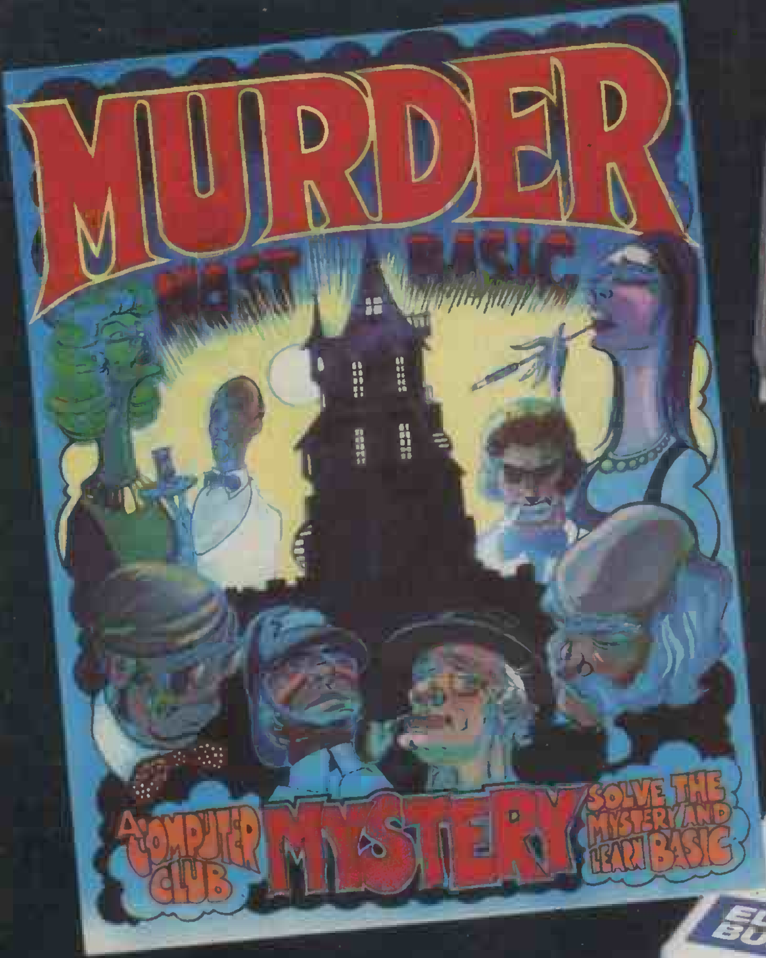
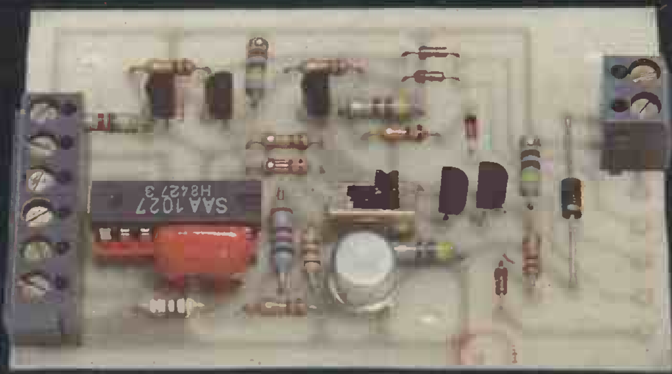
EVERYDAY ELECTRONICS and computer PROJECTS

AUGUST 1985 £1·00





STEPPING MOTORS
STEPPER MOTOR INTERFACE

New Series...
ELECTRONIC BUILDING BLOCKS

TREMOLO/VIBRATO UNIT · TRI STATE THERMOMETER

Australia $1.75 New Zealand $1.95 Malaysia $4.95

BAKERS DOZEN PARCELS

All the parcels listed below are brand new components. Price per parcel is £1.00, but if you order 12 you get one extra free.

1 – 5 13 amp ring main junction boxes
2 – 5 13 amp ring main spur boxes
3 – 25 13 amp fuses for ring mains
4 – 5 surface mounting switches suitable insulated for mains voltage
5 – 3 flush electrical switches intermediate type, will also replace 1 or 2 way switches
6 – 5 in flex line switches
7 – 4 in flex line switches with neons
8 – 2 80 watt brass cased elements
9 – 2 mains transformers with 6v 1a secondaries
10 – 2 mains transformers with 12v ½a secondaries
11 – 1 extension speaker cabinet for 6½" speaker
12 – 5 octal bases for relays or valves
13 – 12 glass reed switches
14 – 4 OCP 70 photo transistors
15 – 25 assorted germanium transistors OC45 etc
16 – 4 tape heads, 2 record, 2 erase
17 – 2 ultra sonic transmitters and 2 ditto receivers
18 – 2 15000 mfd computer grade electrolltics
19 – 2 light dependent resistors similar ORP12
20 – 5 diff micro switches
21 – 2 mains interference suppressors
22 – 2 25 watt crossover units
23 – 1 40 watt 3 way crossover unit
24 – 250 various screws and self tappers
25 – 1 of each wafer switches – 6p 2 way; 4p 3 way; 2p 6 way; 1p 12 way
26 – 2 tape deck counters
27 – 1 6 digit counter 12v
28 – 1 6 digit counter mains voltage
29 – 1 BOAC in flight stereo unit (second hand)
30 – 2 Nicad battery chargers
31 – 1 key switch with key
32 – 2 humidity switches
33 – 2 aerosol cans of ICI Dry Lubricant
34 – 96 x 1 metre lengths colour-coded connecting wires
35 – 4 battery operated model motors
36 – 2 air spaced 2 gang tuning condensors
37 – 2 solid dielectric 2 gang tuning condensors
38 – 10 compression trimmers
39 – Long and Medium wave tuner kit
40 – 4 x 465 KC IF transformers
41 – 8 Rocker Switches 10 amp Mains SPST
42 – 6 Rocker Switches 10 amp Mains SPDT
43 – 5 Rocker Switches 10 amp SP DT Centre Off
44 – 4 Rocker Switches 10 amp DPDT
45 – 1 24 hour time switch mains operated – (s.h.)
46 – 1 6 hour clockwork timeswitch
47 – 2 lever switches 4 pole changeover up and ditto down
48 – 2 6v operated reed switch relays
49 – 10 neon valves – make good night lights
50 – 2 x 12v DC or 24V AC 4C0 relays.
51 – 1 x 12v 2C 0 very sensitive relay
52 – 1 x 12v 4C 0 relay
53 – 2 mains operated relays 3 x 8 amp changeovers (secondhand)
54 – 10 rows of 32 gold plated IC sockets (total 320 sockets)
55 – 1 locking mechanism with 2 keys)
56 – Miniature Uniselector with circuit for electric jigsaw puzzle
57 – 5 Dolls' House switches
58 – 2 telephone hand sets incorporating ear piece and mike (p)
59 – 2 flat solenoids – ideal to make current transformer etc.
50 – 5 ferrite rods 4" x 5/16" diameter aerials
61 – 4 ferrite slab aerials with L & M wave coils
62 – 4 200 earpieces
63 – 1 Mullard Thyristor trigger and modules
64 – 10 assorted knobs ¼ spindles
65 – 5 different thermostats, mainly bi-metal
66 – Magnetic brake – stops rotation instantly
67 – Low pressure 3 level switch
68 – Heavy duty 4 pole contactor – 24v coil
69 – 2 25 watt pots 8 ohm
70 – 2 25 watt pots 1000 ohm
71 – 5 wire wound pots – 18, 33, 50, and 100 ohm
72 – 1 1250 watt dimmer Ultra ref SE20
73 – 4 3 watt wire wound pots 50 ohm
74 – 50 1/3 watt carbon film resistors food spread 10 values
75 – 20-2 watt carbon resistors 10 values
76 – 30 1 watt carbon resistors 15 diff values
77 – 1 time reminder adjustable)-60 mins
78 – 5.5 amp stud rectifiers 400V
79 – 4 2a bridge rectifiers 400V
80 – 2 10a bridge rectifiers 30V
81 – 2 30a panel mounting slydlok fuses
82 – 4 porcelain fuse holders and fuses
83 – 1 fluorescent choke – your choice – 15, 20, 30, 40 or 65 watt
84 – 10 1 mains voltage suppressor condensors
85 – 1 mains shaded pole motor ¾" stack
86 – 2 5" ali fan blades fit ¼" shaft
87 – 2 3" plastic fan blades fit ¼" shaft
88 – Mains motor suitable for above blades
89 – 1 mains motor with gear box 1 rev per 24 hours
90 – 1 mains motor with gear box 1 rev per 12 hours
91 – 2 mains motor with gear box 16 rpm
92 – 4 fluorescent starters suit 4 – 80 w tubes
93 – 4 11 pin moulded bases for relays
94 – 5 B7G valve bases
95 – 4 skirted B9A valve bases
96 – 1 thermostat for fridge
97 – 1 infra red fire element 1000 watts
98 – 1 motorised stud switch (SH)
99 – 5 assorted ferrite shapes
100 – 3 ferrite magnets
101 – 1 2½ hours delay switch
102 – 1 9v mains power supply unit
103 – 1 6v mains power supply unit
104 – 1 4½v mains power supply unit
105 – 1 5 pin flex plug and panel socket
106 – 1 12v vibrating reed bleepers
107 – 5" speaker size radio cabinet with handle
108 – 5 different multi way push switches
109 – 10 ¼" spindle type volume controls
110 – 10 slider type volume controls
111 – 2 musical boxes (less keys)
112 – 1 heating pad 200 watts
113 – 1 fm front end with tuning condensor
114 – 1 1w amplifier Mullard 1172

With most items quantity buyers get good discounts and save on postage costs.

EX-G.P.O. TELEPHONES

Black heavy type	£5.50
Lightweight 746 type	£7.50
Ex-G.P.O. plug	£1.00
Ex-G.P.O. socket	£1.00

SOUND TO LIGHT UNIT

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

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.

4/5A BATTERY CHARGER

Transformer and rectifier £3.95 & £1 post, 3 kits £12.

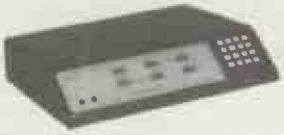
WALL MOUNTING ROOM THERMOSTAT

By Danfoss has a really pretty two tone grey case with circular white scale and dial. Setting temperature from 0 – 30 c – 13 amp 250v contacts. Price £4.60. – 10 for £40.

BLEEPERS

6 or 12v battery or transformer operated, ideal for using in alarm circuits but particularly suitable for can and motor cycle alarms. These give a loud shrill note. Price 69p. 1000 for £345. Jap made.

PRESTEL UNITS

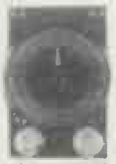


These are brand new and we understand tested, came with manufacturer's guarantee now void as the manufacturer no longer trades. These originally sold for over £150. We offer them complete, except for 7 plug in i.c.'s and price is only £14.95 (less than the value of the modem included).

STABILISED POWER SUPPLY (Mains Input)

By LAMDA (USA) – Ideal for computer add-ons, d.c. output. Regulated for line volts and load current. Voltage regulation .1% with input variations up to 20% – load regulation 1% from no load to full load – or full load to no load. Complete in heavy duty case – Models available: 5v · 9A £23. 12v - 1.5A £13.25. 15v · 1.2A £13.25. 24v · 2A £23.

25A ELECTRICAL PROGRAMMER



Learn in your sleep: Have radio playing and kettle boiling as you wake – switch on lights to ward off intruders – have a warm house to come home to. You can do all these and more. By a famous maker with 25 amp on/off switch. Independent 60 minute memory jogger. A beautiful unit at £2.50.

THIS MONTH'S SNIP

TOP OF THE POPS LIGHTING

if you use our disco switch ONLY £6.90

These have 12 x 10 amp changeover switches each rated at 10 amps so a whole street could easily be lit with one. Switches adjustable and could be set to give a running light, random flashes, etc. etc. 230 volts main operation. Brand new, made by Honeywell. Offered at approximately one third of cost.

COMPUTER DESKS

Again available – Computer desks – size approx 4' x 2' x 2'6" high formica covered, cost over £100 each. Our price only from £9.50 – you must collect – hundreds supplied to schools.

50 THINGS YOU CAN MAKE

Things you can make include Multi range meter, Low ohms tester, A.C. amps meter, Alarm clock, Soldering iron minder, Two way telephone, Memory jogger, Live line tester, Continuity checker, etc. etc., and you will still have hundreds of parts for future projects. Our 10Kg parcel contains not less than 1,000 items - panel meters, timers, thermal trips, relays, switches, motors, drills, taps, and dies, tools, thermostats, coils, condensers, resistors, neons, earphone/microphones, nicad charger, power unit, 90% are unused componants.

YOURS FOR ONLY £11.50 plus £3.00 post.

REVERSIBLE MOTOR WITH CONTROL GEAR

Made by the famous Framco Company this is a very robust motor size approximately 7½" long, 3½" dia. 3/8" shaft Tremendously powerful motor, almost impossible to stop. Ideal for operating stage curtains, sliding doors, ventilators etc., even garage doors if adequately counter-balanced. We offer the motor complete with control gear as follows:

1 Framco motor with gear box
1 manual reversing & on/off switch
1 push to start switch
2 limit stop switches
1 circuit diag. of connections

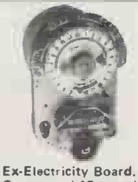
£19.50 plus postage £2.50

J. BULL (Electrical) Ltd.

(Dept. EE), 34 · 36 AMERICA LANE, HAYWARDS HEATH, SUSSEX RH16 3QU. Established 30 YEARS

MAIL ORDER TERMS: Cash. P.O. or cheque with order. Orders under £20 add £1 service charge. Monthly account orders accepted from schools and public companies. Access & B/card orders accepted day or night. Haywards Heath (0444) 454563. Bulk orders: phone for quote. Shop open 9.00 – 5.30, Mon to Fri, not Saturday.

VENNER TIME SWITCH



Ex-Electricity Board. Guaranteed 12 months.

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 24 hrs. This makes an ideal controller for the immersion heater. Price of adaptor kit is £2.30.

EXTRACTOR FANS – MAINS OPERATED

Woods extractor.
5" – £5.75, Post £1.25.
6" – £6.95, Post £1.25.
5" Plannair extractor £6.50. Post £1.25.
4"x 4" Muffin 115v. £4.50. 230v. £5.75. Post 75p.
All the above ex-computer, those below are unused.
4" x 4" £8.50. Post 75p.
9" American made £11.50. post £2.00.
Tangential Blower 10x3 air outlet, dual speed £4.60. Post £1.50.

TANGENTIAL BLOW HEATER

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

Please add post £1.50 for 1 or 3 for £2
Still available: £4.95 + £1.50 post. or have 3 for £16 p 2.5 Kw KIT

ROCKER SWITCHES

Standard size fit 11.5 x 28 mm cut out. Single pole on/off – 15p each 1000 for £75. Single pole changeover 20p each – 1000 for £100. Single pole changeover with centre off – 25p each – 1000 for £125. Single pole on/off with neon – 36p – 1000 for £180.

ROCKER SWITCH DP/DT

15 amp 250 volts suitable for motor reversing etc. – 46p – 100 for £34.50, 1000 for £230.

MICRO SWITCHES

V3 type all 250 10 amp SpST 20p 1000 – £100 Spdt 30p 1000 – £150, very low tongue Spdt 40p 1000 for £200.

The AMSTRAD Stereo Tuner.

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

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

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

Offered at a fraction of its cost: **only £6.00** + £1.50 post + insurance

MINIATURE WAFER SWITCHES

2 pole, 2 way – 4 pole, 2 way – 3 pole, 3 way – 4 pole, 3 way – 2 pole, 4 way – 3 pole, 4 way – 2 pole, 6 way – 1 pole, 12 way.
All at 25p each or 10 for £2.00

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 – Price £3.45.
Ditto, but double ended £4.25.

MAINS MOTORS

We have very large stocks of motors from 2 watts to ¼ hp. Most at a price well below cost, let us know your requirements.

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.

OTHER POPULAR PROJECTS

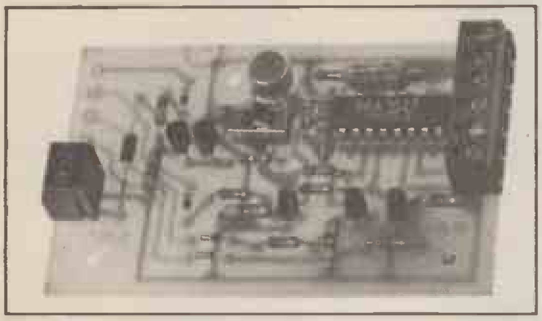
R C Bridge Kit	£9.95
3 Channel Sound to Light – with fully prepared metal case	£14.95
Big Ear, listen through walls	£9.50
Silent sentinel Ultra Sonic Transmitter and receiver	£9.50
Car Light 'left on' alarm	£3.50
Secret switch – fools friends and enemies alike	£1.95
3 – 30v Variable Power Supply	£13.80
2 Short & Medium wave Crystal Radio	£3.99
3v to 16v Mains Power Supply Kit	£1.95
Radio stethoscope – fault finding aid	£4.80
Mug stop – emits piercing squark	£2.50
Morse Trainer – complete with key	£2.99
Drill control kit	£3.95
Interrupted beam kit	£2.50
Transmitter surveillance kit	£2.30
Radio Mike	£6.90
F M receiver kit – for surveillance or normal F M	£3.50
Insulation Tester – electronic megger	£7.95
Battery shaver or fluorescent from 12v	£6.90
Matchbox Radio – receives Medium Wave	£2.95
40 watt amp – hifi 20hz – 20kHz	£9.50
115 Watt Amplifier 5Hz 25kHz	£13.50
Power supply for 115 watt amps	£8.50

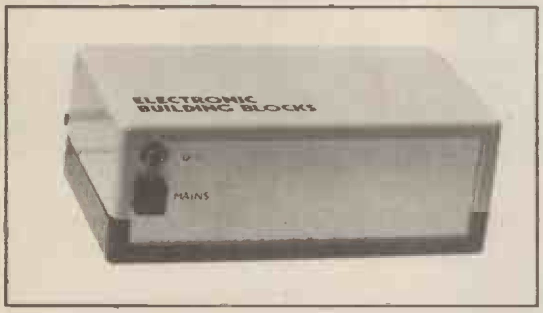
EVERYDAY ELECTRONICS and computer PROJECTS

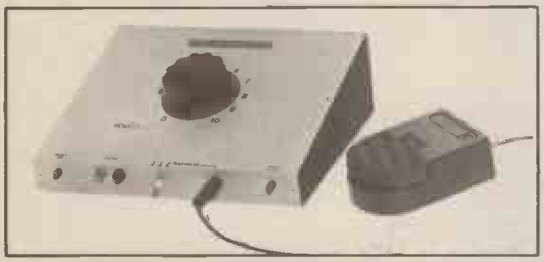
VOL 14 No. 8 AUGUST '85

ISSN 0262–3617

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







PROJECTS

STEPPER MOTOR INTERFACE 418
Microcomputer interface for stepper motor control

LOW COST POWER SUPPLY UNIT 424
Inexpensive but practical dual-rail supply—Building Block project

DRILL CONTROL UNIT by A. R. Winstanley 432
Keep control of your power tool

TREMOLO/VIBRATO by R. A. Penfold 441
Add another dimension to your instrument

TRI-STATE THERMOMETER by T. R. de Vaux Balbirnie 454
Instant indication of incorrect temperature

SERIES

ELECTRONIC BUILDING BLOCKS by Richard Barron 422
Part One: A new series with a new look at electronic design

ACTUALLY DOING IT by Mike Abbott 427
Printed circuit board assembly, and capacitors explained

COMPUTER CLUB by Thakery 436
A Murder Mystery solved in BASIC

ON SPEC by Mike Tooley BA 448
Our regular Spectrum page: Simple Joystick Interface—with software

DOWN TO EARTH by George Hylton 459
Output stages and equivalent circuits

FEATURES

EDITORIAL 415

STEPPING MOTORS by Mark Stuart 416
Construction, specifications and uses

SHOPTALK by Rich. Barron 421
Product news and component buying

MICROPROFESSOR MPF I/88 REVIEW 429
The latest MicroProfessor—using the same CPU as the IBM PC

EVERYDAY NEWS 438
What's happening in the world of electronics

FOR YOUR ENTERTAINMENT by Barry Fox 447
Job Skills; Russianese Video

COUNTER INTELLIGENCE by Paul Young 450
A retailer comments

SPECTRUM DISC OPERATING SYSTEM (SPDOS) by Mike Tooley BA 451
Rapid-access, mass-storage disc interface for serious users

MAN BEHIND THE SYMBOL by Morgan Bradshaw 458
Symbols, and the men they are named after, explained

NEW PRODUCTS 460
Facts and photos of instruments, equipment and tools

PRINTED CIRCUIT BOARD SERVICE 461

Our September 1985 issue will be published on Friday, August 16. ***See page 440 for details.***

Readers' Services ● Editorial and Advertisement Departments 415

SUMMER SALE!!

All those people on the beach making Sandcastles – STOP – 'cos here are some really nice bargains. We're clearing stocks of last years offers at unbeatable prices . . . PLUS – all packs reduced . . . PLUS – a preview of new packs that will be featured later in the year!! All offers must end 31st August, so hurry hurry hurry!!! Minimum order value at these special sale prices is £10. Detail of all items can be found in earlier ads or send SAE for list.

PACKS

K524 Opto Pack £3.95 **£2.95**
K525 Preser Pack £6.75 **£3.95**
K528 Electrolytic Pack £3.95 **£3.20**
K531 Precision resistors £3.00 **£2.50**
K532 Relays £6.00 **£3.00**
K517 Transistors £2.75 **£1.95**
K523 Resistors £2.50 **£2.00**
K520 Switches £2.00 **£1.70**
K522 Copper clad board £1.00 **£0.70**
K530 Polyesters £3.95 **£2.95**
K518 Disc Ceramics £1.00 **£0.70**
K503 Wirewound Resistors £2.00 **£1.50**
K505 Pots £1.70 **£1.40**
W4700 Push button banks £2.95 **£2.00**
K526 Heatsinks £5.50 **£4.00**
K527 Hardware £4.00 **£3.00**

OTHER GOODS

"Crackshot" Joystick (Atari) £8.50 **£4.50**
BBC Joystick £9.50 **£5.50**
Analogue joystick £9.85 **£5.35**
"The Sensible 64" book £5.95 **£2.00**
Bimbox 6006 £2.95 **£2.00**
LP11 compartment tray £2.95 **£2.00**
Storage Bins £3.95 **£2.95**
Ferric Chloride £1.30 **£0.99**
SK1 Antex Kit £11.38 **£7.50**
Veroboxes, two tone grey:
825-21028 £3.38 **£2.50**
825-21029 £3.81 **£2.95**
825-21030 £4.28 **£3.30**
825-21031 £5.72 **£4.50**
Power/VU meter £1.00 **£0.60**
4.8V PCB Ni-Cad £0.99 **£0.70**
Single core Fibre Optic 20m coil £6.30 **£3.50**
Twin core Fibre Optic 20m coil £11.00 **£6.00**

PANELS

Z914 1W mono amp panel £1.50 **£1.00**
Z915 1W stereo amp panel £3.50 **£2.00**
Z916 AM tuner panel £1.50 **£1.00**
Z908 2×TDA1004 panel £3.00 **£1.50**
Z912 IF Panel £2.50 **£1.50**
Z910 RF/IF radio panel £2.50 **£1.50**
"Simon" panel untested **£1.50**
Z925 2 relays + triac £1.90 **£1.20**
Z926 relay + triac + SCR £1.85 **£1.15**
Z927 2×6V reeds £0.60 **£0.40**
Z922 Panel with 36p3w switch £9.50 **£4.50**

NEW PACKS

K534 SLEEVE PACK – wide selections of types and sizes – PVC, rubber, silicone, heatshrink, etc. in boxes from 1mm to 18mm, lengths 9mm to 100mm. Approx. 100 **£1.00**

K536 74 SERIES PACK – 'on board' chips for you to desolder – containing many LS and other types. Good mix.
40 **£1.85** 100 **£4.00**

K537 I.C. PACK – a mix of linear and logic chips, form 6 to 40 pin. All are new and marked, but some may not be full spec.
100 **£6.75** 250 **£14.00** *1000 **£45.00**
*mostly in tubes

K538 DIODE PACK – untested small signal diodes like IN4148 etc. at a price never before seen!!
1000 **£2.50** 10,000 **£20.00**

K539 LED PACK – not only round but many shaped leds in this pack in red, yellow, green, orange and clear. Fantastic mix.
100 **£5.95** 250 **£13.50**

K540 RESISTOR PACK – mostly ⅛, ¼ and ½w, also some 1 & 2w in carbon, film, oxide etc. All have full length leads. Tolerances from 5 to 20%. Excellent range of values
500 **£2.50** 2500 **£11.00**

K535 SPRING PACK – approx 100 assorted compression, extension and torsion springs up to 22mm dia and 30mm long **£1.70**

NI-CAD CHARGER PANEL

177×114mm PCB with one massive Varta Deac 57×50mm Ø rated 7.2v 1000mAH and another smaller Deac 32×35mm Ø rated 3.6v 600mA. The price of these Ni-cad stacks new is over £20. Also on the panel is a mains input charger transformer with two separate secondaries wired via bridge rectifiers, smoothing capacitors and a relay to the output tags. The panel weighs 1kgm. All this for just **£6.00**.

1985 CATALOGUE

More components than ever before! With each copy there's discount vouchers, Bargain List, Wholesale Discount List, Bulk Buyers List, Order Form and Reply Paid Envelope. All for just **£1.00**!!

"SENSING & CONTROL PROJECTS FOR THE BBC MICRO"

Have you ever wondered what all those plugs and sockets on the back of the BBC micro are for? This book assumes no previous electic knowledge and no soldering is required, but guides the reader (pupil or teacher) from basic connexions of the user sockets, to quite complex projects. The author, an experienced teacher in this field, has provided lots of practical experiments, with ideas on how to follow up the basic principles. A complete kit of parts for all the experiments is also available. Book, 245×185mm 120pp **£5.95**. Kit **£29.95**

MOTORIZED GEARBOX

The unit has 2 × 3V motors, linked by a magnetic clutch, thus enabling turning of the vehicle, and a gearbox contained within the black ABS housing, reducing the final drive speed to approx 50rpm. Data is supplied with the unit showing various options on driving the motors. Two new types of wheels can be supplied (the aluminium discs and smaller plastic wheels are now sold out). Type A has 7 spokes with a round black tyre and is 100mm dia. Type B is a solid heavy duty wheel 107mm dia with a flat rigid tyre 17mm wide.

PRICES: Gearbox with data sheets: **£5.95**
Wheel type A: **£0.70 ea**
Wheel type B: **£0.90 ea**

Our shop has enormous stock of components and is open 9-5.30 Mon-Sat. Come and see us!!

GREENWELD

All prices include VAT; just add 60p P&P. Min Access order £10, Sale goods £10 min. CWO value. Official orders from schools etc. welcome – min invoice charge £10.

443D Millbrook Road
Southampton SO1 0HX
Tel (0703) 772501/783740

TELEVISION/COMPUTER FULL-TIME TRAINING

(FULL TIME COURSES APPROVED BY THE BUSINESS & TECHNICIAN EDUCATION COUNCIL)

2 YEAR
BTEC National Diploma (OND)
ELECTRONIC & COMMUNICATIONS ENGINEERING
(Electronics, Computing, Television, Video, Testing & Fault Diagnosis)

15 MONTHS
BTEC National Certificate (ONC)
ELECTRONIC EQUIPMENT SERVICING
(Electronics, Television, Video Cassette Recorders, CCTV, Testing & Fault Diagnosis)

15 MONTHS
BTEC National Certificate (ONC)
COMPUTING TECHNOLOGY
(Electronics, Computing Software/Hardware, Microelectronic Testing Methods)

9 MONTHS
BTEC Higher National Certificate (HNC)
COMPUTING TECHNOLOGY & ROBOTICS
(Microprocessor Based Systems, Fault Diagnosis, ATE, Robotics)

THESE COURSES INCLUDE A HIGH PERCENTAGE OF COLLEGE BASED PRACTICAL WORK TO ENHANCE FUTURE EMPLOYMENT PROSPECTS

SHORTENED COURSES OF FROM 3 TO 6 MONTHS CAN BE ARRANGED FOR APPLICANTS WITH PREVIOUS ELECTRONICS KNOWLEDGE

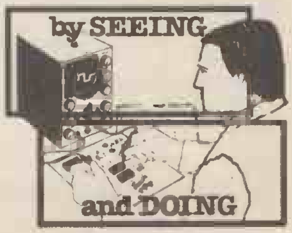
NEXT SESSION TO COMMENCE ON SEPTEMBER 16th

FULL PROSPECTUS FROM

LONDON ELECTRONICS COLLEGE (Dept EE)
20 PENYWERN ROAD, EARLS COURT, LONDON SW5 9SU. Tel: 01-373 8721.

Master Electronics - *Microprocessors* - Now! The Practical *Way*!

- Electronics – Microprocessors – Computer Technology is the career and hobby of the future. We can train you at home in a simple, practical and interesting way.



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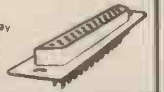
ACCESS AND BARCLAYCARD WELCOME

MIN. D CONNECTORS

	9 way	15 way	25 way	37 way
Plugs solder lugs	55p	66p	90p	150p
Right angle	90p	135p	200p	350p
Sockets solder lugs	80p	100p	135p	260p
Right angle	120p	180p	290p	420p
Covers	100p	90p	100p	110p



CONNECTORS

DIN	Plug	Skt	Jack	Plug	Skt
2 pin	9p	9p	2.5mm	10p	10p
3 pin	12p	10p	3.5mm	9p	9p
5 pin	13p	11p	Standard	16p	20p
Phono	10p	12p	Stereo	24p	25p
1mm	12p	13p	4mm	18p	17p

UHF (CB) Connectors:
PL259 Plug 40p. Reducer 14p.
SO239 square chassis skt 38p.
SO239S round chassis skt 40p.
IEC 3 pin 250V/6A.
Plug chassis mounting 38p
Socket free hanging 60p
Socket with 2m lead 120p

MICRO

Brand new Micro products at lowest ever prices. Take advantage of our volume discounts now!

Type	speed	manfr.	1+	10+	25+
2716	450nS	Hitachi	3.10	2.80	2.50
2764	250nS	Hitachi	3.10	3.80	3.60
27128	250nS	Hitachi	6.60	5.50	4.80
6116P3	150nS	Hitachi	3.10	2.90	2.60
6264P15	150nS	Hitachi	8.90	7.80	6.60
4164	150nS	Hitachi	3.00	2.70	2.40
41256	150nS	NEC	9.20	8.40	7.50
Z80ACPU	4MHZ	SGS	2.90	2.50	2.20

SWITCHES

Subminiature toggle:
SPST 55p. SPDT 60p. DPDT 65p.
Miniature toggle:
SPDT 80p. SPDT centre off 90p.
DPDT 90p. DPDT centre off 100p.
Standard toggle:
SPST 35p. DPDT48p
Miniature DPDT slide 14p.
Push to make 15p.
Push to break 22p.
Rotary type adjustable stop.
1P12W, 2P6W, 3P4W all 55p each.
DIL switches:
4SPST 80p 6 SPST 80p. 8 SPST 100.
Min. DPDT slide 14p. Push-make 15.

