AN ARGUS SPECIALIST PUBLICATION

electronics today

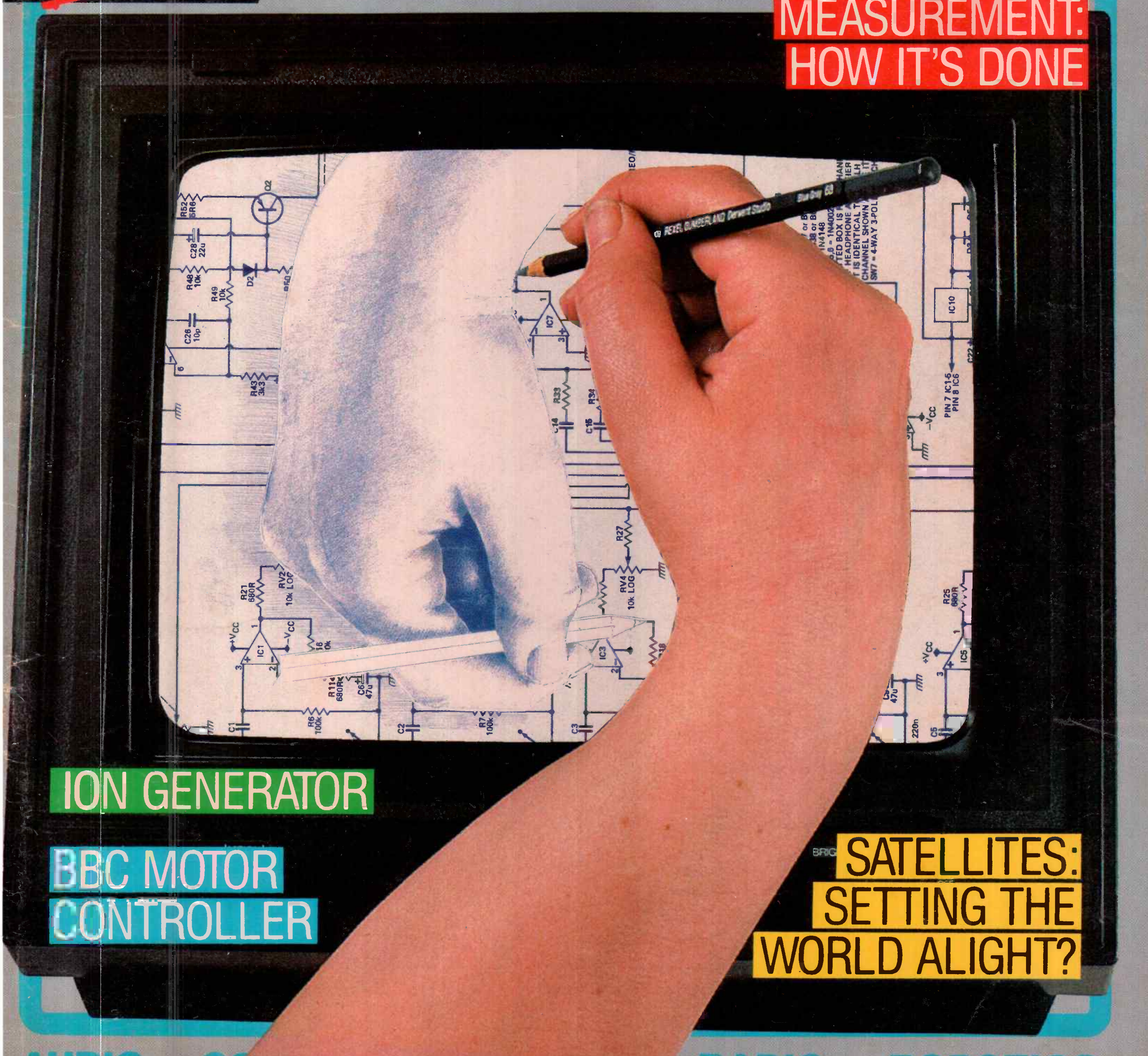
INTERNATIONAL JULY 1986

Rs.25

MICROCOMPUTER ASSISTED CIRCUIT DESIGN

STOP PRESS

RADIATION MEASUREMENT: HOW IT'S DONE



ION GENERATOR

BBC MOTOR CONTROLLER

SATELLITES: SETTING THE WORLD ALIGHT?

AUDIO....C... ..RADIO....ROBOTICS..

electronics today

INTERNATIONAL JULY 1986 VOL 15 NO 7

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Telex 8811896.

FEATURES

PROJECTS

ETCETERA

Due to lack of space, we have had to hold over the final part of Fibre Optics and Lasers until next month. Our apologies.

INFORMATION

Gary Herman: Editor
Ian Pitt: Deputy Editor
Paul Chappell: Project Editor
Jerry Fowler: Technical Illustrator
Paul Stanyer: Ad. Manager
Duncan Neilson
Classified Sales Executive
Andrew Selwood: Copy Control
Dave Bradshaw: Group Editor
– Electronics

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SWITCHES

TOGGLE: 2A 250V
SPST **35p** DPDP **48p**

SUB-MIN TOGGLE

SPST on/off	58p
SPDT c/over	64p
SPDT centre off	85p
SPDT biased both ways	105p
DPDT 6 tags	80p
DPDT centre off	88p
DPDT biased both ways	145p
DPDT 3 positions on/on/on	185p
4-pole 2 way	220p

SLIDE 250V:

DPDT 1A	14p
DPDT 1A c/off	15p
DPDT ½A	13p

PUSH BUTTON 6A 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** (pr).

GAS/SMOKE DETECTORS

TGS812 or TGS813
£6 each
Holders for above **40p**

DIP SWITCHES

(SPST) 4 way **65p**; 6 way **80p**; 8 way **65p**; 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 Amp on/off **88p**

ROTARY: (Make-a-switch)
Make a multiway switch. Shafting 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 **65p**
Mains DP 4A Switch to fit **45p**
Spacers **4p**. Screen **6p**.

ROCKER SWITCHES

ROCKER: 5A/250V SPST	28p
ROCKER: 10A/250V SPDT	38p
ROCKER: 10A/250V DPDT c/off	95p
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	360p

Female IDC Header Jumper Leads 36 inches long

	20pin	26 pin	34 pin	40 pin
Single ended	160p	200p	260p	300p
Double ended	290p	370p	480p	525p

VERO

VERO BOARDS 0.1"

2½ × 1	30p
2½ × 3¾	95p
2½ × 5	110p
3¾ × 3¾	110p
3¾ + 5	125p
3¾ × 17	420p
4¾ × 17	550p
VO Board	195p
DIP Board	395p
Vero Strip	95p

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 **185p**

VERO WIRING

PEN + Spool	380p
Spare Spool	75p
Combs	8p
Pen + Spool + Combs	599p

PHOTO DECs

Veroblock	480p
S Dec	350p
Eurobreadboard	590p
Bimboard	575p
Superstrip S52	1350p

COPPER CLAD BOARDS

	Fibre glass Single-sided	Double-sided
6" × 6"	100p	125p
6" × 12"	175p	225p

DALO ETCH RESIST PEN
Plus spare tip **100p**

FERRIC CHLORIDE
1 lb bag Anhydrous 125 + 50p p&p

EDGE CONNECTORS

	.1"	.156"
2 × 6 way	-	75p
2 × 12 way	-	160p
2 × 15 way	-	165p
2 × 18 way	175p	160p
2 × 22 way	200	170p
2 × 23 way	150p	-
2 × 25 way	250p	245p
2 × 28 way	180p	-
2 × 30 way	280p	-
2 × 36 way	300p	-
2 × 40 way	320p	-
2 × 43 way	400p	-
2 × 75 way	600p	-

DIL SOCKETS

Pin	Low Prof	Wire Wrap	Turned Pin
8	8p	20p	18p
14	10p	23p	28p
16	10p	40p	28p
18	16p	40p	33p
20	20p	58p	37p
22	22p	60p	39p
24	25p	68p	42p
28	28p	78p	52p
40	30p	89p	72p

ANTEX SOLDERING IRON

C-15W	600p	CS17W	820p
G-18W	620p	XS25W	650p
Spare tips, assorted size			100p
Spare elements			245p
Iron stand with sponge			195p

SIL SOCKET
0.1" pitch 20 way **65p**

IDC CONNECTORS

	PCB with Pins Strt	Plugs latch Pins Angle	Female Header Plug	Female Card Edge Conct
10 way	65p	65p	65p	100p
16 way	75p	75p	60p	—
20 way	90p	90p	95p	165p
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

EURO CONNECTORS

Gold Flashed Contacts	Female Strt Pins	Socket Angle Pins	Male Strt Pins	Plug Angle Pins
DIN41617 31 way	125p	—	—	175p
DIN41612 2 × 32 A + B	200p	—	175p	—
DIN41612 2 × 32 A + C	225p	—	185p	210p
DIN41612 3 × 32 A + B + C	260p	290p	295p	300p

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

ZIF TEXTOOL DIL SOCKETS

24 pin	550p
28 pin	695p
40 pin	800p

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	60p
34 way	60p	85p
40 way	70p	90p
50 way	100p	135p
64 way	120p	160p

'D' CONNECTORS

	9 way	15 way	25 way	37 way
Male				
Solder lugs	55p	80p	120p	150p
Angle pins	110p	175p	225p	300p
PCB pins	100p	100p	160p	250p
Female				
Solder lugs	90p	125p	180p	275p
Angle pins	150p	200p	260p	390p
PCB pins	100p	125p	195p	355p
Covers	75p	70p	70p	65p

IDC 25 way 'D' Plug **385p**; Socket **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

AMPHENOL CONNECTORS

	IDC	SOLDER
24 way IEEE plug	465p	460p
24 way IEEE skt	485p	480p
36 way Centronics plug	375p	390p
36 way Centronics skt	480p	450p

PANEL METERS

FSD
60 x 46 x 35mm
0–50μA
0–100μA
0–500μA
0–1mA
0–5mA
0–10mA
0–50mA
0–100mA
0–500mA
0–1A
0–2A
0–25V
0–50V
0–300V AC
520p

CRYSTALS

32.768KHz	100
100KHz	400
200KHz	370
455KH	370
1MHz	265
1.008M	275
1.28MHz	450
1.6MHz	200
1.8MHz	545
1.8432M	210
2.0MHz	225
2.4576M	200
3.12MHz	240
3.278M	150
3.5794M	95
3.6864M	300
4.0MHz	140
4.032MHz	280
4.19430M	150
4.433619M	100
4.608MHZ	200
4.80MHz	200
5.0MHz	150
5.185MHz	300
5.24288M	390
6.0MHz	125
6.144MHz	140
6.5536MHz	225
7.0MHz	150
7.168MHz	175
7.68MHz	200
8.0MHx	140
8.089333M	395
8.86723M	175
9.00MHz	200
10.0MHz	170
10.24MHz	200
10.5MHz	250
10.7MHz	150
12.0MHz	150
12.528M	300
14.31814M	170
15.0MHz	155
16.0MHz	200
18.0MHz	150
18.432M	150
19.968MHz	150
20.0MHz	150
24.0MHz	150
24.930MHz	325
26.69M	150
27.648M	170
27.145M	160
38.6667M	240
48.0MHz	240
100.0MHz	295

RELAYS

Miniature, enclosed, PCB mount.

SINGLE POLE Changeover
RL-91 205R Coil; 12V DC, (10V5 to 19.5V), 10A at 30V DC or 250V AC **195p**

DOUBLE POLE Changeover, 6A 30V DC or 250V AC
RL-113 53R Coil, 6V DC (5V4 to 9V9) **190p**
RL6-111 205R Coil, 12V DC (10V7 to 19V5) **195p**
RL6-114 740R Coil, 24V DC (22V to 37V) **200p**

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- 8 Ohm

2in, 2½in, 2¼in, 3in	60p
2½in 40Ω, 64Ω or 80Ω	60p
6" × 4" 8Ω	200p
7" × 5" 8Ω	225p
8" × 5" 8Ω	250p

VIDEO MONITORS

- ZENITH — 12" Green, Hi-Resolution Popular **£76**
- MICROVITEC 1431. Standard Res. Colour RGB input 14" incl cable **£176**
- MICROVITEC 1451. 14" Medium 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

BT TELEPHONE CONNECTOR

LJU 1/4A	Mini Line Master	435p
LJU 1/6A	Mini Line Slave	295p
LJU 2/4A	Line Master	370p
LJU 2/6A	Line Slave	250p
LJU 3/4A	Flush Master	370p
LJU 3/6A	Flush Slave	240p
LJU 10/3A	Dual Splitter	475p
4 WAY BT Plug		65p

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/0.2A **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/1A3; 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; 2x6V/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 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	—	—
12V	78L12	30p	79L12	45p
15V	78L15	50p	79L15	45p

ICL7660	245p	TAA550	50p
RC4194	375p	TDA1412	150p
RC4195	160p	TL497A	185p
LM309K	135p	78H05 +5V/5V	550p
		78H12+12V/5A	695p
LM317K	250p		
LM317KP	450p	78HG+5V to+25V/5V 5A	550p
LM323K	450p		
LM337	175p	79HG-5V to-24V/5A	765p
LM723 Var	30p		
78S40	225p		

SOLDERCON PINS
Ideal for making SIL or DIL Sockets

100 pins	35p
500 pins	100p

ALUM BOXES

3 × 2 × 1"	65p
4 × 2½ × 2"	100p
4 × 2½ × 2½"	103p
4 × 4 × 2"	105p
4 × 4 × 2½"	120p
5 × 4 × 1½"	99p
5 × 4 × 2½"	120p
5 × 2¾ × 1½"	90p
5 × 2¾ × 2½"	130p
6 × 4 × 2"	120p
6 × 4 × 3"	150p
7 × 5 × 3"	160p
8 × 6 × 3"	210p
10 × 4 × 3"	240p
10 × 7 × 3"	275p
12 × 5 × 3"	260p
12 × 8 × 3"	295p

CMOS

4000	20	4075	25	4543	65
4001	20	4076	60	4548	40
4002	20	4077	25	4549	390
4006	70	4078	25	4553	210
4007	25	4081	20	4554	160
4008	60	4082	20	4555	50
4009	40	4085	60	4556	50
4010	40	4086	60	4557	250
4011	20	4089	120	4558	120
4012	20	4093	25	4559	340
4013	30	4094	70	4560	110
4014	50	4095	70	4561	104
4015	40	4096	100	4562	350
4016	25	4097	260	4566	160
4017	40	4098	70	4568	250
4018	55	4099	110	4569	175
4019	40	4160	95	4572	45
4020	50	4161	96	4580	255
4021	55	4162	96	4581	125
4022	60	4163	95	4582	99
4023	20	4174	96	4583	100
4024	35	4175	105	4584	40
4025	20	4194	105	4585	65
4026	90	4408	650	4597	330
4027	30	4409	650	4599	155
4028	40	4410	725	40085	90
4029	45	4411	750	40097	45
4030	20	4412	805	40098	42
4031	125	4415	590	40100	215
4032	65	4419	280	40101	130
4033	130	4422	770	40102	100
4034	145	4435	650	40103	412
4035	70	4440	900	40104	120
4036	250	4450	360	40105	220
4037	115	4451	350	40106	40
4038	75	4490	450	40107	50
4039	270	4500	395	40108	325
4040	45	4501	40	40109	100
4041	55	4502	50	40110	235
4042	45	4503	45	40114	240
4043	45	4504	100	40161	150
4044	50	4505	250	40163	75
4045	110	4506	100	40173	100
4046	60	4507	45	40174	75
4047	50	4508	130	40175	60
4048	50	4510	55	40181	220
4049	25	4511	55	40182	80
4050	25	4512	55	40192	75
4051	50	4514	150	40193	90
4052	40	4515	115	40194	70
4053	60	4516	115	40195	75
4054	70	4517	50	40244	150
4055	70	4518	275	40245	150
4056	70	4519	50	40257	196
4057	1000	4520	35	40373	220
4059	400	4521	50	40374	220
4060	70	4522	110	45106	566
4061	500	4526	125		
4062	986	4527	70		
4063	80	4528	60		
4066	25	4529	45		
4067	230	4530	60		
4068	20	4531	90		
4069	20	4532	120		
4070	22	4534	65		
4071	20	4536	365		
4072	20	4538	250		
4073	20	4539	60		
		4541	60		
			85		

OPTO ELECTRONICS

LEDs with clips

TIL209	10
TIL211 GRN	14
TIL212 Yel.	14
TIL220 2" Red	12
2" Green, Yellow or Amber	14
0.2" Bi colour Red/Green	100p
Green/Yellow	115p
0.2" Tri colour Red/Green/Yellow	85
Hi-Brightness Red	58
High-Bri Green or Yel	68
Flashing red 0.2" red	55
Square LEDs. Red. Green, Yellow	30
Rectangle Stackable LEDs Red, Green or Yellow	18
Triangular LEDs Red	16
Green or yellow	22
LD271 Infra Red	48
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
ILQ74	275
TIL111/2/4	70
ILCT6 Darlington	135
TIL117	125
4N33 Photo Darlington	136

7 Segment Displays

TIL312 .3" CA	120
TIL313 .3" CC	120
TIL321 .5" CA	140
TIL322 .5" CC	140
TIL729/730	140
DL704 .3" CC	125
DL707 .3" CA	125
FND357 Red	120
FND500	130
.3" Green CA	150
.6" Green CA	215
.3" ± 1 Red CA	150
.3" ± 1 Green CA	150
LCD 3½ Digits	496
LCD 4 Digits	530
LCD 6 Digits	625

OPTO

OCP71	120
ORP12	85
ORP61	66
BPX25	200
BPW21	320
TIL139	225

REFLECTIVE Optical Switch 225
SLOTTED Optical Switch similar to RS Components 295

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SPECIAL OFFER

	1+	10+
2764-250nS	185p	175p
27128-250nS	245p	235p
6116LP-3	170p	145p
6264LP-150nS	315p	305p

COMPUTER CORNER

BBC Master 128K Microcomputer	£425
Seikosha GP50A & GP50S Printers	£69
EPSON LX80 Dot matrix Printer	£188
LX80 Tractor Feed Attachment	£20
LX80 Cut Sheet Feeder	£49
Epson FX85 Dot matrix Printer	£315
Centronics GLP (NLQ) Printer	£99
Tractor feed attachment for GLP	£9
KAGA/TAXAN KP810 Printer	£175
KAGA/TAXAN KP910 Printer	£339
Brother HR15 Daisy Wheel Printer	£285

Securicor Carriage on above	£7
Cable for above Printers to interface to BBC Micro	£6
TEX EPROM ERASER with Safety switch. Erasers up to 25 EPROMS	£28
Spare UV Lamp (Bulb)	£8

CALL IN AT OUR RETAIL SHOP FOR A DEMONSTRATION OF ANY OF THE ABOVE PRODUCTS. BE SATISFIED BEFORE YOU BUY. YOU MAY WRITE IN FOR OUR DESCRIPTIVE MICRO CATALOGUE.

