

electronics today

INTERNATIONAL

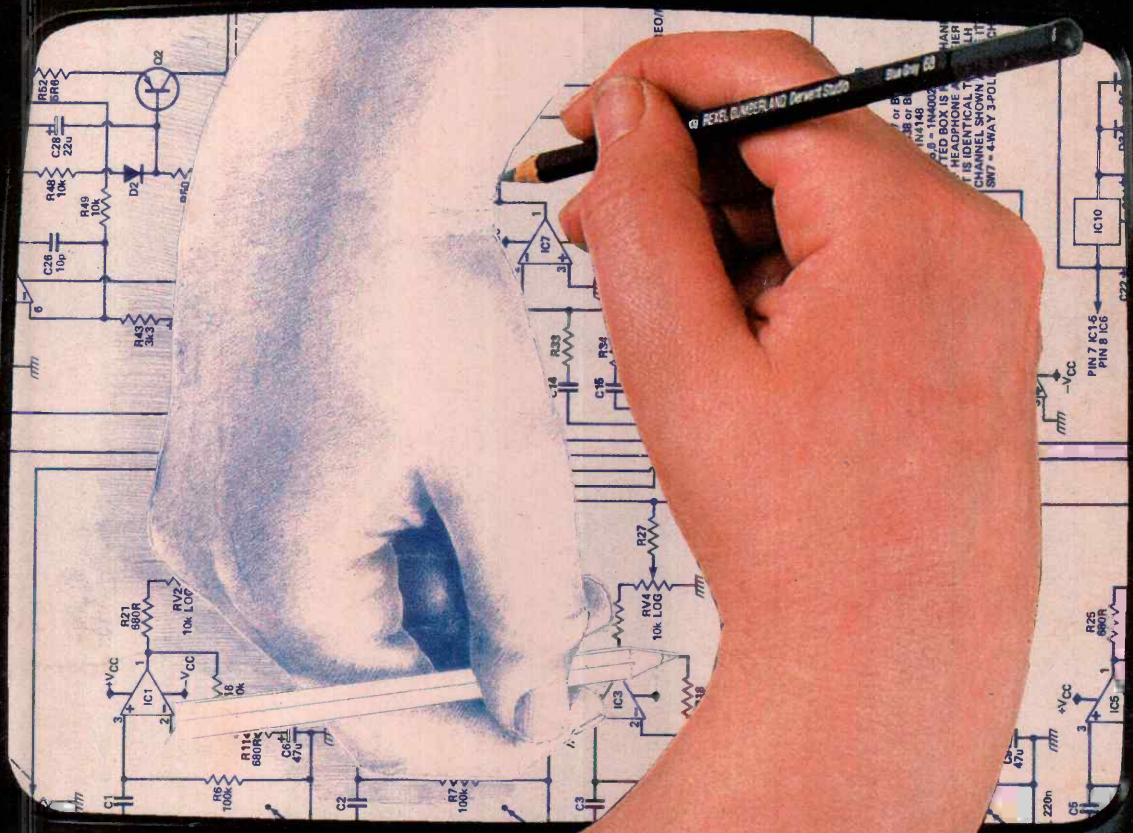
JULY 1986

R5.25

MICROCOMPUTER ASSISTED CIRCUIT DESIGN

STOP PRESS

RADIATION MEASUREMENT: HOW IT'S DONE



ION GENERATOR

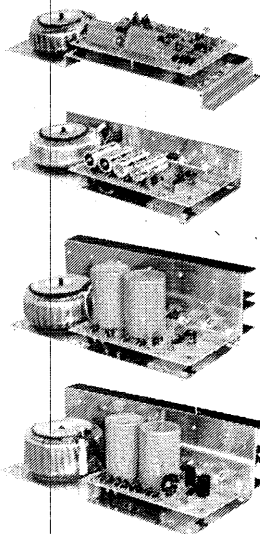
BBC MOTOR CONTROLLER

SATELLITES: SETTING THE WORLD ALIGHT?

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OMP POWER AMPLIFIER MODULES

Now enjoy a world-wide reputation for quality, reliability and performance at a realistic price. Four models available to suit the needs of the professional and hobby market, i.e., Industry, Leisure, Instrumental and Hi-Fi, etc. When comparing prices, NOTE all models include Toroidal power supply, Integral heat sink, Glass fibre P.C.B., and Drive circuits to power compatible Vu meter. Open and short circuit proof. **Supplied ready built and tested.**



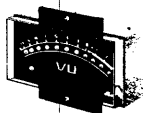
OMP100 Mk II Bi-Polar Output power 110 watts R.M.S. into 4 ohms, Frequency Response 15Hz - 30KHz -3dB, T.H.D. 0.01%, S.N.R. -118dB, Sens. for Max. output 500mV at 10K, Size 355 x 115 x 65mm. **PRICE £33.99 + £3.00 P&P.**

OMP/MF100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz -3dB, Damping Factor 80, Slew Rate 45V/uS, T.H.D. Typical 0.002%, Input Sensitivity 500mV, S.N.R. -125dB, Size 300 x 123 x 60mm. **PRICE PRICE £39.99 + £3.00 P&P.**

OMP/MF200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz -3dB, Damping Factor 250, Slew Rate 50V/uS, T.H.D. Typical 0.001%, Input Sensitivity 500mV, S.N.R. -130dB, Size 300 x 150 x 100mm. **PRICE PRICE £62.99 + £3.50 P&P.**

OMP/MF300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz -3dB, Damping Factor 350, Slew Rate 60V/uS, T.H.D. Typical 0.0008%, Input Sensitivity 500mV, S.N.R. -130dB, Size 330 x 147 x 102mm. **PRICE PRICE £79.99 + £4.50 P&P.**

NOTE: Mos-Fets are supplied as standard (100KHz bandwidth & Input Sensitivity 500mV). If required, P.A. version (50KHz bandwidth & Input Sensitivity 775mV). Order - Standard or P.A.



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 20 oz magnet. 1" ally voice coil. Ground ally fixing escutcheon Res. Freq. 40Hz Freq. Resp. to 6KHz Sens. 92dB. PRICE £10.99 available with black grille £11.99 P&P £1.50 ea.
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 12" 85 WATT R.M.S. C1285GP Lead guitar/keyboard/Disco.
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 3" ally voice coil. Die-cast chassis. Res. Freq. 40Hz. Freq. Resp. to 4KHz. PRICE £54.99 + £4.00 P&P ea.
 10" 60 WATT R.M.S. 1060GP Gen. Purpose/Lead Guitar/Keyboard/Mid. P.A.
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 10" 200 WATT R.M.S. C10200GP Guitar, Keyboard, Disco.
 2" voice coil. Res. Freq. 45Hz. Freq. Resp. to 7KHz. Sens. 101dB. PRICE £51.00 + £3.00 P&P.
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 15" 400 WATT R.M.S. C15400 High Power Bass.
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 5" 70 WATT R.M.S. Multiple Array Disco etc.
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 8" 150 WATT R.M.S. Multiple Array Disco etc.
 1" voice coil. Res. Freq. 48Hz. Freq. Resp. to 5KHz. Sens. 92dB. PRICE £29.49 + £1.50 P&P ea.
 10" 300 WATT R.M.S. Disco/Sound re-enforcement etc.
 1 1/2" voice coil. Res. Freq. 35Hz. Freq. Resp. to 4KHz. Sens. 92dB. PRICE £33.49 + £2.00 P&P ea.
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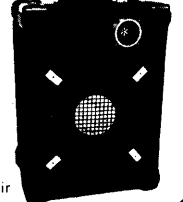
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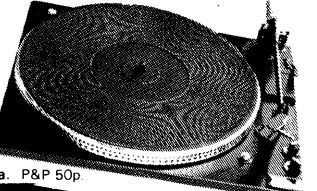
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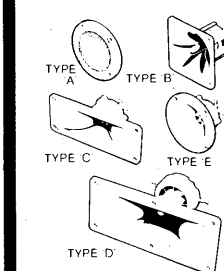


ADC Q4 mag. cartridge for above. Price £4.99 ea. P&P 50p

PIEZO ELECTRIC TWEETERS MOTOROLA

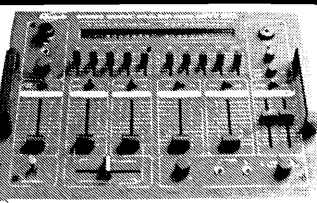
Join the Piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if 2 put in series). **FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER.**

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 Classified Sales Executive
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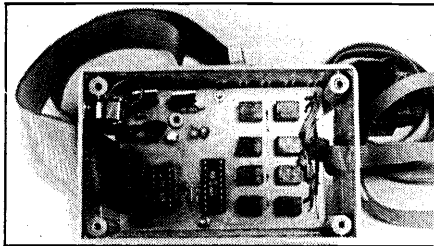
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SWITCHES TOGGLE 2A 250V SPST 500V DDP 48p SUB-MIN TOGGLE SPST on/off 58p SPDT c/over 84p SPDT centre off 85p SPDT biased both ways 105p DPDT 6 tags 80p DPDT centre off 88p DPDT biased both ways 145p DPDT 3 position on/on/on 185p 4-pole 2 way 220p SLIDE SWITCH DPDT 1A 14p DPDT 1A c/off 15p DPDT 1A 13p PUSH BUTTON SA with 10mm Button SPDT latching 150p DPDT latching 200p DPDT moment 200p Mini Non Locking Push to Make 15p Push to Break 25p DIGITAST Switch Assorted Colours 75p each ULTRASONIC TRANSDUCERS 40 Khz 475p (pt). GAS/SMOKE DETECTORS TGS12 or TGS13 £6 each Holders for above 40p	DIP SWITCHES (SPST) 4 way 65p; 6 way 80p; 8 way 85p; 10 way 125p (SPDT) 4 way 190p ROTARY SWITCHES (Adjustable Stop type) 1 pole/2 to 12 way; 2 pole/2 to 6 way; 3 pole/2 to 4 way; 4 pole/2 to 3 way 55p ROTARY: Mains DP 250V 4 Anip on/off 68p ROTARY: (Make-a-switch) Make a multiway switch. Shuffling assembly has adjustable stop. Accommodates up to 6 wafers (max 6 pole/12 way + DP switch). Mechanism only 90p WAFERS: (make before break) to fit the above switch mechanism. 1 pole/12 way, 2 pole/6 way, 3 pole/4 way, 4 pole/3 way, 6p/2 way 85p Mains DP 4A Switch to fit Spacers 4p. Screen 8p	VERO VERO BOARDS 0.1" 2 1/2 x 1 35p 2 1/2 x 3 80p 2 1/2 x 5 110p 3 1/2 x 5 110p 3 1/2 x 7 125p 3 1/2 x 17 420p 4 1/2 x 17 550p V/O Board 85p DIP Board 35p Vero Strip 85p VERO PINS per 100 Single Ended 55p Double ended 60p Wire Wrap S/E 155p Wire Wrap D/E 255p VERO TOOLS Spot face cutters 150p Pin insertion tool 85p VERO WIRING PEN + Spool 380p Spare Spool 75p Combs 8p Pen + Spool + Combs 599p	PHOTO DECS Veroblock 480p S Dec 350p Euroboard 590p Bimboard 375p Superstrip SS2 1350p COPPER CLAD BOARDS Fibre Single-Double- glass sided sided 8" x 6" 100p 125p 8" x 12" 175p 225p DALO ETCH RESIST PEN Plus spare tip 100p	IDC CONNECTORS PCB Plugs with latch Pins Header Strt Angle Female Card Plug Edge Angle Concl 10 way 65p 65p 65p 100p 16 way 75p 75p 60p 100p 20 way 90p 90p 95p 185p 26 way 105p 110p 115p 230p 34 way 115p 130p 135p 320p 40 way 140p 145p 150p 335p 50 way 165p 170p 175p 350p 60 way 195p 210p 225p 495p	PANEL METERS FSD 60 x 48 x 35mm 0-50uA 0-100uA 0-500uA 0-5mA 0-10mA 0-50mA 0-100mA 0-500mA 0-1A 0-2A 0-25V 0-50V 0-300V AC 520p	RELAYS Miniature, enclosed, PCB mount. SINGLE POLE Changerover RL-81 205R Coil, 12V DC, (10V5 to 19.5V), 10A at 30V DC or 250V AC 195p DOUBLE POLE Changerover, 6A 30V DC or 250V AC RL-1133R Coil, 6V DC (5V4 to 9V9) 190p RL-111 205R Coil, 12V DC (10V7 to 19V5) 195p RL-114 740R Coil, 24V DC (22V to 37V) 200p				
ROCKER SWITCHES ROCKER: 5A/250V SPST 28p ROCKER: 10A/250V SPDT 38p ROCKER: 10A/250V DPDT c/off 85p ROCKER: 10A/250V DPST with neon 85p	THUMBWHEEL Mini front mounting switches Decade Switch Module 320p B.C.D. Switch Module 350p Mounting Cheeks (per pair) 95p	JUMPER LEADS (Ribbon Cable Assembly) Length 14 pin 16 pin 24 pin 40 pin Single ended DIP (Header Plug) Jumper 24 inches 145p 165p 240p 380p	ROCKER SWITCHES ROCKER: 5A/250V SPST 28p ROCKER: 10A/250V SPDT 38p ROCKER: 10A/250V DPDT c/off 85p ROCKER: 10A/250V DPST with neon 85p	DIL SOCKETS Pin Prof Wrap Turned Low 12 15 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 8p 20p 28p 36p 44p 52p 60p 68p 76p 84p 92p 100p 16 10p 40p 28p 2 2x 25 way 250p 245p 18 16p 40p 33p 2 2x 28 way 180p 20 20p 58p 37p 2 30 way 280p 22 22p 60p 39p 2 3x 30 way 300p 24 25p 68p 42p 2 4x 30 way 300p 28 28p 78p 52p 2 4x 43 way 400p 40 30p 89p 72p 2 7x 50 way 600p	ANTEX SOLDERING IRON C-15W 60p CS17W 820p G-18W 620p XS25W 650p Spare tips, assorted size 245p Spare elements 195p SIL SOCKET 0.1" pitch 20 way 65p	DIL PLUG (Header) Solder IDC 14 pin 40p 95p 16 pin 45p 100p 24 pin 65p 135p 28 pin 150p 200p 40 pin 200p 255p RIBBON CABLE price per foot Grey Color 10 way 15p 26p 16 way 25p 40p 20 way 30p 50p 24 way 40p 65p 28 way 55p 80p 34 way 60p 85p 40 way 70p 90p 50 way 100p 135p 64 way 120p 160p	ASTEC UHF MODULATORS Standard 6MHz 375p Wideband 8MHz 550p	BUZZERS miniature, solid-state 6V, 9V & 12V 70p PIEZO TRANSDUCERS FB2720 70p	LOUDSPEAKERS Miniature, 0.3W-6 Ohm 2in, 2 1/2in, 2 1/4in, 3in 2 1/2in 40n, 64n or 80n 6" x 4" 8n 7" x 5" 8n 8" x 5" 8n 60p 200p 225p 250p	VIDEO MONITORS ● ZENITH — 12" Green, Hi-Resolution Popular £76 ● MICROVITEC 1431. Standard Res. Colour RGB input 14" incl cable £176 ● MICROVITEC 1451. 14" Microvision resolution £225 ● KAGA 12". Med-res. RGB Colour. Has flicker-free characters. Ideal for BBC, Apple, VIC, etc £210 (car £7) ● KAGA 12". As above but Hi-Resolution £330 (car £7) ● Connecting Lead for KAGA £3 Carriage £7 Securicor
TRANSFORMERS 3-0-3V; 6-0-6V; 9-0-9V; 12-0-12V; 15-0-15V @ 100mA 130p PCB mounting, Miniature, Split bobbin 3VA: 2x6V/0.25A; 2x9V/0.15A; 2x12V/0.12A; 2x15V/0.25A 235p 6VA: 2x6V/0.5A; 2x9V/0.3A; 2x12V/0.25A; 2x15V/0.2A 280p Standard Split Bobbin type: 6VA: 2x6V/0.5A; 2x9V/0.4A; 2x12V/0.3A; 2x15V/0.25A 250p 12VA: 2x4.5V/1A; 2x5V/1A; 2x9V/0.6A; 2x12V/0.5A; 2x15V/0.4A; 2x20V/0.3A 345p (35p p&p) 24VA: 2x6V/1.5A; 2x9V/1.2A; 2x12V/1A; 2x15V/0.8A; 2x20V/0.6A 365p (60p p&p) 50VA: 2x6V/4A; 2x9V/2.5A; 2x12V/2A; 2x15V/1.5A; 2x20V/1.2A; 2x25V/1A; 2x30V/0.8A 520p (60p p&p) 50VA: Outputs +5V/5A; +12V; -25V; -5V; -12V at 1A 620p (60p p&p) 100VA: 2x12V/4A; 2x15V/3A; 2x20V/2.5A; 2x25V/2A; 2x30V/1.5A; 2x50V/1A 955p (75p p&p) P&P charge to be added over and above our normal postal charge	VOLTAGE REGULATORS 1A TO220 Plastic Casing +ve -ve 5V 7805 45p 7905 50p 12V 7812 45p 7908 50p 15V 7815 45p 7912 50p 18V 7818 45p 7915 50p 24V 7824 45p 7918 50p 7924 50p 100mA TO92 Plastic package 5V 78L05 30p 79L05 45p 6V 78L06 30p 8V 78L08 30p 9V 78L09 30p 15V 78L15 50p 79L15 45p IC/L7660 245p RCA194 375p LM309K 180p LM317K 250p LM317KP 450p LM323K 450p LM337 175p LM723 Var 30p 78S40 225p	SOLDERCON PINS Ideal for making SIL or DIL Sockets 100 pins 35p 500 pins 100p	ALUM BOXES 3 x 2 x 1/2" 65p 4 x 2 1/2 x 2" 100p 2 1/2 x 2 1/2 x 2" 103p 4 x 4 x 2" 105p 4 x 4 x 2 1/2" 120p 5 x 4 x 1 1/2" 99p 5 x 4 x 2 1/2" 120p 6 x 4 x 2" 120p 6 x 4 x 3" 130p 7 x 4 x 3" 160p 8 x 6 x 3" 210p 10 x 4 x 3" 240p 10 x 7 x 3" 275p 12 x 5 x 3" 260p 12 x 8 x 3" 295p	'D' CONNECTORS 9 15 25 37 way way way way Male Solder lugs 55p 80p 120p 150p Angle pins 110p 175p 225p 300p PCB pins 100p 100p 180p 250p Female Solder lugs 90p 125p 180p 275p Angle pins 150p 200p 280p 390p PCB pins 100p 125p 195p 355p Covers 75p 70p 70p 65p IDC 25 way 'D' Plug 385p; Socket 450p	AMPHENOL CONNECTORS 24 way IEEE plug 485p 480p 24 way IEEE skt 485p 480p 36 way Centronics plug 375p 380p 36 way Centronics skt 480p 450p	25 way 'D' CONNECTOR (RS232) Jumper Lead Cable Assembly 18" long, Single end, Male 475p 18" long, Single end, Female 510p 36" long, Double Ended, M/M 995p 36" long, Double Ended, F/F £10 36" long, Double Ended, M/F 995p				

CMOS 4075 25 4543 65 4076 80 4548 40 4077 25 4549 300 4078 25 4553 210 4081 20 4081 20 4554 160 4082 70 4082 20 4555 50 4085 60 4085 80 4556 50 4086 60 4086 80 4557 250 4089 40 4089 120 4558 120 4090 40 4093 25 4559 340 4091 20 4394 70 4560 110 4092 40 4095 104 4096 100 4562 350 4097 280 4566 160 4098 70 4568 250 4099 110 4569 175 4100 40 4160 450 4101 95 4161 96 4580 255 4102 95 4162 96 4581 125 4103 95 4163 96 4582 98 4104 55 4174 104 4105 45 4175 105 4584 40 4106 20 4194 105 4585 40 4107 35 4408 650 4597 330 4108 20 4409 650 4599 155 4110 20 4410 725 40085 90 4111 20 4411 750 40097 45 4112 40 4412 605 40098 42 4113 40 4413 550 40100 215 4114 20 4419 280 40101 130 4115 40 4422 770 40102 100 4116 65 4435 650 40103 412 4117 130 4440 900 40104 120 4118 145 4450 380 40105 220 4119 70 4451 350 40106 40 4120 25 4490 450 40107 50 4121 115 4501 395 40108 325 4122 75 4501 40 40109 100 4123 270 4502 90 40110 235 4124 45 4503 45 40114 240 4125 55 4504 100 40161 150 4126 45 4505 250 40163 75 4127 45 4506 100 40173 100 4128 45 4507 45 40174 75 4129 110 4508 130 40175 60 4130 40 4510 55 40181 220 4131 50 4511 55 40182 80 4132 50 4512 55 40192 75 4133 25 4513 150 40193 90 4134 25 4514 115 40194 70 4135 50 4515 115 40195 75 4136 40 4516 50 40214 150 4137 60 4517 275 40245 150 4138 70 4518 50 40257 150 4139 70 4519 35 40373 220 4140 70 4520 50 40374 220 4141 100 4521 110 45106 598 4142 40 4522 125 4143 70 4526 70 4144 600 4527 80 4145 98 4528 45 4146 80 4529 80 4147 25 4530 90 4148 230 4531 120 4149 20 4532 65 4150 20 4534 365 4151 20 4536 250 4152 20 4538 80 4153 20 4539 80 4154 20 4541 85	OPTO ELECTRONICS LEDs with clips TIL209 10 TIL211 GRN 14 TIL212 Yel. 14 TIL220 2" Red 12 2" Green, Yellow or 14 0.2" Bi colour 100p Red/Green 100p Green/Yellow 115p 0.2" Tri colour Red/Green/Yellow 85 Hi-Brightness Red 58 High-Bri Green or 58 Yellow 68 Flashing red 66 0.2" red 50 Square LEDs, Red. 30 Green, Yellow 30 Red/Green Stackable LEDs 30 Red, Green or Yellow 18 Triangular LEDs 18 Red 22 Green or yellow 26 LD271 Infra Red 48 LD178 3" CC 125 SFH205 Detector 118 TIL32 Infra Red 52 TIL78 Detector 55 TIL38 50 TIL100 75 BARGRAPH ARRAY Ten Segments MV57164 Red 225 MV54164 Grn 230 ISOLATORS IL74 75 ILD74 145 ILD74 275 TIL111/2/4 70 ILCTE Darlington 135 TIL117 125 LD704 3" CC 125 Darlington Photo 136
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TTL74

7400	23	7486	36
7407	38	74121	40
7412	23		

74LS

LS00	17	LS123	45
LS01	20	LS124	115
LS02	19	LS125	35
LS03	21	LS126	35
LS04	17	LS132	44
LS05	20	LS133	44
LS08	19	LS138	36
LS09	20	LS139	36
LS10	18	LS151	34
LS11	20	LS153	62
LS13	24	LS154	115
LS14	34	LS155	44
LS15	20	LS156	54
LS20	18	LS157	34
LS21	20	LS161	55
LS22	20	LS163	54
LS27	20	LS164	54
LS28	22	LS165	90
LS30	20	LS166	85
LS32	18	LS173	45
LS33	22	LS181	185
LS37	20	LS192	54
LS38	20	LS197	72
LS42	34	LS221	62
LS73	26	LS240	64
LS74	24	LS241	58
LS75	30	LS242	60
LS76	25	LS244	53
LS78	25	LS245	53
LS83	42	LS247	60
LS85	50	LS251	44
LS90	24	LS257	44
LS93	30	LS266	32
LS95	50	LS273	54
LS107	40	LS367	40
LS109	38	LS373	59
LS112	40	LS374	60
LS113	38	LS393	46

CMOS

4001	14
4013	23
4016	20
4017	34
4019	34
4020	38
4024	28
4027	22
4029	40
4042	30
4047	50
4049	22
4060	45
4066	24
4070	20
4078	24
4093	22
4099	88
40107	52
4518	44
4520	45

COMPUTER IC's

6532	500
6551	525
6800	190
6821	130
MC6802	250
MC6809	550
MC6832	500
MC6840	350
MC6845	600
MC6851	500
8216	150
Z80PIO	240
Z80CTC	250
2764-25	190
27128-25	250

LINEAR

LM 301	30
LM 319	175
LM 324	38
LM 339	38
LM 347	55
LM 348	55
LM 556	90
LM 557	90
LM 741	16
LM 747	58
LM 1488	58
LM 1489	58

RIBBON CABLES

	price/foot	100ft
10way	14	650
16way	24	1025
20way	28	1300
24way	36	1650
26way	38	1700
28way	50	1900
34way	58	1950
40way	67	2625
50way	84	3300

VOLTAGE REGULATOR

78L12	28
7805	40
7812	40
7815	40
7905	40
7912	40
7915	40
LM323K	400

'D' CONNECTORS

male	9	15	25	37
solder	50	80	120	145
angled	110	170	220	290
female				
solder	85	120	175	270
angled	150	200	250	380
cover	70	70	70	80

DIL SOCKETS

low profile	
8 pin	4
14 pin	7
16 pin	8
18 pin	9
20 pin	10
22 pin	11
24 pin	12
28 pin	14
40 pin	18

SWITCHES

DIL 4 way	65
6 way	75
8 way	80
10 way	95

Sub-min Toggle
240v 2A

SPST (2 tag)	55
SPDT (3 tag)	60
DPDT (6 tag)	55
SPST (2 tag)	55
SPDT (3 tag)	60
SPDT (3 tag)	
centre off)	65
DPDT (6 tag)	65
DPDT (6 tag)	
centre off)	70

Rockers	
5A/250v SPST	25
10A/250v SPDT	35
10A/250v DPST (neon)	80

CRYSTALS

100kHz	360
200kHz	350
1.0MHz	260
1.008MHz	260
1.8432MHz	175
2.0MHz	180
2.4567MHz	85
3.278MHz	100
4.0MHz	90
5.0MHz	120
6.0MHz	80
6.114MHz	105
8.0MHz	80
10.0MHz	80
12.0MHz	80
16.0MHz	80
18.0MHz	90
20.0MHz	120

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 APPLE iie to NEC Printer
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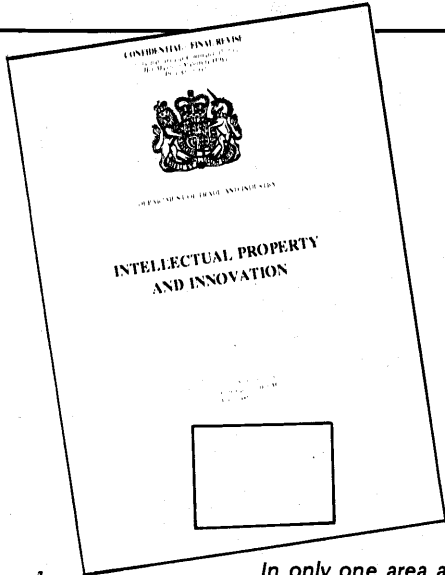
TRANSISTORS

AC127	28	BC149	11	BC184L	10
AC128	28	BC149C	13	BC186	27
AC176	24	BC153	28	BC187	27
AC187	24	BC154	28	BC212	10
AC188	24	BC157	14	BC212L	10
AD161	40	BC158	14	BC213	09
AD162	40	BC159	10	BC213L	10
AF139	40	BC160	45	BC214	09
AF239	50	BC167A	14	BC214L	10
BC107	09	BC168B	12	BD121	95
BC107B	11	BC169C	10	BD124	110
BC108	10	BC170	18	BD131	40
BC108C	11	BC177	15	BD132	40
BC109	10	BC178	16	BD133	48
BC109C	11	BC179	18	BD135	30
BC140	28	BC181	28	BD136	30
BC141	29	BC182	09	BD137	34
BC142	28	BC182L	10	BD138	34
BC143	27	BC183	09	BD139	34
BC147	10	BC183L	09	BD140	34
BC148	10	BC184	10	BD158	65

TOROIDAL TRANSFORMERS

VA	1-9	These prices are for single primary with two secondary taps, with 8" colour coded fly leads. Each transformer is supplied with a mounting kit, consisting of one steel washer, two neoprene pads, and a nut and bolt.
15	5.47	
30	5.56	
50	6.31	
80	6.82	
120	7.40	
160	8.72	
225	9.70	
300	10.84	P&P £2.50 for above items.
500	14.47	
1000	29.76	
1.2KVA	34.32	

DIGEST



Patently A Patch-up

British Government proposals meant to 'encourage innovation' have been published in a White Paper entitled 'Intellectual Property and Innovation' (Cmnd 9712, price £6.70 and available from Her Majesty's Stationery Office.)

Launching the White Paper, the Secretary of State for Trade and Industry, Paul Channon, claimed that the proposals would make the UK's intellectual property system — which covers patents, copyright and trade marks — 'more accessible and relevant'. In fact, the major proposals seem destined to make the system more intrusive and more confusing.

In only one area are the proposals actually likely to encourage innovation — that is, the intention to allow easier public access to the Patent Office database. The patent system itself will remain almost unchanged. The Government's plan to take the Patent Office away from the Civil Service and make it a 'body corporate' rather like the BBC could be seen as a prelude to privatisation. It seems quite plausible that the Government may wish to make the Patent Office a paying business — charging for the traditional and newer services it has on offer.

Circuit designers will not find their position substantially modified as a result of any of the White Paper's recommendations. Protection of circuit designs may be afforded by the patent system — although little has been suggested to make it less unwieldy and

Transistor Failure Investigated

Tests at Sandia National Laboratories are producing the first live TV pictures of silicon chip transistors as they experience a potentially catastrophic current surge. The surge is known as snapback, and if left uncorrected, can ruin the integrated circuit contained on the chip.

The pictures show a 1/100th of an inch square portion of a 1/4"

IC. During snapback, microscopic transistors appear as short bright lines on an infrared TV image. The brightness is caused by high energy electrons flowing through the transistor. Transistors not in snapback do not shine because they have no high energy electrons.

Snapback attacks in-channel metal oxide semiconductor transistors. Some microelectronics experts believe that without proper planning and understanding, snapback could become a problem for the next generation of extremely small ICs, which will have individual features of 1.5 microns or less.

Snapback occurs only if two

Nuff Said

'What we have seen recently is a tragic shuttle failure, two Titan rocket failures, the Delta rocket explosion, the Chernobyl nuclear accident and a surgical bombing

raid on Libya that turned out not to have been so surgical. It confirms what a lot of us knew all along — technology is not perfectible,' John Pike, associate director of the Federation of American Scientists.

expensive than it is. No clarification has been offered on the definition of originality as far as circuits go. There is a problem issue, since it can take vast amounts of time and money to prove a design does more than merely exploit the well-known characteristics of its components parts. For many manufacturers in such a fast-moving field as electronics, market lead has become far more important than patent protection.

It is possible that a proposed 'unregistered design right' may apply to circuit designs — although the White Paper mentions only 'semiconductor chips' in this context. The new right is intended to protect the designs of 'purely functional articles' for a ten year period. Disputes will be settled by the patent office but, unlike patents, the new right will not require the registration of a design.

It could be argued that a circuit design is the perfect 'purely functional article' since it doesn't even necessarily have a physical form, thereby avoiding all aesthetic or decorative aspects of its design. In fact, the White Paper recommends that the new right will come into force with 'the first expression of the design in any independent form, such as a drawing or in a computer, from which the article embodying the design can be produced' as well as from 'the first making of the article embodying the design.' We will, of course, have to wait for the White Paper to become law and for the law to be tested in court before we can safely assume that the new right will benefit circuit designers.

For the public as a whole, perhaps the most significant recommendations in the White Paper are the ones dealing with home taping.

The expected levy on blank tape is to be introduced, but will only cover audio compact cassettes of greater than 35 minutes playing time. 'The levy,' says the Department of Trade and Industry, 'will entitle consumers to make, for private purposes, sound recordings of broadcasts or pre-recorded material but not to copy computer programs.' Make what you will of the fact that videotape, reel-to-reel tape and compact cassettes of 34.9 minutes playing time are excluded from the levy. Make what else you will of the fact that private recording from TV broadcasts is to be legalised but not from pre-recorded video material. The proposals are shot through with such potential legal and moral minefields.

On the whole, the White Paper is a patch-up of the intellectual property system, which barely brings copyright and patent up to date and certainly does not simplify the intellectual property system. The idea that its recommendations will 'benefit . . . innovative talent' (as Paul Channon has said) is, to be kind, probably blind optimism.

One or two minor points worth noting are that the White Paper confirms the current position that computer programs are subject to copyright even in non-human readable form (for example, on ROM chips) and that low power satellite broadcasts for TVRO or SMATV systems will also be subject to copyright.

conditions are present. First, the transistor must be operating at or above a certain voltage, called the snapback voltage. Then an initiating event (weapon-produced x-rays or simple static electricity that can occur during wafer testing, for example) must trigger snapback by producing an overabundance of electrons in a transistor. The excess electrons produce the uncontrolled current.

If allowed to continue, this excessive current can melt the wires that connect an IC to its ceramic package or the wires that interconnect different devices on the IC. Snapback can also cause electron migration, which can lead to short or open circuits.

Sandia's computer-controlled snapback test setup includes a 750 watt pulsed xenon laser (typically used for cutting metal and polysilicon lines on ICs, but used here to simulate the snapback triggering event), an automated probe station (typically used for obtaining a variety of electrical measurements on wafers), an infrared microscope TV camera and monitor, and appropriate voltage and current measuring instruments. The laser pulse deposits enough energy on a 10-micron-square region of the IC to initiate snapback, thus permitting the minimum voltage required for sustained snapback to be measured.

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47 10V	32p	7445	99p
47 6.3V	35p	7447	99p
47 10V	78p	7448	99p
10 10M			
10 10M			
10 6.3V	1.28	7450	35p
10 10V	1.97	7451	35p
10 16V	2.75	7452	35p
10 16V	2.75	7454	35p

CARBON FILM

5% HIGH STAB			
47 6.3V	35p		
47 10V	78p		
10 10M			
10 6.3V	1.28		
10 10V	1.97		
10 16V	2.75		
10 16V	2.75		

2W E12 9p

7460	49p
7470	49p
7472	49p
7473	49p
7474	49p
7475	49p
7476	49p

ULTRASTABLE

0.4W EXTRA LOW NOISE			
10 10M			
10 6.3V	1.28		
10 10V	1.97		
10 16V	2.75		
10 16V	2.75		

ELECTROLYTIC CAPACITORS

10 10M			
10 6.3V	1.28		
10 10V	1.97		
10 16V	2.75		
10 16V	2.75		

AXIALS (Wires each end)

7480	65p
7481	1.75
7482	1.75
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WIRE

3 Core	19p
2.5 Amp 21p	19p
3 Core	19p
13 Amp 62p	19p
SCREENED	
Single 150m	25p
Stereo 23p	
Mini Stereo 16p	
Mini Stereo 13p	
4 Core	49p
4 Screens 49p	
4 Core single	49p
Screen 62p	
8 Core 73p	
12 Core 88p	
Heavy Duty	
Mike Guitar	
Lead 33p	
AERIAL	
500 RH56A	
750 UGSHA	
500 UGSHB	
500 UGSHC	
750 VHF 31p	
3000 Fiat 16p	
RAINBOW	
FIBRON	
Prices per foot	
10way 25p	
15way 30p	
20way 35p	
24way 42p	
30way 72p	
34way 82p	
100 - 100mm	79p
150 - 100mm	129p
200 - 100mm	135p
300 - 100mm	159p
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750 - 100mm	229p
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9000 - 100mm	529p
10000 - 100mm	559p

MISC LOGIC

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ADC0817	20.80
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20 Kilo Cycles

Barry Porter, one of our regular contributors, will be taking part in a sponsored cycle ride in aid of the British Heart Foundation on Sunday June 15th.

Barry, himself a victim of heart disease, will be joining over 20,000 other people on the London to Brighton run. Among those taking part will be three heart transplant patients, a number of people who have suffered various forms of heart disease and a sprinkling of celebrities including John Peel, Kenny Lynch and Sharon Davies. The ride is expected to raise over £500,000 which will go to fund a research group at Oxford.

The ride is now in its eleventh year. It started as an informal event with just 35 participants and last year attracted over 21,000, many taking part in fancy dress and using some rather unconventional forms of transport. The £400,000 raised went to support cardiac care groups.

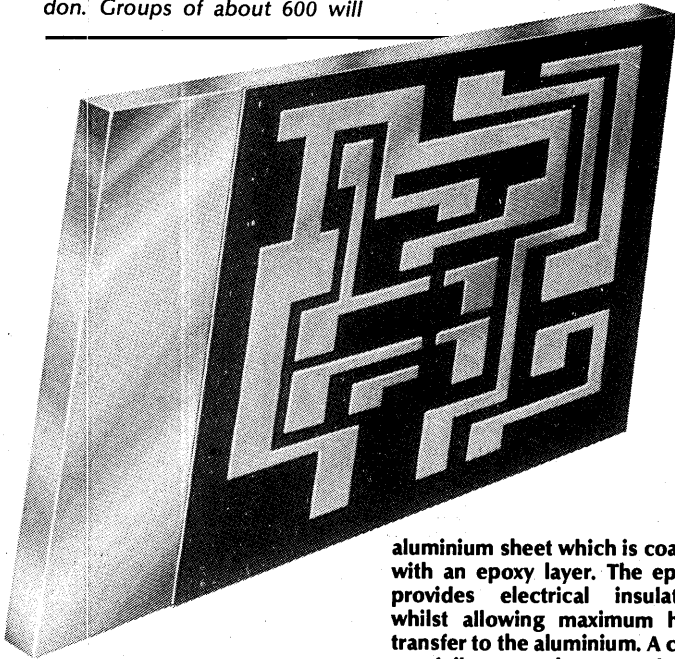
The riders will set out from Clapham Common in South London. Groups of about 600 will

start at half-hourly intervals from around 6.00 am onwards. Barry's group will be setting off at the more civilised hour of 9.00 am.

The route chosen avoids main roads and runs through Mitcham, Carshalton, South Merstam, Smallfield, Turners Hill, Ardingley, Lindfield, Wivelsfield and Ditching. The ride is not a race, and Barry says he will be delighted to stop and accept liquid refreshment from any ETI readers who happen to be lining the route! He will be wearing an ETI T-shirt which is so new that we can't even tell you what colour it will be.

Anyone who would like to sponsor Barry (either by the mile or a fixed amount for the whole distance) should contact him after 7.00 pm on 0582-65231. The organisers are not accepting any more entrants for this year, but anyone who requires more general information should contact the British Heart Foundation, 102 Gloucester Place, London W1.

We hope to include a brief report of Barry's progress next month.



Thermally-Conductive PCB Material

A novel new PCB material from Redpoint offers a solution to some of the cooling problems associated with surface-mounting components. Unlike conventional copper-clad board, it has an aluminium core which conducts away the heat and reduces the risk of local hot spots.

The new material is known as CLEA (Copper Laminated Epoxy Aluminium). It consists of an

aluminium sheet which is coated with an epoxy layer. The epoxy provides electrical insulation whilst allowing maximum heat transfer to the aluminium. A copper foil covers the epoxy layer, enabling PCB tracks to be etched using a slightly modified version of the normal PCB-etching process. The material can be cut to shape using conventional metal-working techniques.