SOLDERING IRONS

Antex CS 17W Soldering iron	430
2.3 and 4.7mm bits to suit	85
Antex XS 25W soldering iron	530
3.3 and 4.7mm bits to suit	85
Solder pump desoldering tool	480
Spare nozzle for above	70
10 metres 22 swg solder	100
0.5kg 22 swg solder	750

VERO

Verobloc	395
Veroboard Size 0.1 in matrix	
2.5 x 1	26
2.5 x 3.75	95
3.75 x 5	120
3.75 x 17	350
4.75 x 17	455
VQ board	190
Veropins per 100.	
Single sided	55
Double sided	65
Spot face cutter	145
Pin insertion tool	185
Wiring pen	375
Spare spool 75p Combs	6

MICRO

2716	310	27128-250	650	6800	200	6522	330
2532	380	6116P3	310	6802	280	6532	520
2732 one time programmable	280	6264P15	850	6809	600	6551	540
2732	430	4164-15	300	6810	140	8085A	320
2764-250	410	41256-15	920	6821	140	8156	380
2764-BBC	430	4164-15	300	6840	360	8251	350
		41256-15	2850	6850	165	8253	370
		Z80A CPU	290	6852	240	8255	320
		Z80A P10	320	6875	500	8259	400
		Z80A CTC	320	6880	100	MC1488	70
		Z80A S10	880	6502	370	MC1489	70
		Z80A DMA	880				

SOCKETS

	Low profile	Wire-wrap
8 pin	7p	28p
14 pin	8p	45p
16 pin	10p	55p
18 pin	12p	60p
20 pin	13p	68p
22 pin	15p	75p
24 pin	17p	82p
28 pin	15p	95p
40 pin	25p	135p

Professional ZIF sockets
24 pin 430p 28 pin 480p
40 pin 595p

COMPONENT KITS

0.25W Resistor Kit. Contains 1000 0.25W 5% resistors from 4.7 ohms thru to 10M. Quantities depend upon popularity i.e. 10x10R, 30x470R, 30x10K, 25x470K. Just £7.90
Ceramic capacitor Kit. Total of 250 miniature ceramic capacitors from 22p to 0.1u. Just £6.90
Polyester capacitor Kit. Total of 110 miniature polyester capacitors from 0.01u to 0.47u. Just £6.90
Preset Kit. Total of 110 miniature preset resistors from 100R to 1M. Horizontal mounting type. Just £6.90
Radial Electrolytic Capacitor Kit. A pack containing a total of 93 miniature caps from 1u to 2200u. Just £7.50
Nut and Bolt Kit. Contains 800 assorted items. 100 each 6BA ½in, ¼in, nuts and wshrs, 4BA ½in, ¼in, nuts and wshrs. Just £3.20

CABLES

20 metre pack single core connecting cable ten different colours.	75p
Speaker cable	10p/m
Standard screened	16p/m
Twin screened	24p/m
2.5A 3 core mains	23p/m
10 way rainbow ribbon	26p/ft
20 way rainbow ribbon	47p/ft
10 way grey ribbon	14P/ft
20 way grey ribbon	28p/ft

REGULATORS

78L05	30	79L05	45
78L12	30	79L12	45
78L15	30	79L15	45
7805	40	7905	45
7812	40	7912	45
7815	45	7915	45
LM317K	270	LM723	40
LM317T	90	78H05	550
LM323K	420		

DIODES

BY127	12	▶1N4001	3
OA47	10	1N4002	5
OA90	8	1N4006	7
OA91	7	1N4007	7
OA200	8	1N5401	12
OA202	8	1N5404	16
1N914	4	1N5406	17
▶1N4148	3	400mW zen	6
		1.3W zeners	13

OPTO

3mm red	8	5mm red	8
3mm green	11	5mm green	11
3mm yellow	11	5mm yellow	11
Clips to suit	3p each.		
Rectangular red	12	TIL32	40
		TIL111	60
green	17	TIL78	40
yellow	17	ORP12	85
ILD74	95	ILQ74	185
TIL38	35	TIL100	75
2NS777	45	Tri-color Led	35

Seven segment displays

Com cathode.		Com anode	
DL704 0.3"	95	DL707 0.3"	95
FND5000 5"	100	FND5070 5"	100

10 bar DIL LED display, red 180
5mm superbright LED 250mcd red 30

HARDWARE

PP3 battery clips	6
Red or black crocodile clips	6
Black pointer control knob	15
Pr Ultrasonic transducers	350
▶6V Electronic buzzer	65
▶12V Electronic buzzer	70
▶PB2720 Piezo transducer	75
▶64mm 64 ohm speaker	70
▶64mm 8 ohm speaker	70
20mm panel fuseholder	25
Red or black probe clip	35
4mm terminals	33
12 way 'chocolate' block	21
ultra-min 6 or 12v rel. SPDT	130
ditto but DPDT	195

EURO CONNECTORS

Gold flashed contacts	Rt. angle plug	Wirewrap socket
64 way A+B	195	230
64 way A+C	220	270
96 way A+B+C	320	330

TRIACS

		400V 8A	65
		400V 16A	95
400V 4A	50	BR100	25

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COMPUTER CONNECTORS

ZX81 2 x 23 way edge connector wire wrap for ZX81	150
SPECTRUM 2 x 28 way edge connector wire wrap	200
AMPHENOL PLUGS	
24 way IEEE IDC	450
36 way Centronix IDC	490

RIBBON CABLE

Grey Ribbon cable. Price per foot

10 way	14	34 way	58
16 way	25	40 way	68
20 way	28	50 way	90
26 way	38	60 way	100

CAPACITORS

Polyester, radial leads. 250v. C280 type: 0.01, 0.015, 0.022, 0.033 - 6p; 0.047, 0.068, 0.1 - 7p; 0.15, 0.22 - 9p; 0.33, 0.47 - 13p; 0.68 - 20p; 1u - 23p.
Electrolytic, radial or axial leads: 0.47/63V, 1/63V, 2.2/63V, 4.7/63V, 10/25V - 7p; 22/25V, 47/25V - 8p; 100/25V - 9p; 220/25V - 14p; 470/25V - 22p; 1000/25V - 30p; 2200/25V - 50p.
Tag end power supply electrolytics: 2200/40V - 110p; 4700/40V - 160p 2200/63V - 140p; 4700/63V - 230p
Polyester, miniature Siemens PCB: 1n, 2n2, 3n3, 4n7, 6n8, 10n, 15n, 7p; 22n, 33n, 47n, 68n, 8p; 100n, 9p; 150n, 11p; 220n, 13p, 330n, 20p; 470n 26p; 680n, 29p; 1u 33p;

Tantalum bead:
0.1, 0.22, 0.33, 0.47, 1.0 @ 35V - 12p. 2.2, 4.7, 10 @ 25V - 20p; 15/16V - 30p; 22/16V - 27p; 33/16V - 45p. 47/6V - 27p; 47/16V - 70p; 68/6V - 40p; 100/10V - 90p.
Cer. disc. 22p-0.01u 50V, 3p each.
Mullard miniature ceramic plate: 1.8pF to 100pF 6p each.
Polystyrene, 5% tol: 10p-1000p, 6p; 1500-4700, 8p; 6800 0.012u, 10p.
Trimmers. Mullard 808 series: 2-10 pF, 22p; 2-22pF, 30p; 5.5-65pF, 35p

BRIDGE RECTIFIERS

		2A 200V	40
		2A 400V	45
		6A 100V	80
		6A 400V	95
1A 50V	20	VM18 DIL 0.9A	
1A 400V	35	200V	50

IDC CONNECTORS

	PCB Plug St.	PCB Plug Rt. ang.	Socket	Edge Conn.
10 way	70	70	70	–
16 way	75	80	80	–
20 way	90	90	95	130
26 way	105	110	115	155
34 way	115	130	130	180
40 way	140	140	145	210
50 way	165	165	170	240
60 way	195	195	200	–

LINEAR

		ICL7611	98	LM358	50	LM3915	265	NE567	130	TDA1024	115
		ICL7621	190	LM377	210	LM13600	110	NE570	370	TL061	40
555CMOS	80	ICL7622	200	LM380	80	MC1310	150	NE571	370	TL062	65
556CMOS	150	ICL8038	295	LM381	150	MC1496	70	NE5532	160	TL064	105
709	35	ICL8211A	220	LM382	130	MC3302	75	NE5534	105	TL071	38
741	16	ICM7224	785	LM386	140	MC3340	130	RC4136	65	TL072	60
748	35	ICM7555	80	LM387	120	MF10CN	330	RC4558	40	TL074	110
AY31270	720	ICM7556	150	LM393	60	ML922	390	SL486	195	TL081	30
AY38910	390	LF347	150	LM710	48	ML924	290	SL490	220	TL082	50
AY38912	430	LF351	40	LM711	60	ML925	290	SN76018	150	TL084	105
CA3046	65	LF353	75	LM725	70	ML926	210	SN76477	380	TL170	50
CA3080E	85	LF356	90	LM733	70	ML927	210	SP8629	250	UA2240	140
CA3089	200	LM10C	325	LM741	16	ML928	210	SP0256AL2	425	ULN2003	80
CA3090AQ	375	LM301A	30	LM747	60	ML929	210	Speech data	50	ULN2004	80
CA3130E	85	LM311	45	LM748	35	NE529	225	TBA800	70	XR2206	365
CA3140E	38	LM318	135	LM1458	35	NE531	135	TBA810	90	ZN414	80
CA3160	95	LM324	45	LM2917N8	195	NE544	170	TBA820M	65	ZN423	135
CA3136	100	LM3342	85	LM3900	45	NE555	20	TBA950	220	ZN424P	130
CA3189	260	LM3352	125	LM3909	85	NE556	45	TCA940	165	ZN425E	350
CA3240E	100	LM339	40	LM3914	265	NE565	115	TDA1008	320	ZN426E	300
ICL7106	680	LM348	60			NE566	140	TDA1022	490	ZN427E	600
										ZN428E	450
										ZN459	285
										ZN1034E	200

TRANSISTORS

				BC548	5	BFR40	23	2N1613	30	2N3906	10		
				BC549	10	BFR80	23	2N2218A	45	2N4037	45		
				BC557	10	BFR81	23	2N2219A	28	2N4058	10		
AC125	35	BC158	11	BC558	10	BFX29	30	2N2221A	25	2N4060	10	TIP35C	125
AC126	30	BC158	10	BCY70	16	BFX84	30	2N2222A	20	2N4061	10	TIP36A	115
AC127	30	BC159	10	BCY71	16	BFX85	30	2N2368	25	2N4062	10	TIP36C	130
AC128	30	BC160	40	BCY72	16	BFX86	30	2N2369	18	40360	40	TIP41A	45
AC176	25	BC168C	10	BD115	55	BFX87	30	2N2484	27	40361	50	TIP42A	45
AC187	25	BC169C	10	BD131	40	BFX88	30	2n2646	60	40362	50	TIP120	60
AC188	25	BC170	8	BD132	40	BFY50	27	2N2904	28	40408	50	TIP121	60
AD142	120	BC171	10	BD133	50	BFY51	27	2N2904A	28	2N5457	30	TIP122	60
AD161	42	BC172	8	BD135	35	BFY52	27	2N2905	28	2N5458	30	TIP141	110
AD162	42	BC177	16	BD136	35	BFY53	30	2N2905A	28	2N5459	30	TIP142	120
AF124	60	BC178	16	BD137	35	BFY55	30	2N2906	28	2n5485	35	TIP147	120
AF126	50	BC179	18	BD138	35	BFY56	30	2N2906A	28	2N5777	45	TIP2955	70
AF139	40	BC182	10	BD139	35	BRY39	30	2N2907	24	2N697	20	TIP3055	60
AF186	70	BC182L	10	BD140	35	BSX20	22	2N2907A	24	2N698	40	TIS43	40
AF239	55	BC183	10	BD204	110	BSX29	35	2N2926	10	2N706A	20	TIS43	40
BC107	10	BC183L	10	BD206	110	BSY95A	30	2N3053	28	2N708	25	TIS44	45
BC107B	12	BC184	10	BD222	85	BU205	160	2N3054	55	2N918	35	TIS45	45
BC108	10	BC184L	10	BF180	35	BU206	200	2N3055	50	TIP29	35	TIS90	30
BC108B	12	BC212	10	BF182	35	BU208	170	2N3442	120	TIP29A	35	TIS91	30
BC108C	12	BC212L	10	BF184	35	MJ2955	99	2N3702	9	TIP29B	35	VN10KM	65
BC109	10	BC213	10	BF185	25	MJE340	50	2N3703	10	TIP29C	35	VN46AF	94
BC109C	12	BC213L	10	BF194	12	MJE520	50	2N3704	9	TIP30	35	VN66AF	110
BC114	22	BC214	10	BF195	12	MJE521	90	2N3705	10	TIP30A	35	VN88AF	120
BC115	22	BC214L	10	BF196	12	MJE3055	70	2N3706	10	TIP30B	35	ZTX107	11
BC117	22	BC237	7	BF197	12	MPF102	40	2N3707	10	TIP30C	40	ZTX108	11
BC119	35	BC238	7	BF198	15	MPF104	40	2N3708	10	TIP31A	35	ZTX109	11
BC137	40	BC308	10	BF199	18	MPSA05	23	2N3709	10	TIP31B	35	ZTX300	14
BC139	38	BC327	8	BF200	35	MPSA06	25	2N3772	170	TIP31C	40	ZTX301	16
BC140	29	BC328	8	BF244B	35	MPSA12	29	2N3773	195	TIP32A	35	ZTX302	16
BC141	30	BC337	8	BF245	35	MPSA55	30	2N3819	32	TIP32B	38	ZTX304	20
BC142	28	BC338	12	BF256B	45	MPSA56	30	2N3820	50	TIP32C	40	ZTX341	20
BC143	30	BC477	22	BF257	32	MPSU05	55	2N3823	65	TIP33A	65	ZTX500	13
BC147	10	BC478	22	BF258	30	MPSU06	55	2N3866	90	TIP33C	75	ZTX501	18
BC148	10	BC479	22	BF259	30	MPSU55	55	2N3903	10	TIP34A	70	ZTX502	18
BC149	10	BC517	30	BF337	35	MPSU56	55	2N3904	10	TIP34C	80	ZTX503	18
BC157	11	BC547	5	BFR40	35	2N118L	22	2N3905	10	TIP35A	105	ZTX504	25

RESISTORS

Carbon film	1+	25+
¼W 5% 4.7ohm - 10M	2p	1p
½W 5% 4.7ohm - 4M7	3p	2p
Metal film		
¼W 1% 10ohm - 1M	4p	3p

25+ price applies to 25+ per value not mixed.

CRYSTALS

		4.194MHz	150
		4.43MHz	100
100KHz	235	5.008MHz	240
1MHz	275	6.0MHz	140
1.8432M	200	6.144MHz	150
2.0MHz	225	7.0MHz	150
2.4576M	200	8.0MHz	140
3.276M	150	10.0MHz	170
3.579M	95	12.0MHz	170
4.0MHz	140	16.0MHz	200

BOXES

Plastic with lid & screws		Aluminium	
		3 x 2 x 1"	65
		4 x 2¾ x 1½"	95
		4 x 2½ x 2"	95
71x46x22mm	50	6 x 4 x 2"	120
95x71x35mm	86	7 x 5 x 2½"	165
140x90x55mm	140	8 x 6 x 3"	205

TTL

		7412	25	7440	25	7476	40	74107	40	74157	80	74180	85
		7413	36	7442	74	7480	50	74109	60	74160	90	74181	230
		7414	60	7444	105	7483	65	74121	50	74161	90	74182	85
7400	25	7416	43	7446	130	7485	110	74122	50	74162	90	74190	120
7401	25	7417	43	7447	98	7486	38	74123	92	74163	90	74191	120
7402	25	7420	25	7448	98	7489	170	74125	50	74164	115	74192	120
7403	25	7421	30	7450	25	7490	55	74126	50	74165	90	74193	110
7404	25	7422	30	7451	25	7491	80	74132	60	74167	200	74194	80
7405	25	7427	30	7453	25	7492	55	74141	80	74170	170	74195	63
7406	45	7428	30	7454	25	7493	55	74145	85	74173	100	74196	120
7407	45	7430	25	7460	25	7494	90	74147	130	74174	100	74197	85
7408	25	7432	35	7472	35	7495	80	74148	105	74175	80	74198	195
7409	25	7433	35	7473	40	7496	80	74150	130	74176	80	74199	195
7410	25	7437	43	7474	36	7497	170	74153	70	74177	80		
7411	25	7438	45	7475	55	74100	125	74154	135	74179	90		

CMOS

		4016	26	4034	145	4054	70	4081	18	4502	50	4529	80
		4017	43	4036	270	4055	70	4082	20	4503	45	4532	65
		4018	55	4039	270	4059	400	4085	60	4507	45	4534	390
4000	18	4019	35	4040	45	4060	70	4086	60	4508	115	4538	70
4001	18	4020	48	4041	55	4063	80	4089	120	4510	48	4543	65
4002	18	4021	55	4042	45	4066	24	4093	26	4511	50	4549	390
4006	65	4022	60	4043	45	4067	230	4094	70	4512	50	4553	215
4007	18	4023	18	4044	50	4068	18	4095	70	4514	115	4555	50
4008	50	4024	35	4046	60	4069	18	4097	260	4515	115	4556	50
4009	40	4025	18	4047	52	4070	22	4098	70	4516	48	4559	390
4010	40	4026	120	4048	50	4071	18	40106	38	4518	48	4560	110
4011	18	4027	28	4049	26	4072	18	40109	100	4520	48	4584	38
4012	18	4028	40	4050	26	4073	18	40163	75	4521	110	4585	65
4013	26	4029	45	4051	48	4075	24	40173	100	4526	70	4724	140
4014	50	4030	18	4052	48	4076	60	40175	75	4527	60		
4015	42	4031	125	4053	60	4077	24	40193	90	4528	45		

LS TTL

		LS20	22	LS75	38	LS123	70	LS161	60	LS221	78	LS365	42
		LS21	22	LS76	28	LS125	37	LS162	60	LS240	105	LS366	42
		LS22	22	LS78	28	LS126	37	LS163	60	LS241	80	LS367	42
LS00	22	LS26	22	LS83	68	LS132	53	LS164	70	LS242	80	LS368	42
LS01	22	LS27	22	LS85	82	LS136	35	LS165	95	LS243	80	LS373	80
LS02	22	LS30	22	LS86	35	LS138	48	LS166	88	LS244	80	LS374	80
LS03	22	LS32	22	LS90	40	LS139	48	LS170	120	LS245	88	LS375	55
LS04	22	LS37	22	LS92	50	LS145	92	LS173	80	LS247	77	LS377	100
LS05	22	LS38	22	LS93	45	LS147	130	LS174	60	LS251	55	LS378	88
LS08	22	LS40	22	LS95	58	LS148	115	LS175	60	LS257	55	LS390	82
LS09	22	LS42	60	LS96	120	LS151	55	LS190	75	LS258	55	LS393	82
LS10	22	LS47	78	LS107	42	LS153	80	LS191	55	LS259	90	LS399	115
LS11	22	LS48	78	LS109	42	LS154	220	LS192	75	LS266	28	LS541	115
LS12	22	LS51	22	LS112	42	LS155	55	LS193	75	LS273	80	LS670	170
LS13	35	LS55	22	LS113	32	LS157	48	LS195	60	LS279	55		
LS14	45	LS73	28	LS114	32	LS158	48	LS196	75	LS283	70		
LS15	22	LS74	28	LS122	56	LS160	60	LS197	75	LS353	85		

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EVERYDAY ELECTRONICS and computer PROJECTS

VOL 14 No. 8 AUG. '85

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SUN AND SOLDER

By the time you read this, hopefully the sun will have become a regular feature and the summer will be well under way. Very often the summer is a time when many soldering irons get put away and outdoor activity takes over from the hobby of electronics. While this is understandable, in some ways it is also a great pity; there are many projects that are useful during the summer months and a little time in the evenings spent on a small project can prove to be rewarding.

The projects I have in mind are such items as a *Fridge Alarm*, a *Personal Stereo PSU* and a *Caravan Alarm*—these will all appear next month, hopefully to go with the sun! For those of you working up to "O" levels for next year or even '87, why not make use of the holiday period by following our *Building Blocks* series? Those qualifications may mean more reward in the years to come.

Of course, some activities increase in popularity through the summer months and in virtually all of them our hobby can help. If you are a musician, no doubt now is your most active time, and it may be that you could use some new effects units or other equipment—just the type of item we publish quite often, *see page 441*.

So don't put the thought of projects out of your mind, many of them come into their own at this time of the year. After all, there is no reason why you cannot take the components outside and work in the sun; it's one of the advantages of modern miniature components and plastic cases. You can assemble your project just about anywhere these days.

If you are new to our hobby, now is as good a time as any to start getting things together for project building and to practise assembling and soldering components for that first project. There is much to be gained from seeing a neatly built project gradually take shape and then perform a useful function, possibly for years to come.

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STEPPING MOTORS

MARK STUART

STEPPING motors provide a very simple means of producing precise controlled movement from digital input signals. For this reason their use has become more and more common in all kinds of computer controlled mechanisms.

CONSTRUCTION AND USE

To explain the operation of a stepping motor a very basic 4-step per revolution model is shown in Fig. 1. This model has a smooth cylindrical rotor which is magnetised with a single pair of magnetic poles. There are two pairs of stator poles set at 90° to each other. Each stator is wound with a coil through which current may be passed in either direction to produce a magnetic field between the poles.

This type of motor where the rotor is a smooth magnetised cylinder and the stators are not permanently magnetised is known as a permanent magnet stepping motor. There is another type of motor construction known as variable reluctance, and a third type which combines the characteristics of the previous two types and is aptly called the hybrid.

The windings shown on the stators of Fig. 1 are centre tapped. The centre taps are connected to one side of the power supply and the remaining ends of the coils are returned to the other side of the supply via four switches. This method of winding is called unipolar because it allows all four windings to be switched to the same supply. This method is particularly suited to simple drive circuitry. For example the four switches could be replaced by transistors which can be driven directly from a computer output port. A particularly useful integrated circuit, the SAA1027, is designed to drive unipolar stepping motors directly.

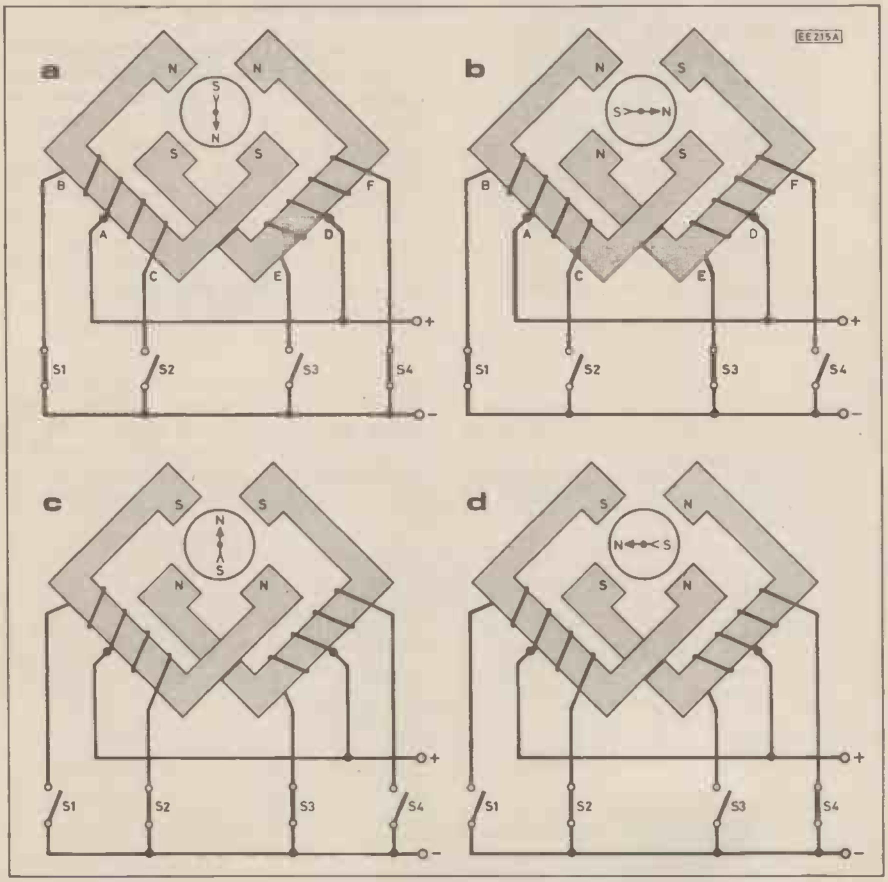


Fig. 1. Basic operation of a 4-step per revolution stepping motor.

Fig. 1a shows the motor in the first position. S1 and S4 are closed, current flows in windings AB and DF magnetising the stators as shown. The stators attract the opposite poles of the rotor which aligns itself as shown.

The second position is shown in Fig. 1b. This time current flows in winding DE instead of DF so that the magnetic polarity of the stator is reversed. The rotor now aligns itself in the second step position. Step 3 and step 4 follow in a similar way as shown in Fig. 1c and 1d respectively.

The switching sequence of the windings is shown in Table 1. Reversing the sequence of switching results in the motor stepping in the opposite direction.

This much simplified model produces steps at 90 degree intervals which are not practical for real applications.

Standard commercial permanent magnet (PM) stepping motors are made with 15 degree or 7·5 degree steps, giving 24 or 48 steps per revolution. The finer steps are achieved by magnetising the rotor with several pole-pairs and using multi pole stators. The maximum number of steps per revolution is limited by the number of pole pairs with which the rotor can be magnetised. This depends on the rotor material (usually a type of ferrite) and the circumference of the rotor. A very large rotor could be produced with a correspondingly large number of pole-pairs but then the mechanical inertia would be so high that the motor acceleration would be severely limited. The practical maximum for this type of motor seems to be 48 steps per revolution.

ID35 MOTOR

The ID35 motor uses the type of construction shown in Fig. 2. The rotor is magnetised as shown with twelve pairs of magnetic poles around its circumference. In all 24 pairs of stator poles are required. These are provided by two identical sets of 12 pairs, one set of which is offset from the other by one quarter of the pole pitch as shown. Each set of 12 pole pairs is constructed from two pressings which resemble large locking washers assembled each side of a coil former so that their teeth interlock. Current passing through the coil magnetises the two pressings with opposite magnetic poles so that the teeth appear as twelve pairs of poles around the rotor (Fig. 2b).

The actual ID35 motor pressings are more complicated than the simplified drawing in Fig. 2 shows. The two outer pressings form the casing of the motor and are drilled to hold the motor bearings. The alignment of the whole assembly is critical so do not be tempted to take one to pieces—it will not fit back together properly.

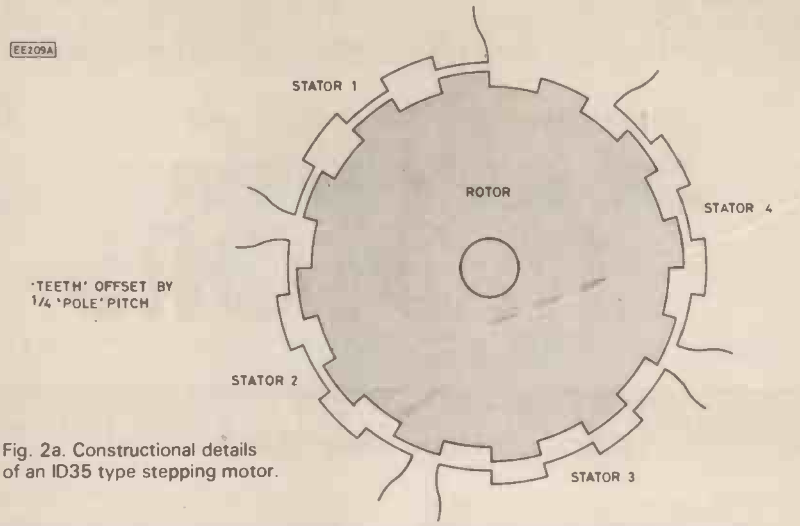


Fig. 2a. Constructional details of an ID35 type stepping motor.

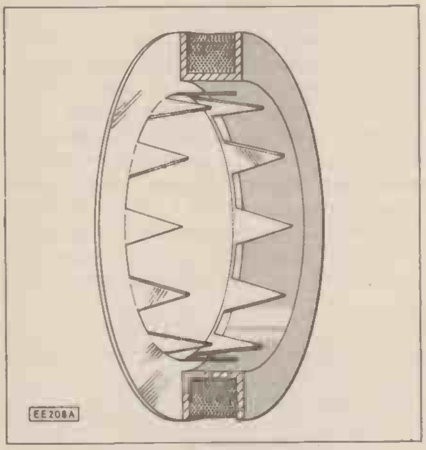


Fig. 2b. Motor assembly.

The permanent magnet motors being of simple construction are at the low cost end of the market.

VARIABLE RELUCTANCE MOTORS

Variable reluctance (VR) motors have an unmagnetised cog shaped iron rotor which is attracted to sets of toothed stator poles magnetised by current flowing in windings around them. These motors have practically no torque when the windings are not energised (the detent torque) and can be useful in applications where freewheeling manual operation and motorised operation of a mechanism are required. A good example of this is the paper feed mechanism on a strip chart recorder where paper is pulled through manually between recordings.

HYBRID MOTORS

The Hybrid stepping motor uses a cog shaped rotor and toothed stator poles as in the VR type, but also has a permanent magnetic field supplied by a magnet fitted to either the stator or rotor. The teeth on the stator poles are offset from each other by a small amount as shown in Fig. 3. As each set of poles is energised the rotor turns so that its teeth line up with them. By energising pairs of poles in the appropriate sequence as with the permanent magnet motors rotation in either direction is achieved. The step angle of hybrid (and VR) motors is not limited by the magnetic materials in the same way as the permanent magnet motor so that much smaller steps angles can be achieved.

Step angles 0·9, 1·8, 1·875 and 3·75 degrees are common yielding 400, 200, 192 and 96 steps per revolution.

VARIATIONS

The motors discussed so far are the most common types encountered. Many variations exist offering better performance or lighter weight and so on. Motors may have two, three, four or even five sets of windings and power outputs vary from milliwatts to a maximum of about 1 kilowatt. For very high power outputs an hydraulic motor has been linked to a stepping motor. The stepping motor operates a set of valves which control the hydraulic fluid to the main motor which follows the stepping motor exactly. Power outputs of up to 150kW are available using this technique. At the other end of the scale is the motor driving the hands of the analogue quartz watch. This must be the most common application of stepping motors.

Table 1. Step sequence.

		S_1	S_2	S_3	S_4
CLOCKWISE ↓	1	ON	OFF	OFF	ON
	2	ON	OFF	ON	OFF
	3	OFF	ON	ON	OFF
	4	OFF	ON	OFF	ON
	1	ON	OFF	OFF	ON

MOTOR SPECIFICATIONS

The full specification of a stepping motor covers a very wide range of mechanical and electrical parameters. Table 2 shows the main parameters for three types of motor. The maximum stepping rate and power output can only be obtained when the motors are driven from the correct power source. The higher power motors employ very sophisticated drive circuits which provide a high voltage current limited supply to the windings. The high voltage forces the current in the windings to rise very quickly. Once the current reaches the maximum rating the current limiting circuit comes into action and prevents the current rising further. This arrangement gives the maximum speed and power output from the motor. Such techniques could be applied to the smaller motors but the complexity and

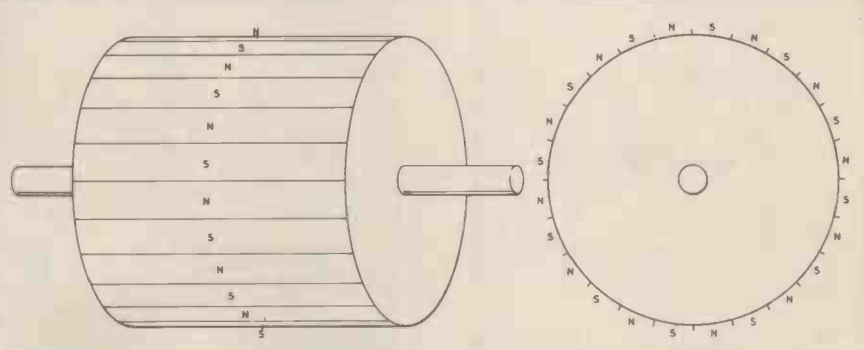


Fig. 3. Hybrid/VR motor construction.

cost of the circuitry are not really justified. It is usually cheaper to use a larger motor.

One interesting feature shown in Table 2 is that the largest motor is capable of better acceleration and top speed than the smaller motors. It is also more efficient.

Stepping motors have been around for a very long time in one form or another. The advent of cheap decoder i.c.s, and power transistors has already given a major boost to their use. The arrival of low cost computers with the need for simple accurate mechanisms in such things as disc drives, printers and plotters must have presented an enormous new market.

The relentless spread of automation into all aspects of life must mean that the future of the stepping motor is guaranteed.

	Step Angle	Holding Torque	Resistance Per Phase (Ohms)	Max Pull In Rate	Max Pull Out Rate	Inductance Per Phase	Rotor Inertia	Max Power Output	Current Per Phase
PHILIPS ID35 35014	7·5°	85mNm	47	130	130	400mH	45gm cm²	1 watt	240mA
PHILIPS HR23	1·8°	450mNm	4·3	300	7000	14mH	100gm cm²	10 watts @ 2000 step/sec	1A
SIGMA SERIES 21	1·8°	4860mNm	0·3	800	20,000	1·65mH	3530gm cm²	275 watts @ 6000 step/sec	9·2A

Table 2. Stepping motor specifications.

STEPPER MOTOR INTERFACE

THIS interface was designed to enable 4-phase unipolar stepping motors of the ID31/35 type to be driven from four output lines of any computer user port.

The computer connections shown in this article are for the BBC Model B. They can easily be varied to suit most other computers provided at least four output lines are available.

In order to keep the programming as simple as possible a special stepping motor decoder/driver i.c. is used. This i.c. takes clock pulses from the computer and produces the correct switching sequence on its outputs to drive directly the four stepping motor coils. A second i.c. input selects the direction of motor rotation by reversing the output switching sequence.

Two additional inputs are provided. One sets the motor in the nearest phase 1 position and inhibits the clock and direction inputs. The other input allows the motor current to be switched between high and low levels, this allows dissipation to be minimised when the motor is stationary whilst still allowing full power during rotation. These last two inputs may be ignored in simpler applications simply by leaving them disconnected. The interface then only requires two output lines to run.

CIRCUIT OPERATION

Fig. 4 shows the full interface circuit diagram. The four motor coils are driven directly from pins 6, 8, 9 and 11 of IC1. Up to 450mA is available for each coil. The output current is controlled by the current fed into pin 4. This current is used to bias the output transistors. The relationship between the output current limit and the bias current is approximately 4 to 1 except at outputs below about 50mA when control becomes very critical.

The bias current is set via R14 and R15. When the output current control input is held low (logic 0) TR6 is turned off and so

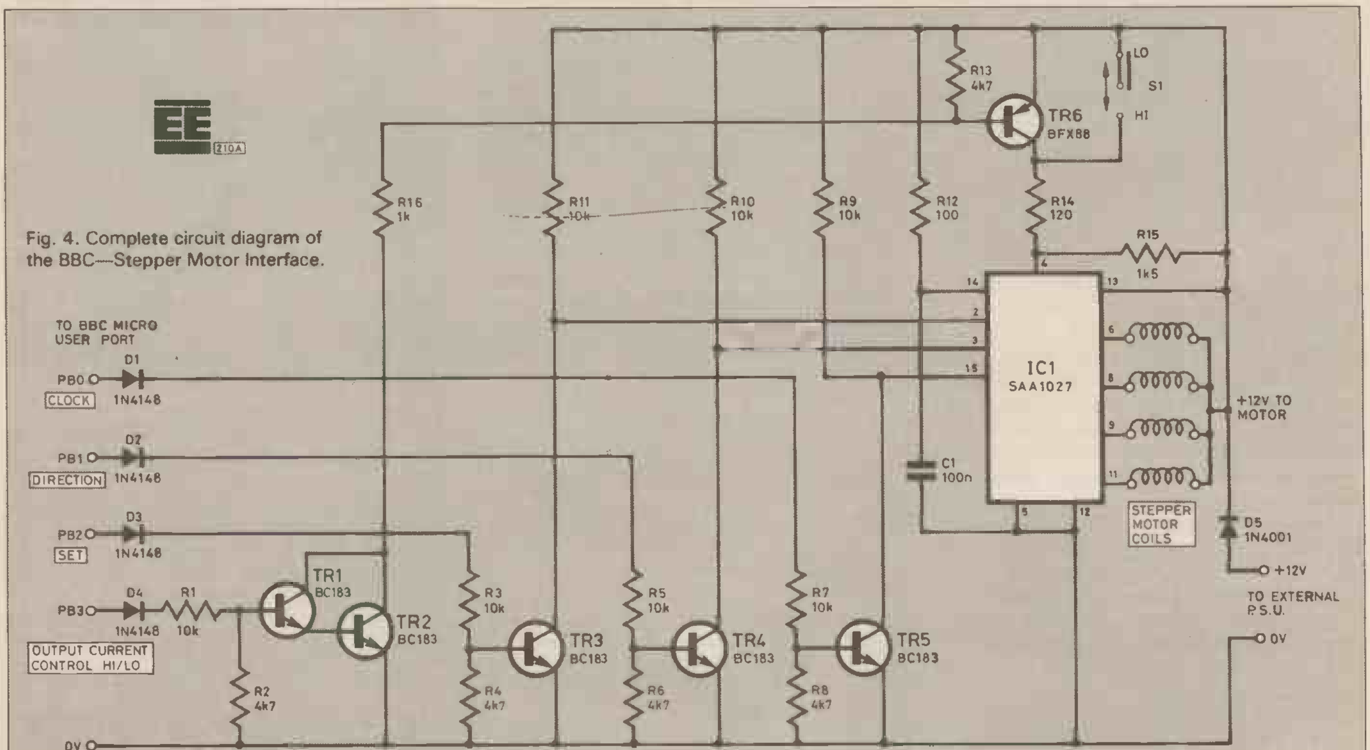


Fig. 4. Complete circuit diagram of the BBC—Stepper Motor Interface.

the supply is removed from R14. The only bias current is thus supplied via R15. The value of R15 is selected to give about 10mA of bias current. This sets the output current limit to about 50mA. Setting the output current control input high (logic 1) turns on TR6 and provides bias current via R14 in addition to that via R15. The output current limit now becomes 400mA, and values of R14 and R15 may be adjusted if required to suit the particular motor and operating conditions. SW1 bypasses TR6 and sets the output current permanently high. This setting allows the interface to be used with the current control input left open circuit so saving one output port line.

The clock, direction, and set functions are all provided by IC1 and are selected by the voltage levels on pins 15, 3 and 2 respectively. It is not possible to drive the i.c. directly from the computer output port because the inputs require a logic high level exceeding 7·5 volts. Transistors TR3, TR4 and TR5 along with their associated components perform the necessary level shifting operation. The component values are chosen so that the transistors are turned on by 2·4 volts from the computer. The pull-up resistors R9, 10 and 11 take the inputs of IC1 up to 12V when the transistors are turned off. When the transistors are turned on they pull the i.c. pins right down to zero volts.

The output current control input has a similar circuit to the other three inputs but instead of a single transistor two are used. These two transistors are connected as a Darlington pair which has a much higher current gain than a single transistor. This is necessary to provide the higher drive current required by TR6. Diodes D1–D4 are fitted to prevent the interface from feeding current back into the computer port when the computer is switched off.

CONSTRUCTION

The interface is built on a single printed circuit board. (See Fig. 5.) Start by fitting the smaller components. Take care with the polarity of the diodes. The cathode end of the 1N4148 types is indicated by a broad band marked on the body. The larger 1N4001 diode has its cathode marked by a silver band. All of the resistors and the capacitor C1 can be fitted either way round.

Next fit the socket for IC1 (taking care to fit the socket the correct way round) and the transistors. Finally fit S1 (either way round) and the terminal blocks. Note that the terminal blocks have a dovetail arrangement which enables a 6-way strip to be made up by sliding shorter ones together.

Having completed the board assembly the ribbon cable should now be connected to the appropriate computer connector. For the BBC I/O port a 20 pin IDC socket is required. Fig. 7 shows the correct assembly of the socket viewed from the end nearest to pin 1. Note the position of the polarising bump and the way that the cable is folded back over the socket before the retaining clip is fitted. For those unfamiliar with IDC sockets the important thing to remember is that the cable insulation does NOT need stripping. The connections are made by pressing the insulated cable down over specially shaped tines which pierce the insulation and make very good contact with the conductors inside.

The cable is connected to the printed circuit as shown in Fig. 6. The lead numbers are counted across the cable starting from pin 1. The required leads should be separated from the ribbon cable, stripped and tinned so that they can be fed down through the p.c.b. from the component side and soldered to the pads on the track side. The ground connection is available on several pins of the BBC. Pin 7 is probably the most convenient. Ensure that the unused leads are cut cleanly and do not have any stray wire ends that might cause short circuits.