5¼" Disc Drives for the BBC

(All Drives are supplied cased with Power Supply and Utilities Disc

- **CS200** — Epson Single 200K, 40 track Double sided £116
- **CS400S** — Mitsubishi Single 400K, Double sided 40/80 track switchable £124
- **CD400** — Epson dual 400K, 40 track, Double sided £205
- **CD800S** — Mitsubishi dual 800K, Double sided 40/80 track switchable £219
- **TWIN Disc drive case** with Power supply and Cables to house your own drives £35
- All Single Drives with Power supply are supplied in a twin case for later inclusion of a second drive.
(Securicor Carriage on Drives £7)
- **DISC INTERFACE KIT** complete £47
- **DFS Manual** (comprehensive) (NO VAT) £7

Top Quality 5" Discs

10 × M4 Single Side Double Density 40 track	£10
10 × M5 Double Side Double Density 40 track	£12
10 × M7 Double Side Double Density 80 track	£17

SPDOS

The only professional Disc Interface for the Spectrum Micro.

SPECIAL OFFER £60

GANG OF EIGHT EPROM PROGRAMMER

Copies up to eight at a pass, 2716 to 27256. EPROM type is set by switches. Erasure is checked automatically. Simple control. Alpha liquid crystal display. Cheksum facility 6 hex digits. FAST or NORMAL programming.
£385

MENTA — The Z80 TUTOR

Designed for Schools and Colleges to teach Z80 Machine code. Menta uses TV for display. Shows STACK & PROGRAM in HEX. Editing facility includes: direct keyboard ASSEMBLER, RS-232 Output DISASSEMBLER. Used to write & debug short machine code routines. Menta is a complete controller with 24 bits of I/D used for ROBOTICS.
£99

BBC & MICROCOMPUTER & ACCESSORIES

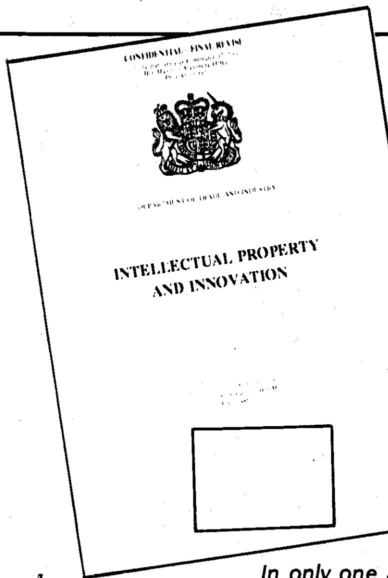
BBC Master 128K **£425**

We stock the full range of BBC Micro peripherals, Hardware & Software like, Disc Drives (Top quality Epson & Mitsubishi), Diskettes, Printers, printer, Paper, Interface Cable, Dust Covers, Cassette Recorder & Cassettes, Monitors, Connectors (Ready made Cables, Plugs & Sockets), Plotter (Graphic Tablet) EPROM Programmer, Lightpen Kit, Joysticks, Sideways ROM Board, EPROM Eraser, Machinecode ROM. The highly sophisticated Watford's 16K BEEB DFS, WORDWISE, BEEB-CALC, Software (Educational Application & Games), BOOKs, etc, etc, Please send SAE for our descriptive leaflet.

DIGEST

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.



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 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 fuctional 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 copright 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.

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 ¼" 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 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.

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.

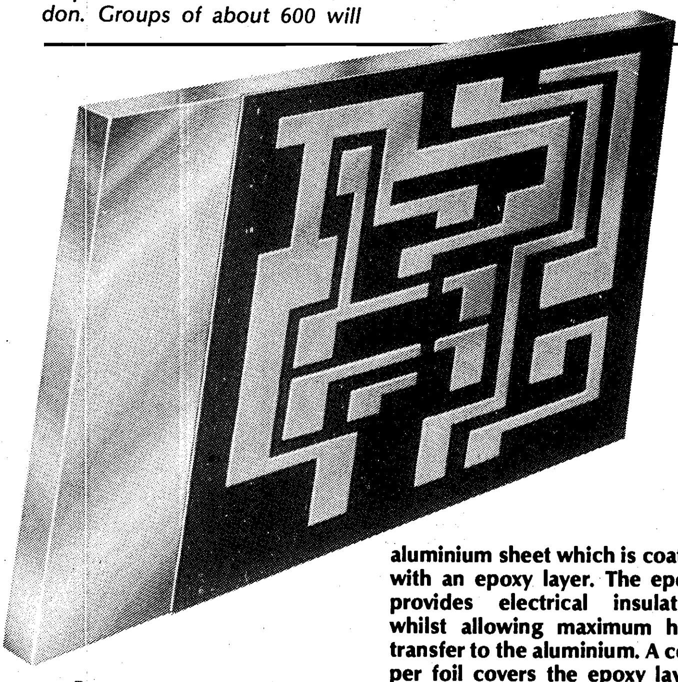
The ride is now in its eleventh year. It started as an informal event with just 35 participants and last year attracted over 21,000, many taking part in fancy dress and using some rather unconventional forms of transport. The £400,000 raised went to support cardiac care groups.

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 213S 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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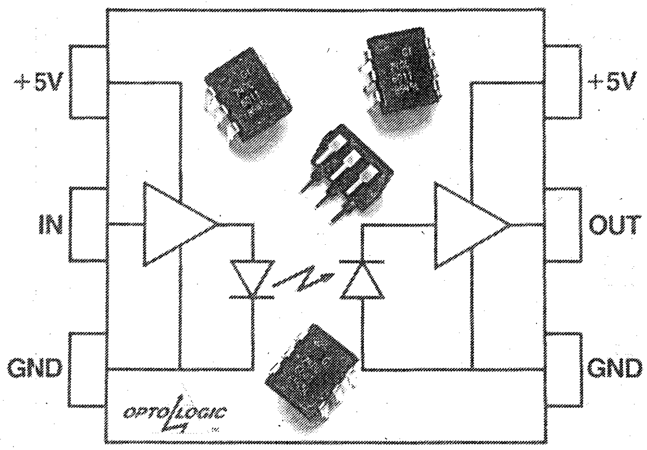


Logic-To-Logic Optoisolator

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, Opto-electronics 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.

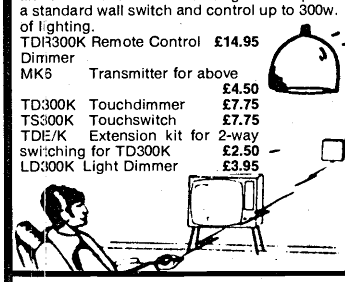
The new arrangement will mean that some boards currently on the list will have to be dropped because they are simply not selling in sufficiently large numbers. How ever, we will contine to make sure that boards remain available for at least a year after an article is published.

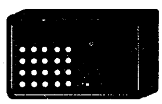
We have also revised the pricing structure to remove some of the anomalies. At present, some small boards actually cost more than some larger boards. We are adjusting prices up and down as appropriate to rectify this situation.

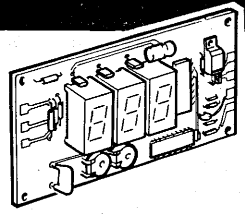
● **Graham Nalty, whose Upgradeable Amplifier is currently running as a project in ETI, tells us that he has access to custom case-building facilities. This might prove useful to those who are still missing parts of the case for their JLLH Audio Design amplifiers. Anyone interested should contact Graham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

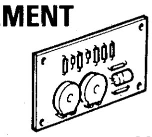
● Spectrastrip is a flat cabling system which allows power, data and telephone wiring to be laid under carpeting with the minimum of trouble. A full set of complementary connectors is also available and the complete system is described in a 4-page brochure which is available on request. Contact Amphenol Ltd, Thanet Way, Whitstable, Kent CT5 3JF, tel 0227 - 26441.

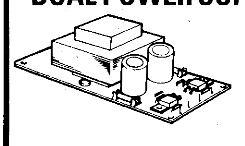
● *Hawnt Electronics describe themselves as the UK's leading passive component supplier. Their new 272-page catalogue is now available and can be obtained from them at Firstwood Road, Garret Green, Birmingham B33 OTQ, tel 021-784 3355.*











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 Exhbitions 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.

ETI

01-208 1177 TECHNOMATIC LTD 01-208 1177

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AMC06 Turbo (65C102) Expansion Module .... **£87** (b)
ADF13 Rom Cartridge .... **£13** (d)
ADF10 Econet Module .... **£49** (c)
ADJ22 Ref. Manual Part I ..... **£14.50** (c)
ADJ23 Ref. Manual Part II ..... **£14.50** (c)
ADJ24 Advanced Ref. Manual . **£19.50** (c)

ACORN ADD-ON PRODUCTS
Z80 2nd Processor .... **£329** (a)
6502 2nd Processor............ **£162** (b)
Multiform Z80 2nd Processor... **£299** (b)
Acorn Teletext Adaptor .... **£125** (b)
Acorn IEEE Interface .... **£278** (a)

UPGRADE KITS
1770 DFS Upgrade for Model B **£43.50** (d)
Dual Disc Controller Board for Model B incl. 1770 controller .... **£35** (c)
1.2 OS ROM .... **£7.50** (d)
DNFS ROM .... **£17.50** (d)
ADFS Rom (for B with 1770 DFS & B Plus .... **£26** (d)

64K Upgrade Kit for B Plus .... **£35** (d)

ECONET ACCESSORIES
Econet Starter Kit .... **£85** (d)
Econet Socket Set .... **£34** (c)
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File Server Level 1 .... **£75** (d)
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Printer Server Rom .... **£41** (d)
10 Station Lead set .... **£26** (c)
Adv. Econet User Guide .... **£10** (d)

COMMUNICATIONS ROMS
Termulator .... **£25** (d)
Communicator .... **£49** (d)
Commstar .... **£28** (d)
DATABEEB .... **£24** (d)

BBC FIRMWARE & SOFTWARE
Database Management Systems. Word Processors, Languages, Spreadsheets, Utilities
ZFP .... **£229** (a)
TZDP 240 ZEP 100 with Technomatic PDP800P dual drive with built in monitor stand .... **£469** (a)
For full details on the wide range of above packages please write to us.

TORCH UNICORN products including the IBM Compatible GRADUATE in stock
For detailed specification or information on our comprehensive BBC range please write to us.

DISC DRIVES

These are fully cased and wired drives with slim line high quality mechanisms. Drives supplied with cables manuals and formatting disc suitable for the BBC computer. All 80 track drives are supplied with 40/80 track switching as standard. All drives can operate in single or dual density format.

PD800P (2 × 400K/2 × 640K 40/80T DS) with built in monitor stand .... **£249** (a)
PD800P (2 × 400K/2 × 640K 40/80T DS) .... **£269** (a)
TS400 1 × 400K/1 × 640K 40/80T DS .... **£109** (b)
PS400 with psu 1 × 400K/1 × 640K 40/80T DS .... **£129** (b)

3.5" DRIVES
1 × 400K/1 × 640K 80T DS TS35 1 .... **£109** (b)
PS35 1 with psu .... **£124** (b)
2 × 400K/1 × 640K 80T DS TD35 2 .... **£199** (b)
PD35 2 with psu .... **£219** (b)

3M FLOPPY DISCS

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.

5¼" DISCS
40 SS DD £10:50 (d)
80T SS DD £14.75 (d)
40T DS DD £12:75 (d)
80T SS DD £16:00 (d)

3½" DISCS
80T SS DD £18 (d)
80T DS DD £25 (d)

PRINTERS

EPSON

LX-80NLQ .... **£195** (a)
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)
Integrex Colour Printer ..... **£549** (a)

PLOTTERS
Epson H180: A4 4 colour Plotter.... **£345** (a)

TAXAN
KP810 80 Col NLQ £220
KP910 156 Vol NLQ .... **£379** (a)
JUKI 6100 Daisy Wheel... **£289** (a)
HR15LX (Serial).......... **£285** (a)
HR15LX (Serial).......... **£365** (a)

Paper:
2000 Sheets Fanfold:
9.5" x 11" .... **£13** (b)
14.5" x 11" .... **£18.50** (b)
Labels: (per 1000)
3.5" x 1 7/16" Single row .... **£5.25** (d)
2 7/16" x 1 7/16" Triple row .... **£5.00** (d)

ACCESSORIES

EPSON
FX plus sheet feeder .... **£129.00** (b)
LX80 Sheet feeder .... **£49.00** (b)
Paper Roll Holder .... **£17.00** (d)
FX80 Tractor attachment .... **£37.00** (c)
Interfaces: 8143 RS232 .... **£28.00** (c)
8148 RS232 + 2K .... **£57.00** (c)
8132 Apple II .... **£60.00** (c)
8165 IEEE + cable .... **£65.00** (c)
Serial & Parallel Interfaces with larger buffers available.
Ribbons: RX/FX/MX80 .... **£5.00** (d)
RX/FX/MX100 .... **£10.00** (d)
LX80 .... **£6.00** (d)
Spare pens for H180 .... **£7.50**/set (d)
FX80 Tractor Attachment **£37** (c)

KAGA TAXAN
RS232 Interface + 2K Buffer .... **£85** (c)
Ribbon KP810/910 .... **£6.00** (d)

JUKI:
RS232 Interface .... **£65** (c)
Spare Daisy Wheel .... **£14.00** (d)
Ribbon .... **£2.50** (d)
Sheet Feeder .... **£182** (a)
Tractor Feed Attachment .... **£129** (a)

BROTHER HR15:
Sheet Feeder .... **£189** (a)
Tractor Feeder .... **£99** (a)
Ribbons Carbon or Nylon .... **£4.50** (d)
Red Correction Ribbon .... **£2.00** (d)

BBC Printer Lead:
Parallel (42") .... **£7.00** (d)
Serial .... **£7.00** (d)
Printer Leads can be supplied to any length.

DISC ACCESSORIES

FLOPPICLENE Disc Head Cleaning Kit with 20 disposable cleaning discs ensures continued optimum performance of the drives ... 3½" **£16** (d), 5¼" **£14.50** (d)
Single Disc Cable .... **£6** (d)
10 Disc Library Case .... **£1.80** (c)
40 Disc Lockable Box .... **£14** (c)
Dual Disc Cable .... **£8.50** (d)
30 Disc Case .... **£6** (c)
100 Disc Lockable Box .... **£19** (c)

MICROVITEC

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

14" RGB
1431 Std Res .... **£179** (a)
1451 Med Res .... **£229** (a)
1441 Hi Res .... **£375** (a)

14" RGB with PAL & Audio
1431 AP Std Res .... **£199** (a)
1451 AP Med Res .... **£275** (a)

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

20" RGB with PAL & Audio
2030CS Std Res .... **£380** (a) **2040CS** Hi Res .... **£685** (a)

TAXAN 12" RGB

SUPERVISION III with amber/green option ...... **£330** (a)
MITSUBISHI XC1404 14" RGB Med Res IBM & BBC Compatible... **£229** (a)

MONOCHROME MONITORS:

TAXAN KX1201G Hi Res 12" Etched Green Screen .... **£90** (a)
TAXAN KX1203A Hi Res 12" Etched Amber Screen .... **£105** (a)
PHILIPS BM7502 12" Hi Res Green Screen .... **£75** (a)
PHILIPS BM7522 12" Hi Res Amber Screen .... **£79** (a)
Swivel Base for Kaga Monochrome fitted with Digital Clock .... **£21** (c)

MODEMS

— All modems listed below are BT approved

SPECIAL OFFER

MIRACLE 3000:
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)
WS3000 V22 (as above plus 1200 baud full duplex) .... **£495** (b)
WS3000 V22bis2400 (as above plus 2400 baud full duplex) .... **£650** (b)

MIRACLE 2000
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.

SPECIAL OFFER

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

ATTENTION

All prices in this double page advertisement are subject to change without notice.
ALL PRICES EXCLUDE VAT
Please add carriage 50p unless indicated as follows:
(a) £8 (b) £2.50 (c) £1.50 (d) £1.00

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)

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)

Serial Mini Test
Minitors RS232C and CCITT V24 Transmissions, indicating status with dual colour LEDs on 7 most significant lines.
Connects in Line. **£22.50** (d)

GANG OF EIGHT INTELLIGENT FAST EPROM COPIER

Copies up to eight eproms at a time and accepts all single rail eproms up to 27256. Can reduce programming time by 80% by using manufacturer's suggested algorithms. Fixed Vpp of 21 & 25 volts and variable Vpp factory set at 12.5 volts. LCD display with alpha moving message. **£395** (b).

