EVERYDAY ELECTRONICS and computer PROJECTS

APRIL 1985 £1·00

Cybervox Robot Voice
Insulation Tester
Fibrelarm

Australia $1.75 New Zealand $1.95 Malaysia $4.95

BI-PAK BARGAINS

HIGH QUALITY MODULES FOR STEREO, MONO & OTHER AUDIO EQUIPMENT

Audio Amplifiers

O/No.	POWER O/P R.M.S.	MAX SUP. VOLTAGE	PRICE
AL 30A	10 Watts	30V	£4.95
AL 60	25 Watts	30-50V	£5.92
AL 80	35 Watts	40-60V	£8.75
AL 120	50 Watts	50-70V	£15.22
AL 250	125 Watts	50-80V	£20.60

Stabilised Power Supplies —

Output current 2.5 Amps

O/No.	AC Input	Price
SPM 120/45	40-48V	£8.05
SPM 120/55	50-55V	£8.05
SPM 120/65	60-65V	£8.05

Mono Pre-Amplifiers – Operating Vtg. 40-65V

O/No.		Price
MM 100	Suitable for Disco Mixer	£14.75
MM 100G	Suitable for Guitar Pre-Amp Mixer	£14.75

Magnetic Cartridge Pre-Amplifier
O/No. MPA30. Sup Vtg. 20-30V. Price £4.29

Monographic Equaliser
GE 100 MKII 10 Channel OUR PRICE ONLY £20.00

Full Specifications and Data available on request.
Please send self-addressed envelope.

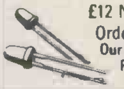
HYBRID LED COLOUR DISPLAYS

Red, Green, Yellow – .3/.5/.6 inch Mixed types and colours NUMERIC & OVER-FLOW Common Anode/Cathode. GaAsP/GaP. Brand New. Full Data incl.

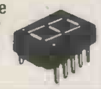
10 pieces (our mix) . . . £4.00
Normal Retail Value Over £10.00
Order No. VP58

BI-PAK'S OPTO SPECIAL

A selection of large and small sized LED's in various shapes, sizes & colours, together with 7 Segment Displays both anode & cathode plus photo transistors emitters and detectors. Cadmium Cell ORP12 and Germ. photo transistor OCP71 included. In all a total of 25 Opto pieces valued over £12 Normal Price



Order No. VP57
Our Super Value Price Just £5.00



SEMICONDUCTORS FROM AROUND THE WORLD

100 A collection of Transistors, Diodes, Rectifiers & Bridges SCR's, Triacs, I.C.'s & Opto's all of which are current every-day useable devices.

Guaranteed Value Over £10 Normal Retail Price.

Data etc in every pack. Order No. VP56

Our Price £4.00

EDGE CONNECTORS

2 × 5 way .1 Pitch Edge Connector (Gold) (O/No. AMP163279 2) £1.20 each. £50 per 50 off

PICK-UP COIL

Large telephone pick-up coil for high sensitivity. Suction pad to stick to telephone 90cm lead to 3.5 jack plug. Connects direct to cassette recorder. Dims 32mm(dia) × 17mm(body) 36mm(dia) sucker. O/No. YP87 **£1.00**

VALUE PACKS

Pak No	Qty	Description	Price
VP1	300	Assorted Resistors Mixed Types	£1.00
VP2	300	Carbon Resistors ¼-½ Watt Pre-Formed	£1.00
VP3	200	⅛ Watt Min Carbon Resistors Mixed	£1.00
VP4	150	½ Watt Resistors 100 ohm-1M Mixed	£1.00
VP5	200	Assorted Capacitors All Types	£1.00
VP6	200	Ceramic Caps Miniature – Mixed	£1.00
VP7	100	Mixed Ceramics Disc. 1pf – 56pf	£1.00
VP8	100	Mixed Ceramic Disc. 68pf – .015pf	£1.00
VP9	100	Assorted Polyester/Polystyrene Caps	£1.00
VP10	60	C280 Type Caps Metal Foil Mixed	£1.00
VP11	50	Electrolytics – All Sorts	£1.00
VP12	60	Bead Type Polystyrene Min Caps	£1.00
VP13	50	Silver Mica Caps Ass. 5.6pf – 150pf	£1.00
VP14	50	Silver Mica Caps Ass. 180pf – 4700pf	£1.00
VP15	25	.01uF 250v Min. layer metallised Polyester Capacitors	£1.00
VP16	50	Wirewound Res. 9W (avg) Ass. 1 ohm – 12K	£1.00
VP17	50	Metres PVC Covered Single Strand Wire Mixed Colours	£1.00
VP18	30	Metres PVC Covered Multi Strand Wire Mixed Colours	£1.00
VP19	40	Metres PVC Single/Multi Strand Hook-Up Wire Mixed	£1.00
VP20	6	Rocker Switches 5 Amp 240v	£1.00
VP21	15	2in. high bright RED LEDs in plastic encapsulation–Large area light source	£1.00
VP22	200	Sq. Inches Total, Copper Clad Board Mixed Sizes	£1.00
VP23	20	Assorted Slider Pots. Mixed Values	£1.00
VP24	10	Slider Pots. 40 mm 22K 5 × Log. 5 × Lin	£1.00
VP25	10	Slider Pots. 40 mm 47K 5 × Log. 5 × Lin	£1.00
VP26	15	Small .125" Red LED's	£1.00
VP27	15	Large .2" Red LED'S	£1.00
VP28	10	Rectangular .2" RED LED'S	£1.00
VP29	30	Ass. Zener Diodes 250mW – 2W Mixed Vlts. Coded	£1.00
VP30	10	Ass. 10W Zener Diodes Mixed Vlts. Coded	£1.00
VP31	10	5 Amp SCR's TO-66 50-400v Coded	£1.00
VP32	20	3 Amp SCR's TO-66 Up To 400v Uncoded	£1.00
VP33	200	Sil. Diodes Switching Like IN4148 DO-35	£1.00
VP34	200	Sil. Diodes Gen. Purpose Like OA200/BAX13/16	£1.00
VP35	50	1 Amp IN4000 Series Sil. Diodes Uncoded All Good	£1.00
VP37	8	Black Instrument Type Knobs With Pointer ¼" Std	£1.00
VP42	10	Black Heatsinks To Fit TO-3, TO-220 Ready Drilled	£1.00
VP43	4	Power-Fin Heatsinks 2 × 10-3 2 × TO-66 Size	£1.00
VP45	50	BC107/8 Type NPN Transistors Good Gen. Purpose Uncoded	£1.00
VP46	50	BC177/8 Type PNP Transistors Good Gen. Purpose Uncoded	£1.00
VP47	10	Silicon Power Trans. Similar 2N3055 Uncoded	£1.00
VP140	50	Precision Resistors. 2-1% tol.	£1.00
VP141	40	1N4002 Sil. Rects. 1A 100v preformed pitch	£1.00
VP142	4	40A Power Rectifiers Silicon TO48 300PIV	£1.00
VP143	5	BY187 12KV Sil. Diodes in carriers 2.5mA	£1.00
VP144	4	100K 1in. Multi-turn pots ideal vari cap tuning	£1.00
VP145	10	Assorted pots. inc. Dual & Switched types	£1.00
VP146	25	Solid Tantalum Caps. Mixed Values	£1.00

OPTICALLY COUPLED MODULES

1 pair SD1/131 Consisting 1 × LS600 Silicon Light Sensor & 1× Matched Gallium Arsenide Light Source – Type TIL23, on ready mounted fibre glass board. Including Data. Ideal Alarm projects etc. O/No. VP147.

BI-PAK Price ONLY £0.60 pr.

LED DISPLAYS

VP130	6	RED 7 Seg. CC 14mm × 7.5mm RDP FND353	£2.00
VP131	4	GREEN 7 Seg. CA .6" LDP XAN6520	£2.00
VP132	5	RED 7 Seg. CC .6" LDP XAN6940	£2.00
VP133	6	RED Over-flow .6" 3 × CA 3 × CC 6630/50	£2.00
VP134	5	GREEN Over-flow .6" CA XAN6530	£2.00
VP135	5	RED 7 Seg. CA .3" XAN3061	£2.00
VP136	3	DUAL RED 7 Seg. .5" CA DL527 DPR	£2.00
VP137	3	DUAL RED 7 Seg. .51" CA DL727 DPR	£2.00
VP138	20	Assorted LED Displays – Our mix with Data	£5.00

RDP = Right Hand Decimal Point; CC = Common Cathode
LDP = Left Hand Decimal Point; CA = Common Anode

ANTENNA SWITCH 2 and 3 WAY

Co-axial switch for one transceiver to two antennae or one antenna to two transceivers. Dims: 86 × 55 × 32mm (Body). O/No. VP 113 **£4.50**

As above but 3-way. O/No. VP 114 **£4.75**

HIGH PASS FILTER/SUPPRESSOR

CB/TV. High pass filter. Reduces unwanted signals picked up by antenna. Dims: 45 × 25 × 17mm. O/No. VP 115 **45p**

LOW PASS FILTER

Designed to reduce harmonics on the VHS and TV band.
Cut-off frequency: 30MHz.
V.S.W.R.: Less than 1.2 to 1.
Insertion loss: –0.2dB @ 27MHz.
Impedance: 50 ohms.
Dims: 80 × 55 × 40mm.
O/No. VP 116 **£2.75**

IC BARGAINS

40 Assorted TTL CMOS INTEGRATED CIRCUITS 74 Series & CD4000 Series – All new Gates. Flip-Flops – MSI etc. GREAT VALUE Data Book & Sheets included. 40 Pieces (Our Mix) £4.00 O/No. UP40

TRANSISTOR PACKS

VP150	20	BC183B Sil. Trans. NPN 30v 200mA Hfe240+ TO92	£1.00
VP151	25	BC171B Sil. Trans. NPN 45v 100mA Hfe240+ TO92	£1.00
VP152	15	TIS90 Sil. Trans. NPN 40v 400mA Hfe100+ TO92	£1.00
VP153	15	TIS91 Sil. Trans. PNP 40v 400mA Hfe100+ TO92	£1.00
VP154	15	MPSA56 Sil. Trans. PNP 80v 800mA Hfe50+ TO92	£1.00
VP155	20	BF595 Sil. Trans. NPN eqvt. BF184 H.F. TO92	£1.00
VP156	20	BF495 Sil. Trans. NPN eqvt. BF173 H.F. TO92	£1.00
VP157	15	ZTX500 Series Sil. Trans. PNP Plastic	£1.00
VP158	15	ZTX107 Sil. Trans. NPN eqvt. BC107 Plastic	£1.00
VP159	15	ZTX108 Sil. Trans. NPN eqvt. BC108 Plastic	£1.00
VP160	20	E5024 Sil. Trans. PNP eqvt. BC214L TO92	£1.00
VP161	25	BC183L Sil. Trans. NPN 30v 200mA TO92	£1.00
VP162	5	SJE5451 Sil. Power Trans. NPN 80v 4A Hfe20+	£1.00
VP163	2	NPN/PNP pairs Sil. Power Trans. like SJE5451	£1.00
VP164	4	2N6289 Sil. Power Trans. NPN 40v 40w 7A Hfe30+	£1.00
VP165	6	BFT33 NPN Sil. Trans. 80v 5A Hfe50-200 TO39	£1.00
VP166	5	BFT34 NPN Sil. Trans. 100v 5A Hfe50-200 TO39	£1.00
VP167	1	BUY69C NPN TO3 VCB 500 10A 100w Hfe15+	£1.00
VP168	10	BC478 eqvt. BCY71 PNP Sil. Trans. TO18	£1.00
VP169	10	BXS21 eqvt. BC394 NPN Sil. Trans. 80v 50mA TO18	£1.00
VP170	10	Assorted Power Trans. NPN/PNP Coded & Data	£1.00
VP171	10	BF355 NPN TO-39 Sil. Trans. eqvt. BF258 225v 100mA	£1.00
VP172	10	SM1502 PNP TO39 Sil. Trans. 100v 100mA Hfe100+	£1.00

TRANSISTORS

100 Silicon NPN Transistors. All Perfect. Coded Mixed. Types With Data And Eqvt. Sheet No Rejects. Fantasic Value. O/No. BP38 **£3.00**

100 Silicon PNP Transistors. All Perfect Coded. Mixed. Types With Data and Eqvt. Sheet. No Rejects. Real Value. O/No. BP39 **£3.00**

The best known Power Transmitter in the world 2N3055 NPN 115W. Our Bi-Pak Special Offer Price.

10 off	50 off	100 off
£3.50	£16.00	£30.00

BD312 COMPLIMENTARY PNP POWER TRANSISTORS TO 2N3055. Equivalent MJ2955 BD312 TO3. Special Price £0.70 each. 10 off £6.50

SEMICONDUCTORS FROM AROUND THE WORLD

100 A collection of Transistors, Diodes, Rectifiers & Bridges, SCRs, Triacs, I.C.s & Opto's all of which are current every day useable devices. Guaranteed Value Over £10 Normal Retail Price. Data etc. in every pack. Order No. VP56

Our Price £4.00

TRANSISTOR CLEARANCE

100 All Sorts Transistors. A mixed bag NPN-PNP Silicon & Germ. Mainly Uncoded You To Sort Pack includes instructions for making Simple Transistor Tester, Super Value. Order No. VP60. **£1.00**

150 De-soldered Silicon Transistors from boards 10mm leads all good. O/No. VP173 **£1.00**

TECASBOTY

THE ELECTRONIC COMPONENTS AND SEMICONDUCTOR BARGAIN OF THE YEAR!

This collection of Components and Semiconductors for the hobbyist is probably the most value-packed selection ever offered, it consists of Resistors, carbon and wirewound of various values. Capacitors: All types, sorts and sizes Including electrolytics. Potentiometers – single, dual, slider and preset. Switches, Fuses, Heatsinks, Wire, P.C.B. Board, Plugs, Sockets etc., PLUS a selection of Semiconductors for everyday use in popular Hobby Projects. These include: SCR's, Diodes, Rectifiers, Triacs & Bridges as well as a first class mix of Transistors and I.C.'s. In all, we estimate the value of this in current retail catalogues to be over £25! So, help yourself to a great surprise and order a Box TODAY – ONLY at BI-PAK. Remember, stocks are limited so hurry! You can call us on 0920 3182/3442 and order with your Barclaycard or Access Card – 24hr Answerphone Service NOW. Order No. VP 85.

just £7.00

PIEZO BUZZERS

PIEZO
Miniature round piezo-electric buzzer. White plastic. Low consumption.
Frequency: 4kH approx.
Output: 70dB (A) @ 1, typ.
Power: 12Vd.c. 4mA.
Dims: 22 (dia.) × 11.5mm.
Fixing Centres: 26.5mm.

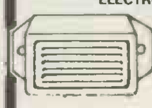
O/No. VP 107 **£1.05**

PIEZO

Piezo buzzer. White plastic. 90mm leads. For use on a.c. mains.
Frequency: 3.5kHz approx.
Output: 85dB (A) @ 1m typ.
Power: 240Va.c. 5mA.
Dims. 32 (dia.) × 14mm.
Fixing centres: 38mm.

O/No. VP 108 **£1.25**

ELECTRONIC BUZZER



Miniature electronic buzzers. Solid state. Ivory plastic. 150 leads Frequency: 500 Hz approx.
Dims: 22 × 16 × 15mm
Output: 82dB (A) @ 1m typ.
Fixing centres: 26mm.

3V 25mA: O/No. VP 82. 6V 25mA: VP 83
9V 25mA: O/No. VP 84. 12V 25mA: VP 86

95p each

POWER SUPPLY

OUR PRICE £3.75

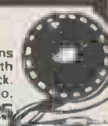
Power supply fits directly into 13 amp socket. Fused for safety. Polarity reversing socket. Voltage switch. Lead with multi plug input – 240v AC 50Hz Output –3 4.5 6 7.5 9 & 12v DC. Rating 300ma MW88.

TAPE RECORDER SWITCH

Unit to control motor of tape recorder. 1.8m cord and 2.5mm plug attached. On/Off switch. Dims: 55 × 20 × 20mm. O/No. VP 127 **£1.00**

(LEARN A LINGO) PILLOW SPEAKER

Slim under pillow unit. 80ohms 2" speaker. 1.5m lead with 3.5mm mono jack plug. Black. Dims: 65(dia) × 17mm. O/No. VP 88 **£1.25**



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Send your orders to Dept EE4 BI-PAK PO BOX 6 WARE, HERTS
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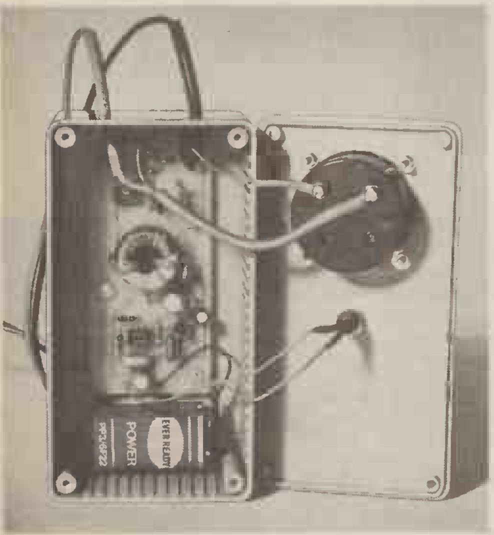
Remember you must add VAT at 15% to your order. Total Postage add £1.00 per Total order.

EVERYDAY
ELECTRONICS
and computer PROJECTS

VOL. 14 No. 4 APRIL 1985

ISSN 0262-3617

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



See Page 204

PROJECTS

CYBERVOX ROBOT VOICE by John M. H. Becker 192
Automatically translates your speech into robot dialect

INSULATION TESTER by Mark Stuart 200
Carry out your own safety checks with this low cost instrument

FIBRELARM by Gideon Tearle 220
Fail-proof security using fibre optic cable

IMMERSION HEATER CONTROL
by T. R. de Vaux Balbirnie 230
A hot water *quantity* programmer

SERIES

COMPUTER CLUB by Thakery 212
A fun outlook on computing—Simple loop program structure

ON SPEC by Mike Tooley BA 214
New regular feature devoted to the Sinclair Spectrum
—Intruder detection system interface

FAULT FINDING by E. A. Rule 218
Part Six: The cassette player—its problems and remedies

DIGITAL ELECTRONICS by D. W. Crabtree 226
Part Seven: Realistic computer design considerations

FEATURES

EDITORIAL 191

SHOPTALK by Mike Abbott 199
Product news and component buying

MAKING PRINTED CIRCUIT BOARDS by Stephen Ibbs 204
A fundamental look at how to etch your own boards

DOWN TO EARTH by George Hylton 209
Operational Amplifiers: theory and applications

CIRCUIT EXCHANGE 210
A forum for readers' ideas

PLEASE TAKE NOTE 210
Sound Operated Flash; Headlight Activated Switch;
Digital Electronics; Motorcycle Codelock (Circuit Exchange)

EVERYDAY NEWS 216
What's happening in the world of electronics

FOR YOUR ENTERTAINMENT by Barry Fox 224
Manual for Divorce; Reverse Charge; Hot Line

COUNTER INTELLIGENCE by Paul Young 229
A retailer comments

NEW PRODUCTS 235
Facts and photos of instruments, equipment and tools

PRINTED CIRCUIT BOARD SERVICE 236

Our May 1985 issue will be published on Friday, April 19.
See page 211 for details.

Readers' Services ● Editorial and Advertisement Departments 191

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TOP QUALITY COMPONENTS, LOW PRICES, QUANTITY DISCOUNTS, FAST SERVICE
FREE P&P OVER £20

LINEAR ICs

555	21	ML926	1.80
556	40	ML927	1.80
741	22	ML928	1.80
748	30	ML929	1.80
AD590	3.30	MM74C911	6.50
AY38910	3.90	MM74C915	96
CA3080	65	MM74C922	3.90
CA3130	85	MM74C926	4.50
CA3140	40	NE567	1.25
ICL7107	9.00	S566B	2.20
ICL7126	8.00	S576D	2.20
ICM7555	95	SAB0529	3.50
ICM8038	3.10	SAB0600	2.50
LF351	40	SL440	1.95
LF353	70	SL441	1.35
LF356	80	SL486	1.85
LM324	40	SL490	2.05
LM334Z	85	TBA800	70
LM335Z	1.20	TBA810AS	90
LM339	40	TDA1024	1.20
LM348	55	TDA4290	1.98
LM358	48	TL061	40
LM380	1.20	TL062	60
LM381	1.40	TL064	1.30
LM382	1.10	TL071	45
LM386	88	TL072	70
LM1035	3.95	TL074	1.30
LM1458	34	TL081	35
LM2917	1.90	TL082	48
LM3900	68	TL084	1.00
LM3909	80	TL170	50
LM3911	1.75	TL507C	1.20
LM3914	2.40	TMS1121	8.50
LM3915	2.40	TMS1601	9.50
LM13600	1.10	UA2240	1.45
LS7210	4.75	ULN2003	75
LS7220	2.75	ULN2004	75
LS7225	2.60	ZN414	80
MF10C	2.97	ZN425	3.40
ML922	3.80	ZN427	5.70
ML924	2.50	ZN428	4.50
ML925	2.10	ZN1034E	1.80

REGULATORS

78L05/12/15	30	7805/12/15	50
79L05/12/15	55	7905	55
Variable LM723	40		
LM317T	85	LM338K(5A)	5.00

CMOS

4000	16	4028	45
4001	18	4040	49
4002	18	4043	42
4007	16	4046	60
4011	18	4047	55
4012	18	4049	32
4013	25	4050	35
4015	42	4060	55
4016	30	4069	18
4017	39	4070	18
4019	28	4071	18
4023	16	4077	20
4024	35	4081	16
4025	16	4093	35
4026	70	4511	48
4027	28	4514	1.00

MEMORIES

2716	3.10	2764	4.75
2732	3.20	6810	1.40

SCRs

C106D	28	.6A/50V	35
TIC106D	40	.6A/200V	35

CRYSTALS

32kHz	80	4.1943M	1.50
1.8432M	2.30	4.1952M	1.80
2.4576M	1.80	6.0M	1.30
3.2768M	1.60	6.144M	1.40
4.0M	1.20		

OPTO

3mm red	9	5mm red	9
3mm green	12	5mm green	12
3mm yellow	12	5mm yellow	12
LED CLIPS	3		

Rectangular, square, arrow or triangular (flat lace)
Red 15 Green 18 Yellow 18

Bicolour	65	Flashing LEDs	
Tricolour Red			50
Round	32	Red	
Rectangular	45	Continuous	55
IL74/TIL111	55	MOC3020	1.10
ILQ74	1.70	MOC3040	1.50
ORP12	75	MEL11	35

Seven Segment LED Displays

DL704 .3 cc	75	4-Dig 1.8" cc	
FND500 .5 ca	85	DIRECT DRIVE	
FND507 .5 ca	85	Display	7.00

COMPUTER ICs

6802	2.45	6852	2.40
6809	4.95	Z80A CPU	1.55
6821	1.20	Z80A CTC	1.55
6850	1.50	Z80A PIO	1.55

IDC CONNECTORS

	Rt. Ang. PCB Plug	Socket
20 way	90	100
26 way	1.00	1.15
34 way	1.10	1.30
40 way	1.30	1.45

400V TRIACS

4A	49	8A	58
6A with diac	85	12A	85
8A isolated		16A	95
tab	65	25A	2.10
8A sensitive		Diac	18
gate	66		

SOCKETS

(Low profile)

8 pin	7	22 pin	15
14 pin	8	24 pin	17
16 pin	10	28 pin	17
18 pin	12	40 pin	25
20 pin	14		

ZIF Sockets

24 pin	3.20	40 pin	4.20

RIBBON CABLE

GREY per metre		Colour Coded per metre	
20 way	95		
26 way	1.50	10 way	70
40 way	2.20	20 way	1.40

Screened cables and connecting wire also stocked.

DIODES

1N4001	4	1N5401	11
1N4004	6	1N5404	13
1N4007	7	1N4148	3
400mW Zeners	8	1.3W Zeners	15

NICADS

PP3	3.95	C 1.2A/h	2.00
AA	90	D 1.2A/hr	2.10
Universal Charger			6.50
PP3 Charger			3.50

SWITCHES

Push to Make			15
Push to Break			25
Push on/off (3A mains)			50
Sub. Min. Toggle:			
SPST	50	DPDT	65
DP Centre Off			89
Slider DPDT			15
DIL Switches:			
4 way	80	6 way	90
8-way	1.00		
Rotary Switches			50
1P12W 3P4W 4P3W			

TRANSFORMERS

Chassis Mounting	
6-0-6V/100mA	1.10
9-0-9V/100mA	1.25
12-0-12V/100mA	1.25
9-0-9V/1A	2.30
12-0-12V/1A	2.90
15-0-15V/1A	3.40

BOXES

Plastic with lid

B1 75 × 56 × 35mm	85
B2 95 × 71 × 35	90
B3 115 × 95 × 37	1.10
B4 140 × 90 × 55	1.50
B5 207 × 122 × 77	2.75
B6 213 × 142 × 57	2.70

Other boxes including wide range of diecast, aluminium and Veroboxes in our catalogue.

D CONNECTORS

	9w	15w	25w
Plug	55	65	90
Socket	80	1.10	1.30
Cover	95	95	95
Right Angle Plug 15W			1.80
Right Angle Socket 15W			2.10

PRINTED CIRCUITS

Fibre glass copper clad laminate

	Plain	Sensitised
160 × 100mm	80	1.80
220 × 100mm	1.55	2.30

Etch resist transfers.
Pads, straight/curved tracks

Dil pads (state type)	50
Ferric Chloride (250mL)	1.50
Etch Resist Pen	75
Titan 12v Drill	10.25
Reliant 9v Drill	6.90
Twist Drills	25

SPEAKERS

1.5in. 8ohm	78	2in. 8ohm	60
2.25in. 8ohm	60	2.5in 64ohm	70
5.5in. 8ohm 8W Horn			6.15
Crystal Earpiece			45
Magnetic Earpiece			25
Ultrasonic trans. (pair)			3.50
Crystal mic insert			50
Telephone pick up coil			65

BUZZERS

6v Metal	75	12V Metal	83
6/12V Plastic Electronic			75
Piezo low current 4mA at 12V			85
Piezo 240V ac			1.00
7-tune alarm unit			2.30

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BOOKS BY T.I. BABANI ELEKTOR STOCKED

KITS

CT1000K	Clock/Timer	£14.90
CT1000KB*	Clock/Timer + Box	£17.40
XK101	Electronic Lock	£11.50
XK102*	3-Note Door Chime	£5.50
XK104	Solid State Switch	£2.40
XK112	Mains Wiring Remote Control	£42.00
XK113	MW Radio	£5.50
TD300K †	300W Touchdimmer	£7.75
TS300K †	300W Touchswitch	£7.75
LD300K †	300W Lightdimmer	£3.95
TDR300K †	IR Remote Controlled Lightdimmer	£14.95
MK6*	IR Transmitter for TDR300K and MK7	£4.50
TDE/K †	Touchdimmer extension	£2.50
TSA300K †	Time Delay Touch Switch (300W)	£5.00
MK1	Thermostat	£4.60
MK2	Solid State Relay	£2.60
MK4	Proportional Temperature Controller	£6.50
MK5	Mains Timer (1KW)	£4.50
MK7	Single Channel Infra Red Receiver (240V)	£10.50
MK16	Mains Powered IR Transmitter	£3.50
MK17	Single Channel Infra Red Receiver (12V)	£10.50

* Includes box. † Includes front panel.
All kits include PCBs, components and assembly instructions.
For further details send S.A.E.

DISCO LIGHTING KITS

DL1000K – This value-for-money 4-way chaser features bi-directional sequence and dimming. 1kW per channel. **£15.95**
DLZ1000K – A lower cost uni-directional version of the above. Zero switching to reduce interference. **£8.95**
Optional opto input allowing audio 'beat'/light response (DLA/1) **70p**
DL3000K – 3-channel sound to light kit features zero voltage switching, automatic level control and built-in microphone. 1kW per channel. **£12.95**

MICROPROCESSOR TIMER KIT

Designed to control 4 outputs independently switching on and off at preset times over a 7 day cycle. LED display of time and day, easily programmed via 20 way keyboard. Ideal for central heating control (including different switching times for weekends). Battery back up circuit. Includes box. 18 time settings.

CT6000K £39.00

XK114. Relay Kit for CT6000 includes PCB, connectors and one relay. Will accept up to 4 relays. 3A 240V c/o contacts £3.90

701 115 Additional Relays £1.65

PANTEC KITS

PN2	FM Micro Transmitter	£7.50
PN3	Stabilised Power Supply	£13.70
PN5	2 × 10w Stereo Amplifier	£14.50
PN6	2 × 40w Stereo Amplifier	£24.95
PN7	Pushbutton Stereo Preamp	£12.80
PN8	Tone & Volume Control	£13.60
PN11	3w FM Transmitter	£11.95
PN13	Single Channel FM Transmitter	£9.80
PN14	Receiver for above	£15.50

DVM/ULTRA SENSITIVE THERMOMETER KIT

Based on the ICL 7126 and a 3½ digit liquid crystal display, this kit will form the basis of a digital multimeter (only a few additional resistors and switches are required — details supplied), or a sensitive digital thermometer (−50°C to +150°C) reading 0.1°C. The kit has a sensitivity of 200mV for a full-scale reading automatic polarity and overload indication. Typical battery life of 2 years (PP3). £15.50

LCD DIGITAL MULTIMETERS

LOW COST! 10M ohm. 3½ digit 0.4 in display. Auto zero and polarity, low batt. indication, overload protection. Includes test leads, battery, spare fuse, manual, carrying case.
AC Volts: 0 200 500.
DC Volts: 0-2-20-200-1000.
DC Current: 0-20m-200mA.
Resistance: 0-2k-20k-200k-2M.
Size: 138 × 86 × 36mm.
(405 202) £25.95

Professional – 10M, 0.5 in, 3½ digit: Overrange and low battery indication. Overload protection. Includes leads, spare fuse, battery, manual and case. Transistor Checker. Size: 175 × 93 × 42mm.
AC Volts: 0-200-750.
DC Volts: 0-200m-2-20-200-1000.
DC Current: 0-20u-2m-20m-200mA. 0-10A.
Ohms: 0-200-2k-20k-200k-2M, 0-20M.
(405 204) £33.50

Auto Ranging. 3½ digit 10mm display. Continuity buzzer, low battery, overload and range indication. 10A internal shunt for AC/DC current measurement. Carrying case supplied.
AC Volts: 0-2-20-200-600.
DC Volts: 0-0.2-2-20-200-1000.
AC Current: 0-200mA, 0-10A.
DC Current: 0-200mA/0-10A.
Resistance: 0-200-2k-20k-200k, 0-2M.
Size: 160 × 85 × 29mm.
(405 206) £44.85

High Sensitivity Temperature Probe. For use with a multimeter to measure temperatures from −50°C to +250°C. Accuracy: 1.5°C@25°C, 2°C@100°C. Response time (in water), 5 seconds. Includes case, calibrated scale and instructions. (405 220) £8.50

INFRA-RED REMOTE CONTROL KITS

These kits are designed to enable infra-red remote control to be incorporated into virtually any application from switching car locks or alarms to controlling Hi Fi or TV. The application will determine the interface circuitry between the receiver and the controlled device. General instructions and applications are supplied. The kits are coded and provide a high degree of security and noise immunity.

MK 18 Transmitter Kit – for use with MK11/MK12 receivers. Requires PP3 battery. Size 8 × 2 × 13cms. Range approx 60 ft £6.80

Keyboards for MK18
MK9 4-way for use with MK12 £1.90
MK10 16-way for use with MK12 £5.40
MK13 11 way for use with MK11 £4.35

MK11 Receiver Kit – mains powered. Provides 10 latched plus 3 analogue outputs ideal for controlling audio amplifiers, TV or lighting where control of light brightness is required. £13.50

MK14 AC Power Controller Kit for (phase) controlling AC loads from MK11 analogue outputs, eg lamp dimming. £5.20

MK19 Stereo Amplifier Controller Kit for remote control of bass, treble and volume (or balance) by MKII. Includes a one of 10 decoder remote channel or input selection. May be connected between the pre-amp and power amp of almost any audio system. £10.70

MK12 Receiver Kit mains powered with 16 latched or momentary outputs. Latched version is for applications requiring one output on at a time, eg TV channel selection. Momentary type gives an output only during transmission. Lines may be latched as required.
Size 9 × 4 × 2cms £13.50

MK15 Dual Latched Solid State Relay for switching mains loads such as lamps, TVs, etc. from the outputs of the MK12 (momentary). 15 items may be switched independently using 8 MK15s. Triacs (not supplied) switch at mains zero to reduce interference £4.50

TK ELECTRONICS

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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 solderlugs	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

27128-250 £12.25

Brand new Hitachi product. Ideal for use with the BBC Micro. Please note this price is not a misprint!!