Finally insert the i.c. into its socket—take care to get it the right way round.

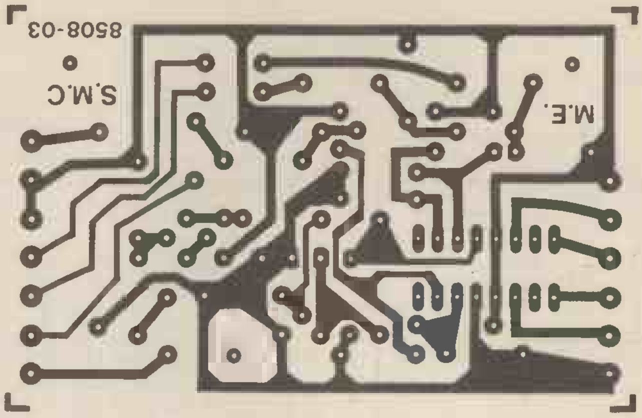


Fig. 5. P.c.b. design for the Stepper Motor Interface.

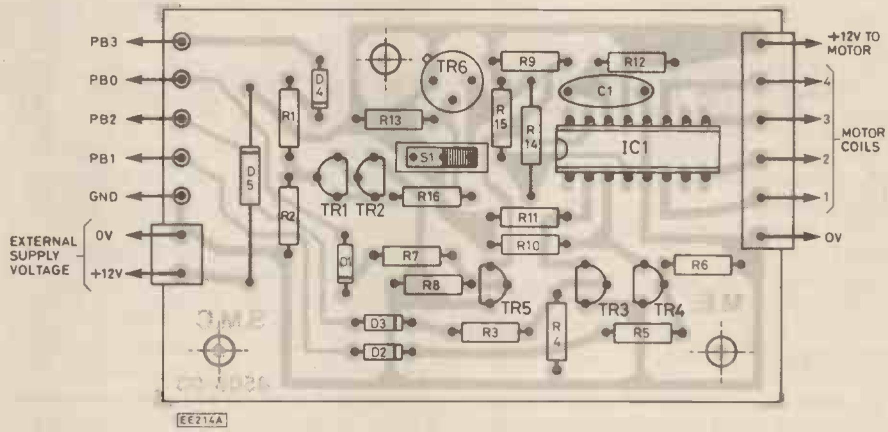


Fig. 6. Component layout for the Stepper Motor Interface.

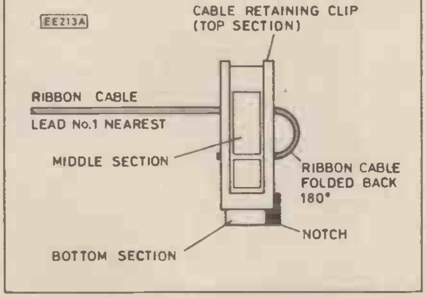


Fig. 7. IDC socket assembly.

COMPONENTS

Resistors	
R1,R3,R5, R7,R9–R11	10K (7 off)
R2,R4,R6, R8,R13	4K7 (5 off)
R12	100
R14	120 ½W
R15	1K5
R16	1K
All resistors ¼W 5% carbon film unless stated	
Capacitors	
C1	100n polyester 16V
Semiconductors	
TR1–TR5	BC183 (5 off)
TR6	BFX88
IC1	SAA1027
D1–D4	1N4148 (4 off)
D5	1N4005

Miscellaneous

S.p.d.t. p.c.b. mounting switch, i.c. socket, p.c.b. terminal blocks, p.c.b., IDC socket to suit computer, ribbon cable.

Approx. cost Guidance only **£15.00**

POWER SUPPLY

The interface requires a 12V supply capable of supplying up to 800mA. The supply need not be regulated as the i.c. will take up to 20V safely. A simple circuit is shown in Fig. 8. This circuit can be built in any suitable small case. Take care to keep the mains wiring separated from the secondary wiring and use insulating sleeving on all of the mains connections. The transformer must be a split bobbin type with plenty of insulation between primary and secondary. The core of the transformer should be connected to earth using a solder tag under one of the fixing screws.

TESTING AND USE

Connect a suitable motor to the output terminals, set S1 to the HIGH position and connect a 12V supply. Do not connect the computer at this stage. Check that the motor is energised and locked into one step. It should now be possible to move the motor one step each time the clock lead is touched onto the +12V supply. If all is well disconnect the 12V supply, connect the interface to the computer user port and reconnect the supply.

The four computer port lines operate as follows:

PB0 This line provides the clock pulses which step the motor. Each time the level changes from logic 1 to 0 the motor moves 1 step.

PB1 Sets the direction of motor rotation. Logic 0 gives clockwise movement, logic 1 anticlockwise. If this is inconvenient it is possible to reverse the directions by interchanging the motor connections.

PB2 This is the SET input which locks the motor into the nearest step 0 position when it is held at a logic 1. In this condition the direction inputs are ignored.

PB3 The current control input when S1 is set to 'low'. This input allows the computer to set the output current. Logic 1 gives High. Logic 0 gives Low.

A full truth table is shown in Table 3.

The simplest program that will run the motor is one which alternately writes 8 and 9 to the port. The speed of rotation of the motor is limited to a maximum of 130 steps per second before the torque falls to zero. This means that a delay loop of around 10 milliseconds will need to be incorporated into the program. As the speed is lowered the torque increases rapidly—at 50 steps per second the torque is 90% of the maximum.

The inertia of the motor and its load influence the rate at which the motor can begin stepping from a standstill. With high inertia loads it is necessary to ramp up and ramp down the speed when accelerating and decelerating. The maximum rate of speed increase and decrease must be found by trial and error. It depends on both the inertial and frictional content of the load.

PB1 = L					PB2 = L	PB1 = H			
PB0	Q1	Q2	Q3	Q4	PB0	Q1	Q2	Q3	Q4
0	L	H	L	H	0	L	H	L	H
1	H	L	L	H	1	L	H	H	L
2	H	L	H	L	2	H	L	H	L
3	L	H	H	L	3	H	L	L	H
4	L	H	L	H	4	L	H	L	H

Table 3. Stepping motor truth table.

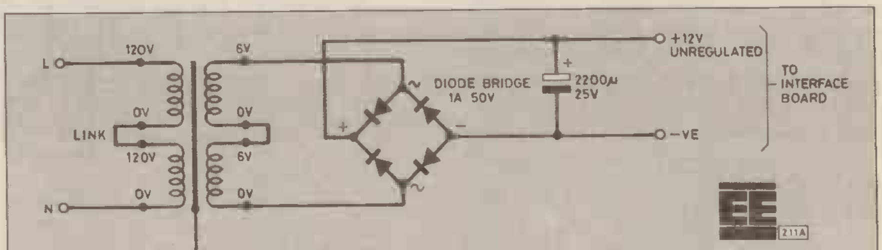


Fig. 8. Suggested p.s.u. design.

BBC COMPUTER PROGRAM LISTING

A simple programme to demonstrate the driving of a stepping motor from the interface is provided. The program includes simple instructions for operation.

Line 10 sets up the port and displays the instructions. The computer asks for the number of steps and direction. Maximum speed is set in lines 160 and 200 which are small FOR-NEXT type delay loops. Acceleration is represented by variable A%, which is used in lines 150 and 190 to provide a steadily decreasing delay loop over 40 pulses. A% can be varied in line 120—a higher number gives a slower acceleration.

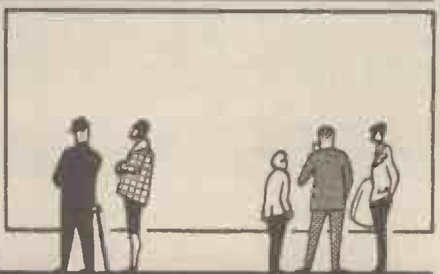
The delay in lines 160 and 200 can be varied by changing the number of loops initially set at 3, e.g. change to "FOR E%=0 TO 10:NEXT" to lengthen the delay.

Although only intended for demonstration purposes the program may be varied as required or embedded in larger programs to provide the motor control function. ☐

```
 10 MODE7:?&FE62=15:VDU 23;8202;0;0;0;
 20 ENVELOPE1,1,0,0,0,100,5,100,10,-1,-1,-1,110,100:PROCINSTRUCTIONS:CLS
 30 INPUT TAB(0,1);"Number of steps."S%
 40 IF S%=0 THEN VDU7:PROCCLEAR:GOTO30
 50 PROCSOUND:PROCCLEAR
 60 INPUT TAB(0,1);"Clockwise/Anticlockwise (C or A)."D$
 70 IF D$="A" OR D$="C" THEN 80 ELSE VDU7:PROCCLEAR:GOTO60
 80 CAD$="AN ANTICLOCKWISE":D%=0:IF D$="C" THEN D%=2:CAD$="A CLOCKWISE"
 90 PROCSOUND:PROCCLEAR
100 PROCSETUP
110 M%=9+D%
120 A%=20:FOR B%=1 TO S%
130 ?&FE60=M%
140 IF A%=0 THEN 160
150 FOR E%=1 TO A%:NEXT E%
160 FOR E%=0 TO 3:NEXT E%
170 ?&FE60=(M%-1)
180 IF A%=0 THEN 200
190 FOR E%=1 TO A%:NEXT E%:A%=A%-.5
200 FOR E%=0 TO 3:NEXT E%
210 NEXT B%
220 PRINT TAB(0,9);"LAST MOVE:";TAB(0,20);SPC(40)
230 SOUND 1,1,33,2:SOUND 2,1,53,2:SOUND 3,1,69,2:GOTO 30
240 DEF PROCSOUND:SOUND 1,1,33,2:SOUND 2,1,49,2:SOUND 3,1,61,2:ENDPROC
250 DEF PROCCLEAR:PRINT TAB(0,0);SPC(120):ENDPROC
260 DEF PROCINSTRUCTIONS:CLS
270 PRINT" STEPPER MOTOR DEMONSTRATION PROGRAM"
280 PRINT" ________________________________"
290 PRINT';"When prompted, enter the data required."'
300 PRINT"Any invalid data will be ignored by the"'
310 PRINT"program and you will be asked to enter"'
320 PRINT"it again."''
330 PRINT"If your stepper motor is connected to"'
340 PRINT"the controller board in the wrong order,"
350 PRINT"it will not be damaged, nor cause any"'
360 PRINT"damage whatsoever to the board. It will"'
370 PRINT"simply either rotate in the opposite"'
380 PRINT"direction or struggle to rotate at all."'
390 PRINT"  * * TAP THE RETURN KEY TO BEGIN * *";
400 A$=GET$:IF ASC A$=13 ENDPROC ELSE 400
410 ENDPROC
420 DEF PROCSETUP:CLS:PRINT TAB(0,10)
430 PRINT;"ROTATE ";S%;" STEPS IN ";CAD$
440 PRINT'"DIRECTION"
450 PRINT TAB(0,20);"*** PRESS RETURN KEY TO DRIVE MOTOR ***";TAB(0,9);SPC(10)
460 A$=GET$:IF ASC A$=13 ENDPROC ELSE 460
```

See Shop Talk page 421

SHOP TALK



BY RICH. BARRON

Catalogues

Despite the apparent slump in the electronics market there seems to be an ever increasing number of component catalogues available to both the hobbyist and industry. It is well worth keeping track of as many of these as possible as prices vary enormously between manufacturers and suppliers. Many component suppliers will dispatch catalogues free of charge and others charge very little.

As well as providing basic information such as prices and pin-outs of various i.c.s, a catalogue is often a good way of keeping ahead of new developments in the industry and the latest chips available. Also some suppliers include practical applications circuits for many of their products and will often provide data sheets free of charge on request. In all, a good collection of catalogues constitutes a basic but essential reference library.

Catalogues Received

The latest catalogue from Electrovalue is now available free from: **Electrovalue Ltd., Dept. EE, 28 St. Judes Road, Englefield Green, Egham, Surrey, TW20 0HB. ☎ (0784) 33603.** Items are listed in alphabetic order together with the price per item. For orders over £5 carriage is free and there are various discounts available for orders over £20.

Electrovalue offer a wide selection of goods including components, adhesives, batteries, books and tools to mention but a few.

The 1985 Cable And Wire Book from STC, as its name suggests specialises in all forms of wire and cable. It contains a comprehensive range including equipment wire, security cable, mains and lighting cable and co-axial. For more details: **☎ (0279) 26777.**

For the hi-fi enthusiast, the latest list from Radio Component Specialists may be of interest. It offers a wide range of turntables, speakers and amplifiers as well as a range of spares for hi-fi equipment. More details from: **Radio Component Specialists, Dept. EE, 377 Whitehorse Road, West Croydon, Surrey. ☎ 01-684 1665.**

Not a catalogue, but a bulletin about solder-absorbing wicks in a wide range of sizes from Orientation Ltd. For more details about these and other products contact: **Orientation Ltd., Dept. EE, PO Box 17, Camborne TR14 8XG. ☎ (0209) 719700.**

A leaflet from Erg Components illustrates a variety of rotary coded d.i.l. switches for use in a variety of applications. Details are obtainable from: **Erg Components Ltd., Dept. EE, Luton Road, Dunstable, Beds. LU5 4LJ. ☎ (0582) 62241.**

Computer Projects

Over the last few years, there has been an increasing interest in and demand for computer orientated projects. We at *EE* have endeavoured to provide a wide variety of such projects including interfaces for most of the popular home micros. Many of you readers may not yet have moved over from the field of pure hobbyist electronics to computer projects; well now is the time to do so.

There have been some major upsets in the computer industry over the last year causing some well known firms to go out of business. Although this in itself is not good news, it does offer many benefits to the home-micro buyer. Competition between manufacturers and suppliers has increased and prices have fallen dramatically resulting in some very good bargains in the market place.

By shopping around you should be able to pick up a computer to suit your requirements at a very reasonable price. Once you have got to grips with the finer points of programming then you will probably move on to the interfacing. If you do, then; YOU, YOUR COMPUTER and EVERYDAY ELECTRONICS make a very good team.

PCB Drills

As a hobbyist you will at some time probably have to either make or work on p.c.b.s. P.c.b. drills and controllers can be quite expensive so it's maybe wise to make your own.

Croydon Discount Electronics offer a range of high torque motors which when fitted with a suitable collet make an ideal mini-drill for p.c.b. work. Also available are various other motors and accessories for the hobbyist including: Controllers (illustrated), mini motors, relays and drill bits. For more details contact: **Croydon Discount Electronics, 40 Lower Addiscombe Road, Croydon CR0 6AA. ☎ 01-688 2950.**

CONSTRUCTIONAL PROJECTS

Drill Control Unit

There should be no problems getting components for this project as they are all quite common. The electronics may fit into any suitable case such as the Tandy 270–266. Details from: **Tandy Corporation (Branch UK), Tameway Tower, Bridge St., Walsall, West Midlands WS1 1LA.**

Stepper Motor Interface

The full kit of parts is available for this project or a selection of stepper motors are available separately. More details and prices are available from: **Magenta Electronics Ltd., Dept. EE, 135 Hunter St., Burton-on-Trent, Staffs. DE14 2ST. ☎ (0283) 65435.**

Tremolo/Vibrato Unit

Once again, no problems foreseen with this one but remember it's wise to shop around.

Tri-State Thermometer

Most of the components for this project are fairly common except for the thermistor, R9. This is a TH-B11 type similar to the GL16. This device is available from: **Maplin Electronics Supplies Ltd., Dept. EE, PO Box 3, Rayleigh, Essex SS6 8LR (0702) 552911.**

Power Supply Unit (Electronic Building Blocks)

Most of the components are readily available and the p.c.b. is available from the EE p.c.b. service. As a bonus the p.c.b.s for four separate projects are provided on one board. This makes each one cheaper—all you have to do is cut the board yourself and use each part when required.

Spectrum Joystick Interface (On Spec)

A Spectrum prototype Interface kit is available from: **Kelan Engineering, 27-29 Leadhall Lane, Harrogate, Yorks.**

ELECTRONIC BUILDING BLOCKS

PART ONE

RICHARD BARRON

OVER the years, we at Everyday Electronics have paid close attention to the needs of all our readers by providing projects and features suitable for beginners through to the experienced hobbyist. To attract and encourage newcomers to this hobby of ours we have produced excellent articles such as Actually Doing It, Down To Earth and Teach-In series. This new series, Electronic Building Blocks, is continuing this tradition in a slightly different way.

Each month we will take a close look at a particular subject and give as much useful practical and technical information as possible about all aspects of the subject. This will include; circuit ideas and principles, design considerations, product specifications and a small but essential dose of formulae. Also an inexpensive constructional project relevant to the current theme will be included to reinforce the ideas and theory learnt.

Whilst being of interest to all hobbyists we think this series will be of particular interest to those studying for the Associated Examining Board O-Level examination, which is treated in a similar fashion. The concepts of modular design and electronic building blocks is common to both the O-Level course and this series.

Obviously this is not a comprehensive electronics learning package so further study is advised, however, after reading a couple of articles in this series and building the associated projects you will quickly become familiar with a wide range of concepts and devices. Additionally we hope that you will become a confident and capable electronic hobbyist able to use these building blocks to design and build your own projects.

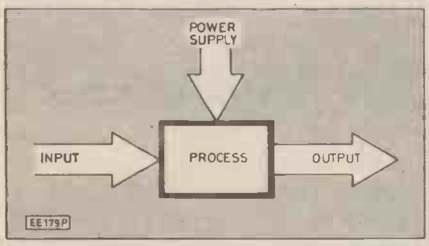


Fig. 1. Components of a basic system.

MODULAR DESIGN

In recent years, modular design has become something of a buzz-word in the world of electronics, largely due to the introduction of medium and large scale integrated circuits. The basic idea being, that any system can be split into a number of sub-systems and circuit elements. Using these sub-systems in a variety of configurations allows a flexible design system to produce a variety of results.

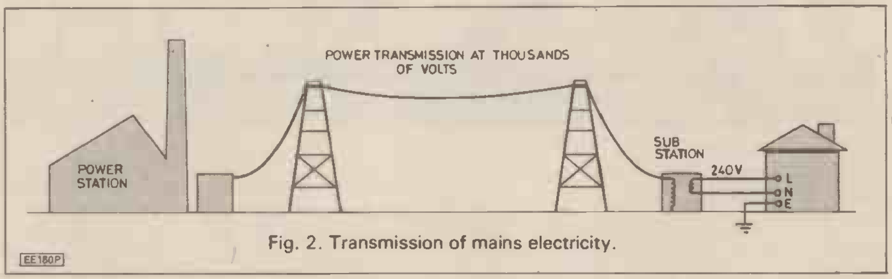


Fig. 2. Transmission of mains electricity.

Take for example, three elements: a power supply, an oscillator and an amplifier. Using the power supply and the oscillator as a basis, things such as signal generators and noise effects units can be produced. Alternatively the power supply may be used as a stand-alone device or used to power other units. The oscillator may be used as a clock system for a computer or the amplifier and the power supply used in an electronic musical instrument.

This principle can be extended even further to discrete components. If it is clear how a device works and its limitations, then it is easy to see how using the ideas above, it can be connected in different ways to achieve different results. This series hopes to combine all these principles so that not only a clear understanding of systems but a practical understanding of components is achieved, allowing sound designs to be easily produced.

SYSTEMS

All systems, electronic or otherwise, perform a process which is dependent on two components; an input and an output. A television or radio converts radio signals (input) into sound and light (output) and a hair drier converts cool air into warm air. Whatever the process, they have one thing in common, because no machine or system is perfect, energy losses must occur during the conversion process.

Sometimes this energy loss is inconsequential but in most cases it is required that the output uses more energy than the input or that the process takes a large amount of energy. In these cases an extra power source is required, either as an extra input or considered as an integral part of the process.

There are two commonly used methods of providing electrical energy, either from a battery or a mains derived power supply. Batteries are useful but have many disadvantages, not least that they are prone to becoming flat.

USE OF MAINS POWER

Electricity is available to us in a seemingly never ending supply from the national grid system. It is generated from a variety of sources but when it enters our home it has the same characteristics whatever the source. In this country domestic electricity is supplied as alternating current (a.c.), at a frequency of 50 Hertz (Hz) and a potential of 240V.

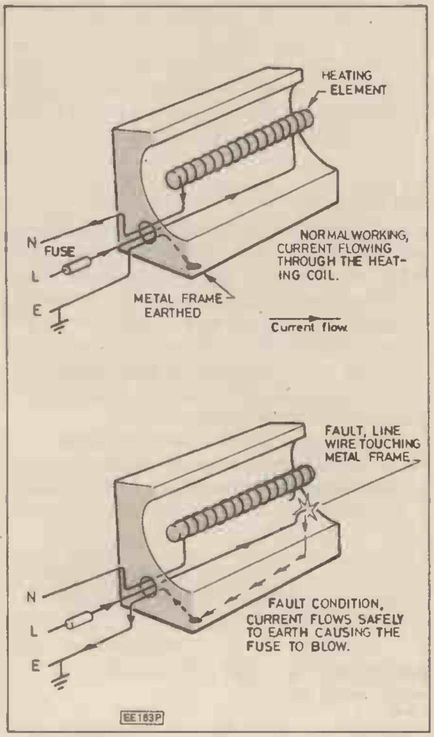


Fig. 3. Earthing arrangements of domestic appliances.

Whilst electricity in this form is ideally suited to transmission over long distances, it is not very convenient for use in many electrical and electronic appliances. It is also very very dangerous if misused. Make no mistake—**ELECTRICITY CAN KILL!** For these reasons, this month we will take a

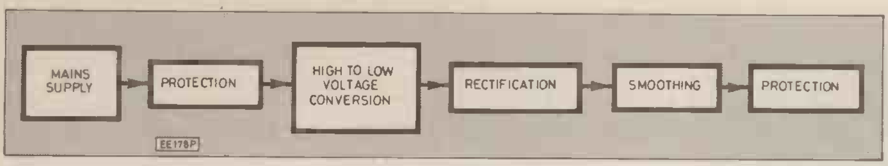


Fig. 4. Components of basic low voltage supply.

close look at the use of mains to provide convenient and safe electrical power for electronic projects.

The block diagram of Fig. 2 shows how electricity reaches our homes. It is generated at very high voltages at the power station and transmitted by overhead or underground cables to sub-stations around the country. Using a transformer it is converted to 240V and then transmitted to our homes using two wires. One wire, the neutral, is connected directly to the ground, which as we shall see is a very important safety feature.

In the home, the domestic supply consists of three wires, the LINE, NEUTRAL and EARTH. (Many people still call the Line wire the Live, which is very misleading because although the neutral should be at earth potential it is or can be LIVE.) When an appliance is connected, current is supplied through the line wire, through the appliance and then returns via the neutral wire.

In the example shown in Fig. 3 of the electric fire, the metal surround of the fire is connected to earth. Now if a fault occurs in the fire, such as the line (live) wire touching the metal case, instead of the case becoming live and thus a potential hazard, current will be safely routed to earth and a fuse will be blown which will cut off the supply.

PROTECTION

From the previous example it can be seen why the earth protection is so important. Also mentioned was the fuse. The fuse should always be incorporated into electrical devices for two reasons, both related to excess current flow. When a circuit is designed, then an idea of the maximum current likely to be required is known. If a fault occurs excess current may be caused to flow around the circuit which will do one of two things, either cause danger to human life by means of electric shock or cause heat to be generated in the cable which could easily cause a fire. Obviously neither is acceptable, so a fuse is included which will disconnect the supply under these conditions.

PRACTICAL USE OF MAINS ELECTRICITY

So far we have had a very brief and simplified explanation of the characteristics of the domestic mains supply. Now we shall see how we can make practical use of this electricity to provide safe and useful power sources for our electronic projects.

The majority of electronic devices and circuits require a low voltage, direct current power supply. This can be produced quite easily from the mains. The first requirement is a reduction in voltage from 240V to the necessary working voltage. Then the alternating current has to be rectified to produce a direct current (d.c.) supply. At all times safety considerations should be in mind. The block diagram of Fig. 4 shows the various stages involved.

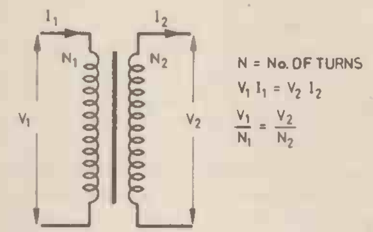


Fig. 5. Principal characteristics of transformer action.

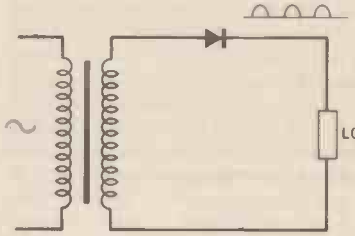


Fig. 6. Half-wave rectification.

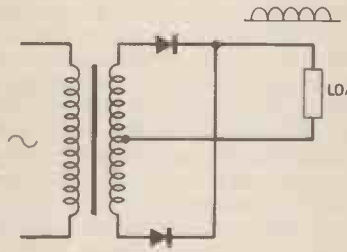


Fig. 7. Centre tap full-wave rectification.

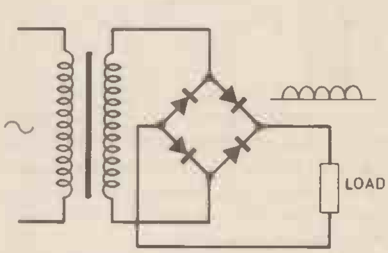


Fig. 8. Bridge circuit full-wave rectification.

EE184P

TRANSFORMERS

Alternating current can easily be transformed from one voltage to another by a voltage transformer. This device consists of two or more separate coils of wire situated close together. When a current flows through one coil, a magnetic field is set up around the coil and if the current is alternating then the magnetic field will alternate in a similar manner. This changing magnetic field will cause an alternating voltage to be induced in the second coil.

There is a close relationship between the voltage and current in both coils which is affected mainly by the number of turns of wire on each coil. Because a transformer is a very efficient device the power input will be equal to the power output (or very nearly). Since power is the product of the current and the voltage it can be seen that in Fig. 5, $V_1 \times I_1 = V_2 \times I_2$. Also the relationship between the voltage across the first coil (primary coil) and the second coil (secondary coil) is directly proportional to the number of turns. This gives us, $V_1/N_1 = V_2/N_2$.

In practice most transformers are manufactured by specialists due to their nature. They usually have a large number of turns of wire and the coils are wound on special cores to enhance the magnetic coupling characteristics.

When selecting a transformer it is not usually necessary to know how the transformer is constructed, but merely to know its input and output characteristics. Since on most occasions the input (primary voltage) will be 240V, the secondary voltage and maximum current is the most important specification. Transformer ratings are usually given as maximum VA specification and as the output voltage is known it is easy to work out how much current it can supply.

RECTIFIERS

Once we have achieved the required a.c. voltage from a transformer then we have to convert it to d.c. This process is called rectification and is done using diodes. Diodes will only conduct current in one direction, thus a rectifier circuit can easily be designed. Fig. 6 shows the simplest method of rectification where a series of the pulses are produced because the diode effectively cuts off current in the reverse direction. This method is called half-wave rectification.

More efficient results come from full-wave rectification where a.c. is produced as a continuous fluctuating wave of current in the same direction. There are two methods of getting full wave rectification depending on the type of transformer used.

In Fig. 7 a centre tapped transformer is used together with two diodes. A centre tapped transformer has a secondary coil which has a connection to the middle of its winding. This means that on each cycle of the a.c., each end of the coil will go more positive and then more negative than the middle. Using two diodes as shown current is routed to the same point to provide a positive terminal, the centre tap being always negative with respect to this point.

Alternatively, a bridge rectifier circuit may be used which is shown in Fig. 8. Here the negative current is routed to one terminal and the positive to another. This circuit is probably the most common and it has the added advantage of providing a positive and negative voltage with respect to a centre tap.

Diodes are semiconductor devices which are used extensively in electronic circuits and have a wide variety of applications. We will be examining the properties of these devices in more detail in some of the forthcoming articles in this series, but for the meantime the following points should be noted.

When selecting diodes for use in power supplies, there are two factors which are important, maximum current and peak inverse voltage ratings. The maximum current rating refers to the maximum current which is drawn by the load and is fairly straightforward. However the peak inverse voltage rating (p.i.v.) is a little more complicated, and will be explained later.

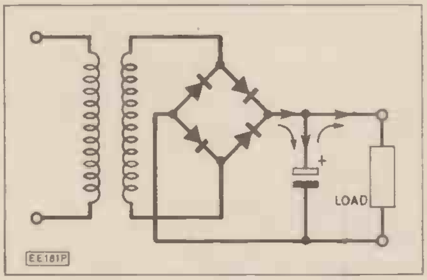


Fig. 9. The capacitor is supplied with energy.

SMOOTHING

Using the transformer and rectifier as described, a d.c. voltage can be produced. This type of fluctuating voltage, in some respects, behaves in much the same way as a.c. which can cause problems in electronic circuits. Ideally we would like a d.c. voltage which does not fluctuate but is constant. For this purpose a capacitor is used.

A capacitor is a device which can store electric charge in the form of an electric field. It also passes a.c. but not d.c., a characteristic which we shall look at more deeply at a later stage. If the capacitor is connected across the output of the bridge rectifier, energy will be pumped into the capacitor and will be stored until it is needed by the load. In Fig. 9 the result of this action is clear.

The energy stored in the capacitor acts like a temporary battery by maintaining a voltage level which is constant and as the load draws current from the capacitor it is topped up again by the transformer. At the same time energy is prevented from being drained back into the transformer by the diode action of the bridge circuit.

The selection of suitable capacitors is mainly dependent on the maximum voltage and the amount of current drawn by the load. Capacitors are rated by the amount of electricity they can store and the maximum working voltage. These values are given in Farads (usually fractions of a Farad) and d.c. voltage respectively. In practical terms, the greater the capacity then the better the smoothing effect. Basically if the capacitor has a low capacity, then in a power supply, current will be drawn from the capacitor quicker than the transformer can top it up. The overall result is a fluctuating voltage.

To some extent this action will occur whatever the capacity, but providing that not too much current is to be drawn the effect can often be negligible. However, there are methods which can be used to nullify this effect to produce an almost perfect d.c. voltage. This is made possible by regulator circuits whose output is operated at a lower voltage than the input. It is able to maintain this lower voltage very accurately providing that so much current is not drawn to reduce the input below this value. These circuits will be the topic of the next article in this series.

PEAK VOLTAGES

Throughout our description of mains electricity we have referred to it as 240V. This figure is true, but due to the nature of a.c. it can be a little misleading. In actual fact this refers to the Root-Mean-Square value of the voltage, which is a mathematical and essentially practical description of the voltage. It represents the equivalent to the d.c. voltage which would have the same heating (power dissipation) effect on a resistor.

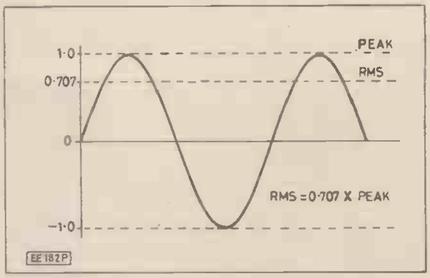


Fig. 10. Comparison of Peak and RMS values.

RMS

By studying the waveform in Fig. 10 it can be seen that the peak voltage is greater than the Root-Mean-Square (RMS) value and it is this voltage which should be taken into account when considering diode p.i.v. and capacitor smoothing circuits.

Suppose for example we have chosen to use a transformer with an output of 6V, then because this refers to the RMS value the peak voltage will be greater. The RMS voltage of a sine wave is equal to 0·707 times that of the peak voltage, which means that the peak voltage will be $(1/0{\cdot}707) \times 6V = 8{\cdot}5V$ approx.

For a full wave bridge circuit with a centre tap transformer, the p.i.v. of the diode will be twice that of the peak voltage due to the negative cycle with respect to the centre tap. These calculations do not take into account small volt drops across the diodes themselves.

NEXT MONTH: We will be taking a close look at regulator circuits and constant voltage and current references.

LOW COST POWER SUPPLY UNIT

This, the first constructional project in the series, is a low cost power supply unit which was designed using many of the techniques and ideas just described. Like all the projects in the series, it will be useful but inexpensive. It is capable of supplying all the necessary power requirements of future projects in the series, and providing its limitations are fully realised, it may be used to power a host of other devices.

THE CIRCUIT

A full circuit diagram of the unit is shown in Fig. 11. The transformer, T1 has two secondary windings, both of which supply 6V RMS. These two windings are connected in series to provide a centre tap which becomes the 0V line.

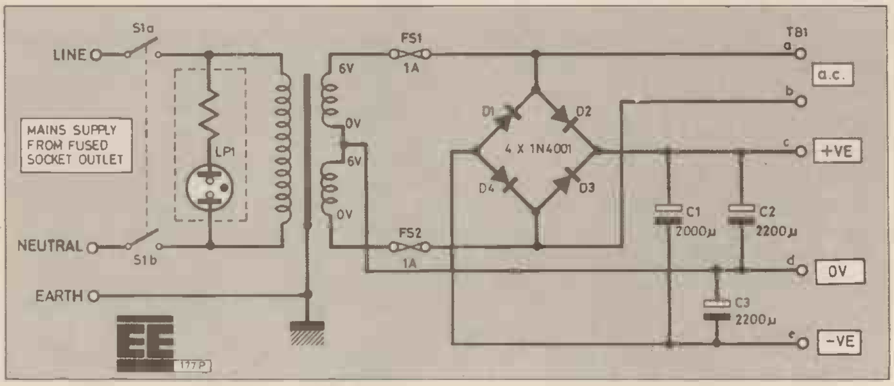


Fig. 11. Complete circuit diagram of the Low Cost PSU.

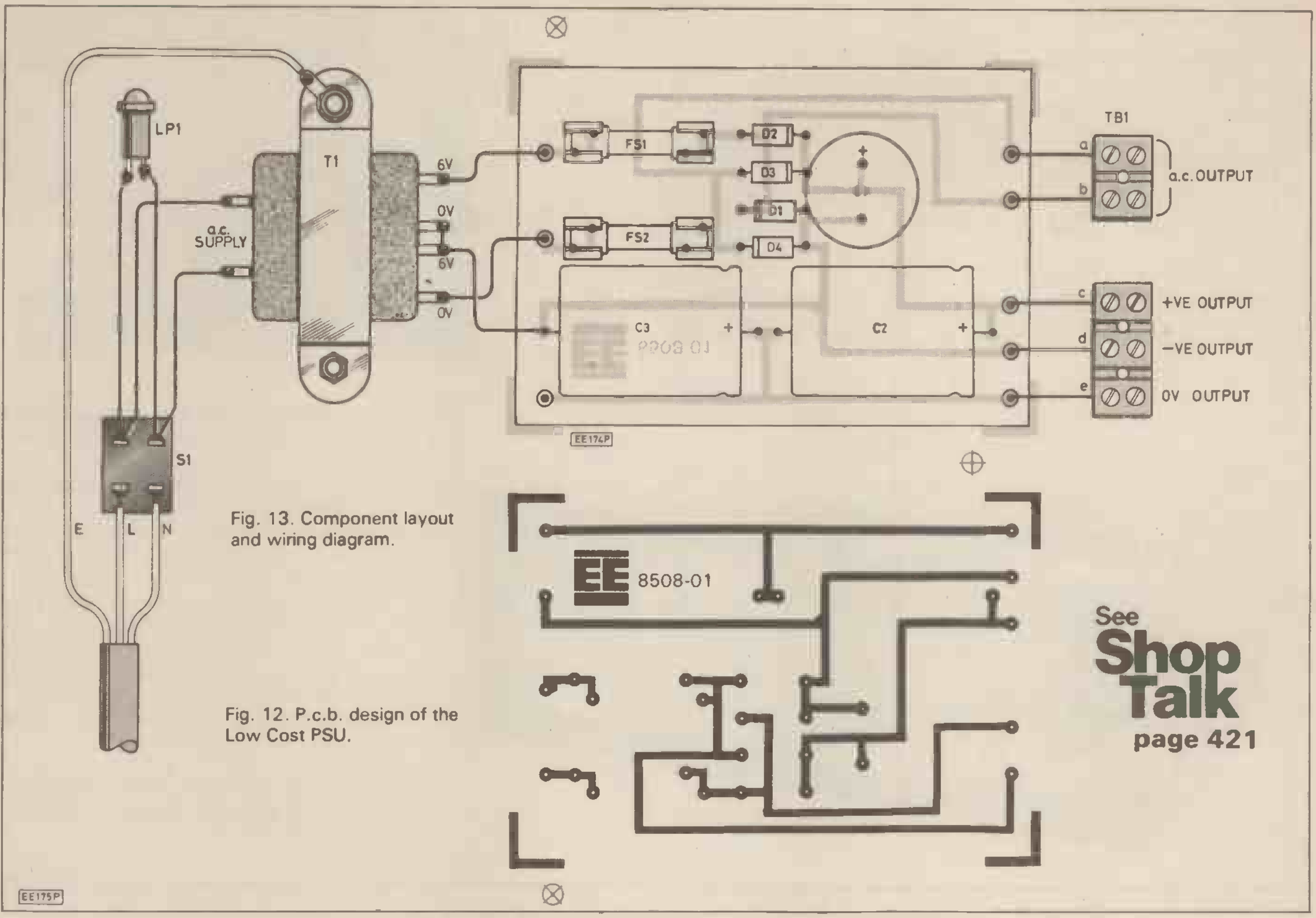


Fig. 13. Component layout and wiring diagram.