SOFTY II

This low cost intelligent eprom programmer can program 2716, 2516, 2532, 2732, and with an adaptor, 2564 and 2764. Displays 512 byte page on TV — has a serial and parallel I/O routines. Can be used as an emulator, cassette interface.
Softy II .... **£195** (b)
Adaptor for 2764/2564. **£25.00** (c)

UV ERASERS

All erasers with built in safety switch and mains indicator.
UV1B erases up to 6 eproms at a time .... **£47** (c)
UV1T 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)

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

EDGE CONNECTORS

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

AMPHENOL CONNECTORS

	Solder	ZDC
36 way plug	500p	475p
36 way skt	550p	500p
24 way plug IEEE	475p	475p
24 way skt IEEE	500p	500p

PCB Mtg Skt Ang Pin
24 way 700p 36way 750p

RIBBON

(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

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 Lock	130	150	175	-

EURO CONNECTORS

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

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

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

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

TEXTOOL ZIF

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

MISC CONNS

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

4-way **90p** 6-way **105p**
8-way **120p** 10-way **140p**

TECHNOLINE VIEWDATA SYSTEM

Using 'Prestel' type protocols for information and orders phone 01-450 9764. 24 hour service, 7 days a week.

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 Troglograph 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 frame aerials are 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 'eliptical loops' of the magentic 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.*

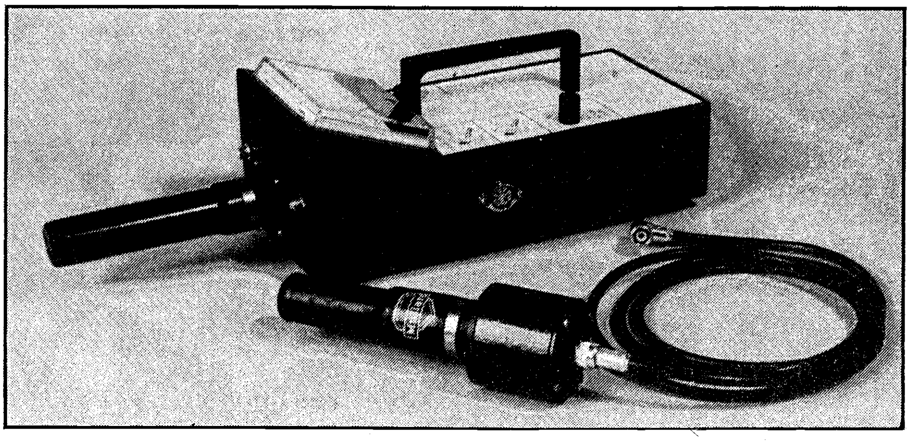
Notwithstanding these technical errors, I am sure Mike has done a good job on producing a piece of working equipment, and that is what it is all about really isn't it? And it is pleasing to see an original project of this sort in ETI.

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.



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.

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 produces in air, under specified conditions, ions carrying ⅓ x 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

far as genetic damage is concerned, there is no safe limit, but the incidence of observable effects rises rapidly for an exposure of more than about 10R over 30 years. From background radiation, the dose to be expected over that time is about 4R, so the margin is very small.

Other units of dosage you may see bandied about in the press are: the rad (radiation absorbed dose) which is 10^{-5}J of absorbed energy per gram of absorbing material, and the rem (roentgen equivalent man) — a unit which takes into account the fact that different types of radiation cause widely differing amounts of damage for the same absorbed energy. Table 1 gives a rough indication of the RBE (relative biological effectiveness) — a nauseating term — of various types of radiation. Alpha particles, for instance, cause 10 to 20 times as much damage for a given energy as gamma rays. The biological dose in rems is calculated by multiplying the absorbed dose in rads by the RBE for the radiation concerned.

Radiation dosage over a period of time is conveniently measured by a device called a dosimeter. A low cost quartz fibre dosimeter is available from

Radiation Type	RBE
X-ray, gamma ray, beta ray	1
Thermal neutrons	2-5
Fast neutrons	10
Alpha particles, high energy ions	10-20

Table 1 A comparison of the relative biological effectiveness (RBE) of different types of radiation.

Audio Electronics, 301 Edgware Road, London W2 1BN (tel: 01-724 3564) for around £7. It looks like a fat fountain pen, and clips to your pocket in a similar way, so it can be carried around at all times. At one end is a lens, giving a view of a scale reading from zero to 5R. The ionisation caused by radiation entering the tube gradually causes it to discharge, moving a pointer across the scale, from which you can read your total radiation dosage.

In the current situation, the main concern is the radioactive material which is finding its way into milk, water and food. A dosimeter is of little use in testing radiation levels directly — if you left it next to some contaminated milk for a week, it would no doubt discharge, but by then the milk would be sour anyway. An indication of the degree of contamination can be obtained by using a Geiger counter. ETI's technical wizards came up with the circuit in Fig. 1 when asked to design one on the spur of the moment.

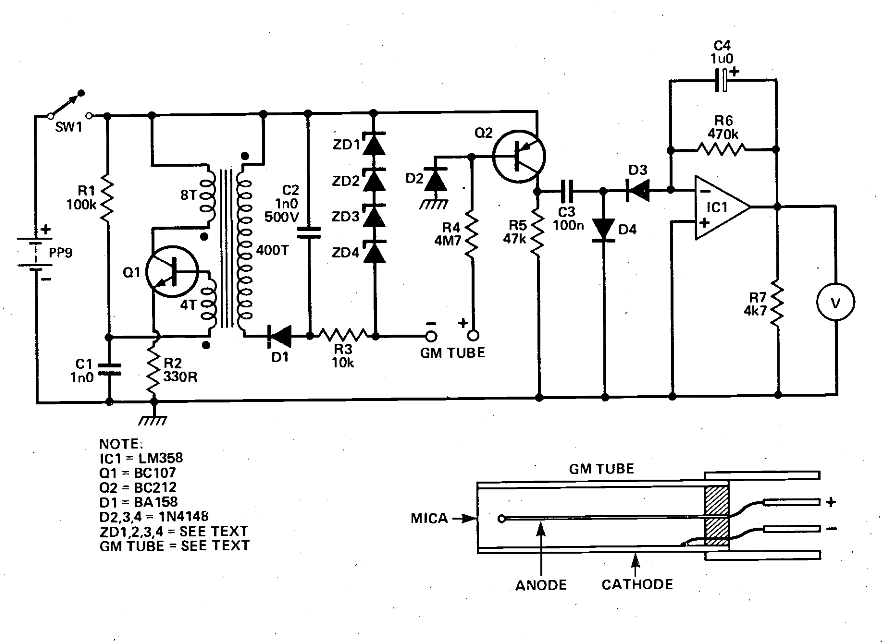


Fig. 1 Circuit diagram of a simple ratemeter.

I should point out that the circuit has not been entirely tested but it should certainly work with the minimum of attention. Strictly speaking, it is a rate meter rather than a Geiger counter, but it would be a simple matter to feed the pulses from Q2 into a counter IC instead.

The coil can be wound on a small pot core, taking a little care over the insulation of the secondary winding, since it produces about 450V. ZD1 to ZD4 are chosen to suit the particular GM tube used — the sum of their voltages should be equal to the tube's recommended operating voltage. GM tubes can be obtained from: Alrad Instruments, Turnpike Rd. Ind. Est., Newbury, Berks RG13 2NS. A general purpose gamma sensitive tube, the ZP1200, costs £45.30 inclusive of postage and VAT.

GM (Geiger Muller) tubes vary in construction, but typically consist of a tungsten anode in the centre of a tubular cathode — a metal cylinder or sometimes a layer of graphite on the inside of a glass tube. The window allows alpha and beta particles to enter with the minimum of obstruction and in some very sensitive tubes the window can be extremely fragile, and may admit ultra violet light, which can also trigger the tube. The best bet is to buy a low cost, general purpose tube, which will be quite adequate for testing your vegetables, and will give fewer spurious readings.

Inside the tube will be an inert gas, often neon, at a low pressure — around 10cm. Hg. In circuit, the applied voltage should be high enough to prevent recombination of any ions formed by radiation entering the tube, but low enough not to exceed the dielectric strength of the gas. The tube will have a recommended range of operating voltages, so choose a voltage towards the centre of the range and fit the zeners accordingly.

Any radiation entering the tube will cause ionisation of the gas. Electrons from the ionisation will be accelerated towards the anode, producing more ions by collision on the way. This secondary ionisation produces more electrons, which produce yet more ions, and so it continues in geometric progression. A single charge in the tube will be enough to trigger a substantial discharge which can be detected as a sudden burst of current from the anode, amplified in our circuit by Q2.

The relatively massive positive ions drift more slowly towards the cathode, taking around 100μS to reach it — by this time they will have considerable energy, and if left to their own devices would cause more electrons to be liberated from the cathode, giving continuous conduction. To prevent this, a quenching agent such as bromine is mixed in low concentration with the neon, to absorb the energy from the positive ions. This process has the unfortunate consequence of making the tube fairly slow to recover after a discharge — around 200μs is needed between discharges if the tube is to behave correctly. If the radiation is too intense, the tube will 'freeze' or 'jam' in a state of continuous conduction. This certainly will not happen in testing your milk contamination, but should be borne in mind if using the meter for other purposes. — Auntie.

ETI

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 inter-dependency 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 aerials 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.

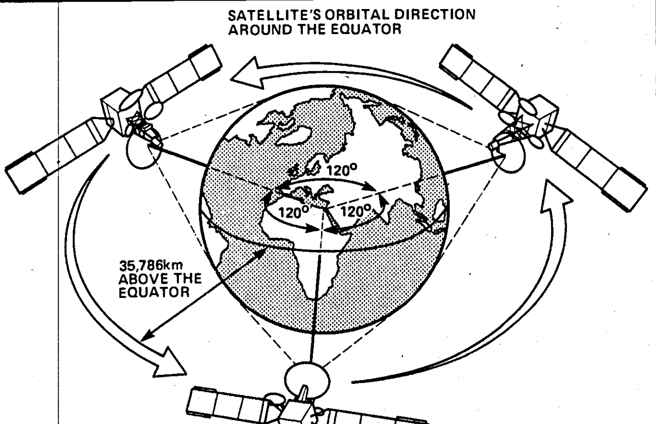


Fig. 1 A satellite in the GSO can transmit radio frequencies with a coverage area of about one third of the earth's surface.

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 aerials 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 here by 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.

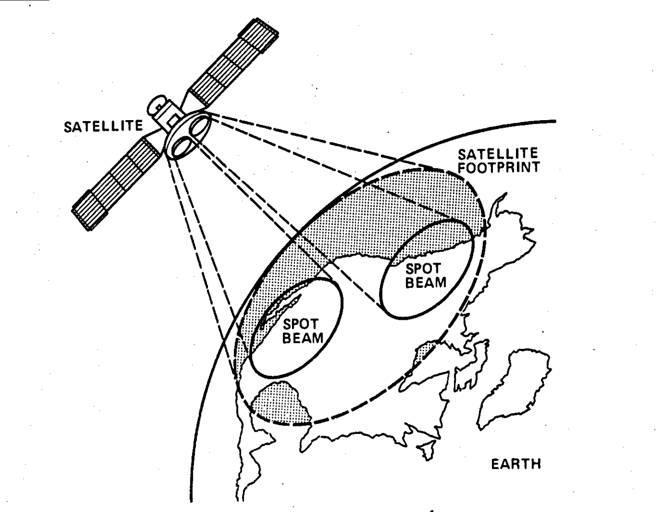


Fig. 2 A satellite in the GSO with a spot-beam can be used to transmit to selected areas of the earth's surface.

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.

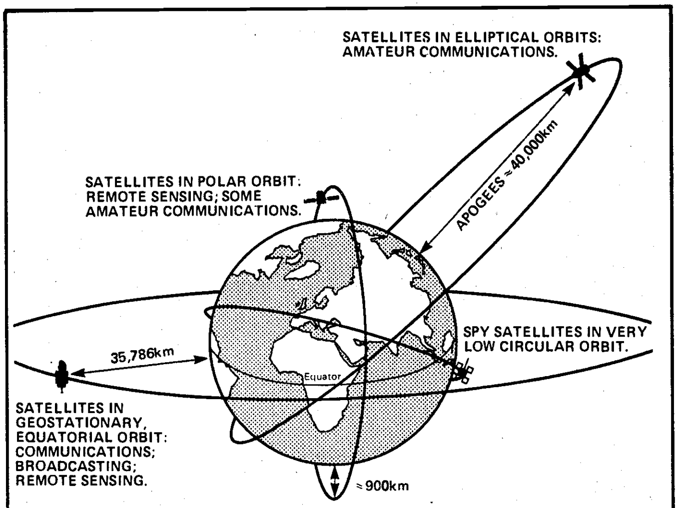


Fig. 3 A variety of possible satellite orbits and uses. Remote sensing satellites usually fly a circular polar orbit, at a height of around 900 km above the earth's surface. Communications satellites are usually in the GSO.

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 aerials 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.

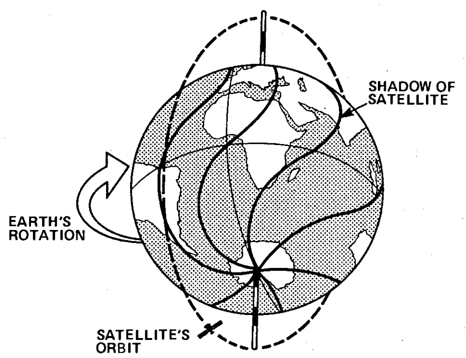


Fig. 4 A circular polar orbiting satellite will cover most of the earth's surface in a number of orbits.

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 554km with a 95 minute period. OSCAR-11 (UoSAT2) is at an altitude of 700km, with a period of 98 minutes. Both satellites transmit telemetrical data at a frequency of 145.825MHz so reception is fairly simply, 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 telemetrical 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 necessary 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.

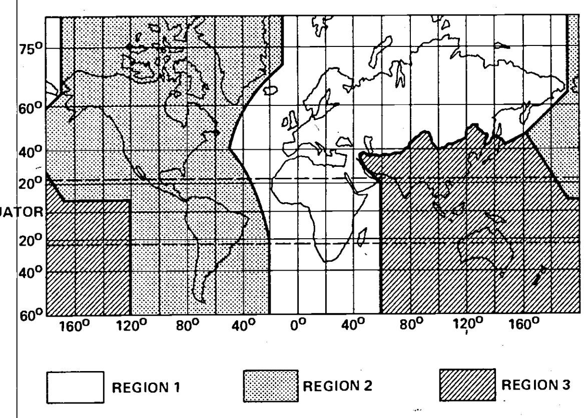


Fig. 5 The three world regions, defined by the International Telecommunications Union, for frequency allocation purposes.

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 longtitude, however, the 'midnight' black-out 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.

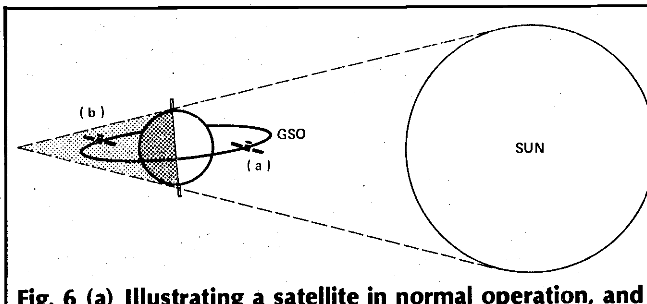


Fig. 6 (a) Illustrating a satellite in normal operation, and (b) a satellite which is in a solar eclipse. A broadcast satellite in this situation cannot transmit as its circuits are solar powered.

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 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 problably 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**

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.

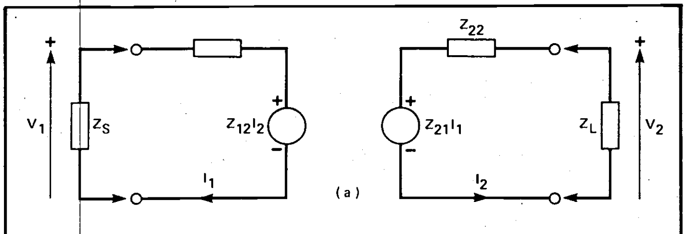


Fig. 1 (a) Equivalent impedance circuit, (b) equivalent admittance circuit.

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:

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

$$Y_{11} = Z_{11}/\triangle Y / Y_{12} = -Z_{12}/\triangle Z / Y_{22} = Z_{11}/\triangle Z / Y_{21} = Z_{21}/\triangle Y$$

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

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:

$$A_V = V_2/V_1$$

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:

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

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

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

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

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 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):

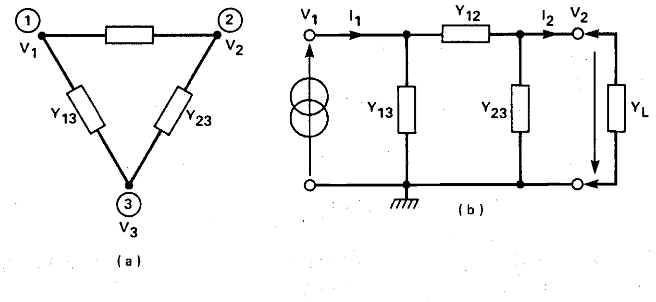


Fig. 2 Indefinite nodal admittance example circuit and its definite equivalent.