TRANSFORMERS

3VA PCB Mounting
2x6V@0.25A;2x9V@0.15A
2x12V@0.12A;2x15V@0.1A 180p

6VA PCB Mounting
2x6V@0.5A;2x9V@0.4A
2x12V@0.3A;2x15V@0.25A 270p

Standard. Chassis Mounting
6VA: 2x6V@0.5A; 2x9V@0.4A
2x12V@0.3A;2x15V@0.25A 240p

12VA: 2x6V@1A; 2x9V@0.6A
2x15V@0.4A;2x20V@0.3A 350p

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

SWITCHES

Submin 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.

MICRO

		27128-250	1225	6800	200	6522	330
		6116P3	390	6802	280	6532	520
		6264P15	2250	6809	600	6551	540
2716	310	4116P4	70	6810	140	8085A	320
2532	380	4164-15	480	6821	140	8156	380
2732 one time programmable	280	41256-15	2850	6840	360	8251	350
		Z80A CPU	290	6850	165	8253	370
		Z80A P10	320	6852	240	8255	320
2732	430	Z80A CTC	320	6875	500	8259	400
2764-250	430	Z80A S10	880	6880	100	MC1488	70
2764 BBC	430	Z80A DMA	880	6502	370	MC1489	70

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 dependent 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 ¼in, ½in, nuts and wshrs, 4BA ¼in, ½in, 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 gery ribbon	14P/ft
20 way grey ribbon	28p/ft

HARDWARE

PP3 battery clips	8
Red or black crocodile clips	6
Black pointer control knob	15
Pr Ultrasonic transducers	390
▶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

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		

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

DIODES

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

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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:		TIL32	40
red	12	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
FND500 0.5"	100	FND507 0.5"	100
10 bar DIL LED display, red			180

5mm superbright LED 250mcd red 30

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

		IC7611	98	LM358	50	LM3915	265	NE567	130	TDA1024	115
555CMOS	80	ICL7621	190	LM377	210	LM13600	110	NE570	370	TL061	40
556CMOS	150	ICL7622	200	LM380	80	MC1310	150	NE571	370	TL062	65
709	38	ICL8038	295	LM381	150	MC1496	70	NE5532	160	TL064	105
741	16	ICL8211A	220	LM382	130	MC3302	75	NE5534	105	TL071	38
748	35	ICM7224	785	LM384	140	MC3340	130	RC4136	65	TL072	60
AY31270	720	ICM7555	80	LM386	90	MF10CN	330	RC4558	40	TL074	110
AY38910	390	ICM7556	150	LM387	120	ML922	390	SL486	195	TL081	30
AY38912	430	LF347	150	LM393	60	ML924	290	SL490	220	TL082	50
CA3046	65	LF351	40	LM710	48	ML925	290	SN76018	150	TL084	105
CA3080E	65	LF353	75	LM711	60	ML926	210	SN76477	380	TL170	50
CA3089	200	LF356	90	LM725	70	ML927	210	SP8629	250	UA2240	140
CA3090AQ	375	LM10C	325	LM733	70	ML928	210	SP0256AL2	425	ULN2003	80
CA3130E	85	LM301A	30	LM741	16	ML929	210	Speech data	50	ULN2004	80
CA3140E	38	LM311	45	LM747	60	NE529	225	TBA800	70	XR2206	365
CA3160	95	LM318	135	LM748	35	NE531	135	TBA810	90	ZN414	80
CA3136	260	LM324	45	LM1458	35	NE544	170	TBA820M	65	ZN423	135
CA3189	260	LM3342	85	LM2917N8	195	NE555	20	TBA950	220	ZN424P	130
CA3240E	100	LM3352	125	LM3900	45	NE556	45	TCA940	165	ZN425E	350
ICL7106	680	LM339	40	LM3909	85	NE565	115	TDA1008	320	ZN426E	300
		LM348	60	LM3914	265	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	38	TIP147	120
AF126	50	BC179	18	BD138	35	BFY56	30	2N2906A	28	2N5777	45	TIP2955	70
AF139	40	BC182	10	BD139	35	BRY39	50	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	BU208	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	36	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	38	VN88AF	120
BC115	22	BC214L	10	BF196	12	MJE3055	70	2N3706	10	TIP30B	38	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	38	ZTX109	11
BC137	40	BC308	10	BF199	18	MPSA05	25	2N3709	10	TIP31B	38	ZTX300	14
BC139	38	BC327	8	BF200	35	MPSA06	25	2N3772	170	TIP31C	35	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	13
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

	1+	25+
Carbon film		
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

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

BOXES

		Aluminium	
		3 x 2 x 1"	65
Plastic with lid & screws		4 x 2¾ x 1½"	95
		4 x 2½ x 2"	95
71x46x22mm	50	5 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	48	7428	30	7454	25	7493	55	74145	85	74173	100	74196	120
7407	48	7430	25	7460	25	7494	90	74147	130	74174	100	74197	85
7408	25	7432	36	7472	35	7495	70	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	4035	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	46	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	66	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	60	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	40	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	60	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	56		
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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MAGENTA

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Adventures with Electronics £3.58. Component pack £20.98 less battery.

VOL 14 Nº4 APRIL'85

EVERYDAY ELECTRONICS and computer PROJECTS

READERS' ENQUIRIES

We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply must be accompanied by a **stamped self-addressed envelope** or a **self-addressed envelope and international reply coupons.**

COMPONENT SUPPLIES

Readers should note that we do not supply electronic components for building the projects featured in EVERYDAY ELECTRONICS, but these requirements can be met by our advertisers.

All reasonable precautions are taken to ensure that the advice and data given to readers are reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it. Prices quoted are those current as we go to press.

OLD PROJECTS

We advise readers to check that all parts are still available before commencing any project in a back-dated issue, as we cannot guarantee the indefinite availability of components used.

We regret that **we cannot provide data or answer queries on projects that are more than five years old.**

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Binders to hold one volume (12 issues) are available from the above address for £5.50 inclusive of postage and packing worldwide.

PCBs

OVER THE past few years more and more EE projects have been built on printed circuit boards rather than Veroboard or any other constructional form. The introduction of the p.c.b. service has encouraged readers to build using this method and we also supply boards to companies, education departments and training establishments both in the UK and around the world.

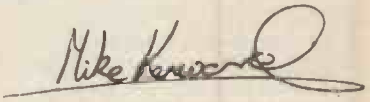
Of course p.c.b.s are used in virtually all forms of commercial equipment, they are very reliable, make wiring up easier, help to eliminate mistakes, enable easier checking and usually result in a neater job. This does not mean that there is no place for Veroboard or plug-in breadboarding systems; they continue to provide excellent means of building prototype and one off units and Veroboard is particularly suitable for hobby electronics.

In this issue we take a look at how the hobbyist can make his own p.c.b.s, either from our designs or to meet his own requirements. Even if you never intend to make your own board this article is well worth reading since an understanding of the principles involved in p.c.b. manufacture is always good background knowledge for the user.

FIBRELARM

The *Fibrelarm* published in this issue is a development of a Bike-A-Larm which won Gideon Tearle his second consecutive prize in the Schools Design Prize competition organized by The Design Council and sponsored by Thorn EMI. Gideon, who is 14, has designed the first EE project to use fibre optics. The use of the optical fibre in this application is an excellent idea and prevents anyone shorting and cutting the loop, as they could with a wire loop. *Fibrelarm* is very secure and, since it can operate a large loop, is also versatile.

We are pleased to be able to encourage such designs and hopefully help a little by publishing the results.. It is apparent that EE plays an important part in the dissemination of information and ideas in electronics, particularly in the educational areas. We intend to continue this and indeed develop our involvement in this important sector.



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CYBERVOX ROBOT VOICE

JOHN M.H. BECKER

AS ANY ANDROID knows, cybernetics is a multilimbed field that also includes robotics. Amongst themselves robots probably banter together in a high speed din of binary, but for human-robot chatting, a vocal interface is needed. The "Cybervox" is just such an interface. Translational confrontations are catered for by producing variations of the Dalek dialect, the cavernous cyborg lingo, and some unidentified alien gibberish just in case.

This multi-lingual module consists of a ring modulator, a reverb unit and a voice gate, with five panel controls and two switches to select the desired vernacular. It is battery powered and can be used with many different speech sources including most microphones, cassette decks and pre-amplifiers. Budding robot communicators are referred to the block diagram in Fig. 1.

GENERAL DESCRIPTION

A voice signal is brought into either the high or the low level input socket, preamplified at an adjustable gain level, fed to the ring modulator controlled by the variable speed and depth low frequency oscillator. The modulated signal then passes through the mixer to the delay stage through which it travels at a variable rate determined by the frequency of the high speed oscillator.

From there it goes to the first of two filter stages where a proportion can be fed back to the delay loop via the mixer. It also passes through the second filter, and on to the voice gate. This consists of two sections, the first being the gate open-close control activated by the signal from the second pre-amp stage, and the other being the gate itself conducting the processed signal through at a level determined by the control section. The final signal can be fed to a normal amplifier system.

INPUT STAGE

Low level voice signals from sources such as microphones are brought in to the first pre-amp stage IC1a where the gain is set at roughly 100 by the relationship of R2 to R3. From here they go to the second pre-amp IC1b which also has a separate input, for higher level signals.

Since IC1b is connected as a mixer, signals from both inputs could be brought in simultaneously. It also acts as a gain stage and low pass filter restricting frequencies above the range set by C4 and C5, though the characteristics will be slightly modified by the setting of VR1.

At 200Hz the gain can be varied by VR1 from one-tenth to 10, at 1kHz the maximum gain is about 2.5. The preamplified signal is then split to the voice gate control stage, and to the ring modulator.

RING MODULATOR

This is the heart of the Dalek type voice production section. IC3 is a balanced modulator-demodulator chip that has two signal inputs and two carrier inputs. In this circuit only one of each is used for the signal and carrier, but the bias on their counterparts is also important for correct operation.

In simple terms, if a carrier frequency is modulated by another, the frequency at the two antiphase outputs will consist of the sum and the difference of the two. Under ideal conditions, suppose the carrier is at 3kHz and the modulating signal at 2kHz, the output will consist of 5kHz (3 + 2kHz) and 1kHz (3 − 2kHz). In reality life is never that simple and using voice frequencies that consist of numerous harmonics and odd waveforms, other combinations of composite waveforms are produced for a given carrier frequency.

With a low frequency carrier, say between 7Hz and 30Hz, variations on the Dalek modulation theme occur.

As the carrier increases so more exotic sounds are produced, gradually acquiring a "metallic" sort of audio fringe at carrier frequencies between 400Hz and 1kHz. Beyond that they lose their intelligibility until by the maximum of 3.5kHz complete gibberish results.

The carrier frequency is generated by the oscillator around IC2a and IC2b. As the output of IC2a crosses the comparator trip point governed by R39–41 so IC2b changes its output state. C19 then varies its charge accordingly at a rate set by the total resistance of R42 and VR6, until the trip point is again crossed, whereupon the cycle reverses. The output from IC2a is a triangular waveform of some 2.5V peak-to-peak. The frequency range available is basically set by C19, which on its own offers a range of 200Hz to 3.5kHz. S1 can also switch in C18, which reduces the range to about 7Hz to 130Hz. The former range is more suited to exotic modulation effects, becoming unintelligible at the extreme limit, and the latter range more suited to Dalek-type vocalisations.

The output of IC2a is taken via C20 and the attenuator R43 to one carrier input of IC3. In the absence of a signal the two carrier inputs, pins 8 and 10 would be held similarly biased by the voltages applied by the equal resistance series R15/44, R16/45. If both inputs are held in exact equilibrium then the modulation signal from IC1b would have no effect and no output would be produced.

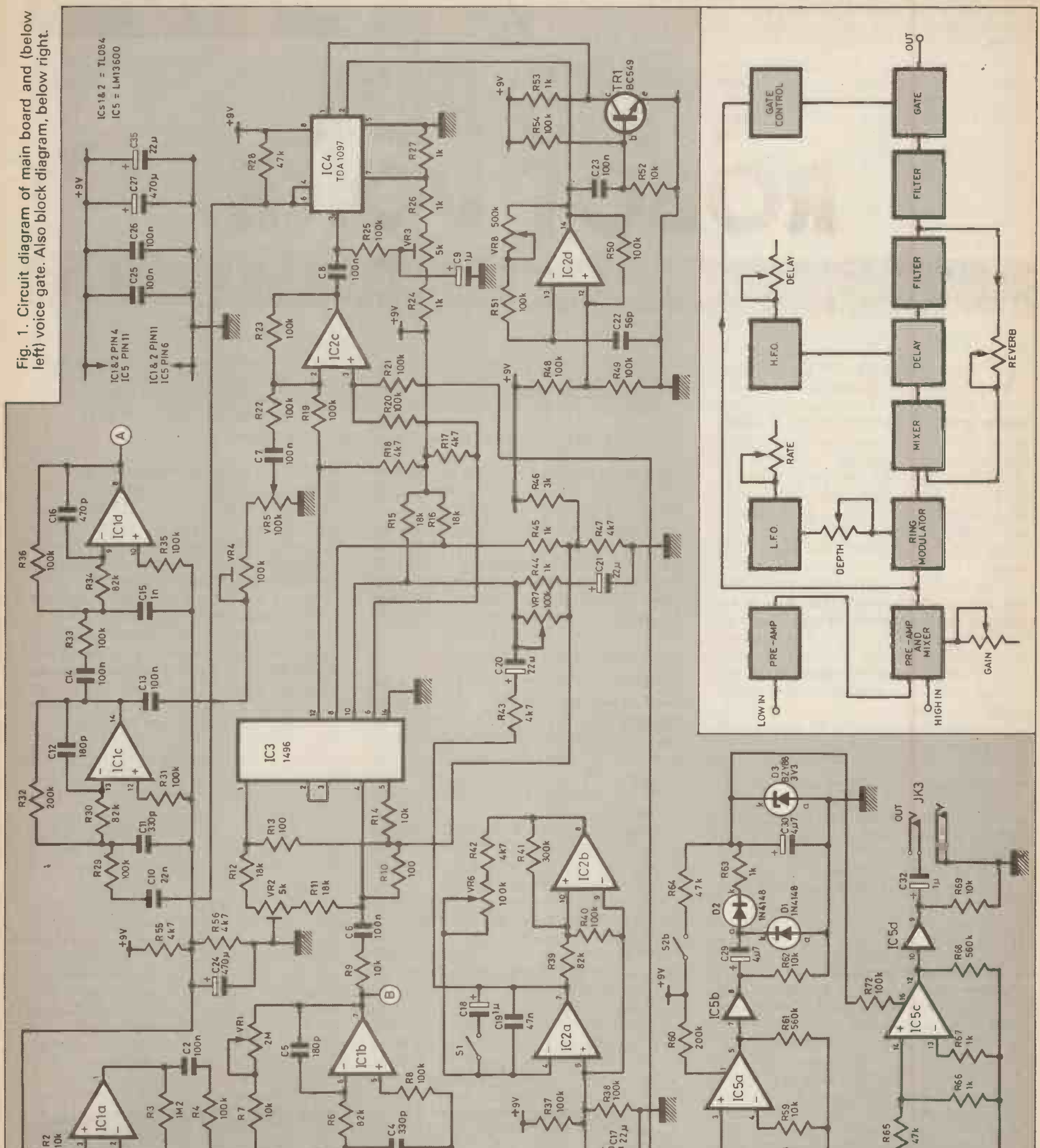


Fig. 1. Circuit diagram of main board and (below left) voice gate. Also block diagram, below right.

In the presence of a carrier signal or d.c. imbalance, the input signal from IC1b and the carrier interact and a composite output results. The modulation inputs, pins 1 and 4, are similarly held at equilibrium by the resistor series R12/13, and R11/10. VR2 is in series with both so that an exact balance point can be achieved. In the absence of a signal from IC1b, with the modulation inputs held in balance, the carrier signal from IC2a is not allowed to pass through.

In practice full suppression of the carrier signal is not possible, and at full carrier strength of 400mV about 10mV p-p breakthrough at each output of IC3 is likely to be experienced. The implications of this are discussed later. In this unit exact balancing of the carrier input bias is not required as it is desirable to be able to vary the emphasis of the carrier waveform, to the extent of removing it entirely allowing only the voice to pass through. VR7 is used as a variable parallel shunt; at maximum resistance it makes no significant difference to the potential drop at the junction of R15 and R44 and the maximum modulating strength is then governed by the ratio of R43 to R44.

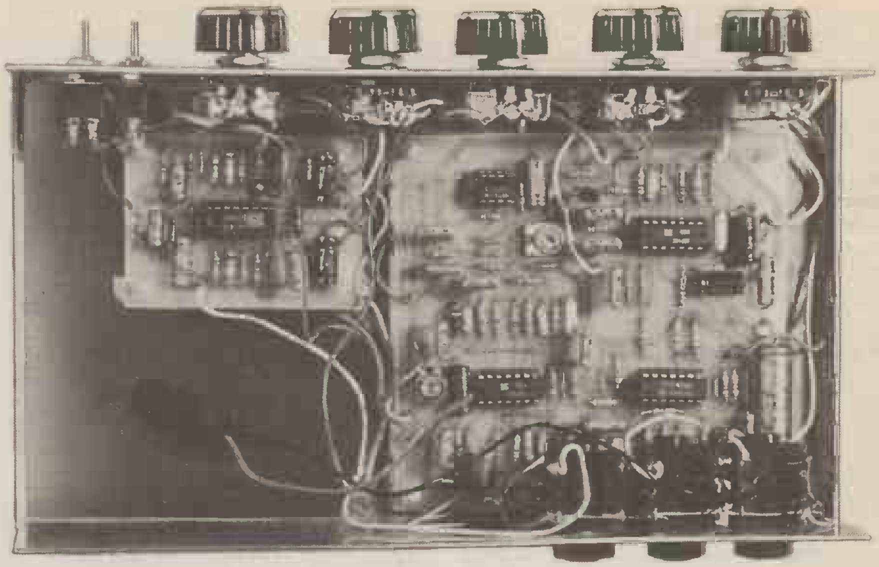
As VR7 is reduced, so too is the carrier level by the diminishing drop across it and R44, and at the same time the balance between the two carrier inputs, pins 8 and 10, is modified. At minimum resistance of VR7, the carrier level is reduced to nil, and the imbalance between the two carrier inputs allows the voice signal to pass through without frequency modification.

The maximum amplitude available at the two outputs of IC3, pins 6 and 12, is governed by the degree of imbalance between the carrier inputs, the current through R14, and the value of the two load resistors R17 and R18. The two antiphase signals are then summed at the differential amplifier IC2c which also serves as a mixer to the feedback loop signal ultimately coming from VR5.

DELAY STAGE

To create a reverberation effect, a time delay has to be given to a signal that is then fed back upon itself. The output from IC2c goes to IC4 which is a 1536 stage delay chip. An optimum d.c. bias is required at its input in order to maintain an even waveform shape of the signal passing through. This bias is delivered from VR3 via R25. IC4 is a recently-introduced, but otherwise standard bucket-brigade device that passes a signal through each "bucket" stage at a rate set by a split-phase clock signal.

The clock is generated by IC2d which is connected as a squarewave oscillator with a frequency set by C22 and its charging rate controlled by VR8 and R51. At maximum resistance of VR8, the clock frequency is at its slowest of around 13kHz, and the time delay in IC4 is at its longest of 59ms. The highest clock of 66kHz gives a delay time of 12ms. The exact delay in milliseconds for a given frequency can be calculated as—(number of delay stages/clock frequency in Hz) × 500. The antiphase counterpart to the clock is achieved by inverting the square wave at TR1. The amplitude imbalance between the two is unimportant in this instance. The twin outputs of IC4 are summed at R28 and sent for filtering in the circuit around IC1c.



Internal view of the Cybervox Robot Voice with all interwiring complete.

FILTER STAGES

It is inherent in bucket-brigade delay line chips that a proportion of the clocking signal is carried over into the output. Even though this lies above 13kHz, it is still desirable to remove most of it. C11 and C12 cause the first filter IC1c to mop up about 15dB of a 13kHz clock, and progressively more of higher clock frequencies. The resulting output is sufficiently clean to be fed back to the delay loop to produce the reverb effect.

The amount of reverb and its quality is governed by the amount of delay and feedback. If too much feedback is given, a perpetual loop can result, causing howl. VR4 is thus inserted and adjusted to keep the feedback just below the critical howl point when VR5 is fully up. Howl is particularly prone to occur with high level bass signals, and a 6dB cut is given to signals at 100Hz, to slightly restrict the lower end of the audio spectrum. From IC1c, the processed signal has the clock residual further removed by the second filter stage IC1d, with a cut-off point set by C15 and C16, and giving an additional 26dB cut to a 13kHz clock.

VOICE GATE

With an ideal response from IC3, and with no carrier breakthrough the signal would at this stage be suitable for feeding direct to a normal amplifier. However, although the maximum signal output can be around 1.5V and the maximum summed breakthrough is only about 20mV, this 37dB difference was found to be unsatisfactory especially in the absence of a voice input. As the maximum frequency of the carrier is up to 3.5kHz, it is not possible in a simple unit to filter it out without also losing the voice signal—an obviously undesirable solution!

In a more complex unit a steep notch filter tracking with the carrier control, could perhaps achieve the required selective reduction. For this unit though, a voice-operated gate provides a simple alternative. This is not just a straightforward electronic switch operating on and off in response to a voice input, but it has also been given a degree of amplitude-following to smooth the start and finish envelope. The processed signal from IC1d is brought to the voltage controlled amplifier IC5c.

In fact this is a current controlled amplifier, but as the current on its control node will change with the variation of the voltage across R72, it can be regarded as a VCA. The signal is first attentuated by R65 and R66 to a level respected by IC5c. With no current flowing through R72, the gate will not conduct; as the current rises, so the conductance increases and with it the output signal amplitude as additionally set by R68. Buffered by IC5d it can be delivered to the normal amplifier. The control signal is derived from the unprocessed pre-amplified one from IC1b.

This is further amplified due to the current through R60 and the value of R61. IC5b buffers and presents it to the diode pump network C29, D1, D2 to be stored in C30. As the amplitude varies, so does the charge on C30, with a maximum limit set by the Zener D3. The varying charge then controls the current through R72, and thus the output volume. The envelope shape has been selected to give a fast attack set by R63, and a moderate decay set by R72. The overall effect is not only suppression of carrier and other noise breakthrough during speech pauses, but also deliberately introduces a slightly staccato effect to the robot voice.

This is best emphasised by selecting a gain at IC1b that does not allow external background noise to undesirably trigger the gate. Despite the high gain given at IC5a the crosstalk between all stages of IC5 is not intrusive. When the unit is used without the carrier, the gate can be switched out by S2, which applies a fixed voltage to C30 to maintain a constant signal gain, and to shunt the input of IC5a to the reference line so eliminating the gate controller variations.

POWER SUPPLY

The unit is designed to run from a 9 volt battery drawing only about 25mA. Several intermediate reference levels occur throughout the circuit, the main one which supplies IC1a–d and IC2c is set by R55 and R56 at half the battery voltage level. The large value given to the smoothing capacitor C24 enables the preamp stages IC1a/b to give high gain with minimal circuit noise.

The expedient of providing two 0V connection points to the main p.c.b. also minimises high gain noise problems. The circuit will operate from a power supply up to 16V, but only if C24, C27 and C35 have their ratings increased accordingly. Both input jack sockets are wired as battery on/off switches and a mono jack plug must be used with one or other of them for correct operation.

ASSEMBLY

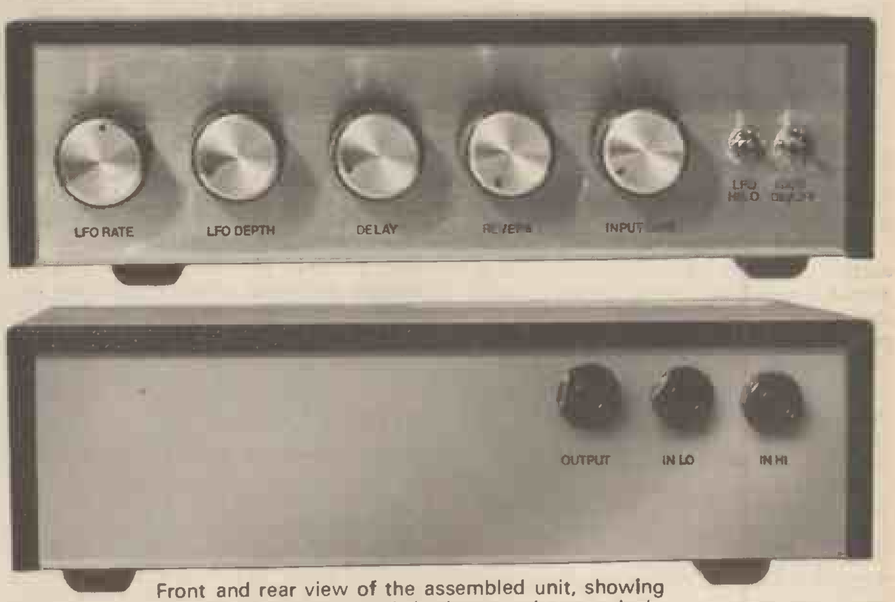
The Cybervox Robot Voice is built on two printed circuit boards. The layout of components on the topside of the Ring Modulator/Reverb board and an actual-size master p.c.b. pattern is shown in Figs. 3 and 4. Layout of components and full-size master pattern for the Voice Gate board is shown in Fig. 5.

Interwiring details of the case-mounted components is shown in Fig. 2. The key numbers relate to wiring points on the printed circuit boards.

There is nothing complex about the assembly of the printed circuit boards though it is preferable for them to be assembled in order of resistors, diodes, small capacitors, i.c. sockets, presets, short wire links (which can be made from resistor offcut wires), large capacitors and finally the transistor.

Insert only a few parts at a time before soldering them and checking the joints with a magnifier. Do not bend the wires on the track side as this makes them tricky to remove if subsequently an assembly error is found, though it is a good idea to slightly angle them before soldering so that components do not fall out when the p.c.b. is inverted. Next, neatly carry out the wiring to the panel controls, keeping the wires moderately short, but long enough for inversion of the p.c.b. for examination.

To minimise the chance of error in assembly, lightly cross off from the drawings each component or wire as it is assembled. Diverse colour coded wiring is recommended so that routing can readily be double-checked. Screened leads within the box should not be necessary, but the box should be grounded through one of the pot bodies as shown. Plan out the box drilling before making holes, then use sharp drill bits, if necessary gently removing burred hole edges with a fine file. Upon completion the box can be painted and panel legends applied. Most stationers stock a variety of rub-down lettering that is suitable.



Front and rear view of the assembled unit, showing front panel controls, and the input and output jack-sockets on the rear panel.

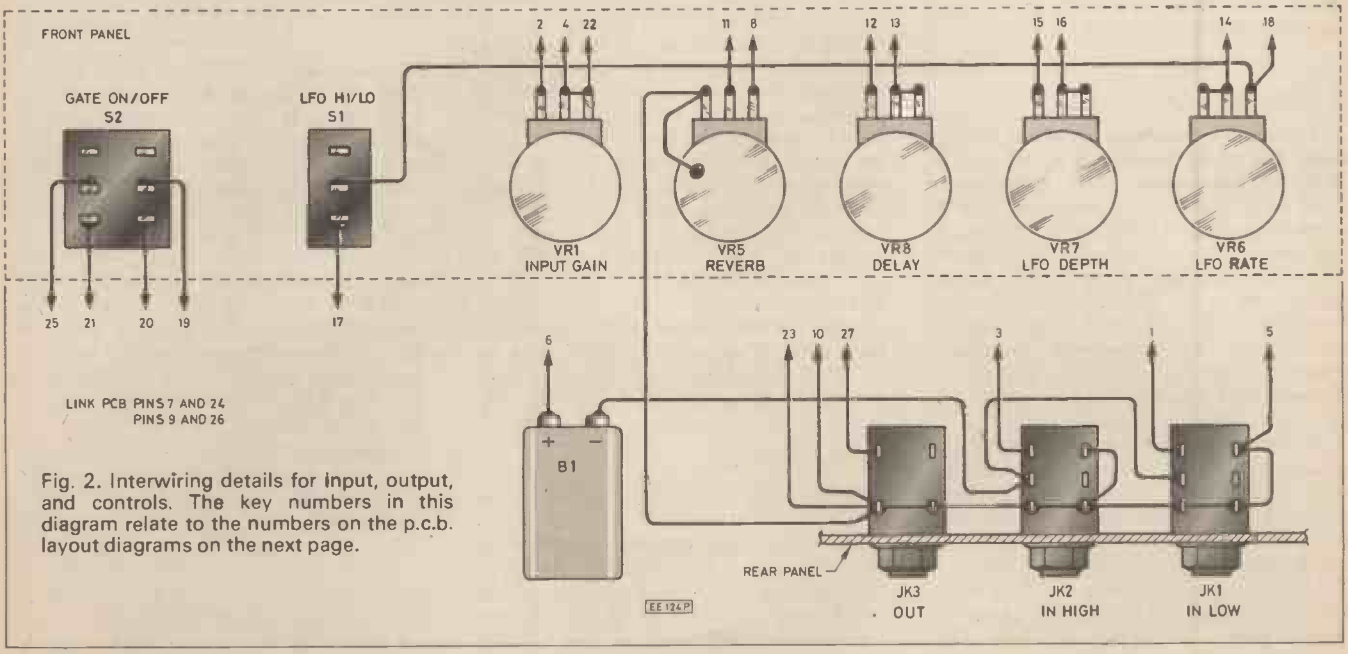


Fig. 2. Interwiring details for input, output, and controls. The key numbers in this diagram relate to the numbers on the p.c.b. layout diagrams on the next page.

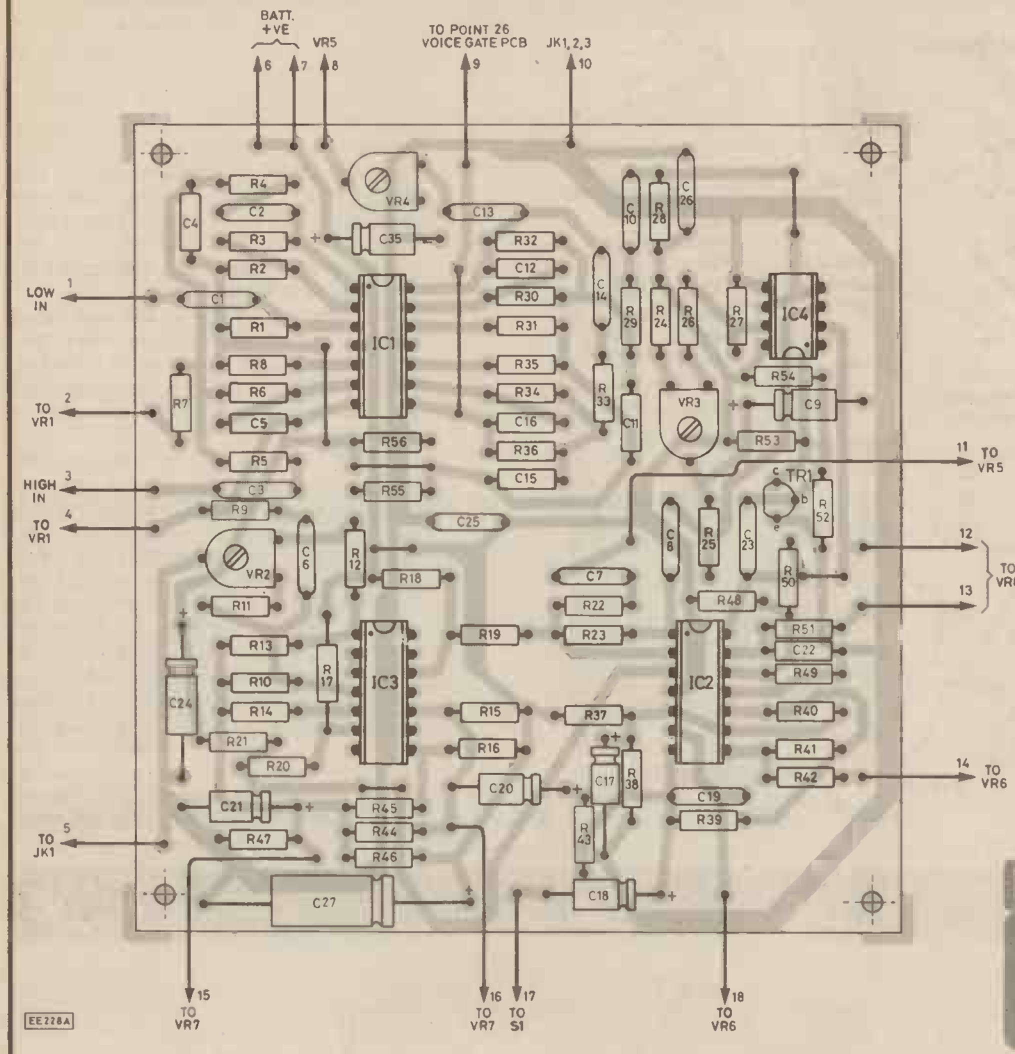


Fig. 3 (left). The component layout for the Cybervox Robot Voice main board, the numbered leads should terminate at the corresponding numbers in Fig. 2.