Fig. 12. P.c.b. design of the Low Cost PSU.

See Shop Talk page 421

A bridge rectifier, D1-D4 is used to give full wave rectification which provides a positive and negative voltage with respect to the centre tap. The capacitor, C1 smooths the supply to provide a steady d.c. output. Capacitors, C2 and C3 also smooth the supply and also help prevent the positive and negative voltages drifting with respect to 0V.

A mains neon indicator is included to let you know when power is supplied to the unit and S1 is an on/off switch. FS1 and FS2 are provided to protect the circuit and wiring from excess current should a fault occur.

Finally the low voltage a.c. is used as an additional output, which is not often provided on other PSUs.

DEVICE CONSIDERATION

As we have seen, the output of the transformer provides two voltages of 6V RMS which means that a peak voltage of $1{\cdot}41 \times 6V$ = approximately 8·5V will be present. Because of the nature of the diode action there will be an almost constant volt drop of 0·6V across the diode when it is conducting, which leaves a maximum of around 8V at the output with respect to 0V. However, since there is a positive and negative supply the smoothing capacitor, C1 will have 16V across its terminals.

The diodes, D1-D4 must have a p.i.v. rating of at least 16V and must supply enough current for maximum working conditions. Remember, when the unit is first switched on, then the capacitors will be discharged, and will draw a large amount of current for a short time. The transformer is rated at 3VA per winding, which as it refers to the RMS voltage and current, we can consider the maximum d.c. value which we know is 8V. This gives us a maximum current of 3VA/8V = 375mA. The fuses which are in the transformer output circuit must be able to supply this current but blow if it is exceeded for any length of time. For this reason 500mA fuses were chosen.

There are few components on the mains side of the circuit, just the neon lamp. A neon lamp was chosen rather than a lamp on the d.c. side of the circuit as it will draw power from the mains and not waste power from output. S1 is a double pole single throw switch which will have to pass current, somewhere in the region of 400mA.

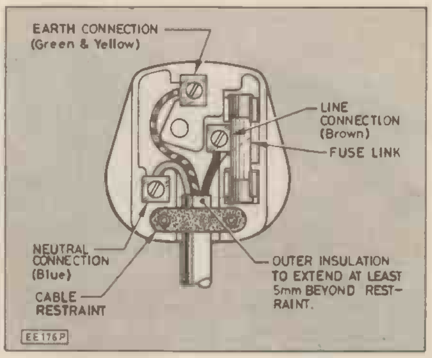


Fig. 14. Correct method of wiring a 13A plug.

COMPONENTS

Capacitors

C1	2000u electrolytic radial
C2,C3	2200u 10V electrolytic axial (2 off)

Semiconductors

D1-D4	1N4001 general purpose 1A diode (4 off)

Miscellaneous

P.c.b. *EE 8508-01;* T1 mains primary, 0V-6V-0V-6V secondary, 6VA transformer; S1 d.p.s.t. switch; FS1,FS2 500mA fuse and holder (2 off); LP1 mains neon indicator; Mains cable, instrument wire, solder etc.

Building Guide:
The p.c.b. for this project is part of a set of four on one board. This allows you to build four separate projects using the same p.c.b. See ShopTalk for more details.

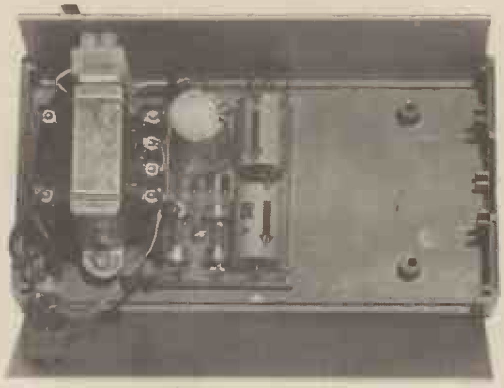
Approx. cost Guidance only £10.50

CONSTRUCTION

Construction of this little project should be fairly straightforward for most hobbyists, but care should be taken on all mains wiring, especially if you are inexperienced. Most of the components are assembled on the small p.c.b. shown in Fig. 12. As normal practice it is best to mount the smaller components first, leaving the capacitors until last.

The transformer, switch and neon are all mounted in a small plastic case together with the assembled p.c.b. Interconnection of these components is provided by colour coded equipment wire and where connections are made to the p.c.b., terminal pins are used to give a neater result.

All the output wires are terminated on a 5A terminal block to allow easy connections to be made to any other equipment at a later date. As can be seen from the photograph, plenty of room has been left inside the case to allow expansion of the unit. In the forthcoming articles various other constructional projects will be described, many of which will fit into this unit. These include a regulator board, simple signal generator and amplifier.



To test the unit for correct operation, the output wires may be brought out through a small hole in the box. (This hole may be utilised for mounting additional switches or test sockets.) With the lid on, the unit may be switched on and tests may be made using a multimeter to monitor the output voltages. If you are inexperienced at home construction, it is probably best to seek guidance at this point, however, providing the wiring has been carried out correctly there should be no problem.

NEXT MONTH: The constructional project will be a useful add-on to the basic Power Supply Unit.

Actually Doing it!!

Sensitive CMOS devices requiring special handling will be the subject of a later article. It is a subject which has been frequently covered in *EE* and its sister magazine *PE*; even so, *Actually Doing It* will reiterate the techniques necessary.

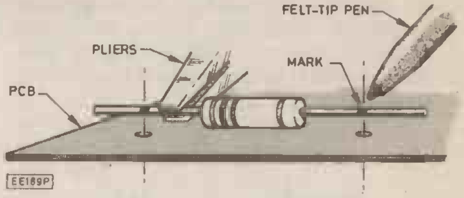


Fig. 5. Marking a component to fit its p.c.b. position.

PEEP at the pages of almost any issue of *Everyday Electronics* and somewhere you'll see a photograph of a "populated" p.c.b. (assembled *printed circuit board*). Undoubtedly, you will also see a component layout diagram which illustrates the component positions "overlayed" on a half-tone reproduction of the p.c.b. track layout. Since, in these diagrams, the copper track is seen *through* the component board, as if the board itself is transparent, the diagram of the trackwork is reproduced as a mirror image of the real layout that you would see by looking directly from the opposite side.

The overall effect of illustrating p.c.b.s in this fashion is to make it easier for the constructor to see where to insert the components, and easier to relate the populated p.c.b. to the circuit diagram. The latter assists in fault-finding, and in wiring up between the board and any external components.

ASSEMBLING A P.C.B.

As for assembling the p.c.b. from scratch, normally the procedure is to insert all links first, if there are any. Readers who underwent the baptism of fire in *Actually Doing It* last month will find this step in the process somewhat familiar. I would only add that any lengthy, or tortuous links should be cut from *insulated* wire, stripped at each end so that when inserted, virtually no bare wire is visible on the component side of the board. See Fig. 1.

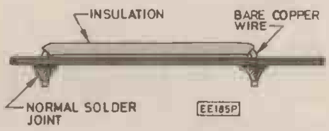


Fig. 1. A p.c.b. link using thin instrument wire is illustrated. Small gauge multistrand wire, or even single-strand "wire-wrap" wire is suitable. Another alternative is to use tinned copper wire and slide some p.v.c. insulation over the exposed portion before forming and inserting it.

COMPONENT HANDLING

It is advisable to use sockets for all i.c.s (integrated circuits), and these sockets should be inserted after the links, making sure they are correctly orientated. See Fig. 2.

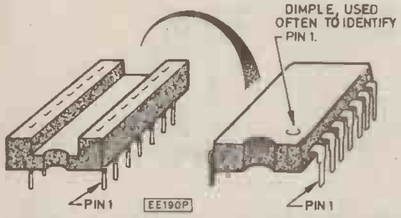


Fig. 2. Orientation of d.i.l (dual in-line) i.c.s and their sockets. The end of the device which has the "nibble", or the "dimple", or both, is designated pin 1.

Next, insert all the resistors, as these will survive *almost* any handling. Should you find yourself snapping resistors in half, or burning them out with your soldering iron, I'm told rock climbing is a rewarding hobby.

Capacitors ought to be mounted after the resistors. The rules for forming and inserting capacitors are the same as for resistors. As Fig. 3 shows, component leads must never be bent adjacent to the component body. Fig. 4 shows the correct method of bending passive component leads, although like all rules, this one is often itself bent by the experienced. The surest way to assess where to bend a component's leads to give a good fit that will not put that component under permanent mechanical stress is simply to offer it up to its p.c.b. position and mark the leads with a felt-tip pen. See Fig. 5.

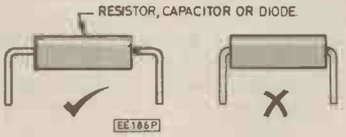


Fig. 3. The rights and wrongs of component lead forming.

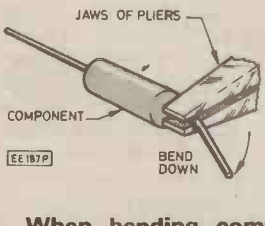


Fig. 4. When bending component leads, place a pair of pliers between the component body and the point on the lead to be bent.

POLARISED CAPACITORS

Electrolytic and tantalum capacitors are internally very different to "poly*whatever*" and "ceramic" types, but the only concern to the constructor is that they have to be inserted the correct way on the p.c.b. Invariably a p.c.b. component layout diagram shows the required orientation clearly by way of a + sign by the hole through which the positive lead of the electrolytic should pass. The capacitors themselves are also marked with either a + sign at the positive end, or a − sign at the negative end. Fig. 6 illustrates examples of typical situations, and it is helpful to realise that if an electrolytic capacitor is crimped at one end, this is always the positive end.

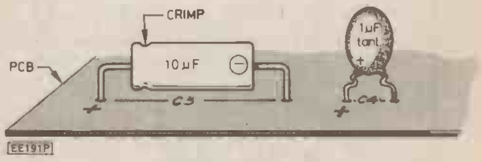


Fig. 6. Identifying the polarity of a typical electrolytic capacitor (left), and a typical tantalum (bead type) capacitor (right).

SEMICONDUCTORS

Semiconductors (excluding i.c.s) should be inserted at this stage; diodes first, and then transistors, *both with care*. Transistors should not require severe lead bending to fit a carefully designed p.c.b., and ascertaining their required orientation on the p.c.b. will generally be a matter of referring to diagrams in component suppliers' catalogues.

However, next month we shall be looking closely at the physical and operating characteristics of components which have differing types that can cause confusion to the beginner. An informed constructor can usually analyse his way out of doubt.

Mike Abbott

Any miscellaneous components should be inserted at this, the final soldering stage. To finish the job, plug in the i.c.s.

A word about diode polarity. Orientation should always be indicated on the component layout diagram, but it is as well to know that the bar on the diode symbol in the circuit diagram represents the stripe on the device itself (see Fig. 7). Couldn't be easier to remember! If you have any doubts, knowing this allows you to look after yourself in the event of a printing omission.

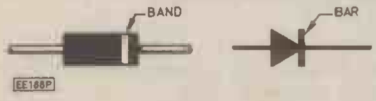


Fig. 7. Listen to the band. Have a drink at the bar. They're both in the same place, even on Zener diodes.

ON END

Sometimes components are mounted on-end, most commonly resistors, although it is not recognised as good practise to mount any axial component this way (shown in Fig. 8). You should certainly cringe if you see diodes on-end on a p.c.b., but there is nothing you can do about it if the board was designed this way, other than to solder extra carefully. When it *is* done, end-on mounting is used to save space and keep printed circuit boards as small as possible.

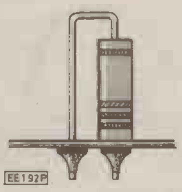


Fig. 8. An end-on mounted resistor.

What is this term, *radial*? Well, if you are unfamiliar with it, it is normally specified against electrolytic capacitors and relates to their physical construction. The two types are shown in Fig. 9. Purchase the wrong type and it will not fit the p.c.b., even though its electrical characteristics might be identical.

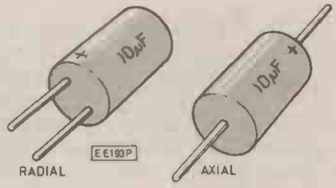


Fig. 9. Two types of electrolytic capacitor.

CAPACITORS: POLY*what*?

Components lists in constructional articles often do not specify capacitors beyond that of their basic value. Working voltages are frequently omitted, and the physical type (dielectric etc.) is seldom specified. The reason is simple. The type, or tolerance, usually does not matter. Even so, it does make component buying an uneasy business for the novice constructor.

A typical example: The components list states that C1 is 100n, and tells you nothing else. Well, first you need to know that this is 100 nanoFarads, which is the same as 0·1µF (10n = 0·01uF and 1n = 0·001uF). The symbol F, for Farad, is often dropped simply because it's a capacitor and not going to be valued in Ohms, or anything else.

WORKING VOLTAGE

The next thing you need to know is the working voltage, for if the voltage rating of the capacitor is exceeded it will break down in use. If you are unable to work out from the circuit diagram what voltage the component will be subjected to, then choose a voltage rating at least as high as that of the supply rail. If the author of an article has omitted to specify a capacitor's voltage rating, it's because he knows you could not possibly buy a capacitor rated too low—*they don't make 'em*! This is invariably the case with non-electrolytic capacitors used in a circuit powered by a 9 volt battery.

As for dielectric types and tolerances, this subject requires a little more explanation:

POLYPROPYLENE

Polypropylene is a 'low loss' dielectric, making these capacitors suitable for *continuous* use at high a.c. voltages. They also have excellent high frequency performance, making them ideal for high voltage, fast rise-time pulse applications. These capacitors are much more expensive than the general purpose polyester types, and so should only be used where specified. Typical range: 1nF to 470nF @ 1000V d.c. and 1500V d.c.

POLYCARBONATE

Polycarbonate capacitors are superior to polyester types in that they have a higher insulation resistance and greater temperature stability. The latter characteristic makes them a good choice for timing circuits such as clock pulse generators, monostable and astable multivibrators. Polycarbonates have a temperature coefficient of ±50 p.p.m./°C which makes them four times as stable as polypropylene and polyester types. For non-electrolytics this type runs to quite high values, but they are not cheap. Typical range: 1µF to 10µF @ 63V d.c.

POLYESTER

Polyester capacitors are available in many guises ranging fron moulded case (brick shaped) to 'dipped' and axial. The prices and shapes vary to suit pocket and p.c.b., but all these may be viewed as general purpose items. They are often stamped in pF followed by the K or M multiple, so that a 47nF capacitor is stamped 47K, and a 1µF capacitor stamped 1M. There will be other numbers depending upon the manufacturer and type, but this is all you need to know when sorting out your bag of components ready to start construction.

CERAMIC

Three main types of ceramic capacitor you will encounter are the resin 'dipped', the epoxy cased (very small), and the disc, which is low in inductance because the plates are not wound. Disc ceramics are consequently first class for shunting sharp spikes to earth, and are therefore popular for decoupling the supplies to TTL logic i.c.s. These are often printed with their value in three digits; the first two indicating the value in pF, and the last indicating the remaining number of zero's. For example, 100n, being 100,000 pF is stamped 104K (the K can be ignored). Typical range (disc): 1nF to 100nF @ 25V, 50V and 1000V. Typical range (epoxy & dipped): 10pF to 1uF @ 100V.

SILVERED MICA

Mica capacitors are highly stable and therefore ideal for oscillators, tuned circuits and filters. A tolerance of 1% is typical, with a temperature coefficient of +75 p.p.m./°C. Typical range: 2·2pF to 10,000pF @ 350V d.c.

TOLERANCE

Looking at specifications in component catalogues you will notice that whilst resistor tolerances of 1% and 2% are commonplace, 5% being fairly slack, capacitors are mostly guaranteed to only 20%—a staggering 20µF in every 100µF.

Guides to help you decipher colour coded resistors and capacitors are widely available, although this topic will be covered in a future *Actually Doing It*.

Microprofessor MPF I/88 *Review*

Mike Tooley BA Principal Lecturer, Department of Technology, Brooklands Technical College.

SINCE its launch in 1981, the IBM PC has dominated a highly competitive market in which bigger—and arguably better—personal computers have appeared with seemingly monotonous regularity. The continued success of the PC can be attributed to a number of factors, not the least of which is aggressive marketing, though immediate availability and competitive pricing have undoubtedly also had their part to play.

SECOND GENERATION CPU

A somewhat less obvious, though none the less significant, factor in the PC's rise to fame has been the use of a second generation 16-bit CPU from Intel, the 8088. This variant of the powerful 8086 appears to have resulted from a shrewd move by Intel to provide a bridge between the exisiting and well-proven 8-bit technology of the 8080/8085 and the entirely new world of the true 16-bit 8086 system.

Like its fully-fledged counterpart, the 8088 performs 16-bit arithmetic; however, its links with the outside world are restricted to an 8-bit (rather than 16-bit) data bus. For the benefit of the newcomer this simply means that, whilst full 16-bit performance is maintained internally, the 8088 fetches its 16-bit instructions and data words from the outside world in two separate bytes.

At first sight this may appear to be something of a disadvantage incurring an obvious speed penalty; however, the use of an 8-bit data bus does mean that conventional 8-bit support devices can be used. The IBM PC has been so successful that other manufacturers, eager to cash-in on the success of the PC and its huge software base, have rushed like lemmings to produce their own PC clones. For them the highest accolade which they can hope for from the computer press can be summarised in just two words: "PC compatible".

Now, whether one likes this state of affairs or not would appear to be largely immaterial. The implication for those of us wishing to graduate to 16-bit systems must be that, since IBM has set a standard which has been followed by a significant proportion of the industry, we would be unwise to ignore it.

A low-cost educational system based on the 8088 processor is thus particularly welcome and it is good to learn that Multitech have risen to the challenge with their new MPF-I/88 system.

FIRST IMPRESSIONS

First impressions of the MPF-I/88 are extremely favourable. The single board system is housed in a most attractive light grey injection moulded plastic case and is fitted (unlike its other Microprofessor predecessors) with an excellent 59-key IBM-style QWERTY keyboard. The rear upper portion of the case (i.e. that which extends beyond the area occupied by the LCD display) is detachable and can be removed to reveal the rear section of the p.c.b. which contains the principal VLSI devices: CPU, ROM and RAM. This is a most useful facility since it would, for example, allow users to connect appropriate i.c. test clips in order to investigate logic levels and waveforms present on the system buses and principal control lines.

The LCD display, which measures approximately 85mm × 20mm, is fitted in the centre of the upper portion of the case immediately above and inclined at the same 5° angle as the keyboard. Despite its small

The MicroProfessor MPF-I/88 Learning Kit. The package includes a User Manual, Reference Manual, and a Monitor Program Source Listing.

SPECIFICATION

CPU	8088 operating at 4·77MHz
RAM	4k CMOS static RAM (2 × 6116) supplied as standard but expandable internally to 24k
ROM	16k EPROM system monitor (27128) supplied as standard but expandable to 48k
DISPLAY	20 character × 2 line LCD window on 20 character × 24 line logical screen; 192 displayable characters on a 5 × 7 matrix
KEYBOARD	59-key IBM style
PRINTER INTERFACE	Centronics parallel standard
CASSETTE INTERFACE	1k or 2kbit/s suitable for standard domestic-type cassette recorder
BUS EXPANSION	32-way double-sided card edge connector (64-way total)
POWER SUPPLY	9V nominal a.c. external mains adaptor
SIZE	305mm × 295mm × 55mm approx.

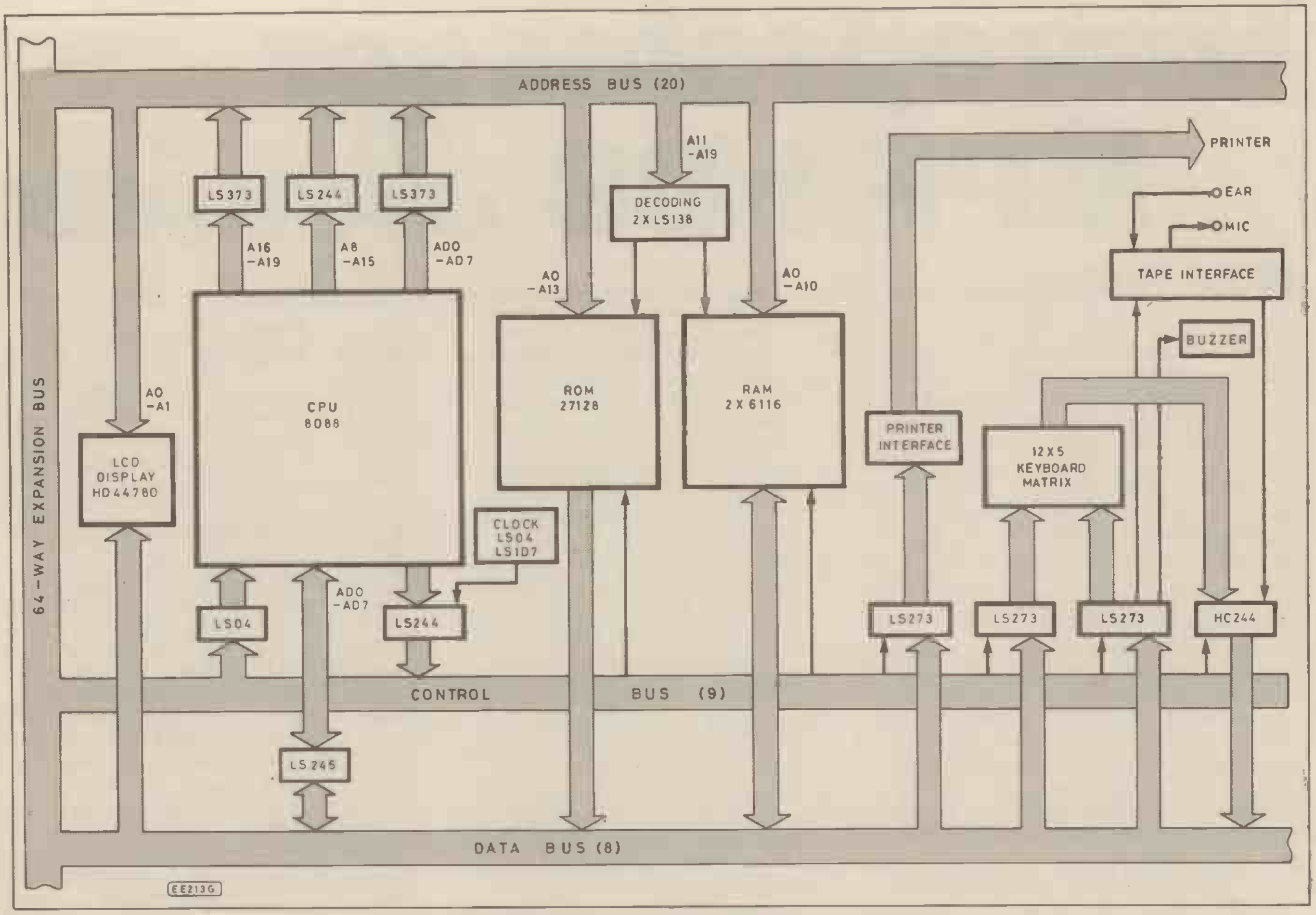


Fig. 1. Simplified block schematic of the MPF-I/88 hardware.

size, the display proved to be eminently readable even under the poorest of lighting conditions.

The display is organised on the basis of 20 characters × 2 lines but effectively provides a window within a much larger 20 character × 24 line logical screen. The display window may be scrolled upwards or downwards through the logical screen by simultaneous depression of the ALT-A or ALT-Z keys respectively. Unfortunately, the scrolling action does not auto-repeat and thus repeated key depression is often required.

To the left of the LCD display is a small, square, blue push-button labelled RESET and two l.e.d.s (one red and one green) marked HOLD and AUDIO respectively. The RESET button performs a warm start which, amongst other things, creates system vector and interrupt tables, initialises the printer port and keyboard, and checks if an auto-run ROM is present.

A cold start is performed whenever power is applied and it is heartening to see that various system diagnostics have been incorporated into the cold start routine. These perform both a full write/read RAM check and a ROM checksum test. The cold start routine also detects the presence of any expansion cards and passes control to any auto-run ROM which may be fitted externally.

The HOLD l.e.d. illuminates whenever a halt (HLT) instruction is executed whilst the AUDIO l.e.d. serves both as a visual "bleep" indication (the audible "bleep" may be disabled by means of an internal jumper) and also indicates serial data loading via the cassette tape port.

To the rear of the MPF-I/88 are two 3·5mm jack connectors (labelled "EAR" and "MIC") for use with a standard cassette recorder, one 16-pin connector for the Centronics parallel printer port, and a 32-way double-sided (64-way total) card edge connector.

Multitech provide an expansion motherboard (IFM-1/88) that will mate with the 64-way connector and facilitate the connection of up to three IBM PC standard expansion cards. All this makes for a versatile and highly expandable system which would, for example, allow bi-directional RS-232C, further RAM expansion, and colour video output.

Not content with this level of expansion, the motherboard also provides a 40-pin connector to allow interfacing with standard MPF-1P family peripherals such as the MPF-1BP EPROM programmer.

SOFTWARE

The MPF-I/88 system monitor supports 19 single-letter commands which range from assembly of instructions entered in standard 8086/8088 mnemonic form to saving and loading data to and from cassette tape. All the usual memory and register display commands have been included together with commands which will disassemble given blocks of memory and insert a maximum of three breakpoints.

An interesting and most useful monitor command (when one considers the obvious limitations of the display) allows the user to adjust the speed of display by inserting a pause (of user defined length) between the display of successive characters.

The assembler operates on individual lines of entered source code text. Provided that no errors are detected (in which case an appropriate error message is generated) the corresponding object code is then generated. Unlike a full-blown two-pass assembler, there is no provision for the generation of a symbol table. This, however, is by no means a severe limitation when one considers that the system is intended purely for educational use. Indeed, by minimising the number of assembler directives (DB and DW are supported) the MPF-I/88 makes things very straightforward for the newcomer to assembly language.

Multitech have provided a set of 26 useful interrupt subroutines within the MPF-I/88 monitor. Each of these performs a predefined function such as returning control to the monitor program, inputting a character from the keyboard, generating a "bleep", etc. The interrupt subroutines are fully documented in the User's Manual and may be called as and when desired.

As an illustration of this feature, suppose, for example, that you wish to ouput a tone from the internal speaker. All you need to do is load the BX and CX register pairs with data values equivalent to the duration and frequency of the sound and then call the subroutine using INT 18H. In the 8088 assembler this would be achieved with four lines of source code something like:

```
MOV BX,mm     ; mm = frequency data
MOV CX,nn     ; nn = duration data
INT 18H       ; call interrupt
                subroutine
INT 7H        ; back to the monitor
```

DOCUMENTATION

The MPF-I/88 is supplied with no fewer than three excellent handbooks: a User's Manual, a Reference Manual, and a Monitor Program Source Listing. It should, however, be noted that, unlike the documentation previously supplied with the MPF-1P series, an "Experiment Manual" has not been included with the MPF-I/88 package. This is a shame since structured exercises can be invaluable in pointing the student in the right direction. One can only hope that this shortcoming will be put right at a later date, perhaps with a "Student Workbook" of the type provided to complement the MPF-1P.

The User's Manual's initial seven chapters are entitled "Getting to know your MPF-I/88", "Introduction to System Hardware", "Entering and Executing a Sample Program", "Using a Tape Recorder with MPF-I/88", "Monitor Commands", "Line Assembler", and "Useful Subroutines". No fewer than 13 appendices then follow and these include a complete summary of the 8086/8088 instruction set.

One small but nevertheless important omission from the User's Manual occurs in the chapter devoted to entering and executing a sample program. The program, which incidentally calculates the sum of all the integers between 1 and 100, unfortunately does not run since explicit reference has not been made to the monitor G-command which actually executes the program! (At this point it is reasonable to assume that the reader is blissfully unaware of the monitor commands which are introduced and explained in a later chapter.) Whilst this may appear to be a somewhat trivial omission it is just the sort of thing that is likely to baffle the newcomer.

ADDITIONAL DATA

The Reference Manual contains five chapters entitled: "How to Use Interrupt Service Subroutines", "The MPF-I/88 System Reset", "I/O Programming", "MPF-I/88 Circuit Description", and "Description of I/O Device Drivers". Four appendices then follow, including a complete set of circuit diagrams for the MPF-I/88.

The Monitor Program Source Listing is the largest of the three manuals and contains a commented assembler listing of the monitor ROM. A complete symbol table is included as is a full symbol cross-reference. This document should prove to be invaluable to the serious 8086/8088 assembly language programmer.

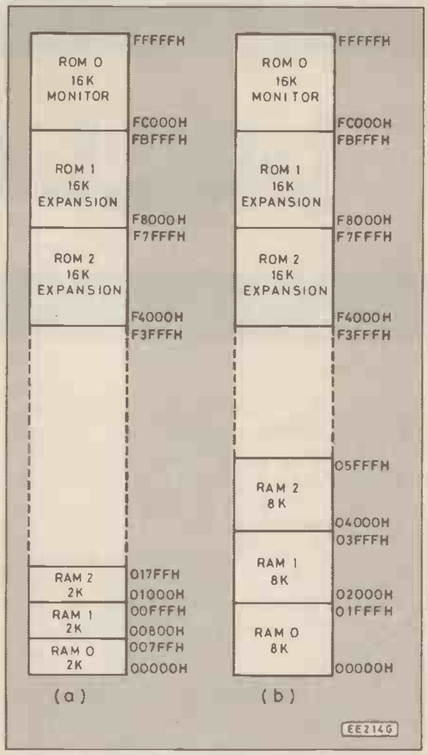


Fig. 2. MPF-I/88 Memory Map: (a) using standard 2k RAM chips, and (b) 8k chips.

CONCLUSIONS

For no other reason than its £380 price-tag, the MPF-I/88 is regrettably not likely to feature greatly in the hobbyist market. It is, however, an extremely attractive system for the educational user and, in this context, it should be noted that a 5-day "hands-on" 8086/8088 course at Intel now costs in excess of £600.

All-in-all the MPF-I/88 can be highly recommended. Not only should it help acquaint students with the architecture of 8086/8088-based systems but it should also prove invaluable to those wishing to take their first steps in programming the 8086/8088.

Since our review of the MPF-I/88, *Flight Electronics* have enclosed the following addenda with all the User's Manuals:

"MPF-I/88 USER'S MANUAL ADDENDA—
NOTE—please read this in conjunction with page 3–1 of the User's Manual.
To execute the example program on page 3–1, you should type 'G' 'return', when the prompt '>' is shown on the screen.
For further details of the 'G' command, refer to page 5–17 of the User's Manual."

The second edition of the manual will be corrected. We are also advised that Multitech are now providing a "Tutorial", which is an introduction to assembly language programming, and a "Student Workbook" will be available later this year.

The Microprofessor MPF-I/88 is available from Flight Electronics Ltd. at Flight House, Quayside Road, Bitterne Manor, Southampton, Hants SO2 4AD. Tel: (0703) 34003/227721.

DRILL CONTROL UNIT

A.R.WINSTANLEY

ONE of the necessary pieces of equipment when producing one's own printed circuit boards is a low-voltage drill capable of accurately drilling holes of 1mm or less. Since many of these drills draw just over 1A or so at full load (e.g. Precision Petite P1 or Reliant), some means whereby the drill can be operated from the mains supply would be highly desirable as battery operation is not particularly feasible. This is especially the case where large or numerous p.c.b.s are produced.

The Drill Control Unit to be described here is a regulated-voltage type of variable mains adaptor which will eliminate the requirement for batteries. It was designed by the author to replace his commercial variable-speed power unit, the performance of which had taken a noticeable turn for the worst: in particular, the drill would after a short period of operation, run either flat out or not at all!

Not only does the Drill Control Unit provide excellent precision-control of many types of low-voltage drill, but it also incorporates several useful features not found on commercially manufactured units.

CONSTANT VOLTAGE

The output of the device is a constant voltage irrespective of the load, and is variable from 1·2V to 16V and the maximum recommended output current is 1·5 amps. Thus it is suitable for the two types of drill mentioned above, although the Titan drill, which apparently consumes up to 3·5A, cannot be driven from this design.

This unit also features an l.e.d. overload indicator which warns when the output current is starting to become excessive: it starts to illuminate at roughly 1·2A or so. The device however won't be damaged by temporary short-circuits but the output current should be restricted to 1·5A peak or roughly 1·2A average when in use.

Also incorporated is a footswitch circuit permitting on-off control of the drill with a suitable foot-operated switch: this can be quite handy when your hands may be occupied with a whirring drill or a printed circuit board!

CIRCUIT

The circuit is shown in Fig. 1. The Drill Control Unit is centred around IC1, an LM317T variable-voltage regulator i.c. and the "T" suffix indicates that the T0-220 plastic package version is employed. It operates by presenting a highly-stable band-gap-type reference voltage of 1·25V across the resistor R5. Generally this resistor is chosen to have a value of 220 or 240Ω so that roughly 5mA flows through it.

The output voltage is controlled by an external resistance connected between the adjustment and ground pins; in this case this resistance is formed of VR1 with R4 in parallel.

If VR1 and R4 = R_v, then the output voltage in this instance is given by the formula:

$$V_{output} = \frac{1{\cdot}25\,(R5 + R_v)}{R5} = 1.25\,(1 + \frac{R_v}{R5})$$

and so with VR1 set at maximum resistance (equivalent to 2·5k when R4 is taken into account) the maximum output voltage is roughly 15·5V. The minimum output will be 1·25V.

The remainder of the circuit functions as follows. Mains voltage is stepped down by T1 to roughly 15V a.c. at full load and this is rectified into d.c. by the four rectifiers D1–4 which are arranged in bridge configuration. A chopped a.c. waveform is the result and this is smoothed by C1 to produce a rather low-quality d.c. voltage of approximately 23V at no load.

The action of IC1 then removes the substantial majority of noise from this voltage and, of course, also enables the voltage to be varied as required in order to adjust the speed of the drill.

No mains on-off switch was considered necessary although the unit is protected by a line fuse FS1 and also the l.e.d. D5 will illuminate to act as a power-on reminder.

OUTPUT

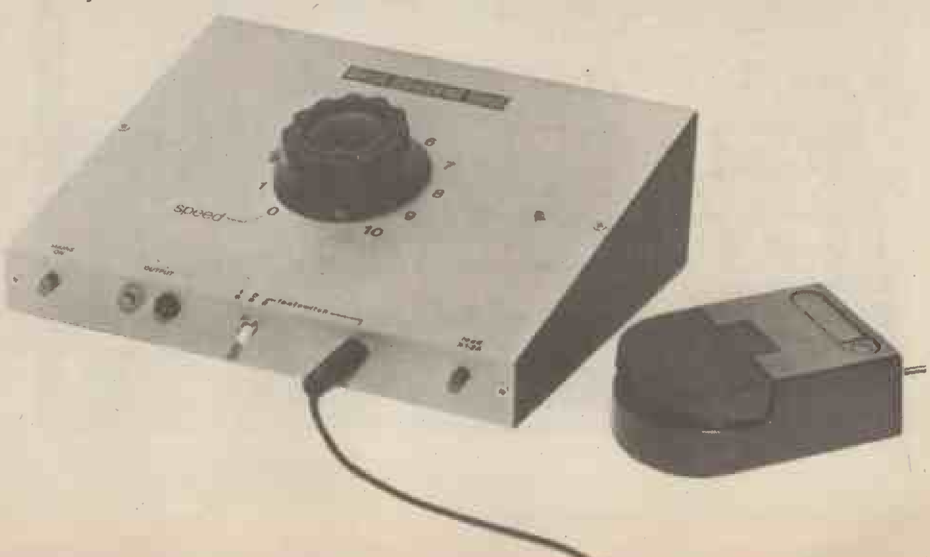
The positive output of the i.c. passes directly to SK1 but the 0V common rail is connected to S1 which acts as an on-off switch for the drill: in fact S1 is a centre-off type so of course when it is in middle position the drill is inoperative. Alternatively the footswitch socket can be brought into circuit if required, the footswitch being plugged into SK3. Otherwise, when S1 is set as shown in the circuit diagram, the drill will run continuously. In this design the 0V rail is earthed through the metal body of JK1. C2 has also been included to suppress noise.