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

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

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

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

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

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:

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

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 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 x 4 with elements Y_{ij}. Thus:

$$I_i = Y_{ij}.V_j.$$

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:

$$I_iY_{44}-I_4Y_{14} = Y_{ij}Y_{44}-Y_{i4}Y_{4j}.V_j.$$

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 x 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 horizonal 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 reactance. 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 PROCphasemod(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.

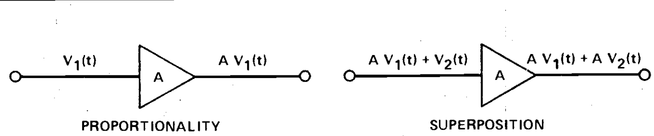


Fig. 5 Superposition and proportionality define linearity.

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, industry 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 reqire help, and to help staff clarify ethical and inter-personal issues for themselves.

Coming up against the military machine?

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

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

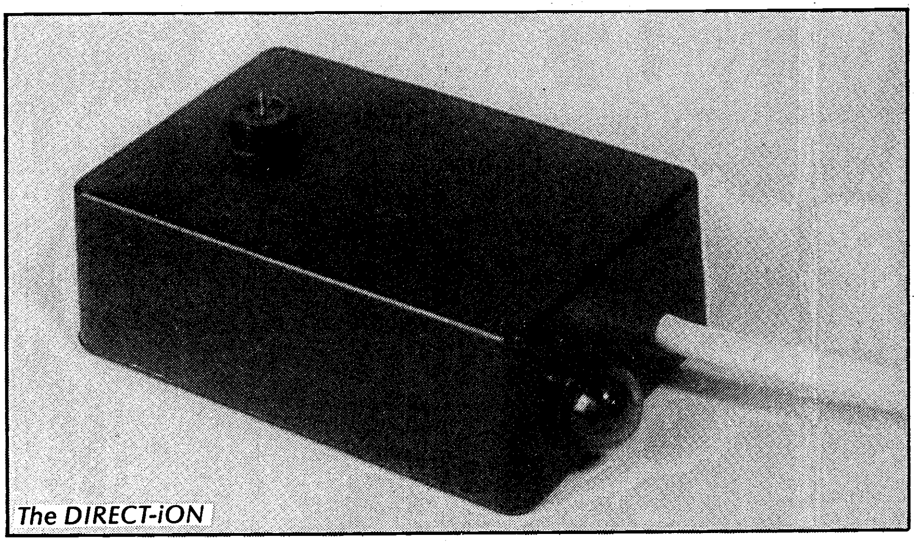
Experiments in restoring the natural ion balance have led to the conclusion that negative ions are the essential 'vitamins of the air'. Positive ions in high concentration have an initial stimulating effect which is followed, after a few hours, by fatigue and possibly headaches. Negative ions have been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

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.

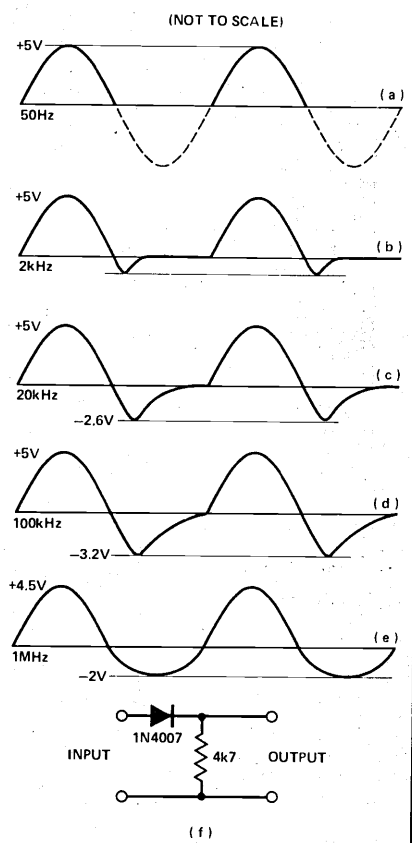


Fig. 1 The performance of the rectifier diminishes with frequency.

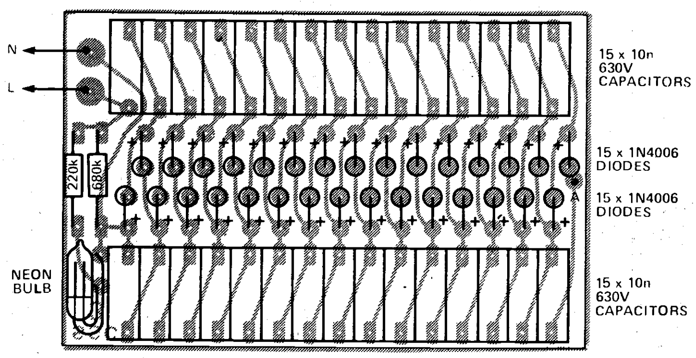


Fig. 2 Component overlay for the ionizer.

After soldering in the resistors, insulate about ½" 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.

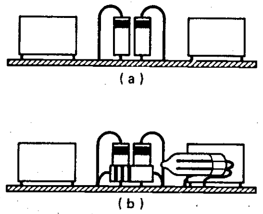


Fig. 3 End views of components on PCB.

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 case, you can easily determine your own hole positions.

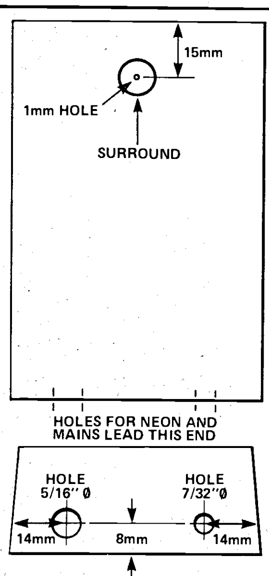


Fig. 4 Drilling the T3 case.

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 (¼W, 5% unless stated)

R1	**680k**
R2	**220k**
R3-R7	**2M7 ½W**

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 1mm 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.

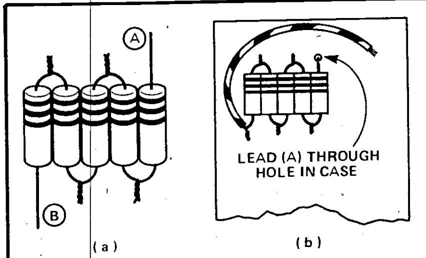


Fig. 5 The resistor assembly is mounted in the case.

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 jointed to the 2M7 resistors — to point X in Fig. 2.

Remove about ⅜" 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 10n 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 ½" 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

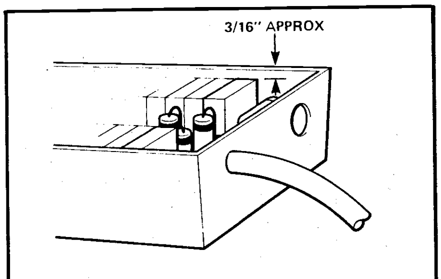


Fig. 6 The PCB inside the case.

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 ⅜" 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 netural 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!

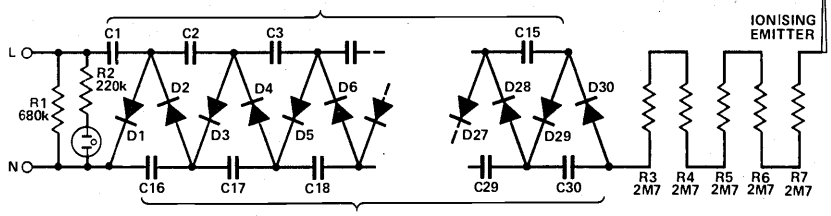
Improvements in health due to ionization occur over several days, rather than at the first breath of ionized air. The best position for an ionizer is by the bedside, where

HOW IT WORKS

The circuit is a standard Cockroft-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.



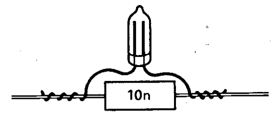


Fig. 7 Abbreviated circuit of ionizer and a simple tester.

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. **ETI**

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

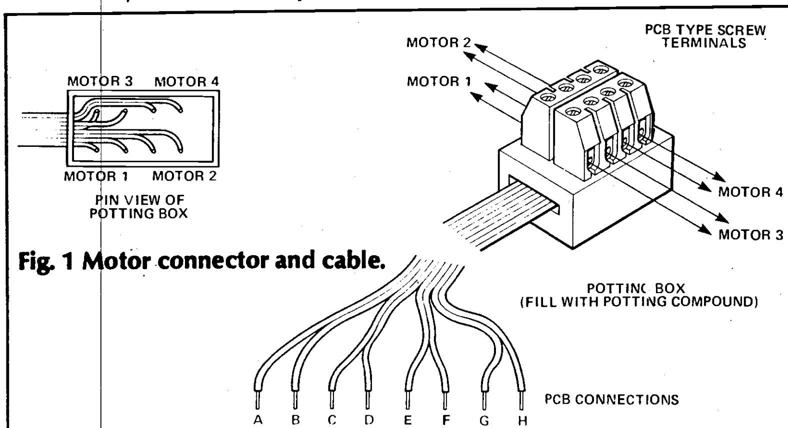


Fig. 1 Motor connector and cable.

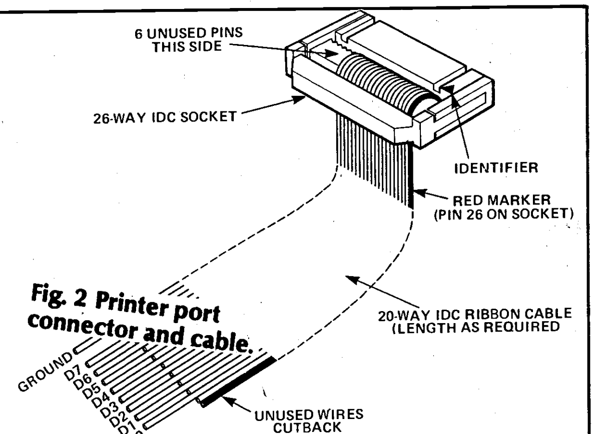


Fig. 2 Printer port connector and cable.

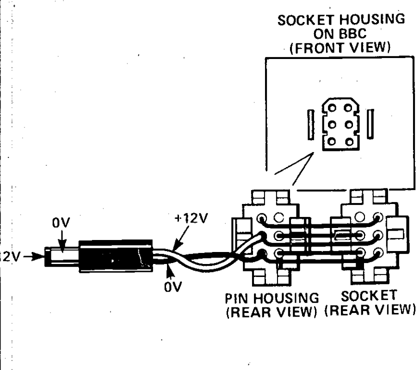


Fig. 3 Supplying power from the BBC.

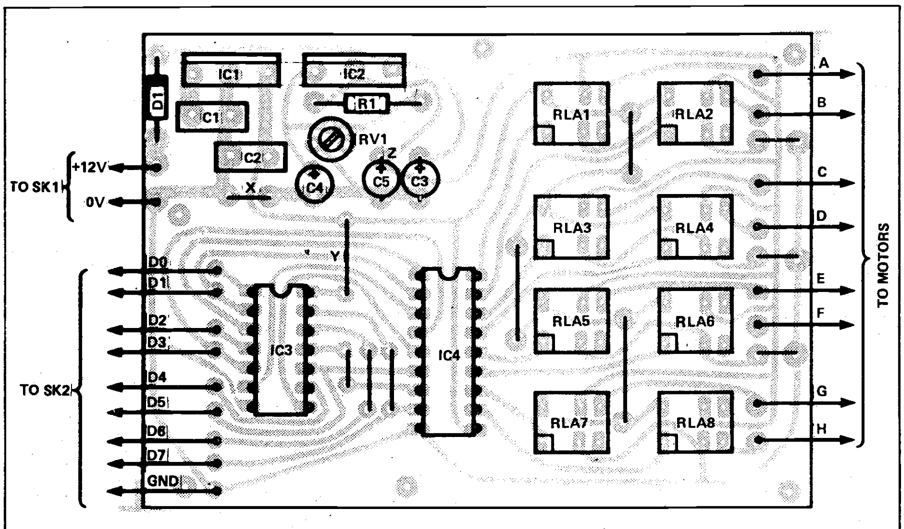


Fig. 4 Component overlay for the interface.

power leads from the 2.1mm 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.

PARTS LIST

RESISTORS	
R1	**240R ½W**
RV1	**2k0 cermet**
CAPACITORS	
C1	**330n ceramic**
C2	**100n ceramic**
C3, 5	**4µ7 16V tant**
C4	**22µ 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).

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 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 simultanteous control of more than one motor.

If the PROGRAM option is selected from the menu, PROCprogram is jumped to. This also detects presees 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 occurences of step%(X)= are skipped over.

Control Basic

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

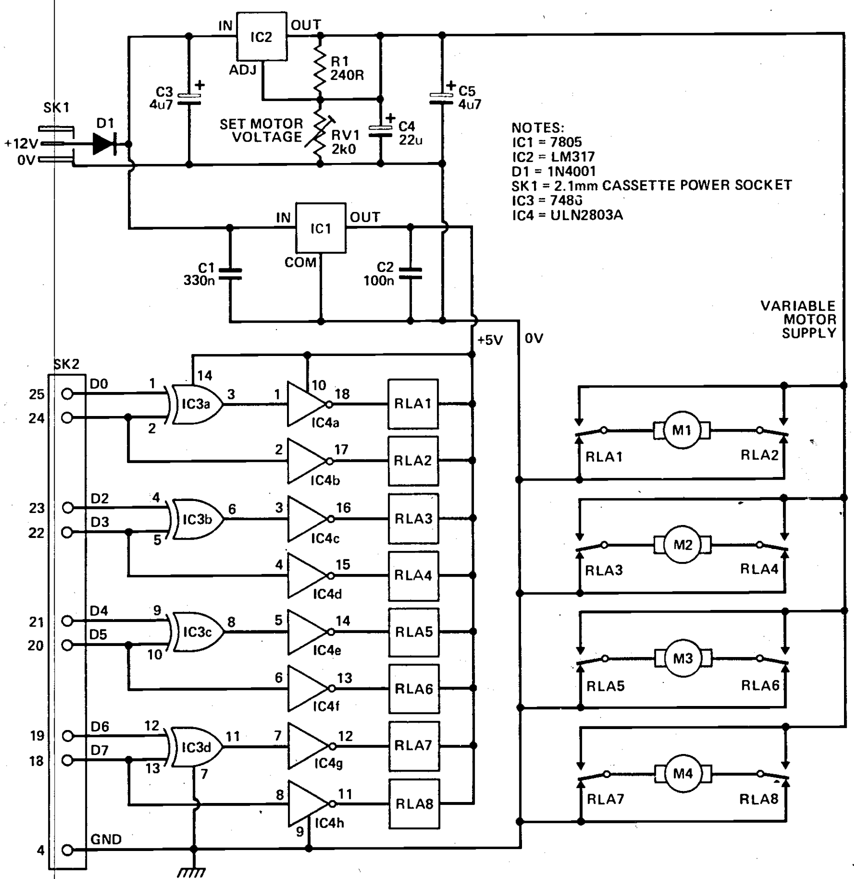


Fig. 5 Circuit diagram of the interface.

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 accidently 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.

Fig 6 Standard motor control truth table.

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

Fig. 8 Truth table for the interface.

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

0 = DE-ENERGISED
1 = ENERGISED

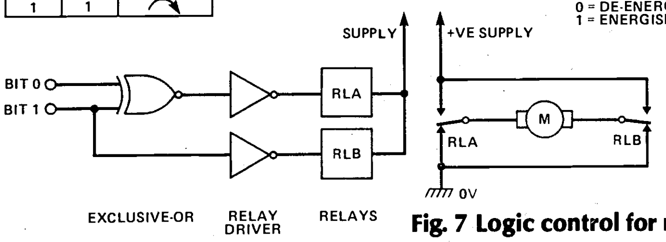


Fig. 7 Logic control for motor action.

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 POKEing 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 Humberside), 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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ols	☐	☐	☐
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0 ...... 1–3 ...... 4–12 ...... more than 12 ......

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our projects normally work first time ? Y ☐ N ☐
ou normally get them to work ? Y ☐ N ☐

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Y ☐ N ☐
Y ☐ N ☐
Y ☐ N ☐

ct, if any, you built? ....

ts
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tely how much you spent on electronics or 12 months?

l–50	☐	£51–100	☐
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☐		

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	Good	Average	Poor	Don't know
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Electronics & Wireless World	☐	☐	☐	☐
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26. Please tick the appropriate box which represents the annual total of your net income (i.e. after tax, National Insurance, etc.)
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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 ☐

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Subscription	☐
Other	☐

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

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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?

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

Name ....

Address ....

....

....

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(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	☐	Technical support/ maintenance	☐	Training/teaching	☐
Consultancy/PR	☐	Skilled manual	☐	Semi-skilled manual	☐
Clerical	☐	Sales	☐	Managerial	☐

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☐ N☐

b) electronic components or consumable items Y☐ N☐

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

Under £1000	☐	£1000 - £9999	☐
£10000 - £99999	☐	£100000 or more	☐

42. Are you registered unemployed? Y☐ N☐

full time student? Y☐ N☐ **retired?** Y☐ N☐

disabled? Y☐ N☐ **housewife/husband?** Y☐ N☐

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?

....

....