Fig. 4 (opposite). The printed circuit master pattern for the main board (full-size).

COMPONENTS
approximate cost £45.00

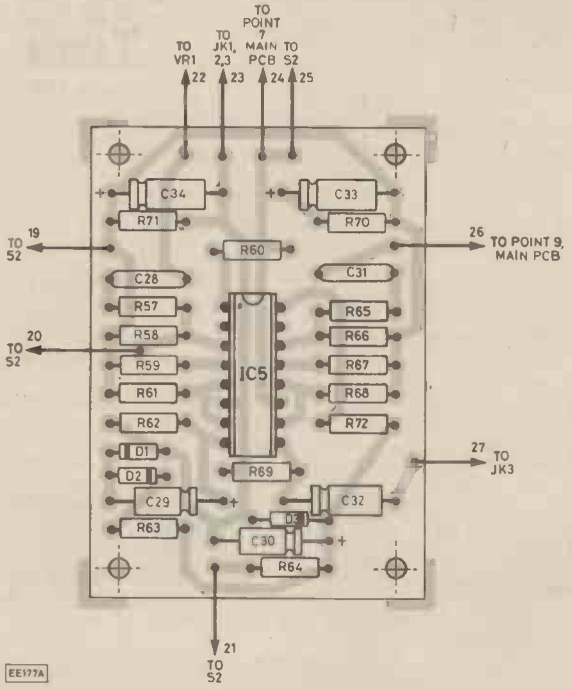
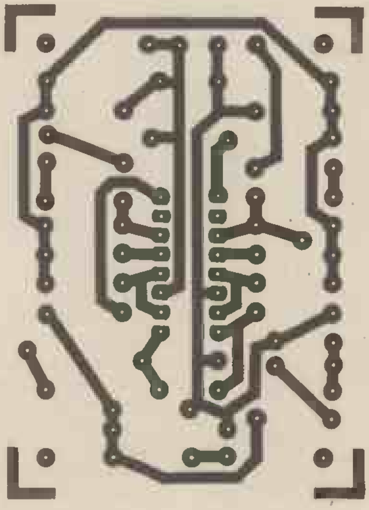
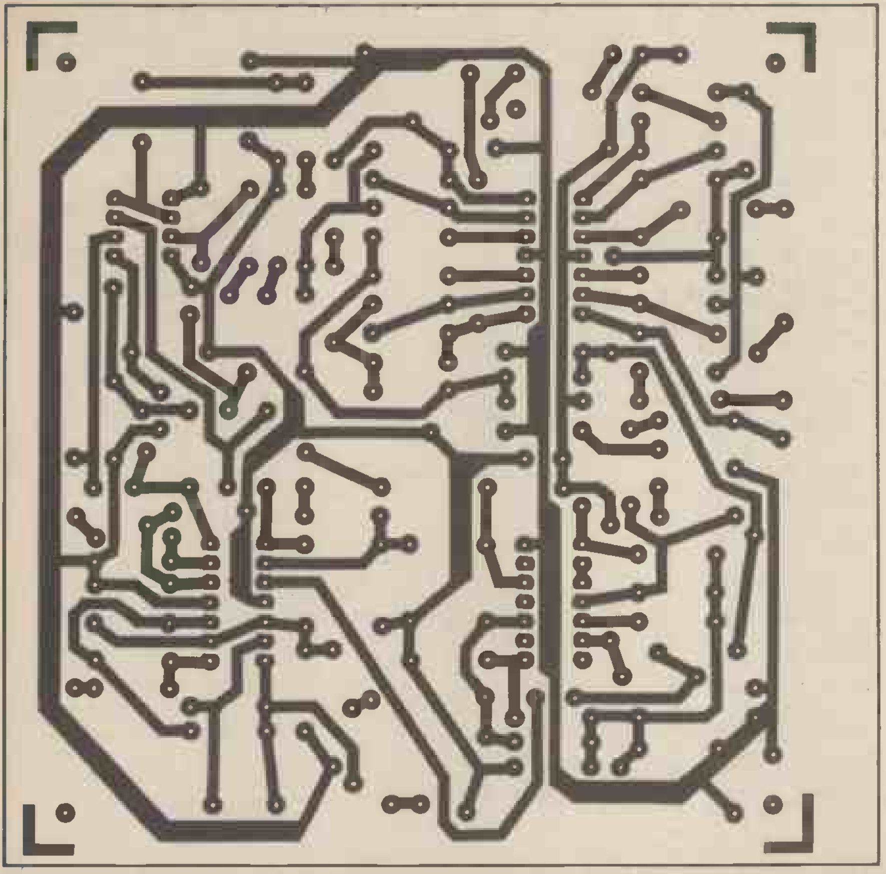


Fig. 5 (left). The layout of components on the topside and (below) actual-size master pattern for the Voice Gate board. See also previous page, for details of the internal layout and wiring.





CHECKING AND SETTING

There are only three presets to be adjusted, and although they do not require specialised equipment, it is worthwhile adjusting them with patience to attain the best response. For setting up and general testing it is preferable to use a good voice recording from a cassette deck. This should be as free from background noise as possible and of a consistent amplitude. First, VR1 min, VR2 and VR3 midway, VR8 and VR4 max, VR5, VR6 and VR7 min, S1 down, S2 up.

Plug the cassette into the high input socket, and output into the main amplifier. Check that the cassette recording reaches the main amplifier, adjusting VR1 to suit if necessary in order to achieve a reasonable level.

Adjust VR3 around its midway point until the minimum distortion is apparent at higher signal levels. If no difference is heard, leave midway and ignore until other setting up is completed. Fully rotate VR5 and slowly reduce VR4 until a slight reverb effect is heard. Set VR8 for the slowest clock speed whereupon the reverb will deepen. Further reduce VR4 until the best echoing reverb hollowness is achieved. Taking VR4 too far may result in spontaneous "howl" occurring on heavier voice inputs; if it does, sharply back off VR4 and start again. Aim for the closest you can get without howl. Playing around with VR8 and VR5, the full range of delay effects will be found.

COMPONENTS

Resistors

R10,R13	100 (2 off)
R24,R26,R27,R44, R45,R53,R63,R66,R67	1k (9 off)
R46	3k
R17,R18,R42,R43, R47,R55,R56,R70,R71	4k7 (9 off)
R2,R7,R9,R14,R52, R58,R59,R62,R69	10k (9 off)
R11,R12,R15,R16	18k (4 off)
R28,R64,R65	47k (3 off)
R6,R30,R34,R39	82k (4 off)
R1,R4,R5,R8, R19–R23,R25,R29,R31, R33,R35–R38,R40 R48–R51,R54,R57,R72	100k(25 off)
R32,R60	200k (2 off)
R41	300k
R61,R68	560k (2 off)
R3	1M2

All $\frac{1}{4}$W 5% carbon film

Capacitors

C1–C3,C6–C8,C13, C14,C23,C25,C26,C31	100n polyester (12 off)
C10,C28	22n polyester (2 off)
C19	47n polyester
C22	56p polystyrene
C5,C12	180p polystyrene (2 off)
C4,C11	330p polystyrene (2 off)
C16	470p polystyrene
C15	1n polystyrene
C9,C18,C32	1µ, 63V, axial elect. (3 off)
C17,C20,C21,C33–C35	22µ, 10V, axial elect. (6 off)
C29,C30	4µ7, 63V, axial elect. (2 off)
C27	470µ, 10V, axial elect.
C24	470µ, 6·3V, axial elect.

See Shop Talk page 199

Semiconductors

IC1,IC2	TL084 (2 off)
IC3	MC1496
IC4	TDA1097
IC5	LM13600
TR1	BC549
D1,D2	1N4148
D3	BZY88 3·3V, 400mW Zener.

Potentiometers

VR2,VR3	5k skeleton, horizontal mounting (2 off) (may be 4k7)
VR4	100k skeleton, horizontal mounting
VR7	100k log., rotary pot.
VR5,VR6	100k rotary pot. (2 off)
VR8	500k rotary pot. (may be 470k)
VR1	2M log., rotary pot.

All linear tracking unless stated otherwise

Miscellaneous

S1	s.p.d.t. switch, sub-min.
S2	d.p.d.t. switch, sub-min.

Printed circuit boards; i.c. sockets; jack sockets; p.c.b. clips; PP3 battery clip; pot knobs.
Case—9 × $5\frac{1}{4}$ × $2\frac{1}{2}$ in. approx.; stick-on feet.

Next, VR5 min, VR8 min (highest clock—shortest delay), S1 up, VR6 midway, VR7 max. A moderate Dalek type modulation to the input voice should be heard. VR7 will vary its depth, and VR6 the rate of modulation. Switch down S1 and the rate will increase dramatically and be accompanied by a high pitch whistle. As the highest setting of VR6 is approached, the voice output will become virtually unintelligible as the extreme modulation effect increases. With the high pitch whistle at its most apparent setting, fully turn down VR1 and also the voice input source volume control so that only the whistle remains.

Do not pull out the jack plug from the input as this will turn off the battery, and thus remove power from the unit. Now very carefully and with patience rotate VR2 around its midway point until the minimum whistle is heard. It will never be completely nullified by VR2 but will drop to a markedly lower level as the modulation input bias of IC3 is absolutely balanced. Turning down VR7 it should totally disappear. The voice gate can now be checked but requires no setting up. With S2 down the gate is under control from the signal coming from IC1b.

The operation of the gate under automatic voice control will of course depend on the level of the signal at IC1b. Too high a level will increase any background noise present and this will be amplified by the control to above the gate operation threshold. Too low a signal and the gate will be reluctant to open. The best setting of VR1 is that which will cause the gate to open and close regularly for moderately spaced words or phrases. This gives the semi-staccato effect to the unit when the carrier is being used. For the reverb on its own, the gate can usually be switched off allowing the reverb effect to die away of its own accord. With the gate on the reverb will naturally die as the gate closes.

Experiment for a while with various settings of all the panel controls and attain a feeling for the flexibility of the simulator, if necessary slightly adjust any of the presets. Any adjustment to VR2 though should only be made after the unit has been switched on for several minutes as the balance may be slightly temperature sensitive.

USE

Either of the inputs may be used, to suit the strength of the incoming voice signal. Within reason it will not harm the unit to have the wrong strength on the wrong jack socket, it will only produce signal distortion or reduction. IC4 is the most sensitive to overloading and has a maximum desirable signal input level of 1.5V rms.

The maximum output from IC3 is approximately the same as that from IC1b, depending on the setting of VR7 which will give a slight reduction at full carrier modulation. To this level IC1c can add a similar level via VR5. Substantially this means that the signal from IC1b should be no more than half of 1.5V rms, i.e., 750mV. With the wide reduction and expansion range offered by VR1 the unit will cope with signal levels up to 7.5V. The maximum output though is dictated by the imbalance created between the two carrier inputs of IC3.

Without the reverb in circuit and with VR7 turned down so removing the carrier, the gain factors throughout have been set to give roughly a 1.5 volt output at IC5d for a 1.5 volt output at IC1b. This is the maximum output level that can be expected and increasing VR1 further will be likely to lead to distortion, but not output gain. Incidentally VR1 will only significantly increase signals below the filter cut off region as set by C4 and C5.

There is no reason why the unit should not be used with musical sources if odd effects are required, but the frequency bandwidth is too restricted for full range serious musical use. However, any sort of voice input will produce results. The most dramatic results though come from words spoken in a uniform monotone fashion. For those with drama facilities the unit plus a small amplifier could be inserted into a model robot for supreme realism. But even for lesser time lords without stage props a lot of realistic fun can be had with only the unit, a microphone and an amplifier. Just plug in, switch on and enjoy a spot of social cyberchat. □

SHOP TALK

BY MIKE ABBOTT

Catalogue Received

We have received the latest **Cricklewood Electronics** catalogue, and as a general electronics components supplier with an emphasis on semiconductors we can recommend this company as a useful source of parts for the hobbyist. In addition to multimeters and soldering irons, knobs, boxes and connectors, p.c.b. making accessories, nuts, bolts and heatsinks, there are some surprise items like valves and thermal fuses. Telephone orders can be accepted on most major credit cards by simply quoting your card number and shopping list. To obtain a current catalogue just telephone **Cricklewood** (✆01-450 0995) with your details and they will arrange to send you one free of charge.

Suck Blow

Dealing a blow to the underworld of micro-debris is the smallest vacuum cleaner in the world, *as far as we know*. With the Mini-Vac, a lightweight miniature vacuum cleaner powered from a single 9V battery, you can remove dust and filings from your equipment with peace of mind.

As every hobbyist knows, you can always blow swarf from a freshly drilled metal box, but the mischievous debris you seek to remove invariably siezes the opportunity to lodge somewhere more devastating. Mini-Vac will 'bag' the blighters for you, and the bag may be quickly removed for emptying, by way of a Velcro seal.

The tool has an optional attachment to turn it into a blower. The two-brush vacuum head is described as 'lense' quality and is therefore of interest to photographers also.

The vacuum cleaner is clearly not intended for use as a solder sucker. Mini-Vac costs £19·60 + VAT and should be found generally available, otherwise contact **O & S Photographic Co., South Block, The Maltings, Sawbridgeworth, Hertfordshire**, for more information.

Surprising Spectacles

Stand-mounted magnifying glasses are the most widely used aid to fine detail benchwork, but they tend to be bulky and not cost justifiable to the hobbyist. An alternative exists in the shape of the Leeda Magnifier. These prismatic, half-lense magnifying spectacles have a focal length of around 255mm (10 ins), and may be perched on your nose whilst modelling or inspecting those terrifyingly minute tracks of a micro computer p.c.b. If nothing else, they will earn you the sympathy of your friends (unless you explain what they're for).

The spectacles seem an obvious idea for today's electronics hobbyist, although (shshsh!) they were originally conceived to assist trout fishermen with their artificial flies! A sobering thought. If you cannot find them locally you can order a pair from **Leeda Ltd., 14 Cannon St., Southampton SO9 2RB. Send £13·70 to include VAT and P&P.**

CONSTRUCTIONAL PROJECTS

Insulation Tester

A full kit of parts for the *Insulation Tester* project is available from **Magenta Electronics Ltd., 135 Hunter St., Burton-on-Trent, Staffordshire DE14 2ST.** The kit price is £16·96.

You may purchase the p.c.b. separately for £2·98, and both these prices include VAT, although 60p extra per order should be sent to cover P&P. All parts for this project are available separately.

Fibrelarm

In fact, there is no cause for alarm with the *Fibrelarm* project. All components are readily available. The light fibre specified is available from RS Components, although only in bulk amounts; and from Maplin in short lengths. T1 is Tandy No. 273 7011. The BPX25 phototransistor is available from Magenta Electronics, for £4.75.

Immersion Heater Controller

Most of the components required for the Immersion Heater Controller are widely available from suppliers such as Maplin and a host of other companies which you will find listed in the Advertisers' Index at the back of this magazine. A flip through the aforementioned Cricklewood catalogue reveals that this company sells the thermistor type VA1067 (do obtain a catalogue for ordering details), and 2-pole/6-way rotary switches, but no suitable relay for RLB, nor the BTX 18-400 thyristor.

Relay RLA can be the Maplin 10A mains relay, although any 12V relay with normally open contacts rated at 1A or more at 240V a.c. will do. It is worth noting that when relays and transformers are specified, and very often switches too, substitutes may be found that have adequate electrical characteristics but differ in physical configuration.

Stripboard layouts, such as the one illustrated in the Immersion Heater Controller may of course be altered to accommodate components which are electrical substitutes but which have different physical configurations, or size, although this is unfortunately not so with p.c.b.s. But beware switches, typically rotary switches, when following wiring diagrams because, again, physical variations occur—wiring diagrams, as opposed to circuit diagrams, can sometimes only be a guide.

For RLA the author used relay UOD featured in the Cirkit catalogue, details of which may be obtained from **Cirkit Consumer Division, Park Lane, Broxbourne, Hertfordshire EN10 7NQ.** ✆0992 444111. Relay RLB was selected from RS Components' range (RS 348-403) but any 20A mains relay with 240V coil will suffice. A suitable choice would be Arrow Code No. 30A026 (order code 258-35375E) from **Verospeed, Stanstead Rd., Boyatt Wood, Eastleigh, Hampshire SO5 4ZY.** ✆0703 644555.

Robot Voice

A complete kit of parts for *Cybervox Robot Voice* is available from **Phonosonics, 8 Finucane Drive, Orpington, Kent BR5 4ED.** ✆Orpington 37821, and costs £44 inclusive of VAT and P&P. The two p.c.b.s are available separately for £6.07 inclusive. The TD1097 can be ordered individually for £12.86 which includes VAT and 50 pence postage. The following components are available also from RS Components: TDA1097, LM13600 and TL084.

The MC 1496 is available from Maplin Electronics. Note that parts from trade supplier RS Components can be obtained through: **Ace Mailtronix Ltd., 26 Castle Rd., Wakefield, West Yorkshire WF2 7LZ.** ✆0924 250375.

INSULATION TESTER

MARK STUART

MOST electronics enthusiasts will at some time have been called upon to install or check domestic appliances and mains wiring.

Using a standard multimeter on resistance range it is easy to check for continuity, and the correct operation of switches etc. The difficulty comes when the *quality* of insulation is to be tested. Most meters use standard 9V or 15V batteries on the 'high' resistance ranges; this voltage is clearly a long way below the working voltage of the wiring and so the readings obtained can be very misleading. Insulation which breaks down dangerously at mains voltage can appear to be fine at 15 volts.

To overcome this limitation it has become standard professional practice to measure insulation at a potential of 500 volts using an instrument known as a 'Megger'. The original Meggers used a small hand cranked generator to produce the 500 volts. Modern versions are now available which derive the test voltage from a few 1·5V cells via an electronic inverter. The problem is that commercial instruments are rather expensive for occasional use by the hobbyist.

This project is a reliable 500 volt insulation tester at a reasonable price.

CIRCUIT

The circuit diagram is shown in Fig. 1. IC1 produces a 30kHz pulse waveform which drives TR2, the inverter output transistor, via R4. The collector of TR2 drives L1, which is the primary of a toroidal transformer. When TR2 is turned on the current in L1 builds up and energy is stored in the ferrite core. At the end of a drive pulse TR2 is turned off.

The sudden interruption of the current in L1 causes a high voltage 'back e.m.f.' pulse to be produced in L1, and in the other windings on the core. This high voltage pulse on L1 is stepped up by the winding ratio of the transformer (50:9) and produces a pulse of 250 volts across L3. The maximum voltage of the pulse is determined by the amount of energy stored in the core of the transformer and by the load connected to L3.

A third winding on the core (L2) provides feedback, which stabilises the voltage of the back e.m.f. pulse regardless of the battery state or the load presented across the probes. Diode D1 and capacitor C4 rectify and smooth the voltage from L2. The resulting d.c. voltage is fed via D7 to the base of TR1.

If the voltage across C4 rises to more than 3·6 volts TR1 begins to turn on. As TR1 turns on the Threshold Control pin of IC1 is pulled towards the negative supply rail. This alters the output waveform from IC1 resulting in narrower drive pulses being supplied to TR2. In turn this means that less energy is stored in the transformer core during each pulse and the output voltage falls.

This feedback results in the circuit settling so that the voltage across C4 is always maintained at 3·6 volts. Allowing for the efficiency of D1 this gives a peak voltage of 5 volts across the single turn winding L2. The peak voltage at TR2 collector is 9 × 5 = 45 volts and the voltage across L3 is 50 × 5 = 250 volts.

The secondary voltage from L3 is connected directly to D2 and also via C5 to D3 and D4. This arrangement works as a voltage doubler producing 500 volts across the series combination of C6 and C7. Resistors R7 and R8 ensure the rapid discharge of the capacitors when power is removed.

The test voltage is fed to the meter via R6, which limits the output current to 500μA.

The components around the meter are arranged to remove some of the scale non-linearity which occurs in ohm-meters at high values of resistance. At low currents there is insufficient voltage across the meter to enable D5 to conduct and so the meter acts as a standard 100μA meter. Above half scale D5 begins to conduct and introduces the shunting effect of VR1 across the meter. This changes the sensitivity to 500 microamps. In this way the meter can display a wider range of resistance values without scale cramping.

A single p.c.b. is used for this circuit. Fig. 2 shows the copper foil pattern. Refer to Fig. 3, the component layout diagram, and fit the components as shown. The inverter transformer consists of a ferrite toroid core upon which three windings must be threaded for L1, L2 and L3. The windings should be neat single layers positioned as in Fig. 3. Begin by winding L3. Approximately 2 metres of 28 s.w.g. enamelled copper wire are required. Leave approximately 10cm of free wire at each end and secure the winding with adhesive tape. Note that the winding does not need to be covered with tape, use just enough to stop the ends unwinding.

Next use $\frac{1}{2}$-metre of 28 s.w.g. enamelled wire to wind the primary winding L1. It is important that the windings have the correct polarity. The 'dots' shown on Fig. 1 and Fig. 3 indicate the starts of the windings. Keep the same side of the core uppermost and start each winding by passing the wire up through the centre of the core. The polarities of the windings will then be correct.

When L1 and L3 are complete, wind L2 by passing a length of insulated connecting wire once through the core. Attach the core to the board using a length of insulating sleeving passed around the core and through the holes in the board, as shown in Fig. 3. Do not use bare wires to fix the core as this would become a shorted turn, and prevent the circuit from working.

Carefully scrape away the enamel from the ends of L1 and L3 before soldering the wires to the p.c.b.

It is important to note that only the specified ferrite core should be used. The design of inverter circuits depends upon the inductance of the windings and the properties of the ferrite. Some types of ferrite core may look very similar but be completely unsuitable for this circuit. It is also important to use the specified diodes for D1, 2, 3 and 4. Ordinary rectifiers such as 1N4005 are designed for use at 50Hz. They are practically useless at 30kHz because of their slow response.

When the board is complete the case lid should be cut out to take the meter and the test switch S1. The p.c.b. is mounted in the bottom of the case using two bolts with nuts as spacers—the high voltage end lies beneath the meter. This leaves sufficient room for a PP3 battery next to the low voltage end of the board. Fig. 5 shows the layout of the components in the case.

Wiring up must be done before the p.c.b. is finally fixed in position. Ensure that leads between the case and the lid are long enough to allow access for setting up adjustments, and battery changing. The two test leads pass out through a grommet at the meter end of the case. Use well insulated flexible leads, about 1 metre long. An insulated crocodile clip on one lead and a hook grip probe on the other are best for the type of measurements that will usually be made.

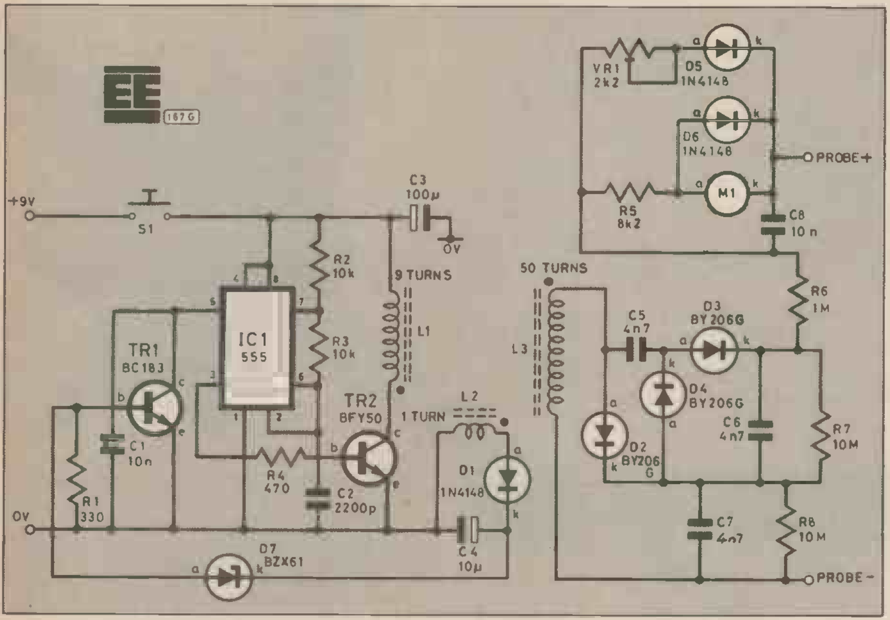
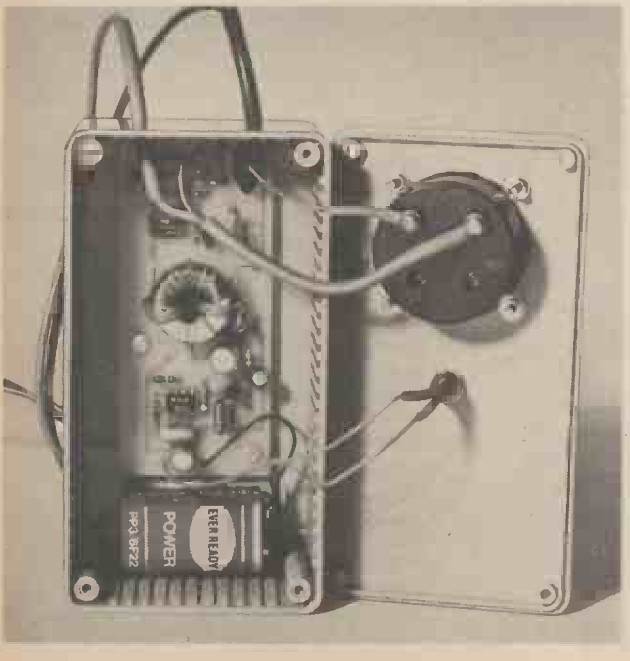


Fig. 1. Complete circuit diagram for the Insulation Tester.



TESTING

Before applying power, double check the transformer windings, and that D1–D6, D7, C3 and C4 are the right way round. If everything looks correct set VR1 to mid position and connect a PP3 battery. Clip the two probes together and press S1. The meter M1 should read somewhere between half and full scale. Set the meter reading to exactly full scale by adjusting VR1. Release S1 and separate the probes. Clip a selection of high value resistors, one by one, across the probes and check the meter reading given for each. Take care—only press S1 when your fingers are away from the probes. The circuit is incapable of producing dangerous levels of current; however, 500 microamps can feel quite unpleasant.

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SAFETY

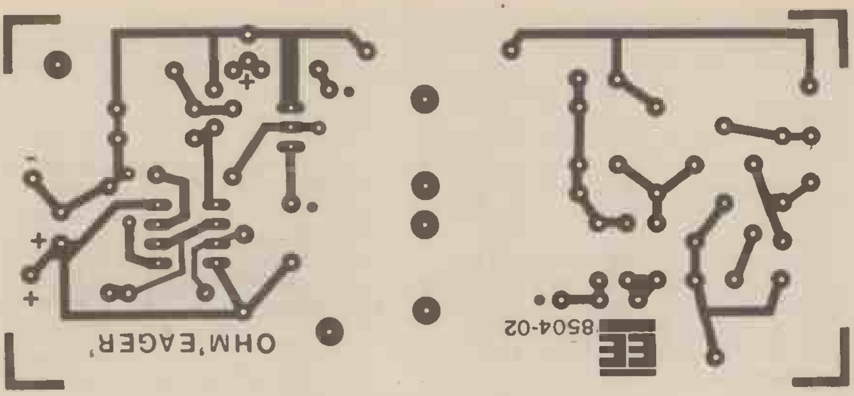


Fig. 2. Printed circuit layout (actual size).

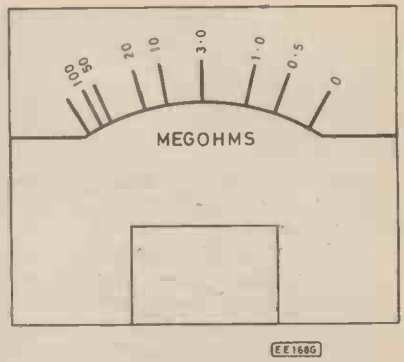


Fig. 4. This scale may be used with the specified meter.

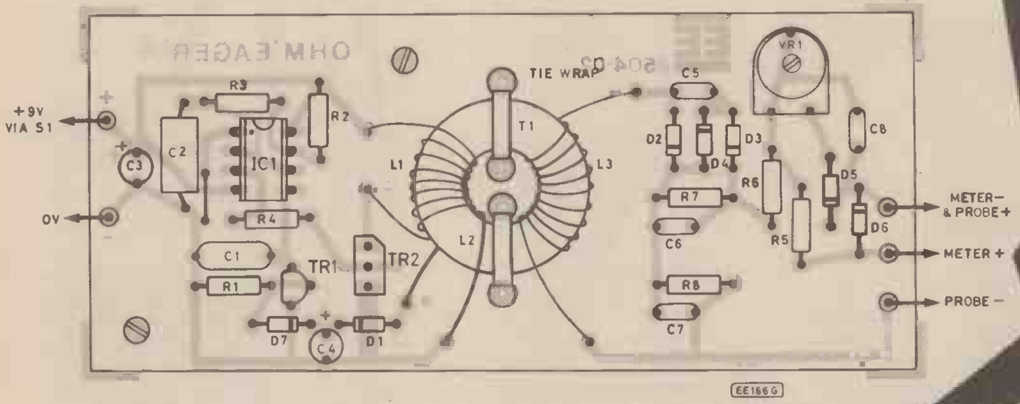


Fig. 3. Component layout on the topside of the printed circuit board. TR2 may be a TO5 can transistor.

CHECKS MAINS INSULATION TO 500V

COMPONENTS

Resistors

R1	330
R2,3	10k (2 off)
R4	470
R5	8k2
R6	1M
R7,8	10M (2 off)

All resistors ¼W 5% carbon film

Potentiometer

VR1	2k2 preset

Capacitors

C1	10n C280
C2	2200p poly
C3	100µ 16V elect. radial
C4	10µ 10V elect.
C5,6,7	4n7 ceramic 500V
C8	10n 50V ceramic

Semiconductors

D1,5,6	1N4148
D2,3,4	BY206G high speed 300V
D7	BZX61 C3V0
TR1	BC183
TR2	BFY50
IC1	555

See **Shop Talk** page 199

Miscellaneous

S1	Momentary action push button switch
T1	Toroidal transformer core type ROF241212
M1	100µA meter approx. 4K resistance (MR45)

Leads—1M red and black well insulated

Probes—1 probe and 1 crocodile clip

Case plastic—approx. 150 × 80 × 50mm

PP3 battery, clips, feet, fixings, 28 s.w.g. enamelled copper wire, sleeving. Printed circuit board

The meter can be calibrated by using a range of resistors and marking the readings each time on a blank piece of paper fitted over the scale. Alternatively, if the specified meter is used Fig. 4 can be cut out or traced and fitted to the meter.

If a multimeter is available the voltage across the probes can be measured. This should be between 450 and 550 volts. The battery current consumption is between 20 and 60 milliamps depending upon the resistance across the probes. With the probes open-circuited the battery current should not exceed 35mA.

USE

An insulation tester is very straightforward to use. Clip the probes across the component or wiring to be tested and press the test button. When testing mains wiring take care to disconnect the power first and check between Live and Earth, and Neutral and Earth, as well as between Live and Neutral. When testing electrical appliances always check for insulation between the mains terminals and exposed metal parts.

