mounted on a single printed circuit board as detailed in Figs. 3 and 4. This board is available from the *EE PCB Service:* code EE546.

Before commencing construction you must first decide whether you want to use the "Disable" facility or not. If you do then resistor R1 is included and link LK3 is omitted, if not then R1 is omitted and LK3 is included. Secondly, you must decide how many outputs you require. This will determine the number of l.e.d.s and current limit resistors used and also the position of link LK1.



Completed Chaser Light showing the bank of l.e.d.s mounted directly on the board.

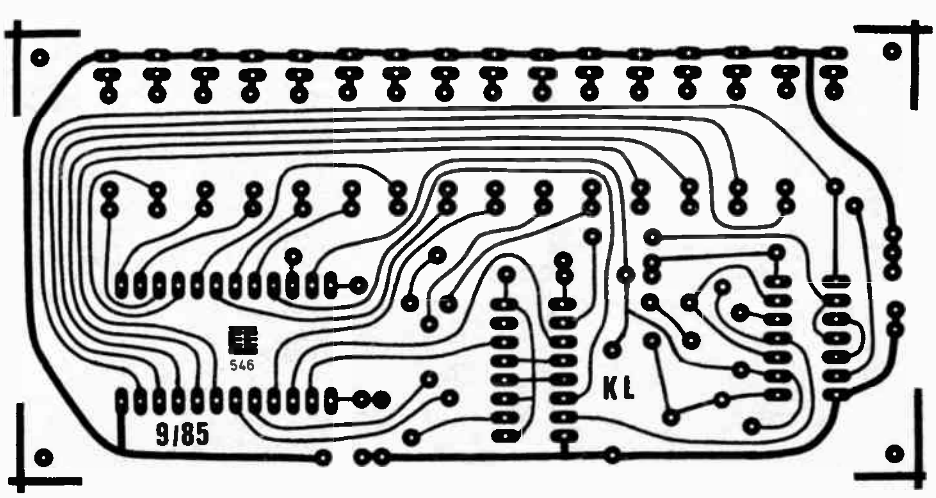


Fig. 3. Full size printed circuit master pattern for the Chaser Light

COMPONENTS

CHASER LIGHT

Resistors
R1 100k (see text)
R2 10k
R3–R18 1k (16 off)
All ¼W carbon ±5%

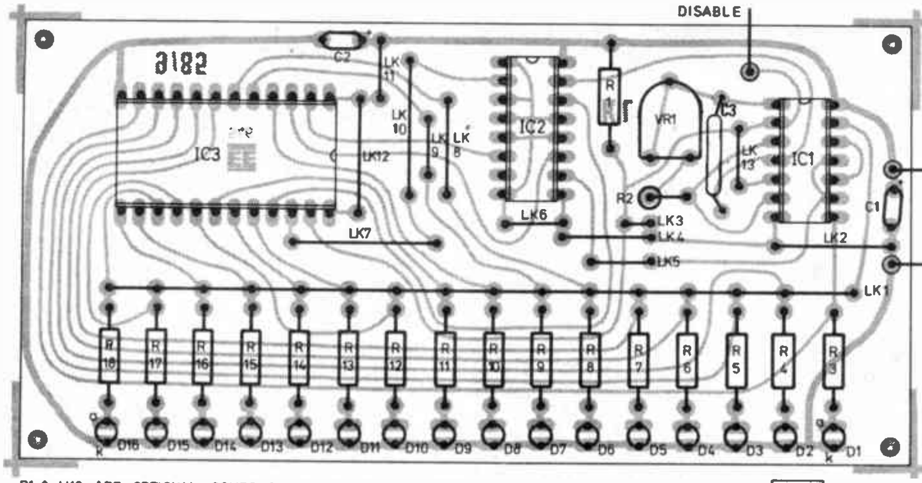
See Shop Talk page 537

Potentiometers
VR1 1M lin. Miniature horizontal preset

Capacitors
C1,C2 10µ tantalum 25V (2 off)
C3 330n polyester

Semiconductors
IC1 4001B CMOS NOR gate
IC2 4516B CMOS Binary Up/Down Counter
IC3 4514B CMOS 4 to 16 Line Decoder
D1–D16 TIL209 or similar (16 off)

Miscellaneous
PP3 9V battery and battery clips (if required); 14-pin, 16-pin and 24-pin i.c. sockets; printed circuit board, available from the *EE PCB Service* code EE546; wire; solder etc.



R1 & LK3 ARE OPTIONAL COMPONENTS. (SEE TEXT)

Fig. 4. Component layout and wiring to the printed circuit board. Make sure that all link wires are in position before testing. This board is available from the *EE PCB Service*, code EE546.

Begin construction by fitting wire links LK1 to LK12 observing the conditions stated above for LK1 and LK3. Next fit the i.c. sockets, preset, resistors and capacitors ensuring correct polarity for capacitors C1 and C2.

Next fit the l.e.d.s again ensuring correct polarity, designated by a "flat" against the cathode (k) connection. The l.e.d.s need not necessarily be mounted on the p.c.b. but this will depend upon the application.

Finally, connect wires for the power supply and the Disable input (if required) and insert IC1, IC2 and IC3 taking care to get them the right way round.

TESTING

Set VR1 to mid-position and connect the unit to a suitable power source. If LK3 is not fitted connect "Disable" to 0V. The display should now be working. Adjust preset potentiometer VR1 to change its speed.

If the circuit fails to work switch off and thoroughly check the board for mistakes especially the orientation of l.e.d.s, capacitors and i.c.s.

Once the board is working correctly it is ready for its intended purpose. Final assembly will depend upon the application but holes are provided for mounting the p.c.b.

INTERFACING

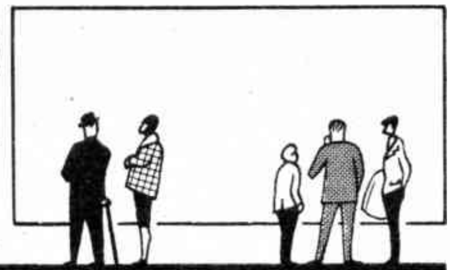
As stated previously the circuit need not be limited to driving l.e.d.s. With a suitable interface any type of lamp may be driven including mains lamps.

For low voltage lamps I would suggest the use of a ULN2801 octal (8 pin a package) Darlington Driver Array which will drive loads of up to 50V at 500mA. Outputs may be paralleled to increase current capability.

Interfacing to mains lamps must only be undertaken by the experienced reader because of the obvious dangers involved. The January 1985 edition of *Everyday Electronics and Computer Projects* describes a *"Power Lighting Interface"* for home computers which is ideal.

The interface will need to be driven by ULN2801s because the 15mA l.e.d. current required by the opto-isolators used in the project is beyond the capability of CMOS. □

SHOP TALK



BY DAVID BARRINGTON

Catalogues Received

This month we have received two "bumper" catalogues from companies with a long and historical association with the early days of electronics, particularly the home construction side, in this country. These are the **Henry's Audio-Electronics** Catalogue and the introduction of the **Electromail** Catalogue from **RS Components**.

The name RS Components is well known to readers of EE and is synonymous with high quality components. Many of our author's/designer's swear by their components and they are always being recommended in projects.

Being unavailable to the general public we have, until now, had to ask constructors to approach local approved *bona-fide* traders to obtain these components. Now RS have announced the launch of Electromail—an easy-to-buy distribution service available to everyone.

To mark the launch, Electromail have issued a catalogue offering the full RS range of over 12,500 quality products. The 688 page catalogue lists each item's price, product description, order code and, in most cases, an accompanying photograph. It also contains valuable product technical information.

The Electromail catalogue is excellent value at £2.50 and to receive a copy (only available to UK customers) readers should telephone their Access/Visa number or send their remittance to: **Electromail, Dept 300, PO Box 33, Corby, Northants NN17 9EL. Tel: 0536 204555.**

When the Henry's catalogue arrived in the office it was a welcome surprise to see that, instead of being dominated by audio accessories, there is a fairly even balance between audio, test equipment, tools and general components. In fact, although the audio section is still fully comprehensive the combination of test gear and general components seems to make up about two-thirds of the catalogue.

The catalogue is split into 15 sections and contains approximately 200 fully illustrated pages. It covers items ranging from PA equipment and computer accessories to semiconductors and miniature d.c. motors.

The catalogue costs just £1, plus 46p postage UK (£1 overseas), and also contains redeemable £1 discount vouchers for use against orders over £20 in value.

Copies of the Henry's Audio-Electronics catalogue may be obtained from: **Henry's Audio-Electronics, Dept EE, 404–406 Edgware Road, London W2 1ED.** A large, 305mm × 230mm, envelope would be appreciated.

Micro Tracer Unit

We do not envisage any component buying problems for the *Micro Tracer Unit*.

A full kit of parts (£23.92) for this versatile unit, including a printed circuit board, may be obtained from **Phonosonics, Dept EE, 8 Finucane Drive, Orpington, Kent BR5 4ED.** The printed circuit board may be purchased separately for the sum of £3.35 inclusive: quote code 261A.

10W Audio Amplifier

Our major project this month and likely to be the most popular is the *10W Audio Amplifier*. Glancing down the components list, the only items that could be classed as "difficult" are the TL071 low-noise BI-FET op-amp, the TDA2004 class-B dual audio amp i.c. and the power supply mains transformer.

The choice of separate bobbins for the primary and secondary windings of the mains transformer is to reduce the risk of any mains borne interference to a minimum. It is quite possible that other transformers will work here, but the one used in the prototype was purchased from Magenta.

The TL071 op-amp is currently listed by Marco, Maplin, Cricklewood and CPL Electronics. The TDA2004 power amp i.c. is stocked by Cricklewood, Omni Electronics and Magenta.

A complete kit of parts, including the printed circuit boards, for the amplifier is available (£35.75 inclusive) from **Magenta Electronics Ltd., Dept EE, 135 Hunter Street, Burton-on-Trent, Staffs, DE14 2ST**. The printed circuit boards for this project are available through our *PCB Service*: code EE543 and EE544.

Spectrum Escape Interface

Readers undertaking to build up the circuit for the *Spectrum Escape Interface* —see *On Spec*—should not experience any difficulties in purchasing the semiconductors for this circuit. Practically all of our component advertisers seem to hold stocks of these devices.

Light Rider

Looking at the components called for in the three *Light Rider* projects we only expect the odd item to cause local supply problems.

The "high efficiency" l.e.d.s used in the *Lapel Badge* version are only now becoming readily available and could prove difficult to locate. If readers do experience any problems they may be purchased from Magenta. It is not necessary to use the case specified but obviously, as it will be worn on a person's clothing, the smaller the case the better.

The capacitor C3 used in the *Disco Lights* mains version must be a high quality "mains suppressor" type, with a working voltage not less than 250V a.c. The reason for this is that should the capacitor break down the full mains supply will "hit" the circuit with catastrophic results. Provided the specified capacitor is used the likelihood of a breakdown is fairly remote.

The triacs CSR1 to CSR6 specified in the disco lights version have very sensitive gates and are currently stocked by Magenta.

The components used in the *Chaser Light* project all appear to be standard "off-the-shelf" items and should not give any buying problems.

A full kit of components, including p.c.b.s, for the *Lapel Badge* (£10.71 inclusive), *Mains Disco Lights* (£19.69) and the *Chaser Light* (£13.99) may be purchased from **Magenta Electronics Ltd., Dept EE, 135 Hunter Street, Burton-on-Trent, Staffs DE14 2ST.**

The printed circuit boards for all the Light Rider projects may be purchased through the *EE PCB Service*. These should be ordered as follows: Lapel Badge—code EE540 and EE541; Disco Lights—code EE542; Chaser Lights—code EE546.

Finally, with the large number of l.e.d.s required for the display it may be possible to obtain them from our advertisers at a "special price" for numbers over 10. It is certainly worth looking at some of the special component packs.

Exploring Electronics

A suitable "breadboard" for building up the demonstration circuits in the *Exploring Electronics* series would be the same as the one used in our recent *Teach In '86* series.

exploring electronics

OWEN BISHOP

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

Part 4 Thermistors

THIS month we investigate the properties of a useful electronic component. Its name suggests that it has something to do with temperature. Find out more by following the instructions below.

Thermistors

A thermistor is made by mixing nickel, cobalt, manganese and other oxides. The mixture is heated to fuse it into a bar, disc or bead. As the temperature increases, the resistance of the material decreases. We say it has a negative temperature coefficient. The "-t" in the symbol used for this device indicates this fact (Fig. 4.1). Thermistors with a positive temperature coefficient are also available.

Light emitting diodes

Light emitting diodes (l.e.d.s) are diodes in which the semiconducting material is gallium phosphide or gallium arsenide. When the diode is forward biassed and current flows through the junction (i.e. from the anode to the cathode terminal, Fig. 4.2), light is emitted. The l.e.d.s are made in a variety of shapes and sizes; most emit red light, but are available in yellow, green, blue and infra-red.

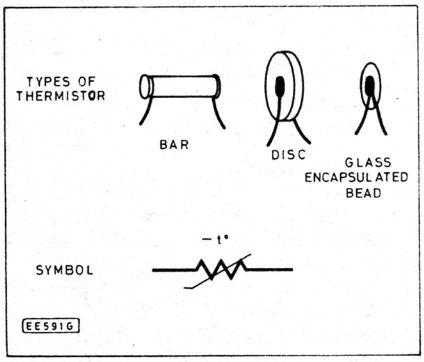


Fig. 4.1. Types of thermistor.