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2

THIRD FOLD

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SECOND FOLD

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% ARE 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 PROGRAMING*****
  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 MENU ON f9
  540IF a%<>olda% ?&FE61=a%:steptime%(count%)=TIME:step%(count%)=olda%:olda%=a%:TIME=0:count%=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 MENU 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 STATES"
 1000PRINTTAB(10,12)"2...RUN WITHOUT WAIT STATES"
 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 MEP SYH Control Basic
   20MAKE PRINTER OUTPUT
   30REPEAT
   40IF INKEY(-33)=TRUE AND INKEY(-114)=FALSE PROCmotor1left
   50IF INKEY(-114)=TRUE AND INKEY(-33)=FALSE PROCmotor1right
   60UNTIL FALSE
   70
   80DEFPROCmotor1left
   90REPEAT
  100MAKE BIT 0, HIGH
  110MAKE BIT 1, LOW
  120UNTIL INKEY(-33)=FALSE
  130MAKE BIT 0,1, LOW
  140ENDPROC
  150
  160DEFPROCmotor1right
  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 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.

Listing 3 Program to assemble machine code motor driver.

```
   10REM ASSEMBLER MOTOR DRIVER
   20FOR pass%=0 TO 3 STEP 3
   30P%=&3000
   40[OPT pass%
   50LDA &71        \ load A with "direction" (0-2)
   60BEQ store      \ if "direction" zero then O.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
  100.store
  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
  230 .loop1
  240ROL &72
  250ROL &72        \ rotate mask left two bits
  260DEX
  270 BNE loop1     \ repeat loop according to motor number
  280.jump1
  290LDA &FE61
  300AND &72        \ and contents of printer port with mask
  310
  320LDY &71        \ load Y with motor "direction"
  330STY &72        \ store motor "direction" in &72 as second mask
  340LDX &70        \  load X with motor number
  350BEQ jump2      \ if motor number is zero no need to shift mask left
  360CLC
  370.loop2
  380ROL &72
  390ROL &72        \ shift mask left twice
  400DEX
  410BNE loop2      \ repeat loop according to motor number
  420.jump2
  430ORA &72        \ "OR" A with second mask
  440STA &FE61      \ send byte to printer port
  450STA &72        \ store byte in &72
  460.end
  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
```

ETI

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 Vce = 5V, I_c = 200 microamps and R_s = 2k ohms.

At first glance it appears that 4dB relative to a source impedance of 2k0 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 specificially 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

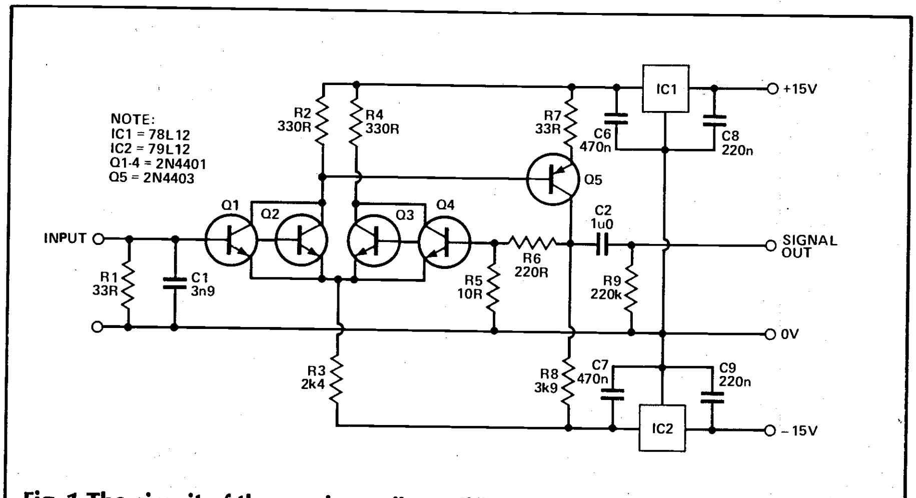


Fig. 1 The circuit of the moving coil amplifier in its standard or 'economy' form.

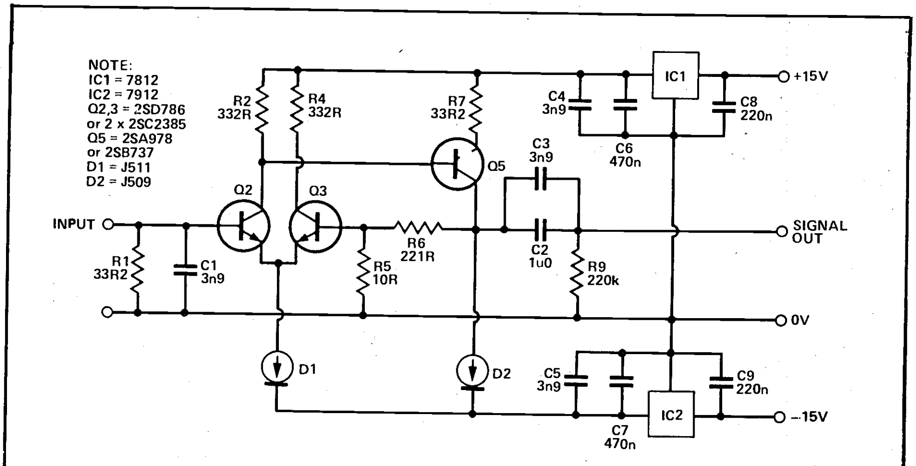


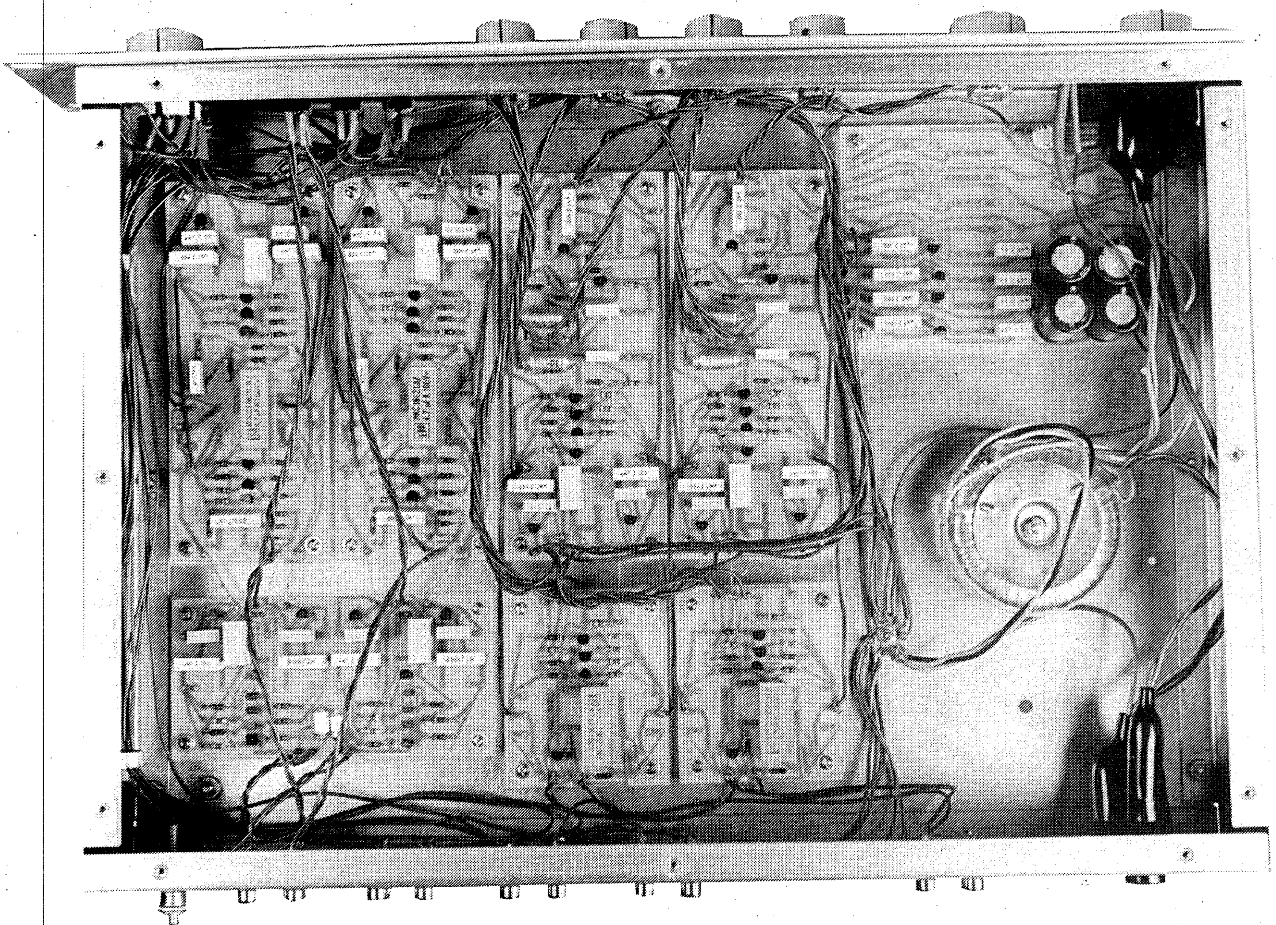
Fig. 2 The circuit of the moving coil amplifier in its upgraded form.

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 3µ9 µ to 10 µ. 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 the power supply ripple voltage feedback to the input from the negative supply and greatly improves sound quality.

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 preamplifier (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.

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 insert 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 ±15V to ±25V to the board (up to ±35V if you are using 1A regulators) and check all voltages with a DVM or

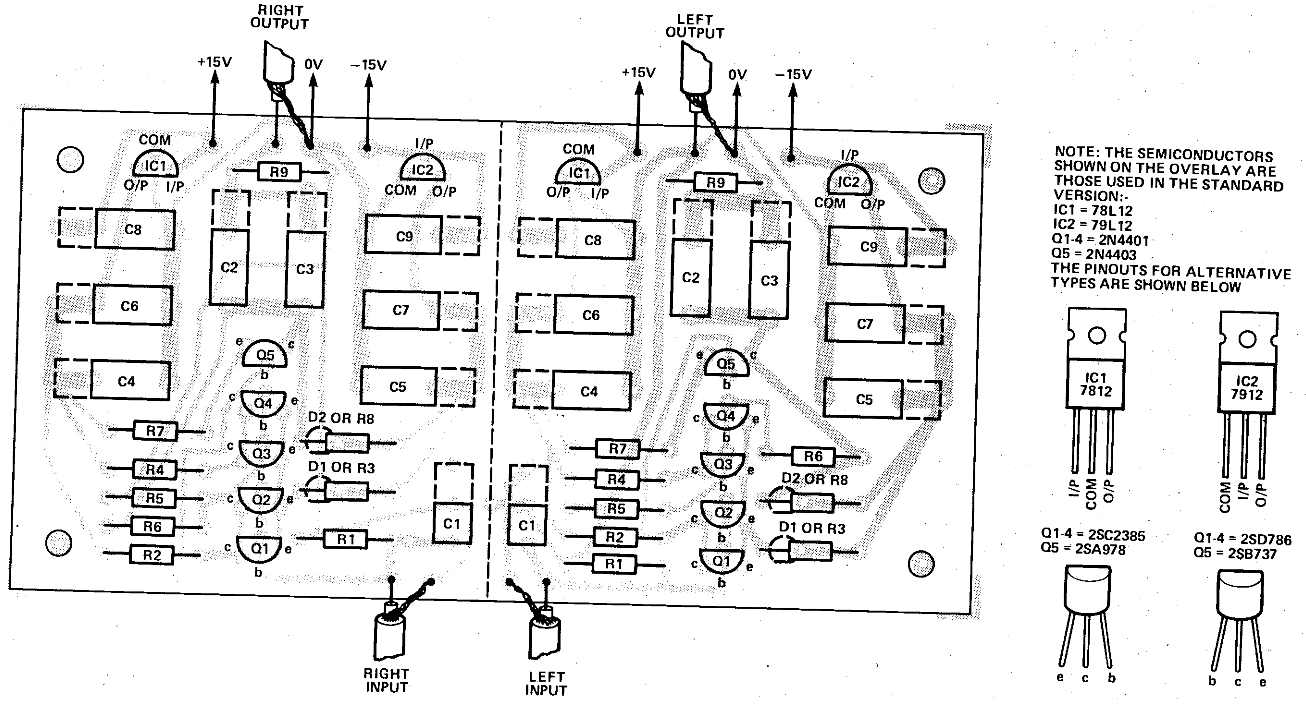


Fig. 3 Component overlay for the moving coil amplifier board.

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 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

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.

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

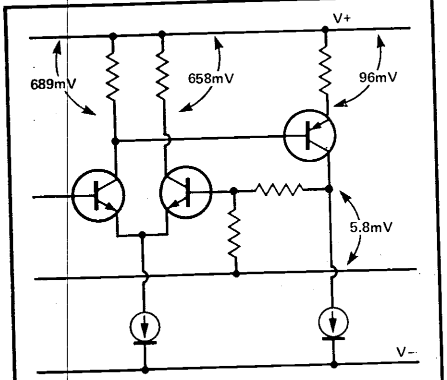


Fig. 4 Typical voltages measured on a fully-upgraded MC stage.

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

Current = 4.09 mA

Base Current through Q5

= 0.01 mA (Hfe = 300)

Total Current = 4.1 mA

Current per transistor = 2.05 mA

Voltage required across R2

= 689mV

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

= 336 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 currrent 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 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.

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.

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 ± 12V regulators allow it to be hooked into almost any preamplifier which has ± 15 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

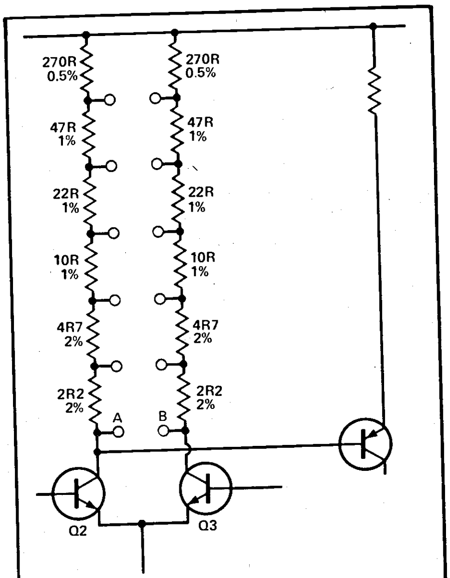


Fig. 5 Test circuit used to set equal collector currents in the input transistor pair.

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.

References

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**

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.

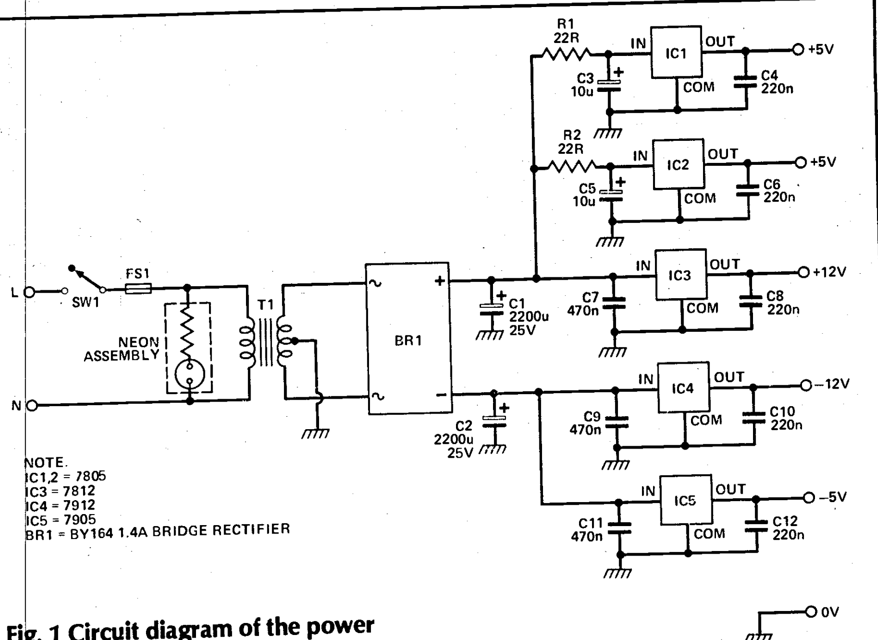


Fig. 1 Circuit diagram of the power supply.

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

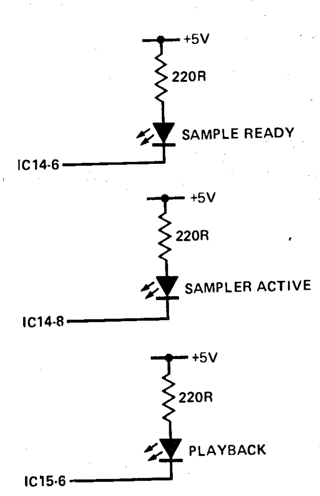
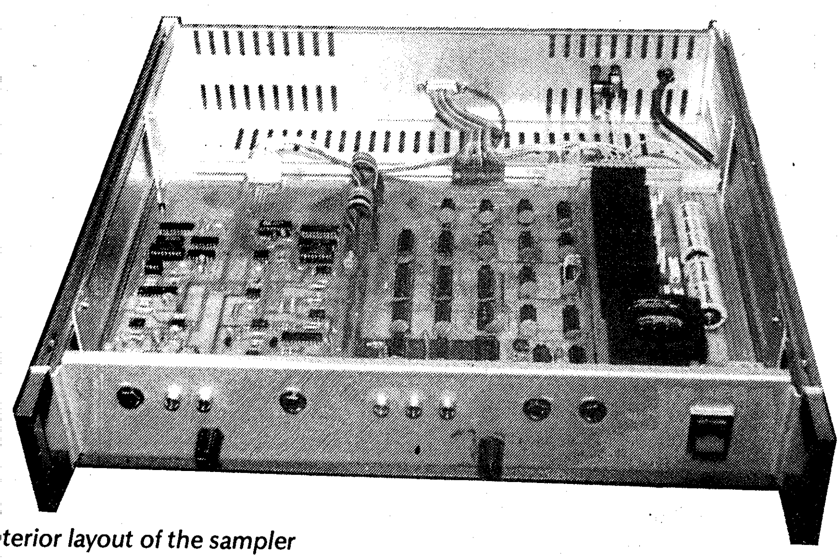


Fig. 2 Status indicator connections.