Take special care when testing circuits with suppressor capacitors. These will be charged to 500 volts and will give a very nasty shock if touched. To prevent this problem always release the test button and wait for a few seconds before discon-

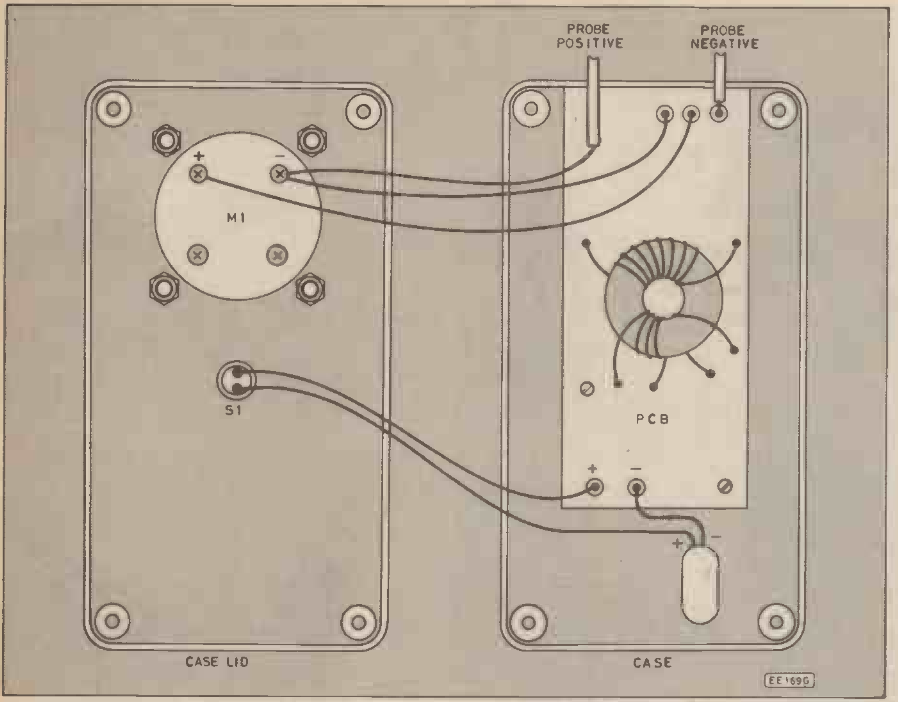
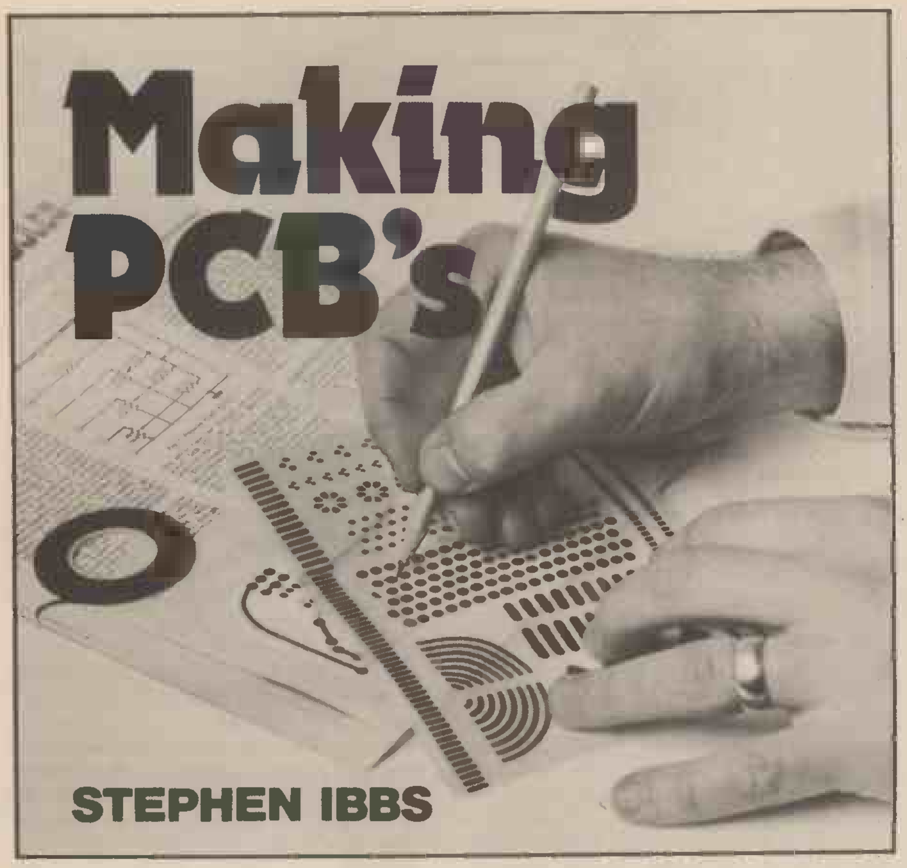


Fig. 5. Wiring diagram and mechanical layout of the Insulation Tester.

necting the probes. This will allow the external capacitor to discharge via R6, R7 and R8.

The tester can be used to check high voltage semiconductors such as power rectifiers and thyristors etc., provided they are rated above 500 volts. Never use the tester on integrated circuits or low voltage semiconductors. The circuit is designed to withstand being accidentally connected to the mains. The battery life should be very long since current is only taken during tests. When the battery is getting low it will no longer be possible to get full scale readings on the meter when the probes are shorted. This is a simple test that should be carried out prior to each test. □



MOST of the projects published in magazines have p.c.b. designs, and yet many readers may be unfamiliar with this form of construction technique and are still using Veroboard, or 'bird's nest' wiring arrangements. This article has been written to sweep away many of the fears, and to show how simple the process really is, given a bit of tenacity in the learning stages.

Printed circuit boards replace as many connecting wires as possible with solid copper tracks bonded to a sheet of material, usually 'Synthetic Resin Bonded Paper' (SRBP), or fibreglass. The components are then mounted on the plain side, with the leads inserted through holes onto the various connecting points (pads) on the track side. They are then soldered to make the inter-connections. The art is in drawing the tracks so that the components can be mounted neatly, and with as few link wires as possible.

If you look at a complicated circuit, you will realise that to join all the components together without any of the tracks crossing each other (which is obviously impossible, as they will short circuit) requires a good deal of forethought and planning with a sheet of graph paper. However, let's start simply. How do you 'draw' the tracks?

When you go to an electronics shop for p.c.b. materials you will be presented with a sheet of plain *'copper-clad'* board, either a special pen, or some transfers, and a bottle of horrible brown liquid called 'Ferric Chloride'. Before going any further a *WARNING. This liquid gets everywhere and stains everything, so the use of an apron and rubber gloves is recommended.* Tracks are drawn on the copper side with the pen or transfers which are etch-resistant, and the board is then placed in a tray containing the Ferric Chloride. The 'tracks' prevent the Ferric Chloride from dissolving away the copper underneath them, and when the process is finished, the board is cleaned. Copper tracks will be left where you have placed the lines, pads, etc. Holes are then drilled, and the components inserted and soldered. The best way of learning this is with simple examples.

PREPARING A SIMPLE PCB

Look at the circuit in Fig. 1 which turns on an l.e.d. when the pushbutton is pressed. The transistor is actually superfluous, but has beeen included for a special reason, to show that you must think in *reverse*. You are preparing the drawing for the 'track side', and this will then be turned upside down to insert the components on the 'component side'. Thus the pin-out for a common BC109 *npn* type transistor *from underneath* is reversed as in Fig. 2. Usually it is best to try to place the supply lines at the top and bottom of the p.c.b. The following spacings can be used as a rule of thumb. Allow $\frac{4}{10}$" for a resistor, $\frac{3}{10}$" for diodes, and $\frac{2}{10}$" for l.e.d.s, ceramic and tantalum capacitors. Polyester capacitors vary so much in size that one spacing dimension will not suffice.

From the collector of TR1 we need to have one pad to connect the l.e.d. cathode, then another pad for the anode, $\frac{2}{10}$" away, linked to the 470 ohm resistor. The spacing for this is $\frac{4}{10}$", and it is placed East to West to keep the overall p.c.b. size small (Fig. 3). From this end we need a pad for the 1k resistor, placed North to South, and another pad for the positive supply. The other end of the 1k resistor has a pad attached for one lead to the pushbutton, the other lead being connected to a pad from the base of TR1. Also from the base is a pad for the 100k resistor, again placed East to West. Small pads are used for components, the larger pads used for interconnecting leads, to a) accommodate Veropins, and b) to differentiate them from component pads.

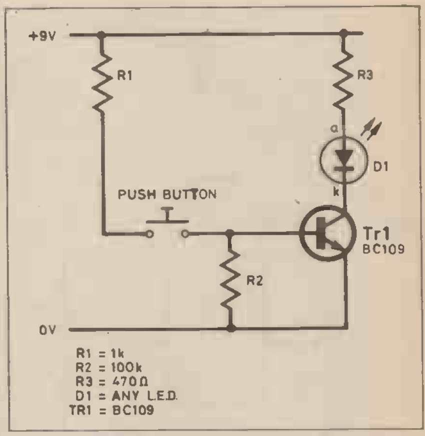


Fig. 1. Simple pushbutton circuit diagram.

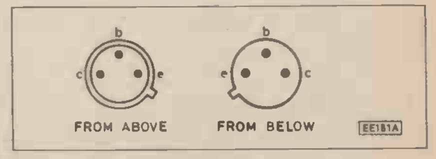


Fig. 2. Pin-out of BC109 from above and below the p.c.b.

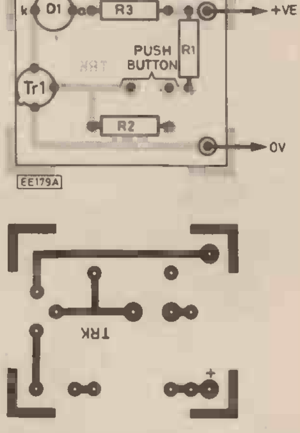


Fig. 3. Track layout and component overlay for the simple pushbutton circuit.

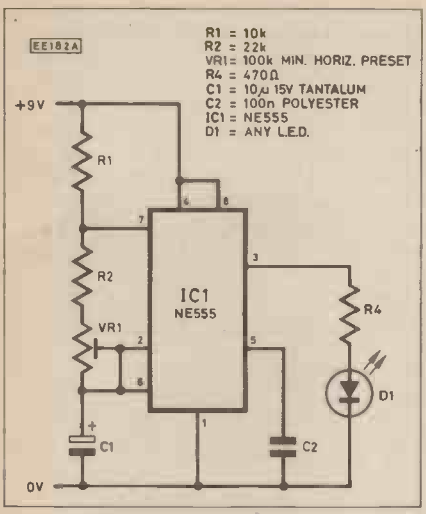


Fig. 4. Circuit diagram for l.e.d. flasher circuit.

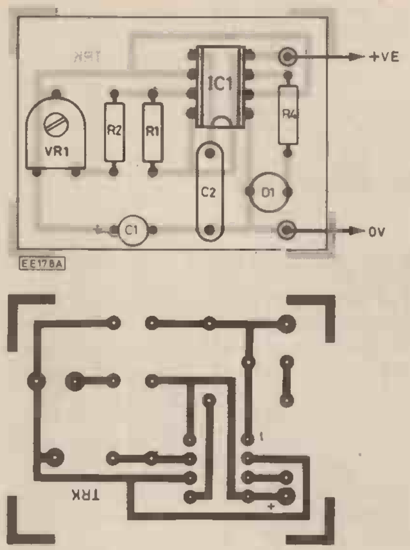


Fig. 5. Track layout and component overlay for the l.e.d. flasher.

ICs, PRESETS, ETC

It may seem pedantic to arrange the components in straight lines but it really does make following the circuit a lot easier; important for other people who may build the same circuit and use your p.c.b. design. This is particularly true as the circuit becomes slightly more complicated as in Fig. 4. This is a simple NE555 based l.e.d. flasher, but it incorporates some more elements into p.c.b. design, namely a polyester capacitor, a preset pot, and an i.c. It is here that the warning about thinking in reverse becomes vitally important. If you look at the i.c. and then turn it upside down, i.e. looking from the track side, you will note that pin 1 is in the top *right* hand corner. (See Fig. 5.)

It is likely that most designers of p.c.b.s. have forgotten this fact at some time or other, and ruined a p.c.b. because the i.c. was back to front. To avoid wasting numerous p.c.b.s. always use a sheet of $\frac{1}{10}$" graph paper, and draw the i.c. block in ink, with the pin numbers starting with '1' at the top right, then numbering round clockwise, so that from the beginning the i.c.s will be correct. The use of imperial measurements may seem old-fashioned, but the fact is that i.c. pins are exactly $\frac{1}{10}$" apart, with the two rows $\frac{3}{10}$" apart ($\frac{6}{10}$" for the large i.c.s).

Looking at the circuit in detail, the 0·1 microfarad polyester capacitor is allowed a $\frac{4}{10}$" spacing, and the tantalum $\frac{2}{10}$". The components have been spread out a little to help explain the principles; obviously these 'rules' have to be broken if space is at a premium, e.g. resistors may need to be placed on end. *Note* the preset; this has a spacing of $\frac{2}{10}$" for the two legs, with the 3rd (the 'wiper' leg) spaced $\frac{4}{10}$" away (larger pads were used for the preset).

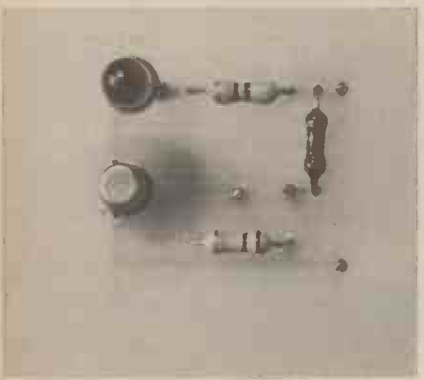
The prototype was drawn using graph paper, so that mistakes are easy to rub out, before committing pen to copper. All the components are again placed N/S or E/W, and the aim is to avoid using link wires. The resistors have been placed $\frac{2}{10}$" apart and $\frac{2}{10}$" from the i.c., but in practice they can be closer together, if necessary. The '+ve' Veropin pad has been placed only $\frac{1}{10}$" away from the end of one resistor, and this is quite acceptable if the soldering is neat. The i.c. has pin 1 to 0ve, so is placed with pin 1 at the bottom of the p.c.b.

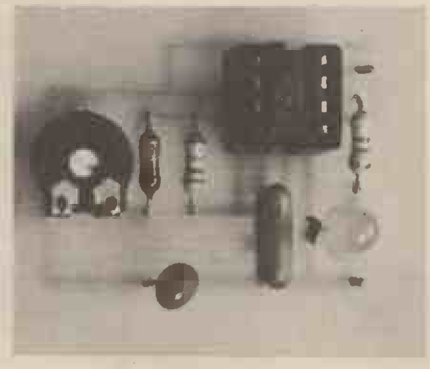
When the design is finished, the board can be prepared by cleaning it thoroughly, either with wire wool or a special p.c.b. cleaner (RS 555–308). Lay the graph paper over the copper and secure with 'Sellotape'. Using a sharp stylus, press the point through the paper to mark the various pads onto the copper. Also mark the corners of all the lines so that they can be drawn straight using a ruler. The paper is then removed and the pads and lines drawn with the pen (or transfers). As a general rule make the lines thick, both in width and in consistency. Pale straggly lines will get eaten away by the solution. *Do not* touch the cleaned copper, otherwise the grease from the hands will affect the etching process. The board is then placed in the Ferric Chloride.

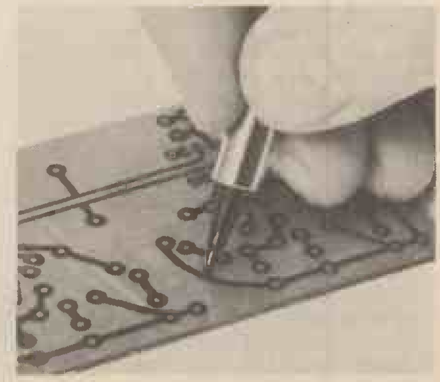
ETCHING

There are many schools of thought about how the board should be immersed. It is true that placing the board in the bottom of the tray, copper side up will result in a very slow process. This is because as copper is etched away it remains on the board, preventing fresh solution from reaching the copper. Thus the use of a slender container is advised, insert the boards vertically. This has the advantage of enabling double-sided boards (see later) to be etched easily.

If the solution is bought in powder form it needs to be mixed with water. *Important* This is an 'exothermic' reac-



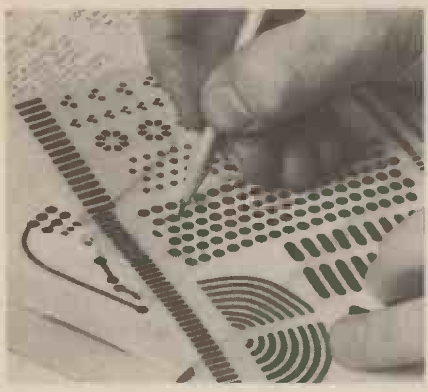




tion, i.e. it gives off heat, so *do not* add water to the powder, as it will spit and fume. Pour the powder gently into the water.

It is difficult to find a list of recommended mixing amounts, but 4 oz of powder to 10 fl oz of water seems to be about right. Manufacturers' claims of 10 minutes etching time may be rather optimistic; if the solution is cold, allow about $1\frac{1}{2}$ hours! If the solution can be warmed the process will be much faster; standing the container in a bowl of hot water will speed up the process.

When the etching is complete remove the board and rinse with clean water. The etch-resist can be removed with wire wool or scouring powder, after which you should be left with a perfect p.c.b. waiting to be drilled. It is preferable to use a mini-drill with a 1mm bit, after which the components can be inserted with confidence, knowing that the circuit will work first time (you hope). You will find that using a stylus to mark the pad positions has the advantage of providing ready made 'starters' for the mini-drill which would otherwise tend to 'skate' over the smooth copper surface.



TRANSFERS

You may feel after a time that pens do not give neat results, even using a ruler, and there are aids to make life easier and the result more professional. Rub down transfers can be purchased, and these can be simply placed direct onto the copper (again *very* clean) and etched as normal. Sheets of pads, i.c. configurations, lines, etc., and special crepe tape can be purchased in various thicknesses to quickly produce the lines. They are very simple to use, and the final p.c.b.s look much better.

As a general rule, try to avoid running lines between i.c. pins, but if this is unavoidable, special transfer packs of i.c. designs with lines between individual pins are available. Obviously it is quite easy to run lines between the two separate rows of i.c. pins, usually assume that three can be drawn with relative ease, using very thin crepe tape; this has, on occasion, been increased to six where necessary. Packs of transfers are available from most electronics shops, and readers may like to note that 'Letraset' and similar makes are also etch-resistant. Very effective badges can be made using lettering and etching, e.g. radio hams' callsign badges.

PHOTO-ETCHING

Taking the production of p.c.b.s a stage further, those readers who are interested in developing their own projects and p.c.b.s will find any of the above methods very time-consuming. This is almost invariable because the p.c.b., after it has been etched, will need modifications, improvements, etc., and to completely redraw the whole board again is very annoying, particularly as copying errors will often creep in.

To alleviate this, a process of photo-etching is possible. This involves using the same transfers, lines, pads, etc., but instead of placing them direct onto the copper they are rubbed onto a clear acetate sheet. Graph paper is placed underneath,

and the process is very similar to that used when drawing the board, with the exception that mistakes, modifications and improvements can be made much more easily by removing the lines and pads from the acetate by gentle scraping.

The completed sheet is then placed onto a piece of photo-sensitive board (which has had its protective plastic layer removed) and inserted into an 'Ultra-violet box'. Make sure the design is the right way round; rub down lettering can be used to add the word 'TRACK' to the p.c.b. side. It is also a good idea to include a small figure '1' by pin 1 of each i.c. to help orientation when inserting the components. The coating on the board is sensitive to Ultra-violet light, so the whole board is exposed for about three minutes. The pads and tracks prevent the light reaching the copper in the required areas, and after the allotted time the board is placed in a solution of caustic soda (3 teaspoons of powder to 2 beakers of water). The reaction is again 'exothermic', and rubber gloves should be used as this solution is not kind to the hands!

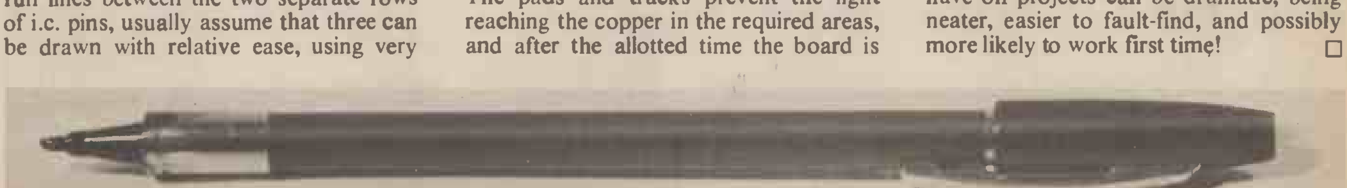
Within a few seconds a stunning change will occur and the p.c.b. design will appear. When this is clear and contrasted, the development time being approx one–two mins, remove the board, and rinse gently in cold water. Do not touch the board as the design is soft and can be easily damaged. Leave to dry and harden for about half an hour, and then etch as normal in the Ferric Chloride. The big advantage of the system is the ease of modification, and repeatability, the disadvantage being the cost of photo-sensitive boards and the light box.

DOUBLE-SIDED BOARDS

Sometimes a circuit is just so complicated that one set of tracks will not suffice, and the choice is between having several link wires, or preparing a second set of p.c.b. tracks on the *component* side (double-sided). This obviously raises many difficulties—avoiding the compo-

nents themselves, matching the two sides together, etc.—but the effect can sometimes be extremely dramatic in shrinking the size of a completed board and making the final assembly straightforward. It is outside the scope of this article to explain how double-sided boards are made. Experimenters, however, may like to know that using the 'photo' technique the acetate sheets can be placed on top of each other, immediatley showing up any problem areas where, e.g. the pads from the track side will interrupt the tracks on the component side.

This article has been written not to frighten people off, but to show that with a bit of determination, p.c.b. design and production can be mastered quite easily, it really is worth it. The effect this will have on projects can be dramatic, being neater, easier to fault-find, and possibly more likely to work first time! □



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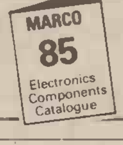

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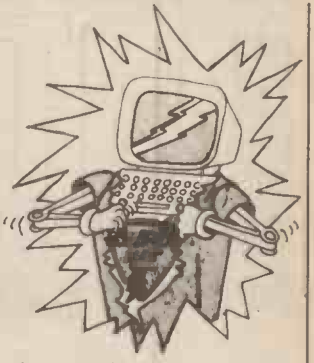

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DOWN TO EARTH

BY GEORGE HYLTON

WHY is it that some operational amplifiers need two batteries and others only one?

Like many integrated circuits, the operational amplifier is a small miracle of technology. Operational amplifiers once existed in non-integrated form; indeed, they existed back in the days of radio valves. When it was realised that quite simple electronic circuits could perform quite difficult mathematical functions (such as integration); engineers set about designing a standardised amplifier which could be adapted for performing mathematical tasks.

NUMBERS

In these tasks, numbers were represented by voltages: 2V = 20, 3V = 30, for example. If a circuit was arranged to add, then with the values just given, 20 + 30 required an output of 5V (= 50). Since the Input voltages (2V and 3V) were measured with respect to a zero-voltage (0V) line, then the output voltages must also be measured with reference to the same zero line. In other words (Fig. 1), the zero line had to be common to both input and output.

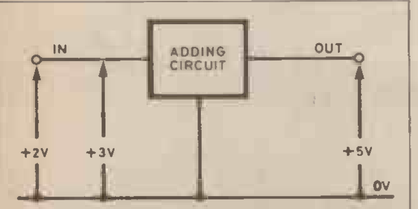


Fig. 1. Simple voltage addition.

Now, valves and transistors have this in common: the output of an amplifier (at a collector or anode) is normally at a different voltage level from the input.

A transistor stage with an input to the base of 0V has an output at the collector at some other voltage, such as +10V. This is no use in analogue computing, where +10V means a number (in our case, 100). For computing purposes, the steady output must somehow be reduced to zero.

SPLIT SUPPLIES

The solution (Fig. 2) is to use split power supplies. The standing voltage at TR1's collector must be positive with respect to the zero line. The standing voltage at the lower end of R3 is negative. The voltage at the junction of R2 and R3 is somewhere between the collector voltage and B2−. If the values of R2 and R3 are chosen correctly the voltage is zero.

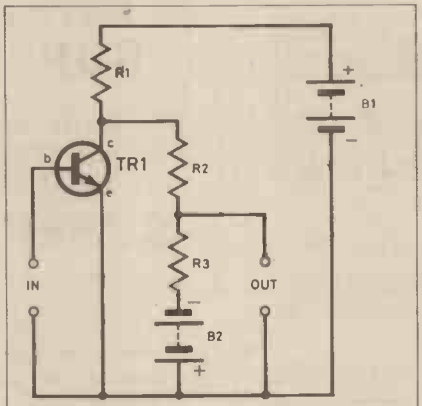


Fig. 2. Split power supplies.

Any change of collector voltage (due to input signal) now changes the output (at the junction of R2 and R3) from zero. The change can be positive or negative, so the circuit can handle both positive and negative numbers.

OPERATIONAL AMPLIFIERS

The idea of an operational amplifier evolved from such analogue computing circuits.

A pre-requisite was that inputs and outputs should be referenced to a common zero line and this called for split power supplies.

Certain other needs affected the design. One was that the amplifier should have a very high gain: because analogue computing calls for great accuracy. If an operational amplifier has an extremely high gain, and the gain is then reduced to some required value, say 100, by negative feedback, then the reduced gain can be set by two resistances and is virtually independent

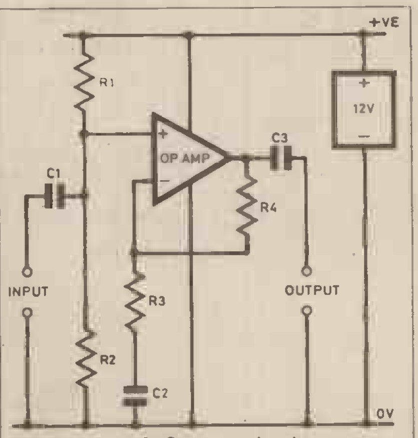


Fig. 3. Op-amp circuit.

of the 'real' or internal gain of the amplifier (called on data sheets the *open loop* gain).

Another requirement was very low output impedance. This ensures that the output voltage stays constant irrespective of the amount of current taken from the output. The amplifier has to be stable (not oscillate) when negative feedback is applied, even when the whole of the output is fed back to the input (which sets the gain to 1 or −1, a mathematically useful condition).

Finally, the operational amplifier must go on working properly in the face of supply voltage variations, temperature changes, mains pick-up and similar nuisances.

When the small miracles happened, and all this performance was pushed into an integrated circuit, and sold at a low price, everybody wanted to use operational amplifiers. Not just for analogue computing (which is specialised), but for everyday jobs like audio amplification.

For many of these new users there was no need of a common input/output 'zero line'. They were quite happy to take an a.c. output from a point at a d.c. level different from the input. If the d.c. was embarrassing, it was easy enough to insert a coupling capacitor.

CHEATING

Almost any operational amplifier designed for split-supply operation can be worked as an a.c. amplifier from a single supply. The trick is to set the d.c. input and output voltages to half the supply voltage. This is done (Fig. 3) by making R1 = R2. Direct current feedback from output to the inverting (−) input (via R4) then forces the d.c. output voltage to be the same as the voltage applied to the non-inverting (+) input; d.c.-wise, the amplifier operates as if its supplies were 6V + 6V instead of a simple 12V; a.c.-wise it doesn't care.

The coupling capacitors C1 and C3 allow the output to swing about the zero line, going negative or positive, though of course the output terminal of the operational amplifier really sits at +6V.

SINGLE-SUPPLY

It would be nice not to have to cheat in this way; i.e., to have an operational amplifier whose inputs could be applied d.c.-wise as well as a.c.-wise, between the input terminals and "zero", without blocking capacitors and d.c. biasing.

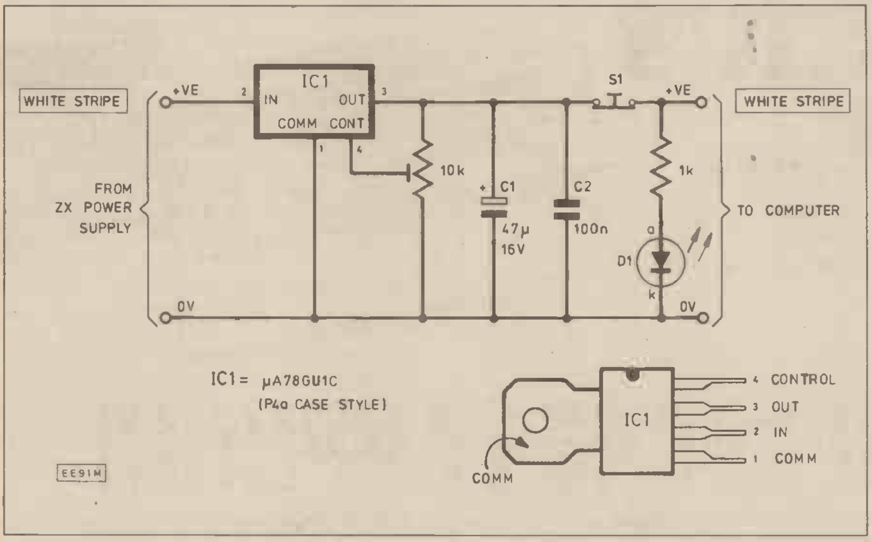
Unfortunately, some operational amplifiers have an Achilles' heel. If the voltage at one of their input terminals goes negative with respect to the negative end of the battery, the amplifier draws a large and uncontrollable current and is destroyed.

This is known as latch-up, and since the kind of single-supply operation we are interested in makes it inevitable that the input voltage will swing below battery negative (on the negative half cycles of input signals), something must be done.

Something has been. Single-supply operational amplifiers whose input can safely be taken a little negative of battery minus are now available.

CIRCUIT EXCHANGE

This is the spot where readers pass on to fellow enthusiasts useful and interesting circuits they have themselves devised. Payment is made for all circuits published in this feature. Contributions should be accompanied by a letter stating that the circuit idea offered is wholly or in significant part the original work of the sender and that it has not been offered for publication elsewhere.



The ZX Power Supply Add-On also provides a reset facility.

ZX POWER SUPPLY ADD-ON

THIS IS a design for a circuit which will reduce the heating effect in the ZX81 by reducing the voltage fed to the regulator. It is suitable for computers which use a 9V supply, such as the ZX81, ZX Spectrum and ZX Spectrum+.

The output of the ZX Power Supply is about 15V of rectified and smoothed a.c., which the internal regulator reduces to 5V for the TTL chips and the processor. The 10V extra voltage leads to heating of the regulator and heatsink, which can cause errors and mechanical failures, due to the high internal temperature.

The circuit included pre-regulates the 15V to about 9V which is fed to the computer.

IC1 should be mounted on an aluminium plate about 50 × 50mm, or the case of an aluminium box. The tab of the i.c. is internally connected to pin 1, so if the unit is boxed in a metal enclosure it should be isolated by mica washers and insulating bushes.

It is recommended that the small power plug which plugs into the computer is cut off with some cable left to connect it to the output of the circuit, and the cable from the ZX Power Supply is connected to the input of the circuit.

The 10k preset should be adjusted so that 9V or just over appears on the output terminals, before connecting it to the computer. When this is done, it is ready to be used with the computer, which should not heat up as much as before.

One of the let-downs of many home computers is the exclusion of an on/off switch or reset facility. As a bonus to the main purpose of this project this facility is provided by a simple break switch.

The push button S1 (which is a push-to-break type) provides a "reset" facility, and D1 shows when power is applied to the computer.

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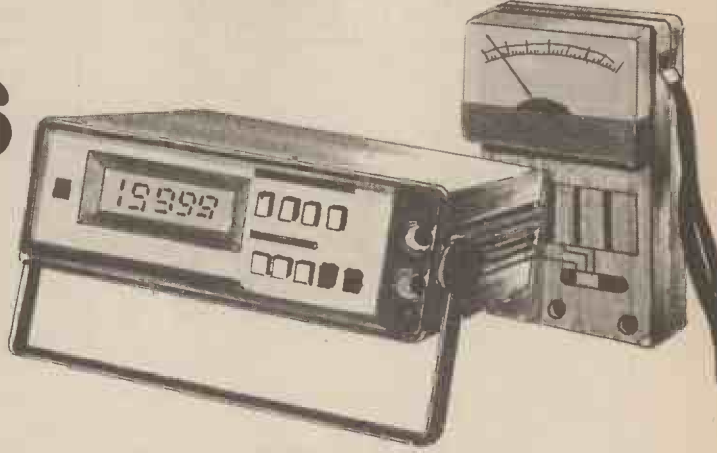

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AMSTRAD CPC 464 AMPLIFIER

If you own an Amstrad CPC 464 microcomputer why not build our stereo amplifier add-on, and give your machine true arcade quality sound effects when running games. The amp will also prove handy when developing multi-channel sound programs.

VOLTAGE PROBE

This very useful hand-held probe is easy to use and gives an instant bar-graph display of voltage levels up to 12 volts on the low range, and up to 120 volts on the high range.

AUTO PHASE

Musicians—Build a really <u>nasty</u> foot controlled effects box. To be different, this phaser uses signal amplitude to shape the envelope. Auto-phaser is simple and economical to construct.

EVERYDAY ELECTRONICS and computer PROJECTS

MAY 1985 ISSUE ON SALE FRIDAY, APRIL 19

COMPUTER CLUB

by Thakery

Hallo, welcome to Computer Club. We'll be looking at a brand new game this month by Joe Drew. We will also be studying a very short program using a simple LOOP program structure for making a star move back and forth across the screen.