CLEA is available in both single and double-sided versions, allowing high component packing densities to be achieved. Redpoint say they expect the material to find applications in both surface-mounting and hybrid assembly processes.

For further details and samples contact Redpoint Ltd, Cheney Manor, Swindon, Wiltshire SN2 2QN, tel 0793-37861.

Amstrad and Eric Hammond Among 1986 Award Winners

Amstrad have gained the 1986 TOBIE award for Electronics Application of the Year with their best-selling PCW8256 word processor. The Electronics Personality of the Year award went to Eric Hammond, leader of the electricians union, who aroused considerable controversy last year by allowing his members to operate Rupert Murdoch's printing plant at Wapping in place of print union staff.

The TOBIE awards (Technology Or Business Innovation in Electronics) are announced annually at the British Electronics Week Ball, held this year at the Grosvenor House Hotel, London, on April 29th. The winners are decided by postal ballot among readers of the weekly trade paper Electronics Times.

There are three nominees in each category. The other candidates for the applications award were Epson with their Taxi Software package and Plessey who have developed an Adaptive Compass which they believe will form the heart of future vehicle and aircraft navigation and weapon guidance systems. Eric Hammond's competitors for the personality award were Robb Wilmot of European Silicon Structures, a company producing low volume custom chips by direct writing using electron beams, and Peter Fraiman of Electronic

Brokers who is credited with having personally developed the concept of "second user" test equipment.

Among the other awards, the Inmos Transputer was pronounced Component of the Year and Mars Electronics gained the Product of the Year award with their Gazelle automatic circuit tester, a system said to offer the performance and facilities of products costing four times as much. The Research Achievement of the Year award went to Professor Desmond Smith of Heriot Watt University for his work towards developing the world's first optical computer.

British Telecom and Mercury Communications were both nominees in the Fibre Optic Achievement of the Year category but the award went to Cossor for their 2135 portable fault locator, a device designed for ease of use and reliability. The award for Export Achievement of the Year went to Rodime, who maintained their export growth record in disc drives in spite of a market slump, and the Distributor of the Year award went to Farnell for their continued record earnings growth.

The TOBIE awards are administered by Evan Steadman Services Ltd, The Hub, Emerson Close, Saffron Walden, Essex CB10 1HL.

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Your monitor from its computer! For only £24.95 it becomes a SUPERB HIGH QUALITY * COLOUR * TV SET

The fabulous TELEBOX, an INVALUABLE MUST for the owner of ANY video monitor with a composite input, colour or monochrome. Made by a major UK Co. as a TOP QUALITY, stand alone UHF tuner and costing OVER £75 to manufacture, this opportunity to give your monitor a DUAL FUNCTION must not be missed! The TELEBOX consists of a compact, stylish two tone charcoal moulded case, containing ALL electronics tuner, power supply etc to simply plug in and convert your previously dedicated computer monitor into a HIGH QUALITY COLOUR TV SET, giving a real benefit to ALL families! Don't worry if your monitor doesn't have sound - THE TELEBOX even has an integral 4 watt audio amplifier for driving an external speaker. PLUS an auxiliary output for superb quality television sound via your headphones or HI FI system etc. Other features include: Compact dimensions of only 15.75" w x 7.5" d x 3.5" h, latest technology, BRITISH manufacture, fully tuneable 7 channel push button tuner, Auto AGC circuit, SAW filter, LED status indicator, fully isolated 240V AC power supply for total safety. Mains ON-OFF switch etc. Many other uses.

LIMITED QUANTITY - DON'T MISS THIS OFFER!!!

ONLY £24.95 OR £19.95 if purchased with ANY of our video monitors. Supplied BRAND NEW with full instructions and 2 YEAR warranty. Post and packing £3.50 *When used with colour crt.

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SYSTEM ALPHA 14" COLOUR MULTI INPUT MONITOR

Made by the famous REFUSION Co. for their own professional computer system this monitor has all the features to suit your immediate and future requirements. Two video inputs: RGB and PAL Composite Video, allow direct connection to BBC/IBM and most other makes of micro computers or VCR's, including our very own TELEBOX. An internal speaker and audio amp may be connected to computer or VCR for superior sound quality. Many other features: PIL tube, Matching BBC case colour, Major controls on front panel, Separate Contrast and Brightness - even in RGB mode. Separate Colour and audio controls for Composite Video input, BNC plug for composite input, 15 way 'D' plug for RGB input, modular construction.

THE MUST BE ONE OF THE YEAR'S BEST BUYS. PC USER

Supplied BRAND NEW and BOXED, complete with DATA and 90 day guarantee. ONLY £149.00 as above OR IBM PC Version £165.00 15 Day 'D' skt £1.00, BNC skt 75p BBC interface cable £5.50

DECCA 80 16" COLOUR monitor, RGB Input.

Little or hardly used manufacturer's surplus enables us to offer this special converted DECCA RGB Colour Video TV Monitor at a super low price of only £99.00, a price for a colour monitor as yet unheard of! Our own interface, safety modification and special 16" high definition PIL tube, coupled with the DECCA 80 series TV chassis give 80 column definition and quality found only on monitors costing 3 TIMES OUR PRICE. The quality for the price has to be seen to be believed! Supplied complete and ready to plug direct to a BBC MICRO computer or any other system with a TR RGB output. Other features are: Internal speaker, modular construction, auto degaussing circuit, attractive TEAK CASE, compact dimensions only 52cm W x 34 H x 24 D, 90 day guarantee. Although used, units are supplied in EXCELLENT condition. ONLY £99.00 + Carriage.

DECCA 80, 16" COLOUR monitor, Composite video input. Same as above model but fitted with Composite Video input and audio amp for COMPUTER, VCR or AUDIO VISUAL use. ONLY £99.00 + Carr.

REDIFUSION MARK 3, 20" COLOUR monitor. Fitted with standard 75 ohm composite video input and sound amp. This large screen colour display is ideal for SCHOOLS, SHOPS, DISCOS, CLUBS and other AUDIO VISUAL applications. Supplied in AS NEW or little used condition ONLY £145.00 + Carr.

BUDGET RANGE EX EQUIPMENT MONOCHROME video monitors. All units are fully cased and set for 240V standard working with composite video inputs. Units are pre tested and set up for up to 80 column use. Even when MINOR screen burns exist - normal data displays are unaffected. 30 day guarantee.

12" KGM 320-1 B/W bandwidth input, will display up to 132 x 25 lines. £32.95
12" GREEN SCREEN version of KGM 320-1. Only £39.95
9" KGM 324 GREEN SCREEN fully cased very compact unit. Only £49.00

Carriage and Insurance on all monitors £10.00

DC POWER SUPPLY SPECIALS

GOULD OF443 enclosed, compact switch mode supply with DC regulated outputs of +5v @ 5.5a, +12v @ 0.5a, -12v @ 0.1a and -23v @ 0.02a. Dim 18 x 11 x 6 cm. 110 or 240v input. BRAND NEW only £15.95

GOULD G640A 5v 40 amp switch mode supply NEW £130.00
AC-DC Linear PSU for DISK drive and SYSTEM applications. Constructed on a rugged ALLOY chassis to continuously supply fully regulated DC outputs of +5v @ 3 amps, -5v @ 0.6 amps and +24v @ 5 amps. Short circuit and overvoltage protected. 100 or 240V AC input. Dim 28 x 12.5 x 7 cm NEW £49.94

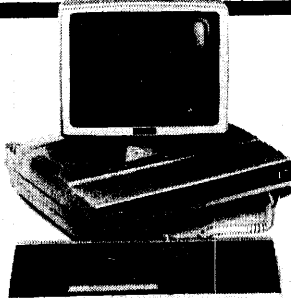
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AMKEY MPNK-114 Superb word processor chassis keyboard on single PCB with 116 keys. Many features such as On board Micro, Single 5v rail, full ASCII coded character set with 31 function keys, numeric keypad, cursor pad and 9600 baud SERIAL TTL ASCII OUTPUT! Less than half price

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PERTEC D3422 5+8 Mb
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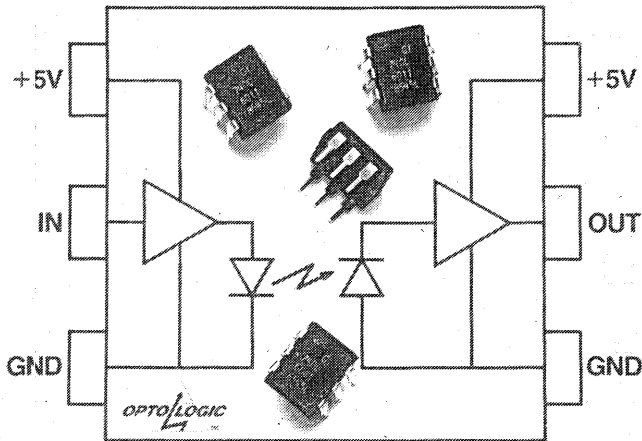
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Unless stated all drives are refurbished with 90 day guarantee. Many other drives and spares in stock - call sales office for details.

All prices quoted are for U.K. Mainland, paid cash with order in Pounds Sterling PLUS VAT. Minimum order value £2.00. Minimum Credit Card order £10.00. Minimum BONA FIDE account orders from Government Depts., Schools, Universities and established companies £20.00. Where post and packing not indicated please ADD £1.00 + VAT. Warehouse open Mon-Fri 9.30-5.30, Sat 10.30-5.30. We reserve the right to change prices and specifications without notice. Trade, Bulk and Export

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Logic-To-Logic Optoisolator

General Instrument claim their new family of optoisolators will save design engineers a lot of time and trouble. Unlike existing types, they have inputs and outputs which can be connected directly to logic circuitry.

Called Optologic, the new devices are available either as inverters or buffers and offer a choice of TTL-compatible totem-pole outputs or an open collector arrangement for use with 4.5-15V CMOS. Both types have LS-TTL-compatible inputs and feature a propagation delay of 60ns.

The new optoisolators come in standard 6-pin DIL packages and have an isolation voltage of 440V RMS continuous, 2500V RMS maximum. General Instrument expect them to be used in level shifting and for interfacing between different logic families. In addition, they could be used to drive power semiconductor devices like MOSFETS.

General Instrument, Optoelectronics Division, Times House, Station Approach, Ruislip, Middlesex HA4 8JG, tel 08956-36522.

ETI PCB Service

Whisper it quietly, but it does begin to look as though this ill-fated service may yet survive. A new agreement has been thrashed out with our existing supplier and we hope to re-start the service next month.

All outstanding orders should now have been cleared. If anyone is still waiting for a board they have ordered, please get in touch with our Readers' Services department at Hemel Hempstead.

The new arrangement will mean that some boards currently

on the list will have to be dropped because they are simply not selling in sufficiently large numbers. However, we will continue to make sure that boards remain available for at least a year after an article is published.

We have also revised the pricing structure to remove some of the anomalies. At present, some small boards actually cost more than some larger boards. We are adjusting prices up and down as appropriate to rectify this situation.

● **Graham Nalty, whose Upgradeable Amplifier is currently running as a project in ETI, tells us that he has access to custom case-building facilities. This might prove useful to those who are still missing parts of the case for their JLLH Audio Design amplifiers. Anyone interested should contact Graham at the address given in the Buy-lines section on page 40.**

● Spectrastrip is a flat cabling system which allows power, data and telephone wiring to be laid under carpeting with the minimum of trouble. A full set of com-

plementary connectors is also available and the complete system is described in a 4-page brochure which is available on request. Contact Amphenol Ltd, Thanet Way, Whitstable, Kent CT5 3JF, tel 0227-26441.

● Hawnt Electronics describe themselves as the UK's leading passive component supplier. Their new 272-page catalogue is now available and can be obtained from them at Firstwood Road, Garret Green, Birmingham B33 0TQ, tel 021-784 3355.

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BC239J	0.11 MJE385	1.50 SN74LS137	0.30 SN74LS402	DA2596	5.00	HM6266P-15	63.00
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BC239L	0.11 MJE385	1.50 SN74LS139	0.30 SN74LS402	DA2598	5.00	HM6266P-15	63.00
BC239M	0.11 MJE385	0.30 SN74LS139	0.30 SN74LS402	DA2599	5.00	HM6266P-15	63.00
BC239N	0.11 MJE385	0.95 SN74LS14	0.30 SN74LS402	DA2600	5.00	HM6266P-15	63.00
BC239O	0.28 OC24	0.80 SN74LS145	0.80 SN74LS402	DA2601	5.00	HM6266P-15	63.00
BC239P	0.38 OC27	0.50 SN74LS147	1.10 SN74LS402	DA2602	5.00	HM6266P-15	63.00
BC239Q	0.10 OC73	0.50 SN74LS148	0.18 SN74LS402	DA2603	5.00	HM6266P-15	63.00
BC239R	0.15 OC74	0.50 SN74LS149	0.18 SN74LS402	DA2604	5.00	HM6266P-15	63.00
BC239S	0.15 OC76	0.50 SN74LS151	0.30 SN74LS402	DA2605	5.00	HM6266P-15	63.00
BC239T	0.10 OC77	0.85 SN74LS153	0.50 SN74LS402	DA2606	5.00	HM6266P-15	63.00
BC239U	0.12 OC81	0.40 SN74LS156	0.40 SN74LS402	DA2607	5.00	HM6266P-15	63.00
BC239V	0.10 OC82	1.50 SN74LS157	0.30 SN74LS402	DA2608	5.00	HM6266P-15	63.00
BC239W	0.10 OC83	1.50 SN74LS157	0.30 SN74LS402	DA2609	5.00	HM6266P-15	63.00
BC239X	0.75 OC84	1.20 SN74LS158	0.30 SN74LS402	DA2610	5.00	HM6266P-15	63.00
BC239Y	2.00 TIP100	0.80 SN74LS160	0.50 SN74LS402	DA2611	5.00	HM6266P-15	63.00
BC239Z	1.00 TIP101	0.50 SN74LS161	0.50 SN74LS402	DA2612	5.00	HM6266P-15	63.00
BD124P	0.60 TIP120	0.60 SN74LS162	0.55 SN74LS402	DA2613	5.00	HM6266P-15	63.00
BD131	0.50 TIP122C	0.62 SN74LS163	0.50 SN74LS402	DA2614	5.00	HM6266P-15	63.00
BD133	0.48 TIP125	0.90 SN74LS164	0.55 SN74LS402	DA2615	5.00	HM6266P-15	63.00
BD135	0.30 TIP126	1.25 SN74LS164	0.50 SN74LS402	DA2616	5.00	HM6266P-15	63.00
BD136	0.30 TIP127	1.60 SN74LS166	0.75 SN74LS402	DA2617	5.00	HM6266P-15	63.00
BD137	0.30 TIP29	0.30 SN74LS169	1.10 SN74LS402	DA2618	5.00	HM6266P-15	63.00
BD138	0.30 TIP29A	0.35 SN74LS169	0.80 SN74LS402	DA2619	5.00	HM6266P-15	63.00
BD139	0.30 TIP29B	0.35 SN74LS170	0.80 SN74LS402	DA2620	5.00	HM6266P-15	63.00
BD140	0.30 TIP29C	0.38 SN74LS173	0.40 SN74LS402	DA2621	5.00	HM6266P-15	63.00
BD176	0.40 TIP295	0.65 SN74LS174	0.35 SN74LS402	DA2622	5.00	HM6266P-15	63.00
BD235	0.30 TIP30	0.30 SN74LS175	0.40 SN74LS402	DA2623	5.00	HM6266P-15	63.00
BD236	0.32 TIP30B	0.40 SN74LS175	0.40 SN74LS402	DA2624	5.00	HM6266P-15	63.00
BD237	0.32 TIP30C	0.40 SN74LS182	2.00 SN74LS402	DA2625	5.00	HM6266P-15	63.00
BD239	0.32 TIP305	0.65 SN74LS183	1.50 SN74LS402	DA2626	5.00	HM6266P-15	63.00
BD240	0.30 TIP31	0.45 SN74LS190	0.55 SN74LS402	DA2627	5.00	HM6266P-15	63.00
BD245B	0.55 TIP31A	0.35 SN74LS190	0.55 SN74LS402	DA2628	5.00	HM6266P-15	63.00
BD517	0.70 TIP31C	1.25 SN74LS192	0.50 SN74LS402	DA2629	5.00	HM6266P-15	63.00
BF154	0.80 TIP31C	0.40 SN74LS193	0.50 SN74LS402	DA2630	5.00	HM6266P-15	63.00
BF167	0.75 TIP32	0.45 SN74LS194	0.60 SN74LS402	DA2631	5.00	HM6266P-15	63.00
BF176	0.65 TIP32A	0.45 SN74LS194	0.60 SN74LS402				

DIARY

Advanced Infrared Detectors And Systems — June 3-5th
Institution of Electrical Engineers, London. See March '86 ETI or contact the IEE at the address below.

Hitachi Summit Conference — June 9th
Wembley Conference Centre, London. An opportunity to learn about the latest developments at Hitachi from the Japanese design engineers responsible. Areas covered include telecommunications, computing and control, and image capture, processing and display. Tickets cost £29.50 inclusive from Hitachi Electronic Components (UK) Ltd, 21 Upton Road, Watford, Hertfordshire WD1 7TB, tel 0923-46488.

Network '86 — June 10-12th
Wembley Conference Centre, London. For details see March '86 ETI or contact Online at the address below.

Power Electronics and Variable Speed Drives — June 10-12th
Institution of Electrical Engineers, London. For details see June '86 ETI or contact the IEE at the address below.

The Scottish Electronics Show — June 10-12th
The Anderston Centre, Glasgow. For details see June '86 ETI or contact Network Events Ltd, Printers Mews, Market Hill, Buckingham MK18 1JX, tel 0280-815 226.

The International ISDN Conference — June 10-12th
Wembley Conference Centre, London. For details see June '86 ETI or contact Online at the address below.

Amstrad Computer Show — June 13-15th
Novatel, London. For details contact Database Exhibitions, 68 Chester Road, Hazel Grove, Stockport, Cheshire SK7 5NY, tel 061-456 8835.

Scottish Technology Week — June 17-19th
The Scottish Exhibition & Conference Centre, Glasgow. For details see June '86 ETI or contact Cahners at the address below.

Computer '86 — June 24-26th
G-Mex Exhibition Centre, Manchester. For details see June '86 ETI or contact Cahners at the address below.

Image Processing And Its Applications — June 24-26th
Imperial College of Science And Technology, London. Conference organised by the IEE at which over 60 papers from 14 countries will be presented, accompanied by technical sessions on image enhancement and restoration, interpretation, industrial and medical applications, etc. For details contact the IEE at the address below.

Association of Professional Recording Studios Exhibition — June 25-27th
Olympia, London. For details contact the APRS, 23 Chestnut Avenue, Chorley Wood, Herfordshire WD3 4HA, tel 09278-72907.

Radio Receivers And Associated Systems — July 1-4th
University College of North Wales, Bangor. Conference organised by the IEE, the IERE and RSGB in this country in association with a variety of overseas bodies. Topics covered will include general and low-cost receiver design, digital techniques, mobile radio and ICs for telemetry and navigational systems. For details contact the Institution of Electronic & Radio Engineers, 99 Gower Street, London WC1E 6AZ, tel 01-388 3071.

Voice Processing — July 2/3rd
Wembley Conference Centre, London. Conference. For details contact Online at the address below.

Addresses:

Cahners Exhibitions Ltd, Chatsworth House, 59 London Road, Twickenham, Middlesex TW1 3SZ, tel 01-891 5051.

Institution of Electrical Engineers, Savoy Place, London WC2 0BL, tel 01-240 1871.

Online Conferences Ltd, Pinner Green House, Ash Hill Drive, Pinner, Middlesex HA5 2AE, tel 01-868 4466.

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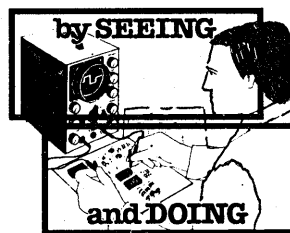
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For detailed specification or information on our comprehensive BBC range please write to us.		

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PD800P (2 x 400K/2 x 640K 40/80T DS) with built in monitor stand.....£249 (a)	3.5" DRIVES
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TS400 1 x 400K/1 x 640K 40/80T DS.....£109 (b)	PS35 1 with psu.....£124 (b)
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High quality discs that offer a reliable error free performance for life. Each disc is individually tested and guaranteed for life. Ten discs are supplied in a sturdy cardboard box.

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DISC ACCESSORIES

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All 14" monitors now available in plastic or metal cases, please specify your requirement.

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Swivel Base for Plastic 14" Microvitecs.....£20 (c)	

20" RGB with PAL & Audio

2030CS Std Res.....£380 (a)	2040CS Hi Res.....£685 (a)
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TAXAN 12" RGB

SUPERVISION III with amber/green option.....£330 (a)

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EPSON

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Optional Tractor Feed.....£20 (c)
FX85 (80col) NLQ 8K RAM.....£315 (a)
FX105 (136col).....£449 (a)
JX90 4 colour printer.....£420 (a)
LQ800 (80col).....£495 (a)
LQ1000.....£729 (a)
LQ1500 (136col) 2K buffer.....£875 (a)
LQ1500 (136col) 32K buffer.....£950 (a)
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PLOTTERS

Epson H180: A44 colour Plotter...£345 (a)

TAXAN

KP810 80 Col NLQ.....£220
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JUKI 6100 Daisy Wheel.....£289 (a)
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ACCESSORIES

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	Serial & Parallel Interfaces with larger buffers available.
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	Ribbon KP810/910.....£8.00 (d)
JUKI:	RS232 Interface.....£85 (c)
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MODEMS

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A new range of microprocessor based modems offering of upto 2400 baud, full duplex. Features include 'HAYES' protocol compatibility, auto answer, auto dial, speed buffering, printer port, data security option etc. Mains powered.

WS3000 V2123 (V21 & V23).....£295 (b)
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A world standard modem covering V21, V23 (Bell 103/113/108 outside UK) and including 75, 300, 600, 1200 baud ratings. Optional Auto dial, auto answer cards, complete control from computer keyboard. WS2000 £102 (b)

GEC DATACHAT 1223:

BABT approved modem complying with CCITT V23 standard. Supplied with software.....£75 (b)

Data Cables for above modems available for most computers.

Serial Test Cable

Serial Cable switchable at both ends allowing pin options to be re-routed or linked at either end using a 10 way switch making it possible to produce almost any cable configuration on site. Available as M/M or M/F.....£24.75 (d)

SPECIAL OFFER

2764-25.....£2.00
27128-25.....£2.50
6264LP-15.....£3.40

Serial Mini Patch Box

Allows an easy method to reconfigure pin functions without rewiring the cable assy. Jumpers can be used and reused. £22 (d)

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Adaptor for 2764/2564. £25.00 (c)

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All erasers with built in safety switch and mains indicator.
UV1 B erases up to 6 eproms at a time.....£47 (c)
UV1 T as above but with a timer.....£59 (c)
UV140 erases up to 14 eproms at a time.....£88 (b)
UV141 as above but with a timer.....£88 (b)

CONNECTOR SYSTEMS

I.D. CONNECTORS

(Speedblock Type)	Header	Recep.	Edge Conn.
No of ways	Plug	tacle	
10	90p	85p	120p
20	145p	125p	195p
26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS

No of Ways	9	15	25	37
MALE:				
Ang.Pins	120	180	230	350
Solder	60	85	125	170
IDC	175	275	325	-
FEMALE:				
St.Pin	100	140	210	380
Ang.pins	160	210	275	440
Solder	90	130	195	290
IDC	195	325	375	-
St.Hood	90	95	100	120
Screw	130	150	175	-
Lock	-	-	-	-

TEXTPOOL ZIF

SOCKETS	24-pin	£7.50
	28-pin	£9.00
	40-pin	£12

EDGE CONNECTORS

2 x 6-way (commadore)	0.1"	0.156"
2 x 10-way	150p	300p
2 x 12-way (vic 20)	350p	-
2 x 18-way	140p	-
2 x 23-way (ZX81)	175p	220p
2 x 25-way	225p	220p
2 x 28-way (Spectrum)	200p	-
2 x 36-way	250p	-
1 x 43-way	260p	-
2 x 22-way	190p	-
2 x 43-way	395p	-
1 x 77-way	400p	500p
2 x 50-way (S100conn)	600p	-

EURO CONNECTORS

DIN 41612	Plug	Socket
2 x 32 way St Pin	230p	275p
2 x 32 way Ang Pin	275p	320p
3 x 32 way St Pin	260p	300p
3 x 32 way Ang Pin	375p	400p
IDC Skt A + B	400p	-
IDC Skt A + C	400p	-

For 2 x 32 way please specify spacing (A + B, A + C).

MISC CONNS

21 pin Scart Connector	200p
8 pin Video Connector	200p

AMPHENOL CONNECTORS

	Solder	ZDC
36 way plug	500p	475p
36 way skt	550p	500p
24 way plug	475p	475p
24 way skt	500p	500p
PCB Mtg Skt Ang Pin	36way	750p
24 way 700p	-	-

GENDER CHANGERS

25 way D type	
Male to Male.....	£10
Male to Female.....	£10
Female to Female.....	£10

RS 232 JUMPERS

(25 way D)	
24" Single end Male	£5.00
24" Single end Female	£5.25
24" Female Female	£10.00
24" Male Male	£9.50
24" Male Female	£9.50

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(grey/metre)			
10-way	40p	34-way	160p
16-way	60p	40-way	180p
20-way	85p	50-way	200p
26-way	120p	64-way	280p

DIL HEADERS

	Solder	IDC
14 pin	40p	100p
16 pin	50p	110p
18 pin	60p	-
20 pin	75p	-
24 pin	100p	150p
28 pin	160p	200p
40 pin	200p	225p

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7402	30p	74183	140p	74LS164	75p	74S11	75p	4067	230p
7403	30p	74184	180p	74LS165A	110p	74S12	75p	4068	25p
7404	30p	74185A	180p	74LS166	150p	74S13	75p	4069	24p
7405	30p	74190	130p	74LS167	130p	74S14	50p	4070	24p
7406	30p	74191	110p	74LS168	100p	74S15	50p	4071	24p
7407	30p	74192	110p	74LS169	100p	74S16	50p	4072	24p
7408	30p	74193	110p	74LS170	100p	74S17	50p	4073	24p
7409	30p	74194	110p	74LS171A	100p	74S18	50p	4074	24p
7410	30p	74195	80p	74LS172	75p	74S19	50p	4075	24p
7411	30p	74196	130p	74LS175	75p	74S20	50p	4076	25p
7412	30p	74197	110p	74LS176	75p	74S21	50p	4077	25p
7413	30p	74198	220p	74LS181	200p	74S22	50p	4078	25p
7414	30p	74199	220p	74LS182	200p	74S23	50p	4079	25p
7415	30p	74201	110p	74LS191	75p	74S24	50p	4080	25p
7416	30p	74202	110p	74LS192	80p	74S25	50p	4081	25p
7417	30p	74203	110p	74LS193	80p	74S26	50p	4082	25p
7418	30p	74204	110p	74LS194	80p	74S27	50p	4083	25p
7419	30p	74205	110p	74LS195A	75p	74S28	50p	4084	25p
7420	30p	74206	110p	74LS196	80p	74S29	50p	4085	25p
7421	30p	74207	110p	74LS197	80p	74S30	50p	4086	25p
7422	30p	74208	110p	74LS198	80p	74S31	50p	4087	25p
7423	30p	74209	110p	74LS199	80p	74S32	50p	4088	25p
7424	30p	74210	110p	74LS200	80p	74S33	50p	4089	25p
7425	30p	74211	110p	74LS201	80p	74S34	50p	4090	25p
7426	30p	74212	110p	74LS202	80p	74S35	50p	4091	25p
7427	30p	74213	110p	74LS203	80p	74S36	50p	4092	25p
7428	30p	74214	110p	74LS204	80p	74S37	50p	4093	25p
7429	30p	74215	110p	74LS205	80p	74S38	50p	4094	25p
7430	30p	74216	110p	74LS206	80p	74S39	50p	4095	25p
7431	30p	74217	110p	74LS207	80p	74S40	50p	4096	25p
7432	30p	74218	110p	74LS208	80p	74S41	50p	4097	25p
7433	30p	74219	110p	74LS209	80p	74S42	50p	4098	25p
7434	30p	74220	110p	74LS210	80p	74S43	50p	4099	25p
7435	30p	74221	110p	74LS211	80p	74S44	50p	4100	25p
7436	30p	74222	110p	74LS212	80p	74S45	50p	4101	25p
7437	30p	74223	110p	74LS213	80p	74S46	50p	4102	25p
7438	30p	74224	110p	74LS214	80p	74S47	50p	4103	25p
7439	30p	74225	110p	74LS215	80p	74S48	50p	4104	25p
7440	30p	74226	110p	74LS216	80p	74S49	50p	4105	25p
7441	30p	74227	110p	74LS217	80p	74S50	50p	4106	25p
7442	30p	74228	110p	74LS218	80p	74S51	50p	4107	25p
7443	30p	74229	110p	74LS219	80p	74S52	50p	4108	25p
7444	30p	74230	110p	74LS220	80p	74S53	50p	4109	25p
7445	30p	74231	110p	74LS221	80p	74S54	50p	4110	25p
7446	30p	74232	110p	74LS222	80p	74S55	50p	4111	25p
7447	30p	74233	110p	74LS223	80p	74S56	50p	4112	25p
7448	30p	74234	110p	74LS224	80p	74S57	50p	4113	25p
7449	30p	74235	110p	74LS225	80p	74S58	50p	4114	25p
7450	30p	74236	110p	74LS226	80p	74S59	50p	4115	25p
7451	30p	74237	110p	74LS227	80p	74S60	50p	4116	25p
7452	30p	74238	110p	74LS228	80p	74S61	50p	4117	25p
7453	30p	74239	110p	74LS229	80p	74S62	50p	4118	25p
7454	30p	74240	110p	74LS230	80p	74S63	50p	4119	25p
7455	30p	74241	110p	74LS231	80p	74S64	50p	4120	25p
7456	30p	74242	110p	74LS232	80p	74S65	50p	4121	25p
7457	30p	74243	110p	74LS233	80p	74S66	50p	4122	25p
7458	30p	74244	110p	74LS234	80p	74S67	50p	4123	25p
7459	30p	74245	110p	74LS235	80p	74S68	50p	4124	25p
7460	30p	74246	110p	74LS236	80p	74S69	50p	4125	25p
7461	30p	74247	110p	74LS237	80p	74S70	50p	4126	25p
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7463	30p	74249	110p	74LS239	80p	74S72	50p	4128	25p
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7465	30p	74251	110p	74LS241	80p	74S74	50p	4130	25p
7466	30p	74252	110p	74LS242	80p	74S75	50p	4131	25p
7467	30p	74253	110p	74LS243	80p	74S76	50p	4132	25p
7468	30p	74254	110p	74LS244	80p	74S77	50p	4133	25p
7469	30p	74255	110p	74LS245	80p	74S78	50p	4134	25p
7470	30p	74256	110p	74LS246	80p	74S79	50p	4135	25p
7471	30p	74257	110p	74LS247	80p	74S80	50p	4136	25p
7472	30p	74258	110p	74LS248	80p	74S81	50p	4137	25p
7473	30p	74259	110p	74LS249	80p	74S82	50p	4138	25p
7474	30p	74260	110p	74LS250	80p	74S83	50p	4139	25p
7475	30p	74261	110p	74LS251	80p	74S84	50p	4140	25p
7476	30p	74262	110p	74LS252	80p	74S85	50p	4141	25p
7477	30p	74263	110p	74LS253	80p	74S86	50p	4142	25p
7478	30p	74264	110p	74LS254	80p	74S87	50p	4143	25p
7479	30p	74265	110p	74LS255	80p	74S88	50p	4144	25p
7480	30p	74266	110p	74LS256	80p	74S89	50p	4145	25p
7481	30p	74267	110p	74LS257	80p	74S90	50p	4146	25p
7482	30p	74268	110p	74LS258	80p	74S91	50p	4147	25p
7483	30p	74269	110p	74LS259	80p	74S92	50p	4148	25p
7484	30p	74270	110p	74LS260	80p	74S93	50p	4149	25p
7485	30p	74271	110p	74LS261	80p	74S94	50p	4150	25p
7486	30p	74272	110p	74LS262	80p	74S95	50p	4151	25p
7487	30p	74273	110p	74LS263	80p	74S96	50p	4152	25p
7488	30p	74274	110p	74LS264	80p	74S97	50p	4153	25p
7489	30p	74275	110p	74LS265	80p	74S98	50p	4154	25p
7490	30p	74276	110p	74LS266	80p	74S99	50p	4155	25p
7491	30p	74277	110p	74LS267	80p	74S00	50p	4156	25p
7492	30p	74278	110p	74LS268	80p	74S01	50p	4157	25p
7493	30p	74279	110p	74LS269	80p	74S02	50p	4158	25p
7494	30p	74280	110p	74LS270	80p	74S03	50p	4159	25p
7495	30p	74281	110p	74LS271	80p	74S04	50p	4160	25p
7496	30p	74282	110p	74LS272	80p	74S05	50p	4161	25p
7497	30p	74283	110p	74LS273	80p	74S06	50p	4162	25p
7498	30p	74284	110p	74LS274	80p	74S07	50p	4163	25p
7499	30p	74285	110p	74LS275	80p	74S08	50p	4164	25p
7500	30p	74286	110p	74LS276	80p	74S09	50p	4165	25p

AD7581	£15	LM393	385p	TBA231	120p	1802CE	650p	AD7581	£15	81LS95	140p	CHARACTER GENERATORS
ADC0808	1180p	LM394	400p	TBA800	80p	2650A	1050p	ADC0808	1180p	81LS96	140p	R03-32513
AM7910DC	£25	LM709	35p	TBA810	80p	6502	400p	AM25LS2521	£11	81LS97	140p	UC
AN103	3200p	LM710	35p	TBA820	80p	6502A	450p	AM25LS2538	350p	81LS98	140p	LC
AY-3-380	100p	LM711	100p	TBA820M	75p	6800	250p	AM26LS31	£14	81LS99	140p	UC
AY-3-8910	450p	LM712	100p	TBA820	80p	6802	250p	AM26LS32	£14	81LS100	140p	KEYBOARD ENCODERS
AY-3-8912	450p	LM713	100p	TBA820	80p	6809	250p	AM26LS33	£14	81LS101	140p	AY-5 2376
CA3018A	110p	LM714	100p	TBA820	80p	6809E	250p	AM26LS34	£14	81LS102	140p	74C922
CA3028A	110p	LM715	100p	TBA820	80p	6809E	250p	AM26LS35	£14	81LS103	140p	74C923
CA3046	110p	LM716	100p	TBA820	80p	6809E	250p	AM26LS36	£14	81LS104	140p	74C924
CA3056	110p	LM717	100p	TBA820	80p	6809E	250p	AM26LS37	£14	81LS105	140p	74C925
CA3066	110p	LM718	100p	TBA820	80p	6809E	250p	AM26LS38	£14	81LS106	140p	74C926
CA3080E	110p	LM719	100p	TBA820	80p	6809E	250p	AM26LS39	£14	81LS107	140p	74C927
CA3088	110p	LM720	100p	TBA820	80p	6809E	250p	AM26LS40	£14	81LS108	140p	74C928
CA3098E	110p	LM721	100p	TBA820	80p	6809E	250p	AM26LS41	£14	81LS109	140p	74C929
CA3098A	110p	LM722	100p	TBA820	80p	6809E	250p	AM26LS42	£14	81LS110	140p	74C930
CA3130E	110p	LM723	100p	TBA820	80p	6809E	250p	AM26LS43	£14	81LS111	140p	74C931
CA3130I	110p	LM724	100p	TBA820	80p	6809E	250p	AM26LS44	£14	81LS112	140p	74C932
CA3140E	110p	LM725	100p	TBA820	80p	6809E	250p	AM26LS45	£14	81LS113	140p	74C933
CA3140I	110p	LM726	100p	TBA820	80p	6809E	250p	AM26LS4				

READ/WRITE

Common Concern

Dear Sir,

I have no wish to continue the Greenham Common controversy — however, I have now read two letters in Read/Write from readers who wish to cancel their ETI subscription because of the article.

The article occupied three-quarters of one page, an informative documentary feature like mercy killing or abortion would be on BBC 2 television — if you don't like it, you turn over. Considering there are 66 other pages to choose from, the majority of which are straight-to-the-point projects without even an SDP abbreviation, I feel anyone who cancels the magazine must be out of their tiny minds. Perhaps, more to the truth, they prefer the £1.20 in their pockets.

It has taken engineers like myself many years to climb the tree of success, over 30 years since my first crystal set in Luton in 1956. Do we stand still or do we progress? Technology and defence are linked and breakthroughs in technology will always find their way into defence. In my son's lifetime Star Wars will make Greenham Common obsolete, just like Fleet Street and black and white newspapers today.

Each month ETI is a chunk of progress — the latest innovations, advances in technology and new products — an Aladdin's cave of new thought every month. If no one dares to include a comment, an article, for fear of offending someone somewhere, what a dull lot and a dull country this would surely become.

Like many readers I have learned more about the nuclear industry in the past weeks than in all my schooldays. Through all the argument, the rights, the wrongs, the facts, one thing has become apparent to me. We are more likely to have nuclear accidents than nuclear war, and in a densely populated country such accidents

could have similar effects to a nuclear war. Such accidents as a fire leading to a meltdown in an old-style magnox reactor could cause an explosion which could not be contained. The result, as everyone knows from April 26 in Russia, is pollution of the air, the ground, the rain, the milk and the food chain, leading to cancer and certain death within a 30 mile radius within three days... in a word, threads. Such an accident would not grant us 700 miles isolation and survival like Sweden. It is also apparent that such an accident whether caused by human error, component failure or terrorist attack could not offer a safe evacuation of the population in time.

The words I can hear are safe; inspected; automatic safeguards; cannot go wrong... everything made by man goes wrong sooner or later and a designer of nuclear reactors says he expects one to blow up every five years (First Tuesday — ITV — May 6).

Perhaps two readers who cancelled ETI are reading this. Yours faithfully,
Keith Lawrence B.Sc.,
Ilkley,
West Yorkshire.

Of Caves and Waves

Dear Sir,

Mike Bedford, in his article on the Troglolith cave radio (ETI May '86) has made some fundamental errors in his explanation of the underlying electro-magnetic theory. Of course, it is not necessary to understand the e-m theory in order to produce a working practical design, but I am surprised that you should print and thereby perpetuate certain misconceptions about such a fundamental subject.

Mike states that we normally mean the electric field when referring to radio waves. In fact transistor radios with their ferrite

rod aerials, and radio amateurs with their, and radio amateurs both making use of the magnetic part of the radiated field, which does not in this case drop off under an inverse cube law as Mike states.

Mike also states that the electric field of 'normal' radio radiates in straight lines which is why direction finding (DF) is easier than using the 'elliptical loops' of the magnetic field. This is not true. As I have mentioned above the magnetic field can be used for DF with no problem. (Rotate your transistor radio until the signal fades — the direction of the ferrite rod is then at right angles to the direction of the transmitter).

Thirdly, Mike states that electric fields need aerials of the order of a quarter or half a wavelength in order to radiate. Having an aerial of this size certainly helps, but it is not true in the general case and a circular loop can radiate a perfectly good electric field, just as a wire can produce a magnetic field.