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

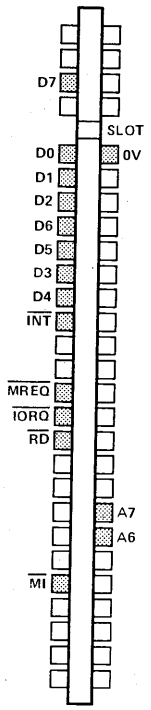
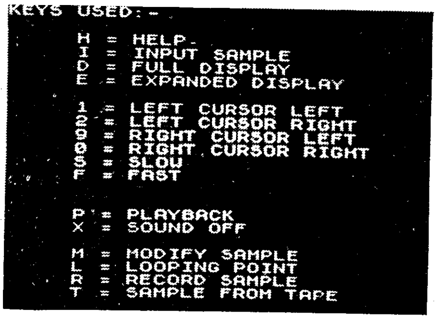


Fig. 3 Spectrum edge connector, showing connections used for the sampler.

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.



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 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.

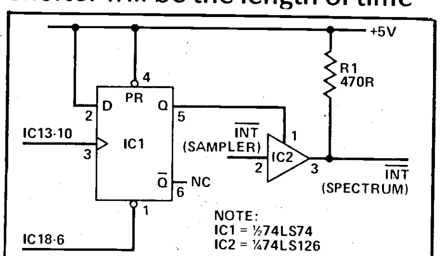
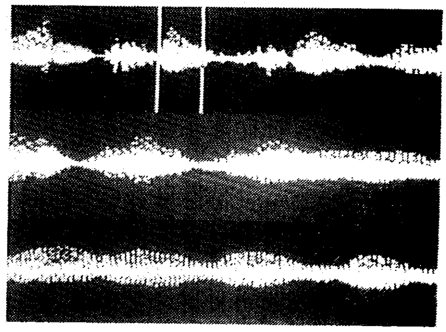
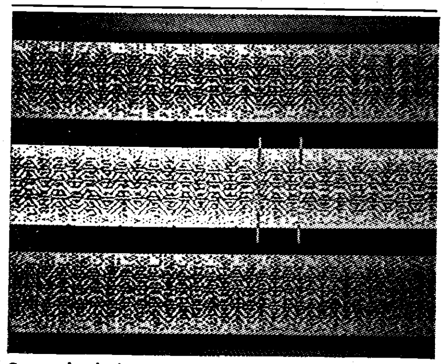


Fig. 4 Circuit for turning on the sampler's interrupts automatically.

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



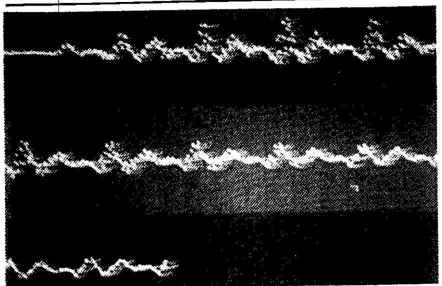
Sampled sine wave

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.

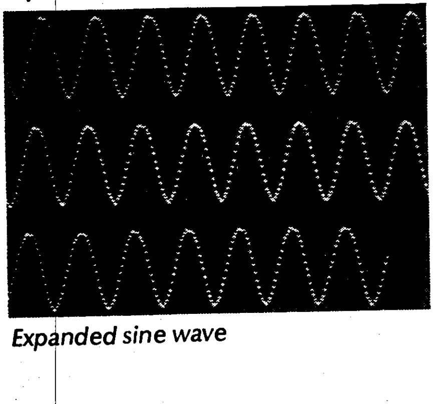
The sample in memory can be edited — you can cut out parts that are not required, by moving the cursors, and you can also alter any sample to modify the waveform, or even to create your own waveforms.

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 wafeform



Expanded sine wave

2C	53	52	2B	25	39	33	00	35	33	25	24	1A	0D	28	00	1D	00	28	25
2C	30	29	00	1D	00	29	2E	30	35	34	00	33	21	2D	30	2C	25	24	00
1D	00	26	35	2C	2C	00	24	29	33	30	2C	21	39	25	00	1D	00	25	38
30	21	2E	24	25	24	00	24	29	33	30	2C	21	39	11	00	1D	00	2C	25
26	34	00	23	35	32	33	2F	32	00	2C	25	26	34	12	00	1D	00	2C	25
26	34	00	23	35	32	33	2F	32	00	32	29	27	28	34	19	00	1D	00	32
29	27	28	34	00	23	35	32	33	2F	32	00	2C	25	26	34	10	00	1D	00
32	29	27	28	34	00	23	35	32	33	2F	32	00	32	29	27	28	34	33	00
1D	00	33	2C	2F	37	26	00	1D	00	26	21	33	34	2F	00	1D	00	25	24
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00	33	21	2D	30	2C	25	2C	00	1D	00	2C	2F	2F	30	29	2E	27	00	30
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00	26	32	2F	2D	00	34	21	30	25	00	33	4F	46	54	57	41	52	45	00
26	41	52	4D	00	11	19	18	15	33	25	2C	25	23	34	00	33	21	2D	30
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F6	21	00	59	06	00	CB	F6	23	10	FB	3E	05	D3	FE	C9	C5	D5	E5	1A
6F	26	00	29	29	29	01	00	3D	09	EB	06	08	E1	E5	1A	77	CD	68	60
13	10	F8	E1	D1	C1	23	13	0D	20	DD	C9	06	40	79	AE	77	CD	68	60
10	F8	C9	7C	3C	E6	07	28	02	24	C9	3E	F8	A4	67	3E	20	85	6F	D0
3E	08	84	67	C9	01	FE	FE	ED	78	E6	1F	FE	1F	20	F8	CB	00	38	F4
C9	ED	5B	01	62	A7	ED	52	ED	5B	03	62	16	00	01	00	00	A7	ED	52
03	30	FA	0B	79	E6	07	3C	CB	38	CB	19	CB	38	CB	19	CB	38	CB	19
16	80	3D	28	04	CB	3A	18	F9	79	E6	1F	6F	79	E6	60	0F	0F	67	CB
F4	C9	3A	03	62	32	04	62	2A	05	62	7E	23	22	05	62	2A	07	62	CD
B9	61	CB	79	28	05	CD	29	61	18	03	CD	8F	61	3A	09	62	B6	77	2A
0A	62	11	01	00	A7	ED	52	C8	22	0A	62	21	04	62	35	20	CE	3A	03
62	32	04	62	21	09	62	CB	0E	30	C1	2A	07	62	7D	3C	E6	1F	28	03
2C	18	08	7D	E6	E0	6F	3E	08	84	67	22	07	62	18	A8	4F	7C	E6	07
81	4F	E6	07	47	7C	E6	F8	B0	67	79	E6	F8	CB	27	CB	27	85	6F	30
04	3E	08	84	67	C9	CB	7F	C0	2F	CB	BF	C9	00	00	D9	08	ED	A2	3E
FD	BC	28	05	D9	08	FB	ED	4D	3E	40	D3	7F	AF	D3	7F	3A	00	62	CB
D7	32	00	62	D9	08	FB	ED	4D	D9	08	7E	09	7C	BA	38	04	7B	BD	38
05	D9	08	FB	ED	4D	2A	10	62	D9	08	FB	ED	4D	00	00	00	00	4F	E6
07	47	7C	E6	07	90	47	30	07	E6	07	47	3E	08	81	4F	7C	E6	F8	B0
67	79	E6	F8	CB	27	CB	27	4F	7D	91	6F	30	05	0E	08	7C	91	67	C9
4F	E6	0F	57	79	CB	BF	CB	3F	CB	3F	CB	3F	CB	3F	28	35	47	FE	04
28	23	30	10	CB	3A	FE	03	28	1B	CB	3A	FE	02	28	15	CB	3A	18	11
37	CB	12	FE	05	28	0A	37	CB	12	FE	06	28	03	37	CB	12	3E	01	07
10	FD	3D	82	CB	3F	CB	3F	CB	3F	C9	00	30	75	2D	00	00	00	00	00
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0A	01	FE	BF	ED	78	CB	67	C2	09	63	CD	13	60	21	00	40	11	88	5E
0E	0B	CD	39	60	21	45	40	11	93	5E	0E	08	CD	39	60	21	65	40	11
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40	11	BB	5E	0E	14	CD	39	60	21	E5	40	11	CF	5E	0E	14	CD	39	60
21	05	48	11	E3	5E	0E	15	CD	39	60	21	25	48	11	F8	5E	0E	15	CD
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A2	5F	0E	18	00	00	00	21	68	50	11	E7	5F	0E	0C	CD	39	60	01	FE
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0E	0C	CD	39	60	21	E3	50	11	A2	5F	0E	18	00	00	00	CD	7E	60	01
FE	FB	ED	78	CB	57	CA	28	62	01	FE	F7	ED	78	0E	80	06	02	0F	30
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62	01	BF	00	D9	21	00	62	79	D3	7F	CB	77	20	27	01	FE	FB	ED	78
CB	57	20	06	AF	D3	7F	C3	28	62	01	FE	F7	ED	78	CB	4F	20	06	3E
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2F	FC	22	12	62	C3	57	64	3E	00	D3	7F	C3	16	62	F3	3E	40	D3	7F
AF	D3	7F	FB	C3	28	62	CB	CE	CB	56	28	B4	21	2F	FC	22	12	62	18
0C	01	FE	FD	ED	78	CB	57	20	43	CD	13	60	21	30	75	22	05	62	22
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12	62	A7	ED	52	22	0A	62	11	00	03	AF	3C	A7	ED	52	28	02	30	F8
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E6	81	CB	F7	32	00	62	CD	7E	60	01	FE	F7	ED	78	CB	47	20	29	3A
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FF	7B	2F	3C	5F	F1	CB	67	28	05	21	14	62	18	03	21	10	62	18	74
01	FE	F7	ED	78	CB	4F	20	18	3A	00	62	F5	01	20	00	CB	7F	20	05
11	01	00	18	06	ED	5B	03	62	16	00	18	D0	01	FE	EF	ED	78	CB	47
20	1F	3A	00	62	01	08	00	CB	7F	20	05	11	01	00	18	06	ED	5B	03
62	16	00	CB	67	C2	25	66	21	12	62	18	2B	01	FE	EF	ED	78	CB	4F
C2	9A	66	3A	00	62	CB	67	C2	25	66	01	F8	FF	CB	7F	20	05	11	FF
FF	18	0A	ED	5B	03	62	16	FF	7B	2F	3C	5F	21	12	62	3A	00	62	E6
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CD	8E	60	C1	E5	D5	60	69	CD	8E	60	4A	F1	D1	B9	28	0A	F5	CD	5D
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3E	60	85	6F	3E	07	84	67	F1	D5	E5	D5	CD	B9	61	CB	79	28	05	CD
29	61	18	03	CD	8F	61	D1	7E	AA	77	2A	14	62	01	FE	EF	ED	78	CB
4F	20	14	7E	FE	80	20	03	AF	18	0A	30	07	3C	FE	80	28	02	18	18
3D	18	15	7E	FE	00	20	04	3E	80	18	0C	FE	80	38	07	3C	FE	00	28
02	18	01	3D	77	E1	CD	B9	61	CB	79	28	05	CD	29	61	18	03	CD	8F
61	D1	7E	AA	77	00	00	00	00	01	FE	FD	ED	78	CB	4F	20	05	21	00
62	CB	BE	CB	5F	20	05	21	00	62	CB	FE	01	FE	7F	ED	78	CB	57	C2
2D	67	2A	10	62	E5	11	00	03	19	11	2F	FC	A7	ED	52	E1	38	03	21
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32	09	62	CD	CB	60	2A	14	62	CD	8E	60	4A	CD	5D	60	3A	00	62	E6
81	CB	E7	32	00	62	01	FE	7F	ED	78	CB	57	28	F7	00	01	FE	FB	ED