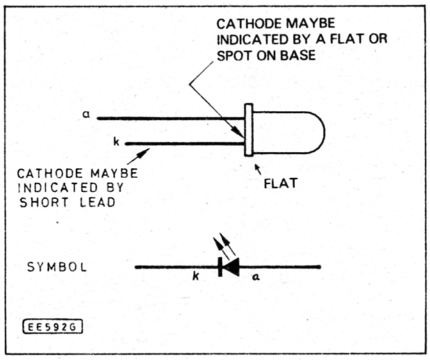


Fig. 4.2. Symbol and identification of an l.e.d.

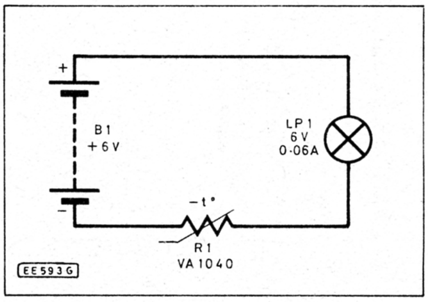


Fig. 4.3. Circuit for investigating the properties of a thermistor.

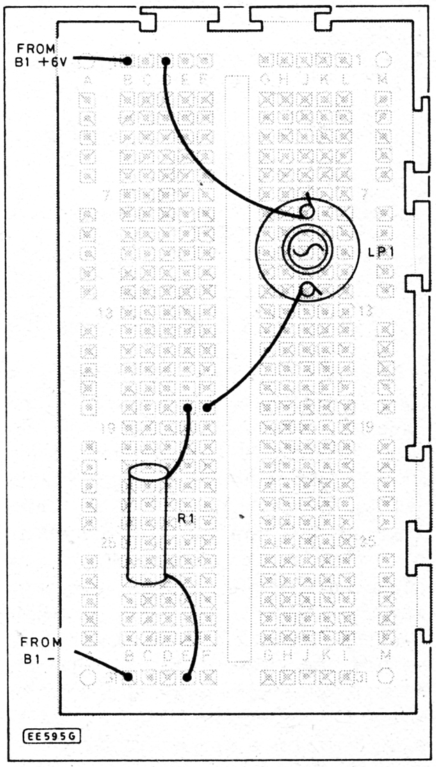


Fig. 4.4. Breadboard layout of the circuit of Fig. 4.3.

What does a thermistor do?

Set up the circuit of Fig. 4.3 and connect the battery (as shown in Fig. 4.4). Does the lamp glow at its full brightness? If not, it suggests that the thermistor has electrical resistance. It is a type of resistor. Make the thermistor colder by holding a cube of ice against it. Or put the whole thermistor in the deep-freezer for a few minutes. What happens to the brightness of the lamp? What does this tell us about the resistance of the thermistor?

Now try making the thermistor hotter. Put it in front of an electric fire or near a reading-lamp, but make sure that the heat is not too great or the breadboard may be damaged. What happens to the brightness of the lamp? What does this tell us about the resistance of the thermistor?

In each of the tests above, does the lamp recover its normal brightness when the thermistor is brought back to normal room temperature? If so, this shows that its resistance is not permanently changed by making it hot or cold for a while. A device such as this could be a useful temperature sensor. The next project shows how.

THERMOMETER

The circuit of Fig. 4.5 uses a light emitting diode in place of the filament lamp of the previous circuit. This circuit relies on the fact that the resistance of a thermistor decreases as it

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OWEN BISHOP

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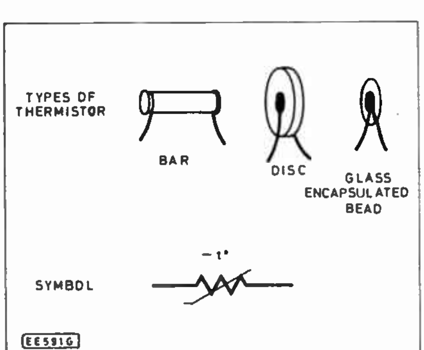

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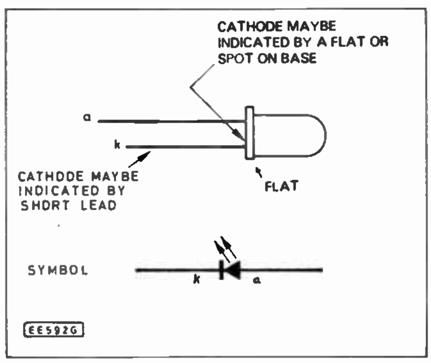

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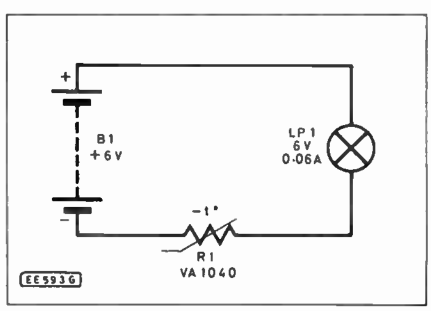
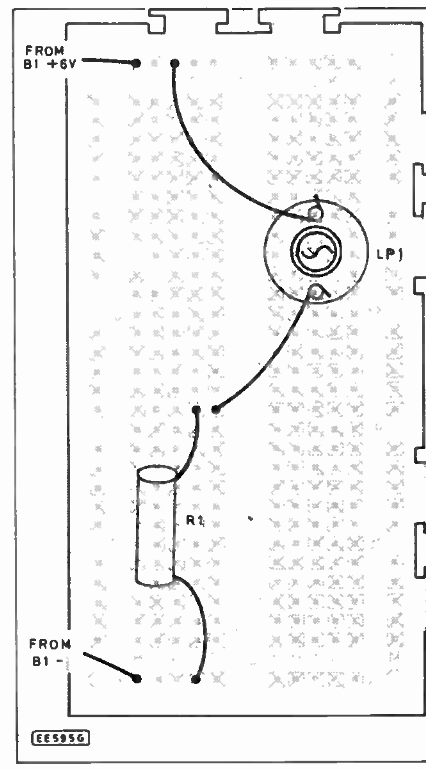


Fig. 4.3. Circuit for investigating the properties of a thermistor.



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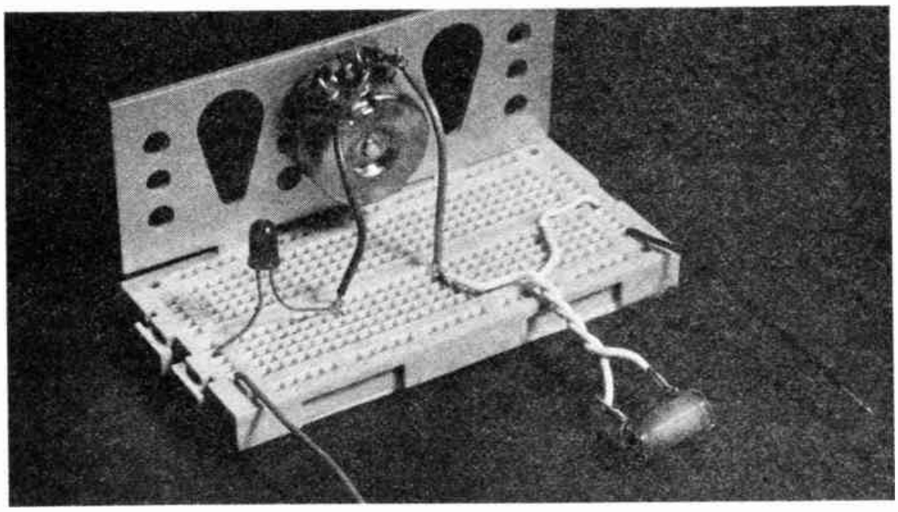


COMPONENTS

R1	Thermistor, type VA1040 (or any similar type with a resistance of about 150 ohms at 25°C)
VR1	Variable resistor 1k lin.
LP1	Filament lamp 6V 0·06A with holder
D1	TIL209 or similar light emitting diode
B1	Battery—box with four 1·5V cells

Breadboard (e.g. Verobloc); pointer knob for VR1.

Approx. cost
Guidance only **£5**

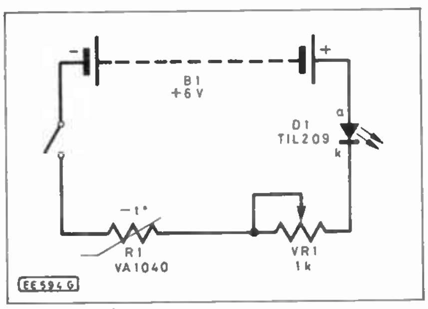


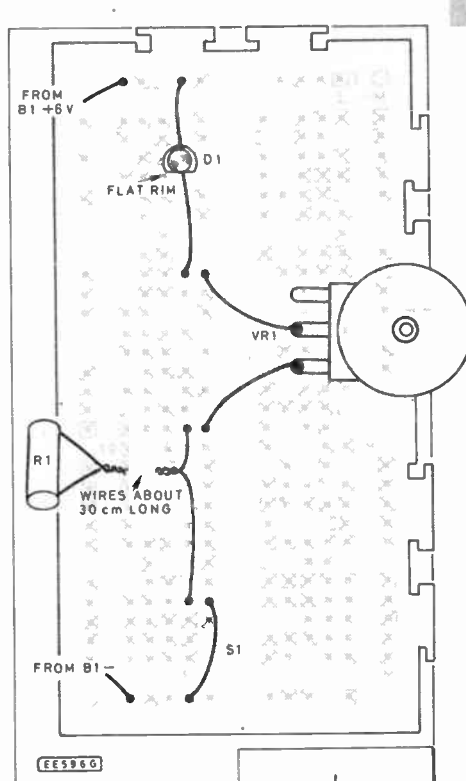
Fig. 4.5. Circuit for a simple thermometer.

gets hotter. When the thermistor is as cold as melting ice, we adjust VR1 so that the total resistance of R1 and VR1 is just enough to stop the l.e.d. from glowing. When the thermistor becomes warmer than melting ice, its resistance becomes less and the l.e.d. begins to glow. But if we turn the knob of VR1 to make its resistance greater, the lamp can be stopped from glowing. The hotter we make R1, the more we need to turn the knob of VR1 so that the total resistance remains the same as when we started, and the l.e.d. stays dark. If we put a piece of card on VR1 so that the positions of its pointer-knob can be marked, we can construct a thermometer.

Construction

The thermistor is best connected to a pair of long wires. The switch S1 is made by cutting a small wire link and placing it in position when the circuit is to be switched on (Fig. 4.6). Fix the piece of card on the variable resistor, retaining it firmly with the nut and washer provided. Replace the pointer-knob and fix it firmly to the spindle by tightening the grub screw.

Put the thermistor in a cup or glass containing cold water and some ice. Allow it to settle for a few minutes. Switch on the circuit. Then turn the knob of the variable resistor to the left until the lamp just goes out. Mark the position of the pointer knob by drawing a short line on the card. Ice melts at 0°C, so this mark can be labelled "0".



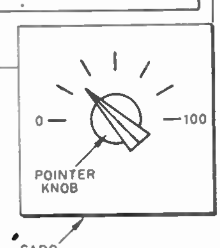
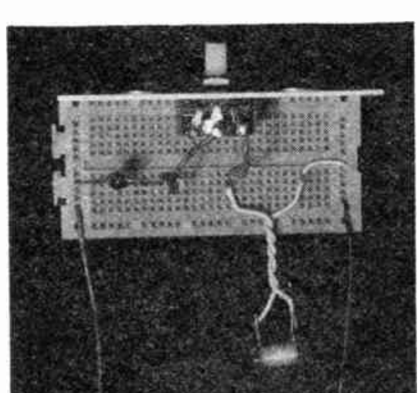


Fig. 4.6. Breadboard layout of Fig. 4.5.



Support the thermistor just above the surface of some water in a saucepan. Bring the water to the boil, so that the thermistor is surrounded by steam. It is very hot now, so do not try to touch it with your bare fingers. Now switch on the circuit. The l.e.d. should be glowing fairly brightly. Turn the knob until the l.e.d. just goes out. Mark the position of the pointer knob, and call this "100" (the temperature of steam is 100°C under normal conditions). Divide the angle between the two marks into ten equal parts, and label the new marks from "10" to "90", in order. This completes the scale of the thermometer.

To use the thermometer for measuring the temperature of a room, a greenhouse, or the outdoor temperature, switch on and turn the knob until the l.e.d. just goes out. The pointer will indicate the temperature, in degrees Celsius.

A simple circuit such as this cannot be expected to give precise readings. For one thing, the result you get depends on your judgement about when the l.e.d. is out. A more precise circuit based on the same principles will be described in a future part of this series.

Next Month: Triggered Circuits, plus a simple stripboard project—Light Operated Switch.

You will Need . . .

Resistors
R1 100 R2 56
R3–R5 1k (2 off)
All ¼W carbon ±5%

Transistors
TR1–TR3 ZTX300 *npn* (3 off)

Miscellaneous
VR1 1k carbon track, lin.
VR2 100k carbon track, lin.
ORP12 (or similar) cadmium sulphide light-dependent resistor; 0·1 inch matrix stripboard, 10 strips × 24 holes; knob for VR1 or VR2; LP1 filament lamp 6V, 0·06A; holder for lamp; 6V audible warning device or 6V relay; 1mm terminal pins (5 off); connecting wire.

Actually Doing it!!

WHILE much of electronics construction is pretty straightforward, there are a few traps that need to be avoided, and in this month's article we will look at some of the more common ones.

TRANSFORMERS

The best advice for beginners is to avoid any mains powered projects for as long as possible, but eventually though, you are almost certain to find a mains powered project that you wish to construct, and it is virtually certain to have a mains transformer in the power supply section. The mains transformer performs two basic functions, which are to provide safety isolation and to provide a voltage step-down.