I think Mike may be getting confused because what happens very close to an aerial (much less than a wavelength away) is very different to what happens at larger distances in terms of the way the fields behave. The maths is quite complicated, but in simple terms what happens is that a current oscillating in a wire or a loop causes both electric and magnetic fields to be set up in the surrounding medium. The maths can be simplified if we are either very close to or very far from the source of the fields. At large distances the electric and magnetic fields have a fixed relationship, and the magnitude of both (in certain directions at least) drops off with an inverse distance relationship. The result of this is that the power carried by the wave drops off as an inverse square relationship. This field is often called the radiation field, or the far field.

At close distances the picture is different. The dominant terms in

the maths do not suggest any power radiation. The electric and magnetic fields behave as if they originated from static conditions and are called the electrostatic and induction fields, or together they are called the near field. For a current loop the induction field drops off as an inverse cube relation, and the electrostatic field as an inverse square. For a short wire aerial the relationships are the other way round. The magnitudes of all the field components depends on a number of factors, and a good approximation at low frequencies is to forget the radiation field altogether.

The field patterns are not quite as Mike states. It would take far too long to explain here why they are different, but it is important to realise that magnetic waves are not inferior to electric waves. It is a question of the orientation of the transmitter and whether it is the near or far field that is important.

In Mike's diagram of the magnetic field lines (Fig 2, page 26) the electric field lines would be concentric circles, not straight lines as he states, and for an electric dipole (a short wire aerial) the role of the electric and magnetic fields are reversed — no straight lines anywhere!

A personal view is that Mike is wrong to think that induction loops are used because waves can be somehow 'propagated' more easily than from an electric dipole. Both vertical and horizontal wires can perform well, if not better than a loop aerial. They have disadvantages in that they are less portable, require high voltages and are not (superficially at any rate) as easy to understand as loops. For anyone who wants further information I suggest the book *ELF Communications Antennas* by Burrows, published by Peregrinus which Mike himself quotes as a reference. A good book on e-m theory is *Introduction to*

Electromagnetic Theory by Clemmow, published by the Cambridge University Press.

Notwithstanding these technical errors, I am sure Mike has done a good job on producing a piece of working equipment, and that is what it is all about really isn't it? And it is pleasing to see an original project of this sort in ETI.

Yours faithfully,
David Gibson,
Broadstone,
Dorset.

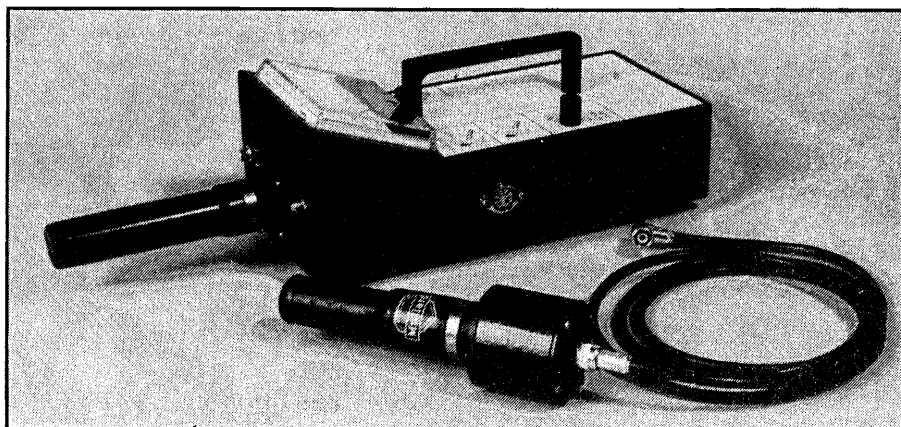
We spoke to Mike Bedford, who agreed with the points made in the letter and suggested that the confusion is substantially semantic. Throughout the articles, read *electromagnetic field for electric field and induction field for magnetic field*. In the context of this project, the induction field is all that need worry the constructor.
— Ed.

AUNTIE STATIC'S PROBLEM CORNER

Since the fire at the Chernobyl nuclear reactor, and the consequent rise in radiation levels throughout the British Isles, we have had numerous 'phone calls from ETI readers concerned about health hazards from contaminated food, milk, water, and from the general rise in background radiation levels. The Editor has asked me to devote my page this month to describing some of the ways that radiation can be detected and measured.

It has been known since the end of the last century that some elements are radioactive — that is to say, they spontaneously disintegrate, emitting high energy radiations. The three main types of radiation involved are alpha particles (helium nuclei), beta particles (electrons) and gamma rays (short wavelength radiation, which overlaps the high frequency end of the X-ray spectrum, and continues into very short wavelengths — 0.5Å to about 0.005Å.)

There are a number of measurements and guidelines to 'safe' exposure to radiation. The most commonly used unit of exposure is the roentgen, R, defined as the amount of radiation that



A portable ratemeter with accessories. It can be used with a Geiger-Muller tube attached to a socket on the front (as shown) or with an extension lead and socket which allows the GM tube to be some distance away from the ratemeter. The applied voltage can be varied from about 350V to 600V to suit different tubes. The remaining controls select the count range and time constant, and a socket is also provided so that a semiconductor alpha particle detector can be used instead of a GM tube.

produces in air, under specified conditions, ions carrying $\frac{1}{2} \times 10^{-9}$ coulombs of charge. Air was chosen because its mass absorption coefficient is almost the same as that for body tissue. The damage caused by radiation will depend on the absorbed dose, the exposure rate and the parts of the body exposed (hands and feet can receive comparatively high doses

without permanent injury, whereas the eyes are particularly sensitive).

The effects of acute radiation exposure over the whole body (ignoring carcinogenic effects and genetic damage) are: 20-50R, some changes in blood composition; 100-250R, severe illness, but recovery within six months; 400R, fatal to 50% of people exposed; 600R, always fatal. As

SATELLITES — SETTING THE WORLD ALIGHT?

With our ever-watchful gaze on the skies, we bring you an update on the world of satellites and the satellites of the world. Keith Brindley supplies the words.

During the Second World War considerable effort was spent on developing rocket propulsion for purposes other than communications. It became clear that manufactured Earth satellites could exist if rockets could be used to launch them high enough above the surface of the Earth. At the right altitude, a satellite could travel fast enough for its own centrifugal force to counter the tendency of gravity to bring it crashing down. Despite Werner von Braun's best efforts, it was not until 1957 that the first satellite (Sputnik 1) was launched. And it stayed only three weeks in orbit.

The world's first *communications* satellite (Score) was launched the following year by the USA. Like Sputnik 1, Score only lasted a short time. But satellite communication had been born, some 15 years after it had first been envisaged.

Figuratively Speaking

Since Sputnik 1 there have been an estimated 2,770 launches of satellites. Some of these have been multiple launches, so the total number of artificial earth satellites launched is nearer to 3,000. There are actually 5,560 or so objects, artificial or otherwise, in orbit. They range from the Moon right down to fragments which have broken off other satellites.

Of the 3,000 launched satellites, about 1,000 have come down again. Few of the remaining 2,000 are still transmitting — a realistic estimate of as low as 10% to 15% makes only 200 to 300 satellites functioning at this moment! This is a very difficult figure to establish beyond question because nobody wants to admit to poor design. Authorities on both sides of the Iron Curtain keep this sort of information under their hats, merely ignoring the fact that satellites have failed until everyone's forgotten about them anyway.

Very roughly, there are about 100 new satellites put into orbit each year and about 80% of these are of Soviet origin (a figure which must embarrass the USA). Thought for the day must be why the Soviets launch so many. Is it because they see World supremacy in whoever has the best satellite systems? Or is it because their standard of electronic production is so poor that their satellites have only a very short working life? Or is it because while the USA puts all its efforts into glamorous, high profile projects like Moon landings and shuttles, the USSR prefers a more methodical and less publicity conscious form of

space exploration and exploitation?

In any form of satellite communication one of the first problems which has to be overcome is exactly how to transmit to and receive from an orbiting satellite. The satellite must be thousands of kilometres up in space for it to orbit, so transmissions to and from it will be quite weak by the time they have traversed the distances. On Earth, a satellite receiving station (commonly called an Earth Station) must have an acceptable aerial — or antenna — system to pick-up transmissions. The aerial must be accurately pointed at the transmitting satellite. Easy to say, but not so easy to do!

On The Right Tracks

The problem of ensuring that the aerial always points at the satellite closely and tracks it accurately is fairly complex. The aerial's horizontal and vertical position is commonly varied by steering systems, which are in turn controlled by the strength of the received signal so that, as the satellite traverses the sky, the aerial follows it and makes sure that maximum signal strength is obtained. Such aerial systems are complex, heavy and expensive; not the sort of thing to have on your roof, strapped to your chimney.

Even with this reception restraint, satellites with such orbits are used for a number of purposes. However, there is a way to overcome the tracking problem and make light work of transmission and reception.

This is the so-called geo-stationary orbit, first considered by science fiction writer Arthur C. Clarke in an article in the October, 1945 issue of 'Wireless World'. With brilliant foresight, Clarke realised that the interdependency of satellite orbit radius and period could be used to direct advantage by positioning a satellite so that its orbit radius ensured an orbital period equal to the Earth's rotational period. By putting the satellite in orbit about the Earth's equator, travelling in the same direction as the turning Earth, the satellite would appear stationary to an observer on the planet's surface.

The radius of the Clarke orbit is 42,164km — that is 35,786km above the Earth's surface. Orbital speed at this height is 3,075 metres/second and period is approximately 23 hours and 56 minutes. This period is that of the sidereal day, and not the solar day which is exactly 24 hours. The orbit is, of course, circular.

The geo-stationary orbit (GSO) is of immense value, as earth stations with fixed aeriels can be used to receive transmissions from satellites in GSO. This has meant the development of low-cost reception systems aimed at domestic consumers.

The first satellite to be launched to a geo-stationary orbit was the Syncom 3 communications satellite. It reached a geo-stationary orbit on 19 August 1964.

Near And Far

The GSO is quite a long way out in space: about 5½ times the Earth's radius from its surface, in fact. At this distance, a single satellite with a sufficiently wide angle of transmission can broadcast line-of-sight radio frequencies with a 'coverage area' (sometimes called a 'footprint') of about one third of the Earth's surface (Fig. 1). As few as three satellites can be used to cover the whole of the Earth's surface and a signal can be transmitted from one Earth station via a satellite to any other station on the Earth's surface. On the other hand, satellites in GSO with narrow angles of transmission can be used to broadcast to precise, fixed areas on the Earth's surface (Fig. 2). Earth stations outside a 'spot-beam' will not be able to pick up the transmissions.

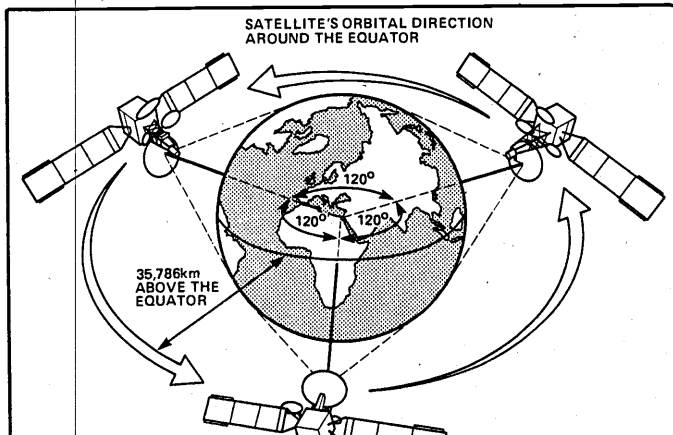


Fig. 1 A satellite in the GSO can transmit radio frequencies with a coverage area of about one third of the earth's surface.

In practice, limits on GSO satellite transmissions are reached at latitudes north or south of the equator of about 60° because the angle of arrival of the transmission becomes low enough to be blocked by hills, buildings and other surface features close to the Earth station. Adverse weather conditions at such latitudes may also attenuate satellite signals. This is not to say that satellite transmissions can't be received by Earth stations outside the 60° latitudes, just that larger aeriels must be used to pick up the weaker signals, and aerial positioning becomes more critical.

For some purposes, the GSO is not useful. Earth surveillance satellites (that is, satellites with on-board sensors and cameras — more commonly called 'remote sensing satellites') need to be close to the Earth's surface to allow sufficient resolution of details such as weather, crops, drought, pollution, mineral resources and ocean currents. At a tenth of the distance to the Moon, the GSO is just too high.

Latest surveillance satellites can resolve detail down to ten metres and their uses are as yet limitless. If you need to know anything about any aspect of the Earth's surface, a remote sensing satellite could check it out for you easily and quickly — and more often far more cheaply than sending out a team of observers would cost.

Remote sensing satellites usually fly a circular polar orbit (Fig. 3) at a height of around only 900km. As the earth turns beneath them, they can survey the whole surface in a few orbital periods (Fig. 4). Earth stations which receive transmissions direct from such satellites encounter the tracking problems previously discussed. The GSO can help hereby providing a geostationary data collection and transmission relay, allowing simple earth stations to receive transmissions from satellites in other orbits, without the inherent tracking problems.

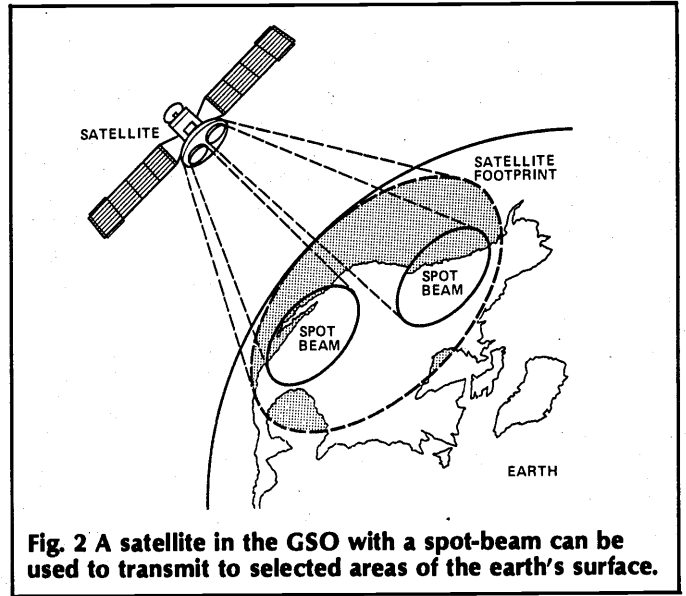


Fig. 2 A satellite in the GSO with a spot-beam can be used to transmit to selected areas of the earth's surface.

Spy satellites are really surveillance satellites in extremely low orbits so that they can resolve the finest of details, even — it is sometimes said — down to the headlines on a newspaper. As a result of such low orbits, severe atmospheric drag is common and spy satellites often re-enter the atmosphere only a few weeks after launch.

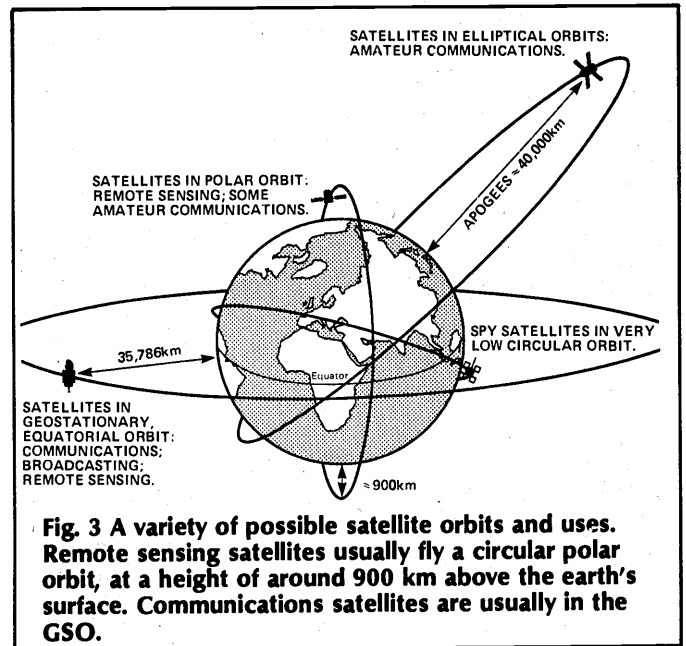


Fig. 3 A variety of possible satellite orbits and uses. Remote sensing satellites usually fly a circular polar orbit, at a height of around 900 km above the earth's surface. Communications satellites are usually in the GSO.

There is nothing against the GSO being used to hold a remote sensing satellite (as long as the resolution limits are acceptable), nor is there anything to prevent a circular or elliptical orbit being used to fly a communications satellite (provided that adequate tracking aeriels

are used). It really all depends on the use.

Weather Satellites

There are a number of weather satellites, in various orbits, transmitting on various frequencies. Most of them transmit their data — cloud cover pictures, temperature profiles, sea state, ice precipitation, snow cover and so on — using the automatic picture transmission (APT) system, in which each picture is transmitted in an analogue line-by-line format similar to television pictures but at a much slower rate — 120 lines per minute. A 2400Hz carrier is amplitude modulated between 5% (black) to 80% (white), separated into lines by square wave synchronization pulses. Although these pictures can't be displayed by a basic television, some simple software running on a home computer is all that's required to re-process them to a form that can be displayed in your living room.

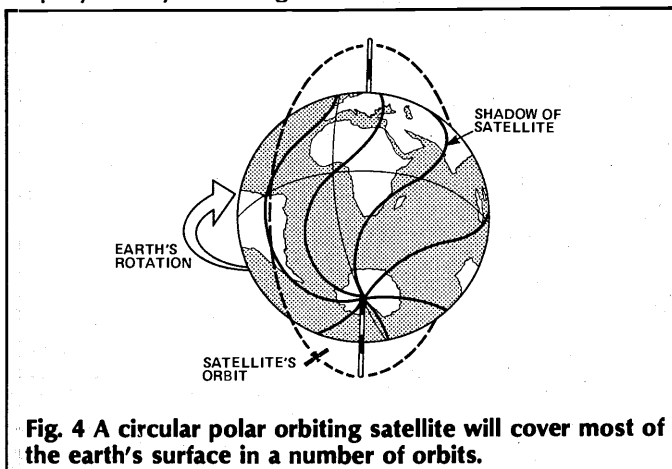


Fig. 4 A circular polar orbiting satellite will cover most of the earth's surface in a number of orbits.

The best type of orbit for weather satellites is polar, circular and at a height of about 900km above the Earth's surface. Tiros (television infra-red orbital satellites) series satellites are launched and controlled by the National Oceanic and Atmospheric Administration (NOAA). The satellites are often known by the 'NOAA' acronym, and there are currently four Tiros series satellites in orbit: NOAA-6, 7, 8, and 9, spread around the Earth. All of them have a 101 minute polar orbit, so pretty much all of the Earth's surface is covered over comparatively short time periods.

As they transmit at a relatively low frequency (137-138 MHz) reception is fairly simple, with few tracking problems as ordinary non-directional dipole aerials can be used. APT pictures consisting of two scenes side by side, one of visible light and one of infra-red conditions, are continuously transmitted by each NOAA satellite.

Similar satellites launched and controlled by the Soviets, known as Meteor satellites also transmit APT pictures in the same frequency band between 137 and 138MHz. Their transmissions are of single scenes in the visible spectrum.

Weather pictures commonly seen on television are usually taken from geostationary satellites, such as Meteosat, which is positioned directly over the Greenwich meridian at 0° latitude. There are a number of similar satellites spaced around the GSO so the whole world is effectively covered. Their data comes not only from on-board cameras, but also from hundreds of data collection platforms (DCPs) on the earth's surface. DCPs can be land-based, sea-based, or airborne. They can be automatic or semi-automatic and they can transmit only when the satellite requests information, on a pre-determined weather event.

Each satellite's correlated data are first transmitted to a receiving and processing Earth station, where they are processed to enhance picture quality and add country outlines together with latitude and longitude lines. The data are then transmitted back to the satellite for general transmission either in a basic APT format or in digital high bit rate format similar to the original format used to transmit the data Earthwards in the first place.

In either case, the pictures are of high quality due to the processing, and in the case of the digital high bit rate format very high resolution pictures can be received. Transmissions are at frequencies around 1.6 to 1.7GHz, and are outside most amateur reception capabilities. Dish aerials, low noise converters and receivers are available from a number of sources, at prices up to about £2,000 for a system. It's probably better to buy a telly, and wait for the weathermen at those prices!

Amateur Satellites

There are a few satellites in orbit designed mainly for communications and telemetry purposes for radio amateurs and educational establishments. The two satellites of direct interest in the UK are UoSAT-2 — designed and built by the Department of Electronic and Electrical Engineering at the University of Surrey (hence UoSAT).

The two UoSATs are sometimes known as OSCAR-9 and OSCAR-11 (Orbital Satellite Carrying Amateur Radio). Both are in polar orbits but at different altitudes, and so have different orbital periods.

OSCAR-9 (UoSAT-1) is at an altitude of 554 km with a 95 minute period. OSCAR-11 (UoSAT2) is at an altitude of 700km, with a period of 98 minutes. Both satellites transmit telemetry data at a frequency of 145.825MHz so reception is fairly simple, with few tracking problems, although Doppler shift takes the apparent received frequency to about 145.830MHz when the satellite approaches, and 145.810MHz as it recedes. Data is transmitted on other frequencies too, up to 10.47GHz in fact.

Another amateur satellite is OSCAR-10, like the other OSCARs but allowing two-way amateur radio communications. Separate uplink and downlink frequency bands are used for this facility, which is known as 'transponding'. The uplink frequency band is from 435.027 MHz to 435.179 MHz and the downlink band is from 145.825 MHz to 145.977 MHz. Any satellite which allows two-way communications uses this principle and has at least one transponder.

OSCAR-10 has an elliptical orbit, which means that the satellite is difficult to track as it approaches and recedes. At its apogee (the furthest point from the Earth, at about 33,500 km), however, the satellite appears stationary for quite long periods and simple aerial systems suffice.

There are a number of Soviet amateur satellites (the RS series, standing for *Radio Sputnik*) with transponders and telemetry beacons in circular polar orbits with periods of around 2 hours.

Broadcast Satellites

For reasons which should be apparent, any broadcast satellite television service must use satellites in the GSO — bandwidth requirements and the number of channels desired mean that high transmission frequencies must be used, which impose tracking problems if the broadcasting satellite is in anything other than a geostationary orbit. At high transmission frequencies, dish aerials are most suitable (although some new designs are currently being investigated and the neces-

sary tracking devices would make the aerial systems far too expensive for general public requirements. A satellite in the GSO, together with fairly small, cheap, fixed aerials are essential — particularly when it comes to direct broadcasting by satellite (DBS). DBS transmissions (to be distinguished from cable transmissions) are meant to be received by individual households. The transmissions will be more powerful than existing cable satellites produce and the recommended dish size is 0.9m.

In 1971, the International Telecommunications Union designated frequencies in the 12 GHz frequency band for use by broadcasting satellites. For frequency allocation purposes the ITU divides the world up into three regions:

- Region 1 — Europe, Africa and the Soviet Union;
- Region 2 — the Americas;
- Region 3 — Australia, Asia including China and Japan.

The three regions are shown in Fig. 5. Frequencies in each region are slightly different and have to be shared on an equal basis with other services such as terrestrial broadcasting, fixed and mobile services. The frequency allocations for region 1 is from 11.7GHz to 12.5GHz.

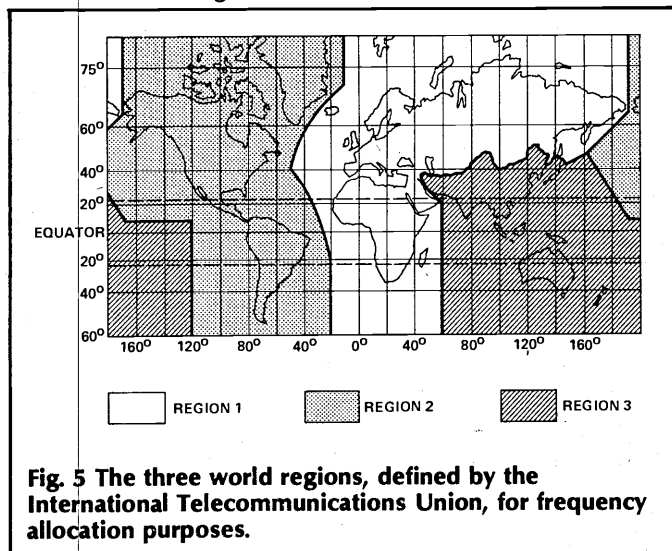


Fig. 5 The three world regions, defined by the International Telecommunications Union, for frequency allocation purposes.

This sharing of allocated frequencies with other services implied that action had to be taken to define exactly which frequencies could be used for which services, so a World Administrative Planning Conference (WARC) was set up in 1977. WARC77 defined the general guidelines which affect broadcast satellite services, such as channel allocations, channel widths, transmitter power and satellite positions in the GSO. These were only intended to be provisional and a number of minor changes to the guidelines have been made since 1977.

WARC77 confirmed that it should be possible to assign five channels to each country in the world by allowing each country a position in the GSO where its satellite could be orbited. The UK's satellite position, for example, was 31° west of the Greenwich meridian, and the five assigned channels were channels 4, 8, 12, 16, and 20, sharing the same GSO position with the Azores, the Canary Islands, the Ivory Coast, Spain, Iceland, Ireland, Liberia and Portugal.

This positioning of the satellite spot at about 30° west of the UK's longitude is typical of most countries and there is a specific reason. Figure 6a shows a non-scale illustration of the Earth, Sun and satellite in normal operation with no broadcast problems. Figure 6b shows the same set-up with a problem: the satellite is in solar eclipse, so that the earth stands between it and the sun.

As the satellite circuits are solar powered, it is non-operational and cannot broadcast.

This situation will occur for a few minutes at or around each equinox in a year (these are the only times when the sun, Earth and satellite are directly in line), at about midnight. By positioning the satellite some 30° west of the country's longitude, however, the 'midnight' blackout occurs at the satellite's longitude, that is about two hours after the country's midnight or around two o'clock in the morning when few programmes will be broadcast. Future satellites may be battery-backed with rechargeable cells to avoid these complications.

Another solar problem can occur when the satellite is directly between the Sun and the Earth, and an effect known as 'sun outage' takes place when the receiving aerial on the Earth, pointed directly at the satellite, is also pointing directly at the Sun, and so picks up extraneous noise. Again, this effect will happen at or around the two equinoxes for a few minutes at a time, around twelve hours after the eclipses — about two o'clock in the afternoon. There is no practical solution to this problem and broadcasters will simply have to schedule programmes so that no broadcasts are in progress at the time.

At the time of WARC77, a number of estimates as to receiver technologies were made, to define transmitter power and aerial size required. Developments in receiver technology have surpassed those estimates, and lower DBS transmitter power or smaller DBS receiving aerials — or both — will be the outcome. All that DBS is now waiting for is an economically viable plan — satellite receiver and aerial technologies are well developed and the major problem is cost. Later this year, France and Germany will be launching DBS satellites — TDF-1 and TVSAT, as they will be called.

Sidestepping DBS

Satellite Master Antenna Television (SMATV) uses satellites built for communications purposes to transmit signals basically for the use of cable television operators. The operators pick up the transmitted television signals and relay them to users on the cable network.

Where television signals like these are received by organisations such as hotels, pubs or clubs, the set-up suffers a name change and becomes a Television, Receive Only (TVRO) system. Communications satellites have transponders of much lower powers than planned DBS satellites (about 20W, against 200W). The receiving SMATV or TVRO aerials need to be significantly larger than DBS aerials (often twice the size at 1.8M or so) and are, therefore, somewhat more difficult to site.

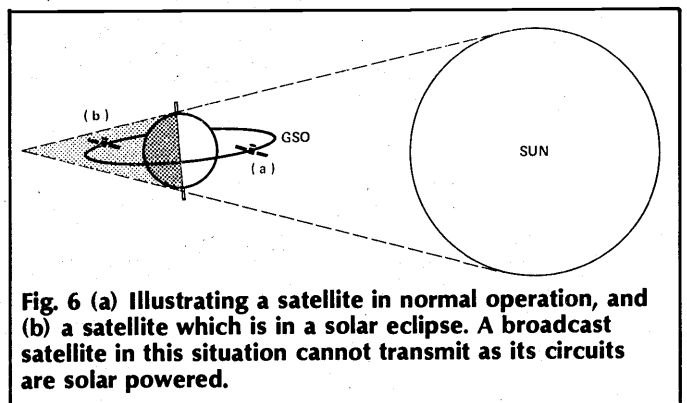


Fig. 6 (a) Illustrating a satellite in normal operation, and (b) a satellite which is in a solar eclipse. A broadcast satellite in this situation cannot transmit as its circuits are solar powered.

Had suitable DBS systems been developed and started as originally planned, SMATV and TVRO would have stayed exactly where they were intended — in pubs, hotels, clubs, and cable head-ends. But a market has

FEATURE: Satellites

grown up around SMATV and TVRO, demanding that it becomes available on a wider basis. The public, it seems, wants the choice which even existing satellite television offers, and never mind the large dish aerials and expensive receivers. For £10, the Department of Trade and Industry in the UK will sell you a licence to receive SMATV signals.

To meet this demand (or help create it?) several manufacturers have developed reasonably cheap equipment (£1,000 to £2,000) to receive the transmitted signals and convert them into a form suitable for use with domestic television receivers. At least one manufacturer's equipment is currently available for rental from selected DER television rental shops in the South East of England, on a trial run as a home-reception satellite television system. If the trial is successful, it's likely that the equipment will be made more widely available. As this availability increases it may be perfectly correct to think of the SMATV and TVRO signals as 'broadcast' television — much like DBS signals, but of lower power.

Currently, some 18 television services are 'broadcast' over the UK and Europe using transmissions from two communications satellites, although some of these services double-up and use the same channels. Most of the services are in English, with four or five in Italian, French or German. The more famous of the services are probably The Children's Channel, Premiere, Mirror-Vision, Music Box, Screen Sport, and Sky Channel.

The two satellites, European Communications Satellite 1 (ECS 1 or Eutelsat 1) and Intelsat V are primarily used to trunk telephone calls over Europe and between Europe and North America. They are both in orbit in the GSO — ECS 1 at 13° east of the Greenwich meridian, and Intelsat V at 27.5° west. **ETI**

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MICRO-COMPUTER AIDED CIRCUIT DESIGN

Julian Burt takes us through the first stages of circuit analysis on a home micro by way of nodal admittance and two-port networks.

There are two sides to computer aided circuit design. The main aspect of it is the actual analysis of a designed circuit — information about a circuit is fed into the computer and, after some number-crunching, the required response is found. This aspect can be split into smaller areas: linear frequency domain analysis (AC small signal analysis); linear DC operating point analysis; and non-linear analysis. In this series we shall mainly be concerned with the first two since the third is a very complex matter hard to implement on a microcomputer.

The other aspect of CACD is the use of a computer to help with the mathematics of circuit design: solving simultaneous equations, numerical integration and so on. We will be looking at circuit transfer functions, which describe the output of circuits with respect to their inputs.

AC Analysis

Perhaps the most important area of circuit analysis is linear small signal analysis. The term 'linear' is used loosely as all components are non-linear to a degree (see Fig. 5). Luckily, they can be assumed linear over a small range of working conditions. We work on this assumption to form a method of analysis for linear circuits.

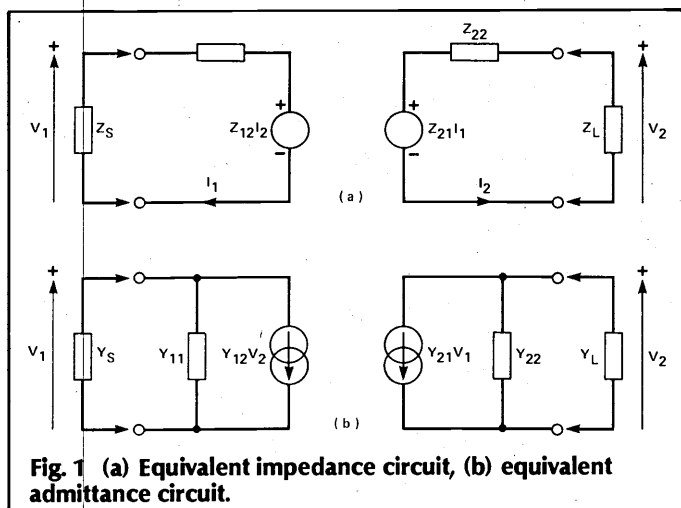


Fig. 1 (a) Equivalent impedance circuit, (b) equivalent admittance circuit.

A large number of circuits are of the two port type: they accept an input of some form and produce a corresponding output, as amplifiers and filters do.

All two port networks can be represented by a simple equivalent circuit. Because the circuit will probably use reactive components, we have to use an equivalent impedance circuit as shown in Fig. 1a. The input of this is defined by I_1 and V_1 , Z_{11} being the input impedance. The output, similarly, is defined by I_2 and V_2 with Z_{22} representing the output impedance:

$$Z_{11} = V_1/I_1 \text{ with } I_2 = 0$$

$$Z_{12} = V_1/I_2 \text{ with } I_1 = 0$$

$$Z_{22} = V_2/I_2 \text{ with } I_1 = 0$$

$$Z_{21} = V_2/I_1 \text{ with } I_2 = 0$$

Standard conversion formulae allow us to convert freely between impedance and admittance parameters:

$$Z_{11} = Y_{11}/\Delta Y, Z_{12} = -Y_{12}/\Delta Y, Z_{22} = Y_{11}/\Delta Y, Z_{21} = Y_{21}/\Delta Y$$

$$Y_{11} = Z_{11}/\Delta Z, Y_{12} = -Z_{12}/\Delta Z, Y_{22} = Z_{11}/\Delta Z, Y_{21} = Z_{21}/\Delta Z$$

$$\Delta Z = Z_{11} Z_{22} - Z_{12} Z_{21}, \Delta Y = Y_{11} Y_{22} - Y_{12} Y_{21}$$

Now we can draw an admittance equivalent circuit (Fig. 1b) where:

$$Y_{11} = I_1/V_1 \text{ with } V_2 = 0$$

$$Y_{12} = I_1/V_2 \text{ with } V_1 = 0$$

$$Y_{22} = I_2/V_2 \text{ with } V_1 = 0$$

$$Y_{21} = I_2/V_1 \text{ with } V_2 = 0$$

These results can be applied to a circuit we are analysing. For example, voltage gain is defined as:

$$A_V = V_2/V_1$$

FEATURE: Micro-aided circuit design

where V_2 = output voltage and V_1 = input voltage.

By Ohm's law we know that $V = IZ$ or $V = I/Y$, so that

$$V_2 = I_2/Y_{out} = -Y_{21}V_1/(Y_{22} + Y_L)$$

but A_v is V_2/V_1 . So, if we divide the equation above throughout by V_1 , we get an expression for voltage gain:

$$A_v = V_2/V_1 = -Y_{21}/(Y_{22} + Y_L)$$

The minus sign indicates that input and output currents are shown, in the equivalent circuit, as having opposite directions.

We can do a similar exercise with current gain, $A_i = I_2/I_1$.

Looking back at the impedance circuit (Fig. 1a) we can see that:

$$-Z_{21}I_1 = (Z_{22} + Z_L) I_2$$

By rearranging this equation, we obtain an expression for current gain in terms of impedance. By applying the conversion formulae given above, we can express current gain in terms of admittance:

$$I_2/I_1 = -Z_{21}/(Z_{22} + Z_L) = Y_{21}Y_L/(\Delta Y + Y_1Y_L)$$

A similar technique will yield expressions for the input and output impedance of the circuit for which Fig. 1 represents two equivalents.

$$Z_{in} = (Y_{22} + Y_L) / (\Delta Y + Y_{11}Y_L)$$

$$Z_{out} = (Y_1 + Y_S) / (\Delta Y + Y_{22}Y_S)$$

Y_S = source admittance and Y_L = load admittance.

From these expressions, it is clear that only values of admittance are needed. Because admittance is a complex quantity, we can also find the relative phase of each result — a subject dealt with elsewhere in this article.

Admitting Everything

We need a way to calculate admittances. One that is relatively simple and well-suited to computers (because it uses a large number of repeated calculations) is called the indefinite nodal admittance method. This involves the formulation of a set of equations which describe the currents and voltages at each node of a circuit.

The simplest way to explain this method is to consider the example shown in Fig. 2 — a basic two port passive circuit. The nodes and components have each been labelled to show their position in the circuit. A set

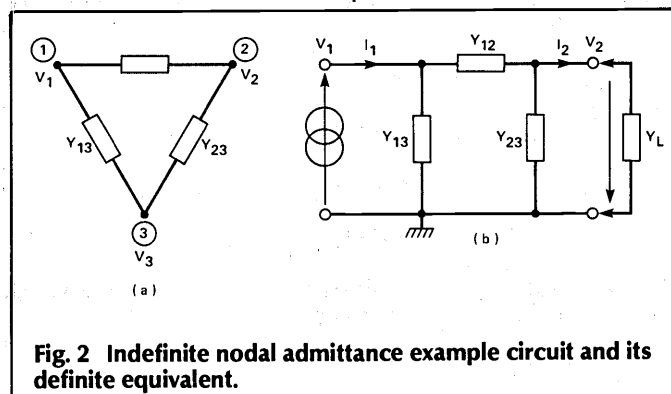


Fig. 2 Indefinite nodal admittance example circuit and its definite equivalent.

of simultaneous equations to describe the circuit will show currents summed at each node in terms of admittances and voltages measured with respect to an external reference (for example, ground):

$$I_1 = (V_1 - V_2) Y_{12} + (V_1 - V_3) Y_{13}$$

$$I_2 = (V_2 - V_1) Y_{12} + (V_2 - V_3) Y_{23}$$

$$I_3 = (V_3 - V_1) Y_{13} + (V_3 - V_2) Y_{23}$$

These equations can be rewritten in matrix form (Fig. 3).

$$\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} (Y_{12} + Y_{13}) & -Y_{12} & -Y_{13} \\ -Y_{12} & (Y_{12} + Y_{23}) & -Y_{23} \\ -Y_{13} & -Y_{23} & (Y_{13} + Y_{23}) \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}$$

Fig. 3 Indefinite nodal matrix of sample circuit.

The 3 x 3 matrix of admittance values is the nodal admittance matrix that we require and we can observe certain properties of the elements, Y_{nm} , where 'n' is the column and 'm' the row number:

- $Y_{nm} = Y_{mn}$ (the matrix is symmetrical);
- row and column elements sum to zero;
- Y_{nm} equals minus the admittance between nodes 'n' and 'm';
- Y_{nn} equals the sum of all admittances connected to node 'n'.

Using the above rules, the formation of the nodal admittance matrix is a trivial task on a computer — and the rules are generalisable. The problem lies in properly organising the data in the first place, but before discussing that we must continue the explanation of the analysis method. A good understanding of this is imperative in order to write useful programs.