LINK-UP

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

START ⇨				R	E	G	E	R	
Y	H	P	A	O	U	E	N	A	T
E	X	T	R	R	L	F	N	O	I
S	N	E	G	O	B	O	T	T	O
O	M	E	T	E	R	G	N	I	M
M	O	D	E	P	M	I			
E	T	E	R	E	X	P	O		
O	M	E	S	I	L	A	N		
S	F	L	T	T	M	I	E		
T	E	B	A	L	U	T	N		

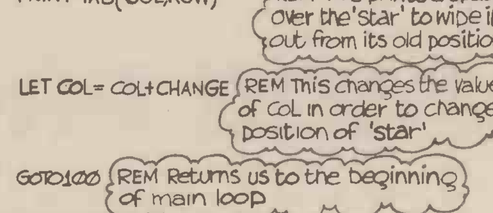
WORD	CLUE
_ _ G _ _ _ R _ _ _ N	Feedback.
FLUO _ _ _ _ P _ _	Image on screen
_ X _ E _ S _ _ _ T _ R	MEASURES change
B _ _ _ _ _ _ G	Below the KNEE
_ _ P _ _ _ M _ _ _	Measures impedance
_ _ P _ _ _ _ _ _ _ L	... Curve
M _ _ _ _ _ T _ B _ _	Not one stable state
_ O _ _ _ T	Metal oxide...

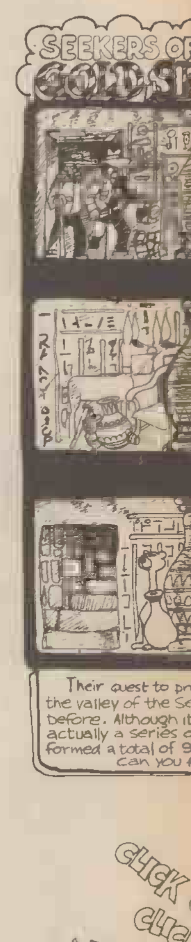
Solutions on page 225

Let's look closely at the Bouncing star program. The information in the 'CLOUDS' are REMarks (REM for short) and has no effect on the program. Keep it there for future reference during the COURSE on how to write your own computer game BUT ALWAYS TYPE IN REM or these notes WILL become part of the PROGRAM and it WILL NOT WORK. Don't worry about the abreviations used...
COL IS COLUMN
CLS IS CLEAR SCREEN
VDU IS VISUAL DISPLAY UNIT
TAB IS TABULATE

```
10   REM Title "Bouncing star"
20   ROW=10  REM star will travel along row 10
30   COL=0   REM star will start at column 0 which is on the left: NOTE! many items in computing start at 0 rather than 1
40   CHANGE=+1  REM change is the amount we add to "col" to change stars position. At first the star moves to the right so change=+1: when it hits the R.H. edge then we change direction by making change=-1
50   CLS  First thing to do is to clear the screen
60   VDU 23,1;0;0;0;0;  REM This makes the cursor disappear
70   INPUT TAB(0,20) "HOW MUCH DELAY", LONG
     REM This prints a message at col 0 row 20 asking you to input the length of delay in stars movement
80   REM up to here is "INITIALISATION"
90   REM *** Here is the beginning of the main program loop. NB There is no end to this loop so to stop the program you must press 'ESCAPE'
100  PRINT TAB(COL,ROW) "*"  REM This prints the "*" at the current value of COL and ROW
110  FOR SLOW=1 TO LONG: NEXT SLOW
     REM This is the delay loop: it is a 'FOR' loop: the variable 'SLOW' starts with the value before the 'TO' and is increased by 1 until it is greater than the value after the 'TO' ie long
120  IF COL=39 THEN CHANGE=-1
130  IF COL=0 THEN CHANGE=+1
140  PRINT TAB(COL,ROW)" "  REM This prints a 'space' over the 'star' to wipe it out from its old position
150  LET COL=COL+CHANGE  REM This changes the value of COL in order to change position of 'star'
160  GOTO100  REM Returns us to the beginning of main loop
170  REM        END OF PROGRAM
180  REM Notice that we have GOTO100. This brings up the point that line numbers in basic programs are used both to 'EDIT' programs while they are being written ie. to put the program into proper order even when its being changed.
190  REM and LINE numbers are used when the program is running so that GOTO statements have a (unique) way of identifying which line you are to GOTO.
```

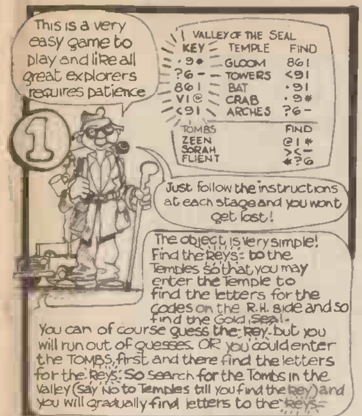
```
>RUN
   PRESS 'RETURN' KEY
```

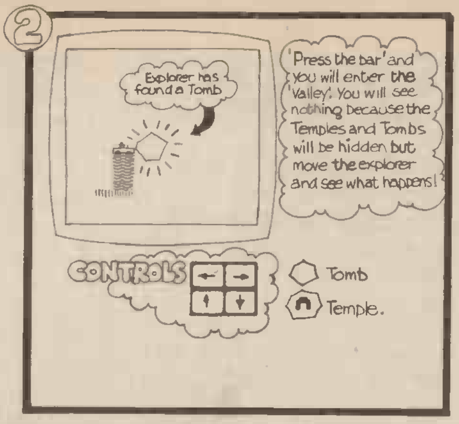


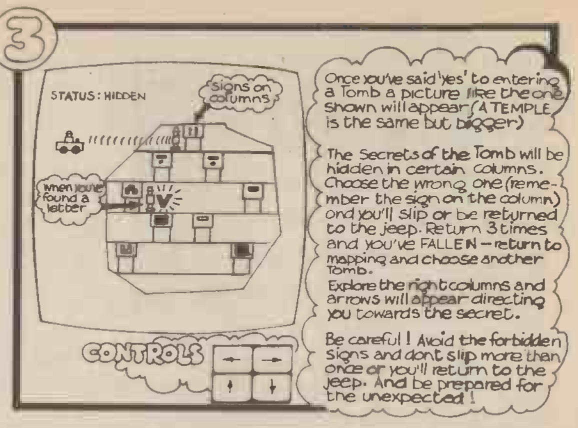


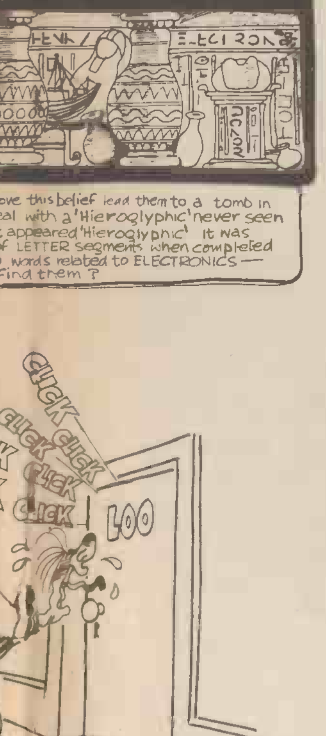
Their quest to pr
the valley of the Se
before. Although it
actually a series c
formed a total of 9
Can you f

"THIS HAPPENS EVE
WAKE UP AT THREE
THE C










```
10MODE2:PROCse:REPEATIFa% PROCtab
20REPEATPROCmo:UNTILV%>0:S%=V%-4:L%?S%=0:F%=F%-1:W%=S%-(S%=1)*11
30 PROCv19(V%,W%):PROCtw(2):PRINTN$(S%) ":found"
40REPEATINPUTTAB(7,2) "Enter(y/n) " TAB(17,2) T$:UNTILT$="y" ORT$="n"
50 COLOUR128:CLS:IFT$="n" PROCbrd(0,1):a%=0 ELSEPROCtry(C%,R%)
60UNTILF%=0:PROCv19(1,6):COLOUR1:VDU26,4:PRINTTAB(1,20)"Run out of sites!":END
70DEFPROCtry(C%,R%) a%=2:PROCtab:PROCtw(3)
80 IFS%<5 T%=0:T$="by Key" ELSET%=1:T$="Free"
90 PRINTTAB(7,0) N$(S%) TAB(2,1)"Entry is " T$:IFT% PROCgt(2):GOTO120
100 T%=3:REPEAT:INPUTTAB(0,2) "The KEY?" SPC12 TAB(8,2) T$:T%=T%-1:UNTILT$=K$(S%) ORT%=0
110 IFT%=0 COLOUR6:PRINTTAB(0,2)" Too many guesses":a%=0:PROCgt(3):PROCv1:ENDPROC
120 VDU22,1:PROCv19(3,6):COLOUR3:PROCbrd(1,0)
130 K%=64:O%=0:f%=2:A%=0:PROCu(0):PROCq
140 T%=SGN(C%-x%?S%*5+1):W%=SGN(R%-y%?S%*4+1):N%=T%*8-(W%=1)*190+28
150 C%=608+T%*512:R%=480+W%*320:M%=N%:I%=C%:J%=R%:MOVEC%,R%:PRINTJ$:GCOL3,3:MOVEC%,R%:PRINTM$
160REPEATPROCmo:V%=G%?N%:IFA%ANDV%>5ANDV%<90 PROCfnd
170 IFA%AND(V%=1ORV%=2)PROCar ELSEIFV%=3 A%=(A%+1)MOD3:PROCu(A%)
180 IFV%=4 A%=0:PROCu(0) ELSEIFV%=5ANDA%<>2 f%=f%+1:PROCu(f%):L%?S%=0
190 IFV%=4ORf%=4 X%=I%:Y%=J%:N%=M%:PROCshft(M$,M$)
200UNTILX%=I%ANDY%=J%ANDZ%=5:a%=1:F%=1:ENDPROC
210DEFPROCfnd LOCALC%,R%:PROCwr:FORP%=0TO262:PROCv19(3,P%):NEXT:PROCwr
220 GCOL0,1:T%=0:FORR%=96TO864 STEP64:FORC%=64TO1216 STEP64
230 W%=G%?T%:IFW%ANDW%<6 MOVEC%,R%:VDU238 ELSEIFW%<>V% THEN250
240 FORP%=1TOU%:IFh%?P%=T%:h%?P%=0:NEXT ELSENEXT
250 T%=T%+1:NEXT:NEXT:GCOL3,3:G%?N%=0:PROCq
260 PROCst(V%):PROCwr:IFL%?S%=0 PROCu(5):f%=4:ENDPROC ELSEENDPROC
270DEFPROCwr MOVEX%+32,Y%:VDUV%:ENDPROC:
280DEFPROCst(T%) LOCALQ%,S%:IFT%=0THEN330
290 V%=0:REPEATV%=V%+1:UNTILE%?V%=T%:V%=V%+96
300FORS%=0 TO4:W$=C$(S%):T$=""
310 FORP%=1 TOLENW$:M$=MID$(W$,P%,1):IFM$=CHR$T% T$=T$+CHR$V% ELSET$=T$+M$
320NEXT:C$(S%)=T$:NEXT
330Q%=0:FORS%=0TO7:W$=H$(S%):W%=LENW$:IFW%=0THEN360
340 T$="":FORP%=1 TOW%:M$=MID$(W$,P%,1):IFM$<>CHR$T% T$=T$+M$:Q%=Q%+1
350 NEXT:H$(S%)=T$
360L%?S%=LENH$(S%):NEXT
370 M$=CHR$239+CHR$8+CHR$11+CHR$240:IFQ%ENDPROC
380 VDU26:MOVE0,1020:GCOL0,3:FORP%=0TO70:PRINT"The seal is found ";:NEXT:VDU24,320;192;928;864;16
390 W%=0:GCOL0,2:X%=288:Y%=224:S%=1:REPEATI%=I%(S%)-15:PROCv:V%=247
400REPEATPROCwr:V%=V%+1:X%=X%+64:IFX%=928 X%=288:Y%=Y%+64
410UNTILV%=252:W%=W%+1:S%=(S%+1)MOD8+1:UNTILW%>23:END
420DEFPROCu(A%) VDU4,30:PRINT"Status: " A$(A%):VDU7,5:ENDPROC
430DEFPROCq Q%=0:FORP%=1 TOU%:W%=h%?P%:IFW% Q%=P%
440NEXT:ENDPROC
450DEFPROCmo REPEATZ%=0:V%=0:X%=C%:Y%=R%
460 IFINKEY(-58) Z%=1:Y%=R%+K%:W%=N%+19:V%=FNsk(C%,C%+104,Y%,Y%)
470 IFINKEY(-42) Z%=3:Y%=R%-K%:W%=N%-19:V%=FNsk(C%,C%+104,R%-36,R%-36)
480 IFINKEY(-122) Z%=2:X%=C%+K%+O%:W%=N%+1:V%=FNsk(X%,X%,R%-28,R%)
490 IFINKEY(-26) Z%=4:X%=C%-K%:W%=N%-1:V%=FNsk(X%,X%,R%-28,R%)
500 IFINKEY(-74) Z%=5 ELSEIFZ%ANDK%=64 V%=FNpt
510UNTILZ%>0ANDV%>TRUE:IFZ%=2 X%=X%-O%
520IFK%=64 N%=W%:PROCshft(M$,M$):ENDPROC ELSEIFV%=0ANDK%=8 PROCshft(B$,J$):ENDPROC
```

Only part of the program is given above, more will appear in the next "Computer Club".
A cassette tape of "Seekers of the Gold Seal" is available for the BBC Micro from the editorial office, price £2.30 including VAT and postage.

ON SPEC

a regular feature for the Spectrum Owner...

by Mike Tooley BA

THIS MONTH, as promised, we shall turn our attention to a simple four channel input interface for use with the Spectrum and Spectrum-Plus. This device will allow you to connect up to four switches or TTL-compatible devices which can be "sensed" by the Spectrum in order to determine whether they are "on" or "off". Before going further, let's briefly consider a practical application of such an interface in the form of an "intelligent" security alarm.

Intruder Alarm

Suppose that we wish to protect a room against intruders. To each door and window we could fit a magnetic reed switch. These switches would open whenever their respective window or door is opened and close whenever their respective window or door is shut.

Assuming that the room has three windows and one door, each of the four reed switches could be wired to its own input on the interface. With the aid of some relatively simple software (written in BASIC) it is possible to repeatedly sense the state of all four switches. We could then arrange for an alarm signal to be generated whenever any one, or more, of the switches was found to be open and print an appropriate warning message on the screen to indicate which entrance has been opened.

Sounds complicated? Not at all, the four channel input interface requires only three common TTL integrated circuits and can be built in less than an hour for an outlay of less than £5! The added bonus with using a computer as an "intelligent" controller is that it becomes very easy to make changes to the operation of the system by simply altering the control software.

If, for example, we wished to incorporate some sort of delay in order to permit brief opening and closing of the door without setting off the alarm, all we need to do is include a suitable delay loop (or PAUSE in ZX BASIC) within our control program. Alternatively, we could include a routine within our software to record each individual opening and closing of a door or window storing also the time and period for which the door or window was opened.

Hardware

The complete circuit of the four-channel input interface is shown in Fig. 1. An eight-input NAND gate, IC2, is used to partially decode the address bus, $\overline{IORQ}$ and $\overline{RD}$ signals in order to produce an active-low enable signal for the four-channel tri-state multiplexer, IC3. The decoding produces a low signal to enable IC3 whenever the following address and control bus pattern appears:

$\overline{IORQ}$	$\overline{RD}$	A7	A6	A5	A4	A3	A2	A1	A0
0	0	1	X	X	1	1	1	1	1

(where X = don't care)

It should be noted that the $\overline{IORQ}$ and $\overline{RD}$ control lines go to logic 0 whenever the Z80 CPU executes an IN instruction (corresponding to the ZX BASIC IN function).

Further address decoding is provided within IC3 which has its select inputs connected to A5 and A6 of the address bus. The particular input port selected is thus governed by the state of these lines and, assuming that all of the other address bus lines are "high", the input port assignment is as follows:

A6	A5	INPUT PORT (decimal)	INPUT CHANNEL (fed to D0 line)
0	0	159	A
0	1	191	B
1	0	223	C
1	1	255	D

The four 1k resistors connected to each input line act as "pull-up" resistors and ensure that a disconnected line or switch open produces a "high" or logic 1 input. Conversely, a closed switch produces a "low" or logic 0 input.

Construction

The interface components are assembled on a small piece of Veroboard measuring approximately 80mm x 80mm. Whilst the precise dimensions of the board are not critical, 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 will require approximately 5 rows of holes across the full width of the stripboard. The board will thus stand vertically when the connector is mated with the Spectrum.

Before soldering any of the components to the stripboard, it is important to leave 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.).

Whilst component layout is not usually critical, care should be taken to ensure that the supply decoupling capacitors, C1 to C3, 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 purpose or, if such a device is not available, use can be made of a small sharp drill bit.

Links on the underside of the board are best made using appropriate lengths of miniature insulated wire of the type normally employed for wire wrapping. Readers requiring further information on the connector should refer to last month's *On Spec*.

When the stripboard wiring has been completed, the three integrated circuit devices should be inserted into their respective 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.

Software

The status of the four input channels may be read from BASIC using IN (port number). For example, to assign the current value of channel D to a variable, d, we could use the following BASIC program line:

```
110 LET d=IN 255
```

Since all of the unused data lines (D1 to D7) will be at logic 1, the value of d will be either 255 or 254 depending upon whether the switch is open (D0 = 1) or closed (D0 = 0) respectively. The following program prints the logical state of input channel D:

```
110 LET d=IN 255
120 LET d=d-254
130 PRINT d
```

This simply returns "1" for switch open and "0" for switch closed. Alternatively we could use:

```
110 LET d=IN 255
120 IF d=255 THEN PRINT "off"
130 IF d=254 THEN PRINT "on"
```

Sensing

Either of the above routines can be incorporated into a loop so that the state of the input line is repeatedly sensed. In a practical situation, however, it is a good idea to include PAUSE between statements containing IN, as shown in the following program which prints the status of all four input channels (1 = "off", 0 = "on"):

```
  1 REM Displays the logical
  2 REM state of inputs A to D
105 PAUSE 10
110 LET d=IN 255
112 LET d=d-254
115 PAUSE 10
120 LET c=IN 223
122 LET c=c-254
125 PAUSE 10
130 LET b=IN 191
132 LET b=b-254
135 PAUSE 10
140 LET a=IN 159
142 LET a=a-254
145 PAUSE 10
150 PRINT AT 0,0; "DCBA"
152 PRINT AT 2,0;d;c;b;a
155 GO TO 105
```

A complete listing of an intelligent security alarm program is included in our first "Spectrum Update". To receive your copy, you need only send a large stamped addressed envelope to:

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

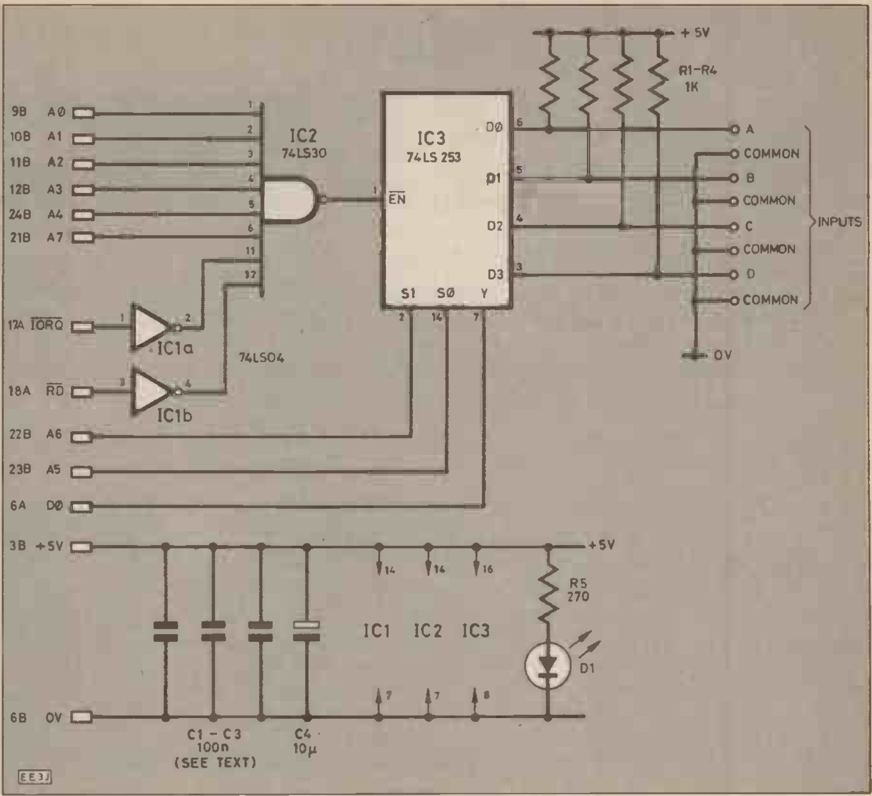


Fig. 1. Circuit diagram of the four-channel interface for the intruder-detection system.

COMPONENTS

Semiconductors

IC1	74LS04
IC2	74LS30
IC3	74LS253
D1	Red l.e.d.

See Shop Talk page 199

Resistors

R1–R4	1k (4 off)
R5	270

All ¼W ±5%

COMPONENTS approximate cost £5.00

Capacitors

C1–C3	100n polyester (3 off)
C4	10µ 16V electrolytic

Miscellaneous

14-pin low-profile sockets (2 off)
16-pin low-profile d.i.l. socket (1 off)
28-way open end double-sided 2·54mm pitch connector
Terminal pins (8 off) or 8-way 2·54mm pitch p.c. connector
2·54mm hole pitch stripboard measuring approx. 80mm × 80mm (minimum 28 strips)

It is worth noting also, that a firm called Kelan Engineering make a standard prototype kit for Spectrum and Spectrum-Plus interface projects, which includes double-sided connector, stripboard, and case.

Kelan are at 27-29 Leadhall Lane, Harrogate, and at around £9, their HB/2090 interface port would seem to be good value. We hope to have more information on interfacing kits in future articles.

Finally, don't forget to include any comments, queries, or suggestions for inclusion in *On Spec*—see you next month!

NEXT MONTH: Interfacing temperature and light sensors.

EVERYDAY news ... from the world of

PAYPHONES for the 21st CENTURY

* *An entirely new range of up-to-date telephone booths will be appearing on Britain's streets as part of a major "shake-up" of BT's payphone services.*
* *All new booths will be equipped with the latest push-button payphones.*

A GLIMPSE of the 21st Century was the claim being used by British Telecom with the unveiling of a £160 million investment programme to introduce a completely new range of modern telephone booths, using the most up-to-date electronic payphones and new concepts in cashless calling.

Introducing the modernisation programme, Mr Iain Vallance, BT's Managing Director, Local Communications Services, said: "The New British Telecom will take a radical approach to the problems inherent in today's outdated payphone service.

"We aim to encourage greater use of payphones by making them more convenient and attractive to use and by extending the facilities they offer . . ."

Added Mr Nick Kane, Director of Marketing "We are spending £35 million on these new booths over the next ten years and a further £125 million on payphone equipment.

"The familiar red kiosks will not disappear immediately. They may be kept where there are special local reasons such as in conservation areas. But they no longer meet the requirements of our customers. Few people like to use them.

"We are also planning to have payphones which take ordinary credit cards or no cards at all—a customer's own identification number will do".

*The new **CreditCall** phones are fully automatic and accept Access, Visa and American Express charge and credit cards.*

Calls from these phones cost the same as normal coin operated ones but there is a 50p initial charge for five units. The cost of calls is charged to the user's credit card account in the normal way.

Kiosks

The new booths have been specially designed with the needs of the handicapped in mind and allow easy access by wheelchair users. It is claimed that they are cheaper to maintain, more brightly lit and fitted with sound proofing and vandal-resistant panelling.

The range consists of models with and without doors, "walk-in" booths and hoods which cover only the telephone equipment. Decisions on which designs to use at which sites will be taken locally by district managers.

Back-to-back pedestal booths is one solution to the problem of fitting them into crowded town centre sites. Future designs, for shopping precincts, concourses and busy sites, will also include a triangular-plan design.

The full length booth will be used in quieter locations where traffic noise does not intrude on the conversation. The open design does not allow litter or smells to accumulate but still protects the equipment and the user from the elements.

All new booths will be equipped with the latest push-button electronic payphone.

The old traditional, warm and cosy, "red" telephone/bus kiosk was first introduced in 1936 and was operated by the now famous "push button A and button B" sequence. The new, in some cases open to the elements, push-button payphone booth is ideal for wheelchair-bound users.

Payphones

Two new types of cashless payphones are planned. The first service, entitled CreditCall, operates on a customer's own credit card, such as Access, Visa or American Express. The customer inserts his or her card in a special unit attached to the payphones. This reads the card, records the details of the call and transmits the information to special equipment in the telephone exchange. The customer is then charged on his credit card account in the usual way.

Trials are being held in London, at Heathrow Airport, and British Rail Waterloo. The Heathrow experiment involves equipment fitted with an automatic "voice response" message to guide users.

The other service, entitled AccountCall, will soon go on trial in Bristol. Modern push-button payphones are used, linked to special equipment at the exchange.

The customer dials his account number and personal identification code number before making a call. The call charges are then added to the user's home or business telephone account.

Other payphone developments for the future include extending the "Trainphone" trial on British Rail's Western Region to other services and the introduction of public payphones on express coaches and ferries. This service would be through BT's radio network.

It's not often that you can find fault with BT's services or new products, but in this case for the sum of £160 million a "multipurpose" booth that accepts cash as well as credit cards is surely to be expected. After all not everyone wants to become reliant on "credit cards".—See Barry Fox's comments in *"For Your Entertainment"*, page 224.

SKY RIDER

Cars guided by satellites are being developed by Austin Rover.

Just as satellites help with ships navigation, so they will be linked by computer to vehicles to tell the driver which way to go for the quickest, least hazardous or less congested route.—Who knows they may even be able to monitor vehicle speeds on motorways and so prevent some of the fatal pile-ups!

This small peep into the future came about recently when Austin Rover's chief executive, Mr. Harold Musgrove, opened an Advance Technology Centre at Warwick University. The centre is to research ways of applying aerospace technology to the design of future family cars.

Eric Sawkins has been appointed Land-based Sales Manager of Electra Communications, a division of the Marconi International Marine.

Name Change

When Computer Link (UK) Ltd., was first registered a search of UK company names was made but not of foreign registrations. It now transpires that a foreign company exists which has exactly the same name.

Although the foreign company does not supply the same goods they have raised strong objections to the use of the name. So Computer Link (UK) have agreed to change their name. In future they will be trading as R.S.D. CONNECTIONS LTD., PO Box 1, Ware, Herts.

Honeywell on Dole

The prestigious contract to supply minicomputers and terminals to the DHSS for unemployment benefit offices has been awarded to Honeywell Information Systems.

The contract was won from a short list including Honeywell, British Telecom and Standard Telephone & Cables.

BBC SHUT-DOWN

A milestone in the history of British broadcasting came to a close recently when all of the remaining BBC 405-line transmitters were switched off.

When the 405-line service started in 1936 it was described as *"The World's first regular public service of high-definition television programmes"*. The number of viewers had been dwindling since the introduction of the duplicate 625-line ultra-high frequency (u.h.f.) colour service in 1969.

The closure comes as the result of an announcement by the Home Secretary in 1983 that the frequencies used by the 405-line transmitters should be released by the broadcasters for mobile radio communication. The close-down of the last transmitter, at Melvaig in West Scotland, was carried out by Syd Garrioch, the local transmitter manager.

In its hey-day, the 405-line network comprised one hundred and seven transmitters.

Former Engineer-in-Charge at the BBC's Crystal Palace (London) transmitter station, Bill Busby, switched off the 405-line sound transmitter on 2 January 1985.

The purchase of a 27,000 square metres manufacturing facility in Taiwan is announced by Motorola.

Situated in Chung-Li, it will be used to manufacture, assembl' and test a variety of products, including integrated circuits.

Cellnet Captures Birmingham

Cellnet became the first cellular operator to move outside the London area when the service opened in the Midlands at the beginning of February. The historic first call was made during a conference held at the Hilton, Park Lane and was seen by the guests by mean of a live video link.

The initial City of Birmingham service allows existing customers (more than 750) to extend their use of the system. Additional "cells" will be added over the next few weeks to offer a comprehensive coverage of the West Midlands area.

Work has now started on more than 100 cells which will extend the service along the motorways radiating from London to cover, Birmingham, Liverpool, Manchester and Leeds by April, and Severnside and the south coast from Bournemouth to Brighton by June.

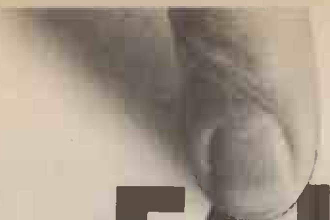
A TOUCH OF CLASS

Now firmly settled in their new modern 9,200 sq ft premises, Watford Electronics have come a long way in only twelve years. Thanks to the entrepreneurial skills of their Managing Director, Mr N. Jessa, they topped the £5 million turnover figure last year, mainly through mail order.

The new premises, located in the High Street, Watford, have been specially designed to meet their every need. This includes improved storage, packing and administration areas, plus customer car parking facilities in front of the building.

Watford stock a very large range of general components, including probably one of the most comprehensive stocks of i.c.s and microprocessor chips in the UK. Also, the range of custom designed BBC Micro peripherals has been highly acclaimed by both amateur and professional alike.

Their pricing strategy on all computer based items is second to none and a visit to their new demonstration "studio" is to be recommended. Their full address is: ***Watford Electronics, Jessa House, 250 High Street, Watford, Herts, WD1 2AN.***



FAULT FINDING

E.A. Rule Part 6

THE cassette recorder is found in most homes these days, either used as a means of reproducing music tapes or used with a home computer. In general these machines are very reliable, but they can and do go wrong. From time to time they require servicing if maximum performance is to be maintained. In view of this a brief look at some of the common faults may be helpful.

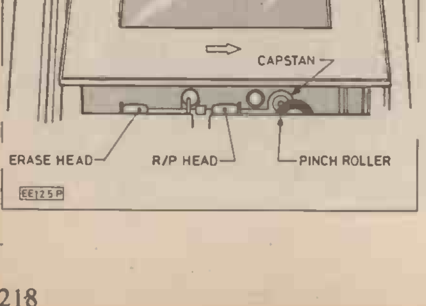
COMMON FAULTS

One of the most common faults to come into the workshop is where the cassette recorder will not record, and will only replay with either low output or very poor frequency response. In almost every case this is due to dirty record/replay heads. The oxide wears off the tape and builds up onto the heads and tape transport mechanism resulting in the head gap being filled with oxide dust.

Recording/replay heads have a very small gap across which the magnetic flux is transferred either from tape to head or head to tape. Once this gap is filled with oxide dust it is in effect 'shorted out' and it becomes impossible to record. Long before this happens however there is a gradual falling off in high frequency response and volume on replay. This dust can also affect the erase head causing poor erasure and leaving a residual on the tape from earlier recordings.

The first job when servicing a cassette recorder then is to clean the heads and tape transport mechanism. To make a thorough job of this the unit should be removed from its case so that it can be worked on in the open. First clean the heads using a cotton bud (these can be obtained from most chemists) soaked in a specialised video-head cleaning fluid. Gently wipe the cotton bud across the head and also up and down along the line of the gap, with really dirty heads you may need to repeat this a number of times. The final cotton bud should be a clean one. Then use a *dry* cotton bud to finish off.

Fig. 1. Typical cassette recorder layout (before removal from case).



Once the heads are cleaned, use the same method to clean the tape guides, capstan and pinch roller. Be thorough in your cleaning or you may get misleading results later during the service. Sometimes the capstan is so dirty that a cotton bud just will not remove the oxide dust, in these cases hold a small screw driver blade *very gently* against the capstan while it is rotating and then finish off again with the cotton buds. Use only gentle pressure and *do not touch the heads* with the screwdriver.

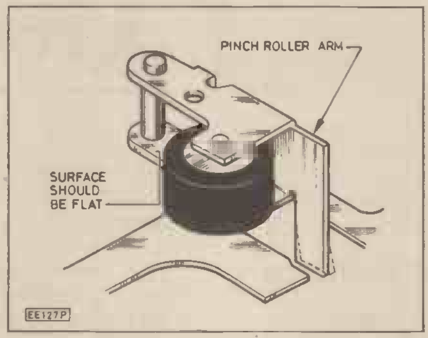


Fig. 2. Pinch roller assembly. Its surface should be flat. Clean with same solvent used for the heads.

Oxide on the capstan can be one reason for a variation in tape speed resulting in a high level of 'wow' but another cause is a faulty pinch roller. The surface of this against the capstan should be clean and flat as its job is to keep the tape in constant contact with the capstan, see Fig. 2.

After much use they become distorted and the surface becomes rounded, when this happens it can cause tapes to 'ride' up and jam. A replacement pinch roller is the only satisfactory answer and you may need the services of a skilled engineer to effect a replacement.

Another cause of speed variations is grease on a drive belt or motor pulley, these can also be cleaned with cotton buds etc. but often the drive belt will be found to have stretched and a replacement may well be required.

Another fairly common fault on cassette units is oscillation on replay. Quite a number of cassette recorders are received with this symptom in the author's workshop. The cure is simple. Clean the record/replay switching. To do this use an aerosol switch cleaner spray to spray the switch contacts and then operate the switch a number of times. This will clean off the tarnish and oxide from the contacts and it is the high resistance due to this that causes the oscillation. (This is because both inputs and outputs are switched via the same contacts on many cassette recorders.)