The most simple type of mains transformer has a primary winding to which the mains supply is connected, and a single secondary winding from which the low voltage output is taken. It does not normally matter which way round the mains input leads are connected, or the low voltage output leads either.

However, the result of connecting the mains supply to the primary winding by mistake would almost certainly be catastrophic. A fuse or cutout would probably cut off the mains supply very quickly, and the mains transformer would probably survive the burst of heavy current that would pass through its primary winding. Unfortunately, by connecting the transformer in reverse it will provide a voltage step-up rather than a step-down, and the likely result would be the destruction of every semiconductor component in the circuit.

Usually mains transformers are clearly marked so that there is no doubt which tags or leads are those for the primary, and which are for the secondary winding. Rather than markings such as "pri" and "sec", the primary tags are often marked something like "0V" and "240V" while those for the secondary will be physically well separated from them and marked "0V" and "6V" (or whatever).

If in any doubt and you have a multimeter, try measuring the resistance between the two pairs of tags. There will be a higher resistance of typically around 20 to 2000 ohms through the primary, and only a few ohms or less through the secondary (larger transformers generally having lower resistances).

If you are unable to determine for certain which way round a mains transformer should connect, do not complete the project until you can, and certainly do not consider the trial and error method of finding the right method of connection.

TAPPINGS

Most mains transformers have either a tapped secondary winding or multiple secondaries, and these can be a bit confusing for the uninitiated. Taking tapped transformers first, one popular type is the so-called "multivoltage" type, and these have a "0V" output terminal plus tappings at (typically) 12V, 15V, 20V, 24V and 30V.

By using the "0V" terminal and the appropriate tapping the corresponding output voltage is obtained. Less obviously, using two terminals where neither of them are the "0V" one will give an output potential equal to the voltage difference between the tappings (e.g. the "12V" and "30V" tappings would give an output of 18 volts).

Although these mains transformers can be used to provide low voltages, this is an inefficient way of doing things in that it would result in only a small fraction of the transformer's potential output power being used. This is also a rather expensive way of doing things, and would mean that a physically large component would be used where a much smaller one would suffice.

This type of transformer normally has the secondary tags clearly marked, although in some cases the tappings are taken to leads of various colours, and an information sheet provided with the component should then make it clear which tapping corresponds to which colour. Be sure to keep the information sheet in case you need to refer to it at some later date.

The other common type of tapped transformer is the centre tapped type for use with a two rectifier ("push-pull") power supply circuit. Here the centre tapping is usually called "0V", with the other two terminals being marked "6V" (or whatever), as in Fig. 1a.

VERSATILE TWINS

Many transformers these days seem to be designed for maximum versatility and they have twin secondary windings. These can be connected in three basic ways, one of which is to mimic the centre tapped variety. Fig. 1b shows the appropriate method of connection, which is perhaps not the obvious one.

What in some ways would seem to be the more logical method of connection would be to connect the two "0V" terminals together and to then use them as the "0V" centre tapping of the transformer (as in Fig. 1c). This is a common error, and one that will not produce dire consequences. It won't produce any output either—*the two windings effectively cancel each other out.*

The second type of connection for twin secondary windings is the series method shown in Fig. 2a. This combines the two windings to give a boosted output voltage which is merely equal to the sum of the two winding's voltages.

In this example two 6V windings are used to effectively give a single 12V winding. The current rating of the 12V winding is equal to the current rating of the two 6V windings (or to whichever of them has the lower rating if they are unequal for some reason).

Parallel connection, as in Fig. 2b, is the third method of connection, and this gives no change in the output voltage, but does give a maximum current rating equal to the sum of the current ratings of the individual windings. Thus two 6V 600mA windings would give an output of 6V rated at 1200mA, or 1·2A in other words.

It has to be pointed out that the parallel method of connection is a little risky in that any slight mismatch in the output voltages of the two windings will result in one

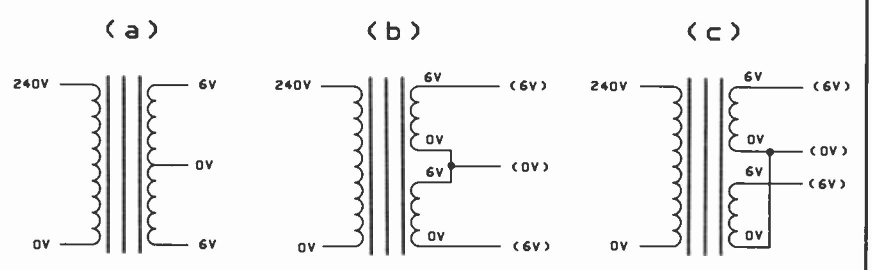


Fig. 1. The tapped secondary winding of (a) can be replaced by the twin windings of (b). The method of connection shown in (c) is incorrect.

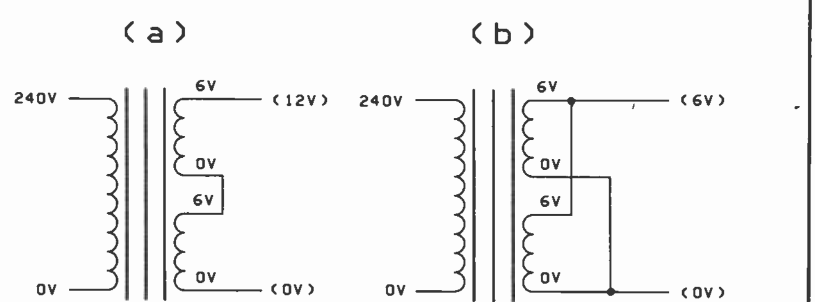


Fig. 2. Using twin secondary windings in series (a) and in parallel (b). The latter should only be attempted with suitable transformers.

forcing a high current through the other with the strong possibility of the component overheating. This is something that should therefore only be tried with transformers that are specifically designed to permit parallel operation (as many are). The retailers' or manufacturers' literature should state if parallel connection is acceptable, and it should ***not*** be used unless the literature does specifically say that the component is designed to operate in this way.

As a matter of interest, the usual method of ensuring that two windings are accurately matched is to use the "biflar" method of winding. This is just taking two insulated wires and winding them around the former together rather than winding the coils one at a time. Although this is a very simple solution to the problem, it is very effective and an extremely precise match is obtained in this way.

When constructing mains powered projects always connect the mains plug last. This avoids the possibility of getting the plug muddled in with other mains plugs and accidentally plugging in the project you are working on (which is potentially fatal).

SWITCHES

Although switches are relatively simple components they provide plenty of opportunities for errors. Some of the terminology can be a little confusing, especially the terms "SPST", "SPDT", "DPST" and "DPDT".

An SPST switch is a "single-pole single-throw" type, or just an ordinary on/off switch in other words. SPDT means "single-pole double-throw", and an alternative term is SPCO (single-pole changeover). This is a three terminal switch where the pole terminal connects to one or other of the other tags, depending on the setting of the switch. A "D" at the start of the name indicates that the switch is a "double"-pole type, which is effectively two switches which operate in unison.

The relationship between the electrical symbols and the physical tag arrangements for SPST and SPDT switches is shown in Fig. 3. There is no real problem with the single-throw type as there are only two tags to contend with.

More than one contact arrangement is possible with the double throw type, but I do not recall encountering a switch of this type where the pole tag was anything other than the middle one. With double-pole switches the contact arrangement is generally the same as for a single-pole type, but with two sets of tags mounted side-by-side.

Rotary mains switches can be a little confusing, and the switches fitted to potentiometers are, if anything, even more confusing. It is very important to connect these correctly since an error will almost certainly result in a short circuit across the mains supply when the equipment is switched on, which at best is likely to result in the switch being ruined. With a battery powered project the switch may survive the experience if an error is made, but the battery will be very short lived.

The proper method of connection for the most common style of rotary on/off switch and the standard form of switched potentiometer is shown in Fig. 4. Remember that if you are in doubt as to the connections to a switch, a quick check with a continuity tester will usually enable things to be sorted out in seconds.

LIGHT EMITTING DIODES

Light emitting diodes (l.e.d.s) represent one of the more awkward types of component. Most types have the cathode ("k" or "+") terminal indicated by either a shorter lead, or a slight flattening on that side of the component, as in Fig. 5. This diagram is rather exaggerated though, and on the l.e.d.s I have encountered the flattening of the case is so slight as to be almost undetectable.

Unfortunately, a few l.e.d.s have the shorter lead or the flat to indicate the anode terminal. Sometimes the retailers catalogue will give leadout details for the l.e.d.s they sell, but often it is a matter of making a simple test to determine the polarity.

The easiest way of doing this is to connect the l.e.d. across the test prods of an analogue multimeter set to a low ohms range (about 20 to 200 ohms centre scale). If the l.e.d. lights up and there is some deflection of the meter, the positive test prod is connected to the cathode (k).

If the l.e.d. does not light up and there is no deflection of the meter, the positive test prod is connected to the anode (a) leadout wire. If you should accidentally connect a l.e.d. round the wrong way it is unlikely to sustain any damage, and simply swopping over the connections should render the device operational.

Robert Penfold

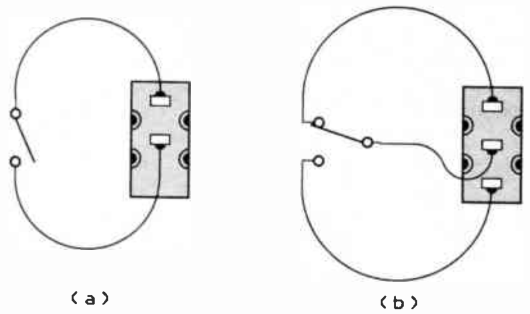


Fig. 3. The relationships between the electrical symbols and tag arrangements of (a) SPST and (b) SPDT switches.

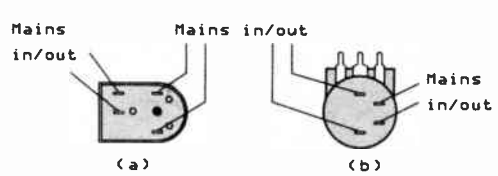


Fig. 4. Correct method of connection for (a) a rotary mains switch and (b) a switched potentiometer.

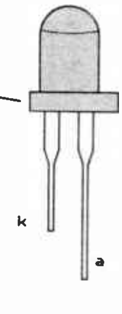
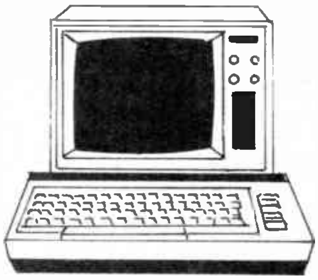


Fig. 5. A shorter lead or a flat side on the case usually indicates the cathode.

MICRO TRACER UNIT



JOHN BECKER

A useful piece of test gear for the constructor with a computer

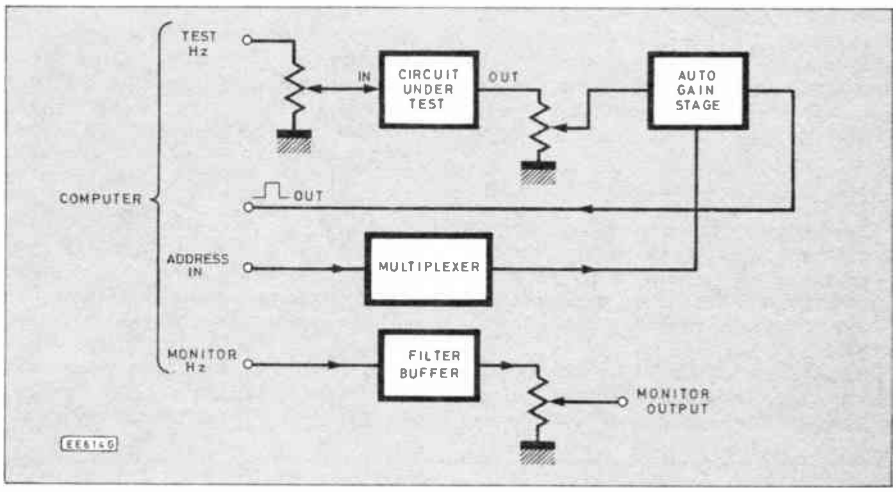


Fig. 1. Block diagram of the Micro Tracer Unit.

THE Micro-Tracer shows an interesting way in which a computer and two integrated circuits can be used as a signal injector and tracer. The software has been written for the BBC, C64 and PET series of computers. Details on its use with other computers are given below.

It has been designed for the constructor who occasionally assembles a project, but does not have access to an oscilloscope for tracing the course of signals through it if it malfunctions. From the block diagram (Fig. 1) it will be seen that in addition to the computer there are four very simple stages. The first allows the computer to send an audio tone out to the unit under test. The second amplifies the probed signal from the circuit under examination, to a level suitable for sending to the computer. The third controls the amplifier gain and is under computer control. Simple analytical data about the probed circuit is displayed on the screen.

The computer also puts out a second audio signal which can be fed to an ordinary amplifier. This signal consists of a series of bleeps, the frequency and rate of which depend on the strength of the probed signal. Rudimentary information on the frequency probed is also shown on the screen as a bar graph.

INJECTION SIGNAL

All the computers mentioned above have internal timers that can produce a program controlled frequency output as a 5V peak to peak square wave. Here this is set for approximately 440Hz, though the value can be changed if preferred. It is put out onto one of the handshake lines of the output port. Since this line is often used for calling the attention of external equipment, it is referred to here as the ATN (Fig. 2) or attention line. In the unit C7 gives a.c. coupling, and VR2 enables the desired signal strength to be set, to suit the circuit under test. Switch S1 then selects for a.c. or d.c. coupling of the injection output.