So far, we have not taken the frequency dependent component of impedance — reactance — into account. Capacitive reactance is calculated as $1/2\pi fC$ and inductive reactance as $2\pi fL$. To incorporate these elements of impedance, we could produce a nodal admittance matrix for a range of frequencies sufficient to give an accurate picture of circuit behaviour. This is easy to program and memory-efficient but the calculations involved take a long time. An alternative technique, which is quicker but memory-inefficient, is to set up a capacitive and an inductive matrix using $2\pi C$ and $1/2\pi L$ as respective admittance figures. At any given frequency, actual admittance is derived by multiplying each matrix (that is, each element of each matrix) by the frequency and adding the two matrices. The result is a generalised indefinite nodal admittance matrix for the purely reactive aspects of the circuit. Mathematically, this is a matrix of imaginary numbers. The corresponding real matrix represents the resistive characteristics of the circuit.

Node Trouble

A circuit with any number of nodes may be represented by an indefinite nodal admittance matrix. The next stage in the analysis is to convert this indefinite matrix into a definite one. This is done simply by assuming one node to be at the same voltage as the reference node — in effect, by defining one node as ground, the reference point for all other nodes.

In the matrix representation, this simply involves removing the row and column corresponding to the

voltage we are setting to zero. In the basic example above, we might assume V_3 to be zero with the result that the matrix would now look like this:

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} (Y_{12}+Y_{13}) & -Y_{12} \\ -Y_{12} & (Y_{12}+Y_{23}) \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

Fig. 4 Input-output conditions.

Note that rows and columns no longer sum to zero, but that the definite nodal admittance matrix could have been obtained from the indefinite matrix in which rows and columns did sum to zero by applying simple row and column additions. The process effectively demonstrates Kirchoff's laws, and results in a matrix — in the general case — which can easily be further reduced.

The rank order two matrix shown in Fig. 4 can be interpreted as a statement of the input-output characteristics of the network. I_1 and I_2 are the input and output currents, previously ignored by assuming only internal currents and voltages. This type of matrix is, in general, what we are after since it expresses the equivalent circuit parameters of the original network.

The two port equivalent of more complicated networks can be derived by reducing the appropriate definite nodal admittance matrix. The process should be well-known to anyone familiar with the techniques for solving linear equations, and for further mathematical details readers are referred to any comprehensive text on matrices and/or linear equations.

The actual reduction method used here combines Gaussian row reduction with an application of what is known as Cramer's rule. Also involved — notionally, at least — are Kirchoff's laws which allow us the simplifying assumption that the sum of currents in all nodes of a closed circuit will be zero. This means that we can select input and output nodes as appropriate and set every other current value to zero. It helps with the manipulations if we make the input and output nodes 1 and 2 right from the start.

Let's assume we have a five node circuit which provides a definite admittance matrix of the order 4×4 with elements Y_{ij} . Thus:

$$I_i = Y_{ij} \cdot V_j$$

Cramer's rule allows us to determine a value for V_4 and thereby remove it from the system of equations. The new system of equations is described by:

$$I_1 Y_{44} - I_4 Y_{14} = Y_{ij} Y_{44} - Y_{i4} Y_{4j} \cdot V_j$$

Since I_4 is zero this can be simplified. In general, if we are removing V_k from the system all we have to do is replace each element of the definite nodal admittance matrix, V_{ij} by

$$Y_{ij} - Y_{ik} Y_{kj} / Y_{kk}$$

and then remove the k -th row and column. Assuming that nodes 1 and 2 have been chosen as input and output nodes, we can repeat this replacement in descending order of nodes until we have a simple 2×2 matrix which is the two port admittance matrix we are looking for.

In general, any circuit will contain reactive and resistive elements. Indeed, any real component will be both reactive and resistive to a degree — a capacitor has its equivalent series resistance, a wirewound resistor will clearly be inductive, even a length of wire will display some capacitance. Readers may be interested in pursuing this matter by reference to the series of articles by John Linsley Hood which appeared in ETI in 1985.

An actual program for nodal analysis will allow the addition of a small capacitance of about 1-2 pF in parallel with each resistor. This can be done by adding a notional capacitor to the reactive matrix in the same position as the resistor since we are using admittances. A resistance of about 1-10R might also be included in series with every inductor. The listings provided are not complete programs and are intended to be incorporated into programs written by readers.

Routine Treatment

Listing 1 is a routine to perform basic complex arithmetic. Complex arithmetic utilises so-called 'j-notation' (at least, it does if you're not a mathematician, for whom j -notation becomes i -notation). The central idea is that the phase changes in AC signals introduced by reactive components can be represented by use of the square root of -1. This number is purely imaginary and can only be combined with real numbers to form so-called complex numbers. A complex number is actually no more than a two-dimensional number in which the real part can be thought of as indicating a position along a single horizontal axis at the centre of which we conventionally described as magnitude (or amplitude) and of as indicating a similar position along a single vertical axis. In this way, any position on a plane can be associated with a unique complex number of the form $a+jb$. The co-ordinates of the position on the plane are, of course, a and b . Fundamental AC signals can also be represented as two-dimensional quantities — conventionally described as magnitude (or amplitude) and phase. These two are actually equivalent to polar co-ordinates rather than cartesian ones, but the principle is the same.

The square root of -1 itself can be thought of as a single unit along the positive direction of the vertical axis of our plane. A single unit in the opposite direction would be $-j$. These two, j and $-j$, represent 90° phase differences with respect to quantities in the horizontal direction. Purely reactive components produce such phase changes so that, for example, the AC current through a capacitor reaches its maximum before the voltage across it. With a resistor, voltage and current change simultaneously — or in phase. With the capacitor, current leads voltage by 90° and with an inductor, currents lags behind voltage by 90° .

```

100 DEF PROCcomplex(a,b,c,d,type)
110 LOCAL outa, outb, outc, outd
120 LOCAL denom
130 IF type > 2 THEN GOTO 230 ELSE GOTO 140
140 IF type = 1 THEN GOTO 150 ELSE GOTO 190
150REM **** addition ****
160 outreal = a + c
170 outimag = b + d
180 ENDPROC
190REM **** subtraction ****
200 outreal = a - c
210 outimag = b - d
220ENDPROC
230 outa = a * c
240 outb = b * d
250 outc = b * c
260 outd = a * d
270 IF type = 3 THEN GOTO 280 ELSE GOTO 320
280REM **** multiplication ****
290 outreal = outa - outb
300 outimag = outc + outd
310 ENDPROC
320REM **** division ****
330 denom = c^2 + d^2
340 outreal = ( outa + outb ) /denom
350 outimag = ( outc - outd ) /denom
360 ENDPROC

```

Listing 1 Complex arithmetic.

We need to take account of these phase changes in determining the impedance of a network. Impedance is usually given as a single figure in ohms, but in fact it is a complex quantity whose real part represents pure resistance and whose imaginary part represents pure reac-

tance. Only the latter is associated with phase changes and only the latter varies with signal frequency.

Very often we will need to combine two complex quantities, expressing impedance or admittance. The rules for handling such combinations follow from the graphical representation of them (or, indeed, from the fact that $j^2 = -1$). If $Z = a + jb$ and $W = c + jd$, then:

$$Z + W = (a + c) + j(b + d)$$

$$Z - W = (a - c) + j(b - d)$$

$$ZxW = (ac - bd) + j(bd + ac)$$

$$Z/W = (ac + bd)/(c^2 + d^2) + j(bc - ad)/(c^2 + d^2)$$

and the magnitude and phase of Z are, respectively, $\sqrt{a^2 + b^2}$ and $\arctan(b/a)$. Magnitude and phase are dealt with in Listing 2.

```
100 DEF PROCphase(a,b)
110 LOCAL moda, phasea
120 moda = (a^2 + b^2)
130 phasea = b/a
140 modZ = SQR(moda)
150 phaseZrad = ATN(phasea)
160 phaseZdeg = DEG(phaseZrad)
170 ENDPROC
```

Listing 2 Complex phase and magnitude routines

Listings 3 and 4 are routines to handle the reduction of matrices. Matrices are, in effect, equivalents to arrays. The matrix element A_{ij} can be identified with the array element in a BASIC program $A(i,j)$. Matrix manipulation is therefore relatively easy in BASIC. Listing 4 operates about twice as fast as Listing 3, but it is not structured.

Both routines operate on the complete definite nodal admittance matrix of a circuit. That is, the input matrix is assumed to have complex elements and to have already had the 'ground node' taken into account. In fact, rather than have one matrix with complex elements, the routines use two matrices — **Yreal(i,j)** and **Yimag(i,j)**. The routines need to know how many nodes the matrices have (the variable is 'nodes' and each matrix will be of order 'nodes' x 'nodes'). Matrix elements are held in the relevant array elements and Listing 3, at least, calls the procedure PROCcomplex from the routine in Listing 1. The result of the 'condensation' process is placed in a reduced matrix with elements Yreal (or Yimag) (1,1), (1,2), (2,1) and (2,2).

```
1000 DEF PROCpivot(nodes)
1010 FOR K%=nodes TO 3 STEP -1
1020 FOR I%=1 TO K%-1
1030 FOR J%=1 TO K%-1
1040 PROCnew(I%,J%,K%)
1050 NEXTJ
1060 NEXTI
1070 NEXTK
1080 ENDPROC
1100:
1110:
1120:
1130 DEF PROCnew(I%,J%,K%)
1140 PROCcomplex(Yreal(I%,K%),Yimag(I%,K%),
Yreal(K%,J%),Yimag(K%,J%),3)
1150 PROCcomplex(outreal,outimag,Yreal(K%,K%),
Yimag(K%,K%),4)
1160 PROCcomplex(Yreal(I%,J%),Yimag(I%,J%),
outreal,outimag,2)
1170 Yreal(I%,J%)=outreal
1180 Yimag(I%,J%)=outimag
1190 ENDPROC
```

Listing 3 Matrix reduction routine.

```
100 DEF PROCpivotcondense(nodes)
110 FOR I%=nodes TO 3 STEP -1
120 FOR J%=1 TO I%-1
130 FOR K%=1 TO I%-1
140 pivota = Yreal(I%,I%)^2 + Yimag(I%,I%)^2
150 pivotb = Yreal(J%,I%) * Yreal(I%,K%)
- Yimag(J%,I%) * Yimag(I%,K%)
160 pivotc = Yreal(I%,K%) * Yimag(J%,I%)
+ Yimag(I%,K%) * Yreal(J%,I%)
170 Yreal(J%,K%) = Yreal(J%,K%) - (pivotb
* Yreal(I%,I%) + pivotc * Yimag(I%,I%)) / pivota
180 Yimag(J%,K%) = Yimag(J%,K%) - (pivotc
* Yreal(I%,I%) - pivotb * Yimag(I%,I%)) / pivota
190 NEXT K%:NEXT J%:NEXT I%
200 ENDPROC
```

Listing 4 Fast matrix reduction routine.

Listing 5 - calculate results

```
100 DEF PROCresults
110 PROCcomplex(Yareal(1,1),Yaimag(1,1),
Yareal(2,2),Yaimag(2,2),3)
120 Dreal=outreal:Dimag=outimag
130 PROCcomplex(Yareal(1,2),Yaimag(1,2),
Yareal(2,1),Yaimag(2,1),3)
140 PROCcomplex(Dreal,Dimag,outreal,
outimag,2)
150 Dyreal=outreal:Dyimag=outimag
160REM ***** input impedance *****
170 PROCcomplex(Yareal(2,2),Yaimag(2,2),
YLreal,YLimag,1)
180 Areal=outreal:Aimag=outimag
190 PROCcomplex(Yareal(1,1),Yaimag(1,1),
YLreal,YLimag,3)
200 Breal=outreal:Bimag=outimag
210 PROCcomplex(Dyreal,Dyimag,Breal,
Bimag,1)
220 Creal=outreal:Cimag=outimag
230 PROCcomplex(Areal,Aimag,Creal,
Cimag,4)
240 Zinreal=outreal:Zinimag=outimag
250REM ***** output impedance *****
260 PROCcomplex(Yareal(1,1),Yaimag(1,1),
YSreal,YSimag,1)
270 Areal=outreal:Aimag=outimag
280 PROCcomplex(Yareal(2,2),Yaimag(2,2),
YSreal,YSimag,3)
285 PROCcomplex(Dyreal,Dyimag,outreal,
outimag,1)
290 PROCcomplex(Areal,Aimag,outreal,
outimag,4)
300 Zoutreal=outreal:Zoutimag=outimag
310REM ***** voltage gain *****
320 PROCcomplex(Yareal(2,2),Yaimag(2,2),
YLreal,YLimag,1)
330 PROCcomplex(-1*Yareal(2,1),
-1*Yaimag(2,1),outreal,outimag,4)
340 Avreal=outreal:Avimag=outimag
350REM ***** current gain *****
360 PROCcomplex(Yareal(2,1),Yaimag(2,1),
YLreal,YLimag,3)
370 Areal=outreal:Aimag=outimag
380 PROCcomplex(Yareal(1,1),Yaimag(1,1),
YLreal,YLimag,3)
400 PROCcomplex(Dyreal,Dyimag,outreal,
outimag,1)
405 PROCcomplex(Areal,Aimag,outreal,
outimag,4)
410 Aireal=outreal:Aiimag=outimag
420 ENDPROC
```

Listing 5 Impedance and gain calculations.

Listing 5 makes use of PROCcomplex to calculate input and output impedances and voltage and current gain of the circuit under examination. The routine requires two arrays — **Yareal(2,2)** and **Yaimag(2,2)** — which contain the two port admittance parameters of the circuit derived in Listings 3 and 4. The output impedance is given by 'Zoutreal' and 'Zoutimag' which give the resistive and reactive parts. Input impedance is given by 'Zinreal' and 'Zinimag'. Voltage gain is given by 'Avreal' and 'Avimag' and current gain by 'Aireal' and 'Aiimag'. Magnitudes and phases can, of course, be found by further manipulating these results with the routine in Listing 2.

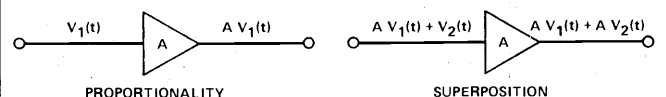


Fig. 5 Superposition and proportionality define linearity.

Next month we will look at equivalent circuits for active components including bipolar transistors, ideal transformers, transmission lines, op-amps and FETs. Following from that, we'll look at methods of writing your own programs and coping with the lack of memory of most home micros — a discussion which will cover such topics as editors, data files and program overlay. **ETI**

JOBS FOR A CHANGE?

Exchange Resources is an employment agency for people in electronics and computing. It was launched at the British Electronics Week exhibition by the group Electronics for Peace. Tony Wilson, their coordinator, explains how the agency came into existence and what makes it different from existing employment agencies.

Since Electronics for Peace was founded in 1982, people have been writing in and asking for advice on how to avoid working on military equipment. Many have sent their CVs in the hope that we might find them suitable work. Similarly, response to articles in ETI and other media has demonstrated that there are many people already working in or about to enter the electronics and computing industries who are concerned about the effects their work might have on other people, but who find it very difficult to obtain suitable work without military or other undesirable content. This is particularly obvious when I visit universities, polytechnics and sixth forms.

The picture is no better on the company side of the fence. One company I know has twice developed high tech servo mechanisms for the entertainments industry only to have the MoD take over. Rather than work with the MoD, this company gave their patented rights away. In another case, artificial limb development was delayed for years through lack of funds until the all-powerful MoD took an interest.

One of the effects of this is that people become alienated from their work and end up cynical, inefficient and dissatisfied. Companies find it hard to get venture capital for commercial products, and cannot patent anything without the very serious risk that the MoD will intervene "in the national interest".

I'm not arguing for no defence. I believe that this country needs a strong and effective defence — indeed, I work as a consultant to defence companies. I believe I have the right to work in the defence industry and to criticise and try to change it. Our industry is rapidly going down the pan because of the enormous amounts of government money devoted to military research and development. It is well known that military investment is the least productive in terms of jobs, sales and growth, yet the trend continues and our imports increase as our exports decrease.

We don't need so much defence. If we spent one tenth as much as we do, not only would it be more effective than the shambles we have now (useless Nimrod, unuseable Trident, fiasco Falklands, et al), but there would be an extra £17,000,000,000 per year in R & D money alone to boost our education, indus-

try and other essentials. That is the only way this country can be strong — not through military posturing but by real economic and social strength.

One of the aims of the new agency is to raise awareness in our industry of these issues. In my work in the defence industry I see people afraid to discuss the issues openly, not only at work but outside too. I want to see people talking openly to decide what kind of future we all want. Government needs a lead from us.

In Good Company

Exchange Resources already has a large number of companies willing to use our services. We are now busy talking to them so that they can be classified on our database according to the type of work they have and their employment policies. People who approach us for work will be asked to describe the sorts of things they are not prepared to do as well as what they hope to do. We will then try to match people with companies. There are some existing agencies who are prepared to work with us in helping to place people, and this is going to be extremely useful in our early days when resources will be stretched. It should mean that we will be at least as effective as the average agency, and perhaps more so. For those who want it, there is a counselling service to help clarify issues and develop confidence in taking decisions (it is not an advice service, although advice will be available).

Existing agencies charge from 10 to 20% of the first year's salary for anyone they place — this can range from less than £1,000 to over £10,000 and would typically be around £2,000. Exchange Resources in its first year of operation will charge only a registration fee of from £50 to £2,000 depending on the size of company and the type and quantity of staff required. So, if we place just one person with a company, they pay no more in registration fees than they would otherwise pay, and after that they effectively get any other staff placements free.

There are several good reasons for us doing this. Firstly, we don't need to advertise in the same costly way as do the other agencies. There are magazines and newspapers which are willing to give us editorial

space and once people know we exist they will contact us. Secondly, we regard current fees as extortionate and a burden on British industry. We also want to make it cost effective for people to care about their work and its effects on the world. And thirdly, we're not yet sure of the market, how easy it is to become established, and our effects on it. During this first year of operation, we will be appraising all aspects of our business so that we can set more appropriate rates in our second year. In this we will be aided by a post graduate research worker whose thesis will be based on us. He will be closely involved from the beginning and will give us regular feedback on our activities.

People who normally work as sub-contractors will receive the usual agency service — they will work via their limited companies and the agency will take a (moderate) slice off the top of their earnings. In addition — ad this is surely unique — we will offer the alternative of working directly for the client, with the agency taking a once and for all fee. There are pros and cons involved for both contractor and client, and these will be spelled out before any agreement is reached.

Of prime importance to the smaller client companies, co-operatives and sole trader partnerships is our business-to-business service. Any organisation or individual registered with us, provided they have paid their annual fee, will be able to contact us (telephone, telex, electronic mail or facsimile) for assistance in finding a business service. For example, a small software house might need a specific programming skill for a short job, or an electronics company might need inspection and rectification on a large number of PCBs immediately. We will search our database, contact likely people and put them in touch — very quickly. There might be a small fee for this, say £5 to £20, depending on the amount of time used and the urgency. This service will be developed into a major way of working for us and our clients — thus building up working relationships between companies and people who share a concern for the way they work and, of course, helping to keep costs down. Very soon this service will be extended to include help with starting new ventures.

There are a number of independent consultants in organisational and personal change associated with the agency, throughout the country. They will work with us to improve efficiency in those client companies who require help, and to help staff clarify ethical and inter-personal issues for themselves.

Finally, I should mention that the agency is intended to be in profit in its second year and that all profits generated will go towards furthering the aims of Electronics for Peace and the agency.

In addition to finding staff and positions for client companies and individuals, Electronics for Peace is also trying to find people to run several of its own projects.

The first project is the design and development of a three-waveband (SW/MW/FM) radio that can be assembled and maintained in Eritrea using the resources available locally. There is a pressing need for each village to have its own radio for news and education. The design arrived at must be battery operated with very low power consumption or use a combination of rechargeable batteries and solar power. Provision for an add-on tape module would be useful. The case should be made from PVC and will be produced in Eritrea using a forming tool which will also have to be designed. Those producing the radio design will also have to provide full instructions on assembly and test and on maintenance once in use.

If anyone feels they have skills which would be of use on this project and have time available to work on it, they should contact the agency at the address given below. It is hoped that at least one person will be able to go to Eritrea when the project is complete to see

the radios being assembled and used.

The second project is the formation of a full-time monitoring team to build up a database on non-ionizing radiation emissions in the UK and their effects on people. EFP hope to assemble the core of a team and then raise funding for the work. It is intended that the monitoring should start as soon as possible and preferably within six months. Again, anyone interested should contact the agency at the address below.

Electronics for Peace would also be interested to hear from anyone who has an idea for a project which uses technology in a socially beneficial way.

Tony Wilson and Exchange Resources can be contacted at Townsend House, Green Lane, Marshfield, Nr. Chippenham, Wiltshire SN14 8BR, tel 0225 - 891710.

Discussions have taken place between ETI and Exchange Resources with a view to our publishing a short, regular feature on jobs available through the agency. We would be interested to hear your views on this proposal. ETI



Coming up against the military machine?

THE ETI DIRECT-ION

Paul Chappell reveals how you can be a magnet for ions and, amid a welter of puns, produces possibly the smallest ionizer ever.

Many claims have been made for the benefits of air ionization. Supposedly, it can cure hay fever and bronchitis, and speed up the healing of burns. Ionization is said to improve concentration, reduce susceptibility to colds and flu and turn insomniacs into deep sleepers. Some of the effects are genuine and well documented; others should probably be taken with a middling to large pinch of salt.

Air ionization is a natural process, and both positively and negatively charged oxygen molecules are abundant in areas far removed from the main centres of population. Mountain tops are the romantic locations used as an example by the health magazines, but similar concentrations can be found in the middle of Dartmoor — or the Sahara desert, for that matter.

The lack of ions in man-made surroundings is easily measurable — it is often found to be less than the natural concentration by a factor of 100 or more. This depletion of oxygen ions is associated with pollution, modern buildings and the use of synthetic fabrics and furnishing materials. It has been blamed for everything from listlessness, depression and absenteeism to violence and murder! (See *The Ion Effect* by F. Soyka for the gruesome details).

Restoring The Balance

Experiments in restoring the natural ion balance have led to the conclusion that negative ions are the essential 'vitamins of the air'. Positive ions in high concentration have an initial stimulating effect which is followed, after a few hours, by fatigue and possibly headaches. Negative ions have

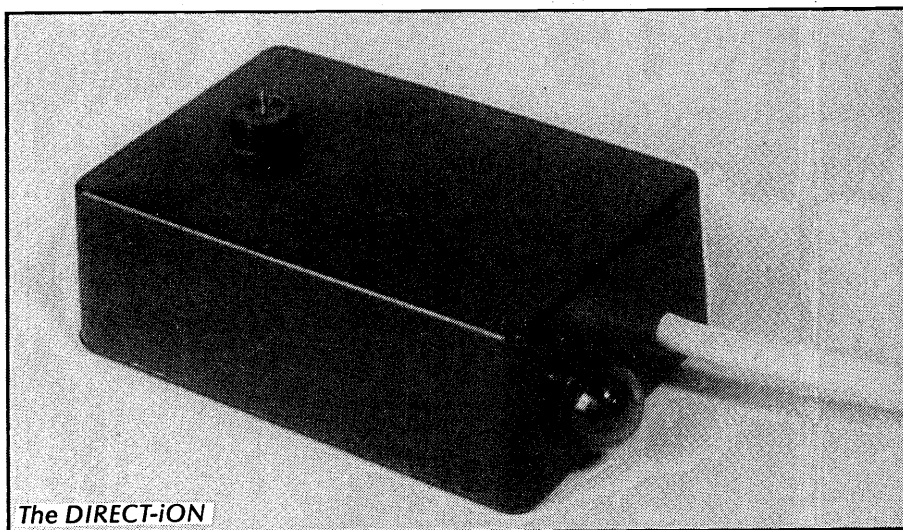
been found to give more profound benefits without any side effects, so air ionizers aim to produce these.

The method used is to apply a high negative voltage, several kV in fact, to a sharply pointed emitter. The negatively charged air is repelled from the emitter resulting in an 'ion breeze' you will feel if you put your hand close to the ionizing point.

There have been several published designs for air ionizers over the past few years, but we

achieved by running the oscillator at a fairly high frequency.

In the present design, the ladder runs directly from the mains. This cuts out the first two stages of the usual ionizer circuit. Larger capacitors are needed — 10nF as opposed to 100pF or so — but they are not much bigger in physical size. As the circuit uses no active components at all, it is almost certain to work first time, testing is easy, and the final circuit can be run continuously for years without problems.



The DIRECT-ION

make no apologies for offering another.

Previous circuits have, almost without exception, been split into three stages. First of all, the main voltage is reduced to 12V or so, then rectified and smoothed. Next there is an oscillator driving a transformer to step the voltage back up to a few hundred volts again. Finally, there will be a ladder of rectifiers and capacitors to step the voltage up to a few kV. The justification for this cumbersome process appears to be little more than the reduction in size of the ladder capacitors,

Rectifiers

Another advantage of running the circuit at 50Hz instead of 50kHz or so is that 1N4007 rectifiers can be used. Ordinary rectifiers are not too keen to work at high frequencies, the main reason being their painfully slow reverse recovery time, which begins to degrade circuit performance at frequencies as low as 2kHz in the case of a 1N4007. Readers may be interested in the results of applying a sine wave of increasing frequency to the circuit shown in Fig. 1.

At low frequencies, the output is a half-wave rectified sine wave, as you would expect.

At 2kHz, a small reverse conduction spike is already visible, and by 10kHz conduction does not stop until the input is at about -1.8V. From then on, the situation gets progressively worse. By 1MHz, whatever the 1N4007 is doing, it certainly isn't rectifying!

Construction

The 1N4007 rectifiers are mounted vertically on the board in the four central rows of holes and the capacitors are mounted in the outer rows as shown in the component overlay (Fig. 2). Figure 3a is an end-on view of the board with the first rectifier and capacitor in each row shown. All the rectifiers are mounted the same way around.

When putting in the capacitors, you will find it easier to put them all in place at once and hold them with a rubber band while soldering, rather than trying to solder them in one at a time. If any capacitor seems a tight fit, just turn it around — sometimes the leads are not quite central.

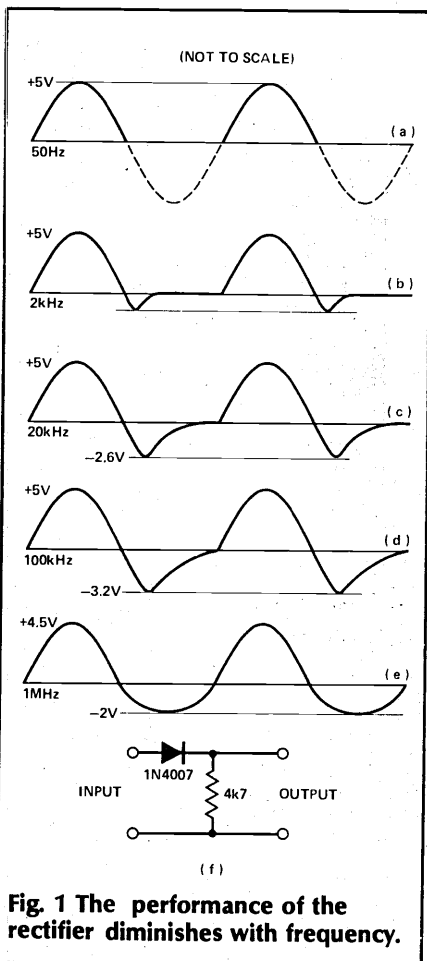


Fig. 1 The performance of the rectifier diminishes with frequency.

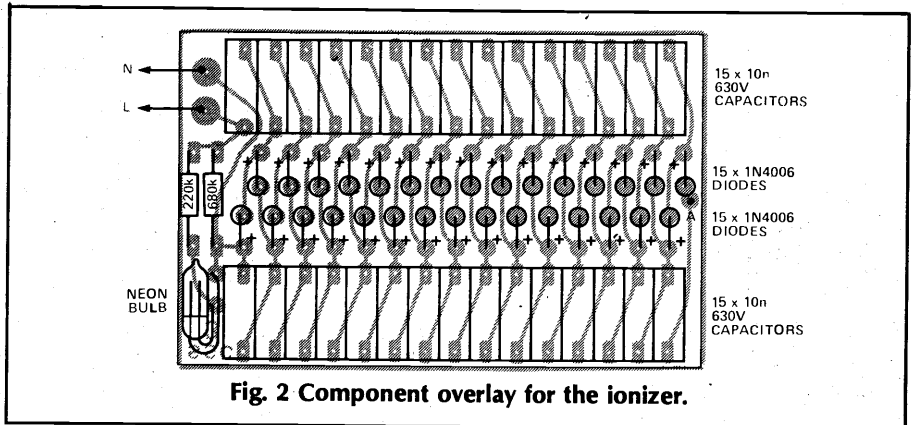


Fig. 2 Component overlay for the ionizer.

After soldering in the resistors, insulate about 1/2" of each lead of the neon bulb. Solder the bulb in place and, if you are using the recommended case, bend the leads so that it lies roughly parallel to the board as shown in Fig. 3b. If you are using a larger case, you may prefer to let the neon poke through, or to use a complete neon lamp assembly.

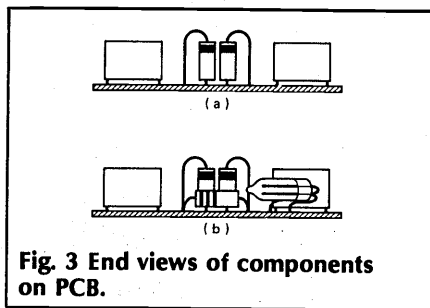


Fig. 3 End views of components on PCB.

Assembling The Case

Drill two holes in one end of the case (Fig. 4). If you are using the recommended case, follow the instructions with regard to positioning. If you use a larger

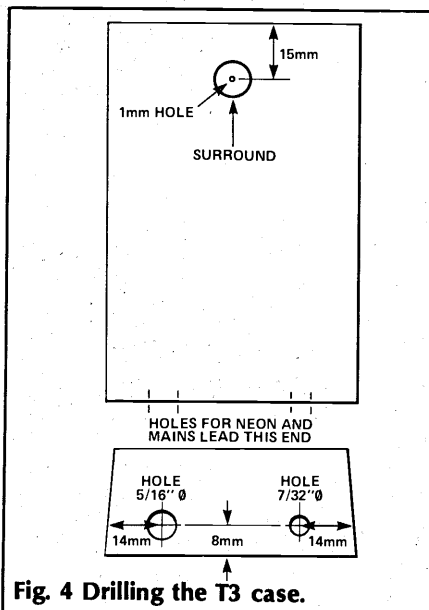


Fig. 4 Drilling the T3 case.

case, you can easily determine your own hole positions.

To position the holes accurately, you will find it easier to drill a small hole first, then widen it out with a larger drill to the correct size. A small hole is also needed at the top of the case, half way between the two sides and 15mm from the *undrilled* end (Fig. 4). This hole can be made with a 1mm drill if you have one, otherwise you can hold a soldering iron to the lead of one of the 2M7 resistors and use the hot wire to melt the hole. The hole needn't be perfectly tidy as it can be covered up later, but don't let the soldering iron touch the case.

The hole is meant for the actual emitter — a length of pointed wire. You may, of course, use an emitter of your own devising. As long as it includes sharp points and is conductive, practically anything will do.

The neon cap is glued in place over the left-hand hole of Fig. 4a. A surround may be glued around the 1mm hole in the top of the case to obscure the emitter. Use quick

PARTS LIST

RESISTORS (1/4W, 5% unless stated)

R1	680k
R2	220k
R3-R7	2M7 1/2W

CAPACITORS

C1-C30	10nF 630V polyester
--------	---------------------

SEMICONDUCTORS

D1-D30	1N4007
--------	--------

MISCELLANEOUS

Neon bulb and suitable cap; emitter surround; length of mains lead; insulated connecting wire; insulation; 10nF 100V capacitor and neon bulb for tester; (71x46x22mm); epoxy resin; mains plugs; optional emitter (for example, PB22 phosphor bronze rifle cleaning brush available from gunshops).

setting epoxy resin for all the gluing operations.

Join the five 2M7 resistors together by twisting the leads, soldering and then trimming (Fig. 5a). Glue the resistor assembly to the inside of the top of the case with lead A protruding through the 1 mm hole. This lead will form the emitter, or it may be soldered to a needle or other suitable object — for example, a phosphor bronze rifle cleaning brush makes an attractive and efficient emitter. Solder about 3" of insulated wire to lead B, and trim the lead (Fig. 5b). Cover the resistor assembly and exposed leads with epoxy for insulation.

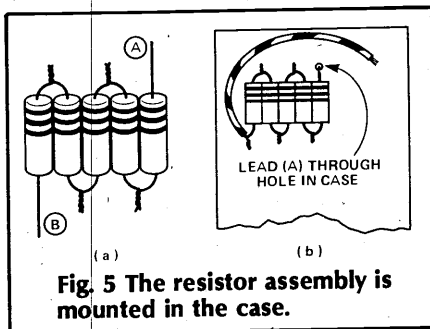


Fig. 5 The resistor assembly is mounted in the case.

Final Assembly

First, check the board carefully. Make sure that all the rectifiers are the right way around and all the components are in the correct position. Check the track side of the board for solder bridges, and also for excess flux residue, which could provide a leakage path — clean it off if necessary. Solder the free end of lead B — the wire joined to the 2M7 resistors — to point X in Fig. 2.

Remove about 3/8" of the white outer sheath of the mains cable and about 3/16" of insulation from the conductors and solder the live (brown) wire to point L and the neutral (blue) wire to point N on the overlay. Be sure to get the mains lead connections the right way around, and don't remove more of the outer sheath than is absolutely necessary.

There is no room for mounting screws in the recommended case, so the PCB has been made for a tight friction-fit into that case. First of all, cut the corners of the PCB as shown by the dotted lines on the overlay. Feed the mains cable through the right-hand hole (Fig. 4a) and gently ease the board into the case with the component side facing outwards. Push down on the board gently until it is held in place by the pillars at each corner of the case. Adjust the position of

the neon bulb so that it is behind the neon cap, but don't try to push it through the hole. Screw the base of the case in position, attach a plug with a 1A fuse to the mains lead, and straighten the emitter wire so that it points vertically upwards. Using a pair of side cutters with the flat face upwards, cut a small amount of wire from the end of the emitter. Using the cutters 'upside down' should leave the emitter wire with a sharp point at the end.

A larger case would be easier, if less elegant. The board can be fixed in a larger case with three or four blobs of epoxy, after testing.

Testing

A simple tester can be made from a 10nF capacitor and a neon bulb (see Fig. 7). Plug in the ionizer, and, if all is well, its own neon lamp will glow and a few seconds later you will hear a soft hiss from the emitter. If you hold one lead of the tester and move it towards the tip of the emitter, the neon bulb on the tester will begin to flash when its free lead is about 1/2" from the emitter, and will flash faster as it is brought closer. The flashing is not very bright, so it won't show up in direct sunlight.

If the ionizer's neon does not light, unplug the unit at once and touch the mains plug to the emitter to remove any residual charge on the capacitors. Check the mains connections, plug fuse and wiring of the 220k resistor and neon lamp.

If the ionizer's neon glows, but the emitter does not hiss and the tester's neon does not flash, re-trim the emitter wire and try to get a sharper point on it. If there is no sign of activity at the emitter at all, check again for a solder bridge between tracks, one of the diodes back to front, a short circuit in one of the capacitors, or a dry solder joint.

Finishing Touches

After testing, discharge the ionizer and remove the base. Take out the PCB and spray a few coats of anti-corona compound onto the back. If you do not have any anti-corona spray, a smear of epoxy resin will do instead.

Place the board in its case. Now is the time to glue it in position. If you're using the recommended case, press the PCB down until the tops of the capacitors are about 3/16" below the rim of the case (Fig. 6). Run

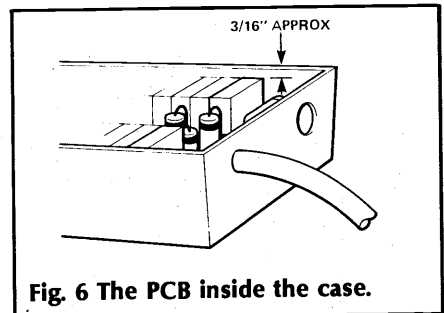


Fig. 6 The PCB inside the case.

some glue onto the corners of the board and put some around the mains lead where it enters the case. For the sake of safety, the mains lead must be held firmly in place, so use a strain relief grommet, too, if you have room.

If you've got plenty of epoxy, fill the neon cap with it and cover the neon bulb. This gives a pleasant, diffused light when the neon glows.

Now, screw the case together. Fill the emitter surround with epoxy (this is not essential, but it improves the appearance) and trim the emitter wire to about 3/8" above the top of the surround (making sure to get a fine point on it).

Life With The Ions

Although some of the benefits of air ionization may be exaggerated, the action itself is real enough. One consequence of using an ionizer is that the ions attach themselves to any dust, dirt or pollen particles that happen to be floating around. The dust then becomes charged and will be attracted to the nearest natural surface, which by sod's law will be your expensive new wallpaper!

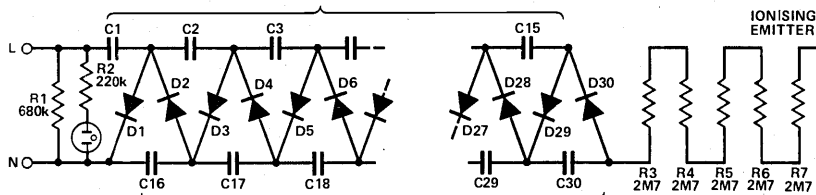
If you intend to run the ionizer within a foot or so of a wall, cover the wallpaper in some way, otherwise, try to position the ionizer towards the centre of the room where any charge dust will end up on the floor and be swept up during normal household cleaning.

The action of precipitating particles from the air is of immediate benefit to asthma and hay fever sufferers, no matter how beneficial the ions themselves may be. If you live in the country and think the air is pure and clean anyway, just try running the ionizer close to a sheet of white paper for a few days!

Improvements in health due to ionization occur over several days, rather than at the first breath of ionized air. The best position for an ionizer is by the bedside, where

HOW IT WORKS

The circuit is a standard Cockcroft-Walton ladder network which steps up the mains voltage to $-10kV$ or so (open-circuit voltage) (Fig. 7). The operation of this type of circuit was described in detail in 'Designer's Notebook 1' in ETI, April 1983. The idea is that charge is transferred backwards and forwards from one row of capacitors to the other on each mains cycle, but always moving further up the chain because of the action of the rectifiers. When all the capacitors are fully charged, there will be a voltage across each of them equal, in theory, to the peak-to-peak voltage of the mains.



In practice, the regulation of this type of circuit is very poor, and the full voltage will never be measured because of leakage, corona discharge, and so on. The tiny ionizing current is quite enough to drop the output voltage to about $-4kV$, which by a strange coincidence is the ideal output voltage for an air ionizer. Voltages above this level tend to produce ozone rather than ions, whereas voltages much lower will not ionize the air efficiently. Touching the emitter directly is enough to reduce the voltage to almost nothing.

Having said that, a word of warning is in order. Although the circuit as a whole

has a very high output resistance, individual capacitors don't, so please take care when you are testing the circuit. The capacitors will retain their charge for some time after the ionizer is unplugged, and a painful shock can be received from the back of the PCB if you are careless. The shock will be harmless to the average healthy ETI reader, but please don't take any risks if you have a weak heart or a pacemaker. The ionizer can be discharged by touching the mains plug to the ionizing point for a few seconds, and just to be certain you can run the mains plug down the line of diode connections on the PCB.