The output current passes through R3 on its return and in so doing will cause a potential difference to appear across this resistor. The end of the resistor connected to TR1 base will also be the most positive and if the current is sufficiently large, then the voltage across R3 will cause the base-emitter junction of the transistor to become forward biased, causing TR1 to turn on like a switch. This completes the circuit to D6 and R2, causing the l.e.d. to illuminate, which acts as a simple current indicator. The current needed to do this is about 0·6V/R3, or 1·2 amps.

Thus the l.e.d. will glow when the output current exceeds 1·2A and it gives the user an idea of how near the maximum output of 1·5A the unit is operating.

PROTECTION

The usual forms of protection are included in IC1 like thermal shutdown and current limiting (i.e. short circuit protection). However, for maximum reliability and performance to be achieved the integrated circuit, which dissipates a lot of power under worst-case conditions, needs to be adequately heatsinked. The components list indicates a suitable type.



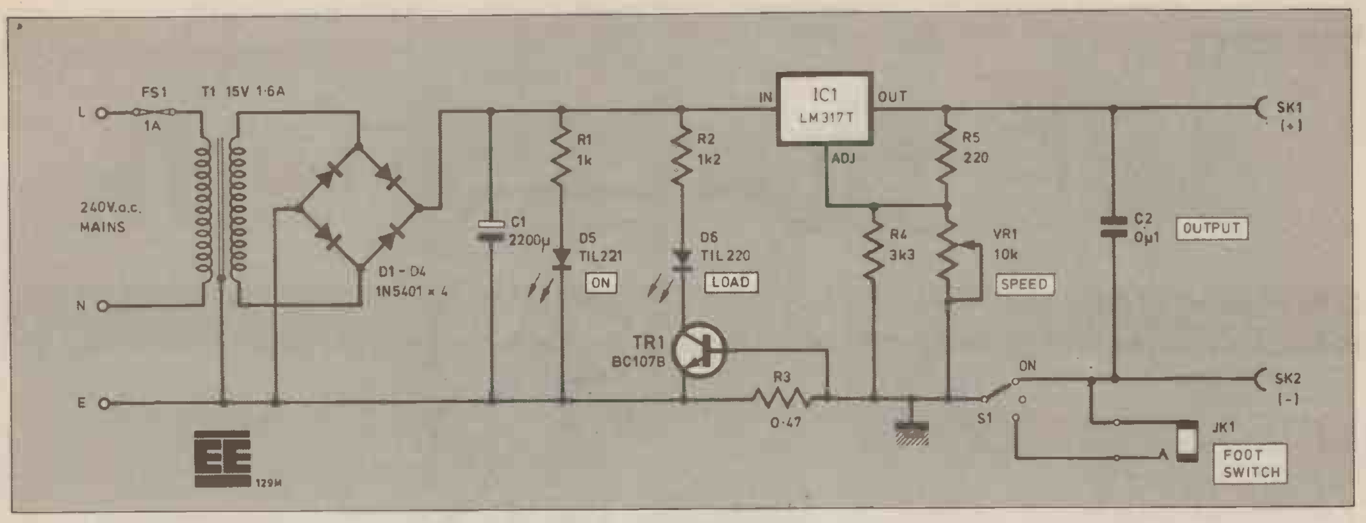
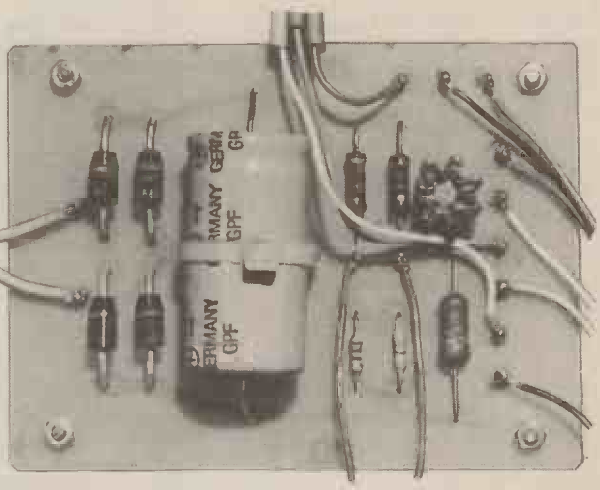


Fig. 1. Circuit diagram.

The output current of the i.c. depends amongst other things on the temperature of the chip, and whilst the approved heatsink will enable the i.c. to pass at least 1·5A, the peak current of the i.c. can exceed 2A under short-circuit output conditions. This is in excess of the rating of the mains transformer: therefore, short circuits across the output should be avoided although in reality they are permissible for brief periods. Indeed it is no coincidence that the l.e.d. D6 was designed to light at only 1·2A. This current was considered the maximum that the Drill Control Unit would encounter under normal operating conditions. It is still able to provide up to 1·5A but in normal use the device should rarely peak at much above 1·2A or so.



CONSTRUCTION

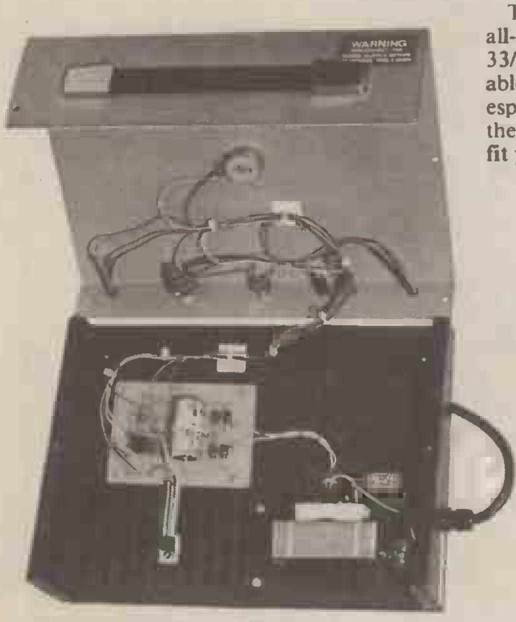
The circuit with the exception of IC1 is constructed on a p.c.b. of dimensions 93 × 72mm, see Fig. 2.

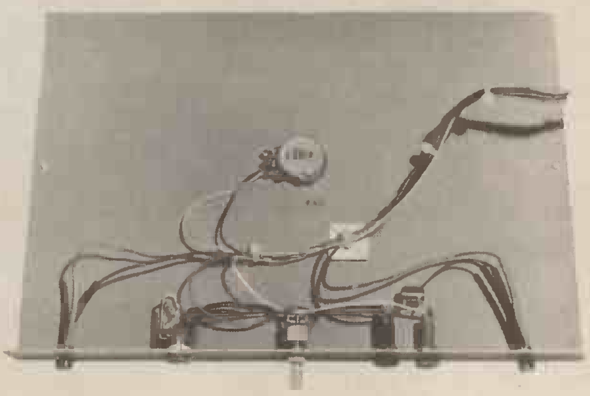
For maximum reliability, the electrolytic capacitor C1 is mechanically secured to the p.c.b. using a nylon tie-wrap of appropriate size. The tie-wrap passes around the capacitor and through holes in the p.c.b. on each side. Also, the transistor TR1 was fitted with a push-on T0-18 heatsink which will aid dissipation when the transistor is conducting.

The prototype unit was assembled in an all-steel sloping case which measured 33/82mm × 267mm × 200mm. It is advisable to obtain all the components, most especially the mains transformer, first and then select a case of suitable dimensions to fit your particular components.

The case must be made of metal for earthing purposes, and preferably steel which will also easily withstand severe wear and tear in the workshop.

The complete interwiring details are given in Fig. 3. Note how the chassis of the case is earthed by soldering the earth input to a solder tag which is placed securely underneath one of the transformer mounting bolts. Furthermore the actual mains cable itself is taken through a grommet in the chassis in order to prevent chafing of the insulation; then the cable must be fixed





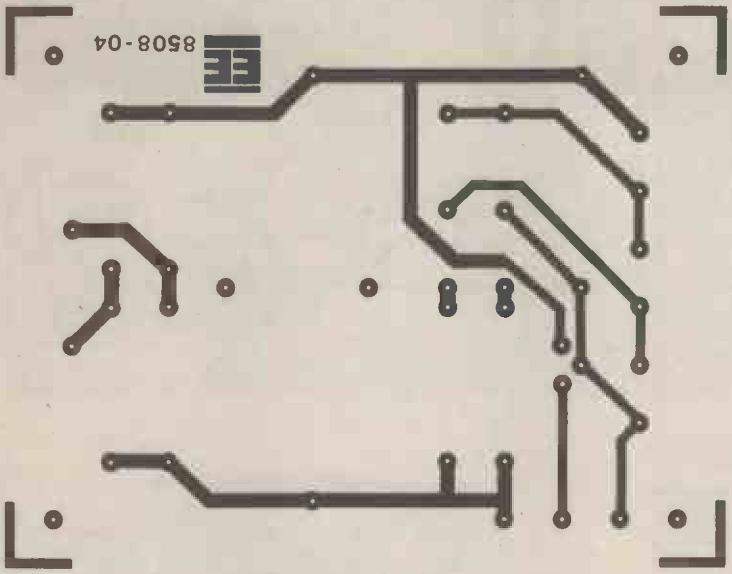


Fig. 2. Printed circuit board (actual size) for the Drill Control Unit. This board is available from the *EE PCB Service,* quote order code: 8508-04.

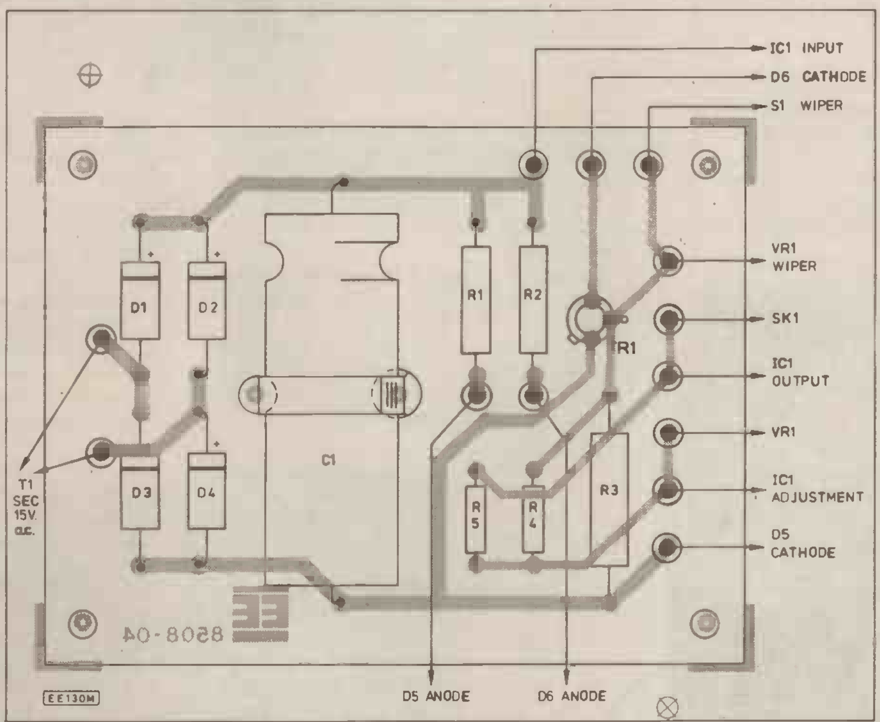


Fig. 3. Component layout and interwiring details for the Drill Control Unit.

COMPONENTS

See Shop Talk page 421

Resistors
- R1 1k
- R2 1·2k
- R3 0·47R 3W W/W
- R4 3·3k
- R5 220

All $\frac{1}{4}$W 5% except R3

Potentiometer
- VR1 10k 1in.

Capacitors
- C1 2200μ 40V axial lead elect.
- C2 0·1μ polyester C280

Semiconductors
- IC1 LM317T variable voltage regulator i.c., T0–220 case
- D1–4 IN5401 100p.i.v. 3A rectifier (4 off)
- D5 TIL221 0·2inch green l.e.d.
- D6 TIL220 0·2inch red l.e.d.
- TR1 BC107B silicon n.p.n.

Miscellaneous
- T1 mains primary, 0–15 + 0–15 2 × 0·8A secondary
- FS1 1A 20mm chassis-mounting fuseholder
- SK1,2 4mm socket, one each red, black (see text)
- JK1 0·25inch mono jack socket
- S1 single pole centre off double throw toggle switch

Printed circuit board, available from the *EE PCB Service*, order code 8507/0X, metal case, e.g. Tandy 270–266, heatsink type 10DNA 2°C/W or better, $\frac{1}{2}$" T0-18 push-on heatsink, T0-220 insulation kit, control knob, interconnection wire, 3-core 6A mains cable, cable grommet and retention clip, l.e.d. lens-clips, one each red, green, 6BA p.c.b. mounting hardware, nylon tie wraps, nuts, bolts, solder tag, spacers, solder, etc.

COMPONENTS approximate cost £20.00

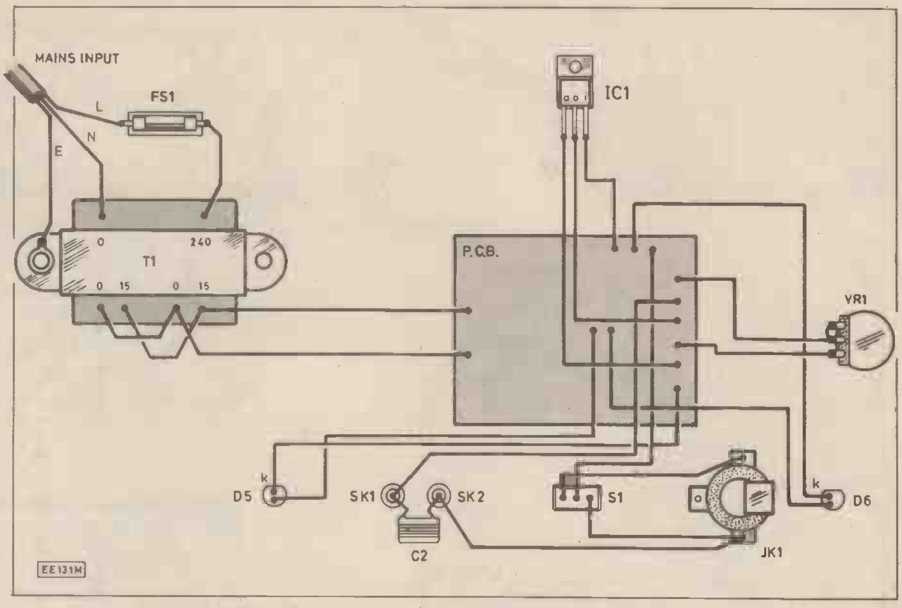


Fig. 4. Wiring diagram.

firmly using a nylon "P" clip or similar so that the cable cannot be pulled out.

The secondary windings of T1 are connected in parallel as shown to supply 15V a.c. at a total of 1·6 amps. This is then wired to the p.c.b. as shown, using heavy-duty hook-up wire (e.g. 32/0·2mm) which should be kept as short as possible.

With the exception of the small amount of mains wiring involved, for which employ at least 32/0·2mm 6A wire, the balance of the interwiring may be completed with general purpose hook-up wire. It is quite desirable to arrange the wiring into neat looms and nylon tie-wraps may be employed for this purpose.

SOCKETS

In respect of SK1 and SK2, the reader may care to choose connectors compatible with those fitted on the drill. The author utilised two 4mm sockets on the prototype. For JK1 a standard $\frac{1}{4}$inch mono jack socket was employed to match the plug fitted on the footswitch. Readers should check the connections to their own jack sockets (if used) in case there is any variation. Notice that the 0V line is earthed courtesy of SK3, since the metal body of the socket will make an electrical contact with the chassis, which is of course earthed.

The footswitch employed by the author was clearly intended for audio or signal use but has successfully been used at up to 1·5A d.c. with no apparent ill-effect.

As previously mentioned, IC1 comes in the T0–220 pack and this is fitted to the heatsink in conjunction with a T0–220 mounting kit. The i.c. ***must be insulated*** since the heatsink is bolted to the chassis and is therefore at 0V. On the other hand the mounting tab of the i.c. is electrically connected to its output and so obviously some form of insulation is necessary if a short-circuit is to be avoided.

Concerning the approved heatsink, it was found that the sink was slightly larger than the steel case would allow once everything was bolted into place. Approximately 25mm was sawn off the heatsink using a large hacksaw. Afterwards the heatsink was sprayed matt black to reduce its thermal resistance. Also it is recommended that some ventilation holes are punched adjacent to the heatsink to permit some throughflow of air and so assist cooling.

FINISH

To finish off the unit, letter the controls as required by using rub-down transfer lettering; naturally this is best done before any controls and fittings are placed into position. The appearance of the device will be further improved if coloured lens-clips are employed to mount the two light-emitting diodes.

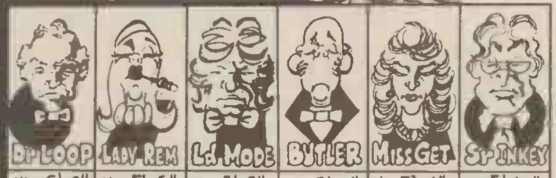
Finally, an extra-long control knob of roughly 75mm diameter was fitted to the potentiometer and this enables the speed of the drill to be controlled easily, even when wearing rather cumbersome protective gloves.

With construction complete, check all the wiring and especially confirm that IC1 is properly insulated from the heatsink before plugging into the mains. Then, with mains applied, the green power-on l.e.d. should light up.

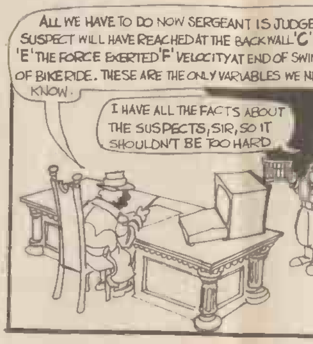
By connecting a voltmeter set to 25V d.c. full-scale deflection across the output sockets (right way round, of course) you can then ascertain that by rotating VR1 clockwise, the output voltage will be seen to vary from 1·2V to approximately 16V. Having satisfied yourself that the other functions perform correctly then the unit is complete and ready for use. □

COMPUTER CLUB

SUSPECTS



DR LOOP	LADY REM	Ld MODE	BUTLER	MISS GET	SIR INKEY
Ht: 6'-0"	Ht: 5'-6"	Ht: 5'-8"	Ht: 6'-4"	Ht: 5'-11"	Ht: 5'-10"
Wt: 67 Kgs	Wt: 37 Kgs	Wt: 70 Kgs	Wt: 60 Kgs	Wt: 49 Kgs	Wt: 76 Kgs.
AGE: 50 yrs	AGE: 30	AGE: 26	AGE: 54	AGE: 34	AGE: 40
SPORTS: TENNIS	SPORTS: EX-MOUNT-AINEER	SPORTS: RUNNING	SPORTS: FENCING	SPORTS: DEEP SEA DIVING	SPORTS: BADMIN-TON.
SKILLS: ORGANISER	SKILLS: MECHANIC	SKILLS: BOXING	SKILLS: ORGANISER	SKILLS: ARTIST	SKILLS: FARMING.



The case of the BASIC VARIABLE

Inspector String didn't know who killed Lord Gosub but he suddenly knew how to find out.

It would take time and a certain amount of patience but the results of the method he had in mind would leave no doubt as to the identity of the murderer.

"But where are the facts?" ask the sergeant "We know that Lord Gosub knew he was already dying from an unknown disease and invited all his family to his country estate so that they may know the contents of his 'WILL'... and thats all we know, sir!"

"That's almost accurate, sergeant" said Inspector String "There's one important fact you didn't know — Lord Gosub made a sudden and unexplained recovery"

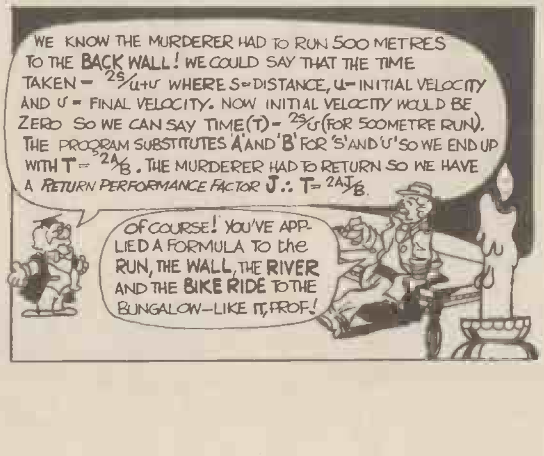
"Of course!" exclaimed the sergeant "While the relatives were grouped in the main lounge the lights went out for about half an hour..."

"EXACTLY half an hour" asserted Inspector String "You see, it took someone exactly half an hour, or less, to run 500 metres, scale a HIGH wall, negotiate a wide stream, travel five hundred metres (using a pre-arranged cycle), climb one floor into Lord Gosubs hospital room and suffocate him to death then return the same way"

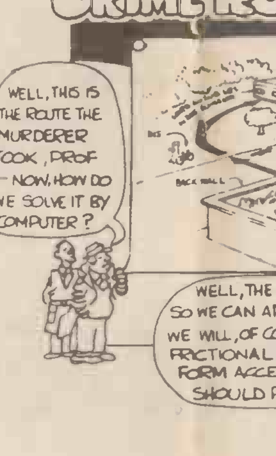
"Why, I see it all now, sir!" uttered the sergeant "Lord Get must be guilty because he's the fittest"

"Not necessarily" said Inspector String "How about Lady Rem, she was a mountaineer and would have made quick work of the wall and building — NO" said the inspector "whoever killed Lord Gosub had the right combination of skills and fitness and there is only one way to discover the true identity of the murderer — by computer"

The sergeant not being versed in the language of computing could only sit back and watch the mystery unfold.

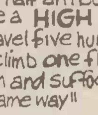


CRIME RO



HOW DO WE ASSESS THE PERFORMANCE OF EACH SUSPECT?

WELL, LET'S FIRST STATE WHAT COULD BE SOME SPEEDS FOR A REASONABLY FIT ATHLETE.



RUNNING	0·5Km/min
CYCLING	1·0Km/min
CLIMBING	SEE LINE 40
SWIMMING	·05Km/min

NOW, LOOK AT LORD LOOPS DETAILS AND YOU MAY CONCLUDE THAT HE COULD REACH A VELOCITY OF SAY ·3Km/min THEN YOU WOULD PUT B = 300m AND SO ON.

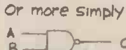
COMPUTER SCIENCE

The INVERTER

The Inverter simply inverts the output: an input 'A' will become output $\bar{A}$ (the line above 'A' makes it NOT A) or if the input is '1' the output is '0'

The Inverter is shown in the output of a gate as:—

Or more simply as:—



NAND-GATE

TRUTH TABLE		
A	B	C
0	0	1
0	1	1
1	0	1
1	1	0

see how the INERTER makes it the reverse of the AND-gate (NOT AND)

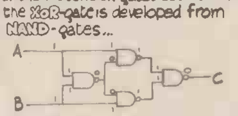
NOR-GATE

TRUTH TABLE		
A	B	C
0	0	1
0	1	0
1	0	0
1	1	0

and of course the inverter makes this gate the reverse of the OR-gate (NOT OR)

The EXCLUSIVE OR-GATE (XOR)

... may be regarded as a development of the Inclusive OR-gate. Let's see how the XOR-gate is developed from NAND-gates...



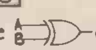
Put A & B at logic '1' and follow through each gate and you'll find that C = logic '0'

The Exclusive OR-gate isn't as simple to follow as the other gates so it's VERY IMPORTANT to study the NAND-gate form above.

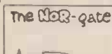
When A & B are at logic '1' output C is at logic '0' (The inclusive OR-gate is at logic 1)

TRUTH TABLE		
A	B	C
0	0	0
0	1	1
1	0	1
1	1	0

Symbol for XOR-gate



The NOR-gate.



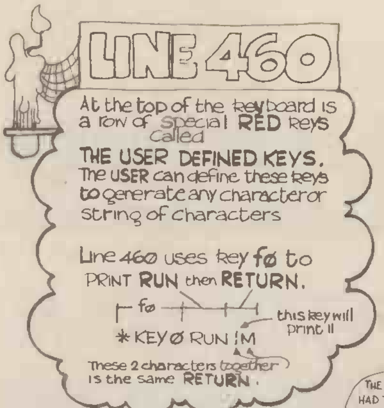
The NOR-gate is very simple Just reverse the outputs of the Inclusive OR-gate.

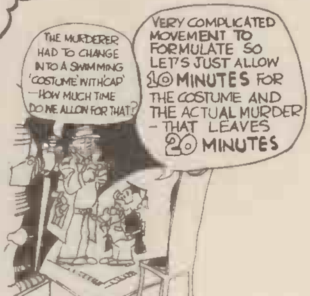
LINK-UP

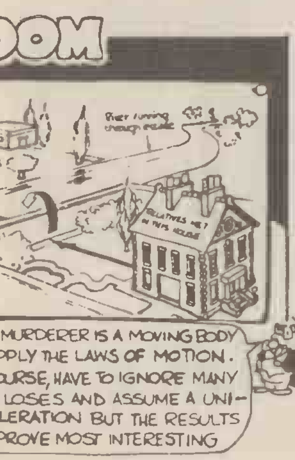
Link-up the letters to form a chain of words related to COMPUTING

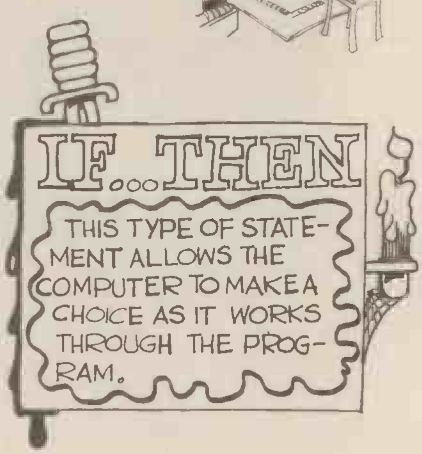
START→				B	A	D	A	R	D
P	O	R	C	R	E	B	O	O	C
R	O	C	I	M	E	R	A	U	R
S	S	E	N	I	C	O	W	E	S
O	R	M	I	U	D	M	A	N	D
A	R	G	O	T	E	R	H	H	S
	P	H	R	E	X	E	K	A	
	C	I	R	O	M	P	E	R	
	M	I	C	C	O	U	T	L	
		E	G	A	U	G	N	A	

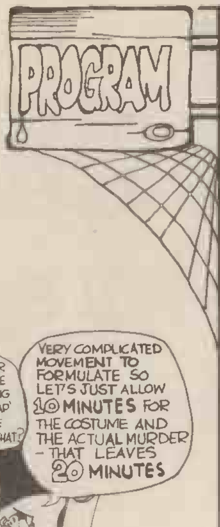
WORD	CLUE
B_ _ _ _ _ _ _D	_BUT NOT FOR BREAD
_ _UR_ _ _ _RE	.. INSTRUCTIONS_
M_ _ _ _ _ _ _ _ _ _ _R	SPECIAL LSI CHIP
_IN_ _ _ _P_TER	LIMITED MEMORY
H_ _D_ _ _ _E	EXTRA SIGNAL
XER_ _ _ _ _ _ _C	- OR JUST 'LASER'
M_ _ _ _ _ _P_ _R	PORTABLE
L_ _ _ _ _ _E	'BASIC' IS ONE







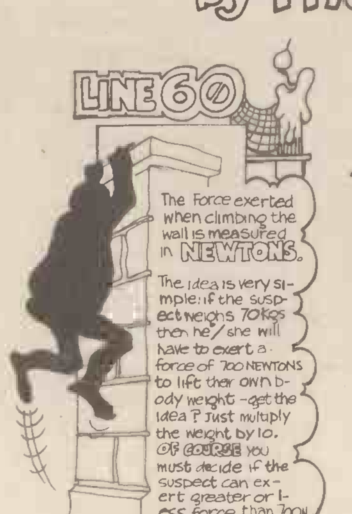


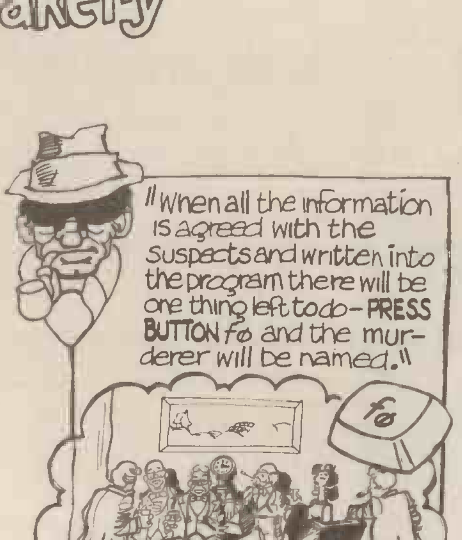


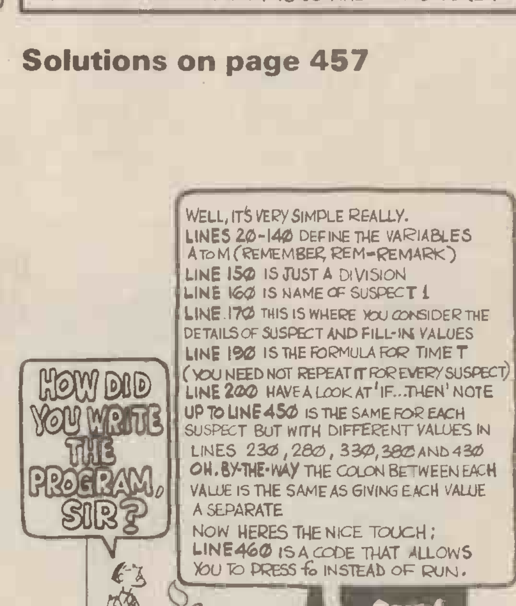

```
10  REM TITLE "THE CASE OF THE BASIC VARIABLE"
20  REM A= 500 m     : DISTANCE TO BACK WALL
30  REM B= VELOCITY REACHED AT BACK WALL
40  REM C= 20m/min VELOCITY AT TOP OF WALL
50  REM D= WEIGHT OF SUSPECT
60  REM E= FORCE EXERTED BY SUSPECT
70  REM F= 25 m      WIDTH OF RIVER
80  REM G= FINAL VELOCITY AT END OF SWIM
90  REM H= 500 m   DISTANCE TO CYCLE
100 REM I= FINAL VELOCITY AT END OF BIKE RIDE
110 REM J= RETURN PERFORMANCE FACTOR
120 REM K=   "        "        "
130 REM L=   "        "        "
140 REM M=   "        "        "
150 REM * * * * * * * *
160 REM 1st SUSPECT "Dr LOOP"
170 A=  :B=  :C=  :D=  :E=  :F=  :G=  :H=  :
    I=  :J=  :K=  :L=  :M=
180 REM. RUN      WALL      SWIM      CYCLE
190 T=(2*A*J)/B+(C*D*K)/E+(2*F*L)/G+(2*H*M)/I.
200 IF T<20 THEN PRINT "LADY REM IS GUILTY"
210 REM * * * * * * * *
220 REM 2nd SUSPECT "LADY REM"
230 A=  :B=  :C=  :D=  :E=  :F=  :G=  :H=  :
    I=  :J=  :K=  :L=  :M=
240 T=(2*A*J)/B+(C*D*K)/E+(2*F*L)/G+(2*H*M)/I
250 IF T<20 THEN PRINT "Dr LOOP IS GUILTY"
260 REM * * * * * * * *
270 REM 3rd SUSPECT "LORD MODE"
280 A=  :B=  :C=  :D=  :E=  :F=  :G=  :H=  :
    I=  :J=  :K=  :L=  :M=
290 T=(2*A*J)/B+(C*D*K)/E+(2*F*L)/G+(2*H*M)/I
300 IF T<20 THEN PRINT "LORD MODE IS GUILTY"
310 REM * * * * * * *
320 REM 4th SUSPECT "BUTLER"
330 A=  :B=  :C=  :D=  :E=  :F=  :G=  :H=  :
    I=  :J=  :K=  :L=  :M=
340 T=(2*A*J)/B+(C*D*K)/E+(2*F*L)/G+(2*H*M)/I
350 IF T<20 THEN PRINT "MISS GET IS GUILTY"
360 REM * * * * * * *
370 REM 5th SUSPECT "MISS GET"
380 A=  :B=  :C=  :D=  :E=  :F=  :G=  :H=  :
    I=  :J=  :K=  :L=  :M=
390 T=(2*A*J)/B+(C*D*K)/E+(2*F*L)/G+(2*H*M)/I
400 IF T<20 THEN PRINT "BUTLER IS GUILTY"
410 REM * * * * * * *
420 REM 6th SUSPECT "SIR INKEY
430 A=  :B=  :C=  :D=  :E=  :F=  :G=  :H=  :
    I=  :J=  :K=  :L=  :M=
440 T=(2*A*J)/B+(C*D*K)/E+(2*F*L)/G+(2*H*M)/I
450 IF T<20 THEN PRINT "SIR INKEY IS GUILTY"
460 * KEY0 RUN||M
470 REM: PRESS RED KEY f0 to find THE MURDERER
```

by Thakery

Solutions on page 457







EVERYDAY news ... from the world of

HISTORICAL RIDE FOR THE PRINCE OF WALES

HIS Royal Highness the Prince of Wales took a trip with a difference last month (June 5), after he officially opened a new £1.25 million venture entitled "Wheels"—Live the Legend of the Motor Car at the National Motor Museum at Beaulieu.

At the opening ceremony Lord Montagu of Beaulieu, founder trustee of the National Motor Museum Trust, said: "The successful completion of Wheels has depended on generous sponsorship from the Kenning Motor Group as principal sponsors, Ford Motor Company and grant aid assistance from the English Tourist Board. At Beaulieu, we are all very grateful for their support and enthusiasm."

This "space age" voyage, in specially designed pods and the application of the latest in digital storage techniques, traces the history and development of the motor car from 1885 to beyond the year 2000. It was conceived, planned and designed by Beaulieu staff to commemorate the Centenary of the Motor Car. It has been ten years in the planning and is quite unique in Britain and, it is claimed, a world's first, in terms of some of the technology involved.

HRH The Prince of Wales takes a trip with Lord Montagu of Beaulieu through 100 years of motoring history.

THE RIDE

In a darkened environment, visitors are transported in specially designed pods, each of which will carry up to two adults and one child, through a series of twenty individual display areas which concentrates on a separate "theme" from the history of motoring in Britain. The ride is designed to run at a speed of 0·4 metres per second. However, the preferred riding speed is 0·3 metres per second with a ride time of 6¾ minutes.

The electric track layout carries 74 chassis on which are mounted 37 pods. If necessary, additional pods may be fitted as required. They move at a predetermined, but variable speed and are capable of rotating 270 degrees to dramatically introduce the visitor to the individual display areas.

Each pod is equipped with its own stereo sound system, and as it passes through and past the illuminated displays, a synchronised effects and commentary sound track is heard within it. Sound and visual effects are also incorporated in individual displays and make use of full-size exhibits, scale models, multi-projection and the latest audio-visual design techniques.

"I told you it would have been easier to have taken out a Subscription."

SOUND SYSTEM

Four basic sound systems are used in the journey. The first is the commentary where passengers hear a digital recorded soundtrack.