Note, because most cassette recorders have a mechanical interlock to prevent accidental recordings, this will prevent the record/replay switch from operating, a simple method of overriding it while cleaning switches is simply to fit a blank cassette into the recorder. (One which has not had the anti-recording tabs removed.)

Do not be tempted to adjust any presets you may find around the recorder. If these are incorrectly set you will need a special recording tape to reset, and these test tapes can set you back about £25, so I repeat do not be tempted unless you really know what you are doing.

Electronic faults can be traced in much the same way as already described in earlier parts of this series. However, an oscilloscope will be found most helpful because in many parts of the circuit you will be dealing with very small audio signals mixed up with high frequency bias signals. Without a scope you will not know what you are measuring. Once servicing is completed the final job should be to demagnetise the heads and tape transport. Suitable demagnetisers are available from a number of sources at reasonable cost and the improvement in signal to noise on recordings makes the investment worth while.

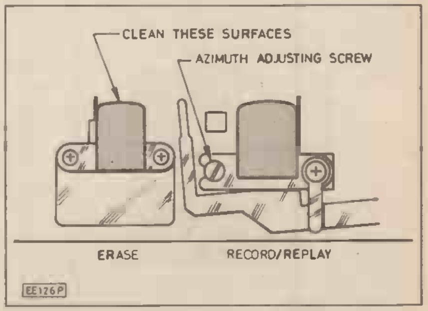


Fig. 3. Enlarged view of heads. These should be cleaned with a specialised head cleaning fluid, such as Bib Video head cleaning fluid.

HEAD CASE

I have not yet mentioned the azimuth adjustment of the record/replay head. To adjust this correctly requires the special test tape, however if the head has been changed or otherwise removed for some reason it is possible to get near to the correct setting by using a good quality commercial music tape. Simply adjust the azimuth screw for maximum high frequency sounds, see Fig. 3.

Worn heads can cause many problems. At first the high frequency starts to fall, then the output volume. Later 'flutter' increases and in extreme cases damage to tape results. The author once had a cassette in for service where the record/replay head had a hole in the front where the gap should be. The customer complained that it was chewing up tapes, no mention of the poor sound quality, it takes all sorts.

Replacing a worn head is not difficult providing you can obtain a suitable replacement. A number of stockists now carry replacement heads and if you tell them the type of machine you have they will advise you on a suitable replacement.

Having obtained a suitable replacement (check it has the same connections) carefully unsolder the leads to the old head, noting which colour leads go to which tag. Remove the old head by undoing the two fixing screws (one each side) one of which will be the azimuth adjustment screw. Note how many turns this requires to remove the head because when fitting the replacement you can screw it down by the same amount. This simple measure will ensure that the azimuth is reasonably near the correct setting. Be careful not to lose any springs, washers etc. It may be easier to solder the leads to the new head before fixing it into position, but this is really a case of personal choice. Be careful not to let the front surface of the new head touch any hard object which could scratch or damage it.

After fitting and setting the azimuth the whole mechanism should be demagnetised. If you have fitted the correct head no difficulties should ensue.

To check for head wear, take a look at the gap surface with a magnifying glass, it should have a 'mirror' finish and be perfectly smooth. If its rough, scratched, or uneven it should be replaced. Erase heads in general do not need replacement and although the author has found about 50 percent of cassettes need new record/replay heads I have never had to replace an erase head. Most cassette recorder faults are due to the mechanical faults mentioned. Electronic faults, if found, can be traced using the same methods as for other equipment.

Next month (final part) we shall look at the various service aids that are available.

FIBRELARM

GIDEON TEARLE

THIS loop alarm system was developed as a unit which could be used as an alternative to conventional wire loop alarm systems which have one major drawback as shown in Fig. 1. This drawback was obviously one which needed to be eradicated, so a more effective loop alarm system was devised using a fibre optic loop.

OPTIC FIBRE

Optic fibre (or fibre optic) is a polymer strand encased in a protective sleeving. The polymer strand is capable of transmitting light round bends whilst still maintaining the brightness and colour of the light.

Thus optic fibre seemed to be the ideal loop. All that had to be designed was some way of sending a light signal down the optic fibre and then picking it up at the other end, and comparing it with the original light source.

CIRCUIT DESCRIPTION

The full circuit diagram of the Fibrelarm is shown in Fig. 2. The mains voltage is stepped down by T1 to 6·3V a.c. which is then rectified by REC 1 and smoothed by C1 to give 9–10V d.c. Power is then applied to D1 and S1 with D1 lighting to show when the unit is connected to the mains.

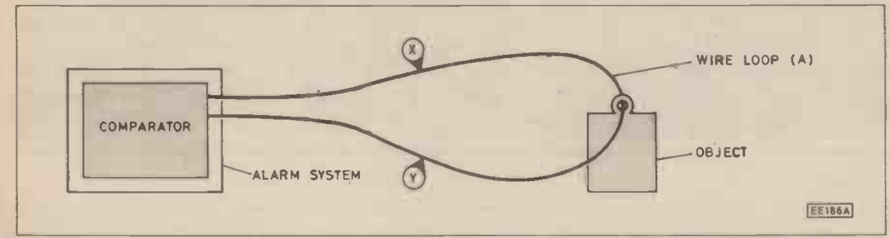


Fig. 1. Conventional loop alarm. The loop can easily be bridged between X and Y, which would foil the system.

When the key switch, S1, is closed, power is applied to the rest of the circuit, indicated by D2 lighting. The timer i.c., IC1, and its associated components, R2, R3 and C2, cause pin 3 to alternate between low and high at about six cycles per second. This is used to flash D3, a red l.e.d. shining down the optic fibre loop. The signal also causes TR1 to turn on in sympathy, whose collector is held low by R5 when pin 3 is high. TR2, a phototransistor at the other end of the optic fibre turns on when it detects light. Its collector is used to turn TR3 on simultaneously. TR3's collector is held low by R6 when TR2 is not conducting.

LIGHT LEVELS

If the logic levels at TR1's collector and TR3's collector are the same, the l.e.d.s, D4 and D5, will not light. This will only be the case if TR2 is receiving light at exactly the same time as D3 sends it, which means that the optic fibre must be in place. If the optic fibre is not in place and TR2 receives daylight constantly then TR3's collector will be high even when TR1's collector goes low. This will cause D4 to light every time TR1's collector goes low.

If the opposite happens and the optic fibre is broken in darkness, TR2 won't conduct so neither will TR3. This means that D5 will light every time TR1 conducts and its collector goes high. In the event of either of the two l.e.d.s going on, TR4, a second phototransistor, will conduct due to its nearness to the two l.e.d.s.

When it conducts it turns on TR5 which in turn energises the relay whose normally open contact keeps the relay on whether or not TR5 is still conducting. The normally closed contact and the common contact of the relay keep the negative terminal of WD1 high when the relay is unenergised, but when the relay energises the negative terminal is brought low by R7 and thus the alarm sounds.

CIRCUIT BOARD

The circuit is constructed on a p.c.b. as shown in Fig. 3 and Fig. 4. The 555 timer can be mounted on an 8 pin d.i.l. socket at the constructor's discretion. First assemble the printed circuit board and the drill holes in the box to accommodate the components as shown in the photo. All components not mounted on the board except for S1, T1 and D1 should be glued in place (Superglue was used in the prototype). S1 and T1 should be bolted as

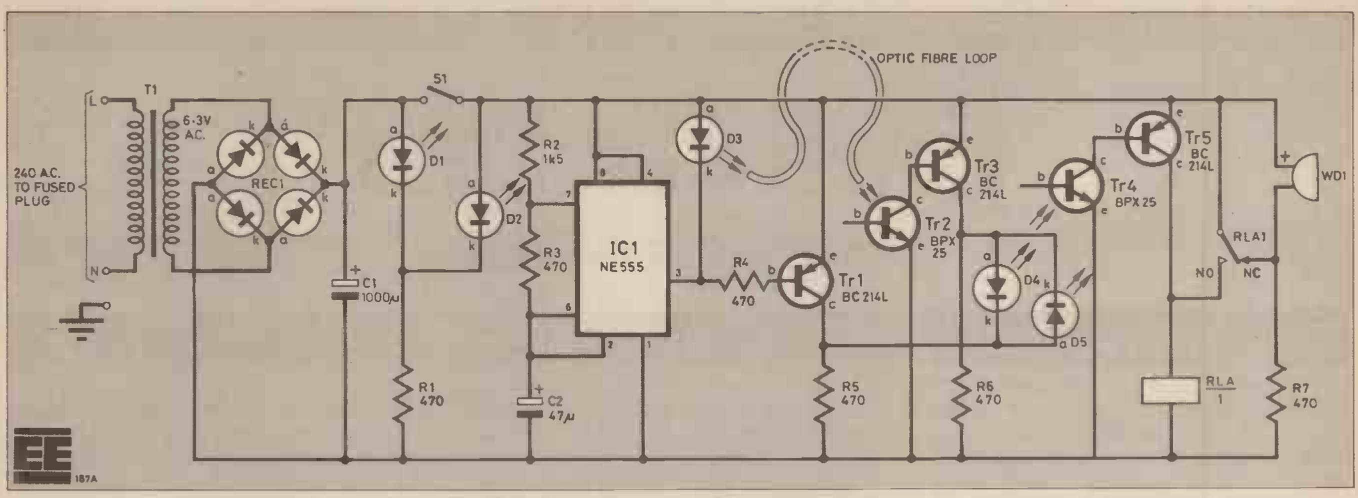


Fig. 2. Complete circuit diagram of the Fibrelarm.

place as shown. Then join all off board components to the board using fairly short wires and Veropins at the board end.

The connection between the mains and the primary side of the transformer should be achieved using a terminal block.

OPTIC FIBRE

The optic fibre should be cut off to the desired length with about $\frac{1}{2}$ cm of the sleeving removed from one end. This should be done very carefully as the sleeving is thick but the fibre is brittle and very easy to fracture. The two ends should be cleaned up by firstly using some fairly coarse sandpaper then draw file the ends with a very fine file.

Check that the ends are good by holding one end up to a light, the light seen at the other end should be exactly the same colour and about the same brightness. It should be realised that the whole unit will not work effectively unless the optic fibre is well polished and unfractured (the fibre will fracture if it is bent into very small curves).

So that the loop can be removed when the unit is switched off, it is only fixed at one end. The end of the optic fibre which has been stripped is held in place on the board, whilst the end in contact with D3 is inserted into a piece of sleeving stripped from 1 core screened cable into which the diode is fitted as shown in Fig. 6a.

Fix the diode in as shown and then glue the other end of the piece of sleeving into the hole for it in the box. The end of

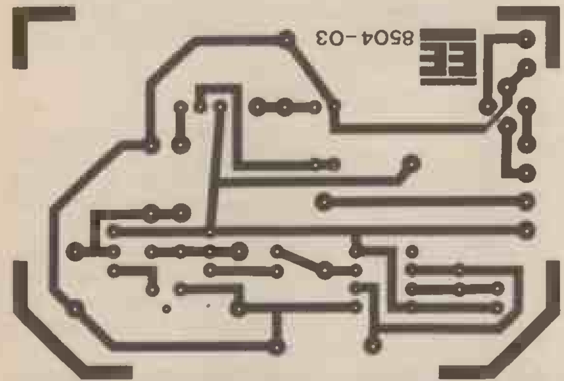


Fig. 3. Actual-size master pattern of the p.c.b. Available from EE PCB Service: Code 8504–03.

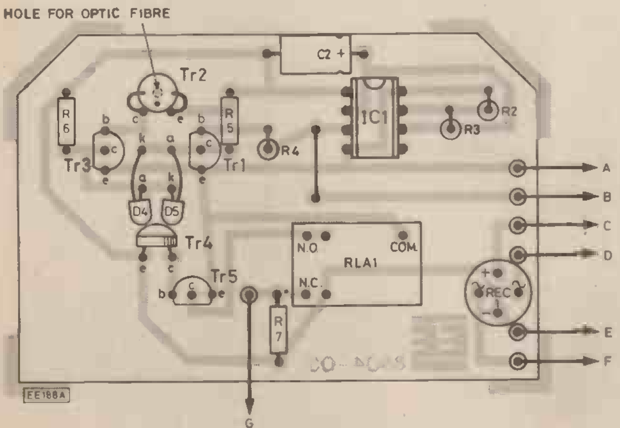
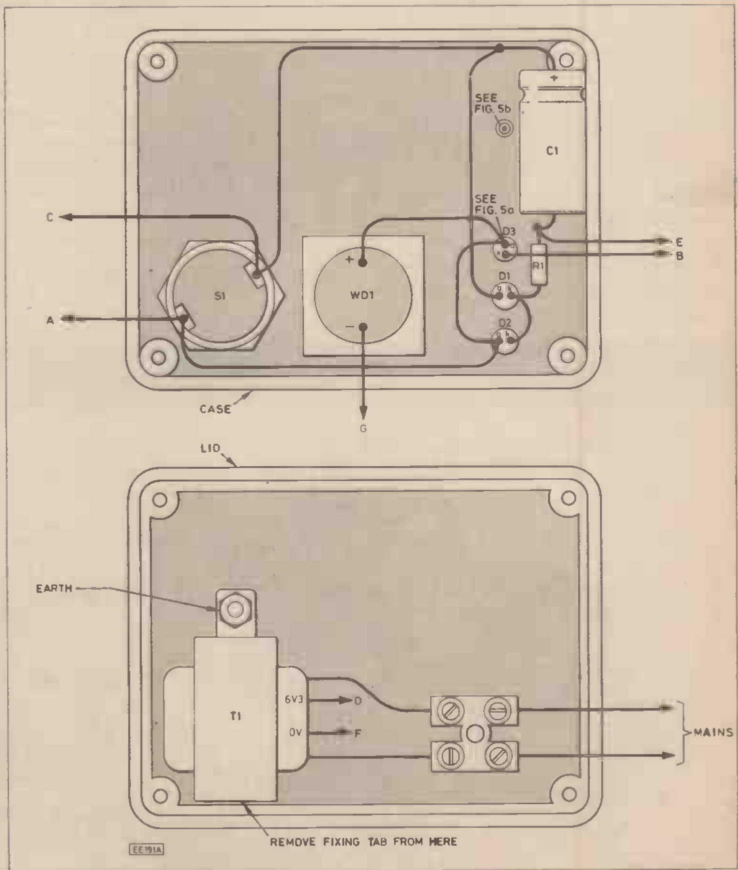


Fig. 4. Component layout of the Fibrelarm.

Fig. 5. Wiring diagram of the Fibrelarm.



the optic fibre in contact with TR2 should be fixed as shown in Fig. 6b, remembering first to stick a small piece of the sleeving mentioned above into the hole shown and then thread the optic fibre through the sleeving. On no account use Superglue on the optic fibre as this greatly weakens it.

Do not put the back on the unit until you have tested and set up the unit.

TESTING

When the unit is built check over the printed circuit board for joined tracks and incorrectly orientated components. If all is well check the off board components for loose connections and joined wires. Also check the orientation of l.e.d.s.

Next disconnect one of the terminals of the buzzer to preserve your sanity when you come to test the alarm, then connect the unit to the mains making sure the plug is fitted with a 3 amp fuse and that the key switch is in the OFF position.

The l.e.d. marked MAINS ON should light. If it doesn't disconnect the alarm immediately and check the wiring of the mains to 9–10 volts d.c. section of the circuit for faults. If all is well and there are no faults, turn the key switch to the ON position. The l.e.d. marked ALARM ON should light.

Insert the optic fibre and darken the room. Then move the phototransistor, TR2, so that the stripped end of the optic fibre (which you should put through the hole directly underneath TR2) is in contact with the transistor. Move the phototransistor around further so that D4 and D5 flash dimly or not at all; the dimmer they flash the more effective the unit will be. Try to make sure that as you do this the only light source that TR2 can pick up is that from the optic fibre.

When you are happy with the position of the transistor, reconnect the buzzer (after you have turned off the mains) and then put the back on the box. Plug the unit back in to the mains and then break the optic fibre (it is probably easier and financially more beneficial to simulate the breaking of the optic fibre by removing it

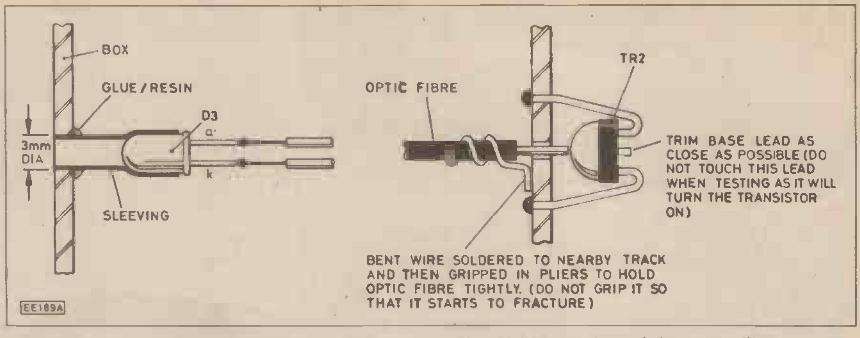


Fig. 6a. The sleeving mounted in the box.

Fig. 6b. Mounting of the optic fibre.

from its piece of sleeving making sure that you remove the optic fibre from the right piece of sleeving).

If the unit is working properly, the buzzer should go off as you 'break' the optic fibre. If it doesn't the problem probably will lie in the positioning of the optic fibre and the phototransistor. If the reader finds that it is very hard to position the optic fibre correctly, it may be wise to change the phototransistor and replace it with a photodarlington which is more sensitive; a suitable one would be the µE MELL 11. Once the unit works, apply any dry transfer lettering. It may be wise to mark the piece of sleeving connected to D3 so that its obvious which end of the fibre is the mobile one.

FURTHER PROTECTION

If the unit is likely to be in a vulnerable place where it could be easily unplugged, it would seem wise to add some extra components to the circuit as shown in Fig. 7. This expansion will give a certain amount of extra protection in the event of a power cut or when the system is unplugged whilst the key switch is in the ON position. To make this adaptation it may be necessary to use a larger box and to slightly alter the p.c.b.

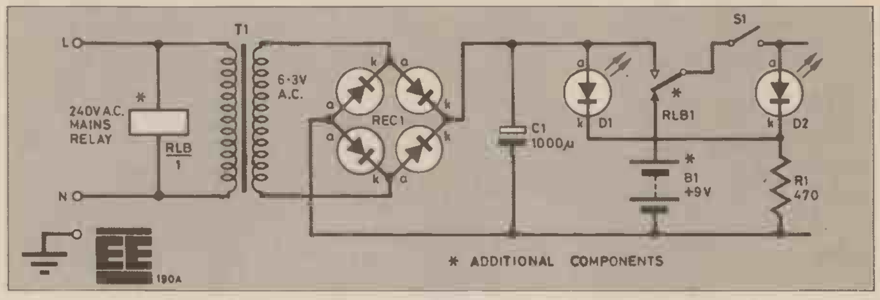


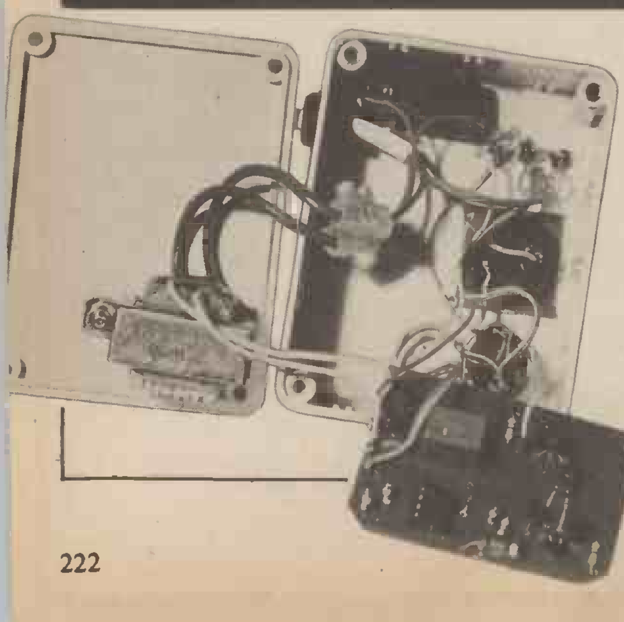
Fig. 7. Additional protection provided by 'mains fail' circuit.

FREQUENCY

The three components R2, R3 and C2 are only given suggested values. These values may be altered to give different pulse rates at the reader's discretion. It is advised that if the reader wishes to change any of the three values, then IC1, D3, R2, R3 and C2 should be assembled on Verobloc or similar to check that the frequency is acceptable, i.e. it's not too fast or too slow.

COMPONENTS

Approx. cost Guidance only **£26.00**



Resistors
- R1,R3–R7 470 (6 off)
- R2 1k5
- all resistors ¼W ±5%

See Shop Talk page 199

Capacitors
- C1 1000µ 16V elect.
- C2 47µ 10V elect.

Semiconductors
- D1,D2 0·2" red l.e.d. (2 off)
- D3–D5 miniature red l.e.d. (3 off)
- TR1,TR3, TR5 BC214L pnp (3 off)
- TR2,TR4 BPX 25 phototransistors (2 off)
- IC1 NE555 timer chip
- REC1 silicon bridge rectifier 2A

Miscellaneous
- RLA subminiature p.c.b. mounted relay n.o. and n.c. contacts 5–10V coil
- T1 240V primary, 6·3V sec.
- WD1 9–12V sounder/buzzer
- S1 key switch

Single core optic fibre; Printed circuit board, EE p.c.b. 8504–03; interconnecting wire; 3 amp 2 core mains cable; 3 amp fuse; plug; grommet; fixing nut and bolt for T1; glue.

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.

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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 0r 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 gemanium transistors OC45 etc
16 – 4 tpae heads, 2 record, 2 erase
17 – 2 ultra sonic transmitters and 2 ditto receivers
18 – 2 15000 mfd computer grade electrolics
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 diaelectric 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
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 & mike (s/hand)
59 – 2 flat solenoids – ideal to make current transformer etc.
60 – 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 module
64 – 10 assorted knobs ¼ spindles

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

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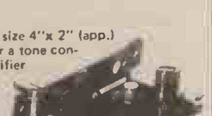
Complete kit of parts for a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for disco work. The unit is housed in an attractive two tone metal case and has controls for each channel, and a master on/off. The audio 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 or £25.00 assembled and tested.

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



Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amp. Brand new, perfect condition, offered at the very low price of £1.15 each, or 10 for £10.00.

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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 – 270 KHz, medium wave band 525 – 1650KHz, FM band 87 – 108MHz, 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.

25w SPEAKER SYSTEMS

By Amstrad

25 watt RMS loading 8" woofer, 4" tweeter with crossover. £12.00 per pair + £4 post. New and unused but cabinets slightly damaged hence this low price, carry our normal guarantee.

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 post paid.

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).

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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.

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TOP OF THE POPS LIGHTING if you use our disco switch

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FLEXIBLE EXTENSION LEAD twin rubber 5mm ideal grass cutter etc. 250 metre coil £25.00. 50 metre coil £6.75

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1 Framco motor with gear box
1 manual reversing & on/off switch
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2 limit stop switches
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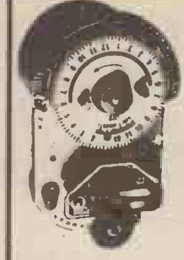

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FOR YOUR ENTERTAINMENT

BY BARRY FOX

Manual for Divorce

I believe the computer industry is on the whole cheating to stay in business. It is selling high technology computers to the general public on the strength of blatantly misleading advertising claims and publicity.

No-one disputes that computers today offer extraordinary power, speed and capacity for their price. They can, and the operative word is *can*, perform all manner of extraordinary tasks. Young people who have been brought up with computers, at school and college, find them easy to tame. Others take up computing as a hobby, like fishing or radio construction.

Up until now the industry has survived mainly on selling computers to people like this, who are computer literate. When they sell to householders and business people who find themselves totally at sea, the computer trade just makes the customer feel guilty for not being able to cope.

That's why so many new computers go straight back into their original boxes and stay in the drawer. That's why businessmen use them only to play games. Even people who get their systems working for business, frequently scratch only the top surface of potential. They use spreadsheets wrongly, never really exploit a data base as intended, and call up only a few word processing demands.

But now the credit is running out. The honeymoon is over. If the computer industry is to continue growing, it must sell to more and more people who are *not* computer literate. As more and more of these people become discontented, and feel cheated, resistance will grow.

In my experience, the main obstacle for people learning about computers in later life is the disgusting state of documentation that goes out with these high technology machines. The computer specialist press is largely to blame. They have pushed the manufacturers into producing new products and getting them on the market, before they are ready.

They have failed in their duty to protect customers against poor documentation and software. They should have blasted and ridiculed inadequate manuals. It is surely quite unacceptable for a computer specialist to review a new product on the strength of prototype hardware, incomplete software and either a draft manual or no manual at all. But in a mad scramble not to be left behind this is what they do.

If the machine gets a favourable review, there is no incentive for the manufacturer to clean out the bugs and produce a decent manual. They are too busy developing the next generation prototype, software lash-up and sketchy draft documentation.

Enough is enough. If the computer press won't sort this nonsense out, then somebody else has got to do it. Earlier this year I got in touch with the Office of Fair Trading, the Government-backed body which exists to protect consumers from nonsense like this. It was the OFT which bullied Sir Clive Sinclair into promising that he would no longer take customers' money before he was ready to send out their goods by mail order.

The OFT (Field House, Breams Buildings, London EC4A 1PR) will not take up personal complaints, for instance on faulty goods. For that you must contact your local council Trading Standards, or Consumer Protection, Officer, or your local Citizens Advice Bureau. What the OFT does do, is keep an eye on any firm which is consistently playing unfair.

The problem with computers is that most people who don't understand them aren't well equipped to explain in clear terms what is wrong with what they have bought. Computer literate buffs, who find handling new equipment a doddle, aren't going to be bothered to complain anyway. But readers of Everyday Electronics are a special breed. They tend not to be dedicated computer buffs, but they do tend to be interested in electronics in general. I know, from letters which I have received over the years, that EE readers have one thing in common, and that's electronic common-sense.

Fox Hunt

My plan, for 1985, is to pass on to the OFT any documentary evidence which might encourage the Office to start policing the computer industry. Quite clearly it isn't going to police itself.

I started on the OFT with some personal experience. I bought an Apricot Xi, hard disc machine, and was astonished at the appalling documentation. It came with six printed manuals (one more through the post made it seven) and a string of postscripts that roll up on the screen as a "Readme" program.

Instructions grasshopper between manuals and Readme, with never a logical thread and important procedures inadequately explained, often in what I take to be the Martian language. One thing the manuals did make clear, was that it was absolutely vital to make safety copies of the programs stored on the master hard disc. But the one thing they did *not* make clear was how to do it!

I followed what I thought was the right

Reverse Charge

Sometimes I do wonder whether people who sell things, ever actually *use* them. Recently British Telecom proudly launched its new range of payphones. The plan is to spend £160 million over 10 years, on updating the 76,500 public payphones around the country.

At the press conference Iain Vallance, Managing Director of the division inside British Telecom, which looks after payphones, and his marketing man, Nick Kane, were astonishingly rude about the existing payphone service. Apparently it lost £50 million last year and is the service of which BT is "least proud".

Even in an age when soap powder companies continually imply that what they have previously sold is no good, by bringing out whiter-than-whiter-than-white improvements, I have seldom heard any organisation be so rude about its existing product. In return the audience of press was pretty rude to British Telecom about what it plans. What made many people, including myself, really hot under the collar, was the technical nonsense talked by BT about a ridiculous deficiency of existing payphones.

As everyone, except a chauffeur-driven BT boss with a radio telephone will know, it is a nightmare trying to find a working payphone. Most are either vandalized or won't work because they are full of money; people then vandalize the phone because it is full and won't work.

Although a full-up telephone will still let you make 999 calls, it won't let you dial 100 and make reverse charges calls. This is crazy, because it infuriates the public and loses BT the healthy revenue available from reverse charge calls.

Under pressure the embarrassed Vallance and Kane double act admitted that new phones also wouldn't allow 100 calls when they are full up or faulty. "It's the software in the microchip," they said. But both 999 and 100 are 3 digit calls, so why can't the system default to both 3 digit options, instead of just 999? Very flustered, Kane and Vallance would say only that they were "actively looking at ways of changing the situation".

Vallance then put his head in a noose by chiding the public for not reporting broken phones. But how can you report a broken phone if you can't dial 100? Vallance then contradicted his own point, by saying that the new phones were self-diagnostic and reported their own faults automatically to the Exchange. So the public needn't report faults after all.

Plessey make the electronics for the old, and new phones. I couldn't believe that Plessey wasn't able to write default software for two 3-digit codes instead of one. And of course they could. The truth of the matter is that Plessey told BT that the new phones should give users the 100 dial option when full or faulty. But heaven knows why BT insisted on 999 only.

Quite recently, with tail between legs, BT went back to Plessey and asked them to change over. Obviously it will take some time, which is why the BT people tried so desperately to hedge the issue at the press conference.

For the record, I am now a BT shareholder. On principle I don't normally own shares because I think it can compromise a journalist to own part of a company which he or she may be writing about. But in the case of BT, I just couldn't miss the chance of going to the annual shareholders meeting, along with around two million other people who are all trying to ask questions like—why can't I dial 100 from a faulty phone?

procedure (it turned out subsequently to be wrong) and ran into trouble. I 'phoned the makers in Birmingham who told me that I was in trouble because some of the programs I was copying were faulty and I should delete them.

When I tried, I ended up deleting the main command program which killed the machine for a week. It sat dead until Apricot sent me the equivalent of a new brain on floppy disc through the post. They then told me by telephone how to do the copying procedure—I never did find it explained in the manuals.

A business friend from America was visiting when I was sitting despondently in front of the newly dead machine. I explained that I had pressed a key twice instead of once and killed it. "Is that the way you do things in this country?" he said in bewilderment.

"When you buy a car you don't expect the steering wheel to fall off if you turn the ignition key in the wrong direction. Or at least if it's going to fall off they put a notice on the dashboard warning you".

At around the same time an insurance broker I know got himself an Apricot and threw up his hands in despair. He paid someone £25 an hour to teach him how to use it but still had to give up.

I wrote a string of letters to ACT, the firm which makes the Apricot, but after a month had heard nothing in reply. If ever you think that journalists get special treatment when they raise queries, think again.

This correspondence has now been forwarded to the Office of Fair Trading. If anyone has similar tales to recount, I'd be pleased to receive them, and forward them too.

Hot Line

If like me, you've been fooled by the cinema into thinking that the "Hot Line" is a red telephone at the end of a line between the White House and Kremlin, think again. It's not, and it never has been. It has always been a text link, not an ordinary speech telephone.

The idea of a hot line dates back to President Kennedy and the Cuba crisis of 1962. Kruschev was putting missiles onto Cuba, and Kennedy blockaded the island. For a while it really did look as if there might be a nuclear war. The main problem was that the two world leaders had to talk to each other through rather clumsy diplomatic channels. So they vowed, never again.

In June 1963 Kruschev and Kennedy signed an agreement for a direct communication link, or DCL, between their offices. It was inaugurated in August 1963. The first DCL worked as an ordinary telex service, using high frequency and microwave radio links. There was also an under-sea telephone cable backup in case the radio links went wrong, or were jammed.

Right from the start they rejected the idea of a speech link, because of the problems of translating inference, implication and innuendo. The typed telex messages were transmitted from America in the English language, and from the Soviet Union in Russian.

Although use of the hot line telex is a classified secret, we know that it was very busy during the 1967 and 1973 Arab-Israeli wars. Almost certainly it prevented escalation.

The radio link soon proved unreliable, because of atmospheric interference. Privately telecoms engineers admitted that they were worried about the submarine cable link, because it relied on copper technology and booster amplifiers and switching stations along the route. Obviously it was vulnerable to anyone who could sabotage a booster or exchange.

In 1978 the radio link was replaced by a dual satellite link. The Russian *Molniya* satellite handles the signal at the same time as the world's telecommunication network of *Intelsat* satellites. But they kept the submarine cable as a last ditch back up.

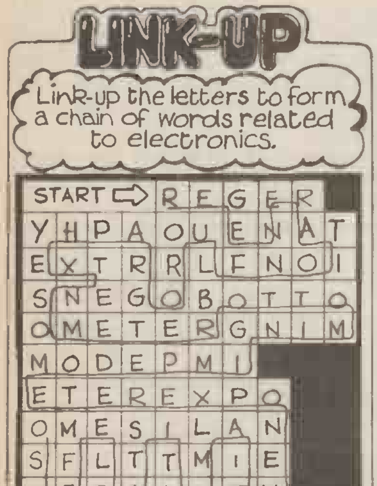
Now all that is changing. President Reagan has apparently been worrying about the time delay needed to type a message into the telex machine. Also, it's not possible with telex to draw sketches, relay photographs or show troop movements on a map.