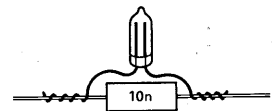


Fig. 7 Abbreviated circuit of ionizer and a simple tester.

you will breathe in the ions for eight hours or so at a time. This design is easily portable and you can move the device into the living room, or take it to work with you during the day.

By the time you are bouncing with health and energy, you'll probably be wondering what else you can do with an ionizer. Here are a few suggestions.

Ion Implants

Connect a length of wire from the ionizer emitter to the soil in the pot of a houseplant — one with sharp pointy leaves is best. Stand the plant pot on an insulating mat or polythene bag. The plant is now the emitter. If you hold a finger close to one of the

leaves, it will be drawn towards you. In the dark you may be able to see a faint blue glow around the leaf tips — this works better with some plants than with others, so try several different types. The plants don't mind at all, by the way, and often seem to thrive on it!

Got My Ion You

Carefully remove about 6" of insulation from some stranded wire, being careful not to break any of the strands. You will probably find it easier to remove the insulation in short lengths rather than all at once. Cut the wire 1" below the end of the insulation so that you are left with 7" of wire — 6" bare and 1"

insulated. Use this as the emitter. When the ionizer is turned on, the emitter seems almost alive and will leap about when you put your hand close to it.

Ion Brew

Fill a glass jar with cigarette smoke, then carefully invert it over the ionizer so that the emitter is inside the jar. Within seconds, the smoke will disappear! This is one of the best demonstrations of ionizer action and with a large jar the effect is quite dramatic. The smoke hasn't disappeared, of course, it is still sticking to the jar — but the air inside the jar is perfectly clear.

Ion A Feeling

Wear rubber soled shoes. Touch the ionizer emitter for a few seconds until your body is thoroughly charged up. When your hair stands on end, that's just about enough. Then give everyone you meet a jolly electric handshake. Just think, you could lose all your friends in a single evening! (A meaner trick still is to charge up a glass of water or a pint of beer ... Even your family won't speak to you after that!)

Electrostatics Experiments

The ionizer can be used as an EHT generator for electrostatics experiments. To generate a positive voltage rather than a negative one, just reverse all the rectifiers.

BUYLINES

This project is simple enough to cause few problems to the constructor wishing to do everything themselves. The biggest problem is undoubtedly the 10n 630V capacitors which are intended to be Plessey/Arcotronics Minibox polyester types. These are probably unobtainable for the constructor but can be replaced, especially if you do not intend to use the existing PCB. Suitable replacements include 10n 600V polyesters from Greenweld, 443 Millbrook Road, Southampton SO1 0HX (tel: 0703 772501/783740) and almost physically identical metallised polycarbs from RS Components available through Crewe-Allen, Scrutton Street, London EC1. The order code for the 10n 630V version (supplied in packs of five) is 113-673. A variety of axial capacitors are available which could be used, but for reference the dimensions of the recommended capacitors are 13x9x4mm (LxHxW) with

pin diameter of 0.8mm, spacing of 10mm and length of 6mm. The key point to remember if using a replacement is to ensure that discharge cannot occur between capacitors. The recommended case is available from Greenweld — or from Farnell, through Trilogic, 29 Holm Lane, Bradford BD4 0QA (tel: 0274 684289). The Verobox 301 is slightly larger and is widely available as are any number of ABS boxes capable of holding the circuit. The box must be made entirely of plastic (with the exception of the fixing screws). Neon bulbs are stocked by Maplin and complete neon indicators are widely available. A complete kit of parts can be obtained from Specialist Semiconductors, Founders House, Redbrook, Monmouth, Gwent for £9.50+60p postage and packing. The PCB alone will become available from our PCB service as soon as normal service is resumed.

MOTOR INTERFACE

This simple circuit and software, developed by Peter Timothy and Jonathan Rabet provides a painless but versatile first step in robotics.

This interface was developed with the help of the Microelectronics Education Programme, Wales, and provides a means of controlling up to four low-voltage DC motors from a Centronics-type printer port. The motor supply is variable between one and ten volts, so the interface may be used with most common types of model motors, including those made by Lego, FischerTechnik and Robotix.

The interface is fitted with connections for the BBC microcomputer range and can be powered from any suitable 12V supply, including the BBC micro's auxiliary output. Although software for the BBC is included in this article, it would be an easy matter to adapt the programs so that the interface could run off any computer with an 8-bit data output. Using a printer port would allow handshaking to be incorporated as an elementary form of simple feedback.

We'll get down to building the interface without further ado.

Construction

It is best to start by constructing the motor connector and cable, since this requires the

use of potting compound. It can be set aside to harden while the rest of the circuit is being completed. The method of construction is shown in Fig. 1. The leads from the base of the PCB-type screw terminals pass through holes drilled in the potting box and will be firmly anchored by the potting compound once it sets.

The completed assembly is small enough to mount on almost any model or robot. At least one metre of ribbon cable should be used since this will allow the cable to stretch from the interface box, normally situated alongside the computer on a bench or table, down to floor level. The screw terminals provide an easy method of connecting up most types of motor and they will accept unmodified Robotix motor lead plugs. The PCB end of the cable will eventually be soldered into eight holes (labelled A to H) on the circuit board.

The printer port cable assembly is constructed as shown in Fig. 2. Only nine of the 20 wires are actually used, but the fitting of the IDC socket is made easier by leaving all the 20 wires intact at that end. The other end of the cable must be dressed as shown. This end will eventually be

soldered into nine holes (labelled D0 to D7 and GROUND) on the circuit board.

If the power for the interface is to be obtained from the auxiliary socket of the BBC micro (the one used for disc drives), then the leads and connectors, shown in Fig. 3, must be made up. This allows the interface to obtain 12V

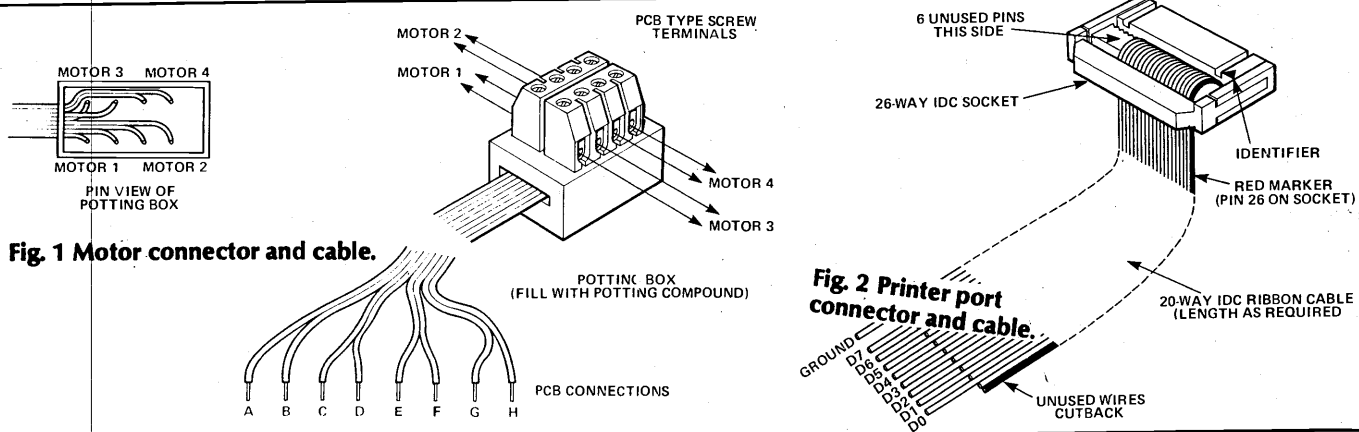
from the computer without disconnecting other devices. If the interface is to be powered from any other supply, it should be capable of delivering at least 2V more than the motor voltage at about 1A DC.

The main circuit components are mounted on a single-sided printed circuit board (Fig. 4). Solder the 11 wire links into position on the compound side of the board. Next insert the IC sockets (if you are using them), making sure that all the pins pass through the holes in the board. Insert the diode, D1, and capacitors C3, C4 and C5, making sure that each is the right way round. Solder these components in place.

Insert and solder resistor R1 and capacitors C1 and C2. Next insert and solder the variable resistor RV1, noting that the hole nearest to R1 is for the centre pin.

Solder IC1 and 2 into position, taking care that the flat, all metal surfaces are nearest the top edge of the PCB. Now insert and solder the eight relays. These are all identical and can only be fitted one way round.

Solder the wires of the printer port cable to the PCB, then the motor connector wires and the



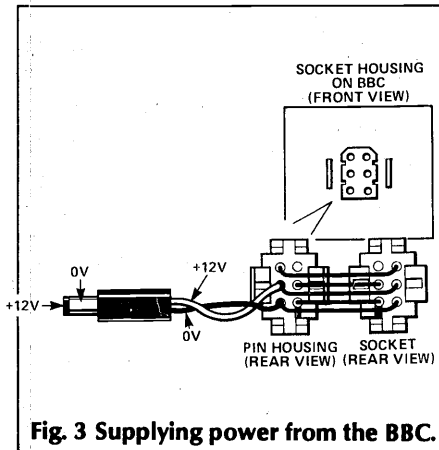


Fig. 3 Supplying power from the BBC.

power leads from the 2.1 mm socket.

Before inserting IC3 and IC4 into their sockets, apply 12 volts DC to the board and check that the voltage regulators are working correctly. IC1 may be checked by measuring the voltage between the links marked 'X' and 'Y' on Fig. 4. This should be 5V. IC2 may be checked by measuring the voltage between link 'X' and point 'Z' on the overlay. By adjusting RV1, this voltage should be variable from about 1.25V to 9.75V. Now adjust RV1 until the voltage matches the rating of the motors to be used with the interface. Once satisfied with the operation of the voltage regulators, remove the power and insert IC3 and IC4 into their sockets.

Software

The programs included here have been written in BBC BASIC, a dialect of BBC BASIC called MEP CONTROL BASIC, BBC 6502 Assembler and Logotron LOGO. They will enable the interface to be used with almost any BBC micro. The BBC BASIC program is menu driven and allows motor sequences to be recorded and repeated (Listing 1). The three programs in other languages are simpler but can be incorporated into more complex structures to enable sophisticated control of up to four motors.

In general, motor control is achieved by writing to the printer port of the computer to which the interface is attached. The idea of using the printer port is to allow an existing user port to provide digital inputs — for example, in case an elaborate robotics system is being contemplated.

On the BBC, the eight lines of the parallel printer port are written to via location FE61H. Two bits are needed for forward and reverse

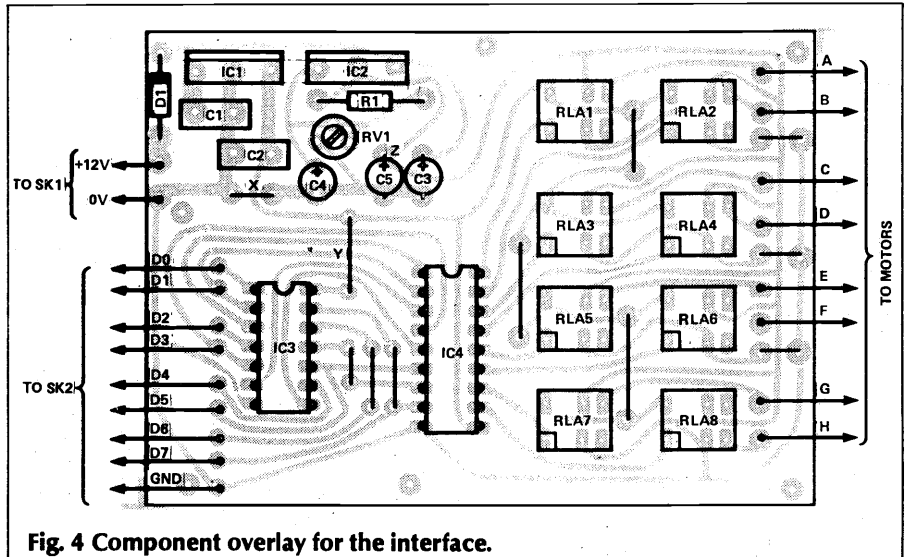


Fig. 4 Component overlay for the interface.

PARTS LIST

RESISTORS

R1 240R ½W
RV1 2kΩ cermet

CAPACITORS

C1 330n ceramic
C2 100n ceramic
C3, 5 4μF 16V tant
C4 22μF 16V elect

SEMICONDUCTORS

IC1 7805
IC2 LM317MP
IC3 7486
IC4 ULN2803A
D1 1N4001

MISCELLANEOUS

RLA1,2,3,4,5,6,7,8 microminiature relays 5–6V coil, SPST 24V 1A contacts; 26-way IDC socket (BS9525)*; 6-way Multicon plug and socket housings and plug and socket pins to order*; 2.1mm panel-mounting power socket; 2.1mm power plug; 4-way PCB mounting screw terminal; small potting box; 14-way and 18-way IC sockets; 20-way ribbon cable; 8-way ribbon cable; potting compound; PCB.
(*Optional, for use with BBC and BBC-type computers).

and are decoded as shown in Fig. 7. The more significant of the eight bits repeat the Fig. 7 pattern for motors 2, 3 and 4.

BBC Basic

On running the program (Listing 1), the user is presented with a menu consisting of three options: PROGRAM, RUN or MANUAL (lines 70 to 290).

Selecting the MANUAL option results in direction to PROCmanual. The screen displays the message: MANUAL CONTROL. The red function keys are used to control up to four motors connected to the interface, each key switching one relay when pressed and f9 returning program control to the main menu.

Using INKEY with a negative argument (lines 790-870) tests for specific key presses and allows simultaneous control of more than one motor.

If the PROGRAM option is selected from the menu, PROCprogram is jumped to. This also detects preesses of the function keys and writes to FE61H to drive the motors. This procedure differs from

PROCmanual in that the length of time a particular combination of keys is pressed is stored in the array, `steptime%(X)`. The contents of FE61H at that time are stored in the array, `step%(X)`.

Selecting RUN from the main menu results in a jump to PROCrunmenu. This procedure puts up a secondary menu allowing selection of one of two run options or a return to the main menu. Option one runs the programmed sequence of operations as they were entered by the user — including any pauses when FE61H was at zero and no motor was on. The second option filters out these 'wait states', producing a smoother execution of the pre-programmed sequence. Both of these options invoke PROCrun, which loops through the array, `step%(X)`, and uses the associated variable, `steptime%(X)`, to provide a delay. If the parameter passed to PROCrun is FALSE, all occurrences of `step%(X)=` are skipped over.

Control Basic

This is an example of a program written using a BBC Basic

HOW IT WORKS

Fig. 5 Circuit diagram of the interface.

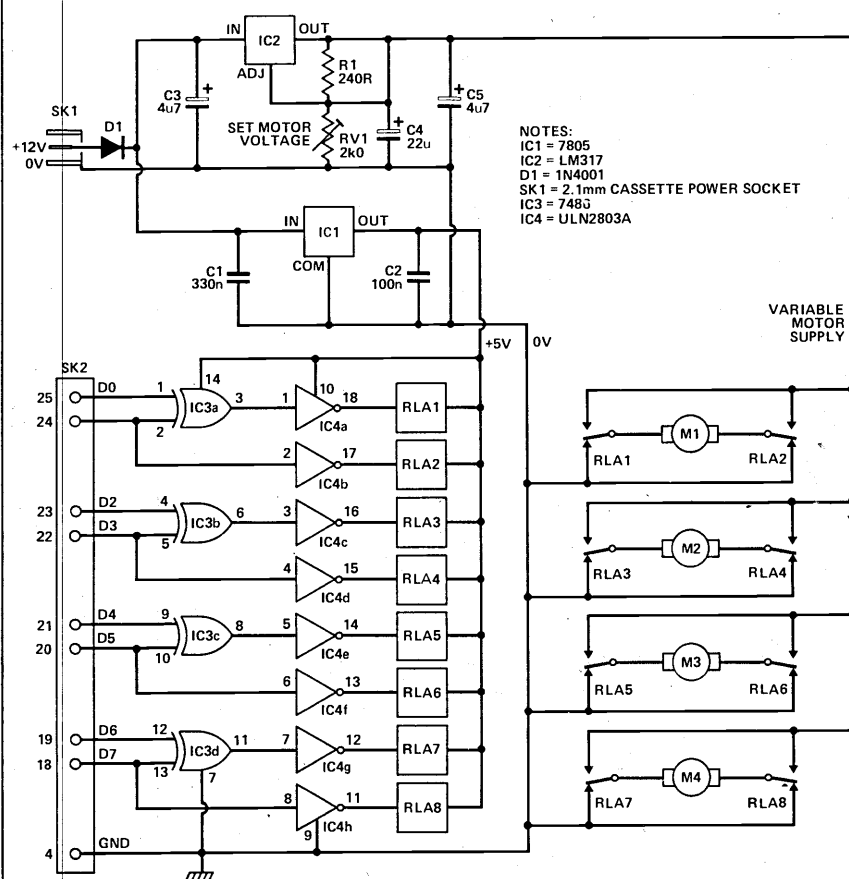
Two voltage regulators are used in the interface (Fig. 5). IC1 takes the incoming 12 volts and series regulates it down to 5 volts. This fixed 5 volts is then used to power the logic (IC3), the relay driver (IC4) and the relay coils. IC2 is another series regulator, but this time it is a variable output device. Its output is determined by the voltage applied to the ADJUST Pin, this voltage being derived from a potential divider, formed by R1 and RV1, connected across the output. The output voltage is adjusted to suit the motors being used. All five capacitors are for decoupling. Diode D1 protects the regulators should a reverse polarity supply be accidentally connected to the interface.

The computer generated signals to control the motors are passed from the computer to the interface via the printer port. Eight data lines (D0 to D7) are available at this port and, since each motor used requires a two bit control signal, a maximum of four motors can be controlled simultaneously without using multiplexing techniques. In common with a large number of industrial motor control systems, bit 0 of the signal determines if the motor is on or off, while bit 1 determines the direction of rotation of the motor. The truth table for this scheme is shown in Fig. 6.

The chosen method of implementing the control scheme is shown, for one motor, in Fig. 7 and its new truth table is shown in Fig. 8.

IC3 is a quad 2-input XOR-gate. IC4 is an octal Darlington driver used to energize the eight relay coils. This device acts as a buffer between the computer's data lines and the relay coils. A buffer is required because each coil takes approximately 40mA when energized — enough to overload a data line or an XOR output.

The relays are ultra-miniature, single-pole change-over, with contacts rated at 24V, 1A DC. Most model electric motors take much less than 1A even on start-up under load.



NOTES:
IC1 = 7805
IC2 = LM317
D1 = 1N4001
SK1 = 2.1mm CASSETTE POWER SOCKET
IC3 = 7485
IC4 = ULN2803A

Fig. 6 Standard motor control truth table.

CONTROL SIGNAL		MOTOR ACTION
BIT 0	BIT 1	
0	0	OFF
1	0	OFF
0	1	OFF
1	1	OFF

Fig. 8 Truth table for the interface.

CONTROL SIGNAL		EXCLUSIVE-OR OUTPUT	RELAY COIL A	RELAY COIL B	MOTOR ACTION
BIT 0	BIT 1				
0	0	0	0	0	OFF
1	0	1	1	0	OFF
0	1	1	1	1	OFF
1	1	0	0	1	OFF

0 = DE-ENERGISED
1 = ENERGISED

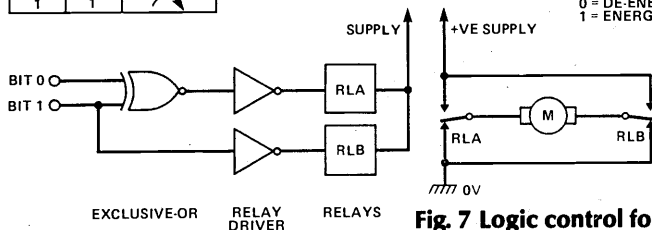


Fig. 7 Logic control for motor action.

extension (Listing 2). This extension allows programs to be simply written which access the Printer and user ports of the BBC microcomputer.

The example program controls a single motor using function keys f0 and f1. The Control Basic keyword, BIT, permits each bit of the printer port to be controlled individually.

Machine Code Motor Driver

The assembler program (Listing 3) will produce a machine code driver for the interface. It can be assembled at any suitable

address and occupies 42H bytes. Once assembled, it can be used by POKing the motor number (1, 2, 3 or 4) into location 70H and the motor action (0=off, 1=forward, 2=back) into 71H, then calling the driver at the address at which it was assembled using CALL.

The program as listed contains a BASIC routine to test the machine code driver. If this program is run, the assembled driver can be saved to disc or tape with
*SAVE DRIVER 3000+42
then load back with
*LOAD DRIVER
and called with CALL&3000.

By specifying a hex address at the end of the *LOAD command, the driver can be reloaded to any suitable location and run by a CALL to that same address.

BUYLINES SOFTWARE

MEP Control Basic is available from MEP (South Yorkshire and Humber-side), Exeter Road, Off Coventry Grove, Doncaster DN2 4PY. Logotron Logo is available from Logotron Ltd., Ryman House, 59 Markham Street, London SW3 4WD.

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...s positive, what was the last item you purchased
 ...alue?

...Index? N

...r copy of ETI? Yes (how many?)

...TI for: Six months A year or more

...owing publications?

Elektor Electronics
 Electronics and Wireless World
 Electronics Weekly
 Electronic Product Design
 Practical Computing
 Studio Sound
 Hi-Fi News & Record Review
 New Scientist

25. Please indicate what you think of the following magazines.

	Good	Average	Poor	Don't know
Practical Electronics	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Elektor Electronics	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Everyday Electronics	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Electronics & Wireless World	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The Maplin Magazine	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Electronics Digest	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

26. Please tick the appropriate box which represents the annual total of your net income (i.e. after tax, National Insurance, etc.)

Less than £4,780 From £4,780 to £5,970 From £5,980 to £7,470
 From £7,480 to £9,340 From £9,350 to £11,680 More than £11,690

27. Are you aware of ETI's scheduled publication day?

Y N

28. If the answer is yes to question 27, do you attempt to purchase the magazine on that day?

Y N

29. Do you normally obtain your copy by:

Chance purchase
 Newsagent home delivery
 Newsagent shop collection
 Subscription
 Other

30. If you do not obtain your copy by subscription, is it due to one of the following:

Subscription too expensive?
 Not every issue required?
 Have subscribed previously, but lapsed?
 Other

31. If you do not subscribe, from which type of newsagent do you most often obtain your copy?

High Street shop Estate shop
 Travel point Corner shop

32. Which if any of the following daily newspapers do you read?

Daily Mail Daily Express Daily Mirror
 The Sun Today The Guardian
 The Times The Daily Telegraph Financial Times

33. Which if any of the following Sunday newspapers do you read?

The Sunday Times The Sunday Telegraph The Observer
 Mail on Sunday Sunday Mirror Sunday Express
 News of the World The Sunday People

34. Do you read?

TV Times Radio Times

It would be a great help to us if you would kindly answer the following questions. The answers will enable us to obtain a more positive image of our readership:

35. Age:

Under 15 15-24 25-34
 34-44 45-54 55-64
 65+

36. Marital Status

Children

Do any of your children follow your interest in electronics? Y N

37. Educational level:

No formal qualifications School certificate
 College or F.E. qualifications Degree

38. Are you in employment?

(if no, please go straight to Q. 42) Y N

Name

Address

.....
(for purposes of the free subscription draw only).

Thank you for your time and help,

The staff of ETI.

39. Please indicate the type of work you do?

- | | | | | | |
|------------------------|--------------------------|-------------------------------|--------------------------|---------------------|--------------------------|
| Research & Development | <input type="checkbox"/> | Technical support/maintenance | <input type="checkbox"/> | Training/teaching | <input type="checkbox"/> |
| Consultancy/PR | <input type="checkbox"/> | Skilled manual | <input type="checkbox"/> | Semi-skilled manual | <input type="checkbox"/> |
| Clerical | <input type="checkbox"/> | Sales | <input type="checkbox"/> | Managerial | <input type="checkbox"/> |

Other (please specify)

40. Is your work connected with electronics?

Y N

41. Are you responsible for the purchase or ordering of:

- | | | |
|--|----------------------------|----------------------------|
| a) electronic test equipment or capital | Y <input type="checkbox"/> | N <input type="checkbox"/> |
| b) electronic components or consumable items | Y <input type="checkbox"/> | N <input type="checkbox"/> |

If yes to either of the above, please indicate annual budget level:

- | | | | |
|-----------------|--------------------------|-----------------|--------------------------|
| Under £1000 | <input type="checkbox"/> | £1000 - £9999 | <input type="checkbox"/> |
| £10000 - £99999 | <input type="checkbox"/> | £100000 or more | <input type="checkbox"/> |

42. Are you registered unemployed?

Y N

- | | | | | | |
|--------------------|----------------------------|----------------------------|--------------------|----------------------------|----------------------------|
| full time student? | Y <input type="checkbox"/> | N <input type="checkbox"/> | retired? | Y <input type="checkbox"/> | N <input type="checkbox"/> |
| disabled? | Y <input type="checkbox"/> | N <input type="checkbox"/> | housewife/husband? | Y <input type="checkbox"/> | N <input type="checkbox"/> |

43. Are you studying (full or part-time?)

Y N

44. If yes, are you studying electronics or a related subject?

Y N

45. If you could make one improvement to the magazine, what would it be?

.....
.....

FIRST FOLD

THIRD FOLD

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SECOND FOLD

PROJECT: Motor Interface

Listing 1 BBC Basic.

```
10REM*****BBC BASIC MOTOR CONTROL*****
20ON ERROR GOTO 70:REM RETURN TO MENU ON
ESCAPE
30total_number_steps%=100
40DIM steptime%(total_number_steps%),step
%(total_number_steps%)
50REM steptime%(X),step%(X) AND count% AK
E GLOBAL
60
70REPEAT
80
90REM*****DISPLAY MAIN MENU*****
100MODE 7
110PRINTTAB(16,2)"MAIN MENU"
120PRINTTAB(16,3)"*****"
130PRINTTAB(16,10)"1...PROGRAM"
140PRINTTAB(16,12)"2...RUN"
150PRINTTAB(16,14)"3...MANUAL"
160
170REM*****ENTER MENU SELECTION*****
180INPUT TAB(16,22)"CHOICE : "q%
190IF q%<1 OR q%>3 GOTO 100
200
210REM*****DISPLAY OPTION SELECTION*****
220REM*****AND BRANCH TO PROGRAMMING*****
230REM*****MANUAL OR RUN MODE*****
240
250IF q%=1 PROCprogram
260IF q%=2 PROCrunmenu
270IF q%=3 PROCmanual
280
290UNTIL FALSE
300END
310
320
330REM*****PROCEDURES*****
340REM*****
350
360
370DEFPROCprogram
380REM*****
390LOCAL a%,olda%
400olda%=0
410count%=1
420TIME=0
430CLS:PRINTTAB(15,10)"PROGRAMMING"
440a%=0
450 IF INKEY(-33) AND NOT (INKEY(-114)) a%=a
% OR 1
460 IF INKEY(-114) AND NOT (INKEY(-33)) a%=a
% OR 3
470 IF INKEY(-115) AND NOT (INKEY(-116)) a%=
a% OR 4
480 IF INKEY(-116) AND NOT (INKEY(-115)) a%=
a% OR 12
490 IF INKEY(-21) AND NOT (INKEY(-117)) a%=a
% OR 16
500 IF INKEY(-117) AND NOT (INKEY(-21)) a%=a
% OR 48
510 IF INKEY(-118) AND NOT (INKEY(-23)) a%=a
% OR 64
520 IF INKEY(-23) AND NOT (INKEY(-118)) a%=a
% OR 192
530 IF INKEY(-120) ENDPROC:REM RETURN TO M
ENU ON f9
540IF a%<>olda% ?%FE61=a%:steptime%(count%
)=TIME:step%(count%)=olda%:olda%=a%:TIME=0:c
ount%=count%+1
550GOTO 440
560
570
580DEFPROCrun(a%)
590REM*****
600LOCAL i%
610?%FE61=0
620FOR i%=1 TO count%
630IF step%(i%)=0 AND a%=FALSE GOTO 680
640TIME=0
650REPEAT
660?%FE61=step%(i%)
670UNTIL TIME>=steptime%(i%)
680NEXTi%
690?%FE61=0
700ENDPROC
710
720
730DEFPROCmanual
740REM*****
750LOCAL olda%,a%
760olda%=0
770CLS:PRINTTAB(13,10)"MANUAL CONTROL"
780a%=0
790 IF INKEY(-33) AND NOT (INKEY(-114)) a%=a
% OR 1
800 IF INKEY(-114) AND NOT (INKEY(-33)) a%=a
% OR 3
810 IF INKEY(-115) AND NOT (INKEY(-116)) a%=
a% OR 4
820 IF INKEY(-116) AND NOT (INKEY(-115)) a%=
a% OR 12
830 IF INKEY(-21) AND NOT (INKEY(-117)) a%=a
% OR 16
840 IF INKEY(-117) AND NOT (INKEY(-21)) a%=a
% OR 48
850 IF INKEY(-118) AND NOT (INKEY(-23)) a%=a
% OR 64
860 IF INKEY(-23) AND NOT (INKEY(-118)) a%=a
% OR 192
870IF INKEY(-120) ENDPROC:REM RETURN TO ME
NU ON f9
880IF a%<>olda% ?%FE61=a%:olda%=a%
890GOTO 780
900ENDPROC
```

```
910
920
930DEFPROCrunmenu
940REM*****
950LOCAL q%
960REPEAT:CLS
970PRINTTAB(16,2)"RUN MENU"
980PRINTTAB(16,3)"*****"
990PRINTTAB(10,10)"1...RUN WITH WAIT STATE
S"
1000PRINTTAB(10,12)"2...RUN WITHOUT WAIT ST
ATES"
1010PRINTTAB(10,14)"3...RETURN TO MAIN MENU
"
1020INPUT TAB(10,22)"CHOICE : "q%
1030IF q%=1 PROCrunscreen:PROCrun(TRUE)
1040IF q%=2 PROCrunscreen:PROCrun(FALSE)
1050UNTIL q%=3
1060ENDPROC
1070
1080
1090DEFPROCrunscreen
1100REM*****
1110CLS
1120PRINTTAB(12,10)"EXECUTING PROGRAM"
1130ENDPROC
```

Listing 2 Motor Control Basic.

```
10REM CAN ONLY BE USED WITH MEF SYH Contr
ol Basic
20MAKE PRINTER OUTPUT
30REPEAT
40IF INKEY(-33)=TRUE AND INKEY(-114)=FALS
E PROCmotorleft
50IF INKEY(-114)=TRUE AND INKEY(-33)=FALS
E PROCmotorright
60UNTIL FALSE
70
80DEFPROCmotorleft
90REPEAT
100MAKE BIT 0, HIGH
110MAKE BIT 1, LOW
120UNTIL INKEY(-33)=FALSE
130MAKE BIT 0,1, LOW
140ENDPROC
150
160DEFPROCmotorright
170REPEAT
180 MAKE BIT 0, HIGH
190 MAKE BIT 1, LOW
200UNTIL INKEY(-114)=FALSE
210MAKE BIT 0,1, LOW
220ENDPROC
```

BUYLINES

There should be no problems with the components, especially since nothing is critical. Connectors are widely available. Maplin, for example, can supply them all (PO Box 3, Rayleigh, Essex SS6 8LR — tel: 0702 552911) and they can also supply the microminiature relays. A ready-built unit (including software can be supplied by Gwentec Electronic Instruments, 26 Churchwarden Drive, Newport, Gwent NP9 0SB (tel: 0633 280526) for £42.50 inclusive. Gwentec will also supply a kit of parts for £29.25 and a PCB for £5.50. Please phone first to check on availability. A slightly modified PCB will be available from our PCB service as soon as it becomes operational again.

Logo Motor Control

Two procedures in Logotron Logo are provided (Listing 4) to show how the machine code driver can be used in a language other than Basic. The procedure, PATCH, loads the driver at 2FC0H. The second procedure has two parameters, motor number followed by motor action. The .CALL in the MOTOR procedure is to the decimal equivalent of

Listing 3 Program to assemble machine code motor driver.

```
10REM ASSEMBLER MOTOR DRIVER
20FOR pass%=0 TO 3 STEP 3
30F%=3000
40OFT pass%
50LDA &71 \ load A with "direction" (
0-2)
60BEQ store \ if "direction" zero then
D.K.
70CMP #3
80BCS end \ if "direction" 3 or more
then exit
90ORA #&1 \ "OR" with 1 to convert 2
to 3 leaving 1 as 1
100store
110STA &71 \ store 0,1 or 3 in &71
120LDX &70 \ load X with motor number
(0-4)
130DEX \ convert to 0-3
140CPX #4
150BCS end \ if 4 or greater then exit
160STX &70 \ store new motor number in
&70
170
180LDY #&FC \ load mask
190STY &72 \ store mask in &72
200LDX &70 \ load X with motor number
210BEQ jump1 \ if motor number 0 no need
to shift mask left
220SEC
230loop1
240ROL &72
250ROL &72 \ rotate mask left two bits
260DEX
270BNE loop1 \ repeat loop according to
motor number
280jump1
290LDA &FE61
300AND &72 \ and contents of printer p
ort with mask
310
320LDY &71 \ load Y with motor "direct
ion"
330STY &72 \ store motor "direction"
in &72 as second mask
340LDX &70 \ load X with motor number
350BEQ jump2 \ if motor number 15 zero n
o need to shift mask left
360CLC
370loop2
380ROL &72
390ROL &72 \ shift mask left twice
400DEX
410BNE loop2 \ repeat loop according to
motor number
420jump2
430ORA &72 \ "OR" A with second mask
440STA &FE61 \ send byte to printer port
450STA &72 \ store byte in &72
460end
470RTS
480
490NEXTpass%
500
510
520
530REM*****TEST*****
540?%FE61=0:?%72=0
550REPEAT
560INPUT "MOTOR (1,2,3,4) : "m%
570INPUT "DIRECTION (0,1,2) : "d%
580?%70=m%:?%71=d%
590CALL &3000
600PRINT"?%72
610UNTIL FALSE
```

Listing 4 Logotron Logo procedures utilising driver.

```
TO PATCH
*LOAD DRIVER 2FC0
END
```

```
TO MOTOR :motornumber :motordirection
.DEPOSIT 112 :motornumber
.DEPOSIT 113 :motordirection
.CALL 12224
END
```

2FC0H. The primitive .DEPOSIT is the equivalent of the BASIC command, POKE.

Before the MOTOR procedure can be used, PATCH must be called once.

The machine code driver could, of course, be used from within any suitable language running on any 6502 system with only minor modifications.

UPGRADEABLE AMPLIFIER

Graham Nalty begins his amplifier at the beginning with an upgradeable moving coil input stage.

The prime requirement of an amplifier for moving coil cartridges is that it should have very low noise. This would not be too much of a problem were it not for the fact that moving coil cartridges have very low impedances, typically around 2-3 ohms. Since it is a requirement of low noise design that the base resistance of the input transistor is as low as the resistance of the cartridge, this calls for a great deal of care both in the choice of transistors and in the configuration of the input stage.

Transistor Choice

The noise figure usually given in transistor data sheets is arrived at from the formula:

$$N = 10 \log \frac{\text{total output noise power}}{\text{noise generated by source only}} \text{ dB}$$

A noise figure of 3dB, therefore, indicates that the source noise and the transistor noise are equal in magnitude. A higher noise figure indicates that the transistor is contributing more noise whilst a lower noise figure indicates that the source is contributing most of the noise.

The specification sheet for a typical low noise transistor, the ZTX 384, shows a noise figure of 4dB, but this alone does not tell us how suitable it is for our particular application. We need more information. Looking again at the noise figures, we see that they apply over a frequency range from 30Hz to 15kHz when $V_{ce} = 5V$, $I_c = 200$ microamps and $R_s = 2k$ ohms.

At first glance it appears that 4dB relative to a source impedance of 2k Ω is far too high for a low impedance, low output moving coil cartridge.



However, if we are prepared to accept a noise figure of 2dB as reasonable, we see from the data sheet that this can be achieved with a source impedance of around 500 ohms over a current range from 100 to 500 microamps. By using five transistors in parallel we could achieve 2dB with a 100 ohm source impedance. This approach was frequently employed when moving coil cartridges first became popular about ten years ago, and I remember one published design that used no fewer than eight transistors in parallel.

Another approach is to use medium power transistors, as did Stan Curtis in his System A preamp described in ETI in July 1981. Transistors designed for higher currents have a lower base

resistance. Medium current transistors such as the 2N4401 and 2N4403 have a base resistance which is higher than that of most moving coil cartridges but considerably lower than the base resistance of most small signal transistors.

For practical purposes there is no reason why we cannot combine the two approaches, without going to the extreme of paralleling five or more transistors. Space is provided on the PCB for two transistors in parallel, and a pair of 2N4401s in this position will give a perfectly satisfactory performance at reasonable cost. This arrangement is recommended for the economy version of the preamplifier.

There are several alternatives when it comes to upgrading this

NOISE VOLTAGE (in V/\sqrt{Hz}) at:

	10Hz		100Hz		1kHz	
	Typ.	Max.	Typ.	Max.	Typ.	Max.
2SB737, 2SD786	0.55		0.4		0.4	
ZN459					1.1	
2N4867A	8	10			2	5
J230-232	8	30			2	
OP37A	3.5	5.5			3.0	3.8
OP37C	3.8	8			3.2	4.5
NE5534					3.5*	
OP71					18	

*Frequency not stated.

Table 1 A comparison of the noise performance of selected low-noise FETs and ICs.

stage. One is to use the same arrangement but choose better quality medium power transistors which offer lower noise. The 2SC2385 transistors suggested in the parts list are ideal for this application and prove extremely quiet in practice.

The other approach is to use a transistor which has been designed specifically for moving coil input stages and which has a low enough base resistance to allow direct matching to the cartridge output. Several transistors of this type have been developed in recent years, and a good choice here is the 2SD786 which has a base resistance of just 4 ohms. These are, inevitably, quite expensive and not terribly easy to come by, but they do seem to offer the lowest noise figure of any type currently available. A comparison of the noise performance of these and other low-noise transistors and ICs is given in Table 1.

The Circuit

Like the other stages in this preamplifier, the moving coil stage is based around a simple but very effective discrete operational amplifier. This allows the stage gain to be determined by the values of two external resistors. As a result, the gains of the two channels can be matched to within very close limits without using preset potentiometers, thus avoiding the inconvenience, cost and sound degradation this would involve.

The circuit of the moving coil amplifier in its basic form is shown in Fig. 1. Transistors Q2 and Q3 form a differential pair in which approximately equal currents flow. The total combined current of Q2 and Q3 is kept almost constant by R3. Transistor Q5 is biased on by the voltage across R2.

With no signal input, the bases of Q2 and Q3 are close to 0V. If a positive voltage is applied at Q2 with respect to Q3, more current will flow in Q2 and less current in Q3. The voltage across R2 will increase, and this will cause an increase in current in Q5. This will raise the voltage across R7 and give a positive output signal.