By means of a probe, the signal can be sent to any part of the circuit under test. This can be at the usual audio input, or somewhere along the rest of the circuit signal path. If preferred an alternative signal source can be used instead. Switch S2 enables the injection signal to be switched back to the computer as a self-check facility.

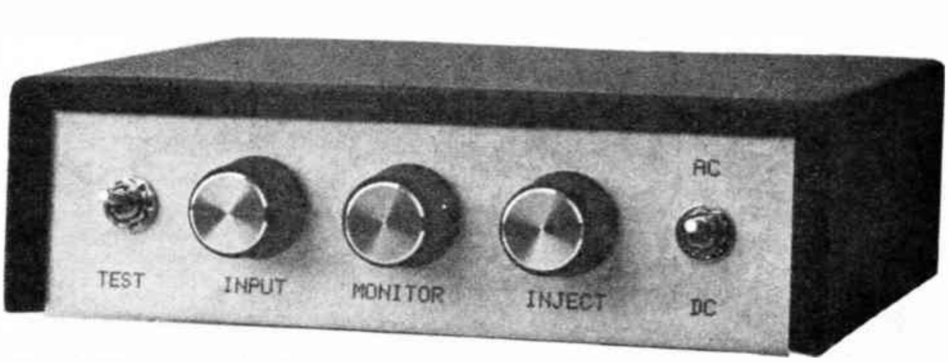
TRACER

With the second probe (Test In), the passage of the injection signal can be followed. The signal is brought back into the Tracer input at C1 via VR3. The next stage is a voltage controlled amplifier around IC1a and IC1b. The amplification of this stage can be adjusted by the computer in accordance with the strength of the traced signal.

The computer adjusts the gain until the output is sufficiently high for the computer to detect it. The screen readout then displays the detected signal strength as falling into one of four categories, Poor, Low, Medium or High. These represent ranges commencing at about 50mV, 150mV, 400mV and 1V respectively. If no signal is detected, this condition is displayed instead. All the time that the computer is acquiring data, an asterisk flashes at the sampling rate.

AMPLIFICATION CONTROL

The characteristics of the VCA around IC1a and IC1b, allow the gain to be adjusted by the amount of current flowing into its control node. This can be set by a resistor in series with the node. Four gain ranges are controllable through resistors R13 to R16 as selected by the multiplexer IC2. The multiplexer is a gate that will allow a voltage through to a particular output. This is



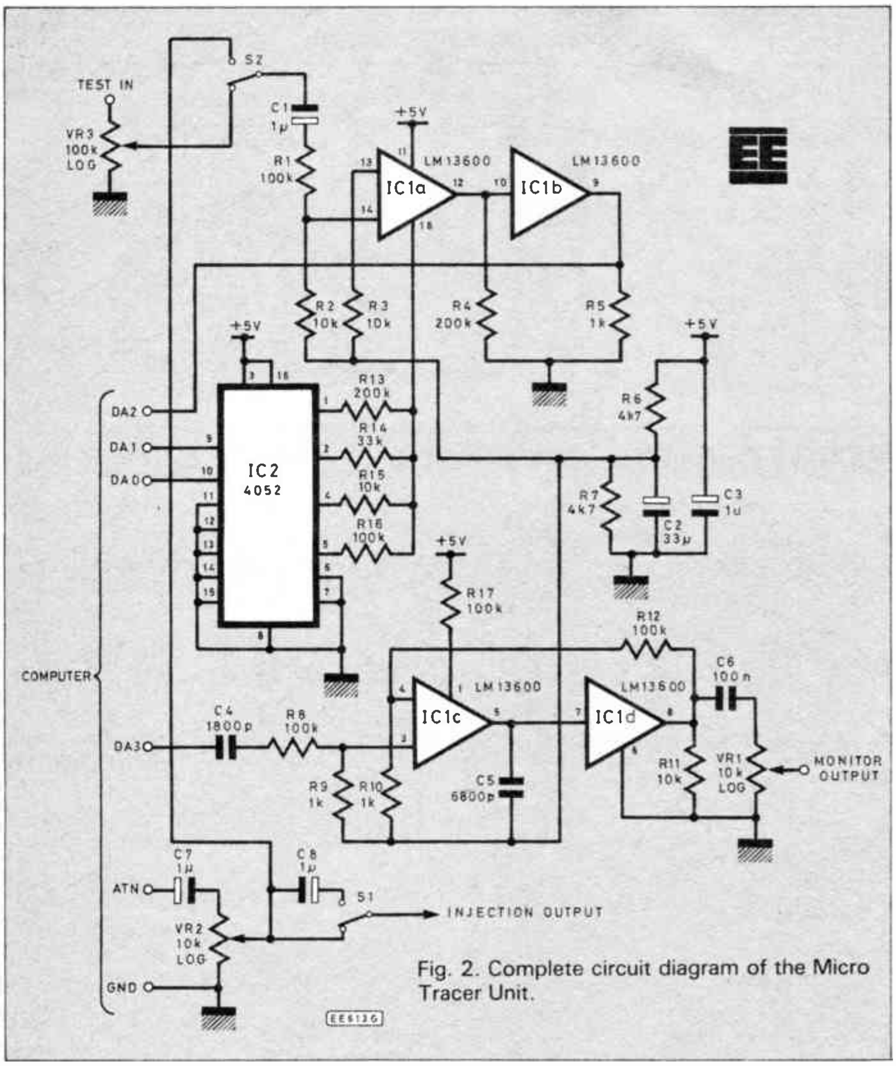


Fig. 2. Complete circuit diagram of the Micro Tracer Unit.

COMPONENTS

Resistors

R1,R8,R12,R16,R17	100k (5 off)
R2,R3,R11,R15	10k (4 off)
R4,R13	200k (2 off)
R5,R9,R10	1k (3 off)
R6,R7	4k7 (2 off)
R14	33k

All ¼W ±5%

Capacitors

C1,C3,C7,C8	1µ elect. 63V (4 off)
C2	33µ elect. 6V
C4	1n8 polystyrene
C5	6n8 polystyrene
C6	100n polyester

Potentiometers

VR1,VR2	10k log. mono rotary (2 off)
VR3	100k log. mono rotary

Semiconductors

IC1	LM13600
IC2	4052

Switches

S1,S2	Miniature s.p.d.t. (2 off)

Miscellaneous

Printed circuit board and mounting clips; knobs (3 off); 16-pin i.c. socket (2 off); 3·5mm jack socket; mono jack socket (3 off); interconnection lead and plug to suit computer.

COMPONENTS approximate cost £24

See Shop Talk page 537

routed by a binary code applied via data lines DA0 and DA1 to its control inputs at pins 9 and 10. Since there are two control inputs, there are four binary codes that can be used.

With a low level expressed as "0" and a high level as "1", the codes are 00, 01, 10, 11. Any of these codes will open the respective gate to one of the resistors. The gate is connected so that a +5V level goes to the selected resistor, while the others remain in a high impedance state. The resulting current through the resistor then sets the VCA gain.

Initially the software program opens the gate to the highest resistor value so that minimum gain is given. The output of IC1b is returned to the computer via the data line DA2. The computer examines the state of this line to see if it is going up and down, as it will if a sufficiently high signal is present from the test probe. If within a preset time, no signal is detected, the computer switches to the next lowest resistor, so increasing the gain. Once more DA2 is examined.

If necessary the computer will continue to select increasing gain factors. If a signal is still not detected, this condition will be displayed on the screen as a series of asterisks in the relevant areas, and the computer will continue to search indefinitely until a response is found.

When a signal has been detected, from the knowledge of the gain factor used, the screen displays the range into which the signal strength falls. This is indicated by an asterisk in the relevant screen box. Having done so it again examines the state of DA2. Since it is necessary to know the minimum amount of gain required to bring the probed signal up to strength, the computer selects the previous higher resistance range each time round the sampling loop. Then, as before, it will continue to increase the gain until a signal is acquired, or the time out factor reached.

PULSE COUNT

When signals are present on the DA2 line, they are squarewave pulses, and so can be counted, irrespective of the injection source. Indeed in some instances it may be an internal clock signal that is under examination. Once a signal has been detected on DA2, the computer counts the number of times the line goes up and down within a set period. The count is then displayed both as a number, and as a bar graph.

This is not a true frequency conversion, but can be used as a rough guide. For example on the PET, a count of two pulses represents a frequency of about 150Hz, 100 pulses about 9kHz, and 255 pulses about 16kHz. For the software though, this is about the maximum rate at which it can distinguish individual pulses. It will be aware of frequencies above this rate, but several pulses may pass while it is processing just one of them. So the pulse count will effectively represent the sub-harmonics of high frequency signals, and intelligent interpretation to the bar graph must be given. The VCA will in fact allow frequencies of at least 1MHz to be detected.

AUDIO MONITORING

In addition to monitoring the screen for data on the probe condition, audio monitoring is also available. After each batch of pulses has been counted, the computer sends a pulsed squarewave frequency onto

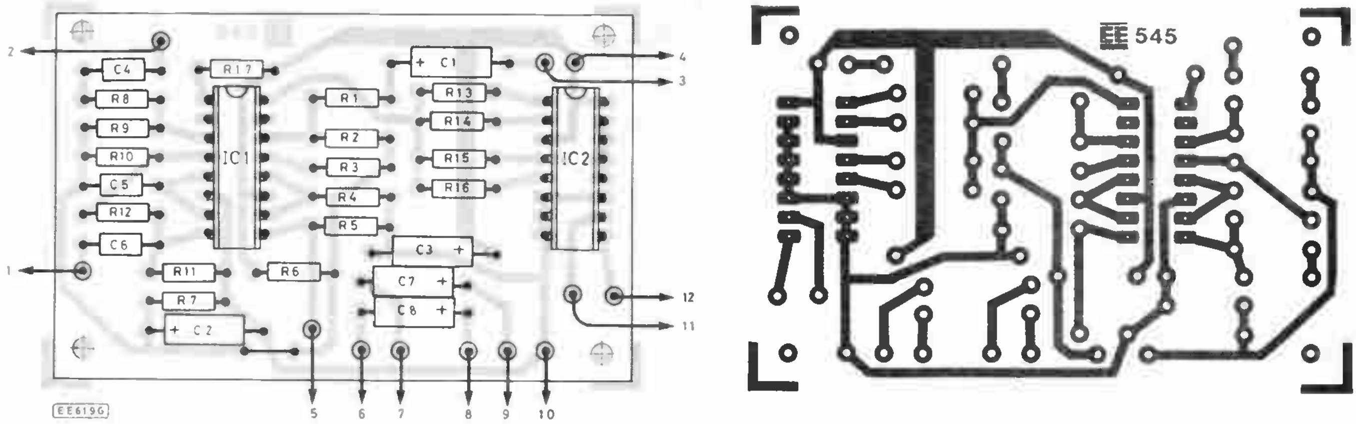


Fig. 3. Printed circuit board layout and wiring.

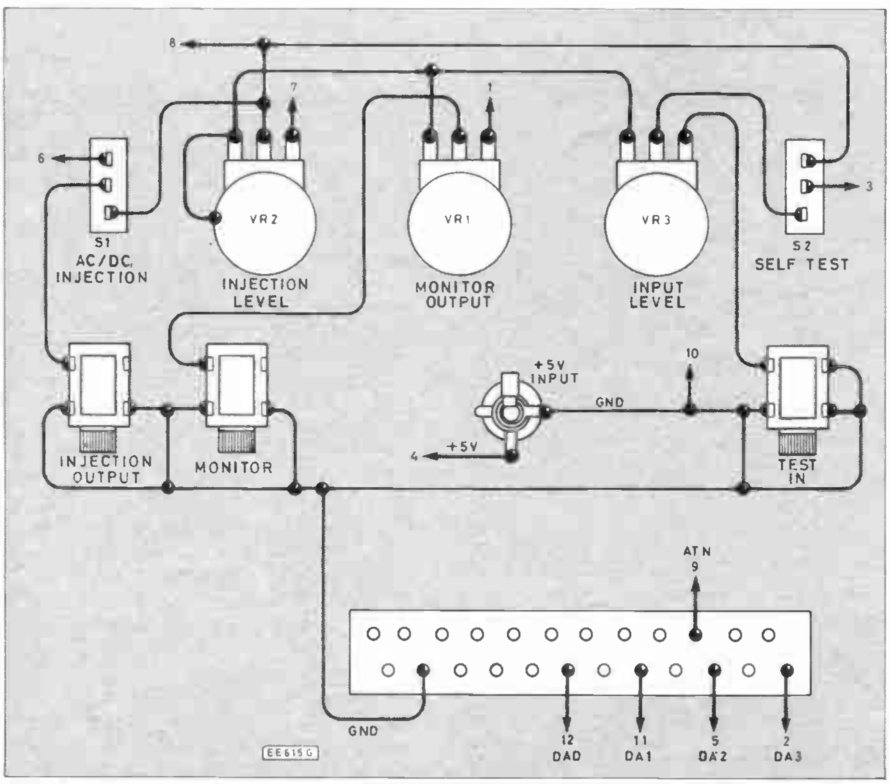


Fig. 4. Layout and interwiring of the components mounted on the case.

data line DA3. This frequency, and its duration, is varied in accordance with the gain range detected. Thus a series of bleeps varying in pitch and spacing is generated. If a signal is not detected the bleeps cease.