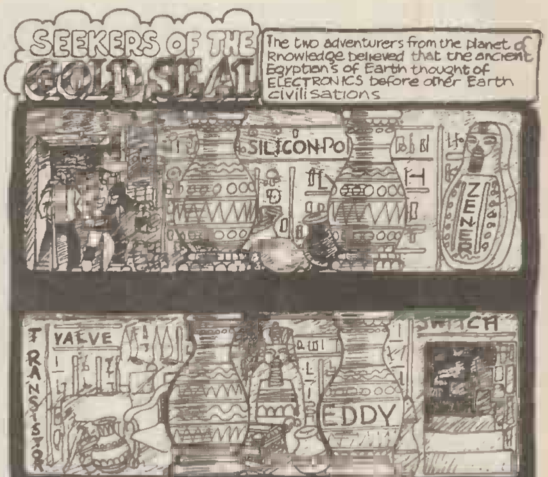
So now ITT in America has been commissioned to install a facsimile link. This has already been tested and should by now be in action. Of course we'll never know how it works, unless it goes wrong—in which case there could be a holocaust and we wouldn't know anyway.

Apparently the facsimile can transmit a page of print or a map inside two minutes. The only snag, for which there seems to be no solution, is that messages still have to be typed out before they are sent, even though they aren't now typed direct into a telex.

Let's hope that if there is a sudden world crisis, the White House or Kremlin typing pool isn't on holiday or out to lunch.

COMPUTER CLUB ANSWERS





DIGITAL ELECTRONICS

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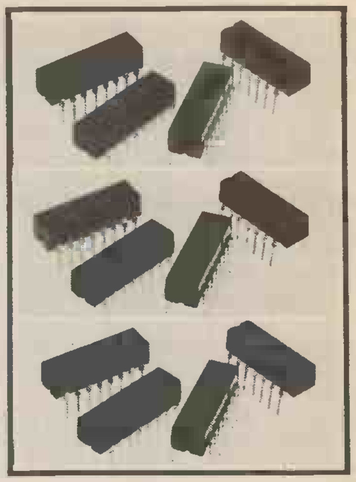
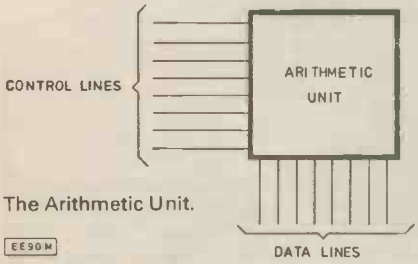
PART SEVEN



In the last article we looked at the basics of numbering and coding systems, and arithmetic processes which are used by some computers. It is now time to describe the computers themselves.

BASIC DEFINITIONS OF COMPUTERS

Basically, a computer is a device, or more correctly, a group of devices, capable of making mathematical decisions and calculations. It then uses the data thus created to assist it in carrying out a fixed set of instructions, called a program. There are several pieces of hardware involved to manipulate the instructions and data, and each of these pieces are described in brief below. For greater detail of the computer architecture, many good books are available for reference.



The Arithmetic Unit.

ARITHMETIC UNIT

The purpose of the Arithmetic Unit is to perform the basic mathematical functions of ADD and SUBTRACT, together with other logic functions such as AND, OR and NEGATE. Referring to the diagram above, the function required is selected by the bit pattern on the control lines, with the data put out onto the data lines, called the DATA BUS.

CONTROL UNIT AND DATA BANK

The purpose of the Control Unit is to read and write data to the arithmetic unit, and to control or select the current function being performed by the arithmetic unit.

The purpose of the data bank/memory is to store data used by the system until required. (See diagram).

INSTRUCTION MEMORY

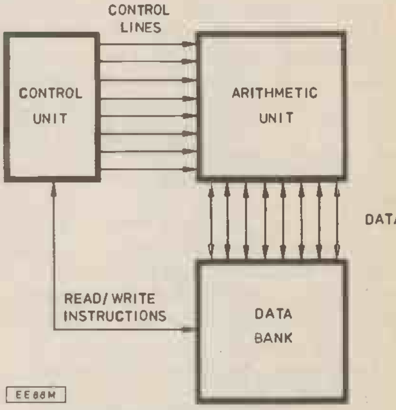
There is an instruction memory built into the computer system whose function is to hold a list of instructions which form the basis of a PROGRAM. This list of instructions is fed, in a logical sequence, to the control unit which then carries out arithmetic logical and data movement operations as required by the information within the instruction being carried out. The details of the instructions are also sent to the data bank in order to select the correct words of data to be operated upon.

The instruction format will be described below and the diagram below shows the basics of the computer layout. The part of the drawing showed within the dotted line represents the Central Processing Unit.

The instruction memory and the data bank will generally be on the physical block. I.e.: The memory or store.

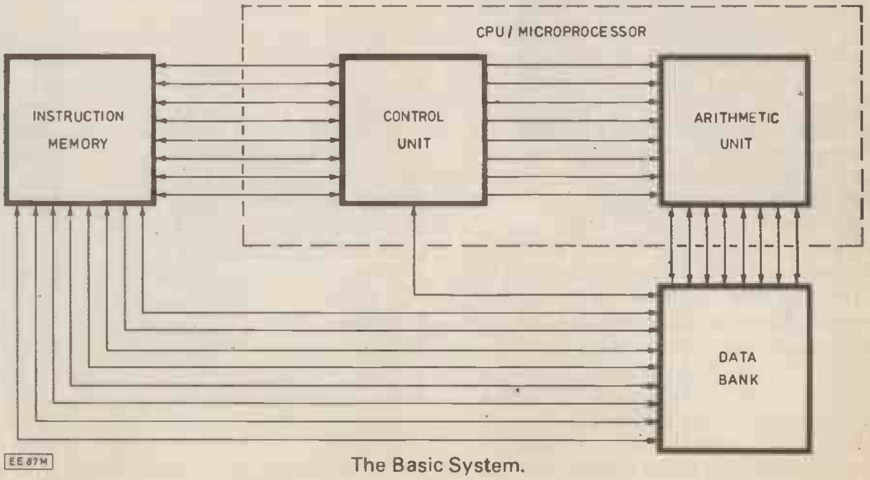
INSTRUCTIONS AND LANGUAGES

The instructions used by the system generally will fall into two parts, the operation part and the address part. The operation part specifies the function being carried out, e.g. add or subtract, whilst the address part specifies the address or location of an item of data within the memory.



The Control Unit and Memory.

The format of the actual instructions used can be of several different types. The actual components within the system only understand machine code language which is the use of binary numbers only, with the size of word being used being dependant upon the type of system being used. For example, early machines used 4-bit word format. Later, 8-bit words became



The Basic System.

used and later still 16-bit words were to be found. Many new machines are now using 32-bit word formats.

Each instruction can carry several words. The format described above is said to be machine readable and is called the Object Program.

Now, for the user, it would become quite tedius to enter an object program into a computer as a series of binary words, especially if 32-bit words were being used. Also, it is likely that many mistakes would result. Instead, the user can write the program as a series of hexadecimal words, usually of 2 digits. This makes the task less tedious but, even then, numbers and figures are still being entered and, again, mistakes are possible.

How much easier it would be to program the computer using a language that was man-readable instead of machine-readable. Well, this is sometimes possible, depending upon the type of system being used. The program can sometimes be entered as mnemonics which is a series of instructions that are fairly easy to understand and read by the user. The mnemonics form the source program and are written in assembly language.

Thus the program is generally written in assembly language (as the source program) and this is then converted by a part of the system called an assembler into the object program that the machine readily understands.

We therefore have three different ways of entering the information of the program into the system, either by entering complete binary words, hexadecimal or by entering mnemonics. Let us now consider a simple piece of a program and look at the comparison of the three different ways of entering the information, without trying to understand what is happening in the program.

Looking at three data words, X,Y,Z, held in three successive memory locations 0200, 0201 and 0202, we compute A=X+Y−Z and store the result in location 0203. (The instructions shown in the table are instructions within the Motorola 6800 microprocessor architecture.)

Now, looking at the three different ways of showing each instruction, using mnemonics must surely be the best method used. It is very useful to see exactly what is happening within a program listing and, using mnemonics, a programmer does have a better idea of what functions are taking place in the program at a particular point. With hexadecimal, the program is listed using pairs of hexadecimal. This is an aid to entering the program into the computer but, at the same time, the task of identifying individual parts of the program, in a long program listing, is very difficult. With binary, the task seems to be almost impossible when the programmer is faced with a continuous stream of 0's and 1's.

Much of what has been said above depends very much on the type of system being used and that system's built-in intelligence but, nevertheless, it should give a useful grounding to the reader.

Instruction	Mnemonic	Hexadecimal	Binary
Load ACC.B from location 0200	LDAB 0200H	F6 02 00	11110110 00000010 00000000
Add the contents of 0201 to ACC.B	ADDB 0201H	FB 02 01	11111011 00000010 00000001
Subtract the contents of 0202 from ACC.B	SUBB 0202H	F0 02 02	11110000 00000010 00000010
Store the contents of ACC.B in 0203	STAB 0203H	F7 02 03	11110111 00000010 00000011

Comparison of instructions.

The example of the program used above was written for a Motorola 6800 series microprocessor. This is an 8-bit processor that has two main registers, A and B, an index register, X (which can carry 16 bits of information) and three other special purpose registers. Of these special purpose registers there is:—

(1) THE CONDITION CODE REGISTER (CCR)

This is an 8-bit register which is capable of storing the states (either '0' or '1') of certain flags used by the system. For instance, if an addition takes place within the processor and a carry takes place, then a CCR 'carry flag' will be set.

(2) THE PROGRAM COUNTER (PC)

This is a 16-bit register that always contains the address in memory of the next instruction to be carried out. That is, a program is written by the programmer and a section of memory is set aside to hold the program, so that for any particular byte of the program, a specific memory location is set aside for it. The program counter, therefore, keeps track of which parts of the program have been carried out already and becomes set to the address of the next instruction in memory. Before the program has been started, therefore, the program counter contains the actual start address of the program.

(3) THE STACK POINTER (SP)

Part of the RAM memory is set aside for use as the stack. This is a section that is used to store results, on a temporary basis, during a run of the program. It is called a stack because the system works on a last-in-first-out basis. The stack pointer, therefore, contains the actual address in memory of the stack. I.e.: it points to it by address.

Most of the instructions available for the device, therefore, include functions that encompass one or more of the above registers. The remaining instructions provide other special facilities. But, as stated previously, the above only concerns the Motorola 6800 series of microprocessors. However, other types of microprocessors have similar structures and similar instructions available. For example the Z80 microprocessor, by Zilog, has, instead of just two main registers, several pairs of main registers together with an alternate set as well. Each pair, say the BC pair, can be used together as a 16-bit register or separately as a B register and a C register, both being 8-bits. As far as the alternate register set is concerned, not all the instructions for the main register set can be used by the alternate register set.

EXTERNAL COMMUNICATION

Computers generally need to have external communication facilities in order to talk to or listen to other devices. Facilities are therefore available to provide communication with printers, visual display units, modems, etc, as well as input/output ports for driving to and from the real world.

MICROCOMPUTER DESIGN

Let us now consider a simple, yet practical microcomputer design. First of all we must formulate our requirements:—

(1) MICROPROCESSOR USED

We must decide which microprocessor should be used as the central processing unit. We have mentioned briefly the Motorola 6800 series and the Zilog Z80 series microprocessors above. Many other processors exist including the Intel 8080, which uses a similar instruction set to that used by the Zilog Z80. The 6800 series offers a limited yet fairly easy to understand instruction set whilst the Z80 offers more computing facilities, if required, by the greater number of registers.

Let us use a Z80 microprocessor in our design.

(2) OPERATING SYSTEM USED

Every computer requires an Operating System, of some kind, to function and usually this is put in firmware form into a ROM (or EPROM) chip. Let us consider that our design utilises a 4K Byte EPROM in the form of two 2716 chips, each of which offers 2K Byte storage of 8-bit words.

(3) TEMPORARY DATA STORAGE USED

Every system needs some form of temporary data storage and as previously stated, this is generally in RAM form. For our design, let us say we require 1K Byte of RAM and we will use two 2114 chips in order to get the 1K Byte required. These chips offer 1K Byte storage of 4-bit words.

(4) INPUT/OUTPUT USED

Let us suppose that our system design requires to include some input/output facilities. This is available using a readily available input/output chip, the 8255, for Z80-based systems and this is the chip that we shall use in our system, giving 24 I/O lines. If we need 24 lines, only one 8255 is required.

All the basic components described above have data lines and address lines and power supply connections. Apart from the Z80 microprocessor we will not consider, the power supply connections, but we will have to show all the data and address line connections for each chip. Now, so far we have discussed all the basic components required but we have not considered how the microprocessor can communicate with each particular chip. Since all the chips utilise the same set of control/data lines, the microprocessor cannot distinguish between one chip and another. Therefore we need to have some type of coding for each chip, so that only the relevant chips are enabled at any one time. Also since all the chips are now going to have a unique coding for each function used, we must have some way of making sure that, in fact, the codes are unique and that no two functions share the same code area. This is called MEMORY MAPPING and is essential if the system design is to be feasible.

MEMORY MAPPING

We look at each component in turn and decide where, in the total possible addressing area, each is to be situated. We split the area up into sections, so much for ROM, so much for RAM and so much for I/O, etc. Hence we are creating a map which shows where each function can be found.

Let us consider the system that we are designing. The Z80 microprocessor has 16 address lines, A_0 to A_{15}, therefore we have facilities to address $2^{16} = 65536$ individual locations. (Note that 65536 = 64K Bytes), or in hexadecimal form, from 0000 up to FFFF.

We can now consider each component function and allocate a space within the available 64K Bytes of memory.

EPROM

We have 4K Bytes of 8-bit words, and we are using two 2K Byte chips to form the total 4K Bytes. Now 2K Bytes represents 2×1024 = 2048 in decimal and 0800 in hexadecimal This last figure is the important one since we can now map our two EPROM chips at memory locations 0000 to 07FF and 0800 to 0FFF, which is a total memory area of 4K Bytes.

RAM

We have 1K Byte of 8-bit words, and we are using two 1K × 4-bit word chips to form the total required.

Now 1K Byte represents 1024 decimal, which is 0400 in hexadecimal. Let us, therefore, map our RAM at memory locations 1000 to 13FF, which is an area of 1K Byte.

I/O

Now for our Input/Output port, we are using one 8255 I/O chip. This has three 8-bit word lines available. That is, any one of three words can be input or output from the device at any time. Now, we have a function available from the microprocessor that can control whether we read/write to memory or to input/output, we are not able to read/write to both at the same time. Therefore we can locate our I/O port at any location we choose. We have three lines as stated, therefore we can locate our lines at, say, locations 20, 21 and 22 hexadecimal.

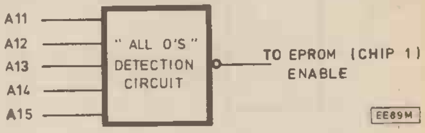
Our memory map will now look like this:—

(Hexadecimal addresses given)

0000 ↕ I/O-20 ↕ 07FF	EPROM (CHIP 1)
0800 ↕ 0FFF	EPROM (CHIP 2)
1000 ↕ 13FF	RAM
1400 ↕ FFFF	SPARE

Now we mentioned, previously, that we needed to code the functions so that each had its own unique memory area. We have now mapped out the memory areas but we have not yet provided the necessary coding (or decoding to be more specific). Let us consider the first EPROM chip, to be situated at memory locations 0000 to 07FF hexadecimal. We require to enable this chip whenever we are in the area of map from 0000 to 07FF only. Therefore, let us look at the 15 address lines, together with the total possible memory area that each line could enable.

Now we need to locate our EPROM memory between 0000 and 07FF, that is, at all times that address lines A_{11} to A_{15} are set to logic '0'. Therefore all we need to do is detect all 0's on A_{11} to A_{15} and enable our first EPROM chip. Our block diagram for this is shown below:—



Simple Address Decoding.

For our second EPROM chip, we need to locate this at memory area 0800 to 0FFF, therefore we detect when the address lines A_{12} to A_{15} are all 0's and A_{11} is a 1.

We next look at the two 2114 RAM chips and note that they need to be decoded between 1000 and 13FF. We therefore look at address lines A_{10} to A_{15} and decode accordingly.

Finally, for the I/O chip, we need to locate this at 20 hexadecimal which is equal to 32 in decimal. Therefore we AND the A_5 address line with the I/O control line so that the chip is enabled wherever 20 hexadecimal is selected on the address. To select the required I/O line at address 20, 21 and 22 we then look at A_0 and A_1 to see when 20, 21 or 22 is addressed.

We have now memory mapped the complete microcomputer system and so we can now draw the (block) diagram to show our complete design (as shown on opposite page).

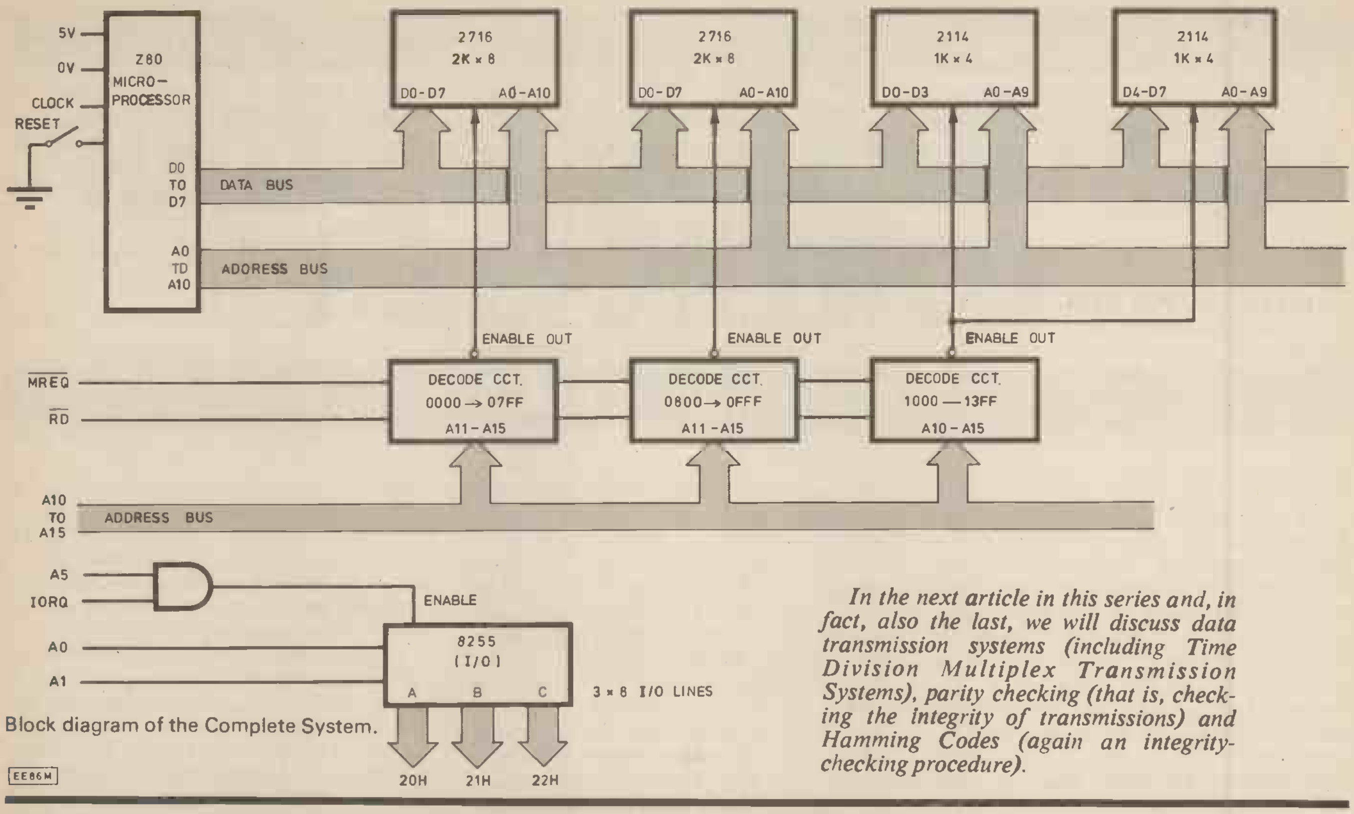
It should be noticed that we also send the data lines to each chip as required. For instance, the 2716 chips are 8-bit word chips so we send data lines D_0 to D_7 inclusive. The 2114 chips are 4-bit word chips so we send D_0 to D_3 inclusive to one chip and D_4 to D_7 inclusive to the other, giving 8-bits in total. We similarly send D_0 to D_7 to the 8255 chips.

Each decoding circuit is fed with the $\overline{MREQ}$ and $\overline{RD}$ controls from the microprocessor which are (active low) Memory Request and Read/Write controls respectively. Likewise the I/O port is fed with the IORQ (Input/Output Request) control as previously mentioned.

The decoding discussed is called Partial Address Decoding because we are only looking at some of the possible address lines. If we looked at all the address lines, then this would be called Total Address Decoding (not generally required).

Above we have discussed the basics of microprocessor system design and we have tried to describe the best way of going about such a design. For further information, several good books are available.

	A_0	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A	A_{13}	A_{14}	A_{15}
(DECIMAL)	2	4	8	16	32	64	128	256	512	1K	2K	4K	8K	16K	32K	64K
(HEXADECIMAL)	0002	0004	0008	0010	0020	0040	0080	0100	0200	0400	0800	1000	2000	4000	8000	10000



Block diagram of the Complete System.

In the next article in this series and, in fact, also the last, we will discuss data transmission systems (including Time Division Multiplex Transmission Systems), parity checking (that is, checking the integrity of transmissions) and Hamming Codes (again an integrity-checking procedure).

COUNTER INTELLIGENCE

BY PAUL YOUNG

Path Finder

If there is one engineering success that would not exist today without the micro chip and modern electronic technology, it is the aircraft flight simulator. That being so, it is nice to be able to report that one of the foremost leaders in the field is British; I refer to Rediffusion. They are the largest manufacturers of aircraft simulators in Europe, and one of the largest in the world.

I was reminded of this a few weeks ago when I was watching the BBC2 *Money Programme*. It showed the flight deck of a DC10 taking off from Heathrow. A few hundred feet up, there was a sudden severe down draught which the pilot skilfully corrected.

The commentator then told us that even if the pilot had failed to correct it, no one would have been hurt as they were in a simulator. At that moment the pilot turned his head, and I recognised an old friend of mine, Captain Charles Coates. I rang Captain Coates next day and he filled me in on the company and its success record.

The modern simulator is an incredible piece of machinery. Externally it looks like a house on steel stilts, but once inside you are immediately transported on to the flight deck of a Jumbo jet, a Concorde, a Harrier or any other aircraft. So effective is the simulator, that a captain of an American airline flew over from the States in a Jumbo jet, spent the requisite number of hours in a DC10 simulator, went down to Gatwick and flew a DC10 back to Los Angeles with a full load of passengers, although he had never flown one before.

Apart from the safety angle, they are cost effective, as the cost of training in a real aircraft is twenty times as much as the simulator. Bearing in mind their average price is about five million pounds, they need to be. In spite of the price, there are no lack of orders and they are being exported all over the world, including America and Japan.

Thunder Struck

When Sir Clive Sinclair announced a year ago that he was going to build an electric car, I thought it won't be long now before the oil sheiks are folding their tents and silently departing. I must admit that the end product has been a great disappointment. The *C5* is little more than a toy. The range, the speed and the carrying capacity are all too low to be of any practical value.

When I read that it will carry one cubic foot of shopping I nearly fell off my chair laughing. Sir Clive ought to line up at the check-out of any supermarket and observe the matrons with their trolleys piled so high you begin to wonder if they have a small pantechnicon in the car park.

However, I haven't given up hope of having an electric car, as I see that Mr. Joe Schwarzkopf (a relative of the singer), with the help of a consortium which includes Varta Batteries, Unipart, Uniroyal Tyres, HB Switch Gear and Berger Industrial Coatings, is producing a kit to convert the family car into an all-electric vehicle. It will have a range of 140 miles, a top speed of 80, and the running costs and maintenance will be almost nil. In addition, no road tax is required.

The conversion will cost about £3,000, and the following cars are particularly suitable for converting. The Austin Mini and Maestro, Ford's Fiesta, Volkswagen Polo and Ford's Sierra. So I am afraid the Editor will have to rough it in his Rolls for a little longer.

A B747 flight simulator installed at American Airlines Gatwick training academy by Rediffusion Simulation.

IMMERSION HEATER CONTROLLER

T.R.de Vaux Balbirnie

INDISCRIMINATE use of the immersion heater can result in large electricity bills. One method of heating only the water required is to switch on for short times. Unfortunately, it is easy to forget to switch off again. This unit switches off the immersion heater when the water in the copper storage cylinder is heated to a predetermined temperature at some chosen level. It is a *one-shot* system initiated by a push-button switch on the unit. When the immersion heater switches off it will stay this way until the switch is pressed again. Potential savings are high.

OPERATION

As the water heats up, it does so from the top of the cylinder downwards. Thermistors attached to the tank at four points act as temperature sensors. When hot water reaches the chosen level, the circuit is triggered and the heater switches off. The level is selected by a rotary switch representing hot water *quantity* on the front panel of the unit. One red light-emitting diode in a row of four illuminates to confirm the level chosen. A similar row of green l.e.d.s light in sequence following the progress of hot water. In this way, the state of the system is seen at a glance. One additional position on the rotary switch selects *Cancel,* and this serves two purposes. If used while the immersion heater is on, it will switch off immediately. If the system is not operating, the green l.e.d.s will light when the *Start* button is pressed allowing the level of hot water to be checked without operating the heater. Another spare position on the rotary switch gives continuous operation if required.

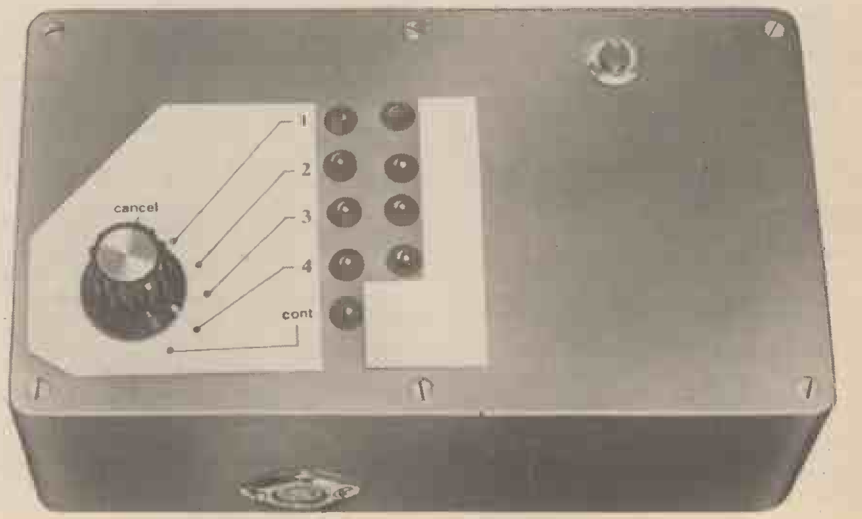
The new circuit takes over all normal operation of the immersion heater—the existing wall switch is retained simply as an isolator. The temperature at which each sensor operates is adjusted at the testing stage and is performed with the lid of the case in position—an important safety point since there are mains connections inside.

CIRCUIT DESCRIPTION

Fig. 1 shows the entire circuit of the Immersion Heater Controller. The single integrated circuit, IC1, contains four separate operational amplifiers, IC1a to d, each responsible for one particular water level—IC1a for the top one and so on. When S2 (Start) is pressed, mains current flows through the primary of T1 and the low-voltage output is rectified by REC1 and smoothed by C1. This supplies power to the rest of the circuit. TR1 turns on due to base current flowing through R13 and this operates RLA connected in the emitter circuit. The normally-open contacts of RLA allow mains current to flow through the coil of RLB and this operates the mains load through its pair of normally-open contacts. RLB also allows current to flow to T1 so the action is now self-sustaining and S2 may be released. This all happens so quickly that momentary pressing of S2 is sufficient for the system to operate.

The non-inverting inputs of all op-amps share the common potential divider R5/R6 which applies a voltage of one-half that of the supply (nominally 6V) to them. The inverting inputs have individual potential dividers—VR1 to VR4 in the upper "arms" and R1 to R4 in conjunction with R15–18 in the lower ones. Thus, the voltages produced at the inverting inputs will depend on the individual adjustments of VR1 to 4 and the temperatures of the thermistors. Since the thermistors are *negative temperature coefficient* types their resistances *fall* as their temperatures rise. When a thermistor senses hot water, the voltage at the inverting input of the corresponding op-amp will fall. In use, VR1 to 4 will be adjusted so that, under cold conditions, the voltages at the inverting inputs will exceed those at the non-inverting inputs and the op-amps will be off. As the level of hot water progresses, the op-amps will switch on in turn operating the green (Progress) l.e.d.s D1 to D4. One pole, S1a, of the double-pole rotary switch, S1, selects the op-amp output appropriate to the level of hot water required. When this op-amp switches on, thyristor CSR1 is triggered by gate current flowing through R11 and TR1 switches off. RLA no longer maintains the coil of RLB and the mains load switches off. Primary current to T1 is also interrupted so the circuit cannot work until S2 is pressed again. The purpose of CSR1 is to provide a switching action at the critical temperature.

The second pole of S1, S1b, operates the red (*Level*) l.e.d.s D6 to D9 or the yellow (*Continuous*) one D10. The Continuous position of S1a is left unconnected so CSR1 never triggers allowing RLB to operate continuously. The existing thermostat prevents the water from overheating. The *Cancel* position is connected direct to supply positive so CSR1



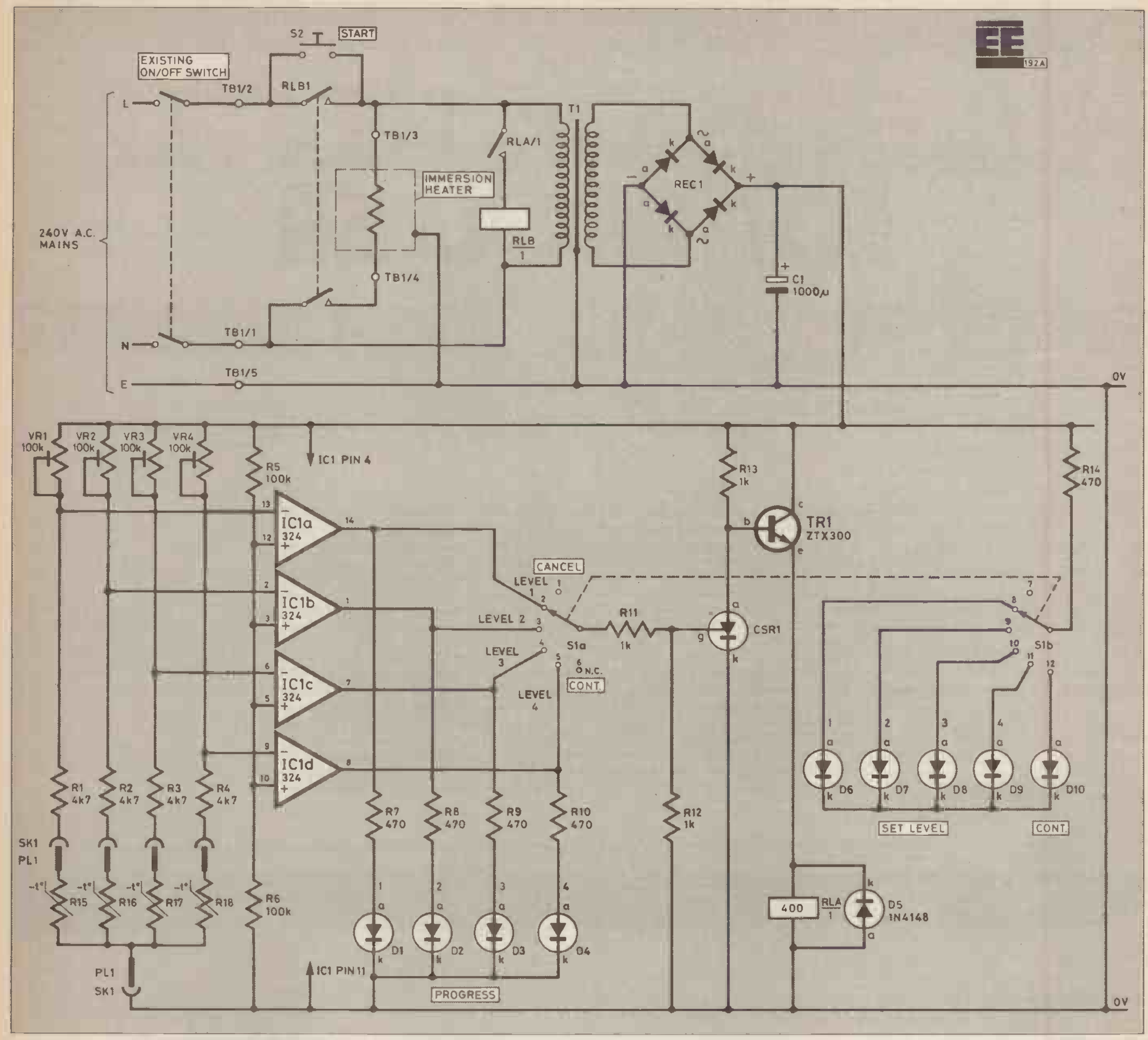


Fig. 1. Circuit diagram. Note: If the mains supply does not come from a 13A fused plug, then a fuse should be inserted in the supply LIVE wire.

is triggered as soon as S2 is operated. This prevents the immersion heater from switching on yet allows the *Progress* l.e.d.s to operate.