The digital sound store was developed specially by a British company, Electrosonics of Greenwich. It uses their ES 1320 Digital Sound Store which does not synthesise sound, but captures any conventionally recorded sound in digital form in non-volatile EPROM. Thus the unit is suitable for both voice and sound effects. Because the information is stored on a microprocessor, the system automatically copes with ride speed changes.

The ES 1320 is actually three stores in one unit; each with its own 5W amplifier. The three "messages" can be selected independently, or synchronised together with, or without, fixed off-set. Playing can be continuous or "on demand".

It can hold up to a total of 96 seconds of sound divided in any required manner between the three outputs; and memory extension boards allow a storage potential of 480 seconds. On the "Wheels" ride a total of 24 ES 1320 units are used.

Background music originates from 16-track tape machines working in tandem. Special sound effects emanate from Mackenzie message repeaters and digital sound stores. These give point source sound effects as required.

In the event of an emergency, a sound system with battery back-up has been installed to give evacuation instructions.

VIDEO

All the required film to be used throughout the ride has been transferred to laser disc, with the appropriate sections transferred by Philips Laser disc players to the appropriate TV monitors. The ride is covered throughout with television surveillance equipment, incorporating six cameras.

IF IT'S A GOOD IDEA . . . PROTECT IT

It's all too true that great minds think alike and in the world of design and invention an individual or company could lose large sums of money if they are not the first to protect their idea by taking out a patent or registering a design or trade mark.

The National Consumer Council has estimated that British industry loses more than £200 million each year through competition from fakes. No one knows how much money is wasted by firms spending time developing something which is already patented.

Registering a design, patent or trade mark may seem a daunting task. In fact it is not. To prove the point the Patent Office have made a video which explains how to do this and the benefits which can come from it. It also illustrates how the Science Reference Library can act as an invaluable source of material with its databank of some two million British patents and 23 million foreign ones.

"Most people will make sure their factory, office or home is burglar-proof—the Patent Office can help them protect their intellectual property and commercial edge against a different sort of thief. We want to make sure that as many people as possible are aware of this and use it to their advantage," said Ivor Davis, Comptroller General of the Patent Office.

Available for sale (£35 VHS or £40 U-Matic) or hire (£9.78—5 days) "The Patent Office" video is obtainable from ***CFL Vision, Chalfont Grove, Gerrards Cross, Bucks, SL9 8TN.***

EUREKA ORIC

One of the leading independent distributors of home computers in France, Eureka Informatique, has purchased Oric Products International of Cambridge from Chater and Mayhill, the receivers.

The purchase, for an undisclosed sum, covers all stocks and parts for Oric's range of home computers. It also includes the right to the company name and trade names, i.e., Oric Atmos and Stratos.

Based in Paris, the company distributes home computers for well known manufacturers including Sinclair, Amstrad and Enterprise. Eureka's plans for the Oric range in the UK will be announced later in the year. Meanwhile, although the warranties lapsed following receivership, existing owners who require service and parts will now be able to apply for assistance to the French company at: Eureka Informatique, 39 Rue Victor Massé, 75009 Paris, France.

Commenting on the acquisition, M. Jean-Claude Talar, President of Eureka, said: *"We are very pleased to have acquired Oric, which has enjoyed a good reputation in France. It is too early to make any assessments about the future but we very much hope that our studies will lead to the continuation of the Oric name and product in Europe.*

"We look forward to hearing from manufacturers of peripherals and software to work out a joint marketing plan."

Memorex UK Ltd., wishes it to be known that it has no link whatsoever with Memtek Ltd., who currently supply audio and video tapes under the brand name of "Memorex".

AMSTRAD FOR AMERICA

Amstrad Consumer Electronics plc has entered the US market with a distributorship deal with Indescomp Inc., a Chicago based electronics importer.

The first Amstrad machine to be sold on the US market by Indescomp is the CPC6128 home computer. This is a 128K machine and was unveiled at the recent American *Consumer Electronics Show* in Chicago.

Commenting on the US move, Amstrad chairman Alan Sugar said: *"The company is fast moving into a number of overseas markets, either through wholly owned subsidiaries as in France, or through distributor deals as in Germany. We view the American market with interest, but the trading conditions there are difficult and we are not prepared to invest there, preferring to trade through an established consumer electronics importer. We have found such a company in Indescomp . . .*

We have no plans at the moment to sell the CPC6128 in the UK this year; indeed it will not be available in the US until the Autumn. As our plans stand at the moment, we are more likely to add it to our range early next year."

Sprague (UK) has appointed HB Electronics as the top Sprague Distributor for 1984.

Philips has presented 300 video units consisting of a video recorder and colour TV set to the International Olympic Committee, the International Sports Federations and all 160 National Olympic Committees around the world.

The 300 video units will be used by the Committees to distribute information on the Olympic movement and forthcoming Olympic events.

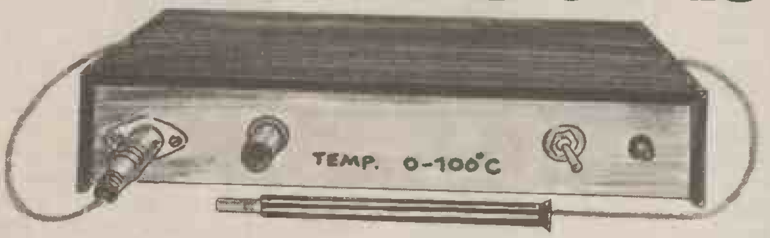
POWERBREAKER AWARD

RECENTLY selected for the Design Centre, the PowerBreaker-20 electrical safety monitor has now received further recognition as the winner of the hardware category of Hardware Trade Journal's product of the year award.

Manufactured in Britain by B & R Electrical, it is simply plugged into any standard 13A socket prior to inserting the appliance and thus affords a high degree of protection against electrocution in the event of an accident.

SEPTEMBER FEATURES...

NEW SERIES
TRANSDUCERS



This series will begin with relatively simple projects, such as temperature measuring devices, and progress to such topics as strain gauges, pressure gauges and flux density indicators. The units may either be used as stand-alone devices, or in conjunction with a home computer.

FRIDGE ALARM

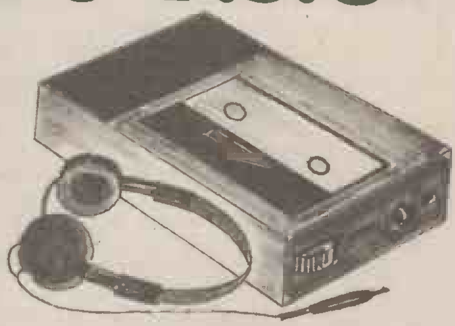
Ever found the fridge door held open by a misplaced bottle or simply forgotten by young children as they pour their own drinks? Then you need our alarm to prevent the food being spoilt. It's simple and cheap and will warn you if the door is left open for more than a minute.

CARAVAN ALARM

A system designed to protect the caravan itself, but also articles left both inside and outside. As it is based on a "loop-alarm" it could also be used for other security applications.

PERSONAL STEREO P.S.U

Build this little project for infinite listening pleasure without running down the batteries —or running up the cost!



EVERYDAY ELECTRONICS and computer PROJECTS

SEPTEMBER 1985 ISSUE ON SALE FRIDAY, AUGUST 16

TREMOLO/VIBRATO

R.A.PENFOLD

MANY musical instruments are capable of producing a vibrato effect (a slight modulation of the output frequency), but not all are capable of this useful effect. It can be implemented externally though, and an advantage of this method is that a number of instruments can be processed together, although care must be taken as excessive vibrato can give very dischordant results. Tremolo (varying the volume of the signal) is one of the oldest of musical effects, and is also one of the most simple. Nevertheless, it is still a worthwhile effect that can be put to good use on occasions.

This unit provides both of these effects, and it is possible to use just one at a time, or the two together with the vibrato and tremolo operating in syncronisation (the two forms of modulation being derived from a common low frequency oscillator). The vibrato effect is obtained with the aid of a bucket brigade delay line, but the unit incorporates a compander noise reduction circuit that enables both a reasonable bandwidth and a good signal to noise ratio to be obtained. The bandwidth is a little over 10kHz, and the effective signal to noise ratio is better than 80dB. The vibrato/tremolo rate is adjustable from less than 1Hz to slightly over 10Hz, and depth controls for both effects are provided.

SYSTEM OPERATION

The block diagram for the unit is shown in Fig. 1. Apart from a common modulation oscillator and power source the vibrato and tremolo circuits are independent of one another.

Taking the vibrato effect first, as mentioned earlier, this effect is obtained with the aid of a delay line. In this case an ordinary analogue (bucket brigade) type is utilized, and this operates by passing input samples along a series of charge storage capacitors. The rate at which the samples are passed along the line is governed by a clock oscillator, and the length of the delay through the circuit therefore depends on the number of stages in the delay line and the clock frequency. In this instance the length of the delay is not important, except in that a reasonably long delay (about a millisecond or two) is needed in order to obtain a reasonable vibrato effect.

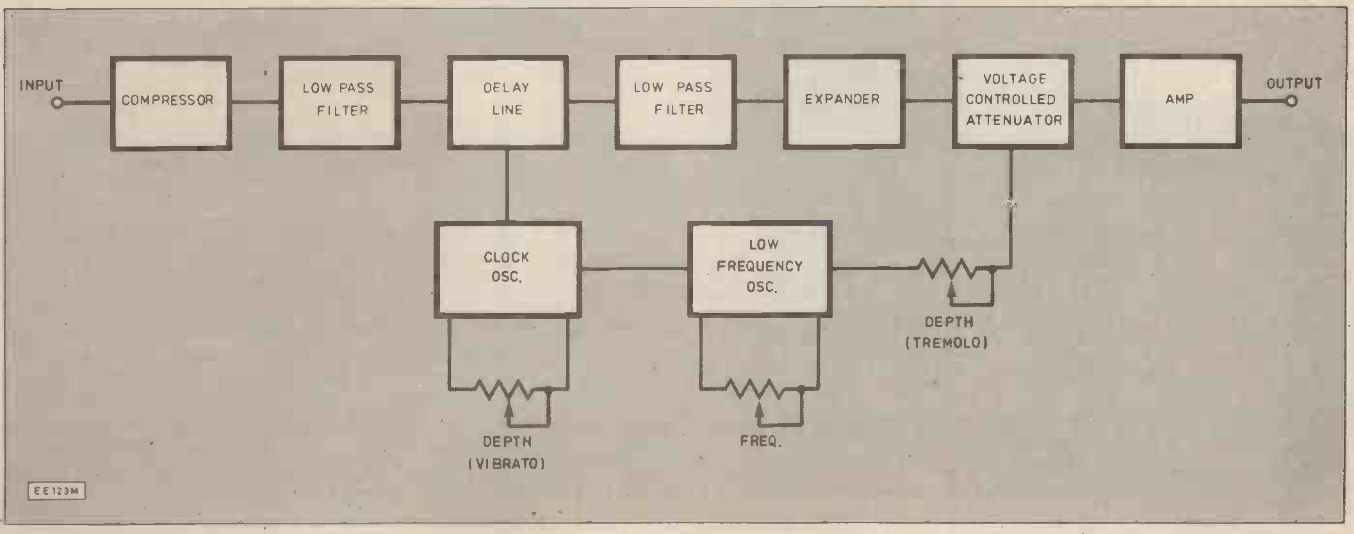
The vibrato is produced by frequency modulating the clock oscillator so that the delay is varied. The way in which this generates the effect is quite straightforward. Suppose that the stages of the delay line contain four complete cycles of a signal, and that a clock frequency of 100kHz was used. If the clock frequency was to be suddenly switched to 200kHz, the signal would be clocked out at double the rate it was clocked into the delay line. If it took (say) two milliseconds for the sample of signal to be clocked into the delay line it would be clocked out in just one millisecond. In other words the signal has been shortened in terms of time by some 50 per cent, but the number of cycles in the signal sample remain the same. The frequency of the signal has thus been doubled by the doubling of the clock frequency. Halving the clock frequency would similarly reduce the output frequency to half the input frequency, with the time taken for the signal to be clocked out being doubled, but the number of cycles remaining unaltered.

MODULATION LEVEL

Of course, this doubling or halving in frequency would only be sustained for a few milliseconds using a short delay line. However, a gradual sweeping up and down in the frequency of the clock oscillator gives a continuous raising and lowering of the input frequency by a relatively small amount, and generates what is a better effect for the present application. The amount of frequency modulation is governed by the length of the delay line and the frequency of the modulating signal, with a long delay and high modulation frequency corresponding to maximum effect. The inexpensive 512 stage delay line used in this unit gives a fair amount of vibrato at modulation frequencies as low as about 1Hz or a little less, and this particular effect is not very good at frequencies much lower than this. At the high frequency end of the range a very strong effect is produced, and it is in fact likely to prove too strong unless the "depth" control is backed off somewhat.

Returning to Fig. 1, the clock oscillator

Fig. 1. Block diagram of the Tremolo/Vibrato.



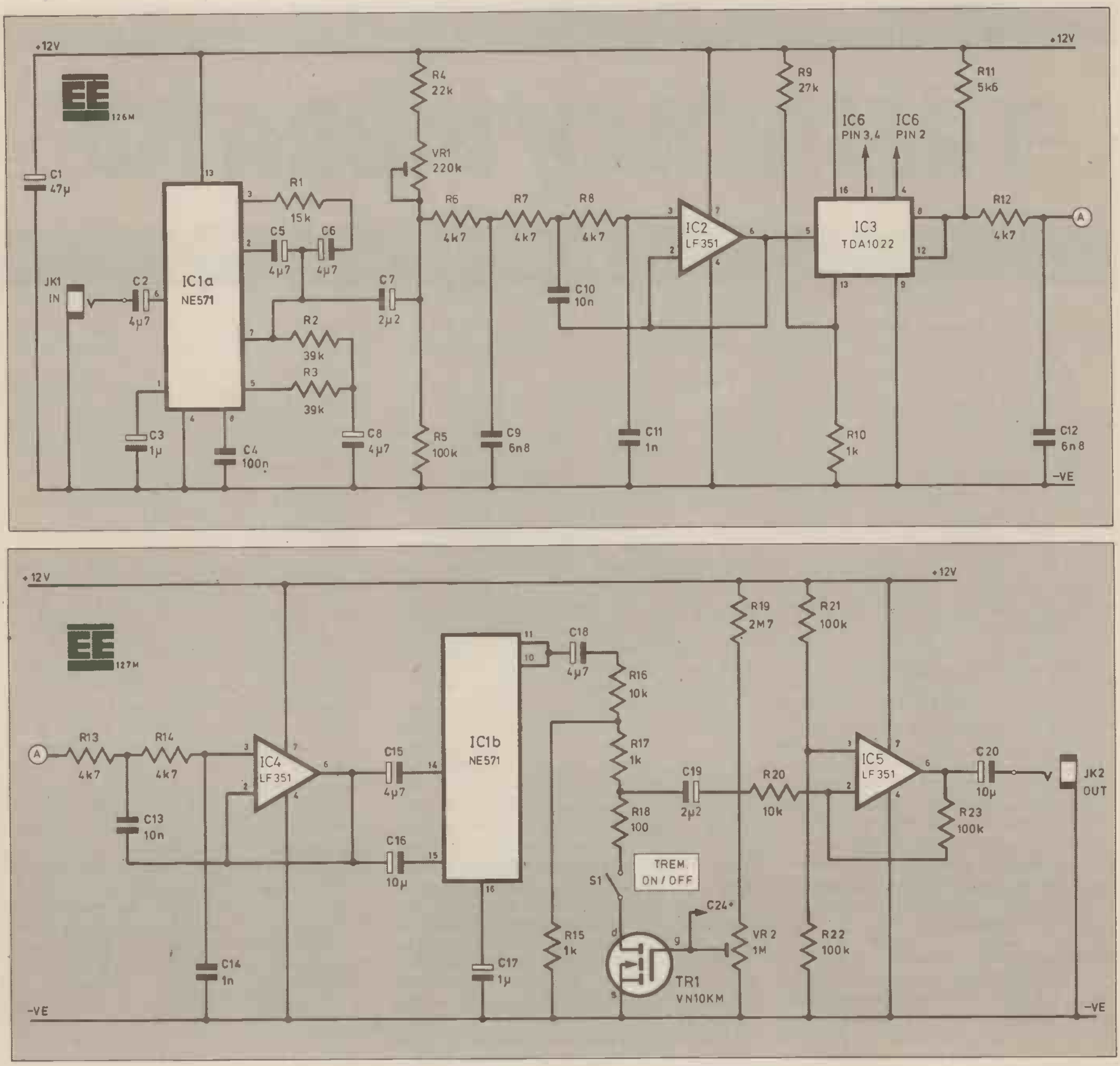


Fig. 2. Main circuit diagram. This is split in two parts—points "A" and the supply lines connect.

for the delay line is frequency modulated by the low frequency oscillator to give the vibrato effect. The centre frequency of the clock oscillator can be adjusted by a potentiometer, and this acts as the vibrato "depth" control. This potentiometer is effectively controlling the length of the delay line, and therefore the depth of the effect as well. Lowpass filters are used at both the input and the output of the delay line. The input filter is needed to avoid a significant amount of "aliasing" distortion, which occurs if an input signal at a frequency close to the clock frequency is allowed to enter the delay line. The clock frequency should be at least double the maximum input frequency, and preferably more than three times this frequency. The filters have a cut off frequency of just over 10kHz, enabling a clock frequency of down to about 20kHz to be used. The output filter is needed to minimise any breakthrough of the clock signal at the output. The output from the delay line is actually a stepped waveform due to the sampling technique used in the circuit, but the filtering removes the high frequency components that produce the steps and leaves the correct waveform.

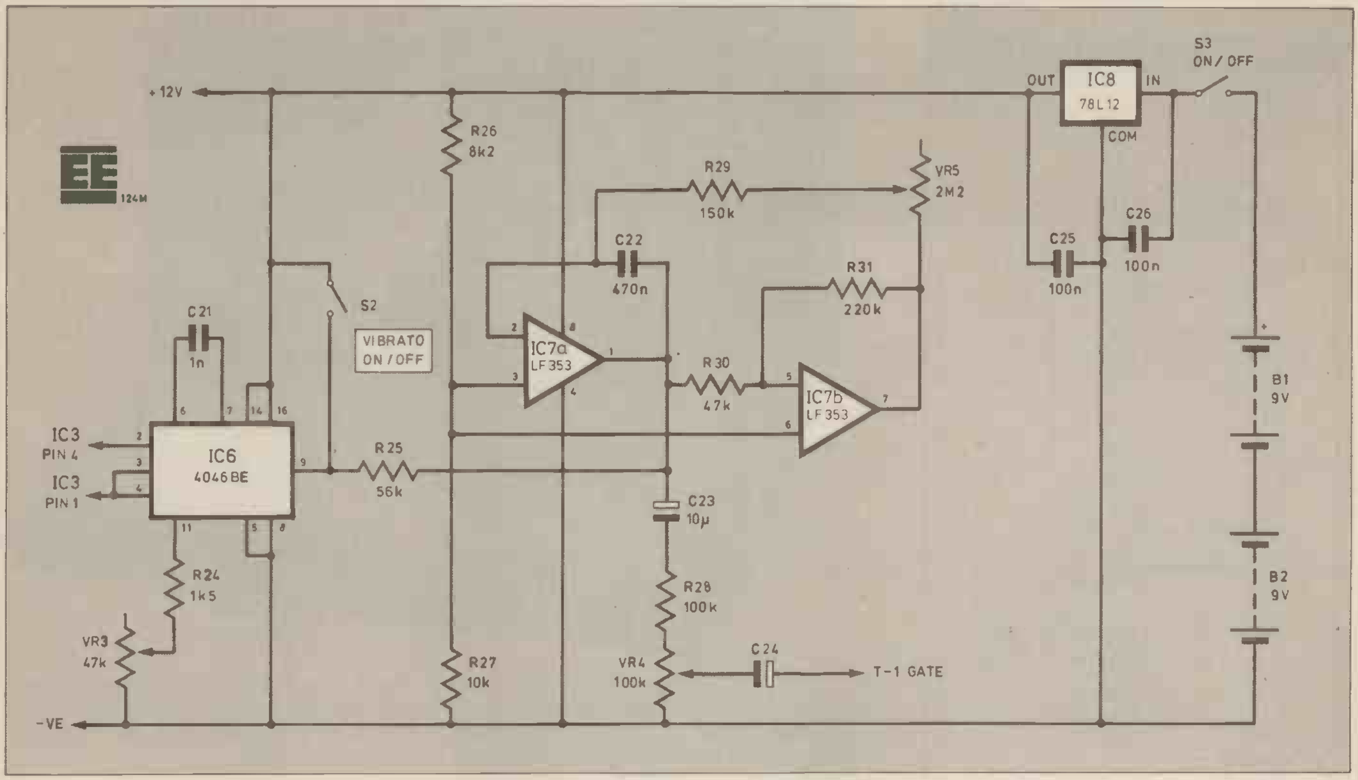


Fig. 3. Oscillator circuit diagram.

NOISE REDUCTION

Although analogue delay lines have a reputation for being excellent noise generators, they are not generally as bad as many seem to imagine. The amount of noise generated depends on the audio bandwidth of the delay line and the clock frequency. A wide bandwidth and low clock frequency give maximum noise. In this case the bandwidth has been made fairly wide in order to give good audio quality, and the clock frequency is swept quite low when the depth control is at maximum. This could give rise to a fairly strong "swooshing" sound as the noise level varies in sympathy with changes in the clock frequency, but this is avoided here by the use of a compander noise reduction circuit.

A compressor is used at the input and this has a two to one compression characteristic. For example, a change of 20dB in the input level would give only a 10dB change at the output, a 30dB change at the input would give a 15dB change at the output, and so on. This has the effect of substantially boosting the input signal when the input level is low, taking the input signal well above the noise level.

An expander is included at the output of the delay line, and this stage has the opposite effect to the compressor, giving a change in output level that is double the change in input level. It therefore restores the dynamic levels to their original values so that there is no dynamic distortion through the unit. When the expander reduces the signal to restore a low level signal to its proper level it also reduces the background noise, giving the required noise reduction. It does not give any noise reduction when the input level is high, since the compressor then provides no significant voltage gain and the expander gives no significant attenuation. The system has to be arranged this way to prevent overloading of the delay line with high input levels. This lack of noise reduction is not of practical importance though as the noise can not be heard over a high level signal, and no noise reduction is needed. It is in fact a feature of all compander noise reduction systems.

TREMOLO

The tremolo effect is produced using a voltage controlled attenuator (VCA) driven by the low frequency oscillator. As the (triangular) output from the low frequency oscillator rises and falls it alters the degree of attenuation through the VCA and produces the necessary changes in volume. An amplifier at the output of the unit boosts the overall voltage gain through the circuit to about unity, and provides the unit with a low output impedance.

CIRCUIT

The circuit diagram of the signal processing stages is shown in Fig. 2, while Fig. 3 shows the circuit of the two oscillators.

Starting with the signal processing stages, IC1 is an NE571 integrated circuit which contains two identical circuit blocks. This device is specifically intended for use as a compander with one section connected as the compressor and the other configured as the expander. This is the manner in which it is used here, and IC1a acts as the compressor with IC1b acting as the expander. Each section of the NE571 has an operational amplifier, a voltage controlled gain block, and a precision full wave rectifier. In the compressor mode the gain block is used to provide feedback over the amplifier, and the control voltage is derived from the output of the circuit via the rectifier. Increased output level thus produces greater feedback and lower gain from the amplifier. The expander uses a somewhat simpler arrangement with the signal being passed through the gain block, and the control voltage being derived from the input signal via the rectifier circuit. Increased input signal level therefore gives increased gain and the required expansion. The amplifier merely functions as a buffer stage at the output of the circuit.

The input and output low pass filters are both conventional three stage (18dB per octave) types, and have IC2 and IC4 as the unity gain buffer amplifiers. IC3 is the delay line, and is a TDA1022 512 stage device. Preset VR1 is adjusted to provide the input bias voltage that gives optimum large-signal handling performance. IC3 requires another bias voltage, and this is provided by R9 and R10. There are actually 513 stages in IC3, but the 513th stage is merely used to maintain the output voltage while the 512th stage is collecting samples from the 511th stage. The outputs of stages 512 and 513 (pins 8 and 12) are simply connected together and have R11 as a common load resistor.

Resistors R15 and R16 form an attenuator which reduces the signal to the VCA by around 20bB. This is done in order to minimise distortion through the VCA which is a simple type having VMOS transistor TR1 as a voltage controlled resistor. Together with R18 this forms the shunt element of the VCA while R17 is the series resistor. Potentiometer VR2 is adjusted to obtain good symmetrical modulation from

COMPONENTS

Resistors

R1	15k
R2,R3,	39k (2 off)
R4	22k
R5,R21,R22, R23,R28	100k (5 off)
R6,R7,R8, R12,R13,R14	4k7 (6 off)
R9	27k
R10,R15,R17	1k (3 off)
R11	5k6
R16,R20,R27	10k (3 off)
R18	100
R19	2M7
R24	1k5
R25	56k
R26	8k2
R29	150k
R30	47k
R31	220k

All resistors $\frac{1}{4}$W $\pm 5\%$

Potentiometers

VR1	220k 0·1W horizontal preset
VR2	1M 0·1W horizontal preset
VR3	47k lin.
VR4	100k lin.
VR5	2M2 lin.

Capacitors

C1	47µ 16V radial elect.
C2,C5,C6, C8, C15,C18	4µ7 63V radial elect. (6 off)
C3, C17	1µ 63V radial elect. (2 off)
C4	100n polyester
C7,C19	2µ2 63V radial elect. (2 off)
C9, C12	6n8 carb. (2 off)
C10,C13	10n carb. (2 off)
C11,C14,C21	1n carb. (3 off)
C16,C20,C23	10µ 25V radial elect. (3 off)
C22	470n carbonate
C24	4µ7 63V axial elect.
C25,C26	100n ceramic (2 off)

Semiconductors

IC1	NE571
IC2,IC4,IC5	LF351 (3 off)
IC3	TDA1022
IC6	4046BE
IC7	LF353
IC8	µA78L12
TR1	VN10KM f.e.t.

Miscellaneous

S1,S2	s.p.s.t. toggle or heavy duty push button (2 off)
S3	rotary on/off
JK1,JK2	standard jack sockets (2 off)
B1,B2	9V (2 off)

Case about 180 × 110 × 50mm; three 16 pin d.i.l. i.c. holders; four 8 pin d.i.l. i.c. holders; four control knobs; two battery connectors; wire; pins; solder; etc.; printed circuit board, available from the *EE PCB Service*, order code 8508-02.

Approx. cost Guidance only **£25**

the circuit. S1 can be used to switch out TR1 and remove the tremolo effect.

The basis of the output buffer/amplifier stage is IC5 and this is an ordinary inverting mode operational amplifier circuit having a voltage gain of about 20dB.

OSCILLATORS

The delay line requires a two-phase clock signal with each signal having a peak to peak voltage virtually equal to the supply voltage. A CMOS logic device is ideal as the clock oscillator, and in this circuit (Fig. 3) CMOS phased locked loop device IC6 is used as the clock oscillator. The VCO section of IC6 acts as the clock oscillator and one of the phase comparators is used as an inverter to provide the second clock phase. Potentiometer VR3 plus R24 are the resistive section of the timing network, and VR3 acts as the vibrato depth control; C21 is the capacitive element of the network.

The clock oscillator can be modulated by means of a control voltage applied to pin nine of IC6, and R25 couples the output of the low frequency oscillator to this pin. The vibrato effect can be switched out by closing S2 so that the control input of IC6 is taken to the positive supply voltage and the modulation is eliminated.

The low frequency oscillator is a conventional triangular/squarewave oscillator circuit having IC7a as the Miller integrator and IC7b as the Schmitt trigger. In this case only the triangular waveform is needed and the squarewave signal at pin seven is ignored. Potentiometer VR5 is the frequency control. The output to the amplitude modulator is taken by way of VR4 which controls the strength of the modulation signal and acts as the tremolo depth control.

A regulated 12V supply is needed for the circuit, and this is obtained from two 9V batteries connected in series. IC8 is a 12V monolithic regulator which gives a well stabilised 12V output from the nominal 18V output of the batteries. The current consumption of the circuit is approximately 10mA. Two small 9V batteries are adequate as the power source, although large types would be preferable if the unit is going to receive a great deal of use.

CONSTRUCTION

The printed circuit track pattern and component layout are shown in Fig. 4. The board is constructed using the normal techniques, but note that both IC3 and IC6 are MOS devices and accordingly require the standard antistatic handling precautions to be observed (do not touch the pins and employ mounting sockets). Although TR1 is a MOS type it has a built-in 15V Zener protection diode which renders special handling precautions unnecessary. There are three link wires on the board which should not be overlooked. Provided the specified types of capacitor and preset resistor are used there should be no real difficulty in building the board, and everything should readily fit into place. Fit pins to the board at the points where connections to the controls and sockets will be made.

A black plastic case which measures about 180 by 110 by 50mm will comfortably accommodate all the components, but any case of about the same size should be equally suitable. The front panel layout used for the prototype can be seen from the photographs, but obviously any reasonably practical layout can be used. On the prototype S1 and S2 are miniature toggle types, but, depending on the way in which the unit is to be used, it might be preferable to fit heavy duty push button switches on the top of the unit instead. This would enable these switches to be foot operated, but obviously a strong case is needed if this method is adopted. A brushed aluminium veneer can be added to the front panel to give the finished unit a neater, more professional appearance.

The printed circuit board is fitted on the rear panel of the case using M3 or 6BA fixings. The board is then wired to the

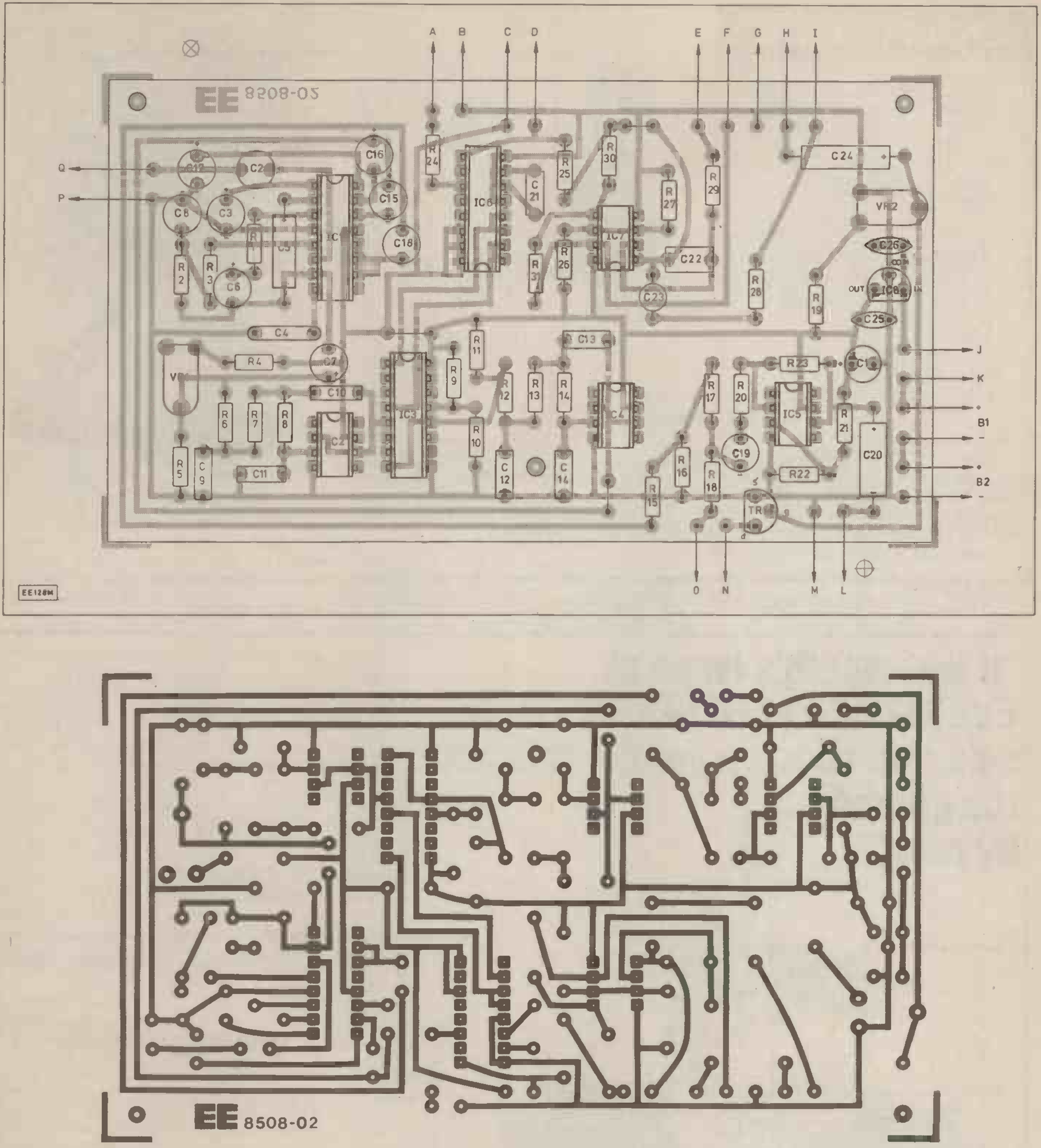


Fig. 4. Printed circuit board layout and wiring.

components on the front panel, and this wiring is illustrated in Fig. 5 (in conjunction with Fig. 4).

IN USE

Preset potentiometer VR1 must be adjusted to enable the largest possible signal to be handled by the unit before the onset of clipping. This can be accomplished in the normal way using an oscilloscope and an audio signal generator, or if suitable test gear is not available VR1 can be given any setting that does not give obvious distortion at high input levels. The unit can accommodate quite high input levels, and signals at about 1V r.m.s. or a little more should not give rise to serious distortion.

It is a little awkward to adjust VR2 for optimum results as the necessarily high values of the resistors and capacitors in this part of the circuit result in a delay of a few seconds before any adjustment of this component fully comes into effect. However, with a little trial and error it should not be too difficult to find a setting that gives a good tremolo effect.

Both tremolo and vibrato effects are

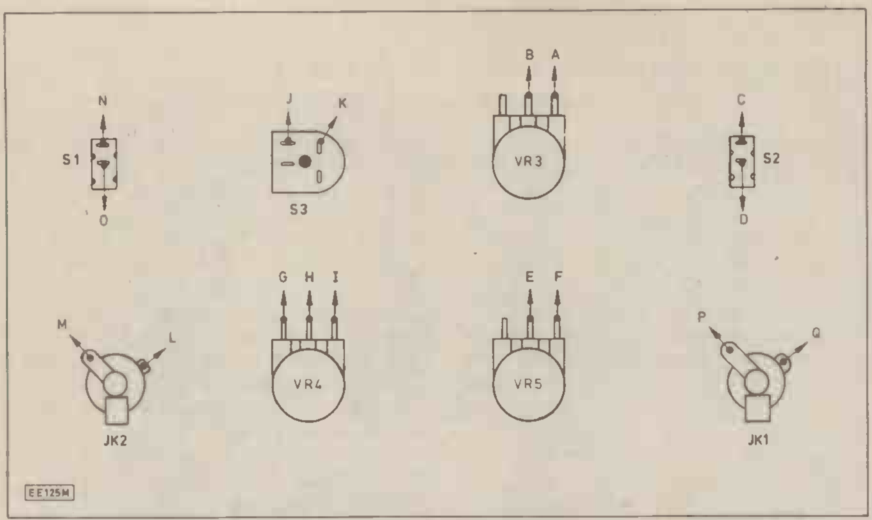
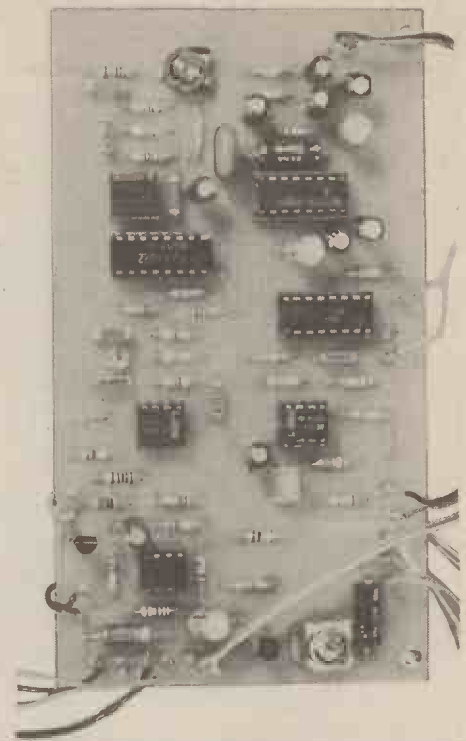


Fig. 5. Front panel wiring.



probably at their best with a modulation frequency of about one to three Hertz, and higher frequencies are apt to give rather strong effects that are difficult to use well in practice. Some interesting effects can be obtained using a fairly high modulation frequency and a moderate vibrato and (or) tremolo depth, but as with any effects unit, it is really a matter of trying the controls at various settings to discover the full range of effects that are available. □

FOR YOUR ENTERTAINMENT

BY BARRY FOX

Job Skills

Over the last ten years I have been round most of the Japanese factories in Britain which are making colour TV sets and videos. I have also been to quite a few on the Continent.