Listing 1 Hex dump of the sound sampler program.

```
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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 56 05 C3 57 64 01 FE
BF ED 78 CB 4F C2 10 6B 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 CB 7F 28
08 A7 CB 79 28 01 37 18 18 79 CB BF CB B8 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 B8 B8 CB 79 28
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 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 C6 FB 01
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 20 07 C3 34 64 7F
C3 28 62 AF DB 7F FE 00 20 08 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 FE 01
28 C8 F3 D9 D5 E5 1E 00 A7 ED 52 E1 D1 D9 30 BB 18 B8 77 D3
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 24 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 09 01 09
01 09 01 11 01 11 01 11 01 19 01 19 01 19 01 21 01 21 01 21
01 29 01 29 01 29 01 31 01 31 01 31 01 39 01 39 01 39 01 41
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 22 01 22 01 22 01 2A 01 2A 01 2A 01 32
01 32 01 32 01 3A 01 3A 01 3A 01 42 01 42 01 42 01 4A 01 4A
01 4A 01 52 01 52 01 52 01 5A 01 5A 01 5A 01 03 01 03 01 03
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 33 01 33 01 33 01 3B 01 3B
01 3B 01 43 01 43 01 43 01 4B 01 4B 01 4B 01 53 01 53 01 53
01 5B 01 5B 01 5B 01 04 01 04 01 04 01 0C 01 0C 01 0C 01 14
01 14 01 14 01 1C 01 1C 01 1C 01 24 01 24 01 24 01 2C 01 2C
01 2C 01 34 01 34 01 34 01 3C 01 3C 01 3C 01 44 01 44 01 44
01 4C 01 4C 01 4C 01 54 01 54 01 54 01 5C 01 5C 01 5C 01 04
02 04 02 04 02 0C 02 0C 02 0C 02 14 02 14 02 14 02 1C 02 1C
02 1C 02 24 02 24 02 24 02 2C 02 2C 02 2C 02 34 02 34 02 34
02 3C 02 3C 02 3C 02 44 02 44 02 44 02 4C 02 4C 02 4C 02 54
02 54 02 54 02 5C 02 5C 02 5C 02 04 04 04 04 04 04 0C 04 0C
04 0C 04 14 04 14 04 14 04 1C 04 1C 04 1C 04 24 04 24 04 24
04 2C 04 2C 04 2C 04 34 04 34 04 34 04 3C 04 3C 04 3C 04 44
04 44 04 44 04 4C 04 4C 04 4C 04 54 04 54 04 54 04 5C 04 5C
04 5C 04 04 08 04 08 04 08 0C 08 0C 08 0C 08 14 08 14 08 14
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08 34 08 34 08 3C 08 3C 08 3C 08 44 08 44 08 44 08 4C 08 4C
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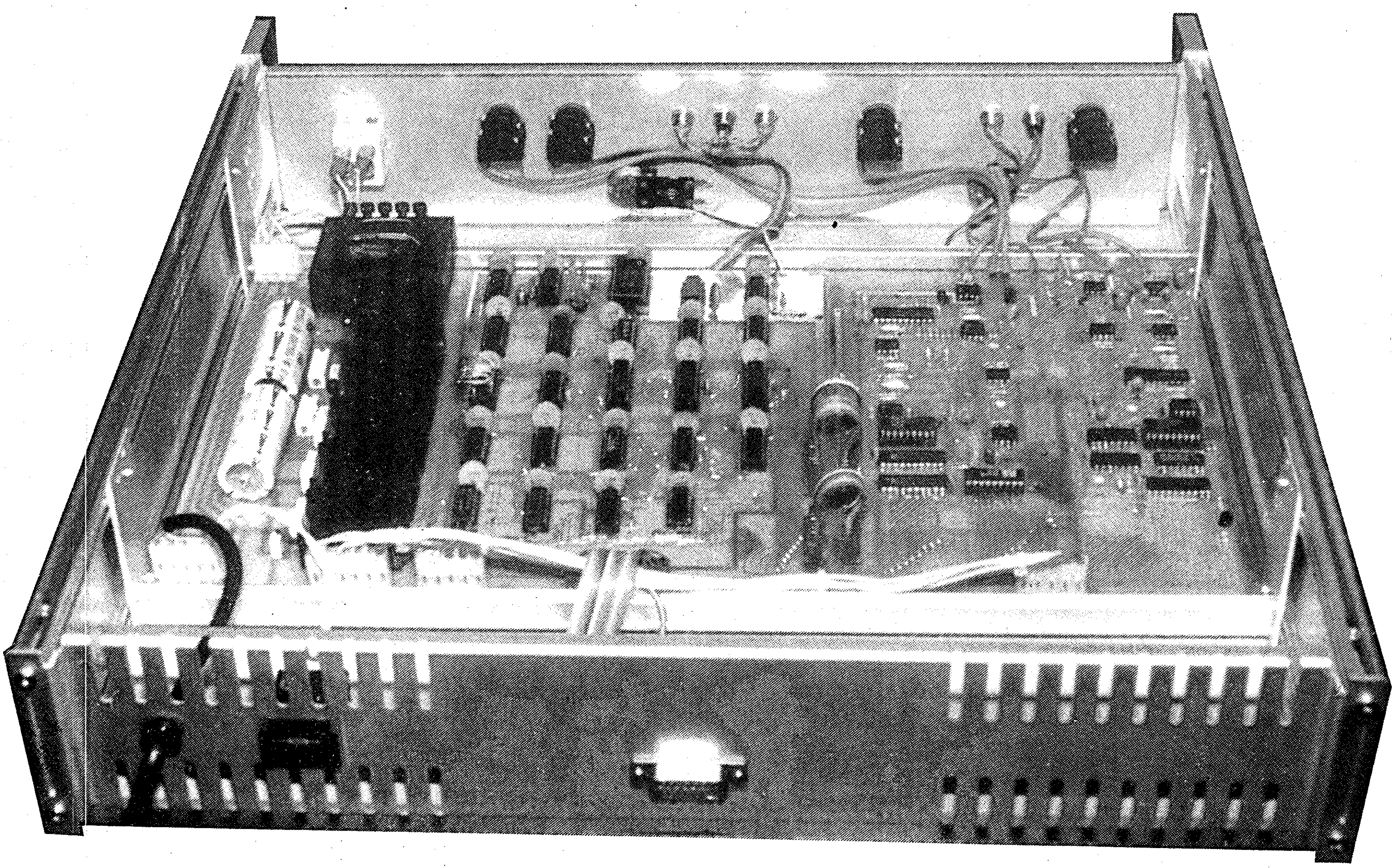


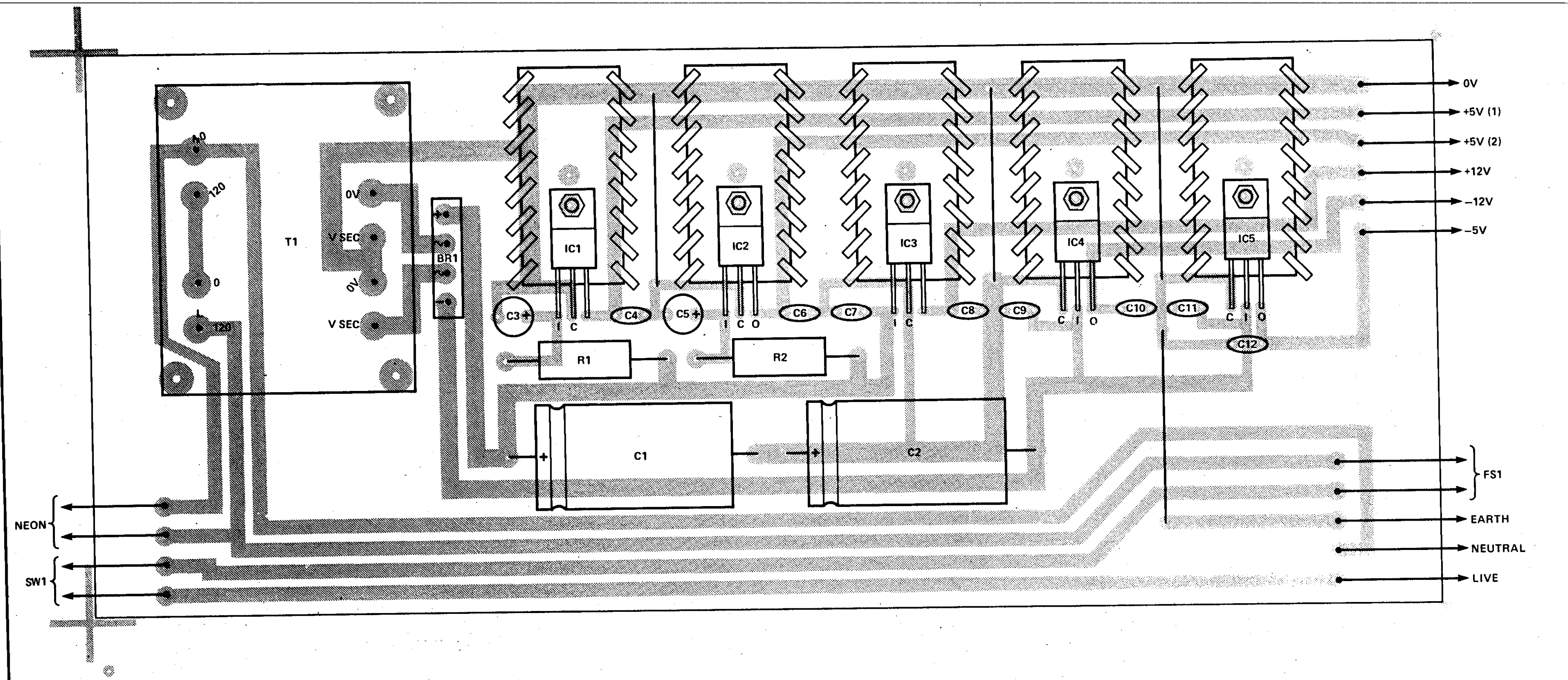


Fig. 5 Component overlay for the sampler PSU board.

PARTS LIST

POWER SUPPLY

RESISTORS

R1	22R 5W
R2	22R 5W

CAPACITORS

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

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.

BUYLINES

The bridge rectifier BY164 is available from Maplin (see ad in this issue), order code QF43W. The transformer is RS 207-699, 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, Craigo 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.

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 Wuljahorodsky 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

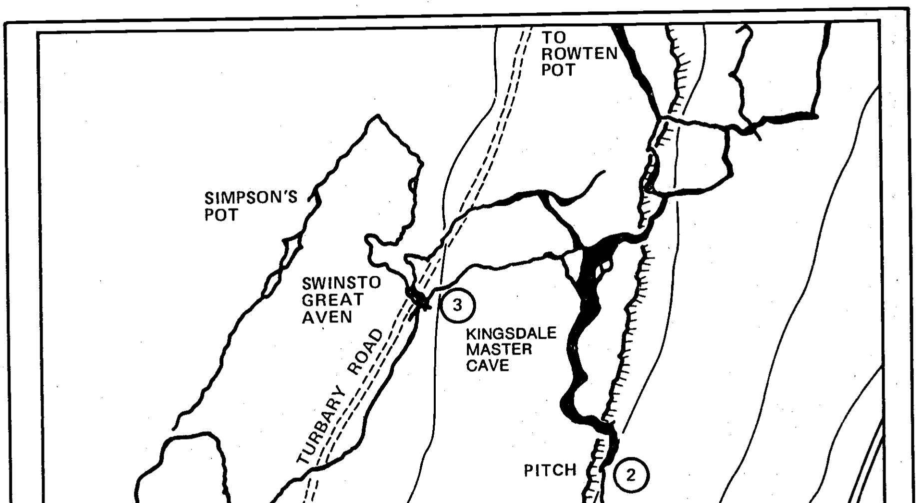


Fig. 1 A map of the West Kingsdale cave system, showing the points where the Troglograph was tested.

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.

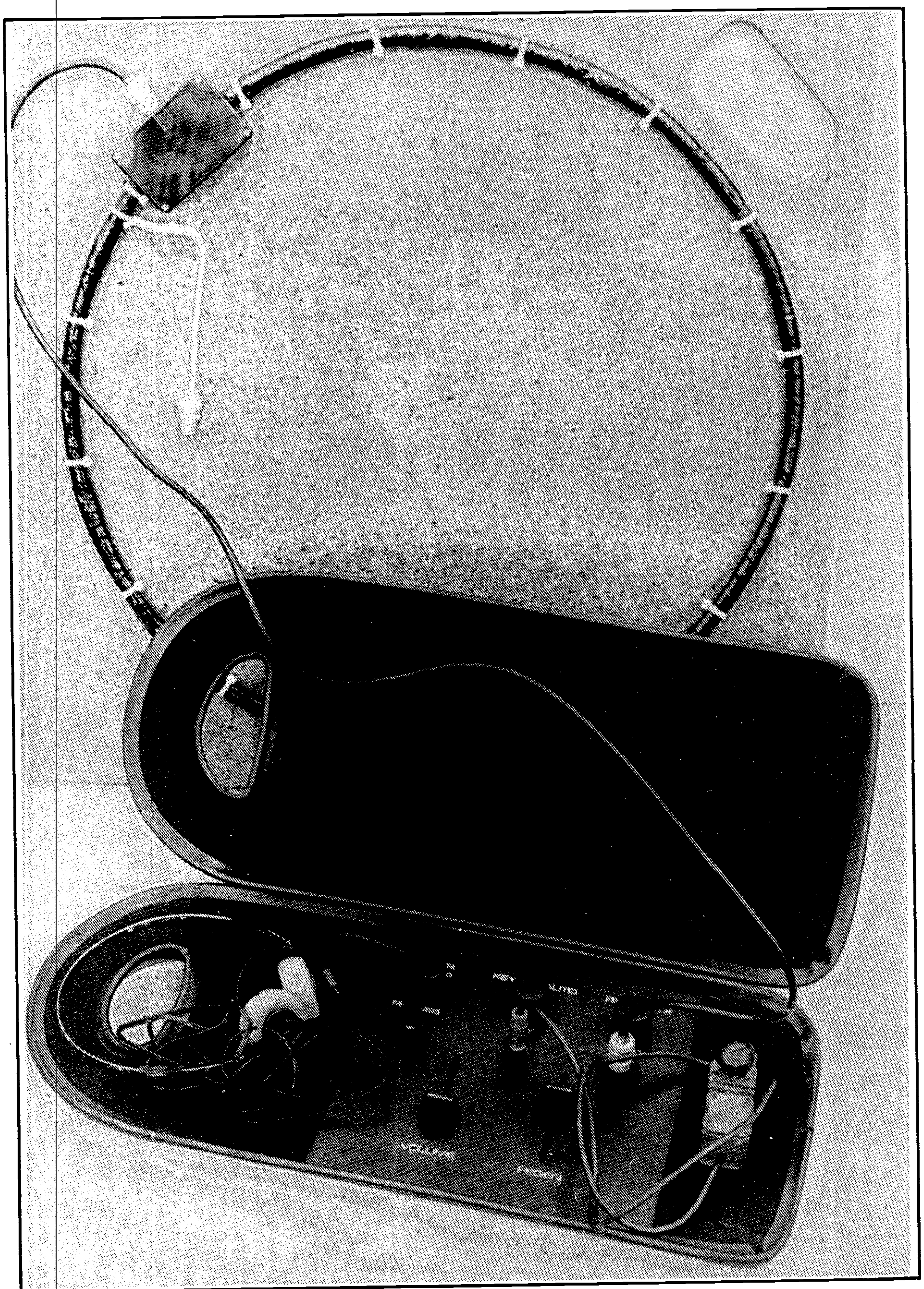
The equipment was packed away and we made our way to the second scheduled point, arriving there with a good five minutes to spare. As James rigged the pitch for our descent, a comparatively dry spot was found to set up the Troglograph. We switched it to receive and were greeted with silence. Our spirits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

Licencing

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 Troglograph 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 Troglograph 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 Troglograph. Accordingly it should be requested that a limit of 100uV per metre at 100 yards

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.

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!

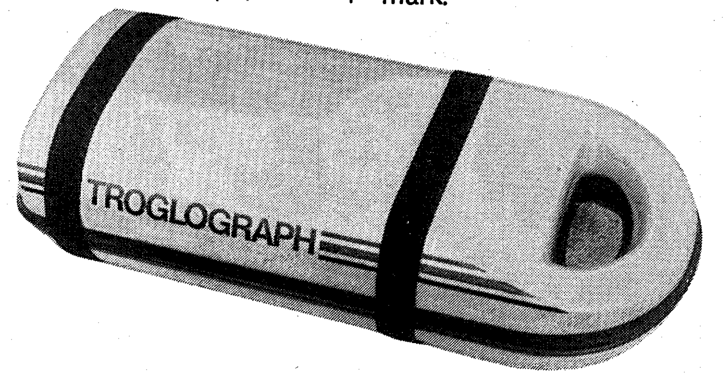
It isn't the intention of this article to encourage irresponsible underground expeditions. Caves and potholes are potentially dangerous places, hazards including pitches (deep vertical shafts), rising water in unsettled weather, route finding and collapses. Whereas all of these hazards can be minimised by taking the proper precuations, 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 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 ones 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 Wuljahorodsky 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.



ETI

NEXT MONTH

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Contrary to appearances, this is not an ETI project. But we're delighted to announce:

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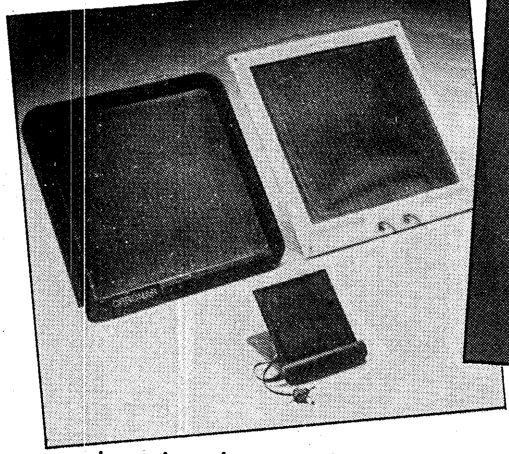
AUGUST ISSUE ON SALE 4th JULY

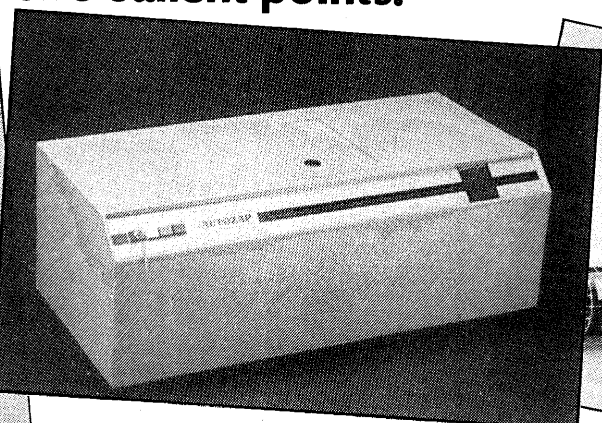
Plus:

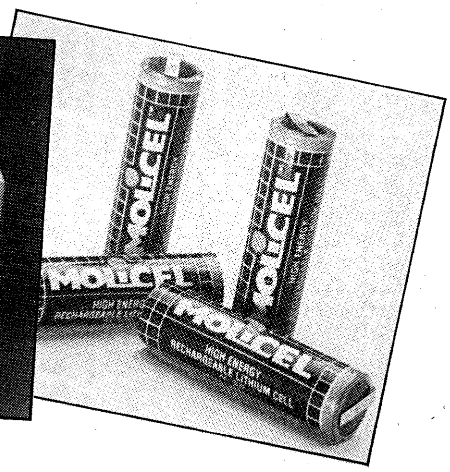
RGB-to-Composite Video Encoder, Health Hazards in The Electronics Industry, Tech Tips, your letters, reviews, news, opinions and lots more.

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 accompaniement 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.

ETI

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We receive a very large number of enquiries. Would prospective enquirers please note the following points:

- We undertake to do our best to answer enquiries relating to difficulties with ETI projects, in particular non-working projects, difficulties in obtaining components, and errors that you think we may have made. We do not have the resources to adapt or design projects for readers (other than for publication), nor can we predict the outcome if our projects are used beyond their specifications;
- Where a project has apparently been constructed correctly but does not work, we will need a description of its behaviour and some sensible test readings and drawings of oscillograms if appropriate. With a bit of luck, by taking these measurements you'll discover what's wrong yourself. Please do not send us any hardware (except as a gift!);
- Other than through our letters page, Read/Write, we will not reply to enquiries relating to other types of article in ETI. We *may* make some exceptions where the enquiry is very straightforward or where it is important to electronics as a whole;
- We receive a large number of letters asking if we have published projects for particular items of equipment. Whilst some of these can be answered simply and quickly, others would seem to demand the compiling of a long and detailed list of past projects. To help both you and us, we have made a full index of past ETI projects and features available (see under Backnumbers, below) and we trust that, wherever possible, readers will refer to this before getting in touch with us.
- **We will not reply to queries that are not accompanied by a stamped addressed envelope** (or international reply coupon). **We are not able to answer queries over the telephone.** We try to answer promptly, but we receive so many enquiries that this cannot be guaranteed.
- Be brief and to the point in your enquiries. Much as we enjoy reading your opinions on world affairs, the state of the electronics industry, and so on, it doesn't help our already overloaded enquiries service to have to plough through several pages to find exactly what information you want.

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ETI should be available through newsagents, and if readers have difficulty in obtaining issues, we'd like to hear about it.

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Backnumbers of ETI are held for one year only from the date of issue. The cost of each is the current cover price of ETI plus 50p, and orders should be sent to: ETI Backnumbers Department, Infonet Ltd, Times House, 179 The Marlowes, Hemel Hempstead, Hertfordshire HP1 1BB. Cheques, postal orders, etc should be made payable to ASP Ltd. We suggest that you telephone first to make sure there are still stocks of the issue you require: the number is (0442) 48432. Please allow 28 days for delivery.

We would normally expect to have ample stocks of each of the last twelve issues, but obviously, we cannot guarantee this. Where a backnumber proves to be unavailable, or where the issue you require appeared more than a year ago, photocopies of individual articles can be ordered instead. These cost £1.50 (UK or overseas surface mail), irrespective of article length, but note that where an article appeared in several parts each part will be charged as one article. Your request should state clearly the title of the article you require and the month and year in which it appeared. Where an article appeared in several parts you should list these individually. An index listing projects only from 1972 to September 1984 was published in the October 1984 issue and can be ordered in the same way as any other photocopy. If you are interested in features as well as projects you will have to order an index covering the period you require only. A full index for the period from 1972 to March 1977 was published in the April 1977 issue, an index for April 1977 through to the end of 1978 was published in the December 1978 issue, the index for 1979 was published in January 1980, the 1980/81 index in January 1982, the 1982 index in December 1982, the 1983 index in January 1984, the 1984 index in January 1985 and the 1985 index in December 1985. Photocopies should be ordered from: ETI Photocopies, Argus Specialist Publications Ltd, 1 Golden Square, London W1R 3AB. Cheques, postal orders, etc should be made payable to ASP Ltd.