DA3 feeds them to the low pass filter stage IC1c and IC1d. This smooths off the edges of the pulses, which in themselves are a bit harsh to listen to. The somewhat smoother output can be fed to an audio amplifier via

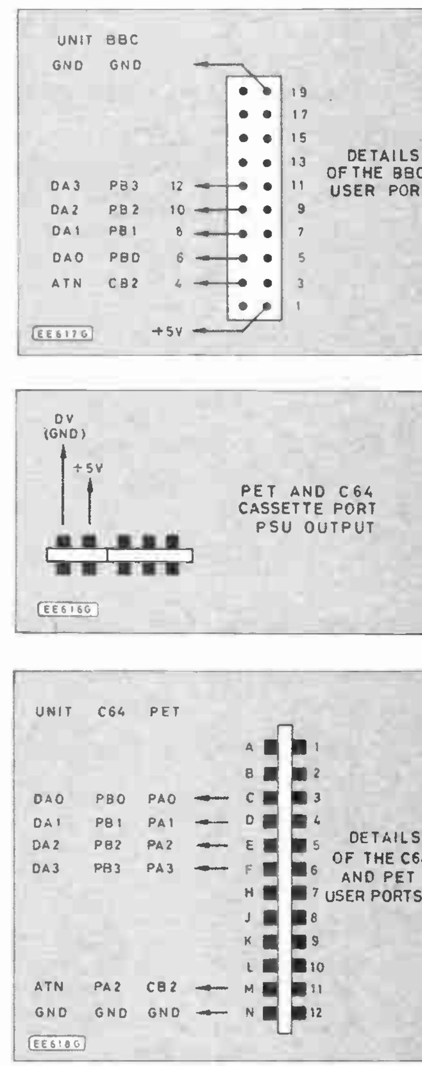
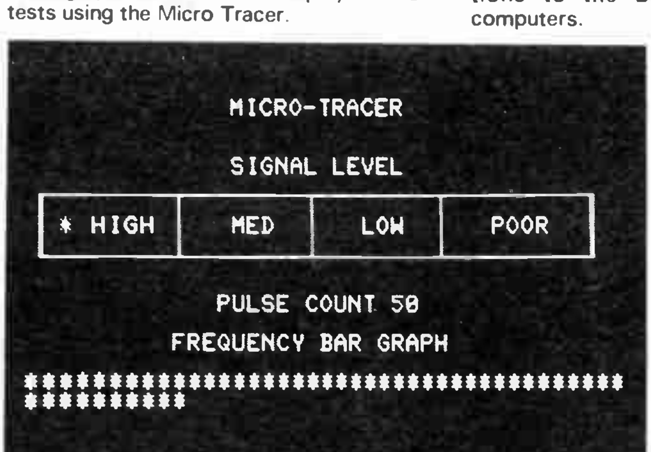
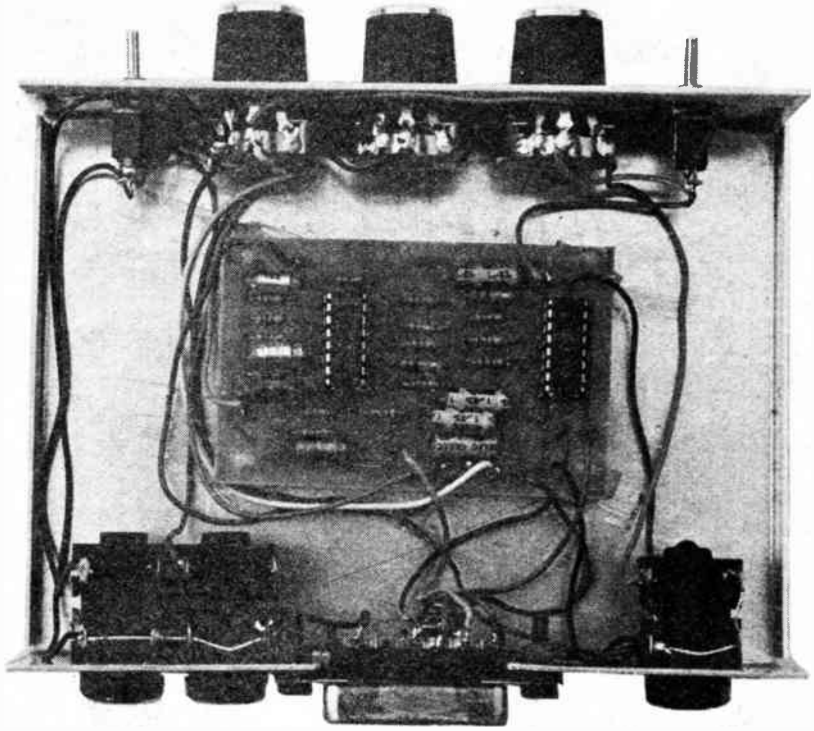


Fig. 5. (above right) Wiring of the connections to the BBC and Commodore computers.

Photographs of the screen display of two tests using the Micro Tracer.