They are here in Europe because, to get a licence for large screen sets under the PAL colour TV patents, they have had to produce locally. More recently, there have been restrictions on video imports into Europe. And there are heavy tariff duties.

The good news is that this creates jobs for Europeans. The bad news is that the jobs are for low-skill workers. The Japanese do all their design work in Japan, except where there are peculiarly local problems on PAL colour, teletext or viewdata. The bad news also is that most of the production lines are little more than screwdriver assembly stations, with the raw material and components shipped in from Japan as kits of parts.

Now the same thing may be happening with audio. I hear on the grapevine that Pioneer is planning some production. For around five years Japanese Aiwa (a subsidiary of Sony) has been making mid-fi audio systems in Wales. But it was only recently that the company felt sufficiently proud of the plant to show the press around.

It was good to see around 150 people employed at the Aiwa factory. Many of them would not otherwise have jobs. It is also good to know that half the factory production, estimated at around £8 million worth this year, is exported, and so helps the British balance of payments. But it is very disappointing to see that the Aiwa audio factory, like most of those Japanese TV factories, is really nothing more than a screwdriver line assembling Japanese kits. Let's hope Pioneer can do better.

Made in UK

The rationale behind Aiwa's screwdriver line is that Aiwa audio products only have a commercial life of around one year. They are designed in Japan, made on a Japanese line for one month and then made in Britain. It would, says the company, take too long to identify a local source, negotiate price and get supply up and running.

Maybe, maybe not. Whatever the truth of this, it is interesting to look at a few of the hard facts behind the complicated Common Market laws which entitle firms like Aiwa to label their products "Made in UK" even though only a very few components are made locally.

I happen to know that a few weeks before the press visited the Aiwa factory, Nicholas Edwards, Secretary of State for Wales, toured with a party of advisers. He was not pleased to see what the press saw all round the plant, namely, Japanese boxes full of obviously Japanese components.

When electronic equipment is imported into the EEC from Japan it attracts heavy duty, averaging about 9 per cent rising to 14 per cent for items like tuners, and even 19 per cent for compact disc players. If the same hardware is made in an EEC factory, it can be exported round Europe without any extra duty.

This only holds good if the factory adds 45 per cent of the ex-works price in local value. The idea, of course, is to stop Japanese companies importing equipment which is 99 per cent made in Japan, with only a couple of extra screws to be tightened locally.

I suspect you would be surprised how easy it is to notch up 45 per cent local added value. You can add value with raw material like cardboard boxes, plastic wrapping, foam padding, and local language instruction books. Import duty paid on incoming parts counts as local added value. So do factory overheads, like heating, lighting and staff wages. Even profit made counts as added value . . .

The Aiwa factory in Wales says it is over the 45 per cent mark: So it can mark its boxes "Made in the UK," even though there is very little local material inside the chassis. At the moment Aiwa buys transformers from Ireland and Britain, and a mains lead, packaging, a fuse and a socket from Britain.

Everything else comes from the Far East. Even though raw component parts also attract an average duty of 9 per cent (and up to 17 per cent for transistors and integrated circuits) it is still cheaper to buy in the Far East than source locally. That, I hasten to add, is the Japanese story, not mine.

According to Aiwa's figures, the material content of an audio system is around 75 per cent of the ex-works price. The rest is labour and overheads. Of this 75 per cent material content, around 70 per cent is imported. Apparently the transformer cost is high, so with packaging there is 30 per cent local added value in material. I'll just have to take their word for this.

The bottom line is that 52·5 per cent of the ex-works price rates as imported material and the other 47·5 per cent rates as local added value. This keeps the EEC bureaucrats happy. And, of course, it's good for those 150 people in Wales employed to add to the value.

But it has to be said that of those 150 people, not a single one is doing anything resembling original design work on the product. The Japanese are certainly not exporting that kind of job, and it's unlikely they ever will. The real thinking power base stays firmly in the Far East.

British politicians, of all parties, who welcome Japanese investment in Britain, don't seem to realise the long-term significance of this sad state of affairs.

Russianese Video

In the early 70s the Russians made their own reel-to-reel, industrial video recorder. It worked only in black and white. Now there is talk of a Russian domestic VTR, compatible with VHS. It *isn't* made under licence from JVC. Only a few hundred have been made. Quality is poor.

Domestic video recorders rely on precision engineering of the head drums and very large-scale integration of the electronic circuitry onto micro chips. The Russians make micro chips, of course, but would be unlikely to tool up for mass production of the dedicated chips needed for domestic video recorders.

Soviet politicians are not at all sure yet whether they want the people to have domestic video recorders. So far most of the VHSki machines have been going to politicians and VIPs.

Obviously they don't want to be seen using an imported Japanese brand. So the Russian machines look Russian, but almost certainly contain imported parts which are particularly tricky to manufacture.

Remember that it may take around half a million pounds to develop a chip, so that it can be mass produced for around a dollar a time. Some Japanese video manufacturers have become very suspicious about curiously large orders for some high precision "spares".

Who actually makes electronic equipment in Russia? Good question. It is all made by Government departments.

The Communications Industry (MIN Prom Svyaz') makes the bulk of the TV sets and some stereo. Video equipment, what little of it there is, is made by three ministries: Min Electron Prom, Min Rad Prom and the Aviation Industry, Min Avia Prom.

Western electronics manufacturers are frequently offered Russian chips at attractively low cost. But they have grown wary. Initially the chips meet the claim specifications, but they very soon fail. It's the connections on the chip that go faulty, especially in bulk production runs.

Lack of competition and the awesome bureaucracy of so many departments help explain why the Russian electronics industry have stuck with valves much longer than the West. Another reason, which may or may not be valid, is that valves are far less susceptible to damage by radiation, for instance the electro-magnetic pulse or EMP which accompanies a nuclear explosion.

The electro-magnetic pulse is a short burst of very intense radiation that induces high currents in any metal or wiring in the area. It pops chips in a puff of smoke. Valves have a much better chance of withstanding EMP.

a regular feature for the Spectrum Owner...

by Mike Tooley BA

THIS MONTH, by popular demand, we shall show how a simple joystick interface can be constructed at a fraction of the cost of a ready made unit. Since there are a variety of joystick protocols in current use (Kempston, AGF, and Protek to name but three) we have decided to use the most universal, i.e. that adopted in Sinclair's own Interface II.

Joystick Port

The Interface II joystick port is mapped to a decimal input port address of 61438 and the joystick functions are made to correspond to the upper right section of the Spectrum's keyboard as follows:

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

This relationship is illustrated in simpler diagrammatic form in Fig. 1.

The complete circuit diagram of the joystick interface is shown in Fig. 2. IC2 is a tri-state non-inverting octal bus receiver which allows data to be fed onto the five least significant system data bus lines whenever its two enable inputs (pins 1 and 19) are taken low.

The port address (61438) is valid whenever address lines A0 and A12 are taken low whilst all other address lines remain high. OR gates IC1a and IC1b produce an active low enable signal for IC2 whenever the $\overline{IORQ}$, $\overline{RD}$, and A0 lines are all simultaneously taken low. This situation arises whenever the Spectrum is performing an I/O read operation from an address in which A0 is low.

To satisfy the additional requirement for A12 to be low, address line A12 is used to pull-down the common line which links together all five of the joystick's switches. A closed joystick switch will, by virtue of the pull-up resistors connected to the data inputs of IC2, ONLY return a logic 0 when A12 is low.

Construction

The joystick interface is assembled on a small piece of Veroboard measuring approximately 80mm × 80mm. The precise dimensions of the board are not critical, but it must have a minimum of 28 tracks aligned in the vertical plane. The 28-way double sided edge connector is mounted along the bottom edge of the board and requires approximately five rows of holes across the full width of the stripboard. The board thus stands vertically when the connector is mated with the Spectrum.

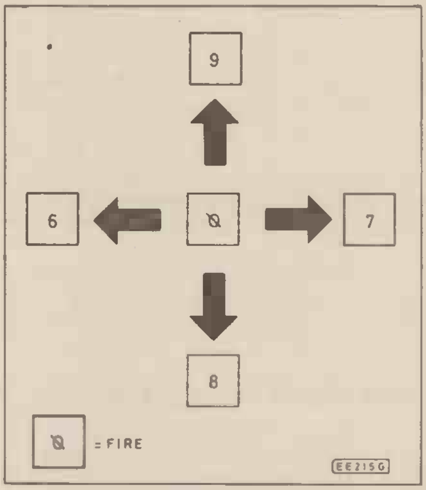


Fig. 1. Relationship between joystick functions and keyboard.

COMPONENTS

Resistors
R1 to R5 10k (5 off)
All ¼W ±5%

Capacitors
C1, C2 100n polyester (2 off)
C3 22µ electrolytic

Semiconductors
D1 to D6 1N4148 (6 off)
IC1 74LS32
IC2 74LS244

Miscellaneous
14-pin d.i.l. socket; 20-pin d.i.l. socket; 28-way open end double-sided 2·54mm pitch connector (e.g. Vero part number 838-24826A); 9-way D-type joystick connector; 2·54mm hole pitch stripboard, measuring approx. 80mm × 80mm (minimum 28 strips)

Note: Kelan Engineering (27-29, Leadhall Lane, Harrogate, North Yorkshire, HG2 9NJ) supply a 'Spectrum Interface Prototype Kit' which includes a double sided circuit board, 28-way edge connector, a 9-way D-connector, and a neat ABS case. The catalogue number to quote is 'HB/2090' and the price is £9.60 (including VAT) plus 60p U.K. postage.

Before soldering any of the components it is important to allow some clearance for the rear "overhang" of the case. For the Spectrum this gap should correspond to 8 rows of holes (20mm approx.) whilst for the Spectrum Plus the gap should be increased to 12 rows of holes (30mm approx.).

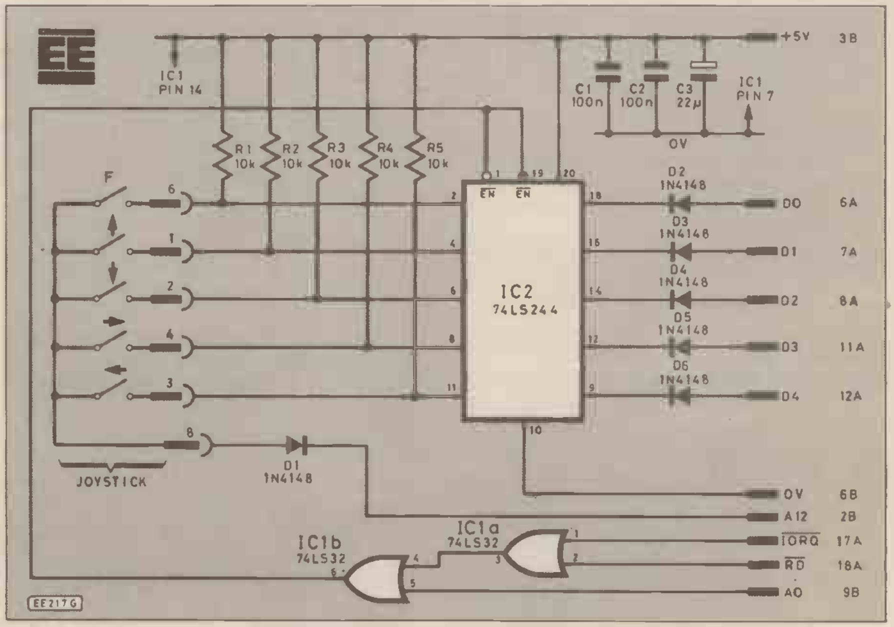


Fig. 2. Complete circuit diagram for the Joystick Interface.

An alternative method of construction, and one which gives a very pleasing and professional finish, can be based upon an interface prototype kit (comprising plastic case, connector, and circuit board) of the type manufactured by Kelan Engineering (for details see the Components List).

Component layout is generally uncritical although care should be taken to ensure that the supply decoupling capacitors, C1 and C2, are distributed around the board (each preferably associated with an individual integrated circuit supply). Great care should be taken to ensure that all unwanted tracks are cut (including those which link the upper and lower sides of the 28-way connector). A purpose designed "spot-face" cutter may be used for this task or, if such a device is not obtainable, a small sharp drill bit may be used.

Links on the underside of the board should make use of appropriate lengths of miniature insulated wire (of the type normally used for wire wrapping). Readers requiring further information on the connector should refer to March *On Spec*. The connections for the standard 9-way D-type joystick connector are shown in Fig. 3.

When the stripboard wiring has been completed, the integrated circuits should be inserted into their sockets (taking care to ensure correct orientation) and the entire board should be carefully checked before connecting to the Spectrum. Note that the Spectrum should always be disconnected from its supply before either connecting or disconnecting any interface module. If all is well, when power is re-applied, the normal copyright message should appear. If not, disconnect the power, remove the interface and check again.

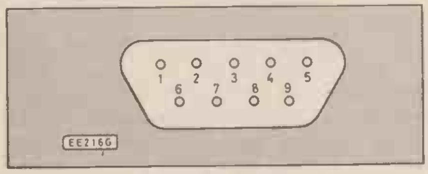


Fig. 3. Pin details for D-type connector.

Joystick Demonstration Program

We shall close this month's instalment of *On Spec* with a program which not only serves to demonstrate the use of the joystick interface from BASIC but is also a useful graphics utility in its own right. This program will allow you to create block graphics on the screen which may be saved for later use, modification, or incorporation within your own programs.

The joystick is made to control the movement of a non-destructive flashing cursor which may be moved around the screen at will. Readers who do not have a joystick interface will be able to control the cursor using the keyboard (as shown in Fig. 1).

```
  1 REM Joystick demonstration
  2 REM Everyday Electronics August 1985
  9:
 10 REM Initialise
 11:
 20 LET l=10: LET c=16: REM Start in centre of screen
 30 LET colour=7: REM white
 40 BORDER 0: PAPER 0: INK 7: CLS
 50 LET flag=0
 99:
100 REM Main loop
101:
105 PRINT £0;AT 3,0;"Colour=c Save=s Load=l Erase=e"
110 REM Start of main loop
115 PRINT £0;AT 0,0;"Line ";l;" Column ";c;" "
120 LET r$=INKEY$: IF r$="" THEN  GO SUB 200: GO TO 120
125 PRINT £0;AT 0,0;"Line ";l;" Column ";c;" "
130 IF r$=" " THEN  PRINT AT l,c;" ": LET flag=0
135 IF r$="e" THEN  GO TO 10
140 IF r$="c" THEN  GO SUB 300
145 IF r$="s" THEN  GO SUB 400
150 IF r$="l" THEN  GO SUB 500
155 IF r$="6" THEN  LET c=c-1: IF c<0 THEN  LET c=0
160 IF r$="7" THEN  LET c=c+1: IF c>31 THEN  LET c=31
165 IF r$="8" THEN  LET l=l+1: IF l>19 THEN  LET l=19
170 IF r$="9" THEN  LET l=l-1: IF l<0 THEN  LET l=0
175 IF r$="0" THEN  LET flag=NOT flag
180 GO SUB 200
185 GO TO 100
199:
200 REM Flash cursor
201:
210 PRINT AT l,c; INK colour;"C": PAUSE 10
220 PRINT AT l,c; OVER flag;" ": PAUSE 10
230 RETURN
299:
300 REM Set colour
301:
310 INPUT £0;AT 0,0;"Colour ? ";colour
320 IF colour<0 OR colour>9 THEN  GO TO 310
330 INK colour
340 RETURN
399:
400 REM Screen save subroutine
401:
410 INPUT £0;AT 0,0;"Filename for saving ?";n$
420 SAVE n$SCREEN$
430 RETURN
499:
500 REM Screen load subroutine
501:
510 INPUT £0;AT 0,0;"Filename for loading ? ";n$
520 LOAD n$SCREEN$
530 RETURN
```

A useful feature of the program is that the location of the cursor (line/column) is displayed at the bottom of the screen. This makes accurate positioning of the cursor particularly easy.

Initially both screen border and paper colours are black but these may be changed by appropriate modification of line 40. As an example, the following line will initialise the border and paper colours to red and blue respectively:

40 BORDER 2: PAPER 1: INK 7: CLS

The fire button is used to toggle the cursor between flashing and non-flashing states. In the non-flashing state the cursor becomes active and will paint the screen with the current colour. After painting one or more blocks the fire button should be depressed to de-activate the cursor so that the cursor may be moved to a new location from which drawing is to commence. The cursor colour can be changed by pressing the C key. The user is then prompted for the new colour. Tape saving and loading commands are also catered for and the necessary prompts are supplied as required.

When keying in the program it is important to note the following:

1. The "C" in line 210 is an inverse graphics 8 □
2. The "£" should be keyed in using #

Having first entered the program it is, as usual, important to SAVE it before running. If desired, the program may be made to auto-RUN by using the following SAVE command:

SAVE "joydem" LINE 10

Finally, if you have any comments, queries, or suggestions for inclusion in *On Spec*, please send them to:

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

P.S. If you would like a copy of our latest "Spectrum Update" don't forget to include a stamped addressed envelope.

NEXT MONTH: A simple D-to-A output interface, using a total of just 18 components, including four readily available integrated circuits.

COUNTER INTELLIGENCE

BY PAUL YOUNG

The Silicon Idol

I never thought the day would come when I should be breaking lances in support of the computer. I always thought it much more likely that I would be breaking them across the heads of the inventors.

However, a recent book dealing with the socialogical aspects of the computer—*The Silicon Idol* by Dr. Michael Shallis, Oxford University Press—compels me to try and put it in correct perspective. The fact that I disagree with Dr. Michael Shallis on many of his points is unlikely to worry him one scrap, as he has probably forgotten more about computers than I shall ever know, so I can proceed with a clear conscience.

His argument is, that the computer will gradually take over, that right and wrong have no meaning for it and it cannot make moral judgements. I am not convinced that it could not be programmed to make moral judgements, though I do admit it would not have the wisdom of Solomon.

How, I wonder, would it have dealt with his famous case of the two women claiming the same baby? For the benefit of the one or two readers who haven't read their Bible lately, Solomon's judgement was that the child should be cut in half, knowing full well that the wrongful claimant would agree and the real mother would opt to give the infant to the other woman.

The computer would probably say, let's cut it in half and ask each of them if they would like it cut long ways or across the middle. A good point in proving that the computer has neither compassion or feeling.

Against that, I recently read a report that a hospital in Washington replaced several of their G.P.s with computers. After six months they removed them and there was a general outcry by the patients, who declared they preferred them to the doctors because they gave them more time and were more caring. I wonder if the results would have been the same with British doctors?

Compassionate Computers

All the same, it does pose the question, is it possible that computers that are programmed by compassionate caring people can be considered as compassionate and caring? It would almost seem so. Dr. Shallis talks of the possibility of a husband working at home, his computer obviating the need for going to the office, and his wife shopping from home with her computer and a VDU. This is already happening.

He says this is a dangerous trend because Homo Sapiens are a gregarious bunch and people need the company of other people to function properly... On this I fully agree with him, but we have a free choice, and it will only be a matter of time before we revert to the old ways, as we instinctively know what suits us best.

He quotes an old Chinese tale of a peasant in a field, engaged in the back breaking task of carrying buckets of water to his garden. A well intentioned stranger explains that a simple machine would reduce his labour to a fraction of what he was expending. The old man replied that he would be ashamed to use it, that those who use the machine become like the machine.

Even if he was quoting Confucius, I would still disagree with him. Machines were invented so we can save our physical energy to expend on more interesting pursuits and also to leave us free to develop our brain power.

It will be argued that computers are sapping our brain power, Dr. Shallis won't have a calculator in his house. I have always consistently stated that we should learn the basics of mathematics and after that we should use the calculators for all the wearying and boring work and save our brain for loftier thoughts.

Pet Options

The key word in all these arguments is "Options". We have the option at all times of retaining the good, and jettisoning the bad, and this we most certainly will do. Dr. Shallis' most chilling remark is that when the computers take over, men will become mere pets.

Can you imagine it? Charlie my friendly computer croaks out in a voice sounding like a station announcement at Waterloo Station, "Paul, fetch me my slippers". Obedient Fido Young lopes off to fetch them, while wondering if slippers for computers come under software. He returns with the slippers, which Charlie puts on those huge metal slabs he calls feet.

"Good lad," he rasps, and pats him twice on the head. Although the pats were meant in the friendliest way the large chunk of iron which serves as a hand raises a bruise the size of an egg—Don't worry readers, it won't happen!

It would be unfair of me to conclude without saying that Dr. Shallis has written a splendid and thought provoking book which everyone should read who is interested in the implications of the effect of the computer on our future.

Spectrum Disc Operating System

Michael Tooley BA

DESPITE the arrival of a host of contenders in the low-cost personal computer market, the Sinclair Spectrum undoubtedly still reigns supreme. The reason for the success of this particular micro is attributable to several factors, not the least of which is the huge base of reasonably priced software.

Having purchased a Spectrum the "serious user" soon realises the need for a reliable mass storage system which will provide rapid access to programs and data without the need to search through vast lengths of cassette tape! It was heartening, therefore, to learn that, following on the success of their Centronics/RS-232 Printer Interface, Watford Electronics have recently introduced a Disc Operating System for the Spectrum. This system (known as SP-DOS) claims to provide "professional computing power" for the U.K.'s most popular home micro. With several other rivals (including Sinclair's own Microdrives) in the fast access/mass storage peripheral market, what has Watford's system got to offer over its rivals?

Before attempting to provide some answers to this question we had perhaps better turn our attention to answering the rather more general question "why use floppy discs?". So, for the benefit of the unconverted, here are just four good reasons why floppy disc storage is preferred:-

1. Disc systems can be expected to provide considerably faster access and loading times and typically offer an improvement in speed of between 5 and 10 times when compared with a Microdrive and several hundred times when compared with conventional cassette storage.
2. Disc systems provide automatic verification of stored programs and data and are inherently more reliable than a tape based counterpart.
3. A wide variety of drives are currently available at reasonable cost. A single drive can be expected to provide a formatted storage capacity of between 200k and 800k bytes depending upon its complexity.
4. Most computer systems intended for the "serious user" are provided with a standard floppy disc interface. The initial outlay spent on a disc drive will not, therefore, be wasted when the time comes to upgrade the system. The user simply transfers his drives to the new system.

SP-DOS essentially comprises three elements; hardware contained in an ABS case which is plugged into the expansion socket at the rear of the Spectrum, software which is supplied on a 5¼ inch floppy disc and last, but by no means least, a spiral bound manual.

HARDWARE

The SP-DOS disc interface is presented in an ABS box measuring approximately 150mm × 80mm × 20mm. This case is rather obviously plastic and has a shiny finish which matches the earlier Spectrum rather than the Spectrum Plus. The box stands up vertically at the rear of the Spectrum. Also, unlike some other peripheral devices, the SP-DOS disc interface fits both the Spectrum and Spectrum Plus equally well.

A through connector is provided in order to extend the Spectrum's rear expansion bus so that it is available for use by other external hardware. The most obvious device to have in this position is, of course, the Watford Centronics/RS-232 Printer Interface. This fits in something of a rather precarious position, particularly when used with a Spectrum Plus which has its keyboard stand erected! Despite my misgivings about this arrangement I should perhaps mention that, at no time during testing, did the arrangement become inadvertently separated nor did any errors occur due to inadequate connection.

Since the ABS box extends to obscure the d.c. power input connector, an ingenious, if somewhat fiddly, through tube allows one to make the necessary connection. This proved to be rather irritating to use and will undoubtedly reduce the life of the power lead where it enters the d.c. connector (one wonders just how much flexing this lead can take!).

The disc interface incorporates two very welcome items in the shape of a reset button (this is a good deal more accessible than the one fitted to the Spectrum Plus!) and a power indicating l.e.d. Connection to the disc drive is made via a 34-way IDC connector located on the right hand side of the ABS box (Watford supply a cable and connector with their compatible range of disc drives).

The system supports up to four double-sided drives and will, in fact, work quite happily with almost any drive which supports double-density operation and which is fitted with a standard Shugart interface. This includes most 40-track and 80-track 5¼ inch drives as well as some of the latest 3 inch and 3½ inch drives.

Dismantling the case reveals half-a-dozen chips neatly laid out on a double-sided p.c.b. To deter plagiarism (at least one assumes that this is the reason!) all identification has been removed from the integrated circuits. Furthermore, dismantling the case is definitely not recommended as it takes some time to get it back together again!

Altogether, the hardware is well above the average quality associated with Spectrum add-ons and appears to be well thought out and shows none of the "afterthoughts" that are often prevalent in early production models.

SOFTWARE

The software supplied with the review model was supplied on an 80-track quad density disc of reputable manufacture. A telephone call to Watford soon confirmed that other formats (e.g. 40-track) could also be catered for. This is re-assuring since there must be many potential users of this system who would like to adapt their existing 40-track drives or purchase second-hand drives for use with SP-DOS.

The disc is supplied with a number of programs. The twelve "visible" files (revealed by the CAT command) account for a total of about 74kbytes. The main DOS routines (such as the RAM resident module of SP-DOS) are "hidden" from the user and remain "invisible" when the CAT command is used.

The RAM resident module of SP-DOS installs itself in high memory and RAMTOP is initialised to 57855 to allow for the RAM resident module of SP-DOS, the sector buffer, system variables and overlay area. In addition, SP-DOS preserves a printer driver area (64290 to 65367) and respects the area normally reserved for User Defined Graphics.

An important feature of SP-DOS is that there is no DOS environment and disc operations are called directly from BASIC. The following commands are used in disc operation:-

CAT CLEAR CLOSE# ERASE FORMAT INKEY$# INPUT# LOAD MERGE MOVE OPEN SAVE

All of the above commands are made to apply to the disc system when preceeded by "PRINT# 4" (stream 4 is reserved for the disc drive). It should also be noted that all of the usual tape SAVE and LOAD commands are still perfectly valid and programs can be loaded from cassette and saved to disc, and vice versa.

IN ACTION

At this stage it is, perhaps, worthwhile giving an example of SP-DOS in action to demonstrate its ease of use from BASIC. Suppose we have a BASIC program in memory which we wish to save to disc with the filename "TESTPROG". The following keyboard entry is required:-

PRINT# 4 : SAVE "TESTPROG" <ENTER>

Now let's suppose that we wish to delete lines 500 to 999 from "TESTPROG" and merge a second program called "OLDPROG". This could be achieved using:-

PRINT# 4 : CLEAR : PRINT 500,999 : PRINT# 4 : MERGE "OLDPROG" <ENTER>

To save the new program, under the filename "NEWPROG", so that it will automatically run from line 10 we would key:-

PRINT# 4 : SAVE "NEWPROG" LINE 10 <ENTER>

Finally, suppose we need a catalogue of all programs on the current disc drive we would simply enter:-

PRINT# 4 : CAT

The bundled software includes three first class programs; Omnicalc, Masterfile, and Tasword Two. Omnicalc is a fairly conventional spreadsheet analysis program which caters for a grid of numbers of up to 99 columns by 250 rows. All of the Spectrum's mathematical functions can be employed, making it relatively easy to build up sophisticated models for finance, engineering and many other applications. Conditional expressions, differential interest rates and variable overheads can be accommodated easily. Models may be linked through an independent work area and a facility is also provided for drawing histograms. The program supports both the ZX-printer and any full-size printer via a suitable interface.

Masterfile is a powerful database which allows fast filing and retrieval of data. The program is fully menu driven and allows a maximum of about 24kbytes of data per file. The program allows the user full control over the display format and provides screen displays of up to 22 records at a time. Masterfile (like Tasword Two) also has a "micro print" feature that allows the user to escape from the Spectrum's somewhat restricting 32-column screen display.

Tasword Two is, quite simply, superb! It has all of the qualities which one would normally associate with word processors costing more than ten times the price and is both powerful and extremely "user friendly". It is not surprising, therefore, that this software has earned the reputation of being the best of all currently available Spectrum word processors.

MANUAL

The manual is neatly presented and contains approximately 50 pages devoted to the workings of SP-DOS plus a full reprint of the manual for each of the bundled software programs. The section on SP-DOS is well written and contains all of the necessary information. Unfortunately no index is included and, at times, it is necessary to sift backwards and forwards through the text to find the required details.

The spiral binding is, as usual, something of a mixed blessing. Once opened, the manual stays that way until the page is deliberately turned, however, after four weeks of fairly constant thumbing, some of the pages were starting to part company with the binding!

The sections devoted to Omnicalc and Masterfile are, to say the least, not particularly "user friendly" and need a great deal of reading and re-reading to obtain the full benefit from this very powerful software. Of the three manual reprints, the section on Tasword is, perhaps, the best of all and, when studied in conjunction with the Tutorial and Tasword's two "help" pages, this makes the program very easy to get to grips with.

IN USE

SP-DOS was tested in conjunction with one of Watford's SPS8 double-sided double-density drives. This drive is one of a range of four drives available from Watford with formatted capacities of between 200k and 1.6Mbytes. It was interesting to find that the drive supplied was identical to those supplied for use with the BBC micro, indeed it was packaged with BBC disc formatting software and a "disc drive guide" designed specifically for the BBC user!

SP-DOS proved to be remarkably simple and easy to use. One quickly gets used to the command syntax and furthermore the repeated use of "PRINT# 4" did not prove too irksome (it requires only four keystrokes thanks to the Spectrum's "keywords").

The SPS8 disc drive behaved impeccably at all times and the system proved to be fully compatible with the Watford Centronics/RS-232C interface. When tested with various other interfaces, however, a few problems arose due to the use of single-line address decoding. The disc interface uses address lines, A1, A3, A4, and A5 whilst the printer interface uses address lines A2 and A7. Hence, with both interfaces present only one of the lower eight address lines (A6) remains unused. Thus it would appear that only one of the 256 I/O ports remains available to the user. With A6 'low' and all of the other address lines 'high' this corresponds to a decimal address of 191. A quick re-configuration of the author's light pen interface proved that this port was indeed still available for user applications! It should be noted that the disc interface is NOT compatible with Sinclair's Interface 1, neither is it compatible with the very popular range of Currah Speech products.

Attempts to transfer the author's software library to disc met with varied success. All of my own programs and data files could be easily transferred to disc from tape but, due to SP-DOS's thirst for memory, only about 50 per cent of the commercial programs tried could be successfully saved to disc. This is a shame and prospective users of SP-

DOS should be fully aware that there could well be problems with loading and saving larger commercial software when the disc operating system is resident in memory. Meanwhile, it remains to be seen as to what support for SP-DOS will be forthcoming from the software houses. Until then, users may have to resign themselves to operating their tape and disc systems side by side!

CONCLUSION

SP-DOS is probably the most advanced of the currently available disc operating systems for the Spectrum. It is, however, a package which is only likely to be of interest to the established Spectrum user and is unlikely to be purchased as part of an initial entry to home computing. In view of this, the excellent bundled software could prove to be something of a disincentive to most Spectrum devotees who will undoubtedly have already purchased one, or more, of the programs supplied (or at least something similar!)

Ignoring all of the powerful advantages of floppy disc based systems, and assuming an average priced drive is used, SP-DOS becomes cost-effective when compared with Sinclair's own Microdrive/Interface 1 combination whenever storage capacities in excess of about 2Mbytes are envisaged. If this sounds a lot, try doing some arithmetic to find out just how much data and programs you currently have. In any event, it should be remembered that one double-sided double-density disc provides the same storage capacity as about ten Microdrive cartridges and these cost about £2 each as compared with about £3 for a single quad-density $5\frac{1}{4}$ inch disc!

The bundled software is excellent and will cope with most eventualities, whether it be dropping a note to your friendly bank manager or keeping track of your Christmas card lists. Indeed, the software is of sufficient quality to make it competitive with some business packages costing ten times more.

It is somewhat ironic, therefore, that SP-DOS and its bundled software is unlikely to find its way into the "small business" environment for no other reason than the dreadful keyboard that Sinclair has inflicted upon us! This is a great shame since an SP-DOS package, together with a compatible drive from Watford, represents excellent value for money. SP-DOS costs £109 plus VAT and postage (£2), this price includes the software.

Abbeydale Designers and Watford Electronics are to be congratulated on a first-class product which can be thoroughly recommended to any "serious user" of the Spectrum. Let's hope we can look forward to seeing more from this particular partnership!

SP-DOS and compatible disc drives are available from:- Watford Electronics, 250 High Street, Watford, Herts, WD1 2AN. Tel: (0923) 40588/37774

TRI-STATE THERMOMETER

T. R. de Vaux Balbirnie

THIS PROJECT is a simple form of electronic thermometer. Instead of the usual scale of temperature, it has three colour-coded light-emitting diodes—green to signal "Low", yellow for "Correct" and red for "High". It may thus replace a conventional thermometer for see-at-a-glance temperature checking.

Possible uses include monitoring photographic solutions and water in fish tanks, winemaking and brewing or simply to check inside and outside air temperatures. The operating point is preset and the range accepted as "correct" adjustable to as little as 1°C if required.

Two power options are available—battery or mains. The battery-operated circuit is unsuitable for continuous use but is cheaper and simpler to construct. It operates only when a push-button switch is pressed so excellent service may be expected from the small battery contained within the case. The mains circuit may be switched on continuously but construction demands greater care.

The sensor itself is a suitably-protected bead thermistor giving rapid response to changes in temperature. For less critical applications, a miniature rod thermistor could be used to reduce the cost. However, response time and accuracy suffer to some extent.

CIRCUIT DESCRIPTION

The circuit for the Tri-State Thermometer is shown in Fig. 1. IC1 is an integrated circuit containing four operational amplifiers. Only three are used in this circuit—IC1a, IC1b and IC1c—all in the comparator mode. IC1a and IC1b in conjunction with the thermistor, R9, detect the "high" and "low" temperatures and operate the corresponding l.e.d.s. IC1c provides the logic for the "correct" l.e.d. (D5) to operate.

VR1 and R1, together with R9, form a potential divider common to both the non-inverting input (pin 3) of IC1a and the inverting input (pin 6) of IC1b. VR2 and VR3 are connected as potential dividers which apply preset voltages to IC1a inverting and IC1b non-inverting inputs (pins 2 and 5 respectively). Since R9 is a *negative* temperature coefficient thermistor, its resistance is *high* at low temperatures and the voltage at pins 3 and 6 will also be high. With proper adjustment of VR1 and VR3, the voltage at IC1a non-inverting input exceeds that at the inverting input. The device then switches on with pin 1 at positive supply voltage and D2 on.

The reverse is true for the input states of IC1b so it remains off, with pin 7 at negative supply voltage and D1 off. At higher temperatures, the resistance of R9 falls so the voltage at pins 3 and 6 falls also. The roles of IC1a and IC1b now interchange, with IC1b and D1 on and IC1a and D2 off. VR2 and VR3 are adjusted so that there is a "space" between the on states of IC1a and IC1b—that is, both op-amps off. This will form the range of temperatures accepted by the circuit as "correct". With both these op-amps off, IC1c will be on, with D5 operating, since its inverting input (pin 9) is at negative supply voltage due to R5 and its non-inverting input is set at one-half supply voltage by the potential divider action of R6 and R7.

Thus the voltage at the non-inverting input is the greater. With either IC1a or IC1b on, a positive signal is directed through D3 and R4 or D4 and R4 to the inverting input of IC1c. This makes the inverting input greater and IC1c switches off. It will be seen that IC1c acts as a NOR gate.