Write For ETI

We are always looking for new contributors to the magazine, and we pay a competitive page rate. If you have built a project or you would like to write a feature on a topic that would interest ETI readers, let us have a description of your proposal, and we'll get back to you to say whether or not we're interested and give you all the boring details. (Don't forget to give us your telephone number).

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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 mssing 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)

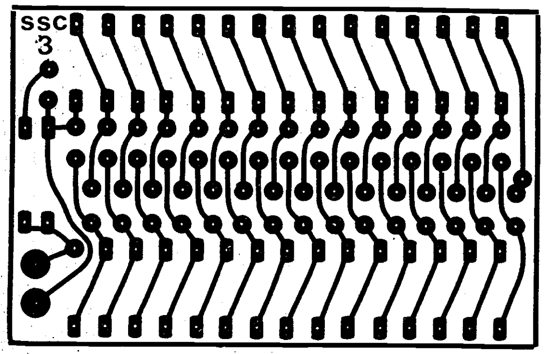
Capacitors C1, C3, C5 and C7 should be 470u 25V types as shown on the circuit diagram, not 47u 25V types as stated in the parts list. We have also been told that one of the companies mentioned in Buylines, Hawke Electronics, no longer supply the MPX100a pressure transducer. The other company recommended,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

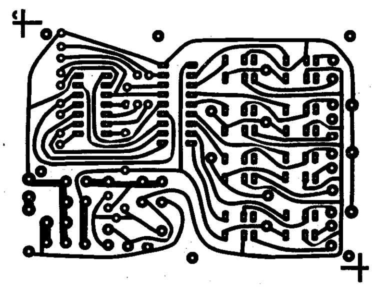
RS232-Centronics Converter (March, 1986)

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.

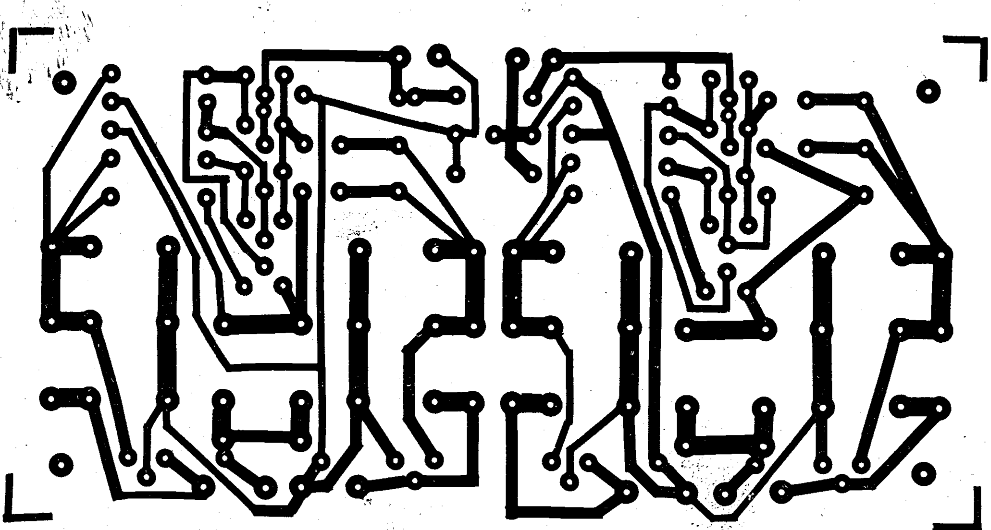
PCB FOIL PATTERNS



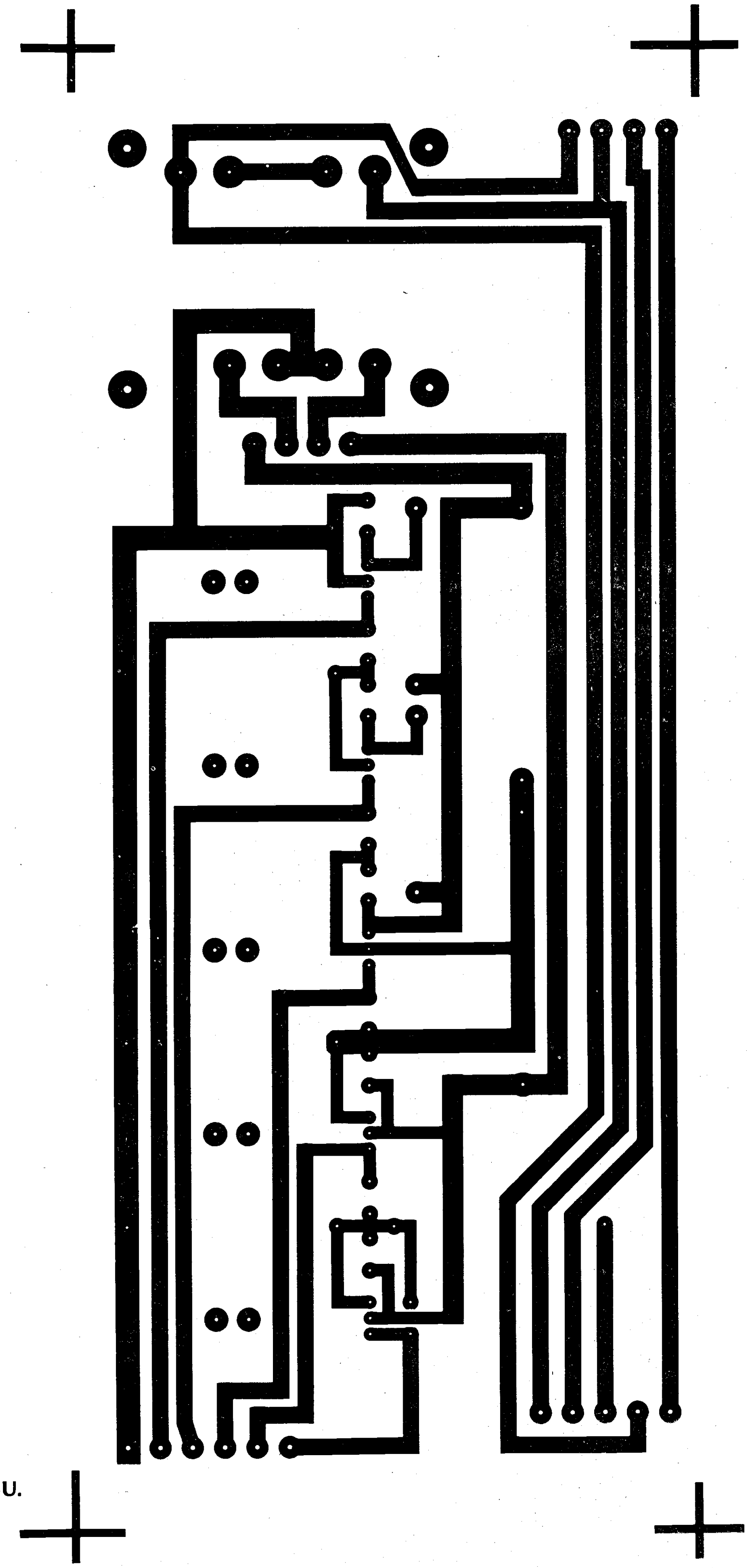
The foil pattern for the Direct-Ion board.



The BBC motor controller foil pattern.



The foil pattern for the Moving coil stage of the Upgradeable Amplifier.



The foil pattern for the Digital Sound Sampler PSU.

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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 effficient. 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 identification, and what's being broadcast on other stations.

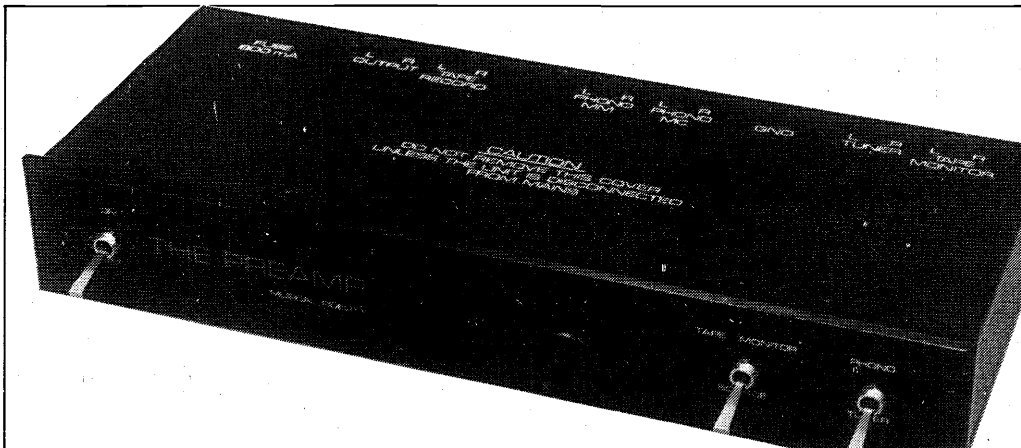
All of this information is not a lot of good for your average tranny, of course, and it will only be a new generation of 'smart' radios which will be capable of receiving and using it. The idea is that, by decoding and using the information, the smart radio will be able to stay tuned to a particular 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



A thing of ther past?

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

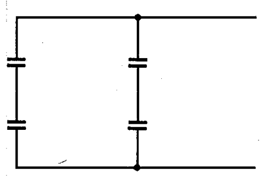

Fig. 1 The problem . . .

if the network is charged to 10V, the energy of $25\mu J$ per capacitor adds up to a total of $100\mu J$, as we would expect for a single $2\mu F$ capacitor charged to 10V. The charge on each capacitor in the network, however, is $10\mu C$, so the total charge on all four capacitors will be $40\mu C$ — twice as much as for a single $2\mu F$ 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 $2\mu F$ 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):

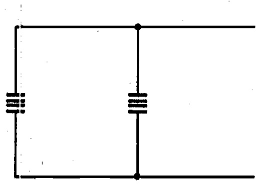

Fig. 2 . . . and the solution.

'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 $10\mu C$ on the series capacitors, and therefore providing a total charge of $20\mu C$ on the arrangement. The argument in the problem did not distinguish between charge provided by the power supply (only $20\mu C$) and charge that was merely rearranged between the plates (also $20\mu C$).

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 $20\mu C$ will flow through it, the rest of the charge being simply redistributed between the capacitors, so externally the network behaves like a single $2\mu F$ 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 neeeded.

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 $2\mu F$ 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 $W = \int_0^\infty I^2R\,dt = 50\mu J$. 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 capacitor 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 qually 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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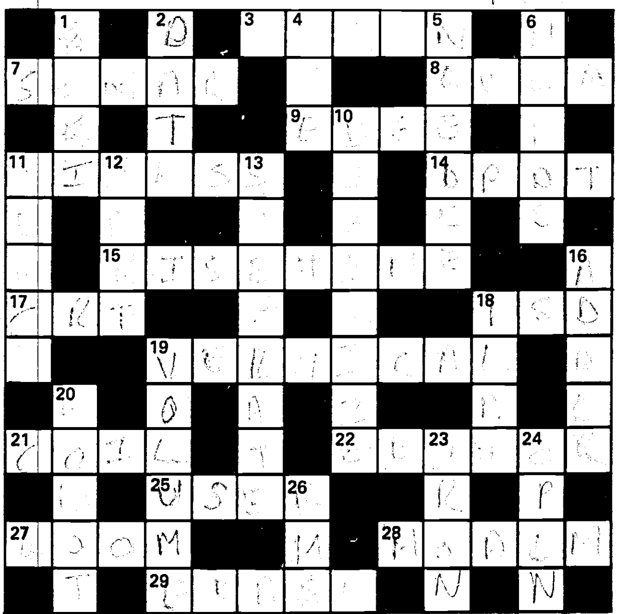

ACROSS
3) Japanese printer manufacturer (5).
7) Underwater object detector using sound waves (5).
8) ________ Parity (4).
9) A square wave has a leading one and a trailing one (4).
11) ________ capacitor, used to reduce the negative feedback effect of an emitter resistor to AC signals (6).
14) Two pole, two way switch (1,1,1,1).
15) When 13 down affects 9 across, this becomes longer (4, 4).
17) Used in both televisions and 'scopes (1,1,1).
18) The maximum a meter can show (1,1,1).
19) The Y-axis of an oscilloscope (8).
21) Wound component (4).
22) Sofware package to create and alter text files (6).
25) A BASIC command (4).
27) Cable ________, a collection of discrete wires tied or wrapped together (4).
28) Modulator/demodulator (short form) (5).
29) To wipe magnetic tape clean (5).

DOWN
1) Major Japanese domestic electronic appliance manufacturer (4).
2) Basic command associated with read and restore (4).
4) European domestic electronics company (3).
5) The old name for a stylus (6).
6) Magnetic recording tape transducers (5).
10) To convert an analogue value into a binary number (8).
11) The colour which signifies zero (5).
12) Microprocessor input/output channel (4).
13) The speed at which a circuit can react to a sudden change in input, measured in $V\mu s^{-1}$ (4, 4).
16) Digital function block, capable of simple binary sums (5).
18) How to describe a circuit with uniform frequency response within a specified bandwidth (4).
19) Amplitude (6).
20) Mechanical man or industrial tool (5).
23) Tool for melting solder (4).
24) No connection (4).
26) Abbreviation for the mathematical expression used to calculate the average power available from a wave form (1,1,1).

Solution to Crossword No. 5

ACROSS
1) Earth loop
8) Laser
9) Magenta
11) Stylus
12) Dialect
13) NEXT
14)* RCA
17) ECL
18) Load
21) Bipolar
23) Top end
24) Festoon
25) Reset
26) Screening

DOWN
2) Atari
3) Treble
4) OTA
5) Plotter
6) Isolate
7) Prescaler
10) Tick
12) Directory
15) All pass
16) Magnets
19) Live
20) Norton
22) Acorn
24) FOR

* Wrongly given as 15 last month.

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1. Please indicate what you think of the following aspects of ETI's coverage:

	Good	Average	Bad	Don't know
New product news	☐	☐	☐	☐
News of events and personalities	☐	☐	☐	☐
New theoretical/technological developments	☐	☐	☐	☐
Sophisticated projects	☐	☐	☐	☐
Basic projects	☐	☐	☐	☐
Introductory features	☐	☐	☐	☐
Telecommunications	☐	☐	☐	☐
Audio	☐	☐	☐	☐
Computers	☐	☐	☐	☐
Semiconductors	☐	☐	☐	☐
Others (please specify no more than three)	☐	☐	☐	☐
......	☐	☐	☐	☐
......	☐	☐	☐	☐

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

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

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

- computer/computer peripherals ☐
- audio/hi fi ☐
- electronic musical instrument ☐
- PA/recording equipment ☐
- radio/satellite/CB equipment ☐
- video camera/monitor ☐
- car electronics ☐
- security equipment ☐
- remote control/robotics ☐
- photographic or darkroom equipment ☐
- test/measurement equipment ☐
- gadgets ☐
- Others (please specify) ....

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

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

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	☐	☐	☐	☐
Audio projects	☐	☐	☐	☐
Music projects	☐	☐	☐	☐
Radio projects	☐	☐	☐	☐
Test equipment projects	☐	☐	☐	☐
TV and video projects	☐	☐	☐	☐
Security projects	☐	☐	☐	☐
Car electronic projects	☐	☐	☐	☐
Lighting projects	☐	☐	☐	☐
Robotics projects	☐	☐	☐	☐
Photographic projects	☐	☐	☐	☐
Novelty projects	☐	☐	☐	☐
Computer software	☐	☐	☐	☐
Interfacing	☐	☐	☐	☐
Basic electronics theory	☐	☐	☐	☐
Advanced electronics theory	☐	☐	☐	☐
General science	☐	☐	☐	☐
Experimental projects	☐	☐	☐	☐
News features	☐	☐	☐	☐
Technical features	☐	☐	☐	☐
Product information	☐	☐	☐	☐
Design hints and tips	☐	☐	☐	☐
Letters	☐	☐	☐	☐
Circuit ideas	☐	☐	☐	☐
Reviews	☐	☐	☐	☐
Opinion columns	☐	☐	☐	☐
Crossword/Alf's puzzle	☐	☐	☐	☐
Technical advice	☐	☐	☐	☐
Competitions	☐	☐	☐	☐
Others (please specify)	☐	☐	☐	☐

....

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

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

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?** Y ☐ N ☐
Do you normally get them to work? Y ☐ N ☐

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

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

13. **What was the last ETI pro**

14. **Do you make your own P**
always ☐

15. **Please indicate approxi**
related hobbies in the las
£20 or less ☐ **£2**
£101–500 ☐ **£5**

16. **Please indicate what other**
Computers
Photography
Film/video
Modelling (railway/aero)
Other (please specify)....

17. **With regard to the advertis**
Read or look through near
Read or look through som
Just read or look through t
Very rarely/never look at

18. **Thinking specifically abou**
rate the three types o
Electromart — in terms
type):

Very useful
Useful
Not very useful
Not at all useful

19. **Do you order or buy prod**

Regularly
Occasionally
Never

20. **If the answer to question 1**
this way, and what was its
....

21. **Do you use the Advertisers**
Y ☐

22. **Does anyone else read you**
No only me ☐

23. **Do you keep your copy of**
One month ☐

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