MICRO TRACER SOFTWARE

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100 REM EE MICRO-TRACER PROG261 05AUG86. THIS PROG CAN BE USED WITH THE
110 REM BBC, C64 AND PET COMPUTERS. BBC USERS SEE END NOTES BEFORE TYPING IN.
120 REM C64 AND PET USERS TYPE IN AS PER THIS LISTING.
130 DATA1-PET USER:REM SUBSTITUTE RIGHT NO & NAME IN THIS LINE = 2-C64, 3-BBC
140 GOTO260
150 FORA=1TO6:D$=D$+CHR$(CD):NEXT:V$=CHR$(CH)+D$+D$+CHR$(CD):D$=CHR$(CH)+D$
160 PRINTD$;TAB(13);"SIGNAL LEVEL"
170 PRINT" ________________________________________"
180 PRINT" |         |         |         |          |"
190 PRINT" |  HIGH   |   MED   |   LOW   |   POOR   |"
200 PRINT" |         |         |         |          |"
210 PRINT" ----------------------------------------"
220 PRINTTAB(52);"PULSE COUNT":PRINTTAB(49);"FREQUENCY BAR GRAPH"
230 POKEDRT,251:POKEZ(0),0
240 SYS(SY):PRINTV$;TAB(23);PEEK(Z(1));CHR$(CL);"   ":GOTO240
250 STOP
260 READA$:A=VAL(A$):ONAGOSUB490,530,570
270 PRINTCHR$(CC);TAB(133)"MICRO-TRACER":PRINTTAB(95);"LOADING"
280 IFA<3THENSY=PEEK(MM)*256+PEEK(ML):GOTO300
290 SY=HIMEM
300 A$="":FORC=0TO4:A$=A$+CHR$(PEEK(SY+C)):NEXT:IFA$="TRACE"THEN340
310 B=SY-210:IFA<3THENHI=INT(B/256):LO=B-(HI*256):POKEML,LO:POKEMM,HI:GOTO330
320 HIMEM=B
330 A$="TRACE":FORC=0TO4:POKE(B+C),ASC(MID$(A$,C+1,1)):NEXT:CLR
340 DIMZ(3):RESTORE:READA$:A=VAL(A$):ONAGOSUB490,530,570
350 IFA<3THENSY=PEEK(MM)*256+PEEK(ML)+5:A=SY-1:GOTO370
360 SY=HIMEM+5:A=SY-1
370 READB$:IFB$="*"THEN150
380 A=A+1:IFB$<"A"THENPOKEA,VAL(B$):GOTO370
390 IFB$="OUT"THENB=OUT:GOTO470
400 IFB$="IN"THENB=IN:GOTO470
410 IFB$="DRT"THENB=DRT:GOTO470
420 IFB$="SCR1"THENB=SCR+679:GOTO470
430 IFB$="SCR2"THENB=SCR+362:GOTO470
440 IFLEFT$(B$,1)="Z"THENB=VAL(MID$(B$,2)):POKEA,Z(B):GOTO370
450 IFB$="SBL"THENPOKEA,SBL:GOTO370
460 STOP
470 HI=INT(B/256):LO=B-(HI*256):POKEA,LO:A=A+1:POKEA,HI:GOTO370
480 REM PET USER
490 CD=17:CL=157:CC=147:CH=19:Z(0)=0:Z(1)=1:Z(2)=2:Z(3)=3:ML=52:MM=53
500 DRT=59459:IN=59457:OUT=59471:DAV=59469:CTL=59467:OSC=59464:SRL=59466
510 SBL=42:SCR=32768:Q=140
520 POKECTL,PEEK(CTL)AND227OR16:POKEOSC,Q:POKESRL,15:RETURN
530 REM C64 USER
540 CD=17:CL=157:CC=147:CH=19:Z(0)=251:Z(1)=252:Z(2)=253:Z(3)=254:ML=55:MM=56
550 DRT=56579:IN=56577:OUT=56577:DAV=56589:CTL=56591:OSC=56582:SRL=56583
560 SBL=42:SCR=1024:Q=95:POKECTL,7:POKEOSC,Q:POKESRL,4:RETURN
570 REM BBC USER
580 CD=10:CL=8:CC=12:CH=30:Z(0)=112:Z(1)=113:Z(2)=114:Z(3)=115:Q=140:SBL=42
590 DRT=&FE62:IN=&FE60:OUT=&FE60:DAV=&FE6D:CTL=&FE6B:OSC=&FE68:SRL=&FE6A
600 SCR=&7C00:POKECTL,PEEK(CTL)AND227OR16:POKEOSC,Q:POKESRL,15:RETURN
610 DATA120,162,0,134,Z1,134,Z2,164,Z0,140,OUT,173,IN,41,4,133,Z0,173,IN,41,4
620 DATA197,Z0,208,16,133,Z0,232,208,242,200,192,4,144,227,160,0,132,Z0,88,96
630 DATA132,Z2,160,0
640 DATA162,1,173,IN,41,4,197,Z0,240,8,133,Z0,200,169,SBL,153,SCR1,232,208,236
650 DATA132,Z1,169,32,200,240,5,153,SCR1,208,248,164,Z2,132,Z0,160,0,228,Z0
660 DATA208,6,169,SBL,132,Z2,208,2,169,32,153,SCR2,152,24,105,9,168,232,224,4
670 DATA208,231,169,32,166,Z0,240,4,10,202,208,252,133,Z3,164,Z2,169,32,153
680 DATASCR2,169,251,141,DRT,162,192,164,Z3,165,Z0,141,OUT,136,208,253,9,8,141
690 DATAOUT,164,Z3,136,208,253,164,Z3,200,208,253,232,208,228,164,Z2,169,SBL
700 DATA153,SCR2,165,Z0,141,OUT,240,2,198,Z0,169,243,141,DRT,88,96,0,*
710 REM BBC USER NOTES
720 REM THE  BBC USES '?' INSTEAD OF 'PEEK' AND 'POKE', THUS 'POKEDRT,251'
730 REM BECOMES '?DRT=251'. FOR 'PEEK' THE '?' CAN BE SUBSTITUTED DIRECTLY,
740 REM THUS 'PEEK(Z(1))' BECOMES '?(Z(1))'. 'SYS(SY)' BECOMES 'CALL(SY)'.
750 REM 'CLR' BECOMES 'CLEAR'. WHEN TYPING IN THE NORMAL BBC REQUIREMENTS FOR
760 A SPACE BETWEEN SOME STATEMENTS SHOULD BE OBSERVED. IF NECESSARY SPLITTING
770 LINES INTO TWO PARTS, GIVING THE 2ND PART A LINE NUMBER INCREMENTED BY 5.
```

the level control VR1. The amplitude is around 1V peak to peak at maximum.

POWER SUPPLY

The unit requires a 5V power supply, and draws only about 3mA. This can be readily supplied by the computer. The BBC has up to 100mA available on its user port, whilst the PET and C64 have cassette ports that can deliver up to 250mA and 100mA respectively. Alternatively a 5V p.s.u. can be used.

ASSEMBLY

The unit is housed in a box 15cm × 13cm × 4·5cm. The potentiometers are mounted 21mm above the base, 30mm apart starting in the centre. Switches are at the same height, 20mm from the sides. The computer socket and its wiring can be selected to suit the computer lead used. The wiring shown for this socket should be regarded just as a guide. Fig. 3 shows the p.c.b. layout and wiring and Fig. 4 shows the interconnection of all other components. Connection details for the three computers are shown in Fig. 5.

SOFTWARE PROGRAM

The BBC, C64 and PET all have BASIC and machine code monitors that are practically identical. The program has been written in PET BASIC, and the machine code is compatible with the 6502 and 6510 microprocessors. The main differences between the three machines are essentially only variations in memory locations and cursor control codes. The software listing gives all the information needed for entering the program into any of these three computers.

Other computers can control the unit if they have normal 8-bit parallel data sockets with an ATN handshake line. User Ports and IEEE 488 ports are suitable. The BASIC should be straightforward to translate for other machines. An assembly language code dump can be supplied if required, so experienced programmers can translate the machine code for other processors. The program requires just over 3K of memory. The machine code subroutine will automatically place itself at the highest memory location available.

USE

The unit will be of assistance in the checking of audio or digital circuits, and for frequencies between about 50Hz and at least 1MHz. Normally VR3 should be at maximum input level for signals below 5V. For signals greater than this, it should be reduced accordingly. The test probes and sockets used are a matter of personal choice. For average signal strength examination, the leads of a multimeter will be adequate. For low level signals though, the probe lead should be screened to avoid mains hum pick up. Oscilloscope probes are ideal, and can be purchased separately from many suppliers. The probes are well screened and available with interchangeable clip or probe tips.

The tracer can be used for checking equipment that has ceased to function after previously working satisfactorily. It can also be used for trouble shooting on a newly assembled project. However, the need to use a trouble tracer can be minimised if the assembly has been carried out correctly and checked carefully in the first place. □

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GRAVITATIONAL WAVES

by George Hylton

THE search is on for a form of radiation which is predicted by theory but has so far never been detected, despite years of attempts. This elusive quarry is gravitational radiation, and if it can be observed astronomers will have a brand-new way of looking at the universe. They will also, at last, be able to prove the existence of Black Holes.

What is gravitational radiation? It is radiation emitted whenever a mass moves. Newton's apple emitted gravitational radiation as it fell, but it was not until Einstein formulated his theories of relativity that its existence was seen to be a necessary element in the universe. A gravitational wave is a ripple which travels through space-time, probably at the speed of light. When the ripple hits two masses which lie apart it either pulls them together or pushes them further apart, depending on whether they lie along the path of the gravitational wave or across it.

DETECTION SYSTEMS

In principle, this mechanical movement could be detected by means of transducers which turn it into an electronic signal capable of amplification. The frequencies involved are for the most part quite low (10Hz–10kHz) so, on the face of it, detection should be easy. The fly in the ointment is the extreme weakness of the interaction between even a very strong gravitational wave and any matter it happens to pass through, such as a detector. A figure quoted recently in the science journal, *Nature,* illustrates the point. Cataclysmic events such as a supernova explosion or the collapse of a star into a black hole in some remote part of the universe would generate gravitational waves which, on reaching the earth, would move a pair of masses spaced apart by one kilometre by an amount equal to a hundredth part of the nucleus of an atom. Not a lot!

This explains the failure of early detectors to find any gravitational waves, despite some claims of success. The first detectors were solid, heavy bars, often of aluminium, suspended like quartz crystals at the points which allowed them to resonate freely when nudged by a passing wave. Electrical outputs were obtained by mounting piezo-electric transducers at strategic points on the bar, or monitoring its movements optically in some way. There is no lack of signals with such a detector, because it acts as an exquisitely sensitive seismometer and responds to any vibrations which happen to be around.

To distinguish real gravitational waves from seismic noises such as passing traffic, distant earthquakes, or the milkman depositing a bottle on the doorstep, two resonating bars were used, spaced well apart. A local signal (such as the milk bottle) then affects only one bar and can be disregarded. A distant seismic signal (such as an earth tremor) is likely to reach one detector an appreciable time before the other, since it travels through the earth only at the speed of sound. But a genuine gravitational wave, at the speed of light, hits both bars at virtually the same time.

LASERS

These first-generation detectors could only have detected gravitational waves from large astronomical events relatively close to the earth: in our own galaxy, say. But this sort of event is rare, and to have a reasonable chance of detecting even a few events per annum it is necessary to make detectors which are sensitive enough to observe waves from at least a reasonable number of more distant galaxies as well. Ideally, a gravitational detector should be sensitive enough to "see" as far as an optical or radio telescope, thus enabling astronomers to look back into space and time in gravitation just as they do with light and radio waves.

To obtain this much-needed increase in sensitivity, some bizarre proposals have been made. One scheme was to use space vehicles to launch a sort of orbiting dumbell with two weights many kilometres apart joined together by a wire. A spring spliced into the mid point of the wire would be stretched or slackened by a passing wave and this could, in principle, be detected.

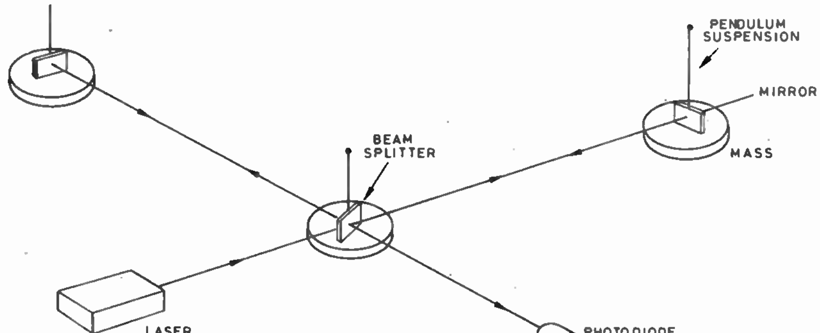
It might be done, some day, but in the meantime plans are being made for some improved down-to-earth detectors. According to *Nature* these will use three masses, suspended like pendulum-bobs on cables. Each mass will be at the corner of a right-angled triangle whose sides are at least a kilometre long. Light from a laser will be reflected back and forth from mass to mass and then to a photodiode. If everything is nice and steady all the reflected light will arive at the photodiode in phase, say. But if the mirrors move apart or together the phase will change and the output with it.

In fact, with the two arms of the detector at right angles the effect of a passing wave is to shorten one arm while simultaneously lengthening the other.

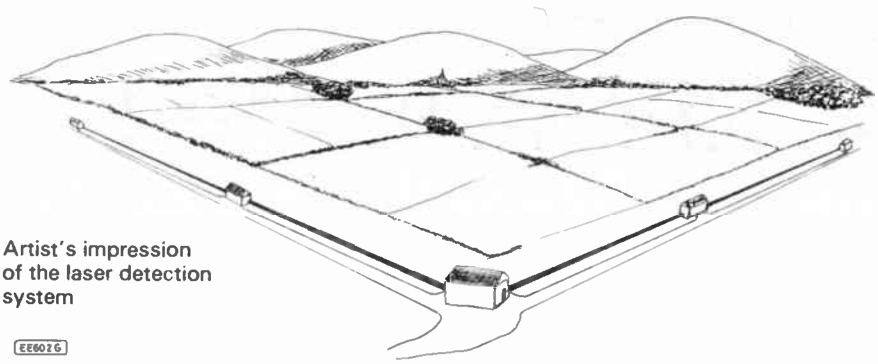
MIRROR TRICKS

Even with this sort of detector the amount of relative movement is too small. Fortunately, the sort of gravitational waves which it is designed for, take some time—a millisecond or so—to pass. To increase their effect the laser beams are shunted back and forth many times before being passed to the photodetector. In this way the effective path length can be increased to tens or even hundreds of kilometres. The resulting increase in phase shifts, plus some very sophisticated signal processing, should just enable the detector to find a few "gravitational events" each year. If several detectors are set up, at different points on the earth, results can be compared and false alarms eliminated.

If the laser beams travel through the



Proposed detection system for gravitational waves.



Artist's impression of the laser detection system

air as they hop from mass to mass, air movements will wreck the system by causing spurious phase shifts in the light. So the light will have to go through long vacuum pipes.

USES AND SPINOFFS

One may well ask, why bother? Why spend all this effort and cash on a search for waves which may not even exist and which are no use anyway? To astronomers and physicists it's important to confirm their existence and to check that they really do travel at the speed of light as Einstein assumed. The existence of black holes in the universe is now in great need of confirmation. By definition, a black hole is invisible. But a gravitational observatory could detect a black hole being formed from a collapsing star, or perhaps the swallowing up of stars by a black hole. These and other matters are academic reasons for making gravitation detectors. Of course, once a detector is avialable it's a good bet to expect it to detect many other things not predicted. After all, nobody expected quasars and pulsars: the radio telescope found them.

Apart from scientific interest there are technological spinoffs. Some of these have arrived already. The frequency and wavelength of the laser in a gravitational wave detector must be stabilized to a high degree. This has been done and is being applied in other fields. To be able to shunt light back and forth many times without too much attenuation calls for mirrors of very good reflectivity. These have been designed. And the signal processing techniques needed to sort the very weak signals from noise are bound to find uses in radar or some other practical technology.

Who will be the first to produce unambiguous evidence that gravitational waves exist? There are plans for large triangular detectors in the USA and Scotland. The West Germans are also doing research. Perhaps the first detection will be of waves from a pulsar. A pulsar, being a rapidly rotating mass, should emit gravitational radiation and this should fluctuate at the pulsar frequency, which is known from radio and optical observations. So it seems a good bet to try to detect the gravitational waves from a known pulsar.

If you fancy a long shot there's another and quite different possibility. It may be possible to detect very long wavelength gravitational radiation with an optical or radio telescope! Not directly, but from its effects on another heavenly body. There is a pulsar which bleeps very steadily with a period of just over a millisecond. It is so steady that it keeps better time than a quartz clock. But if very-long-wave gravitational radiation were to pass through it then the clock would gain or lose. Some astronomical catastrophes, it is thought, must generate gravitational waves with periods of months or years. By comparing the rate of the "millisecond pulsar" with the best atomic clocks, over a long period, small gains or losses should be detectable. It is being done. So it's just possible that the race to find gravitational radiation may be won by a traditional observatory. □

b...Beeb...Beeb...Beeb...Bee

... simple clean-up for page select lines ... data latch ...

SO FAR in this series we have only considered the user and analogue ports, which are probably the two most popular ones for user add-on purposes. The user port has a lot of helpful features and it is certainly very versatile, and it is a subject we will return to in later articles, but for all its good points it is basically just an eight-bit plus twin handshake line type, and this provides inadequate expansion possibilities for the more ambitious digital add-on's.