The effect of the negative feedback network comprising R5 and R6 is to feed some of the output back to the base of Q3. Provided the base of Q2 is at a higher voltage than Q3 the output will remain positive. If the open

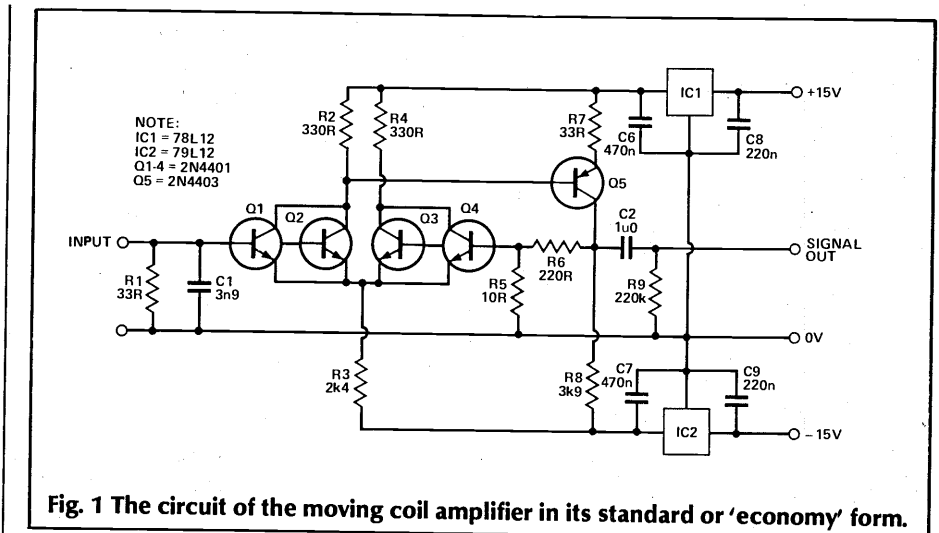


Fig. 1 The circuit of the moving coil amplifier in its standard or 'economy' form.

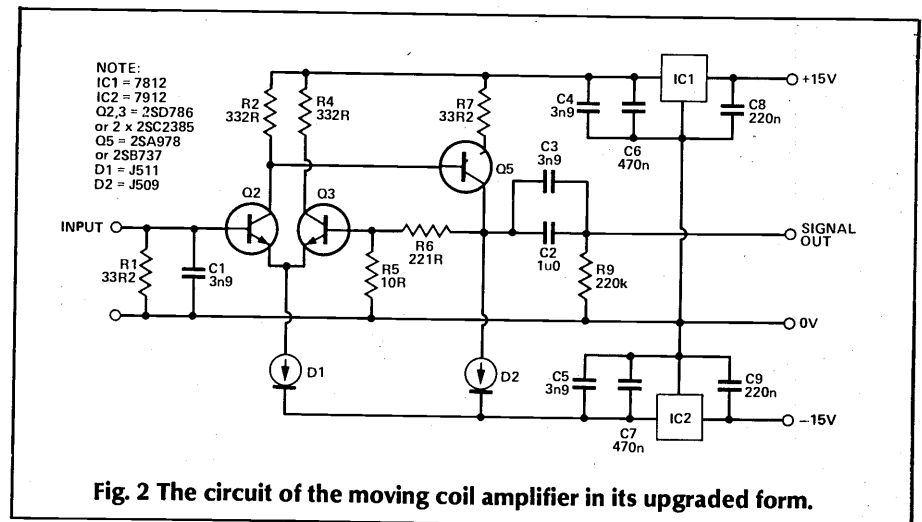


Fig. 2 The circuit of the moving coil amplifier in its upgraded form.

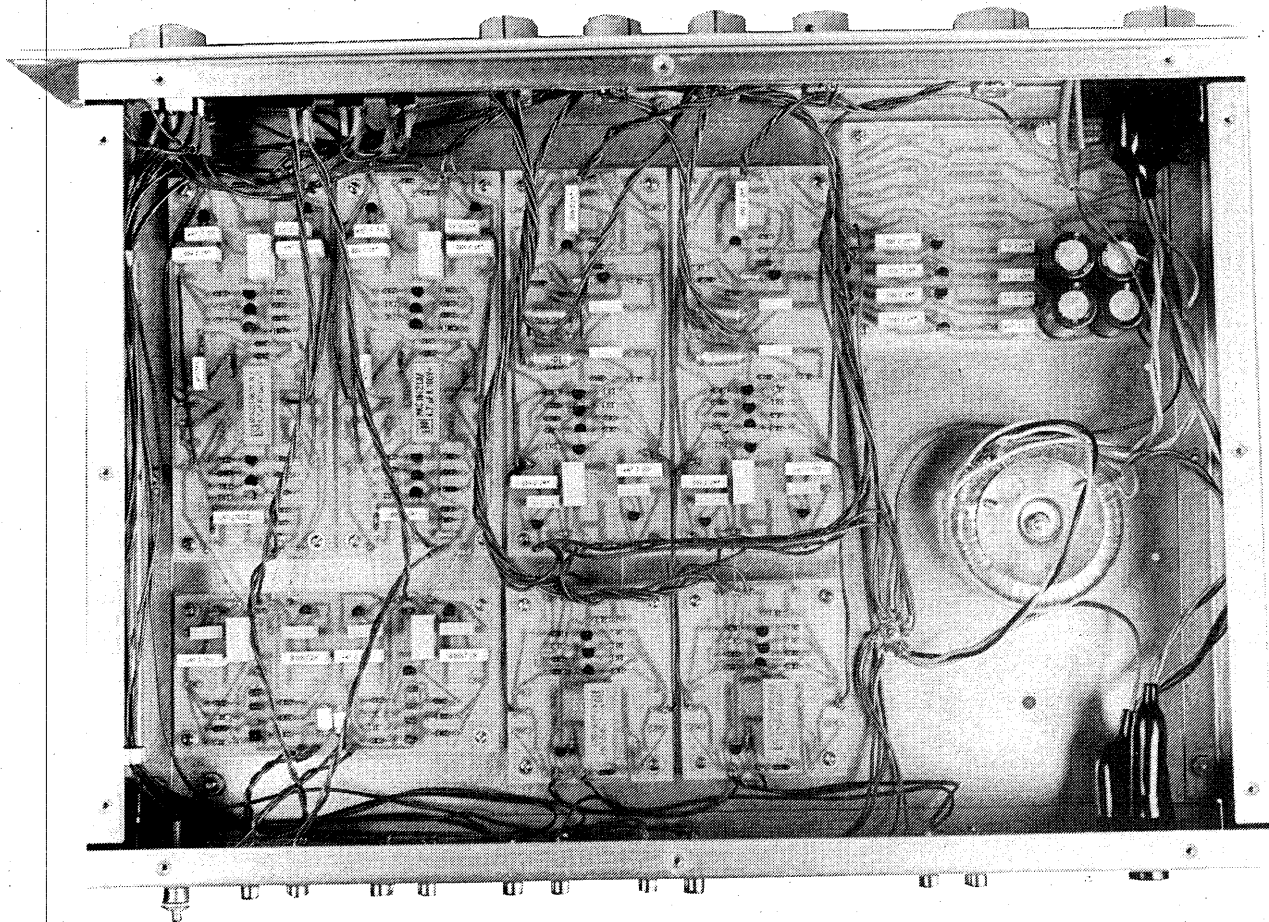
loop gain is much greater than the ratio of the resistors R5 and R6, the voltage difference between the bases of Q2 and Q3 will remain small and the gain will be defined by the values of the resistors.

The use of a differential input is not ideal in terms of achieving the lowest possible noise, but it does remove the need for an input capacitor which would otherwise degrade the sound as well as being physically large and expensive. This means that a small current of the order of 10 microamps flows through the cartridge, but I have not seen any reliable reports which say that this is harmful. I have not observed any ill effects even at higher levels of current, but if you are at all worried by DC flowing through the cartridge, replace R1 by a 10k resistor, connect a 4μ7 plastic film capacitor towards the input and place the original R1 across the input socket. Plastic film capacitors will pick up noise from the mains transformer, and if this is

troublesome you will either have to remove the transformer to a separate box or replace the capacitor with a tantalum type (negative end to transistor) with some degradation at high frequencies.

The input loading resistor on a moving coil cartridge is an important part of the design. A change in the value of this component will change the sound quality of the cartridge, and many people like to experiment to find the optimum loading for their system. As a rough rule, lowering the impedance reduces the high frequency output. A cartridge with a low output impedance will obviously require lower impedance matching from the amplifier and this should be considered when fitting the loading resistor in the circuit. As a practical compromise, a value of 33 ohms is suggested as a standard or a starting point for experimentation.

The performance of the standard version can be further



Internal view of the complete pre-amplifier. The moving-coil stage is the bottom, left-hand board.

improved, mainly by the use of higher quality components. The circuit of the upgraded version is shown in Fig. 2. The upgrading measures are:

- 1) The use of ultra low noise transistors type 2SD786 for the input stage.
- 2) The use of Holco H8 (1/8 watt) precision resistors manufactured by Holsworthy Electronics. These offer better sound quality than standard grade metal film types (Ref. 1).
- 3) The replacement of polyester capacitors with polycarbonate types. Polycarbonate capacitors have a lower dielectric loss (Ref. 1, 2).
- 4) The by-passing of all medium value capacitors with polystyrene capacitors of around $3\mu\text{F}$ to $10\mu\text{F}$. This improves the sound at high frequencies.
- 5) The use of transistor pads for all transistors. This holds them firmly to the board and reduces the possibility of distortion due to vibration. Anyone who has heard the improvement in sound quality

which results when a Mission Isoplat is placed under an amplifier will know what I mean.

6) The use of high power (metal tag) regulators. This should improve the sound quality by reducing the Temperature Generated Distortion (TGD).

7) The use of constant current diodes in place of R3 and R8. The high impedance (Ref. 3) reduces

BUYLINES

A complete kit of components and PCB for the moving coil stage can be obtained from the author at 6 Mill Close, Borrowash, Derby DE7 3GU. The cost is £12.50 for the standard version and £25.00 for the upgraded version. Both prices are fully inclusive. The PCB and parts are also available individually — ask for a price list.

The case for the complete pre-amplifier (see pictures above and overleaf) costs £49.00 including VAT and carriage. An alternative front panel is available for those who do not want tone controls — please specify when ordering.

the power supply ripple voltage feedback to the input from the negative supply and greatly improves sound quality.

Construction

Refer to the components layout, Fig. 3, and start by soldering the resistors into place. Note that there are three holes to accommodate R3 and R8. The holes that are 0.5" apart are for the resistors and the holes that are 0.2" apart are for the FET constant current diodes (D1 and D2) used in the upgraded version. The flat faces of the FETs face the input side of the board and it is a good idea to mount them on transistor pads.

Next install the connecting pins (6 in each channel) and insert and solder the IC regulators. Now install the transistors using the diagrams in Fig. 3 as a guide. The board is completed by soldering the capacitors into position.

Feed a supply of $\pm 15\text{V}$ to $\pm 25\text{V}$ to the board (up to $\pm 35\text{V}$ if you are using 1A regulators) and check all voltages with a DVM or

PROJECT: MC Stage

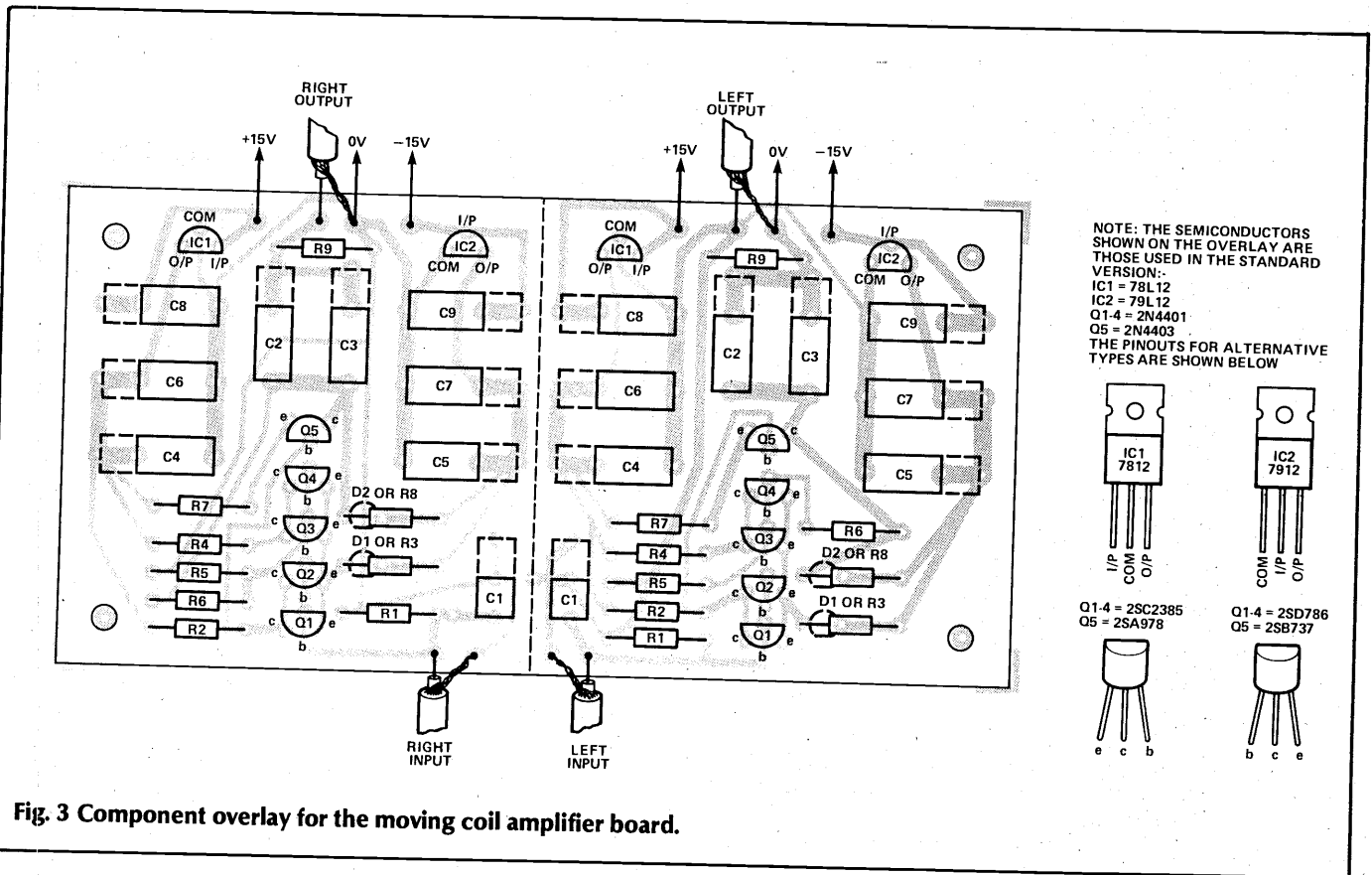


Fig. 3 Component overlay for the moving coil amplifier board.

PARTS LIST

RESISTORS	STANDARD VERSION	UPGRADED VERSION
R1, 7	33R Metal film 2%	33R2 Holco 0.5% 50 PPM
R2 (see text)	330R Metal film 2%	332R Holco 0.5% 50 PPM
R3	2k4 Metal film 2%	see D1
R4	330R Metal film 2%	332R Holco 0.5% 50 PPM
R6	220R Metal Film 2%	221R Holco 0.5% 50 PPM
R8	3k9 Metal Film 2%	see D2
R9	220k Metal film 2%	220k Holco 0.5% 50 PPM
CAPACITORS		
C1	3n9 polystyrene	3n9 polystyrene
C2	1u0 polyester	1u0 polycarbonate
C3, 4, 5	—	3n9 polystyrene
C6, 7	470n polyester	470n polycarbonate
C8, 9	220n polyester	220n polycarbonate
SEMICONDUCTORS		
IC1	78L12	7812
IC2	79L12	7912
Q1, 2, 3, 4	2N4401	2SC2385 or 2SD786*
Q5	2N4403	2SB737 or 2SA978
D1	see R3	J511 (4.7mA)
D2	see R8	J509 (3mA)

*Only two 2SD768 transistors are needed in each channel. The Q1 and Q4 positions should be left empty.

MISCELLANEOUS

PCB; 6 x 1mm PCB pins; 5 off T092 transistor pads (on upgraded version only); PCB pillars; case, power supply, sockets, wiring, etc, according to choice and application.

With the exception of the PCB, all components listed above are for one channel only. Two of each item will be required for stereo.

multimeter. A list of correct voltages is given in Table 2 to aid fault finding. One likely source of error is wrongly connected transistors, bearing in mind the different pin configurations of the various types.

For optimum performance, the current in Q1 (or Q1//Q2) should

Test location	Test voltage
IC1 output - 0V	+12V
IC2 output - 0V	-12V
Junction	
R6/R8 - 0V	less than ± 0.3V
Emitters	
Q1/Q4 - 0V	0.6 - 0.7V
Across R7	0.1V
Across R2	0.7V
Across R4	0.7V
Across R1	less than 1mV

Table 2 Test voltages at various points around the circuit.

be equal to the current in Q3 (or Q3//Q4). It has been shown (Ref. 4) that distortion is least when the currents in each side of a long tail pair are equal. When the circuit is built as recommended, there may be a mismatch of up to 10% in the collector currents of Q2 and Q3. At the low voltage levels of an MC cartridge this will be of very little importance, but anyone seeking the ultimate performance for their amplifier will want to match the

input currents as closely as possible.

There are two ways to do this: the first is by calculation using a DVM. Fig. 4 shows the voltages measured on a fully-upgraded moving coil stage. Current through Q2 is 2mA and through Q3 is 2.09 mA, giving a mismatch of 4.5%. In view of the variations in the

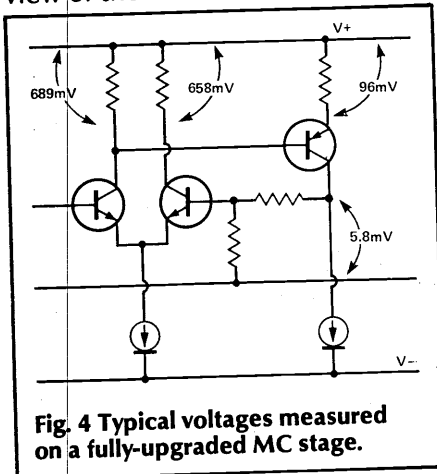


Fig. 4 Typical voltages measured on a fully-upgraded MC stage.

specifications of constant current diodes ($\pm 10\%$) larger mismatches may be expected through R2 and R4.

$$\text{Current} = 4.09 \text{ mA}$$

$$\text{Base Current through Q5} = 0.01 \text{ mA (Hfe} = 300)$$

$$\text{Total Current} = 4.1 \text{ mA}$$

$$\text{Current per transistor} = 2.05 \text{ mA}$$

$$\text{Voltage required across R2}$$

$$= 689 \text{ mV}$$

$$\text{Optimum value of R2} = \frac{689}{2.05}$$

$$= 336 \text{ ohm}$$

The nearest E96 value is 332R or 340R.

The collector currents could alternatively be matched by either changing the value of R7 or by changing D2 (to a J508) or adjusting R8 as appropriate. I will leave the readers to make their own calculations if they wish to pursue these alternative options.

The other method of balancing the currents is by observing a null point with a multimeter or scope. The circuit is set up as shown in Fig. 5, with R2 and R4 replaced by resistors of 270R (0.5%), 39R, 22R, 10R, 4R7, and 2R2. Initially the 10R, 4R7 and 2R2 resistors are shorted out on both sides and a

meter is connected from A to B.

If current flows from A to B, the total resistance value is too high and needs to be reduced. If current flows from B to A, the total resistance value is too low and needs to be increased. The resistance on both sides should be adjusted by equal amounts by restoring the shorted resistances. This procedure should be repeated until a point is found where the current is lowest. That value is recorded and about 1 ohm added to allow for Q5's base current. The value of R2 is the nearest preferred value to this. It is important that the resistance values are exactly the same whilst measurements are being taken.

Whilst the final value of R2 is critical (to set the base voltage of

Negative supply volts	R3	R8
1.2V single nicad	120R	390R
5V	1k0	1k6
9V	1k8	3k0
12V	2k4	3k9
15V	3k3	5k1
18V	3k6	6k2

Table 3 Values of R3 and R8 for use with alternative negative supply voltages.

Q5), the value of R4 after the measurements are taken will have no real effect on the circuit. Either 330R (or 332R in E96 values) or a resistance equal to the final value of R2 would be appropriate.

Applications

Although designed for use with the upgradeable amplifier, the moving coil stage is also well suited for use in other equipment or as a stand-alone unit. Its $\pm 12\text{V}$ regulators allow it to be hooked into almost any preamplifier which has $\pm 15\text{V}$ regulated supplies, and it would make an ideal headamp for John Linsley Hood's Audio Design Preamp and similar amplifiers. In such instances the use of two separate stages of regulation will guarantee excellent sound quality. It would also work well as an isolated head amp with a suitable power supply.

You can also use the moving coil stage without its regulators if you have a high performance discrete regulator or a battery supply. The low noise upgraded version in particular will be extremely quiet on battery power supplies. It will also give

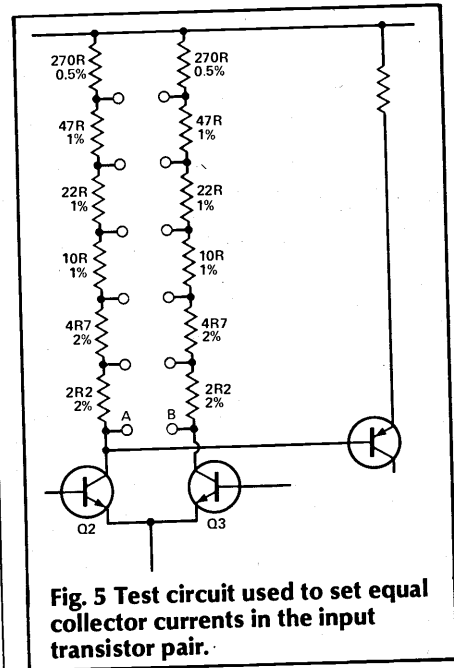


Fig. 5 Test circuit used to set equal collector currents in the input transistor pair.

outstanding sound quality when powered from high capacity batteries, but in this case it is wise to limit the short circuit current which might flow were a semiconductor to fail. The last thing you want is to have the short circuit current of a large rechargeable battery fed to the terminals of an expensive MC cartridge.

To prevent this, connect resistors of at least 10R (or 100R with a 12 V car battery) in series with D1 and D2. I don't think short circuit failure is common amongst FET diodes but I would rather be safe!

Whatever supply you use, it is essential that the correct currents flow from the negative rail. Table 3 shows suitable values of R3 and R8 for some of the more popular negative supply voltages. Constant current diodes are ideal for higher voltage working, but their impedance falls at low voltages. At 4.2 volts the current via the J511 is 10% below the current at 25 volts.

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- 1) Colloms, M. A passive role. Hifi News Oct 1985
 - 2) Colloms, M. Capacity to Change. Hifi News Dec. 1985
 - 3) Nalty, R.G. Constant Care. ETI April 1986
- Taylor, E.F. Distortion in low noise amplifiers. Wireless World Aug/Sept 1977

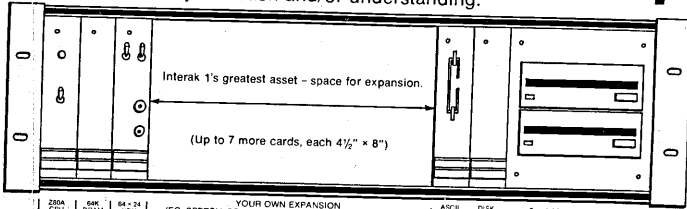
The next article in this series will describe the construction of the moving magnet input stage. **ETI**

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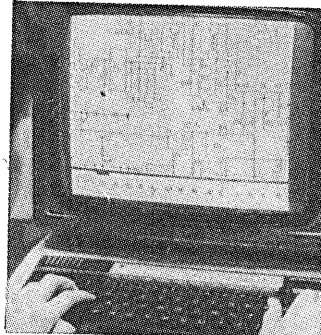
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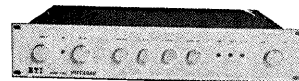
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DIGITAL SOUND SAMPLER

At the risk of repeating ourselves, Paul Chappell puts the sampler into action.

The circuit of the sampler's power supply is shown in Fig. 1, and is assembled according to the component overlay in Fig. 5. The heat sinks mount horizontally on the board with a gap of only a few mms between them, so it would be a wise precaution to use insulating washers wherever a 79-series regulator is next to a 78-series one, as their tabs will be at different voltages. Three of the four wire links on the board run very close to the heat sinks. To avoid the possibility of shorts, these should be insulated.

photograph. You can arrange the front panel layout to suit your own taste, since all the controls are on flying leads.

It would be as well to keep the mains connections as far to the right of the case as possible, to minimize any hum pick up, but apart from that you have complete freedom.

We decided to put the input level control on the front panel, rather than use a preset on the PCB as originally specified. This allows a very wide range of input levels to be accommodated — anything from a microphone input

displayed on the TV screen, but if you'd like to include them, Fig. 2 shows how to do it.

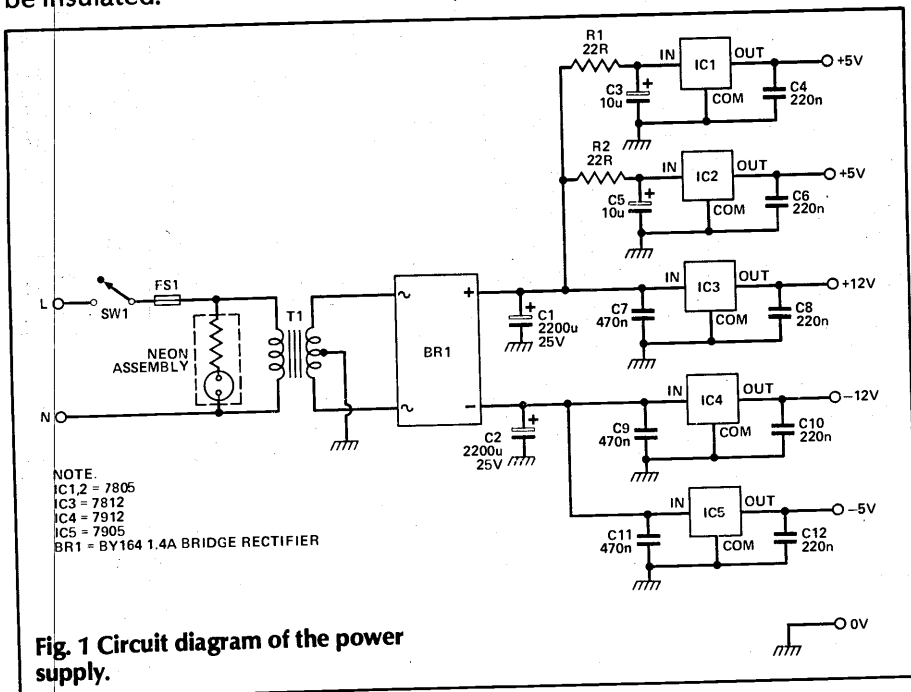


Fig. 1 Circuit diagram of the power supply.

We used a 19" rack-mounting case for the final assembly — there is no need to seek out exactly the same type, but you will need one of a similar size to allow room for the three boards. They fit neatly into the space available in a 19" case, as you can see from the

to several volts from a signal generator. The group of three LEDs is for status indication: they show SAMPLE READY (when sampling is to be triggered by the presence of sound), SAMPLER ACTIVE, and PLAYBACK. These indicators are not essential, as the information is

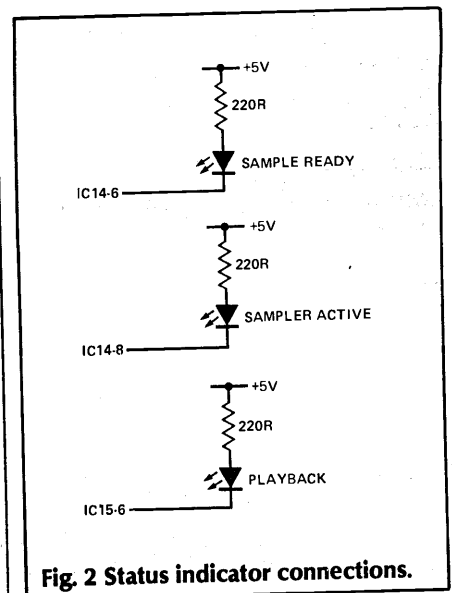
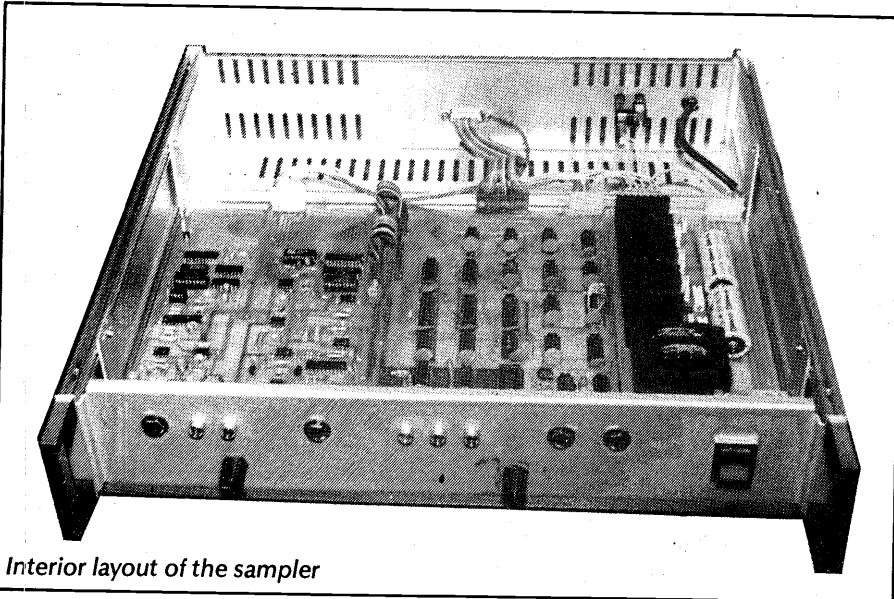


Fig. 2 Status indicator connections.

Connection to the Spectrum was made via a 15-way D-connector at the rear of the case going to a standard, 0.1" edge connector. The ground connection was taken via the shell of the D-connector and the appropriate links to the Spectrum expansion port are shown in Fig. 3.

A single pole toggle switch was inserted in the interrupt line — when the switch is off, it allows the Spectrum to be used for other purposes; when on, the sampler's interrupts jam the Spectrum's own, and the sampler takes control.

If the idea of having to operate a switch is too low-tech for you, the circuit of Fig. 4 will turn on the sampler automatically as soon as the tape has loaded — we didn't include it in the prototype, so it hasn't been allowed for on the PCB, but it shouldn't be any great problem to add it.



Interior layout of the sampler

Using The Sampler

The Sampler and computer must both be turned on and connected together before the program is loaded. If you try to load the tape without the sampler connected, the program will fail immediately, as one of the first things the program does when

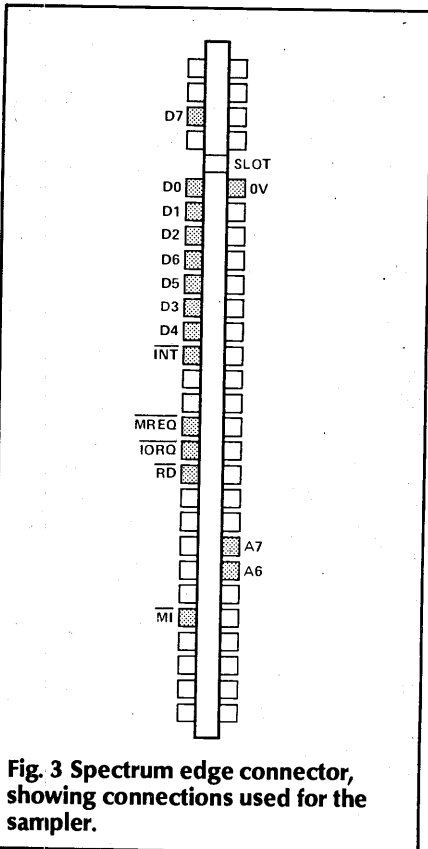


Fig. 3 Spectrum edge connector, showing connections used for the sampler.

loaded is to change the Z80's interrupt mode, and it requires an address from the sampler for the correct service routine.

To load the program, type LOAD "" CODE, followed by ENTER, and then switch on the cassette recorder, and also the switch in the interrupt line if you've plumped for the manual method. As the tape loads, you should see a colourful 'SOUND SAMPLER' logo displayed on the TV. As soon as the loading is complete, this will be replaced by the help screen, as shown in the photograph, which lists the various commands you can use.

```
KEYS USED: -
H = HELP
MOH = INPUT SAMPLE
F = FULL DISPLAY
E = EXPANDED DISPLAY

J = LEFT CURSOR LEFT
D2 = LEFT CURSOR RIGHT
D6 = RIGHT CURSOR LEFT
D5 = RIGHT CURSOR RIGHT
D4 = SLOW
D3 = FAST

D = PLAYBACK
X = SOUND OFF

M = MODIFY SAMPLE
L = LOOPING POINT
R = RECORD SAMPLE
T = SAMPLE FROM TAPE
```

The option menu

To sample a sound, press 'I' on the keyboard (which stands for 'input'), and you will then be given a choice of sampling rates. The higher the sampling rate, the better the sound quality, but the shorter will be the length of time

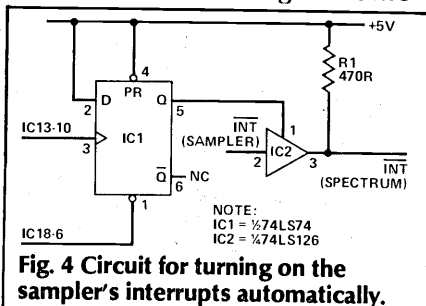
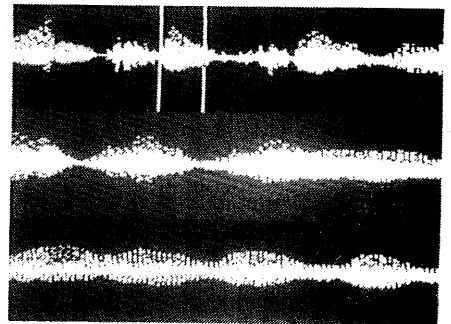


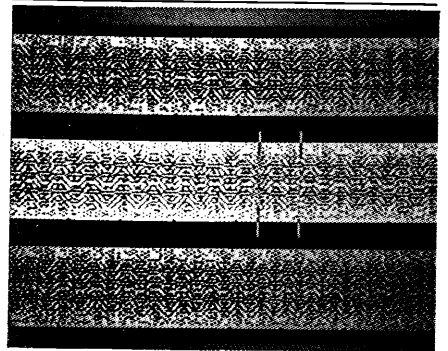
Fig. 4 Circuit for turning on the sampler's interrupts automatically.

you can sample for. Having chosen your sample rate, you will then be given the choice of initiating the sampling by the presence of a sound, or starting it immediately by pressing a key on the computer. A list of options is given on the TV screen at each stage, so there is no need to refer to this article or the instructions.

As soon as the sampling is complete, the computer will display the sampled waveform on the screen, in three rows, as shown in the photograph. Unless the waveform is at a very low frequency, all you will see at this stage is the envelope, so a constant amplitude wave will just appear as three bands across the screen, as you can see for the sine wave.



Sampled voice waveform



Sampled sine wave

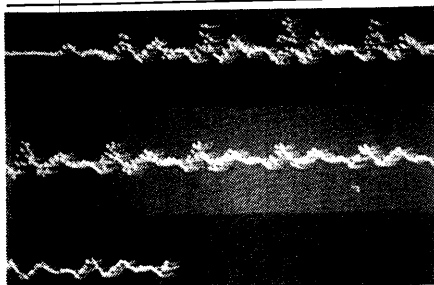
To inspect the waveform in detail, there are two cursors which can be moved to frame the part of the sample you are interested in. Pressing 'E' (for 'expand') on the keyboard will give a detailed picture of the portion of the sampler between the cursors. Photographs of the expanded voice waveform and sine wave show the result of doing this. Both the samples were taken at a low rate, so the individual sample points making up the waveforms can be seen. The samples in memory are in companded form, but the program calculates the correct position for each point so that it appears on the screen as if

the sampling had been linear.

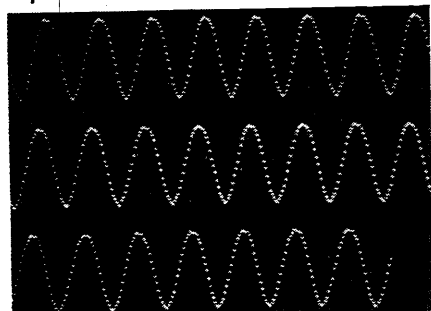
The sample in memory can be edited — you can cut out parts that are not required, by moving the cursors, and you can also alter any sample to modify the waveform, or even to create your own waveforms.

To hear the sound, press 'P' (for 'playback') on the computer. You will then be given the choice of having the sample played back once each time a key is pressed (which you will want if you have sampled a piano note, for instance), or of continuously looping around the sample to give a sustained note. On playback, only the portion of the sample between the cursors will be heard, so to play the entire sample you must move the cursors back to their original positions at either end of the sample. When you are looping around the sample to form a continuous note, there will be a click every few seconds because of the sudden jump from the last sample value to the first. You can eliminate this by choosing your loop beginning and end points (with the cursors) so that the last part of the sample leads smoothly into the first, or if you like the computer will choose the looping points for you automatically. Just press 'L' on the keyboard.

The sampler accepts a control signal from a standard 1V per octave keyboard, with a +5V gate signal. If you prefer to use a MIDI keyboard, you may like to consider building last month's MIDI to CV converter, which will allow any MIDI based instrument to interface with the sampler.