The push-to-make switch, S1, is part of the battery-powered circuit only. The mains circuit receives current from a standard arrangement of mains transformer, full-wave rectifier and smoothing capacitor (Fig. 2).

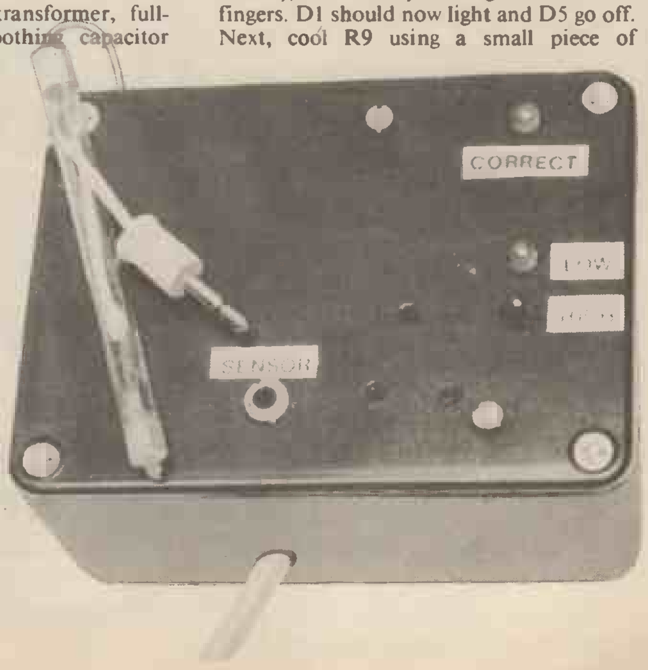
CONSTRUCTION

Refer to Fig. 3 and construct the circuit panel which is based on a piece of 0·1 in. matrix stripboard size 13 strips by 26 holes. Solder the i.c. socket in position and make the breaks and inter-strip links as indicated. Do not insert the i.c. itself at this stage. Check the break at VR2 most carefully—if it is not complete the supply will be *short-circuited*.

Solder the on-board components and drill the fixing holes. Adjust the three preset potentiometers to approximately mid-track position and insert IC1 the correct way round in its socket. The circuit may now be checked using a 9V battery—this is wise even if the mains version is being built.

Refer to Fig. 4 and make connections to the circuit panel as indicated. Connect strips A and M direct to the positive and negative terminals of the battery and strips G and M direct to the thermistor. Since thermistors are extremely delicate devices, use a piece of terminal block to make the latter connections. Some l.e.d.s may be on. Adjust VR2 and VR3 so that D1 and D2 are both just off. D5 will then be on. VR3 controls D2 and VR2 controls D1. If correct adjustment is found impossible, adjust VR1 and try again.

Without touching or wetting the thermistor connections (which would cause false results), warm R9 by holding it between the fingers. D1 should now light and D5 go off. Next, cool R9 using a small piece of



The encased unit with the temperature-sensing thermistor visible at the end of the glass rod.

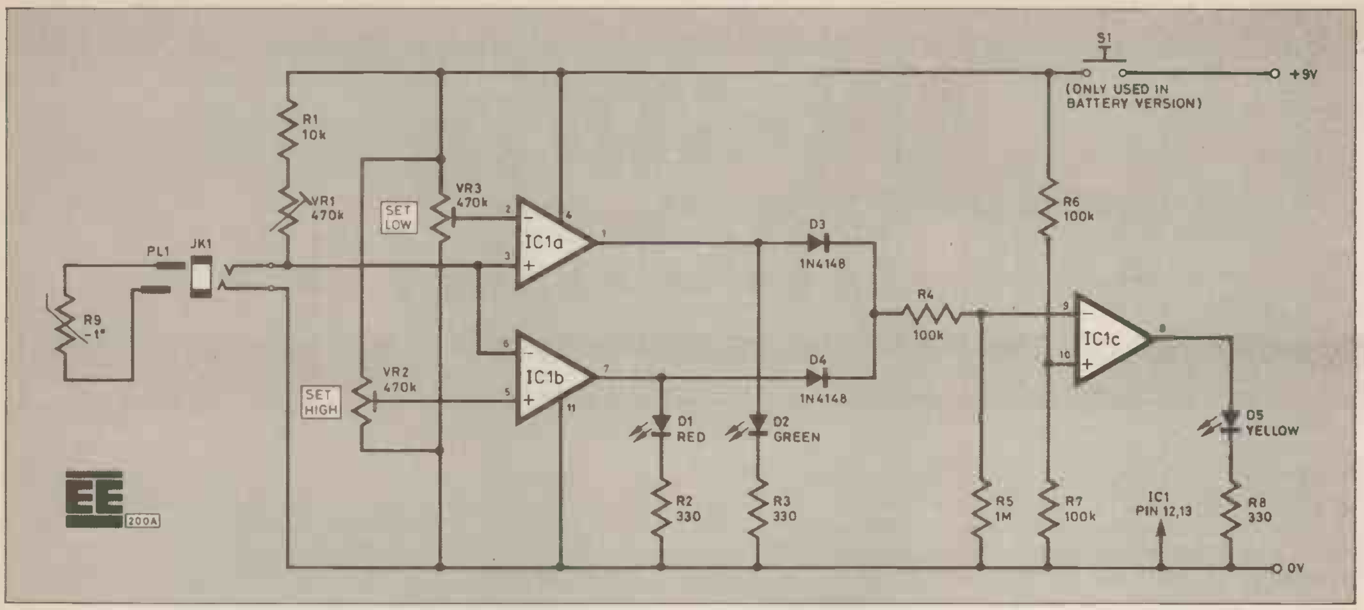


Fig. 1. The complete circuit diagram for the Tri-State Thermometer.

COMPONENTS

Resistors
R1 10k
R2,R3,R8 330 (3 off)
R4,R6,R7 100k (3 off)
R5 1M
R9 GL16 bead thermistor—resistance at 20°C approx. 1M. For less critical applications: VA1067S miniature rod thermistor
All 0·4W ±1% except R9

Potentiometers
VR1,VR2, VR3 470k Sub-min. preset. horiz. mounting (3 off)

Semiconductors
D1 5mm red l.e.d.
D2 5mm green l.e.d.
D3,D4 1N4148 (2 off)
D5 5mm yellow l.e.d.
IC1 LM324N quad op-amp

Miscellaneous
For battery operation:
B1 9V PP3 battery and connector. Adhesive fixing pad
S1 Min. push-to-make switch
For mains operation:
C1 220µ 25V elect.
D6,D7 1N4001 (2 off)
T1 mains transformer with 6–0–6V secondary at 100mA.
0·1 inch matrix stripboard, size 13 strips by 26 holes; 0·1 inch matrix stripboard, size 7 strips by 28 holes (for mains use only); MB2 plastic box 100 × 76 × 41mm internal; 14-pin d.i.l. i.c. socket; PL1/JK1 3·5mm jack plug and socket; 3A 3-way terminal block; 20mm fuse clips (2 off), 20mm 100mA fuse; adhesive plastic feet (4 off)

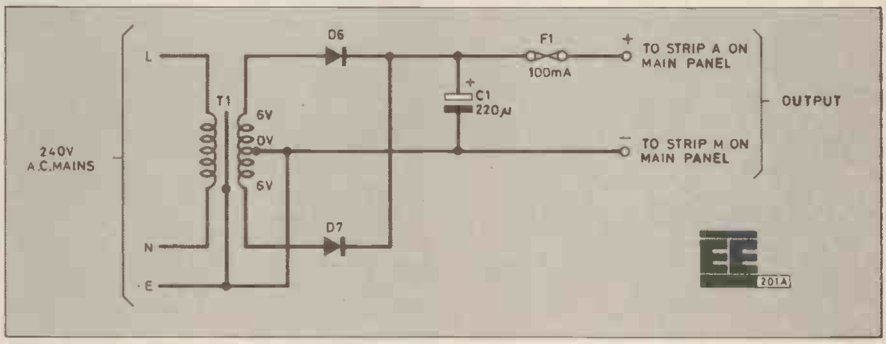


Fig. 2. Optional circuit for mains-powered operation.

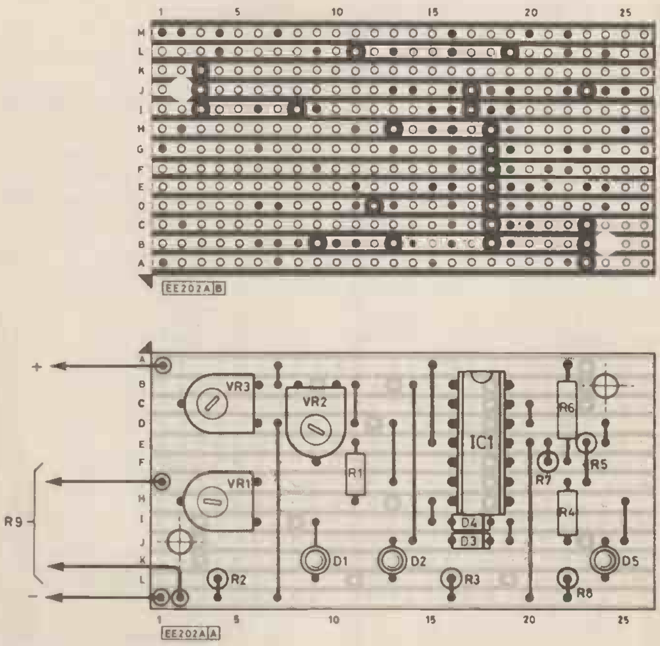


Fig. 3. Component layout and stripboard drilling details.

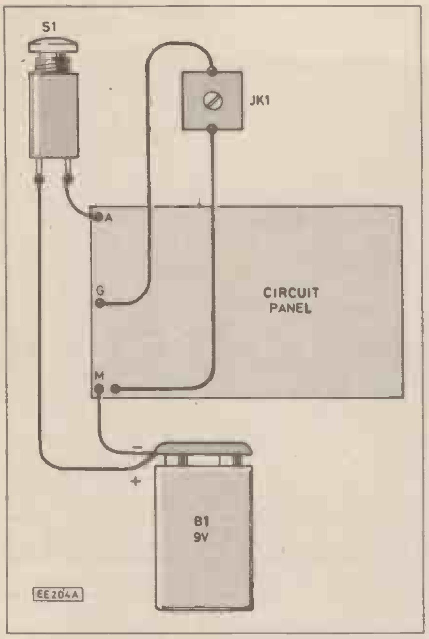


Fig. 4. Connections for battery operation.

ice—this time D2 should light and D5 go off. If the circuit fails to work, examine the circuit panel for errors—particularly for solder "bridges" formed accidentally between adjacent copper tracks.

For the mains circuit, construct the rectifier/smoothing panel (Fig. 5). This is based on 0·1 in. matrix stripboard size 7 strips by 28 holes. Note that the holes for the fuse clips need to be drilled out to 1·5mm diameter.

THE CASE

Begin by drilling holes in the lid. Carefully measure the positions of the preset potentiometers, the l.e.d.s, and the fixing holes in the circuit panel. Drill holes in the lid to correspond with these. Holes for the l.e.d.s should be 5mm diameter while those for the potentiometers and fixing holes should be 3mm diameter. Drill the hole to mount JK1 and, for the battery-operated circuit only, drill the hole for S1.

For the battery circuit, construction may be completed by wiring the battery connector and JK1 to the circuit panel, attaching the circuit panel to the lid of the case and securing the battery itself with an adhesive fixing pad. Short stand-off insulators (plastic tubing) should be included on the fixing bolts for the circuit panel. These will give the necessary clearance.

For the mains circuit, drill a hole in the rear of the case for entry of the mains lead. Mount T1 and the 3-way terminal block on the base including a solder tag beneath one of the T1 fixings, to earth the core. Connect T1 secondary wires to the rectifier/smoothing panel (Fig. 6) and the wires from here to the main circuit panel. Connect JK1 noting the *sleeve* connection to the solder tag T1. Connect the solder tag and T1 primary wires to the terminal block and wire up the mains input lead. Fit a strain relief bush to the mains input lead so that it cannot be dislodged from the terminal block should it be pulled accidentally.

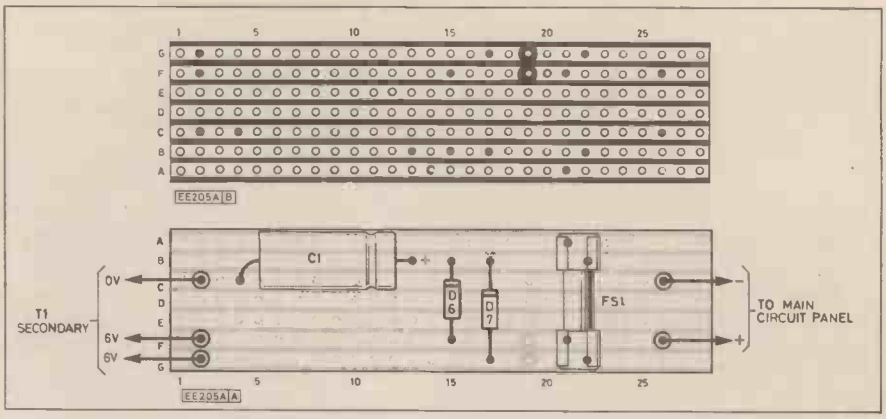
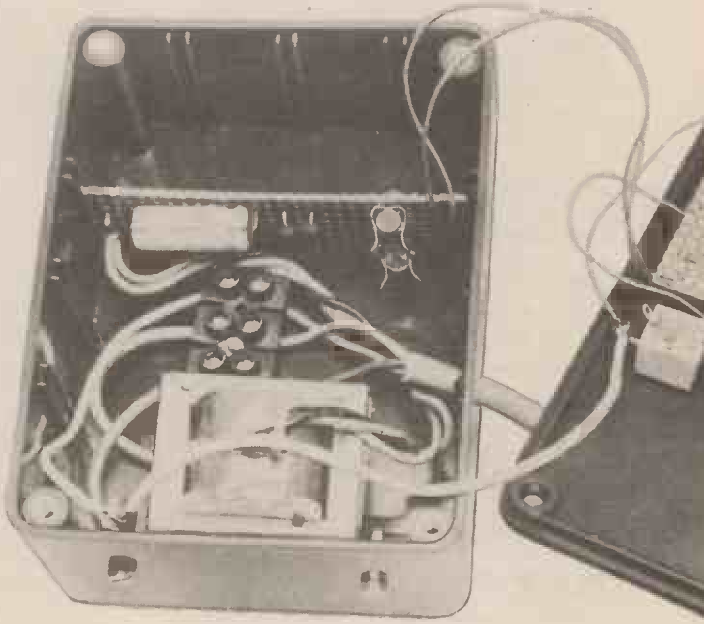


Fig. 5. Component layout for the mains-power circuit.

COMPONENTS
approximate
cost £12.50

See
Shop
Talk
page 421



The unit opened up: the mains-power section can be seen in the body of the case—the thermometer circuit is fixed to the lid.

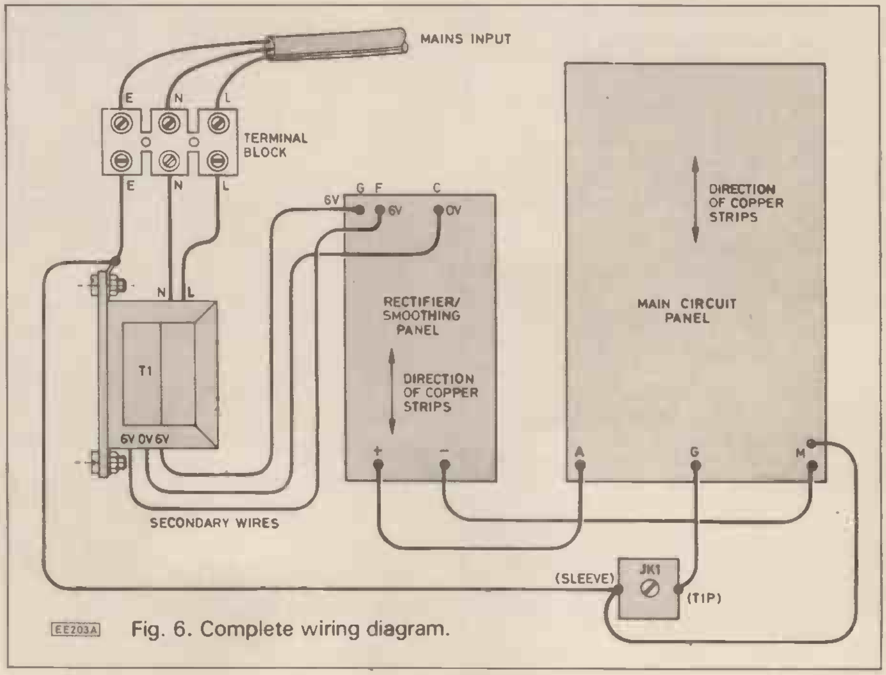


Fig. 6. Complete wiring diagram.

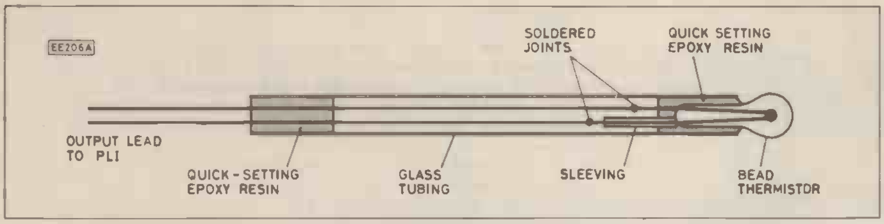


Fig. 7. Suggested arrangement for fixing the bead thermistor in a glass tube, to ensure good insulation.

Secure the main circuit panel to the lid of the case as described previously. Insert the fuse in the rectifier/smoothing panel and slide this panel into position. Check that when the lid is on, the two panels remain clear of one another. Connect a mains plug carrying a 3A fuse and fit the case with plastic feet.

SENSOR

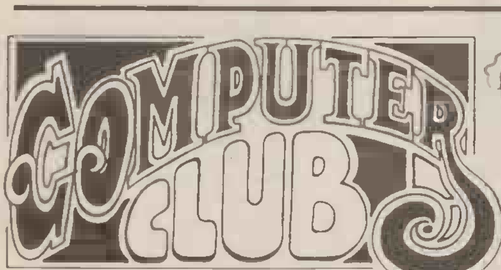
Bead thermistors are recommended for use with liquids. Since they are very delicate, good protection is essential. It is also necessary to prevent conducting liquids (water and solutions in water) from reaching the connections—this would lead to false indications. The arrangement shown in Fig. 7 was found to work well.

If the thermistor was totally encapsulated the probe would be more robust but would respond less quickly to changes in temperature. For measuring air temperatures and less critical applications, some cost may be saved by using a miniature *rod* thermistor. This may be housed in a small plastic box waterproofed as necessary.

ADJUSTMENT

Do *not* use the mains circuit with the lid of the case removed. Adjust the preset variable resistors through the holes in the lid drilled for the purpose. VR2 adjusts the "high" temperature and VR3 the "low" one. VR1 is adjusted so that the temperatures fall within the ranges of VR2 and VR3. A normal thermometer will be needed to preset these temperatures accurately.

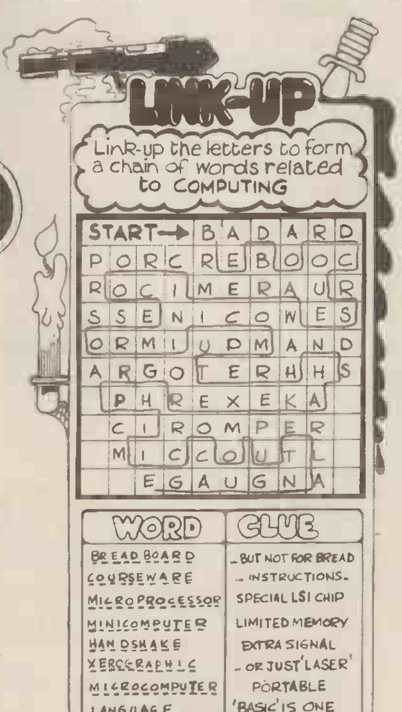
It is normal, in slowly changing temperatures, to see the "Correct" l.e.d. coming on just before the red or green one goes off. This is useful as it indicates "correct and rising" or "correct and falling". Note that in prolonged operation, the case of the mains-operated circuit becomes warm. □



INSPECTOR STRINGS SOLUTION

```
160 REM 1st SUSPECT "Dr LOOP"
170 A=500:B=200:C=20:D=67:E=60:F=25:G=20:H=500:
    I=400:J=3:K=3:L=3:M=25
180 REM RUN          WALL          SWIM        CYCLE
190 T=(2*A*J)/B+(C*D*K)/E+(2*F*L)/G+(2*H*M)/I
200 IF T<20 THEN PRINT "LADY REM IS GUILTY"
210 REM * * * * * * * * *
220 REM 2nd SUSPECT "LADY REM"
230 A=500:B=300:C=20:D=37:E=800:F=25:G=40:H=500:
    I=600:J=3:K=2:L=3:M=4.0
240 T=(2*A*J)/B+(C*D*K)/E+(2*F*L)/G+(2*H*M)/I
250 IF T<20 THEN PRINT "Dr LOOP IS GUILTY"
260 REM * * * * * * * * *
270 REM 3rd SUSPECT "LORD MODE"
280 A=500:B=400:C=20:D=70:E=800:F=25:G=40:H=500:
    I=700:J=2.1:K=2.1:L=2.1:M=2.4
290 T=(2*A*J)/B+(C*D*K)/E+(2*F*L)/G+(2*H*M)/I
300 IF T<20 THEN PRINT "LORD MODE IS GUILTY"
310 REM * * * * * * * *
320 REM 4th SUSPECT "BUTLER"
330 A=500:B=150:C=20:D=60:E=400:F=25:G=25:H=500:
    I=400:J=4:K=5:L=3:M=3
340 T=(2*A*J)/B+(C*D*K)/E+(2*F*L)/G+(2*H*M)/I
350 IF T<20 THEN PRINT "MISS GET IS GUILTY"
360 REM * * * * * * *
370 REM 5th SUSPECT "MISS GET"
380 A=500:B=250:C=20:D=49:E=500:F=25:G=40:H=500:
    I=600:J=4:K=2.1:L=3:M=3
390 T=(2*A*J)/B+(C*D*K)/E+(2*F*L)/G+(2*H*M)/I
400 IF T<20 THEN PRINT "BUTLER IS GUILTY"
410 REM * * * * * * *
420 REM 6th SUSPECT "Sir INKEY"
430 A=500:B=200:C=20:D=76:E=700:F=25:G=30:H=500:
    I=400:J=4:K=2.5:L=3:M=2.5
440 T=(2*A*J)/B+(C*D*K)/E+(2*F*L)/G+(2*H*M)/I
450 IF T<20 THEN PRINT "SIR INKEY IS GUILTY"
460 * KEY0 RUN|M
470 REM: PRESS RED KEY f0 to find THE MURDERER
```

LORD MODE IS GUILTY



The Man Behind the Symbol

No 2 Alexandre Volta

by Morgan Bradshaw

IN THE introductory article we noted that electric current as we now understand it was unknown and, that electrical experiments were based on the forces of attraction and repulsion. Then in 1798 Alessandro Volta, an Italian Physicist, after whom the Volt (Table 1) was named, produced his galvanic battery. But first, like Volta, we must hear the legend of the "frogs thighs".

One evening in 1790 Luigi Galvani, Professor of Medicine at the University of Bologna was patiently waiting for his wife Lucre to finish preparing his favourite dinner, a delicacy of frogs thighs. To skin the frogs the good lady had borrowed one of her husband's instruments. As she was finishing the last thigh the scalpel fell from her hand on to the rear nerve of the frog's thigh and at the same time touched the tin plate. Immediately the skinned thigh stretched and jumped away.

Senora Galvani repeated her actions several times before drawing her husband's attention to the mystery. He immediately "took charge" and exclaimed "I have discovered animal electricity—the primary source of life". As news of this incident spread no frog was safe as experiments with them became the rage of Bologna.

Volta at that time Professor of Physics at Pavia, did not believe in Galvani's animal electricity. He reasoned that the frogs legs played no part in the phenomenon other than providing moisture and that the electricity was produced by the steel of the scalpel and the tin plate set in a moist medium.

GALVANIC BATTERY

Volta pondered on his discovery and set about reproducing and multiplying the effect. In building his first battery Volta used a series of cups containing a saline solution, in which plates of zinc and silver were dipped. Each silver plate of a cup was connected with a wire to the zinc plate of the next cup, and the terminal plates of the series—zinc and silver—formed the poles of the battery from which electricity flowed.

His next battery known as the "pile" comprised a large number of zinc and copper discs separated by moistened cardboard stacked up so that the zinc of each pair was in direct contact with the copper of its neighbour. Volta found the pile gave a shock when opposite ends were touched simultaneously. His "pile" which generated electricity without any external aid was the start of a new era in electrical science, and was the first electric battery in the modern sense.

The modest Volta, wanting to acknowledge his debt to the old Professor called his pile the Galvanic Battery.

Galvani clung to his mistaken theory of "animal electricity" to the end. What he had really discovered was that electricity is a current that flows. He died penniless in 1797, not knowing that electricity would carry his name through the ages.

INTERNATIONAL RECOGNITION

Volta's fame grew and he constantly travelled throughout Europe demonstrating his electrical experiments. In 1801 Napoleon, fresh from his conquests of the Austrian forces, summoned him to Paris, to exhibit his battery before the Institute of France.

So impressed was Napoleon that he had a special medal struck in Volta's honour. Other honours quickly followed. Senator of the Kingdom of Lombardy; the Copley medal of the Royal Society; and, in 1815 the Emperor of Austria made him a director of the University of Padua.

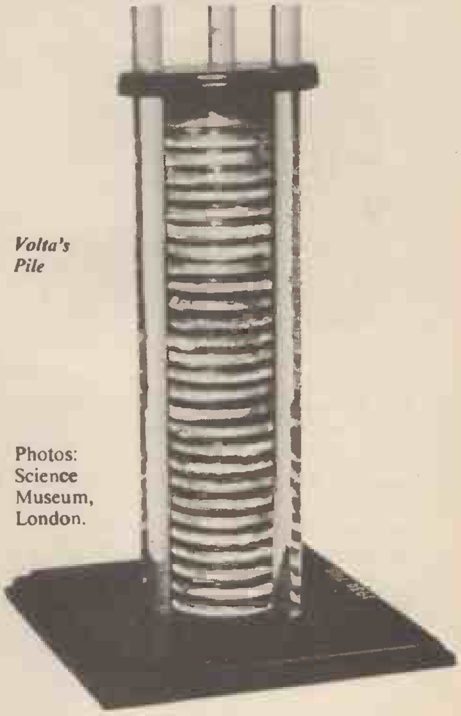
On his retirement he returned to his native town of Como where he died in March 1827. A statue and museum erected to his memory, which is situated on the lake shore is worth a visit.

Before he died Volta made a journey to London to attend a British Association Meeting at which he presented a Voltaic pile to Michael Faraday, whom he had previously met when Faraday had been touring Europe as personal assistant to Sir H. Davey of lamp fame, but more of that and the farad later.

Table 1: THE VOLT (V)

The Volt is the unit of electrical potential or "pressure". It can, perhaps, be most clearly understood by comparing it with water pressure. The higher a water tank is from a tap, the greater the water pressure at the tap. Similarly, with electricity the higher the voltage of a battery or generator, the higher the electric pressure at its output terminals.

The unit was named after Volta in 1836 and was adopted very slowly until it received international recognition in 1881, when it was one of the first practical units to be approved by the International Electrotechnical Committee.



Volta's Pile

Photos: Science Museum, London.

DOWN TO EARTH

BY GEORGE HYLTON

THE EFFECT of connecting a load resistance to a circuit often needs to be determined. It turns out that there are two ways of looking at the problem.

A typical situation is shown in Fig. 1. If, without the headphones, an a.c. output of, say, 1V appears at the collector, what is the output when the phones are connected?

SIMPLIFICATION

To begin with, the circuit can be simplified in various ways. We can assume that R1, being large, has no effect on the output. We can also assume that C2 is virtually a short-circuit to a.c. signals, and that a.c. can pass freely through the power supply. This means that any a.c. from the collector can flow to "earth" either via R2 and the power supply or via C2 and the headphones. For a.c. purposes R2 and the phones are in parallel.

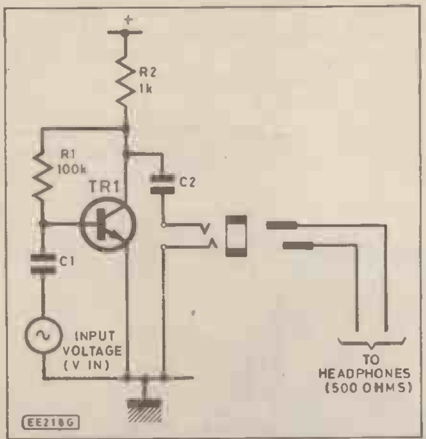


Fig. 1. Typical circuit for connection to an external load resistance.

CURRENT GENERATOR

If the transistor behaves as a current generator, then the circuit is essentially as in Fig. 2. Here the current from the generator divides between R2 and the phones. If we know what the current is, we can find out how much voltage is developed across the phones.

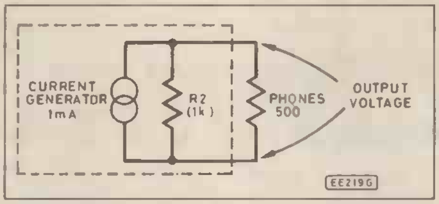


Fig. 2. Equivalent circuit in "current generator" form for the problem.

It is quite easy to find out the current. Assuming that the current-generating transistor pushes out the same current, irrespective of whether the load it drives is large or small, then if we know what the current is in one particular set of load conditions, we know it for all load conditions. We were told, to begin with, that without the phones the output is 1V a.c. This appears across R2 (1k), so the current must be 1mA a.c.

With the phones connected, the current is still 1mA, but now it flows not through 1k but through 1k in parallel with 500Ω. This parallel combination is the equivalent of a single resistance of 333Ω (approximately). The output voltage is what appears across 333Ω when 1mA flows; i.e. 333mV or 0·333V. So 0·333V appears across the 500Ω phones, giving a current of 0·666mA. Since R2 is twice 500Ω, the current through R2 is half this, 0·333mA and the two add together to give 1mA, as they should.

VOLTAGE GENERATOR

In Fig. 3, a voltage generator produces 1V, irrespective of the load connected to it. If the load is 1k, the current must be 1mA. If the load is 1·5k, it must be 2/3mA, or 0·666mA approximately. Now, 1·5k could be made up of 1k and 500Ω in series, as shown. A voltage of 0·666V must appear across the 1k and 0·333V across the 500Ω. So the 500Ω part experiences exactly the same voltage and current as in the first example. So does the 1k part.

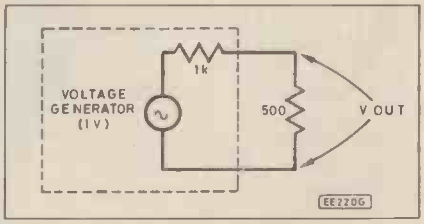


Fig. 3. A "voltage generator" circuit, which is an equally good conceptual arrangement of the actual circuit in Fig. 1.

BLACK BOXES

Now think of the dotted-round portions of Figs. 2 and 3 as "black boxes" which you can't look into. One (Fig. 3) contains a 1V voltage generator and a 1k "series" resistance, the other (Fig. 2) a 1mA current generator with 1k in parallel.

You are given the two black boxes, but not told which is which. Your problem is to find out. You can't open the boxes, but you can connect any meters or resistances you like to the terminals. Let's try a few tests. First, measure the output voltage: 1V in both cases. Now short the output and measure the current through the "short": 1mA in both cases. We already know that when a 500Ω load is connected, both circuits deliver the same voltage and current. Try 1k instead. No difference. Both give 0·5V and 0·5mA.

EQUIVALENCE

Whatever resistance you connect, the results are the same for each black box. There is no test which enables you to distinguish one from the other—apart from looking inside the box. For practical purposes the two circuits are the same.

This puzzle has a useful consequence. When we have a problem like the amplifier-loading problem we can tackle it by regarding the essential circuit *either* as a current generator with parallel resistance, *or* a voltage generator with series resistance. If we put in the right voltage, current, and resistance the two are indistinguishable—exact equivalents. We can then use whichever equivalent circuit is the more convenient. Never mind if a transistor is really a current generator. We can turn it into a voltage generator if that suits us, and get the same answers.

IN REALITY

In fact, a transistor isn't "really" a current generator. That idea itself is a convenient fiction, one way of turning what is really just a lump of semiconductor material into something electrical that can be understood.

You will not now, I hope, be surprised to learn that some equivalent circuits for a transistor incorporate voltage generators rather than current generators.

A TEST

But that's another topic. For the present, here's a quick test to find out whether your home-made equivalent circuits are really equivalent. Compute the output current into a zero-resistance load, and the output voltage into a infinite-resistance load. The answers should be the same for both circuits.

Consider this example: A battery produces 9V off-load but the voltage falls to 8V when 100mA is drawn. What are its equivalent circuits?

Looked at as a voltage generator (Fig. 3), the internal series resistance must be 10Ω, since this loses 1V at 100mA. If shorted, the current would (in theory: don't try it!) be 9V/10Ω = 900mA. The Fig. 2 equivalent is then a 900mA current generator with an internal shunt resistance of 10Ω. The idea of a battery churning out 900mA inside itself may seem ridiculous, but in electrical circuit terms it gives the right answers to the kinds of questions which actually crop up, which is all we want. In real life, of course, it would get a bit hot!

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

SOUND CASE

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The cases are available direct and cost £65 plus VAT. For more information contact:

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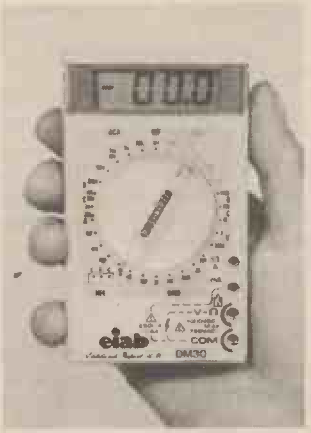
LCD MULTIMETER

A HAND-HELD digital multimeter, type DM30, from **Selectronix** has a half inch-high LCD digital display and is easily operated by a large single function/range rotary switch located in the centre of the case.



Nine functions and 29 measuring ranges are available from the multimeter. The resistance ranges are from 200 ohm to 20 megohm, in six switched ranges. The a.c. and d.c. amps ranges cover from 200μ to 200mA, in four ranges. There is also a position for 10A measurement.

The a.c. and d.c. voltage coverage is as follows: 200mV to 750V a.c. (five ranges) and 200mV to 1000V d.c. (five ranges). Other features include HFE transistor tester, diode test and overload protection on all ranges.

Supplied with two test probe leads, battery, spare fuse and soft carrying case, the DM30 Digital Multimeter costs £46.57, including VAT and p&p. For further details contact:

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The package comes complete with all components, circuit board and 136 page course booklet, needed to conduct a wide variety of investigations. The booklet assumes no previous knowledge of the subject and provides a self-study guide to basic digital electronics and computer building blocks.

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

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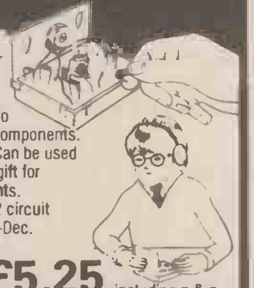

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INDEX TO ADVERTISERS

Bib Audio Video 426
BK Electronics 410
B.N.R.E.S. 411
Bull J. .... Cover II
Cirkit Holdings 463
Cricklewood Electronics 463
Croydon Discount Electronics 464
Den Fer Electronics 463
Electrovalue 410
Flight Electronics .... Cover III
Grandata 412
Greenweld 411
ICS Intertext 463
London Electronics College 411
Lyon Electronics 462
Magenta Electronics 414
Maplin Electronics .... Cover IV
Marco Trading 464
N.J. Edwards 462
Radio Component Specialists 457
Rapid Electronics 413
Riscomp Ltd 410, 463
Roden Products 462
Scientific Wire 462
T.K. Electronics 412

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