The sensors are glued to the surface of the copper cylinder and connected to the unit by means of an audio-type 5-pin DIN plug and socket.

CONSTRUCTION

Refer to Fig. 2 and construct the circuit panel using a piece of 0·1in. matrix stripboard size 17 strips by 41 holes. Check that this fits the runners of the plastic box securely. Mount the i.c. socket and make all the breaks and inter-strip links. Note especially the breaks between the pins of the i.c. holder but *not* between pins 3 and 12 or between pins 5 and 10. Note also the break at the bridge rectifier. Solder the on-board components noting that VR1, VR2 and VR4 have one of their connections cut off close to the body and left unconnected—they are adequately supported by the remaining two soldered connections. The breaks in the copper tracks at RLA isolate the mains section from the rest of the circuit. *For safety reasons, check that these are completely broken.*

For clarity, Fig. 2 shows C1 alongside the circuit panel but when in position its leads are bent so that the lid fits. Connect 20 cm lengths of light-duty stranded wire to the 15 points indicated along the left-hand edge of the panel. Do not make the right-hand connections yet. In view of the possibility of error, it would be wise to use different colours if possible. Make a final check for wiring errors and for accidental solder "bridges" between adjacent copper tracks.

Prepare the case by making holes for the nine l.e.d.s, for S1, S2, SK1 and for mounting T1, RLB and TB1. RLB must be of the heavy-duty pattern specified in the components list and S2 must be rated for mains use. Make holes in the case for the input and output wires which connect to TB1. Measure the positions of VR1–4 on the circuit panel and drill 5mm holes in the side of the case so that they may be adjusted by means of a small screwdriver.

Mount the off-board components (the exact layout will depend to some extent on the size of T1) and, referring to Fig. 3, complete all internal wiring. Note that TB1/5 (mains earth) inter-connects the following: l.e.d. cathodes, solder tag at T1, solder tag at S2 (only needed if this component has a metal body), SK1 body which forms the common thermistor connection and the circuit panel earth lead.

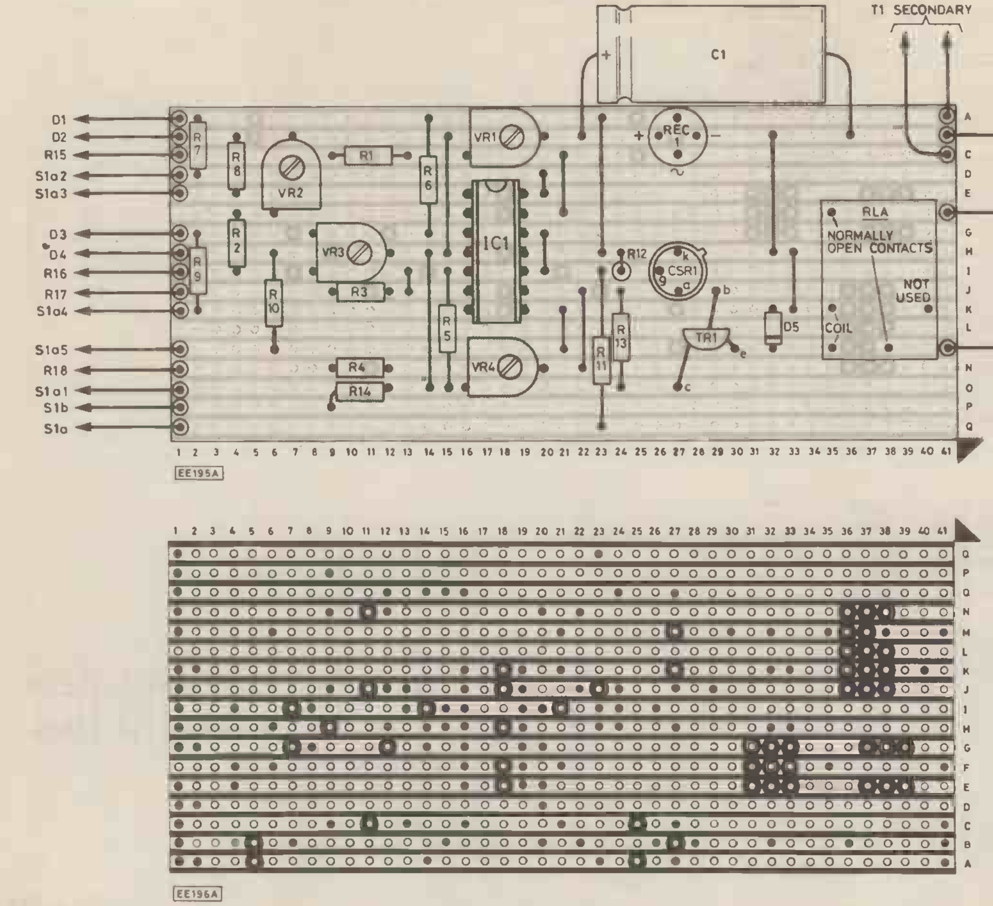


Fig. 2. Stripboard layout of Immersion Heater Controller.

COMPONENTS

Approx. cost Guidance only **£25**

Resistors

R1,2,3,4	4k7 (4 off)
R5,6	100k (2 off)
R7,8,9,10,14	470 (5 off)
R11,12,13	1k

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

Potentiometers

VR1,2,3,4 — 100k min. hor. preset

Capacitors

C1 — 1000µF 16V elect.

Semiconductors

IC1	LM324N quad op. amp.
CSR1	BTX 18–400 thyristor
TR1	ZTX300 npn silicon
D1,2,3,4	green (4 off)
D6,7,8,9	red (4 off)
D10	yellow
D5	1N4148
REC1	W005 bridge rectifier

Miscellaneous

T1	Miniature mains transformer with 240V primary and 12V secondary. 150mA or more current rating.
S1	2-pole 6-way miniature rotary switch—break-before-make action. Pointer knob to suit S1.
S2	Push-to-make switch with 240V contacts.
RLA	P.c.b. mounting relay—400 ohm coil and mains-rated normally-open contacts, e.g. Maplins 10A Mains Relay.
RLB	Heavy-duty relay with 240V coil and double-pole changeover contacts rated at 20A (R.S. type 340–403).
	14-pin integrated circuit socket.

See Shop Talk page 199

5-pin DIN plug and chassis socket.
15A terminal block (5 sections needed).
0·1in. matrix stripboard, size 17 strips by 41 holes.
L.e.d. panel mounting clips (9 off),
solder tags, sleeving,
13A mains wire,
immersion heater wire,
5-core wire.
ABS box size 190 × 110 × 60mm external.

RTH1, 2,3,4 — VA1067S miniature rod thermistors (4 off).

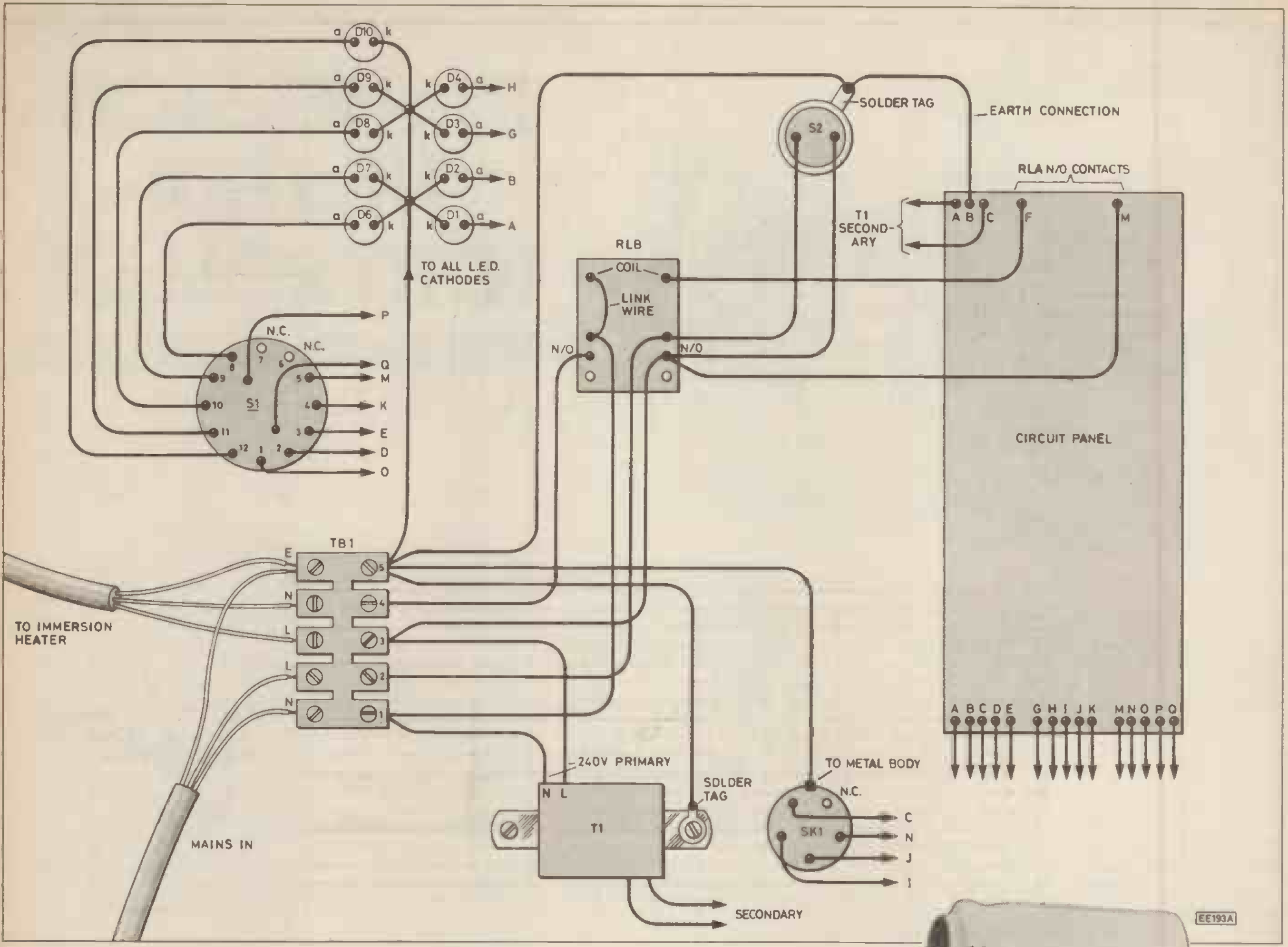
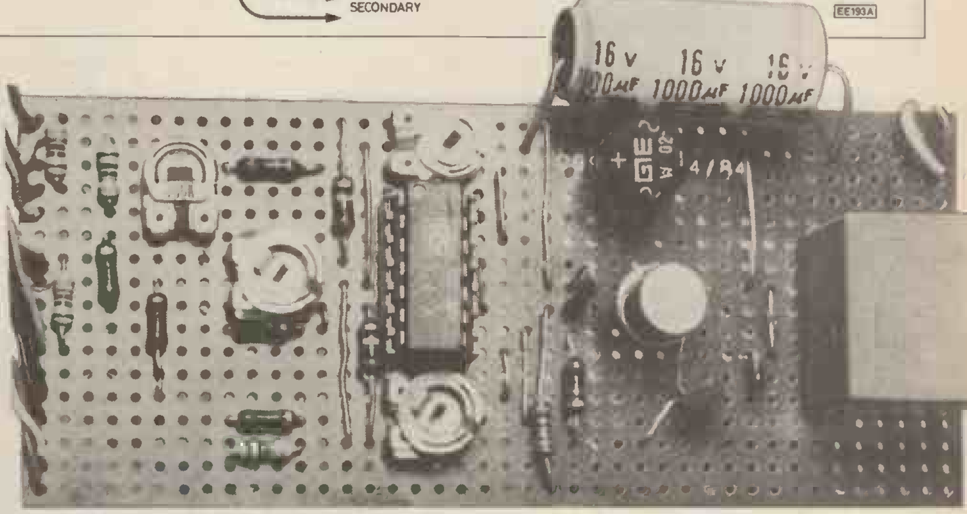


Fig. 3. Wiring diagram.

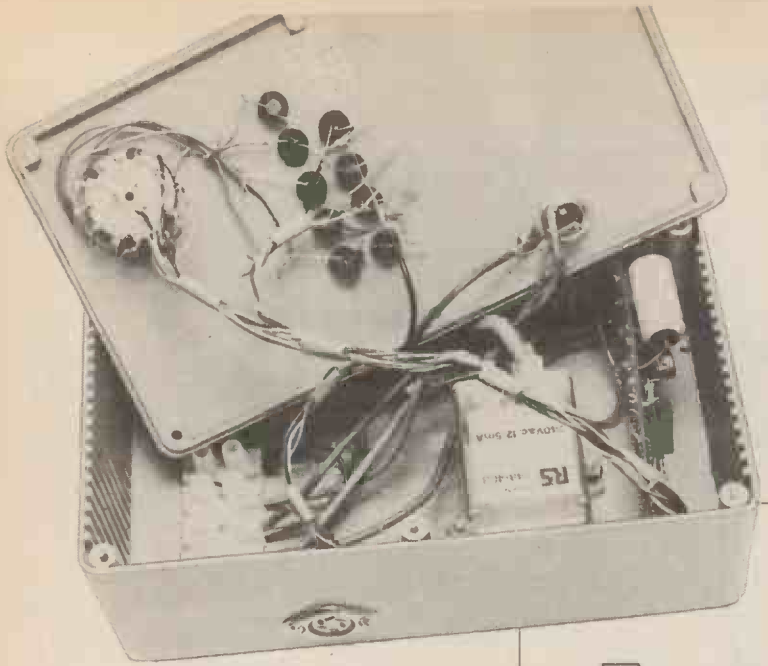


Make RLB connections using $\frac{1}{4}$in. connectors. Do not solder the wires direct. Connections between the contacts of RLB and TB1 must be made with mains wire of at least 13A capacity (40/0·2mm). Those between RLA contacts and RLB also the link wire at RLB and connections to S2 are made using light-duty mains wire.

Leave VR1 to 4 adjusted to approximately mid-track position, slide the circuit panel into position and fit the lid of the case bending the leads of C1 as necessary. Check that there are no trapped wires and that the l.e.d. connections do not cause short circuits.

TESTING

Note: *All tests and adjustments must be made with the lid of the case on.* A basic check may be made on the circuit before attaching the thermistors to the hot water cylinder. Using light-duty mains wire, connect a mains plug to TB1/2, 1 and 5 (Live, Neutral and Earth respectively) and fit a 3A fuse. Connect the Live, Neutral and Earth wires of a table lamp to TB1/3, 4 and 5 respectively. Connect five short temporary wires to the DIN plug noting that the common one is connected to the metal body. Set S1 to Level 1, plug the unit into the mains and press S2. RLB should click distinctly and the lamp light. D6 should light but all other l.e.d.s remain off. Rotate S1 noting that D7 to D10 light in the correct sequence. With S1 at Level 1, connect the Level 1 and Common sensor wires together. D1 should light. Touch the Level 2 and Level 3 wires to those already connected—D2 and D3 should light. Add the Level 4 sensor wire and the system should switch off. Re-activate the circuit and test the *Cancel* position of S1. If all is well attention may be given to attaching the thermistors to the copper cylinder. Begin by extending the leads as indicated in Fig. 4. Although 5 separate lengths of light-duty stranded wire could be used, it is more convenient to use 4-core screened wire with the screening forming the common wire. An



IMMERSION HEATER CONTROLLER

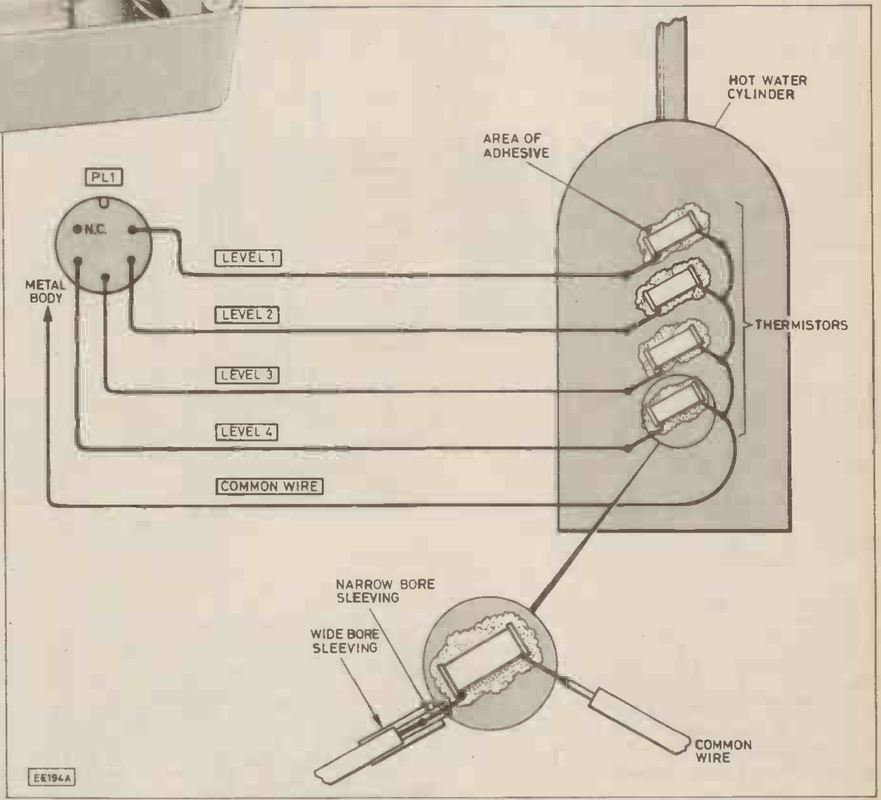


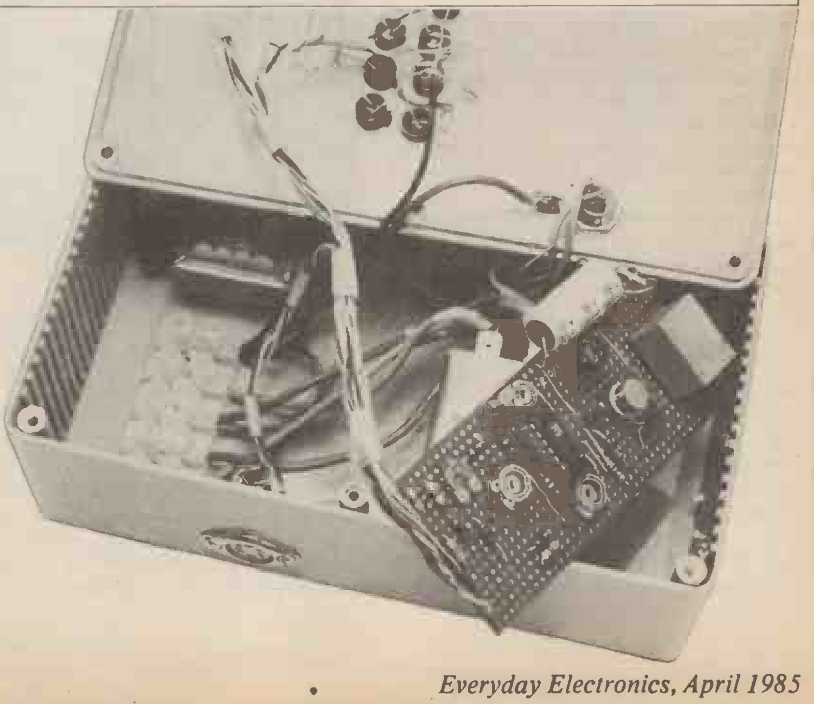
Fig. 4. Wiring between the thermistors and PL1, positioning of the thermistors on the hot water cylinder, and their mode of connection is illustrated

alternative would be to use 4-core telephone line with an additional wire taped to it. Remove the cylinder insulating jacket and clean the copper surface in the chosen areas using emery cloth. In the prototype, these positions were $\frac{1}{5}$, $\frac{2}{5}$, $\frac{3}{5}$, and $\frac{4}{5}$ of the distance from the top of the cylinder. Quick-setting epoxy-resin adhesive should then be used to secure the thermistors. It is necessary to provide insulation between the bodies of the thermistors and the metalwork; if this is not done the circuit will fail to work properly. The film of adhesive provides this insulation but care must be taken not to make it too thick or the free flow of heat will be impaired. Finally, solder the wires to the DIN plug at the other end.

MAINS CONNECTIONS

Make the connections from TB1 to the wall switch and to the immersion heater. It is essential to use wire approved for use in immersion heater installations. This is butyl rubber heat resistant wire of 20A rating. Under no circumstances omit any earth connections. Fit strain relief bushes to the wires where they pass through the case.

After re-connecting the mains supply, the system may be checked and the preset potentiometers adjusted over a period of a few days to give the correct operating temperatures. □



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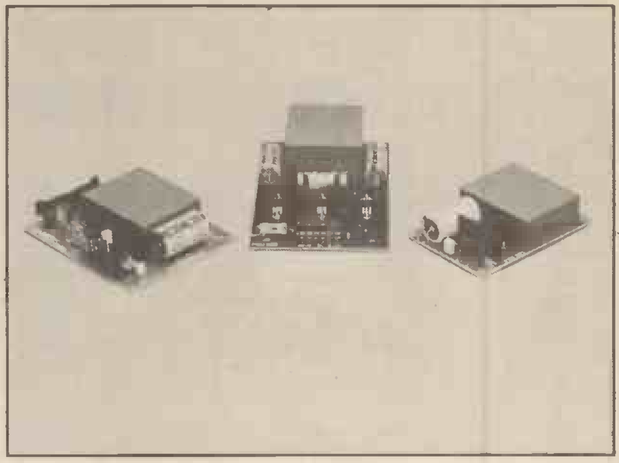

BRIGHT LIGHT

A FAMILY of standard, seven segment l.e.d. displays, driver boards and power supplies are being marketed by **Antech Opto-Systems**.

The standard range of seven segment l.e.d. displays are available in sizes ranging from 1½ to 4 inches in half-inch intervals, individual l.e.d.s being mounted on printed circuit matrix boards. The displays are fully diffused and available in red, yellow and green.

There are three different power supplies for running 1½ and 2, 2½ and 3, and 3½ and 4in. displays.

A range of anciliary boards are available, including a high power driver board with 32 input/output ports and a splitter board for driving two separate displays, each displaying the same information.

Three control boards are included in the display family, a four digit serial data I/O board, 0–2V or 0–200mV DVM board and a BCD input board. In addition to the standard range of displays, the superbright displays are available in sizes manufactured to customer requirements.

For further information, readers should contact:

Antech Opto-Systems Ltd., Dept EE, 14 Bell Street, Maidenhead, Berks SL6 1BR.

CIRCUITMATE

A COMPACT hand-held digital multimeter for only £32.25 (plus VAT) is now being marketed by **Beckman Industrial**

and is available from their network of distributors. The meter is the Circuitmate DM10 which offers all standard multimeter measuring functions—except a.c. current—in a case size of only 120 × 70 × 24mm.

The DM10 measures d.c. voltage in five ranges from 200mV to 1000V; a.c. voltage in two ranges of 200V and 500V; d.c. current in four ranges from 200µA to 200mA, and resistance in five ranges from 200 ohm to 2 Megohm.

A separate diode test function is also incorporated. Measurements are read on a high-contrast, 3½ digit l.c.d. display.

Addresses of nearest stockists may be obtained from:

Beckman Industrial Ltd., Electronic Technologies Division, Dept EE, Mylen House, 11 Wagon Lane, Sheldon, Birmingham B26 3DU.

LOW PROFILE

A RANGE of p.c.b. mounted power supplies has recently been introduced by **Lascar Electronics**. All have an encapsulated low profile transformer giving a compact and rugged construction. The mains 220–240V a.c. input may be changed to 110–120V a.c. by simply moving an on-board link.

The range includes single rail, twin rail and triple rail types, some being fitted with card handles and connectors for rack mounting. All types are over-current, over-temperature and short-circuit protected.

For details of prices and the complete range of output voltages available readers should contact:

Lascar Electronics Ltd., Dept EE, Module House, Whiteparish, Salisbury, Wilts SP5 2SJ.

TIME FOR GAMES

JOINING **Systema's** range of dedicated computer games are three new products of strategy and tactics—**Backgammon, Checkers and Reversi.**

Each game is pocket sized with a large liquid crystal display area and all models have two levels of difficulty and a two player option.

The BM424 Backgammon computer calls for fast thinking and good luck. Your fate rides on the roll of the built-in electronic dice and the keyboard will react as quickly as you can think.

Checkers is better known in the UK as "Draughts" and Reversi also known as "Othello".

All three models are now available from Systema and retail for about £40. For more details readers should write to:

Systema (UK) Ltd., Dept EE, 72/74 South Street, Reading, Berks, RG1 4LG.

EVERYDAY ELECTRONICS PRINTED CIRCUIT BOARD SERVICE

Printed circuit boards for certain EE constructional projects are now available from the EE PCB Service, see list. These are fabricated in glass-fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for overseas airmail. Remittances should be sent to: EE PCB Service, Everyday Electronics Editorial Offices, Westover House, West Quay Road, Poole, Dorset BH15 1JG. Cheques should be crossed and made payable to IPC Magazines Ltd.

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

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

NOTE: Please allow 28 days for delivery. We can only supply boards listed here.

PROJECT TITLE	Order Code	Cost
— JUNE '83 —		
Eprom Programmer, TRS-80	8306-01	£9.31
Eprom Programmer, Genie	8306-02	£9.31
Eprom Programmer, TRS-80 & Genie	8306-03	£1.98
— JULY '83 —		
User Port Input/Output *M.I.T. Part 1*	8307-01	£4.82
User Port Control *M.I.T. Part 1*	8307-02	£5.17
— AUGUST '83 —		
Storage 'Scope Interface, BBC Micro	8308-01	£3.20
Car Intruder Alarm	8308-02	£5.15
High Power Interface *M.I.T. Part 2*	8308-03	£5.08
Pedestrian Crossing Simulation *M.I.T. Part 2*	8308-04	£3.56
Electronic Die	8308-05	£4.56
— SEPTEMBER '83 —		
High Speed A-to-D Converter *M.I.T. Part 3*	8309-01	£4.53
Signal Conditioning Amplifier *M.I.T. Part 3*	8309-02	£4.48
Stylus Organ	8309-03	£6.84
Distress Beacon	*8309-04	£5.36
Distress Beacon Pocket Version	8309-05	£3.98
— OCTOBER '83 —		
D-to-A Converter *M.I.T. Part 4*	8310-01	£5.77
High Power DAC Driver *M.I.T. Part 4*	8310-02	£5.13
Electronic Pendulum	8310-03	£5.43
— NOVEMBER '83 —		
TTL/Power Interface for Stepper Motor *M.I.T. Part 5*	8311-01	£5.46
Stepper Motor Manual Controller *M.I.T. Part 5*	8311-02	£5.70
Digital Gauss Meter	8311-03	£4.45
Speech Synthesiser for BBC Micro	8311-04	£3.93
Car On/Off Touch Switch	8311-05	£3.11
— DECEMBER '83 —		
4-Channel High Speed ADC (Analogue) *M.I.T. Part 6*	8312-01	£5.72
4-Channel High Speed ADC (Digital) *M.I.T. Part 6*	8312-02	£5.29
TRS-80 Twin Cassette Interface	8312-03/09	£7.43
Touch Operated Die (Dot matrix)	8312-05/06	£4.34
Touch Operated Die (7-segment)	8312-05/07	£4.34
Continuity Tester	8312-08	£3.41
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Central Heating Pump Delay	8401-01	£3.33
Biological Amplifier *M.I.T. Part 7*	8401-02	£6.27
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Analogue Thermometer Unit	8401-03	£2.35
Analogue-to-Digital Unit	8401-04	£2.56
Games Scoreboard	8401-06/07	£9.60
— FEBRUARY '84 —		
Eprom Programmer/ROM Card for ZX81	**8402-01	£7.84
Oric Port Board *M.I.T. Part 8*	8402-02	£9.56
Negative Ion Generator	*8402-03	£8.95
Temp. Measure & Control for ZX Comprs Relay Driver	8402-04	£3.52
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Latched Output Port *M.I.T. Part 9*	8403-01	£5.30
Buffered Input Port *M.I.T. Part 9*	8403-02	£4.80
VIC-20 Extension Port Con. *M.I.T. Part 9*	8403-03	£4.42
Com. 64 Extension Port Con. *M.I.T. Part 9*	8403-04	£4.71
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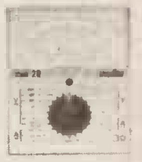

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Type	Model	Size	Watts	Ohms	Price
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Midrange	Mid 100/10	10	100	8	£25.00
Hi-Fi	Major	12in	30	4/8/16	£16.00
Hi-Fi	Superb	12in	30	8/16	£26.00
P.A./Disco/Group	DG45	12in	45	4/8/16	£16.00
Hi-Fi	Woofer	12in	80	8	£25.00
Hi-Fi	Auditorium	15in	60	8/16	£37.00
P.A./Disco/Group	DG75	12in	75	4/8/16	£20.00
P.A./Disco/Group	DG100	12in	100	8/16	£26.00
P A./Disco/Group	DG100/15	15in	100	8/16	£35.00

DISCO **CONSOLE** Twin Decks, **mixer** pre amp **£145**. Carr **£10.**
Ditto Powered 120 watt **£199**; or Complete Disco 120 watts **£300.**
150 watt **£360**; 360 watt **£410.** Carr £30.

DISCO MIXER. 240V, 4 stereo channels, 2 magnetic, 2 ceramic/tape, 1 mono mic channel, twin v.u. meters, headphone monitor outlet, slider controls, panel or desk mounting, matt black facia. Tape output facility. £59. Post £1.
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25 ohm. 3in. £2; 5×3in, 6×4in, 7×4in £2.50. 120 ohm, 3¼in dia. £2.

Make	Model	Size	Watts	Ohms	Price	Post
AUDAX	WOOFER	5½in.	25	8	£10.50	£1
GOODMANS	HIFAX	7½×4¼in.	100	8	£34	£2
GOODMANS	HB WOOFER	8in.	60	8	£13.50	£1
WHARFEDALE	WOOFER	8in	30	8	£9.50	£2
CELESTION	DISCO/Group	10in.	50	8/16	£21	£2
GOODMANS	HPG/GROUP	12in.	120	8/15	£30	£2
GOODMANS	HPD/DISCO	12in.	120	8/15	£30	£2
H+H	Disco/Bass	15in.	100	4/8/16	£44	£3
GOODMANS	HP/BASS	15in	250	8	£72	£4
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INDEX TO ADVERTISERS

AB Microsystems.. 237
AC/DC Electronics 239
AD Electronics 238
American Inventors 238
Benning Cross 240
Bib Audio 219
Bi-Pak .... Cover II
BK Electronics Cover III
B.N.R.E.S. 237
Bull J. 223
Cambridge Learning 208
Computronics 238
Cut Price Electronics 207
Cricklewood Electronics 240
Crofton Electronics 240
Dziubas M 188
Electrovalue 210
Grandata Limited .. 186
Greenweld 186
Ideal Schools 239
ICS Intertext 186
Kelan Engineering 207
London Electronics College 188
Magenta Electronics 190
Maplin Electronics Cover IV
Marco Trading 207
Radio Component Specialists 240
Rapid Electronics .. 189
Riscomp Ltd. 203
Roden Products 239
Skybridge Ltd. 208
T.K. Electronics 187

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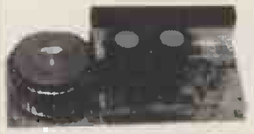

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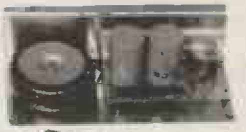

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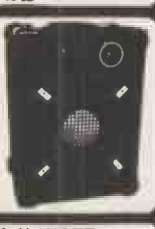

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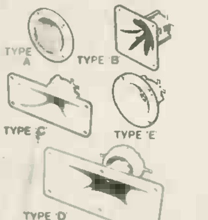

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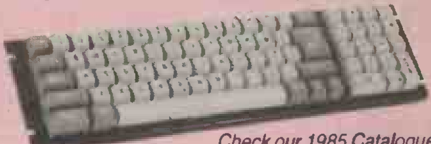

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