Similarly, the analogue port has a lot of good points, including four channel capability and good resolution, but it is inadequate for some purposes. It is not so much a lack of inputs in this case (a problem which is easily overcome as was shown in the previous two articles), but the limited conversion rate of only about one hundred per second. Applications such as audio digitizing require conversion rates of typically around three thousand to one hundred thousand per second.

Port A has two handshake lines which are comparable to those of port B, but CA2 is only available via a simple buffer amplifier circuit, and can only operate as an output. CA1 connects direct to the printer port, and it is usable as a handshake input.

Although there are restrictions on the ways in which the printer port can be utilized, it can be extremely useful in cases where the user port cannot provide sufficient digital lines. In particular, many applications require an 8-bit input port with handshaking plus a separate 8-bit output port with handshaking. These requirements can be accommodated by having the user and printer ports respectively as the input and output ports. Fig. 1, in conjunction with Table 1, gives connection details for the printer port.

It is possible to send data to the printer port in the Acorn approved fashion, but when using this port with user add-on's it is normally much better to directly address

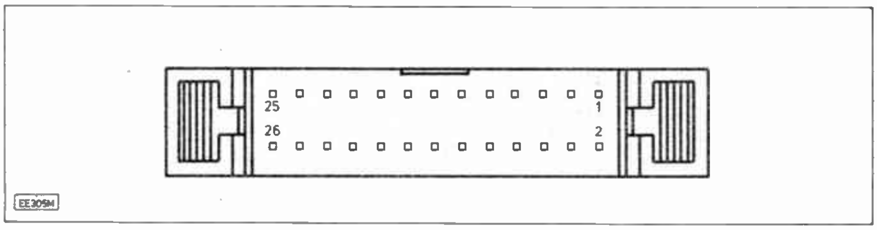


Fig. 1. The Printer Port pin numbering.

Printer Port

Fortunately the BBC machines are not short of ports, and extra digital and (or) analogue lines are easily added. The port usually brought into play for expansion purposes is the 1MHz Bus, but if only limited expansion is required there are alternatives which might be worthwhile considering. One of these is the Printer Port which might be tied up for its intended purpose, but which makes an excellent digital output port if it is not.

As shown by the circuit diagram on page 503 of the *User Guide*, the printer port is provided by port A of the 6522 VIA which also provides the user port. Port A has many features in common with port B, including eight general purpose digital input/output lines. However, there is a 74LS244 octal buffer on these lines which makes them only usable as outputs.

the relevant registers of the 6522 VIA. The two registers of primary interest are the data direction and peripheral registers for port A, and these are located at addresses &FE63 and &FE61 respectively.

As there is no point in setting any of the printer port data lines as inputs, &FE63 should always be set to a value of 255 (all lines set as outputs). Data to be written to the port is sent to address &FE61 in just the same way that data for the user port is sent to address &FE60. Use of the printer and user port handshake lines is less straightforward than that of the data lines, and it is something that will be dealt with in subsequent articles.

1MHz Bus

Most computers have a general purpose expansion port which gives access to the control, data, and address buses, plus a number of other useful lines. On the BBC machine this takes the form of the "1MHz Bus", although this is not exactly a typical computer expansion port.

It gets its name from the fact that it has a 1MHz clock signal and is intended for use with standard 6502 and 6800 peripheral devices, and not the high speed 2MHz types. It has to be remembered here that the BBC machines all have a 2MHz version of the 6502 microprocessor, and that the signals on the 1MHz Bus have to be slowed down in order to make them suitable for the ordinary 1MHz peripherals.

Table 1: Printer Port Connection Details

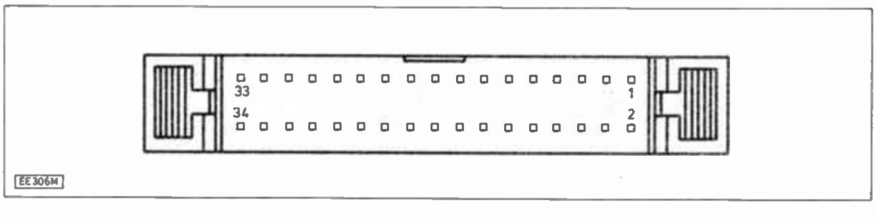
Pin No.	Function	Pin No.	Function
1	CA2	2	Gnd
3	PA0	4	Gnd
5	PA1	6	Gnd
7	PA2	8	Gnd
9	PA3	10	Gnd
11	PA4	12	Gnd
13	PA5	14	Gnd
15	PA6	16	Gnd
17	PA7	18	Gnd
19	CA1	20	Gnd
21	NC	22	Gnd
23	NC	24	Gnd
25	NC	26	Gnd

Connection details for the 1MHz Bus is given in Fig. 2, in conjunction with Table 2. Most of the lines one would expect to find are available, with the obvious exceptions of the eight most significant address lines (A8 to A15). There are two pages of the memory map available for user add-on's (i.e. two blocks of 256 addresses), and these are pages &FC** and &FD**.

Table 2: 1MHz Bus Connection Details

Pin No.	Function	Pin No.	Function
1	Gnd	2	R/W
3	Gnd	4	Clock
5	Gnd	6	NNMI
7	Gnd	8	NIRQ
9	Gnd	10	NPGFC
11	Gnd	12	NPGFD
13	Gnd	14	NRST
15	Gnd	16	AF IN
17	Gnd	18	D0
19	D1	20	D2
21	D3	22	D4
23	D5	24	D6
25	D7	26	Gnd
27	A0	28	A1
29	A2	30	A3
31	A4	32	A5
33	A6	34	A7

Fig. 2. The 1MHz Bus pin numbering.



Rather than making the upper eight address lines available and having external address decoding, the 1MHz Bus helpfully provides two ready decoded outputs—"NPGFC" and "NPGFD". One of these pulses low when any address in the relevant address range is accessed, and these lines can be used to activate add-on's connected to this port. By decoding them with the eight least significant address lines and the read/write line it would in fact be possible to have 512 input and 512 output devices operated from this port, although it is difficult to envisage anything like this level of expansion ever being required.

Much of the available address range has been allocated by Acorn to specific add-on's or types of add-on, and to maintain compatibility with other hardware designed to connect to the 1MHz Bus it is necessary for user add-on's to be fitted into the appropriate address range. Of course, if you do not intend to use the 1MHz Bus with anything other than your own circuits, then there is no need to keep within the recommended address range, but otherwise you should only use addresses from &FCCO to &FCFE.

Note that this last address is not a misprint, and should NOT be &FCFF (which is apparently reserved for memory expansion purposes). This gives a total of some 63 addresses available for user devices, which is still far more than are ever likely to be needed in practice.

When dealing with the 1MHz Bus you may occasionally come across references to "Fred" and "Jim". These are the nicknames given to pages &FC** and &FD** (respectively) of the memory map, for reasons best known to Acorn themselves. The page of memory reserved for internal input/output devices is &FE**, or "Sheila" in Acorn's nomenclature.

Clean-up Circuit

There is a slight problem with lines NPGFC and NPGFD on the original Model B computers in that the process of slowing down the bus signals from 2MHz to 1MHz results in glitches on these page select lines. This problem is supposed to have been ironed out on the Model B+ and Master 128 machines, and is certainly not present on my Master 128.

On the Model B it is not difficult to overcome, and the simple circuit diagram of Fig. 3 is adequate in the vast majority of cases. This is just three 2-input NOR gates, with one used as such and the other two connected to operate as a simple flip/flop. If you wish to use both NPGFC and NPGFD then they will require separate clean-up circuits.

There is a strange omission from the 1MHz Bus in that there is no +5V output, or any form of power supply available come to that. Add-on's to this port accordingly need to be either self-powered, or they must tap off power from one of the other ports that do provide a suitable output (the power port, user port, or whatever source happens to be most convenient). The same is also true of the printer port, but this would normally only be used in conjunction with one of the computer's other ports anyway, and power can then be taken from this other port.

Eight Bit Input

If you examine the circuit diagram of the 1MHz Bus in the Model B's *User Guide* you will find that the data bus is not derived direct from the microprocessor, but is taken via a 74LS245 8-bit transceiver. The primary purpose of this is to provide buffering so that several peripherals can be driven from the port if desired, and it also reduces the risk of any serious damage to the computer if a peripheral circuit malfunctions or is incorrectly connected to the port. The eight available bits of the address bus are also buffered incidentally.

The inclusion of the 74LS245 on the data bus opens up the possibility of using the 1MHz Bus as a simple 8-bit input port. It is not intended for use in this manner, but it is a perfectly legitimate way of utilizing this port.

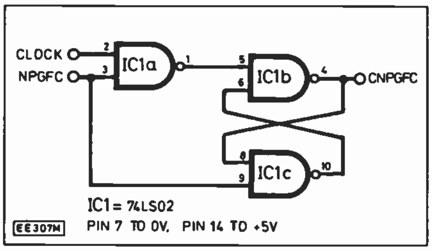


Fig. 3. Circuit diagram for the simple clean-up for page select lines.

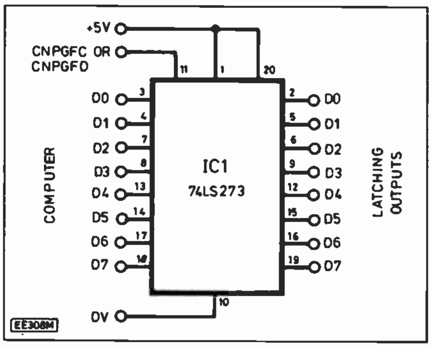


Fig. 4. Circuit diagram for adding a data latch to the 1MHz Bus.

If you try reading the 1MHz Bus by reading any address in the relevant range (e.g. PRINT ?&FCOO) you should find that a value of 255 is returned. This is normally the case when dealing with TTL input ports as TTL inputs that are left unconnected almost invariably float to the high state.

If you try wiring some of the data inputs to earth this should not cause the computer to crash since the data bus signals are not normally present on these lines, and they are only connected through to the microprocessor when an address in the range &FCOO to &FDFF is accessed. If you try reading an address in this range again you should find that the returned value is the correct one for whichever inputs have been pulled low.

There is one minor problem in using the 1MHz Bus as a simple input port, and this is due to the 74LS245 being a transceiver rather than a tristate buffer. What this means in practice is that any data written to the 1MHz Bus will appear momentarily on its data bus, and this would result in outputs driving outputs if a peripheral of some kind is feeding into these lines. Therefore, when using the 1MHz Bus in this way, care must be taken not to send any data to the port, and this should not really present any practical difficulties.

Data Latch

Although the 1MHz Bus will operate perfectly well as a simple 8-bit input, it can not operate as an output port without the aid of some external hardware. This is because the 74LS245 does not provide latching, and data sent to the port consequently only appears on the data bus very briefly.

In order to use this port as an 8-bit output it is necessary to use an 8-bit latch with the latching pulse derived from NPGFC or NPGFD via the clean-up circuit described previously. Fig. 4 shows how a 74LS273 can be used as the data latch.

By using both page select lines in conjunction with two clean-up circuits (Fig. 3) and two data latches (Fig. 4) it is possible to have twin output ports (one accessed using any address in page &FC**, and the other accessed using any address in page &FD**).

With the information provided here anyone with a reasonable knowledge of computer peripheral devices should have no difficulty in interfacing these devices to the 1MHz Bus, but this is a subject we will return to in later articles for those who are unsure about this topic.

In next month's article we will consider the important subject of using the printer and user port handshake lines, and the two timer/counters of the 6522 VIA. Directly addressing input/output circuits is not recommended by Acorn as it will not work reliably when a second processor is in use. The approved way of accessing add-on's will also be briefly described.

If you have any comments or ideas for inclusion in the ***Beeb Micro*** *pages, please send them to: Everyday Electronics, 6 Church St, Wimborne, Dorset BH21 1JH.*

FOR YOUR ENTERTAINMENT

BY BARRY FOX

Wired Society

Nothing is for nothing. Britain should have a direct broadcasting satellite service this year, run by the BBC. Then we were going to have a service jointly run by the BBC, the independent commercial TV companies and a gaggle of private companies like Thorn, Granada and Virgin. The best hope now is for a private commercial service, controlled from the IBA, by the end of the decade. There is no government aid to prime the pump.

Meanwhile, France and West Germany are steaming ahead, with plans to launch direct broadcasting satellites by the end of this year or early in 1987. The recent *Ariane* rocket launcher crash may delay things, but the will is still there. Heavy Government subsidies make it possible.

By now Britain should also have been well on the way to becoming a wired society, with cable stations offering not just entertainment but interactive video services as part of the information technology revolution. That also hasn't happened. There is no Government money to subsidise cable so all but one of the systems being installed use the bare minimum technology. They offer passive, dumb viewing of entertainment TV.

In February 1982 the Prime Minister's own ITAP committee (Information Technology Advisory Panel) recommended that Britain should wire up with hi-tech interactive systems. The ITAP committee and its ideas are dead meat. France has started to wire for the future. Holiday resort Biarritz is wired with optical fibre as an experiment. Residents can have a videphone, free, if they want one!

Switched Star

In Britain only British Telecom is spending money on cable as an IT (Information Technology) tool. BT is now subsidising a £1 million experiment by London University to use interactive television as a way of linking its London colleges, twenty-four hours a day, seven days a week. The technology used is "switched star". This was developed by BT's Martlesham research laboratories when the British Government followed the ITAP line and encouraged new cable stations to install a switched star network.

Switched star works like this. A wide bandwidth trunk line, of optical fibre, carries all the available services and programmes. Local switch boxes, e.g. one per street, convert the optical signals into electrical signals. A few at a time are run by copper coax. into the subscriber's home. The subscriber chooses which signals come into the home by sending digital control signals to the local switch box.

This differs from the traditional "tree and branch" system, in which the main tree trunk line carries all the programmes on offer and the branch lines carry off most or all of these programmes to individual homes. This limits total system capacity. Also it is much more difficult to send signals back up the cable link from the viewer's home to the cable station.

Window Shopping

So far only one cable station is using switched star. That's Westminster and BT is subsidising the installation. The London University network, to be called Livenet, will link up with the Westminster station, to offer home education by cable TV.

The investment will provide BT with a shop window to help sell its switched star technology abroad. The only way you can sell the concept of interactive cable is to show it working. BT is hoping that other countries will buy the technology which Britain developed, but cannot afford to use. BT is also taking advantage of the construction work going on in Westminster to sell the idea of cable to the public. If the experiment fails Britain may never be cabled for anything more than wall-to-wall TV entertainment.

The Starship, a converted luxury holiday home, tours the streets of St. John's Wood and Maida Vale in London. The Starship was imported from the US and converted by Westminster Cable to demonstrate the kind of TV programme which some people in the area can now buy through a cable link. Wherever possible it is parked next to any hole in the road where Telecom engineers are laying cable.

BT claims that the switched star system now being laid in Maida Vale, St Johns Wood and Baker Street is the most advanced large-scale cable TV system in the world. It gives each subscriber an individual choice of programming. In the future Westminster subscribers should be able to send a full TV channel back up the same cable link to the cable station control room. They will then be able to install a TV camera for remote security surveillance, like burglar, fire or baby watching, while they are out. But so far, because the buying public has shown far less enthusiasm for interactive cable than ITAP or the Government anticipated, Westminster is only offering a choice of passive entertainment channels.