Expanded voice waveform



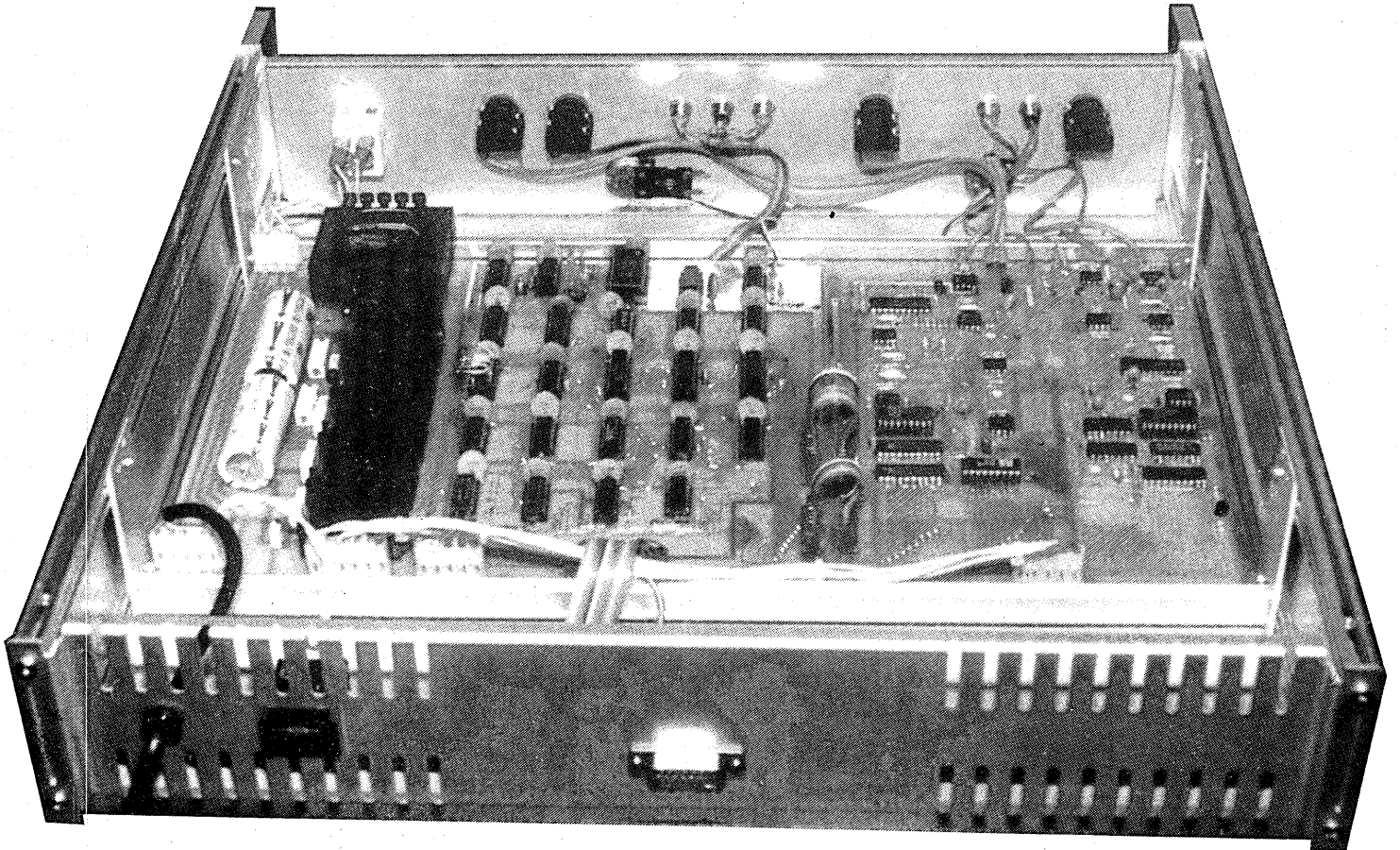
46 Expanded sine wave

2C	53	52	2B	25	39	33	00	35	33	24	1A	0D	28	00	00	00	24	25
2C	30	29	00	1D	00	29	2E	30	35	34	00	33	21	2D	30	2C	21	25
1D	00	26	35	2C	2C	00	24	29	33	30	2C	21	39	25	00	1D	00	25
30	21	2E	24	25	24	00	24	29	33	30	2C	21	39	25	00	1D	00	25
26	34	00	23	35	32	33	2F	32	00	32	25	26	34	12	00	1D	00	2C
26	34	00	23	35	32	33	2F	32	00	32	29	27	28	34	19	00	1D	00
29	27	28	34	00	23	35	32	33	2F	32	00	2C	25	26	34	10	00	1D
32	29	27	28	34	00	23	35	32	33	2F	32	00	2C	25	26	34	10	00
1D	00	33	2C	2F	37	26	00	1D	00	26	21	33	34	2F	00	1D	00	25
29	34	00	2F	2E	30	00	1D	00	30	2C	21	39	22	21	23	28	38	00
00	33	2F	35	2E	24	00	2F	26	26	2D	00	1D	00	2D	2F	24	29	26
00	33	21	2D	30	2C	00	00	00	00	00	00	32	00	1D	00	32	25	23
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2F	32	24	00	33	21	2D	30	2C	25	34	00	1D	00	46	54	57	41	52
00	26	32	2F	2D	00	34	21	30	25	00	33	4F	46	54	57	41	52	45
26	41	52	4D	00	11	19	18	15	33	25	2C	25	23	34	00	33	21	2D
2C	25	00	32	21	13	00	1D	00	1D	00	13	10	2B	48	5A	08	5A	12
12	10	2B	48	5A	08	09	11	00	1D	00	13	10	2B	48	5A	08	5A	12
33	23	21	30	25	09	11	00	1D	00	33	21	2D	30	2C	25	00	32	25
24	39	12	00	1D	00	33	21	2D	30	2C	25	00	33	34	21	32	34	21
40	36	00	23	7C	E6	18	EE	18	20	F6	36	0F	23	7C	E6	03	EE	03
F6	21	00	29	29	29	01	00	3D	09	ED	06	08	E1	5A	1A	77	CD	68
6F	28	00	F8	E1	D1	C1	23	13	0D	20	DD	C9	06	40	79	AE	77	CD
13	10	F8	C9	7C	3C	E6	07	28	02	D4	C9	3E	F8	A4	67	3E	20	85
3E	08	84	67	C9	01	FE	FE	ED	78	E6	1F	FE	1F	20	F8	CB	00	3B
03	ED	5B	01	62	A7	ED	52	ED	58	03	62	16	00	01	00	A7	ED	52
C9	5D	FA	0B	79	E6	07	3C	CB	38	CB	19	CB	38	CB	19	CB	38	CB
16	80	3D	2B	04	CB	3A	18	F9	79	E6	1F	6F	79	E6	60	0F	0F	67
F4	C9	3A	03	62	32	04	62	2A	05	62	2A	05	62	2A	05	62	2A	05
B9	61	CB	79	2B	05	CD	29	61	18	03	CD	8F	61	3A	09	62	B6	77
0A	62	11	01	00	A7	ED	52	CB	22	0A	62	21	04	62	35	20	DE	3A
62	32	04	62	21	09	62	CB	0E	30	C1	2A	07	62	7D	3C	E6	1F	28
2C	18	08	7D	E6	E0	6F	3E	08	84	67	22	07	62	1B	AB	4F	7C	E6
81	4F	E6	07	47	7C	E6	F8	B0	67	79	E6	F8	CB	27	CB	27	85	6F
04	3E	08	84	67	C9	01	FE	FE	ED	78	E6	1F	FE	1F	20	F8	CB	00
FD	BC	2B	05	D9	08	FB	ED	4D	3E	40	D3	7F	AF	D3	7F	3A	00	62
D7	C7	00	62	D9	08	FB	ED	4D	D9	08	7E	09	7C	8A	38	04	7B	BD
05	D9	08	FB	ED	4D	2A	10	62	D9	08	FB	ED	4D	00	00	00	00	4F
07	47	7C	E6	07	40	47	30	07	E6	07	47	3E	08	81	4F	7C	E6	F8
67	79	E6	F8	CB	27	CB	27	4F	7D	91	6F	30	05	0E	08	7C	91	67
4F	E6	0F	57	79	CB	BF	CB	3F	CB	3F	CB	3F	CB	3F	CB	3F	47	FE
2B	23	30	1E	05	28	0A	37	CB	12	FE	06	28	03	27	CB	12	3E	07
10	FD	3D	82	CB	3F	CB	3F	CB	3F	C9	00	30	75	2D	00	00	00	00
00	00	00	00	00	00	00	00	30	75	2F	FC	00	00	3E	15	ED	47	ED
0A	01	FE	BF	ED	78	CB	67	C2	09	63	CD	13	60	21	00	40	11	8B
0E	0E	CD	39	60	21	45	40	11	93	5E	0E	08	CD	39	60	21	45	40
9B	5E	0E	10	CD	39	60	21	85	40	11	AB	5E	0E	10	CD	39	60	21
40	11	8B	5E	0E	14	CD	39	60	21	ES	40	11	CF	5E	0E	14	CD	39
21	05	48	11	E3	5E	0E	15	CD	39	60	21	25	48	11	8B	5E	0E	14
59	60	21	45	48	11	0D	5F	0E	16	CD	39	60	21	65	48	11	8B	5E
08	CD	39	60	21	85	48	11	2B	5F	0E	08	CD	39	60	21	65	48	11
5F	0E	08	00	00	00	21	E5	48	11	3E	5F	0E	0C	CD	39	60	21	65
11	4A	5F	0E	0D	CD	39	60	21	45	50	11	57	5F	0E	11	CD	39	60
65	50	11	68	5F	0E	1A	CD	39	60	21	85	50	11	82	5F	0E	11	CD
60	21	A5	50	11	93	5F	0E	14	CD	39	60	21	ES	40	11	CF	5E	0E
00	00	00	00	7E	60	3A	00	62	E6	87	CB	DF	E3	50	11	8B	5E	0E
7B	CB	57	C2	4E	64	AF	D3	7F	CD	13	60	21	A6	40	11	BA	5F	0E
CD	39	60	21	29	48	11	CC	5F	0E	09	CD	39	60	21	69	48	11	D5
0E	09	CD	39	60	21	A9	48	11	DE	5F	0E	09	CD	39	60	21	E3	50
A2	5F	0E	18	00	00	00	21	68	50	11	E7	5F	0E	08	CD	39	60	21
FB	ED	78	CB	57	CA	28	62	01	FE	F7	ED	78	CB	57	CA	28	62	01
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CD	39	60	21	67	48	11	03	60	0E	10	CD	39	60	21	68	50	11	E7
0E	0C	CD	39	60	21	E3	50	11	A2	5F	0E	18	00	00	00	CD	7E	0F
FE	FB	ED	78	CB	57	CA	28	62	01	FE	F7	ED	78	CB	57	CA	28	62
6E	CB	39	10	F9	18	E4	21	00	62	CB	96	CB	86	C5	CD	13	60	21
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62	01	BF	00	D9	21	00	62	79	D3	7F	CB	F7	20	27	01	FE	FB	ED
CB	57	20	06	AF	D3	7F	C3	28	62	01	FE	F7	20	27	01	FE	FB	ED
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2F	FC	22	12	62	C3	57	64	3E	06	D3	7F	CB	56	28	B4	21	2F	FC
AF	D3	7F	18	C3	28	62	CB	CE	CB	56	28	B4	21	2F	FC	22	12	62
0C	01	FE	FB	ED	78	CB	57	20	43	CD	13	60	21	30	75	22	05	62
01	62	21	6D	47	22	07	62	3E	80	32	09	62	21	00	87	22	0A	62
2D	32	03	62	CD	CB	60	2A	10	62	E6	81	CB	EF	32	00	62	01	FE
CD	8E	60	4A	CD	5D	60	3A	00	62	2A	10	62	22	05	62	22	01	62
ED	78	CB	57	20	40	CD	13	60	2A	10	62	22	05	62	22	01	62	2A
12	62	A7	ED	52	22	0A	62	11	00	03	AF	3C	A7	ED	52	28	02	30
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E6	81	CB	F7	32	00	62	CD	7E	60	01	FE	F7	ED	78	CB	47	20	29
00	62	F5	01	E0	FF	CB	7E	20	05	11	FF	18	0A	ED	58	03	62	16
FF	7B	2F	3C	5F	F1	CB	67	28	05	21	14	62	18	03	21	10	62	18
01	FE	F7	ED	78	CB	57	F1	CB	67	28	05	21	14	62	18	03	21	10
11	01	00	18	06	ED	5B	03	62	16	00	18	D0	01	FE	ED	78	CB	47
20	1F	3A	00	62	01	08	00	CB	7F	20	05	11	01	00	18	06	ED	58
62	16	00	CB	67	C2	25	66	21	12	62	18	2B	01	FE	ED	78	CB	47
C2	9A	66	3A	00	62	CB	67	C2	25	66	01	FB	FF	CB	7F	20	05	11
FF	18	0A	ED	5B	03	62	16</											

PROJECT: Sound Sampler

Listing 1 Hex dump of the sound sampler program.

```
78 CB 5F 20 14 21 00 62 CB 86 AF D3 7F 3E FF DD 21 30 75 11
D0 89 CD C2 04 01 FE FB ED 78 CB 67 20 1B 21 00 62 CB 86 AF
D3 7F 3E FF 37 DD 21 30 75 11 D0 89 CD C2 04 01 FE FB ED 78
BF ED 78 CB 4F C2 10 68 3A 00 62 CB 6F CA 57 64 F3 2A 12 62
CD 8E 60 4A CD 5D 60 ED 5B 10 62 1A 13 13 2A 12 62 2B BE 20
FC E5 A7 ED 52 E1 30 05 21 2F FC 18 F0 47 1A 4F A8 7E 7F 2B
08 A7 CB 79 28 01 37 18 18 79 CB BF CB BB B8 20 0B 7E 47 2B
2B 7E B8 79 20 CF 18 2C CB 79 28 01 3F F5 7E 47 2B 2B 7E 4F
A8 CB 7F 28 06 CB 79 28 0F 18 12 79 CB BF CB BB B8 20 0B 7E
01 3F 38 05 F1 30 1C 18 03 F1 38 17 23 23 22 12 62 E5 D9 D1
D9 CD 8E 60 4A CD 5D 60 FB CD 7E 60 C3 10 68 1B 1A 13 13
C3 92 67 01 FE DF ED 78 CB 4F 18 2C F3 D9 01 01 00 2A 10 62
ED 5B 12 62 D9 3E 52 D3 BF 3E 70 D3 7F 21 00 62 CB 86 01 FE
FE FE ED 78 CB 57 20 08 AF D3 7F 21 00 62 CB 86 01 FE DF ED
78 CB 47 C2 1E 62 CD 13 60 21 A5 40 11 F8 68 0E 14 CD 39 60
21 27 48 11 0C 69 0E 10 CD 39 60 21 67 48 11 1C 69 0E 0E CD
39 60 CD 7E 60 01 FE FB ED 78 CB 57 CA 28 62 01 FE F7 ED 78
E6 03 FE 03 28 EB 32 F7 68 F3 D9 01 01 00 2A 10 62 ED 5B 12
62 D9 3E 70 D3 7F FB 01 FE FE ED 78 CB 57 CA 28 62 01 FE
C3 28 62 AF DB 7F FE 00 20 0B F3 D9 2A 10 62 D9 18 E1 5F 16
00 21 28 69 19 19 7E 23 4E 21 0E 62 BE 20 17 3A F7 68 77 D3
28 CB F3 D9 D5 E5 1E 00 A7 ED 52 E1 D1 D9 30 BB 18 B8 2C 25 23
BF F3 06 00 C5 D9 C1 2A 10 62 D9 18 A9 00 00 33 25 2C 25 23
34 00 30 2C 21 39 22 21 23 2B 00 2D 2F 2A 25 11 00 1D 00 33
29 2E 27 2C 25 00 23 39 23 2C 25 12 00 1D 00 23 2F 2E 34 29
2E 35 2F 35 33 58 01 58 01 58 01 01 01 01 01 01 01 01 01 09
01 09 01 11 01 11 01 11 01 19 01 19 01 19 01 19 01 21 01 21
01 29 01 29 01 29 01 31 01 31 01 31 01 31 01 39 01 39 01 39
01 41 01 41 01 49 01 49 01 49 01 51 01 51 01 51 01 59 01 59
01 59 01 02 01 02 01 02 01 0A 01 0A 01 0A 01 12 01 12 01 12
01 1A 01 1A 01 1A 01 1A 01 22 01 22 01 22 01 2A 01 2A 01 2A
01 32 01 32 01 3A 01 3A 01 3A 01 3A 01 42 01 42 01 4A 01 4A
01 4A 01 52 01 52 01 5A 01 5A 01 5A 01 5A 01 62 01 62 01 6A
01 0B 01 0B 01 0B 01 13 01 13 01 13 01 1B 01 1B 01 1B 01 23
01 23 01 23 01 2B 01 2B 01 2B 01 2B 01 33 01 33 01 3B 01 3B
01 3B 01 43 01 43 01 43 01 43 01 4B 01 4B 01 4B 01 53 01 53
01 5B 01 5B 01 5B 01 5B 01 04 01 04 01 04 01 0C 01 0C 01 14
01 14 01 14 01 1C 01 1C 01 1C 01 1C 01 24 01 24 01 24 01 2C
01 2C 01 34 01 34 01 34 01 34 01 3C 01 3C 01 3C 01 44 01 44
01 4C 01 4C 01 4C 01 54 01 54 01 54 01 54 01 5C 01 5C 01 5C
02 04 02 04 02 0C 02 0C 02 14 02 14 02 14 02 14 02 1C 02 1C
02 1C 02 24 02 24 02 24 02 24 02 24 02 24 02 24 02 24 02 24
02 3C 02 3C 02 3C 02 44 02 44 02 44 02 44 02 4C 02 4C 02 4C
02 54 02 54 02 5C 02 5C 02 5C 02 5C 02 5C 02 5C 02 5C 02 5C
04 0C 04 14 04 14 04 14 04 14 04 1C 04 1C 04 1C 04 1C 04 24
04 2C 04 2C 04 2C 04 2C 04 34 04 34 04 34 04 34 04 3C 04 3C
04 44 04 44 04 4C 04 4C 04 4C 04 4C 04 4C 04 4C 04 4C 04 4C
04 5C 04 04 08 04 08 04 08 04 08 04 08 04 08 04 08 04 08 04
08 1C 08 1C 08 1C 08 1C 08 24 08 24 08 24 08 2C 08 2C 08 2C
08 34 08 34 08 3C 08 3C 08 3C 08 3C 08 44 08 44 08 44 08 4C
```



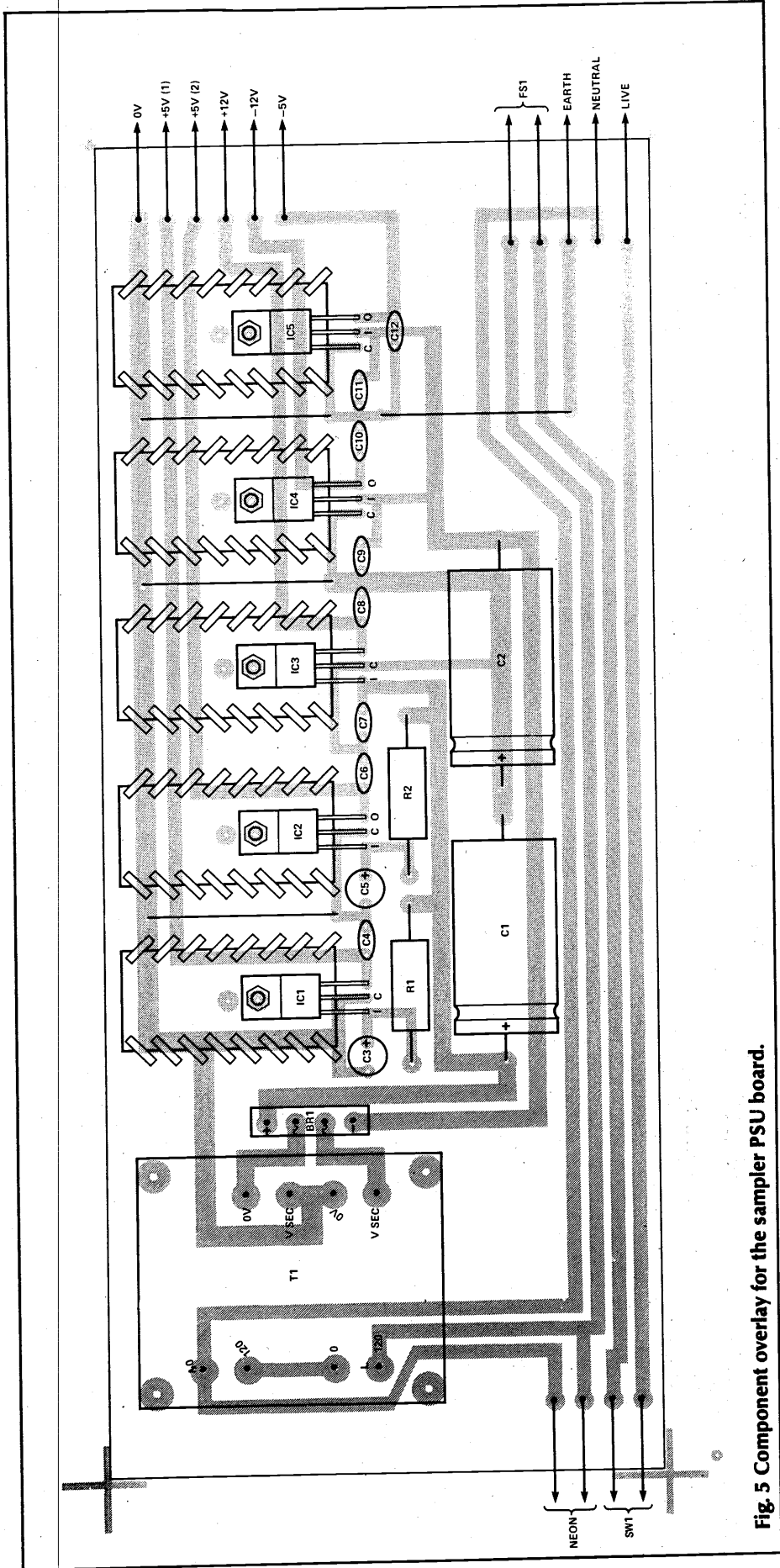


Fig. 5 Component overlay for the sampler PSU board.

BUYLINES

The bridge rectifier BY164 is available from Maplin (see ad in this issue), order code QF43W. The transformer is RS207-699, available through Crewe Allan and Co., 51 Scrutton Street, London EC2. A cassette tape of the program for the sampler, with instructions, is available from: The Software Farm, Craiglo Farm, Tintern, Gwent at £9.50 + 40p postage and packing. The PCB will be available from our PCB service, but see the note in News Digest.

PARTS LIST

POWER SUPPLY

- RESISTORS**
 R1 22R 5W
 R2 22R 5W
- CAPACITORS**
 C1 2200µ 25V axial electrolytic

- SEMICONDUCTORS**
 IC1 7805
 IC2 7805
 IC3 7812
 IC4 7912
 IC5 7905
 BR1 BY164
- MISCELLANEOUS**
 On/off switch; neon panel lamp; fuse-holder and 500mA fuse; transformer (12-0-12-12VA PCB mounting); PCB.

- 2200µ 25V axial electrolytic**
 C1
10µ 25V tant.
 C3
220n polyester
 C4
10µ 25V tant.
 C5
220n polyester
 C6
470n polyester
 C7
220n polyester
 C8
470n polyester
 C9
220n polyester
 C10
470n polyester
 C11
220n polyester
 C12

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THE ETI TROGLOGRAPH

Not so much a field test, more a sort of soak test. Mike Bedford describes the results obtained with his prototype underground communications system and offers some hints on using and modifying it.

Initial tests with the Troglograph were carried out over a distance of about 200 yards with a reasonable received signal strength, but signals started to tail off significantly beyond this. These ranges were very encouraging as they compare favourably with the depths of most British caves and potholes. However, the Troglograph was not developed for surface communication — the acid test was how well it would work in the environment for which it was intended.

The field tests were carried out in a windswept valley in North Yorkshire on a Saturday in January, the surrounding hills still showing the remnants of recent snowfalls. The cave chosen for the tests was the West Kingsdale System, located about 3 miles north of Ingleton. There is an entrance in the valley bottom and the route then passes almost horizontally under the surrounding hills, providing a comparatively easy means of getting the equipment to a quite respectable depth. There is only one vertical pitch on the route chosen yet the final point is in excess of 300 feet below the hill top.

The party consisted of the author, his wife Margaret, Ivan Wuljehorodsky and James Fathers, of which the author and James made up the subterranean contingent. Figure 1 shows the West Kingsdale System, and consists of a survey of the cave passages superimposed upon a map of the surface features. It was used to pin-point corresponding positions above and below ground at which tests would be

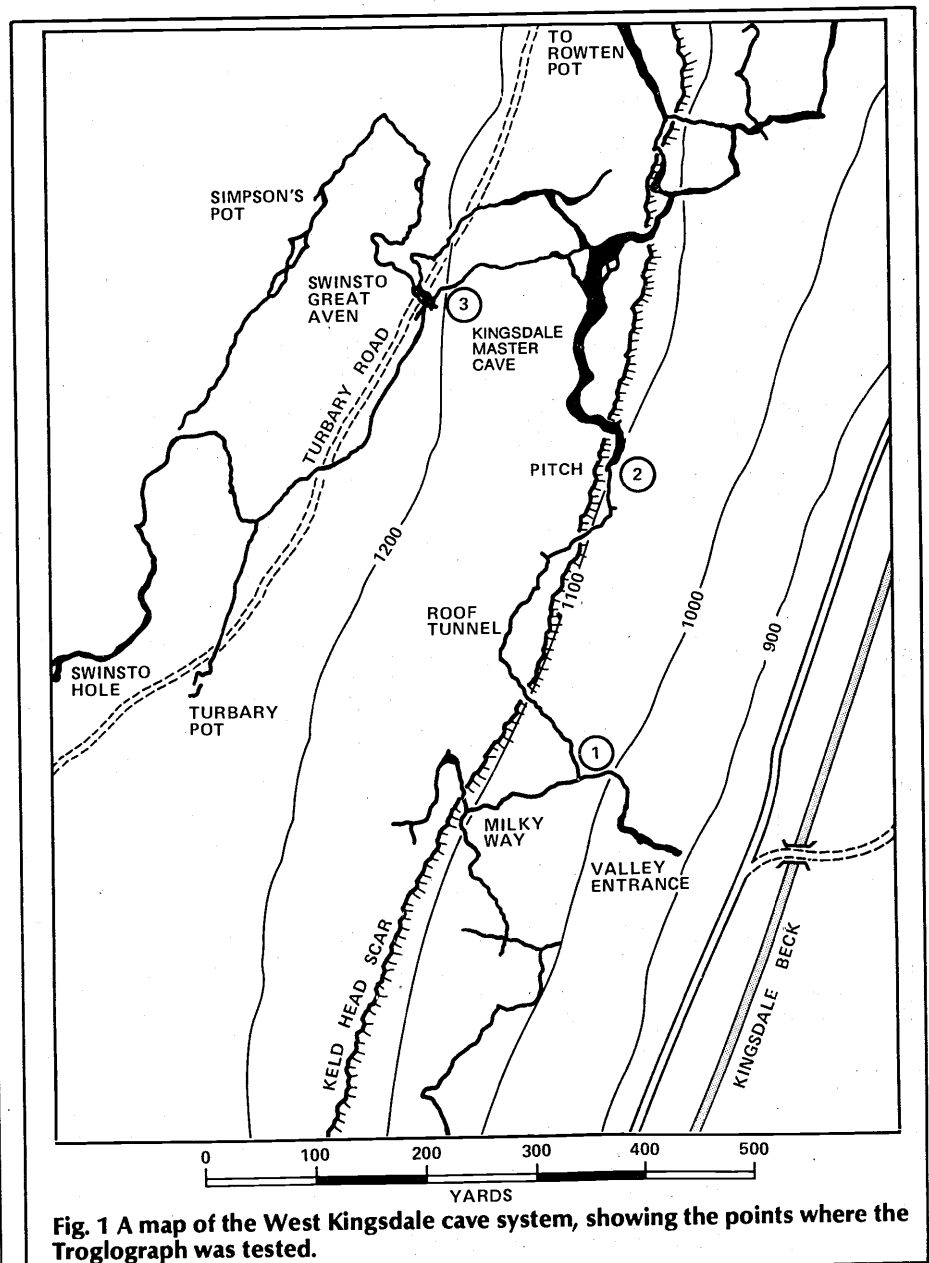


Fig. 1 A map of the West Kingsdale cave system, showing the points where the Troglograph was tested.



The prototype Troglograph undergoing field tests.

conducted. Although the System has a number of entrances, the one used in this expedition was the one referred to as Valley Entrance and the three points selected for tests were those marked 1, 2 and 3 on the map. Assuming that the cave passages are approximately horizontal, it is clear from the contours that these points must be about 100, 200 and 300 feet underground.

The first rendezvous point was reached in a matter of five or ten minutes, the entrance section being for the most part a walking or stooping passage with a couple of deep pools. One of these filled the passage to within a foot or so of the roof, serving to prove that the equipment was indeed waterproof. This first test proved encouraging with reasonably strong signals being received.

The equipment was packed away and we made our way to the second scheduled point, arriving there with a good five minutes to spare. As James rigged the pitch for our descent, a comparatively dry spot was found to set up the Troglograph. We switched it to

receive and were greeted with silence. Our spirits fell. At last, after two minutes of frantic tuning, the signal was heard. We later discovered that it had taken the surface party longer than anticipated to reach their destination — clearly there are times when it is quicker to travel underground! The signal strength was not particularly good, however, and the noise of the stream pouring over the nearby pitch as a waterfall made listening difficult.

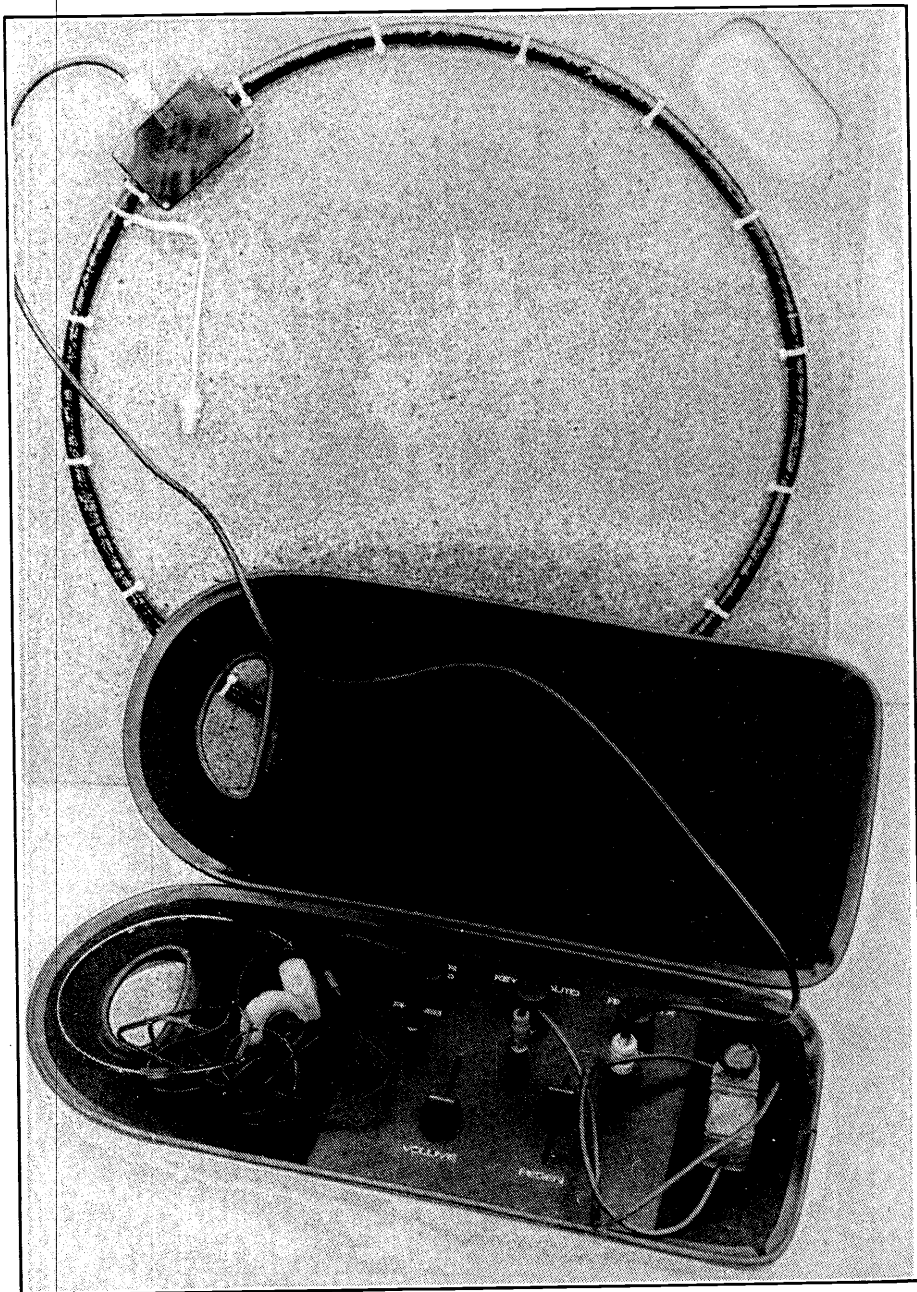
With the second test completed, we went down the 25 foot pitch, the passage enlarging considerably to form Kingsdale Master Cave, the hub of the whole system. The recent snow and rain falls had left the cave much wetter than on previous trips, making progress against the flow of water somewhat slower than expected. At the end of the master cave the route to the third rendezvous point, Swinsto Great Aven, continued as a low crawl with occasional flat-out sections. It soon became clear from the deposits on the roof that this area

had quite recently been flooded completely. In view of the unsettled weather conditions, good sense prevailed and we retraced our steps, leaving a test at 300 feet to another day. Nevertheless, we counted the expedition a success, signals having been received through 200 feet of solid rock and the ergonomic features of the design proven.

Further Developments

It is very unlikely that the first attempt at a project such as this will result in a piece of equipment which can't be improved upon. Indeed, although the field trip was a success, it served to identify a number of areas for future development. The author will probably continue to experiment in these areas, and it would be nice to think that this article will inspire others not only to build the Troglograph but to use it as an experimental project too.

Signal strength at 200 feet below ground was not as good as expected. Means of improving this



Following the field tests, the original Troglgraph was re-housed by James Fathers in the case shown here. Not only is it easier to carry than the original, it also looks a lot better both inside and out (see external photo opposite). The new arrangement also dispenses with the rather cramped control panel of the original version, making operation easier. Note the use of slider potentiometers for the volume and regeneration controls.

have already been mentioned, but to recap slightly they involve increasing the number of turns and/or the coil area (especially of the surface coil) without increasing its resistance.

Audio volume proved something of a problem in locations with high background noise (for example, the waterfall). The LM380 certainly doesn't give its full power output into a 32 ohm load, so a possible solution here

would be to find miniature 8 ohm phones of sufficient power handling capacity. On the subject of phones, it was found that miniature stereo headphones do not fit over the hard hats used for caving. Perhaps it would be possible to fit phones into a hard hat?

Dragging a loop aerial and an ammo box in addition to ladders and ropes along a low passage is somewhat inconvenient. A form of

folding loop which could fit into the ammo box would be a marked improvement.

Perhaps the most ambitious next stage would be to develop speech communications, a facility which would bring it close to the Molephone described in the first part of this article. Initial calculations show that the most significant problem would be obtaining the required 3kHz bandwidth. The traditional solution involves reducing the Q-factor of the loop considerably, which could only be achieved practically by reducing the number of turns. Clearly this reduction in turns would have to be compensated for by a corresponding increase in the coil current. More recent designs such as the Molephone overcome bandwidth limitations by operating at a higher frequency, typically 100kHz.

Licensing

As far as international frequency spectrum agreements are concerned the portion from 0-9 kHz is un-allocated and no regulations restrict its use. Furthermore, since the Troglgraph does not use radio in the normal sense of the word but uses very short range magnetic waves, it would be reasonable to assume that a transmitting licence is not required. In many countries this is the case and the Troglgraph could be used without any sort of official authorisation. In Britain, however, a licence issued by the Department of Trade and Industry is required for all use of the electromagnetic spectrum.

Fortunately, a suitable licence is readily available, this being the one issued for deaf aid inductive loop systems in public halls. The cost of the licence is £12.00 for a period of five years and the application form (Form BR12) may be obtained from the following address: Department of Trade and Industry, Radio Regulatory Division, Waterloo Bridge House, Waterloo Road, London SE1 8UA.

Unless mention is made in the application of the specific requirements, the licence obtained will restrict the loop current to one ampere turn. Although quite suitable for hearing aid systems this is clearly of no use for the Troglgraph. Accordingly it should be requested that a limit of 100uV per metre at 100 yards

PROJECT: Troglograph

OPERATION

The Troglograph has a minimum of controls and is simple to operate. The equipment only has a transmit/receive switch, a switch to select automatic keying or morse, a volume control and a regenerating control.

This latter control is the only one which may need a word of explanation. In very strong signal conditions it really doesn't matter how the regeneration control is set — it will only be necessary to adjust the volume control to a comfortable level. When signals are weak, the regeneration should be advanced as far as possible without it self oscillating, then

the volume can be adjusted.

It should also be remembered that the transmit/receive switch has a third 'S' position. Forgetting this could result in the Troglograph being in its standby mode when it is meant to be transmitting or receiving. In practice it is unlikely that the operator will be unaware which mode the equipment is in. Although no 'sidetone' feature as such is included, the receiver continues to operate (with no aerial) when the Troglograph is transmitting, and enough signal is received to enable the operator to hear what is being sent.

in caving clubs — particularly when one considers the high price of commercial equipment.

One other potential hazard is perhaps not quite so obvious. The loop aerial is tuned to resonance, which means that in common with all tuned circuits, the voltage across the coil could be much greater than the +24V applied to the final amplifier. It doesn't require much imagination to realise how unpleasant it could be to use a poorly insulated aerial whilst standing up to one's waist in a pool of water.

Acknowledgements

The author would like to thank Steven Newhouse who coined the name "Troglograph" and his wife Margaret, Ivan Wuljhorodsky and James Fathers for their assistance in testing it in less than ideal conditions!

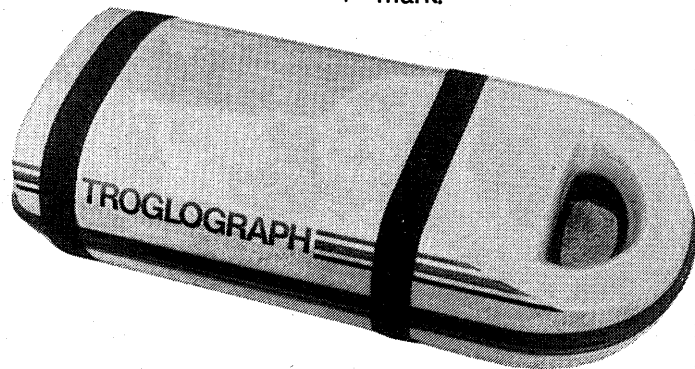
We would also like to point out that the Molefone (on which the Troglograph is based) is available from University of Lancaster Engineering Services, Department of Engineering, Bailrigg, Lancaster LA1 4TY, tel 0524 - 65201. Molefone is a registered trade mark.

from the aerial be applied. It would be wise to apply for this licence in good time as applications are currently taking about two months to process.

A Caution!

It isn't the intention of this article to encourage irresponsible underground expeditions. Caves and potholes are potentially dangerous places, hazards including pitches (deep vertical shafts), rising water in unsettled weather, route finding and collapses. Whereas all of these hazards can be minimised by taking the proper precautions, the inexperienced caver should not be tempted to go underground alone. Anyone wanting to experiment with cave communications is advised to seek some experienced

potholers as companions or preferably to join a club. Numerous caving clubs are scattered around the country, especially in the Yorkshire Dales, Peak District, Mendips and South Wales. With the increasing interest in the Molephone in potholing circles, an electronics enthusiast might well be especially welcome



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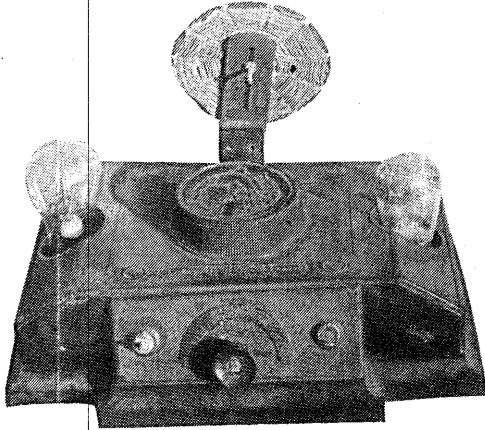
The battle between valves and semiconductor devices is far from won. Many audio enthusiasts swear by valves — and not just because they're supposed to give a 'warmer' sound. Jeff Macaulay has designed a stereo pre-amp to exploit the known advantages of valves — linearity, simplicity, low noise and high overload margins. 'The sound,' he says, 'is a revelation.' But that's only the beginning, because pretty soon Jeff is swapping his triodes for transistors with surprising results.