Westminster Cable will not say how much it is costing to install in the test bed area of London. But 4 years ago BT tested the technology on 18 homes at Milton Keynes. The cost per home, with full optic fibre links, was £1800 for each house.

Installing a simple all-coaxial system, with no switching, has been costing Thorn EMI around £300 per home in Swindon. That's why the company has been trying to sell off its Swindon cable operation to BT. There are not enough customers to make even the simple system pay.

Best estimate is that BT and Westminster are paying around £500 a home for their mixed optic/coaxial system. It is only viable because BT needs somewhere to show off the technology which Martlesham developed.

So far only a few hundred homes are connected but as BT lays more fibre and coax. the system will reach 96,000 homes, 32,000 businesses and 55,000 hotel beds. Already Grosvenor House and The Savoy hotels are plugged in. Subscribers pay around £5 a week for 24 channels of TV.

Satellite signals are received by two 3 metre dish aerials at BT's telephone exchange near Lords' cricket ground. These signals are sent as light pulses on optic fibre to Westminster Cable's headquarters at Baker Street. There the signals are "topped and tailed" with pre-recorded material and announcements and sent by fibre link to BT's Burn House in Marylebone Road.

The full menu of 24 channels is distributed by fibre to 4 hub sites. Each hub site sends the same full menu of signals out to 10 wideband switch points (WSP) where the signals are converted from light to electricity. Each WSP serves up to 300 subscribers via a coaxial link in response to the subscriber's control signals.

The WSP can send two feeds to each home on a single coax. cable. In this way a TV set can have a programme listing available for display or the subscriber can watch one channel while taping another.

The control pulses can be used to send more complex information back to the switch points, for instance voting signals in a quiz game or election. But this is for the future, like the installation of a video camera in the subscriber's home sending picture signals to the local police station.

Livenet

Exactly the same type of technology, to be called Livenet, is used by London University. A computer-controlled switch at the centre of the star configuration will send and receive TV signals and data between Imperial College, King's College, Queen Mary College, Royal Holloway and Bedford New College, University College and London University's Computer and Audio-Visual Centres.

The 37 kilometre run out to Royal Holloway in Egham will be by monomode optic fibre, with one repeater station. The shorter runs will use multi-mode fibre.

Each connection has two separate fibres, to carry four video channels and one data channel into and out of each college. The switch can handle 28 video channels in any combination, so that a lecturer in one college will be able to teach pupils in one or more of the other colleges, while receiving pictures of the pupils and their work in return.

The video channels are analogue f.m. signals, stacked in frequency. The data channel can carry a 2 megabit/second stream of computer text or programming. If this is insufficent, any video channel can be sacrificed and used to carry an 8 megabit/second data stream instead. The video pictures are sourced from cameras, either pointing at a teacher or class, built into a microscope or set up to transmit pictures of diagrams or text.

Although the signals are being carried between colleges as light on optical fibres, they are converted back into electricity and carried by copper coax. once they enter the college. In the future, however, the light link may be extended around the college as an optical fibre network capable of carrying a much larger number of data and video channels.

This is exactly what the 1982 advisory panel had in mind for Britain. But although BT currently operates eight cable stations in Britain, ranging from a large network in Milton Keynes to a small system at the Barbican, London, they are all (except Westminster) using simple tree and branch technology.

NOVEMBER FEATURES...

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EVERYDAY ELECTRONICS and ELECTRONICS MONTHLY

NOVEMBER ISSUE ON SALE FRIDAY, OCTOBER 17

...REPORTING AMATEUR RADIO...

TONY SMITH G4FAI

STEAM RADIO

Railway buffs visiting the 25th anniversary celebrations of the Great Western Society, at Didcot Railway Centre, at the end of May, had an opportunity to see amateur radio in action. Located in an ex-GWR director's saloon coach, special event station GB4GWR, manned by members of the Vale of White Horse Amateur Radio Society, made many contacts while steam locomotives literally puffed their way past the windows of the carriage.

Stations throughout Britain, and overseas, contacted Didcot over the air, using both speech and Morse code. Many of the callers were "old-timers" who as passengers, or as railwaymen, well recalled the days when steam railways were part of everyday life. A number of these operators subsequently visited the Centre during the week-long celebrations, to collect their commemorative QSL cards personally from the radio station.

The amateur radio society has strong links with the railway society, and has mounted similar demonstrations on a number of occasions. Amateur TV transmissions are demonstrated from the footplates of working locomotives, and contacts made over the air from the footplate, on the 2 metre band, are verified by QSL cards signed by both the engine driver and the fireman!

More information about the Vale of White Horse ARS and its activities is available from John O'Hagan, G4PFY, on Wantage 66458. As ever, newcomers to the hobby are made welcome.

AMATEUR HONOURED

Mr Shozo Hara, JA1AN, has been awarded a "Ranjuhosho", a Blue Ribbon Medal, the highest honour for meritorious service or achievement awarded by Japan to a private citizen. His award is for distinguished service in the telecommunications world, and particularly his promotion of amateur radio in Japan for the past three decades.

His interest in the hobby goes back to 1939, and after the second world war he led a campaign to re-establish amateur radio in his country. This was successful in 1952, and today there are something like half a million amateurs in Japan.

He was also instrumental in re-organising the Japanese Amateur Radio League, the country's national amateur radio society, and has been its president since 1970. The award is a well deserved recognition of his work on behalf of amateur radio.

DANISH EMERGENCY GROUP

Radio amateurs in Denmark have formed a new emergency service which is intended to function in the same way as our own Radio Amateurs Emergency Network, *RAYNET*, providing national or international emergency communications, assisting civil authorities, welfare organisations, or police, whenever needed.

Known as Radioamatorernes Signal Tjeneste, or *RST*, an appeal has been made by them to groups in other countries for details of their organisation, procedures, manuals, etc., to help the embryo service learn from the experience of others.

This item, from Region 1 News of the International Amateur Radio Union (IARU), reflects the official view of the International Telecommunication Union, the international radio regulatory body, that national administrations should use the amateur radio bands and, if necessary, amateur stations, to provide for the needs of international disaster communications.

To prepare for this eventuality, national societies everywhere were asked recently, by Richard Baldwin, W1RU, President of the *IARU*, to work towards setting up trained emergency communications corps, if they did not already have them. The Danish initiative is a direct response to that request.

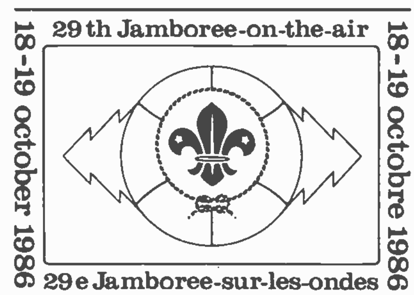
QUESTION CORNER

Q. What is Jamboree-on-the-Air?

A. Amateur radio and the Scout and Guide movements have one thing very much in common. All are dedicated to the ideals of international friendship, each in their own way seeking to overcome the artificial barriers between the different peoples of the world.

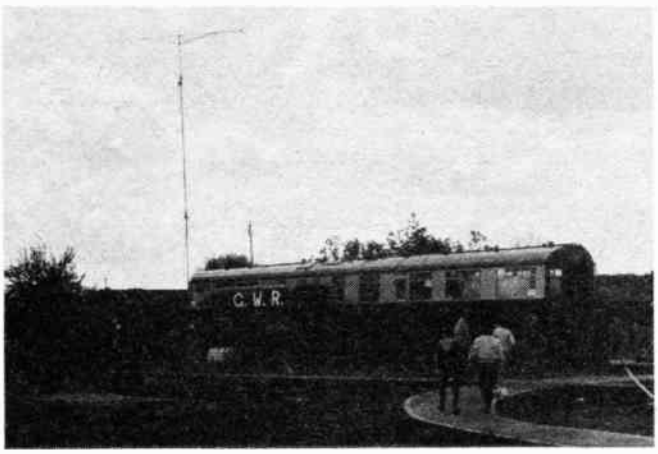
An international gathering of Scouts is called a Jamboree, and one weekend a year Radio Amateurs, Scouts and Guides, combine to create a Jamboree-on-the-Air, known universally as *JOTA*. Amateurs make their stations available to Scout and Guide groups. They are set up in headquarters or camps, and sometimes the amateurs happen to be Scouts as well.

Greetings are passed from group to group by the operators, or by the Scouts and Guides themselves. Until 1982, British participants were at a disadvantage compared to those in other countries, as only licensed operators were permitted to speak on the air. That year, on an experimental basis, and under the control of the licensee, non-licensed persons were allowed to speak into the microphone of a special event station, i.e. one with a GB call-sign, to send simple greetings to other amateur stations within the UK.



The Amateur Radio, Scouts and Guides JOTA logo commemorating the 1986 "Jamboree-on-the-Air".

Located in a GWR coach, the Great Western Society's "shack" was manned by members of the Vale of White Horse ARS.



The GB4 GWR QSL card showing its links with the past age of "steam" locomotion at the Didcot Railway Centre.

It was a step forward, which at least allowed British Scouts and Guides to speak to each other over the air during *JOTA*. Just before last year's event, a further concession was announced by the DTI, extending the experiment to contacts with Canada, the USA, and the Falklands, while negotiations continued in the hope of obtaining similar arrangements with Australia and New Zealand.

7000 STATIONS

Last year there were over 350 specially licensed GB stations operating in conjunction with Scout and Guide groups in Britain. Australian participation is one of the highest in the world, and they had 551 stations, using 1140 different call-signs, logging 6297 contacts. Worldwide, some 7000 stations take part in *JOTA*, in about 100 countries, and it is estimated that well over 100,000 Scouts and Guides participate in one way or another.

There are no special rules. It is simply an opportunity for Scouts and Guides from different countries, or different parts of the same country, to make contact with each other, and extend the hand of friendship through the medium of amateur radio.

Involvement in the operation of the station adds interest to the occasion. They can keep the station log, recording details of each contact made, identify countries from their call-signs, and locate the places they speak to on a map. They can discover from "beam headings", the direction in which a rotatable antenna radiates most power, that the best route from one point to another on the globe is not always what they would expect.

For Scouts and Guides in some countries, this is the only international event in which they are ever likely to take part, and it is especially valuable to them in emphasising the worldwide nature of their organisations.

This year sees the 29th *JOTA*. Back in 1957, it was the brainchild of Scout-Amateur Les Mitchell, G3BHK, following the World Jamboree at Sutton Coldfield, where an amateur station, GB3SP, was organised by another Scout, Alan Dennis, G3CNV, assisted by local radio clubs.

Following that, the first Jamboree-on-the-Air was held in 1958, when it became an officially listed annual Scouting event. Les Mitchell undertook its organisation, and in 1959 it became the responsibility of the World Scout Bureau in Geneva. Les is still national UK organiser and, as you will hear, if you tune the amateur bands on 18-19 October, his original inspiration has gone from strength to strength.

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EE MARKET PLACE OCTOBER '86

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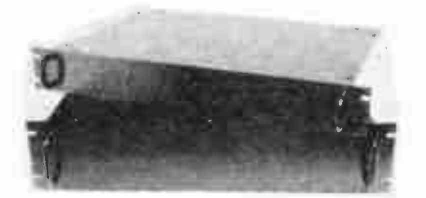

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19×5.25	17×5.0×12	27.5	32.5
19×5.75	17×5.5×12	28.5	33.5
*17×2.5	15.5×2×9	16.5	20.5
*17×3.5	15.5×3×9	17.0	—
*19×3.0	17×2.5×10	—	20.5
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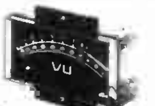

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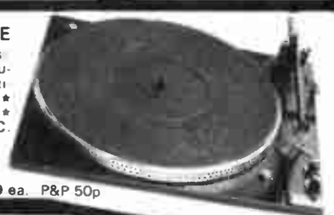
12" 85 WATT R.M.S. C1285GP Lead Guitar/Keyboard/Disco.
2" ally voice coil. Ally centre dome. Res. Freq. 45Hz. Freq. Resp. to 6·5KHz. Sens. 98dB. PRICE £29.99 + £3.00 P&P ea.
12" 85 WATT R.M.S. C1285TC P.A./Disco 2" ally voice coil. Twin cone.
Res Freq. 45Hz. Freq. Resp. to 14KHz. PRICE £31.49 + £3.00 P&P ea.
15" 150 WATT R.M.S. C15 Bass Guitar/Disco.
3" ally voice coil. Die-cast chassis. Res. Freq. 40Hz. Freq. Resp. to 4KHz. PRICE £57.87 + £4.00 P&P ea.
10" 60 WATT R.M.S. 1060GP Gen. Purpose/Lead Guitar/Keyboard/Mid. P.A.
2" voice coil. Res. Freq. 75Hz. Freq. Resp. to 7·5KHz. Sens. 99dB. PRICE £19.99 + £2.00 P&P.
10" 200 WATT R.M.S. C10200GP Guitar/Keyboard/Disco.
2" voice coil. Res. Freq. 45Hz. Freq. Resp. to 7KHz. Sens. 101dB. PRICE £44.76 + £3.00 P&P.
15" 200 WATT R.M.S. C15200 High Power Bass.
Res. Freq. 40Hz. Freq. Resp. to 5KHz. Sens. 101dB. PRICE £62.41 + £4.00 P&P.
15" 400 WATT R.M.S. C15400 High Power Bass.
Res. Freq. 40Hz. Freq. Resp. to 4KHz. Sens. 102dB. PRICE £89.52 + £4.00 P&P.

WEM
5" 70 WATT R.M.S. Multiple Array Disco etc.
1" voice coil. Res. Freq. 52Hz. Freq. Resp. to 5KHz. Sens. 89dB. PRICE £22.00 + £1.50 P&P. ea.
8" 150 WATT R.M.S. Multiple Array Disco etc.
1" voice coil. Res. Freq. 48Hz. Freq. Resp. to 5KHz. Sens. 92dB. PRICE £32.00 + £1.50 P&P ea.
10" 300 WATT R.M.S. Disco/Sound re-enforcement etc.
1½" voice coil. Res. Freq. 35Hz. Freq. Resp. to 4KHz. Sens. 92dB. PRICE £36.00 + £2.00 P&P ea.
12" 300 WATT R.M.S. Disco/Sound re-enforcement etc.
1½" voice coil. Res. Freq. 35Hz. Freq. Resp. to 4KHz. Sens. 94dB. PRICE £47.00 + £3.00 P&P ea.

SOUNDLAB (Full Range Twin Cone)
5" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc.
1" voice coil. Res. Freq. 63Hz. Freq. Resp. to 20KHz. Sens. 86dB. PRICE £9.99 + £1.00 P&P ea
6½" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc.
1" voice coil. Res. Freq. 56Hz. Freq. Resp. to 20KHz. Sens. 89dB. PRICE £10.99 + £1.50 P&P ea
8" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc.
1½" voice coil. Res. Freq. 38Hz. Freq. Resp. to 20KHz. Sens. 89dB. PRICE £12.99 + £1.50 P&P ea
10" 60 WATT R.M.S. Hi-Fi/Disco etc.
1¼" voice coil. Res. Freq. 35Hz. Freq. Resp. to 15KHz. Sens. 89dB. PRICE £16.49 + £2.00 P&P

BSR P295 ELECTRONIC TURNTABLE



★ Electronic speed control 45 & 33⅓ r.p.m. ★ Plus Minus variable pitch control ★ Belt driven ★ Aluminium platter with strobed rim ★ Cue lever ★ Anti skate (bias device) ★ Adjustable counter balance ★ Manual arm ★ Standard ½" cartrige fixings ★ Supplied complete with cut out template ★ D.C. Operation 9-14v D.C. 65mA
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ADC Q4 mag. cartridge for above. Price £4.99 ea. P&P 50p

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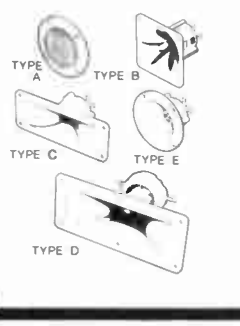

TYPE 'A' (KSN2036A) 3" round with protective wire mesh, ideal for bookshelf and medium sized Hi-fi speakers. Price £4.90 each + 40p P&P
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TYPE 'D' (KSN1025A) 2" × 6" wide dispersion horn. Upper frequency response retained extending down to mid range (2KHz). Suitable for high quality Hi-fi systems and quality discos. Price £9.99 each + 40p P&P
TYPE 'E' (KSN1038A) 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-fi monitor systems etc. Price £5.99 each + 40p P&P
LEVEL CONTROL Combines on a recessed mounting plate, level control and cabinet input jack socket. 85 × 85 mm. Price £3.99 + 40p P&P

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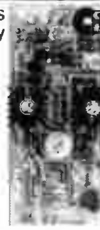

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