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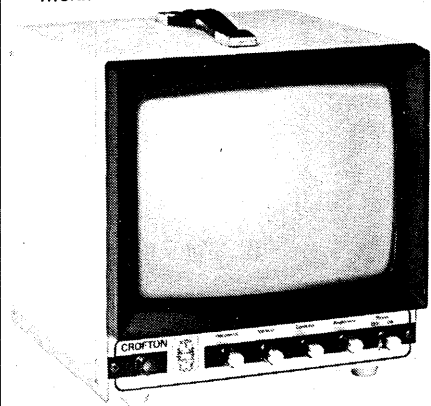
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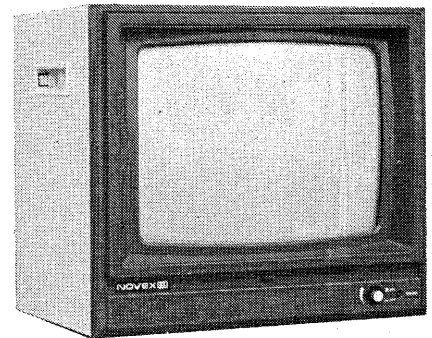
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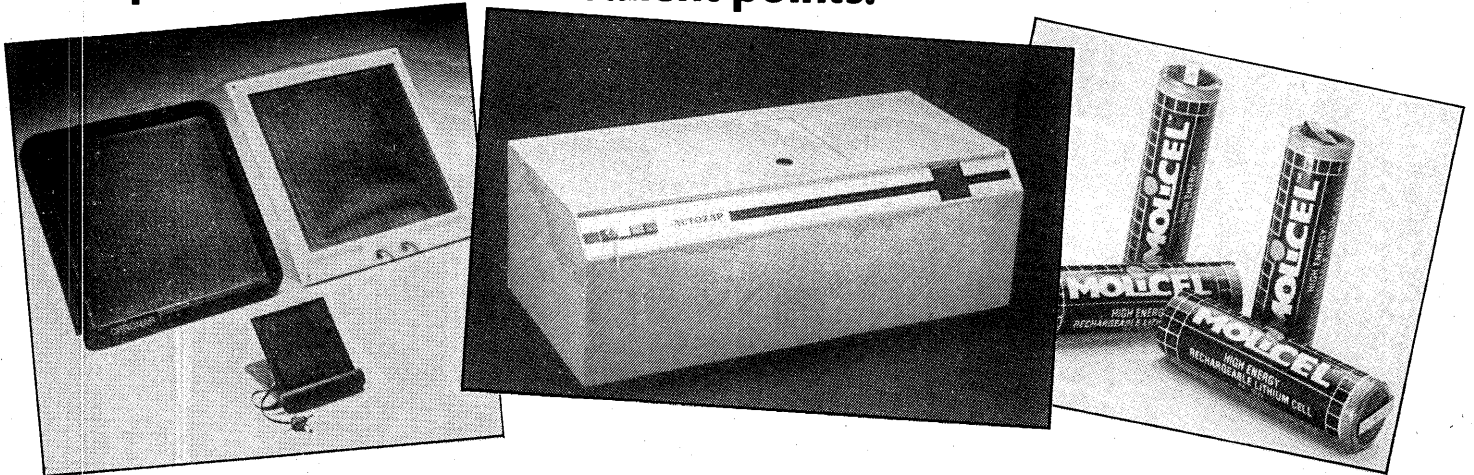
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ETI JULY 1986

THE MAIN EVENT

... and, in the event, AT&T came and so did ETI — neither of us, we're pleased to say, having been blown up. Andrew Armstrong sends in a report from the British Electronics Week exhibition and picks out one or two salient points.



There is a theory going round that less people are taking up electronics as a hobby than in days of yore. This is as maybe, but there is plenty of expansion in the professional area. At this year's British Electronics Week there were said to be about 1000 exhibitors. Certainly there were too many to glance at properly in a day, a far cry from the time when the show occupied a couple of rooms at the Grosvenor House Hotel.

Nominally the show was divided into four sections: The All Electronics Show, Electronic Product Design, Circuit Technology, and Fibre Optics. The first three of these were at Olympia, the last at Earls Court, with a coach shuttle service between the two venues.

Due to lack of time and stamina I gave the Earls Court part a miss. The Olympia part of the show was very popular, and it was sometimes difficult to move through the crowds.

If the show is a pointer to general trends, then I would say that the use of surface mount technology is steadily increasing, and is no longer quite so much of a black art. It is, of course, almost impossible to use a soldering iron on components on a surface mount board, so the ever-obliging manufacturers of assembly equipment will sell you a rework station for a cost just less than the national debt. This uses a very narrow stream of hot air to melt and reflow solder to enable individual components to be fixed or removed. It is the surface mount equivalent of the soldering iron.

Custom and semi-custom ICs were also much in evidence, with the inevitable accompaniment of a large range of computer aided design facilities.

Another sign of the increasing complexity of silicon technology was the profusion of static control products. Nowadays ICs with very small conductor areas can be damaged by an internal static discharge caused by an external static charge, and yet continue to work for some time before the inevitable failure

occurs. What may happen, for example, is that a hole is punched in an insulating layer, and some conductor material is transferred into it. In use, ion migration either reinforces the plated hole into a short circuit, or breaks the damaged conductor.

A company called Hartley Measurements has brought out a machine called the Autozap, which simulates the effect of a static discharge caused by the human body. This should permit reproducible evaluation of the resistance of devices to static.

There were many other items of interest. There were some very bright but tiny surface mount LEDs, and some seven segment LED displays with a surface mount driver chip on the back of the packages (see last month's News Digest). At a quick glance it looks just like an ordinary seven segment display.

Allbatteries had a couple of interesting products — excellent solutions on the prowl for problems. The first is a range of solar power panels, the largest of which is reputed to supply 14.8V at over an amp in bright sunlight, and perhaps 200mA on an ordinary British day! At £297 it is an expensive way to charge up a car battery in a week or two, but it produces enough power to be useful and may find applications in remote locations.

I think that they will sell far more of the new rechargeable lithium batteries. These have double the energy density of nickel cadmium cells, and have the traditional lithium feature of low self discharge. They are very new, and 'handmade', so they cost around £10 each. When automatic machinery is in operation and the price drops, I think NiCads will find it hard to compete. The sale of primary cells may also be hit by the effect of this and the environmental concern over the disposal of used alkaline manganese cells.

Altogether the show was a 'don't miss' event, though these few words cannot begin to do it justice.

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OOPS!

Corrections to projects are listed below and normally appear for several months. Large corrections are published just once, after which a note will be inserted to say that a correction exists and that copies can be obtained by sending in an SAE.

Infra-red Intruder Alarm (August, 1984)

Q11, VN10LK, should be either a VN10LM or a VN10KM. R19 and R20 on Fig.5, p.59, should be R18 and R19. R20 is missing and should be soldered between Q6 collector and a suitable point on the +ve rail, preferably on the underside of the board. There are two C18s — the one on the upper left should be marked C17. C12 is missing. It should be connected just below L2, from Q5 collector to the track connected to R15, C8 and R13. Pads are available. The +ve on C8 is not marked: it should be uppermost. It should also be uppermost on the incorrectly marked C11.

Noise About Noise (July 1985)

In Fig. 5 on page 24, no connection should be shown between the cathode of the diode and the negative side of the 470u capacitor.

The ETI Activator (January, 1986)

Several items were missing from the parts list (p.34). Resistors R33, 93 and 94 are all 100k; R, 7, 45, 46 and 47 are all 1M0; R40 is 47k; R80 is 100k. The list includes two R68's — the second (15k) should be R88. There is no R79 anywhere — for some reason, the number was overlooked. Capacitor C17 is missing — it should be 4μ7 40V minelect. SW1 is missing. It should be a DPDT push-button switch. On the circuit diagram (p.32), the resistor between C5 and pin 10 of IC2c is R8, 10k. R82 should be marked 2k7, R20 should be 39k, R21 should be 1k0 and the component between C10 and R27 is a 10k resistor, R25 (not C25). Some of the IC numberings do not correspond with the PCB overlay. IC8d and IC8c should be exchanged and the pin numbers on the new IC8d and on IC1d and 2d should read, clockwise from the output, 14, 12 and 13. The new IC8c now has pin numbers 8, 10 and 9 (clockwise from the output). IC8a and 8b should be exchanged and the new IC8a should have pins numbered 1, 3 and 2 (clockwise from the output). Likewise, IC8b should have pins numbered 7, 5 and 6. R52 appears twice on the overlay (p.34). The one connected to pin 6 and IC2 should be R11. The parts list and circuit diagram includes two resistors (R27 and 67) specified at 14k each. 15k is the nearest preferred value, although you might prefer to use a 12k fixed and 4k7 trimmer in series to adjust for optimum setting.

Digibaro (February 1986)

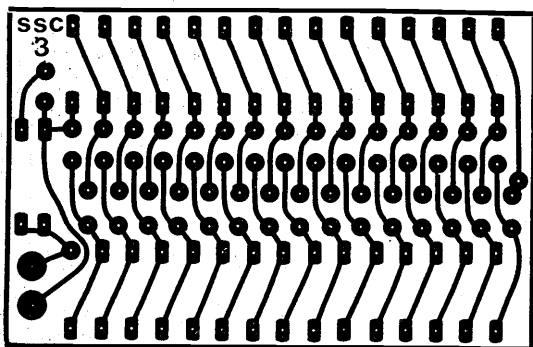
Capacitors C1, C3, C5 and C7 should be 470u 25V types as shown on the circuit diagram, not 47u 25V types as stated in the parts list. We have also been told that one of the companies mentioned in Buylines, Hawke Electronics, no longer supply the MPX100a pressure transducer. The other company recommended, Macro Marketing, should still be able to help.

LED5 on Fig. 7, page 28, the component overlay, is shown as having 16 pins. It should have 18 pins and be extended rightwards to the two pads shown. In the author's prototype the LED displays used were both MAN6710 2-digit types, LED4 having pins 16, 17 and 18 removed.

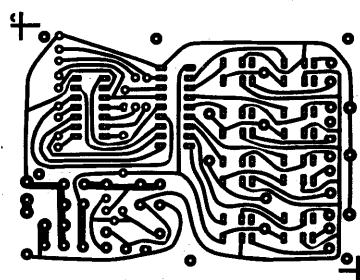
RS232-Centronics Converter (March, 1986)

On the circuit diagram (Fig. 2, p. 53), pin 11 of IC2d should be marked pin 13. Pin 10 of IC3 is missing and should be shown connected to ground. Pin 9 of IC7f becomes pin 8 and vice versa. Also, in Table 1, the figure '8' in column SW1b should be a zero and the '8' belongs in the 'DATA BITS' column. The specification of 74LS121 and 74LS07 is wrong, since LS types do not exist for these devices. They should be replaced with standard TTL. Finally, some confusion seems to have been generated over XTAL1. Although not mentioned in the text, a simple calculation should demonstrate that XTAL1 needs to be 6.144 MHz to produce the baud rates shown.

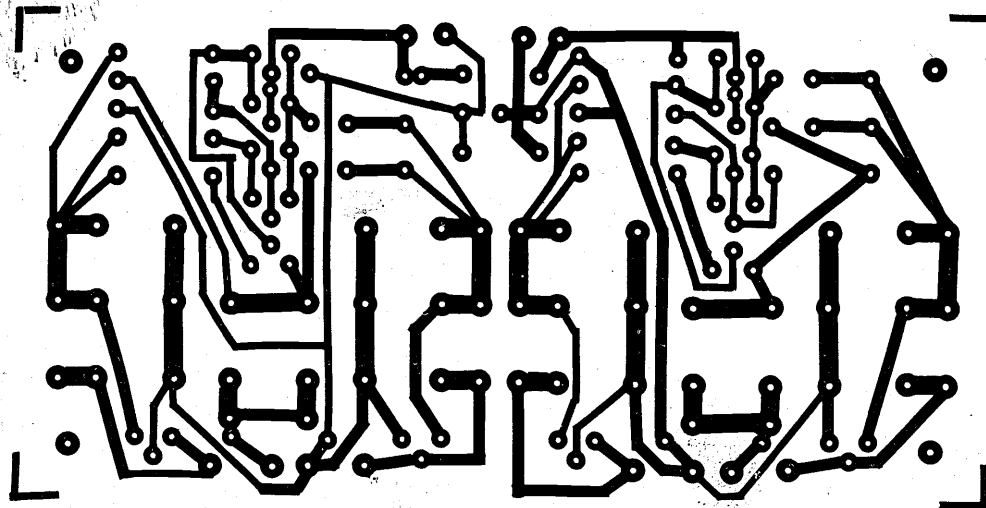
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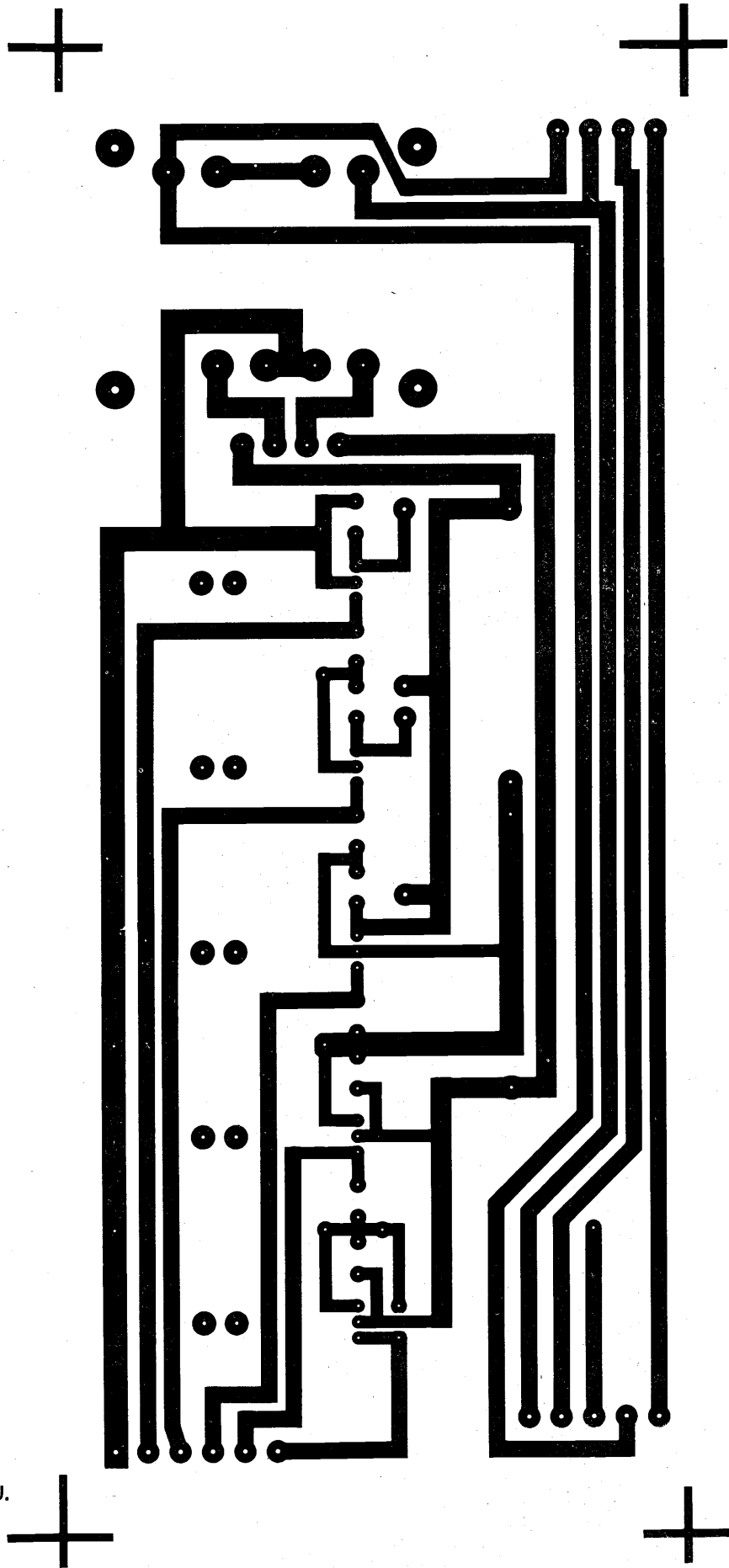
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OPEN CHANNEL

For many months' now I have refrained from making comment about GEC's proposed takeover of Plessey. Both management and employees of Plessey are totally opposed to the takeover, and have referred it to the Monopolies Commission in an attempt to prevent it. The main argument against making comment is that whatever I write takes so long to come into print that it would be out-of-date before the reader sees it. This is a very real problem with something as volatile as the GEC/Plessey affair. However, it has been dragging on for so long that I can refrain no more.

Plessey's argument against the takeover relies on the fact that the company's acquisition will give GEC a monopolistic control of the market. But, as I am sure the Commission already knows, it won't. There are other companies, albeit much smaller, which design, manufacture and market similar telecommunications products — all of which are in direct competition with the

likes of GEC and Plessey. So the argument against a monopoly (which is why the bid was referred to the Commission in the first place) falls down almost immediately.

The Trades Unions stance against the takeover seems, in my view, a much more logical argument, on the other hand. The EETPU suggests that the takeover cannot give any increase in organisational efficiency and that the proposed single organisation will be so large that it will actually be less efficient. The Union is also, understandably, against the takeover on the grounds that a large number of job cuts will probably result.

However, the main function of the Monopolies Commission in this argument is to decide whether GEC would become a monopoly-holding company if the takeover comes about. As I said earlier, it won't — therefore the Commission has no alternative but to overrule Plessey. Or does the Commission know different?

Band III

While the topic is on GEC, I should mention the new Band III national trunked radio network which is due to be brought into

service in about seven or eight months' time. There are only two operators for the network: GEC and a consortium including Pye, Racal and Securicor. Detailed planning is not yet complete and no-one knows how it will work, but already there would seem to be a problem regarding the amount of radio spectrum allocated for the service. The operators, led by GEC, want more, but the Government won't let them have it.

But be fair. There is only a limited amount of radio spectrum, and it's not everyday that a significant portion of it becomes available as this portion did (the old VHF television frequencies). And other users want their bits, too. GEC will just have to make do with Plessey instead (that's if I'm right).

Data Day

In just over a year's time the BBC will start to transmit data signals along with regular broadcasts. These signals will not interfere with your pleasure when tuned to Radio 4's Afternoon Play and, in fact, may help to improve your reception! The signals will include information about the frequencies being used for broadcast purposes, station iden-

tification, and what's being broadcast on other stations.

All of this information is not a lot of good for your average tranny, of course, and it will only be a new generation of 'smart' radios which will be capable of receiving and using it. The idea is that, by decoding and using the information, the smart radio will be able to stay tuned to a particular station by itself, receiving the strongest transmission and hence giving the best sound output. This, I hear you say, is not a lot of good to your average tranny which, under most circumstances, sits in one place tuned only to one station anyway.

On the other hand, and this is the clever bit, radios in cars will certainly benefit. As a car moves around, so does the frequency at which best reception of any particular station will occur. A smart car radio will be able, by decoding the data signals, to follow the strongest transmission and give the best reception. Also, the user will be able to choose the type of programme received: the radio will pick out and automatically tune to, for example, weather announcements on other stations.

Wonderful stuff, this technology.

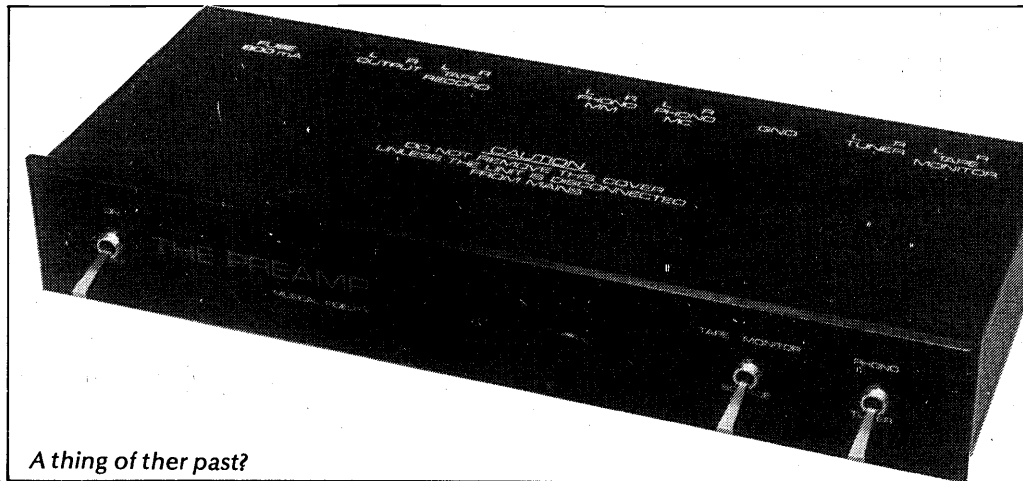
Keith Brindley

PLAYBACK

For many years, preamplifiers have been designed to accept 'flat' line inputs from tuners and tape decks at around 100-200mV. After the volume and balance controls, further amplification raises the signal to about 1 volt, enough to drive the power amplifier. With disc as the main sound source and the cartridge needing amplification from a very low level, the need to drive a power amp directly from a tape deck or tuner never arose.

Then along comes CD, its audio output level of around 2V being more than enough to drive power amps directly. To avoid losses in sound quality from active preamps, the passive preamp is created. As many modern power amps have extra sensitivity, and tuners and tape decks extra gain to cover matching errors it has proved possible to connect a whole system (without a turntable) using only a passive preamp — just volume control, switches and input and output sockets.

So why do CDs have such a high output? Presumably a high output enables much better signal to noise and distortion figures.



A thing of the past?

The use of digital circuitry in audio applications is more likely to increase than disappear, and manufacturers are not likely to change their output levels if this degrades performance or if D to A convertors work at that level. We cannot really accept two completely different line input levels to amplifiers with the pre-to-power level roughly halfway in between.

It is now time to standardise. Modern hi-fi systems do not require tone controls so it makes sense to arrange all high level outputs so that they can drive a power

amp directly using only a volume control and switch. Where tone control is needed, a graphic equaliser will do a better job. Avoiding an additional active gain stage saves on preamp power supply costs and gives better sound quality.

Why not go one stage further? Why not include all the parts of a passive preamp in the power amplifier. The savings in preamp case and cable could either be passed on to the purchaser or used to improve sound quality.

But what of the analogue disc user? A preamp will always be

needed to provide RIAA equalisation and to raise the signal to 'line' level. The opportunity is there to provide specialised disc preamps to go with the turntable. Or why not inside the turntable where the use of balanced input amplifiers would provide such benefits as low radio interference, etc. And one less well-finished box is required!

These developments seem logical, and would improve performance and save money. Whether or not they take place remains to be seen.

Graham Nalty

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ALF'S PUZZLE

The story so far:

Alf and Auntie Static are locked in mortal combat for control of the puzzle page. The key to supreme power lies in the legendary capacitor puzzle which was featured in ETI, May 1986. To restate it:-

Four $2\mu\text{F}$ capacitors are connected as shown in Fig. 1. The arrangement should be equivalent to a single $2\mu\text{F}$ capacitor, and

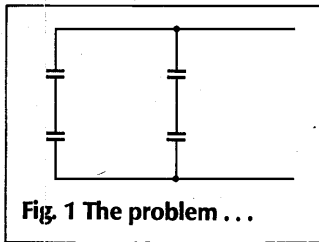


Fig. 1 The problem ...

if the network is charged to 10V, the energy of $25\mu\text{J}$ per capacitor adds up to a total of $100\mu\text{J}$, as we would expect for a single $2\mu\text{F}$ capacitor charged to 10V. The charge on each capacitor in the network, however, is $10\mu\text{C}$, so the total charge on all four capacitors will be $40\mu\text{C}$ — twice as much as for a single $2\mu\text{F}$ capacitor. Does this mean that it would take twice as much current for a given time to charge the network as it would for a single $2\mu\text{F}$ capacitor?

Alf, being completely out of his depth, solicited the help of ETI readers to solve the puzzle, offering a prize of £10 for the correct answer that was easiest to understand. Now read on ...

Alf's choice, from the many correct replies, was difficult to make, but eventually he selected Bernard Chalk's explanation as being the most likely to be understood by a ten-year-old (and therefore by Alf himself):

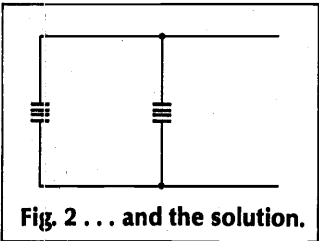


Fig. 2 ... and the solution.

'The solution to the puzzle can be explained by drawing the series/parallel arrangement of capacitors with the inner connecting leads between the series capacitors reduced, as shown in Fig. 2. The charge on the inside plates is brought together and cancels, leaving only the charge of $10\mu\text{C}$ on the series capacitors, and therefore providing a total charge of $20\mu\text{C}$ on the arrange-

ment. The argument in the problem did not distinguish between charge provided by the power supply (only $20\mu\text{C}$) and charge that was merely rearranged between the plates (also $20\mu\text{C}$).

Bernard Chalk,
Southend on Sea,
Essex.'

Two other solutions, which Alf thinks worthy of a special mention for their simplicity, were sent in by Patrick Gaffney of Montenotte Park, Cork, and by Noel Moore of Belfast. Mr. Gaffney points out that if a resistor is connected across the charged network, only $20\mu\text{C}$ will flow through it, the rest of the charge being simply redistributed between the capacitors, so externally the network behaves like a single $2\mu\text{F}$ capacitor. Mr. Moore says that Alf could have used the same spurious argument to claim that a series of capacitors, each with a charge Q , would require nQ coulombs from the supply, rather than the Q coulombs actually needed.

Auntie Static claims that the problem is just as absurd as adding together the currents through all the components in a circuit, and then claiming that this must be the total current provided by the supply. (Just think of two resistors in series, for instance.) Adding the charges in a circuit is equally meaningless, but since we are more used to thinking in terms of currents, the flaw in the argument is not so easy to spot.

As the power struggle between Alf and Auntie has yet to be resolved, we have decided that neither of them can provide the puzzle for this month. Instead, we have an offering, sent in by reader Henry Earle, which — we hope — will finish with capacitors once and for all.

'Insert a resistor R between two $2\mu\text{F}$ capacitors, then charge up to 10V. When the charging is complete, the charge on the capacitors, and the energy stored, will be just the same as if there had been no resistor there at all. The resistor should be 'invisible' to the power supply, since the only current flowing through it is from the charge redistribution between the capacitors, yet it still dissipates an amount of energy given by $W = \int I^2 R dt = 50\mu\text{J}$. Connect an AC supply and you have a free room heater!

Henry Earle,
Nottingham.'

Well, there it is. Any comments? Is Mr. Earle's room heater really free? If not, how does the supply 'know' that there is a resistor between the capacitors.

In the straightforward case of simply charging a capacitor to 10V, all the energy in the capaci-

tor can be recovered — none has been dissipated. With a resistor — as in Mr. Earle's puzzle — the same amount of charge seems to be transferred from the power supply at the same voltage, involving the same amount of energy. Yet some energy will be dissipated by the resistor. The energy stored by the capacitors is equal in both cases, and should be equally recoverable (in the second case, we can short out the resistor as soon as the charging is complete.) So where does the extra energy which the resistor dissipates come from?

Mr. Earle goes on to point out, in his letter, that the energy dissipated is independent of the value of the resistor, and will always be equal to the amount stored by the capacitors.

Once again, a £10 prize for the simplest and most elegant correct solution received.

The answer to last month's puzzle.

The circuit is a voltage to current converter. Let's suppose the input is at 1V, floating with respect to the op-amp's supply, with the 'resistor' side of the input more positive than the 'op-amp' side. If

the output is not loaded at all, the non-inverting input of the op-amp will be at +1V with respect to the inverting input, and as a result the output will rise to its most positive voltage.

With a load on the output of the circuit, the op-amp's output (and therefore the 'left hand side' of the resistor R , by virtue of the input voltage) will rise until the current to the load, via R , is enough to drop 1V across the resistor, at which point the non-inverting and inverting inputs of the op-amp will be at the same voltage. The current into the load will be $1/R$, or for a general input voltage V it will be V/R , regardless of the resistance of the load.

Thus the circuit acts as a voltage to current converter, delivering a current of V/R to the load (which would normally be connected to 0V, and not V — as shown, although the circuit will work in this configuration for op-amps which allow the negative supply as a common mode input).

The circuit is not often seen, since the requirement that the input should be floating with respect to the supply, and that the entire output current should flow through the input, make it impractical in many applications.

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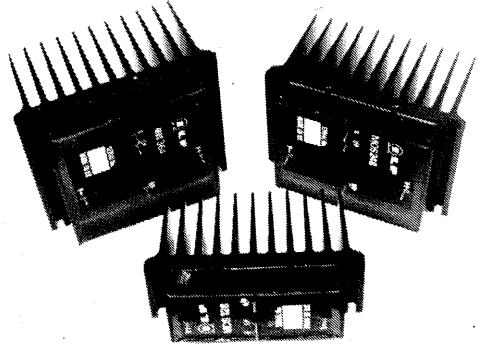
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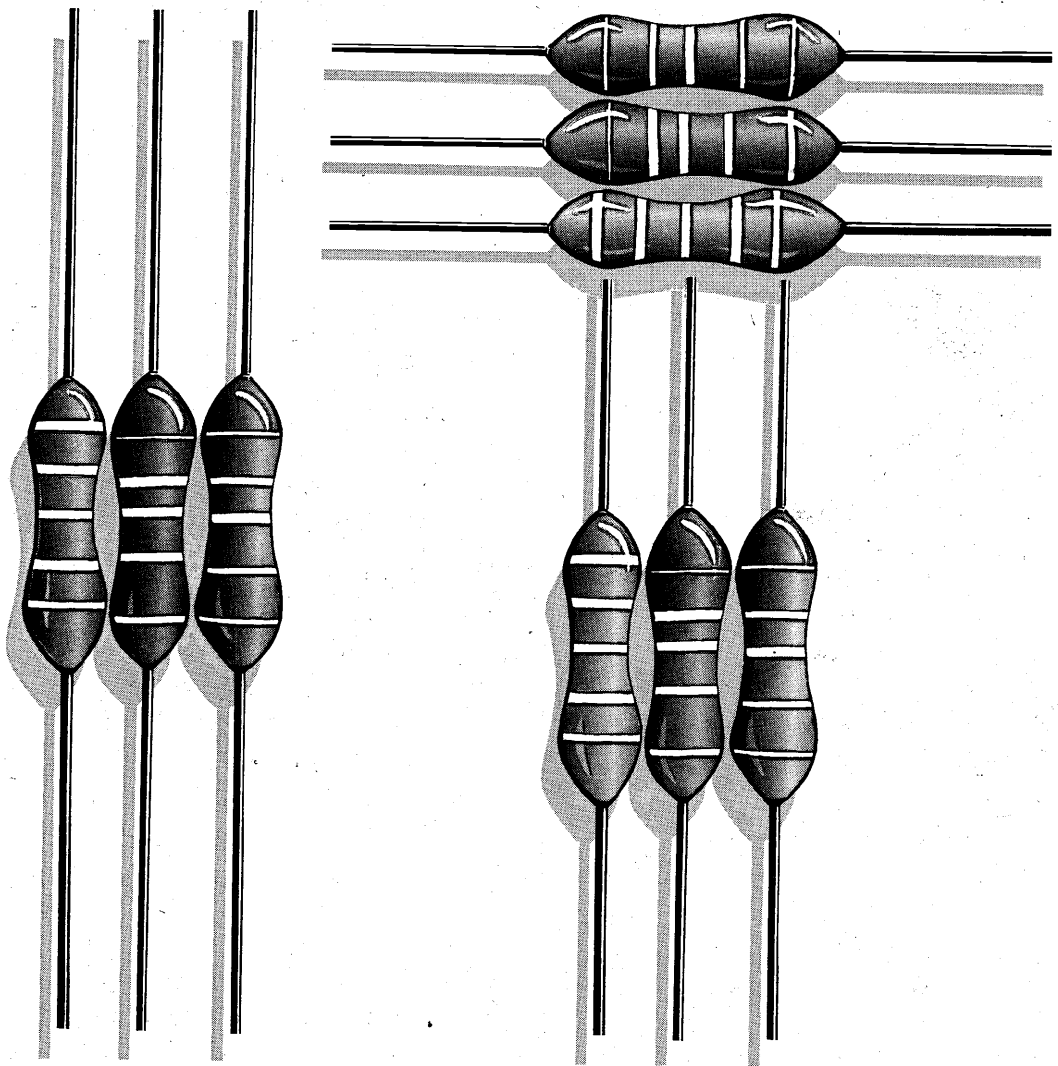
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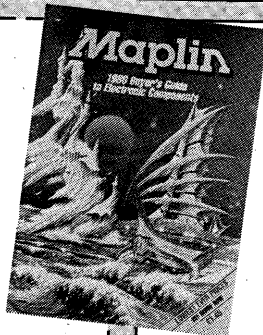
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New product news	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
News of events and personalities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
New theoretical/technological developments	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sophisticated projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Basic projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Introductory features	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Telecommunications	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Audio	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Computers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Semiconductors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Others (please specify no more than three)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
.....	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2. Indicate what you think of the services offered by the magazine:

	Good	Average	Bad	Don't know
PCB Service	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Photocopy service	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Project updates	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Corrections to projects/features	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Foil patterns	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Buylines	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Advice services (Auntie Static etc)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Special offers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Subscriptions (rate & delivery)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Back numbers (price & availability)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Letters page	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. Please indicate whether you own any of the following types of equipment:

computer/computer peripherals	<input type="checkbox"/>
audio/hi fi	<input type="checkbox"/>
electronic musical instrument	<input type="checkbox"/>
PA/recording equipment	<input type="checkbox"/>
radio/satellite/CB equipment	<input type="checkbox"/>
video camera/monitor	<input type="checkbox"/>
car electronics	<input type="checkbox"/>
security equipment	<input type="checkbox"/>
remote control/robotics	<input type="checkbox"/>
photographic or darkroom equipment	<input type="checkbox"/>
test/measurement equipment	<input type="checkbox"/>
gadgets	<input type="checkbox"/>
Others (please specify)	<input type="checkbox"/>

This is your chance to make a really important contribution to ETI, and all we want in return are the answers to a few simple questions. The 1986 ETI Readers' Survey is our chance to listen to you and so improve the quality of ETI. As a small incentive we're also going to offer a free subscription to the first ten completed forms to be picked out of a hat after our August 1 closing date. If you want to be entered for the draw, just include your name and address (or that of a nominee of your choosing) in the form. All information in the form remains strictly confidential and no names will be stored on a computer or in any electronically retrievable form.

Send your completed form to us to arrive by the last post on August 1, 1986.

4. If you already own a computer, please indicate which one:

Spectrum/Spectrum +	<input type="checkbox"/>
Spectrum 128	<input type="checkbox"/>
Commodore 64/128	<input type="checkbox"/>
BBC B/B+/Master	<input type="checkbox"/>
Acorn Electron	<input type="checkbox"/>
Sinclair QL	<input type="checkbox"/>
Amstrad 464/664/6128	<input type="checkbox"/>
Amstrad PCW8256	<input type="checkbox"/>
Atari 600/800/128XL	<input type="checkbox"/>
Atari 520ST/1040ST	<input type="checkbox"/>
Microtan 65	<input type="checkbox"/>
Dragon 32/64	<input type="checkbox"/>
Microbox II	<input type="checkbox"/>
ZX80/81	<input type="checkbox"/>
Interak	<input type="checkbox"/>
Cortex	<input type="checkbox"/>
Others (please specify)	<input type="checkbox"/>

5. Indicate whether you'd like to see more or less in the magazine of the following:

	More	Same	Less	Don't know
Computer projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Audio projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Music projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Radio projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Test equipment projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TV and video projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Security projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Car electronic projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lighting projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Robotics projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Photographic projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Novelty projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Computer software	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Interfacing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Basic electronics theory	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Advanced electronics theory	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
General science	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Experimental projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
News features	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Technical features	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Product information	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Design hints and tips	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Letters	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Circuit ideas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reviews	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Opinion columns	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Crossword/Alf's puzzle	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Technical advice	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Competitions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Others (please specify)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6. Please indicate which of the following you buy and how frequently:

	not at all	sometimes	often
complete electronic kits	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
electronic components	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ETI PCBs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
PCB making equipment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
stripboard/wire-wrap etc.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
preprogrammed ROMs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
unprogrammed ROMs	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
solder/wicks/tips	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
test gear	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
cases/case material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
component storage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
connectors/leads	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
tools	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
electronics books	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
computer software	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
batteries	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
floppy disks/computer tapes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
second-hand equipment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7. Indicate how many kits or projects you hope to build in the next year:
 0 1-3 4-12 more than 12

8. Do you have difficulty locating components:
 Y N

9. Do you prefer to build projects from commercial kits, if they are available?
 Y N

10. Do your projects normally work first time?
 Do you normally get them to work? Y N
 Y N

11. Do you usually build projects as printed or supplied?
 If no, do you make a few or many mods? Y N
 Few Many

12. Do you find ETI projects:
 reliable
 easy to build
 useful

13. What was the last ETI project?

14. Do you make your own PCBs?
 always

15. Please indicate approximate amount spent on hobby-related hobbies in the last year:
 £20 or less £21-50
 £51-100 £101-500 £500+

16. Please indicate what other hobbies you have:
 Computers
 Photography
 Film/video
 Modelling (railway/aero)
 Other (please specify)

17. With regard to the advertisements:
 Read or look through nearly all
 Read or look through some
 Just read or look through titles
 Very rarely/never look at

18. Thinking specifically about ETI, rate the three types of advertising in terms of usefulness (type):

Very useful
 Useful
 Not very useful
 Not at all useful

19. Do you order or buy products from ETI?
 Regularly
 Occasionally
 Never

20. If the answer to question 19 is 'No', indicate how you would like to receive this way, and what was its frequency:

21. Do you use the Advertisers' Enquiries Service?
 Y

22. Does anyone else read your magazine?
 No only me

23. Do you keep your copy of ETI?
 One month

24. Do you read any of the following magazines?
 Practical Electronics
 Everyday Electronics
 Electronics Times
 New Electronics
 Personal Computing World
 Byte
 Electronics & Music Maker
 Ham Radio Today
 Scientific American