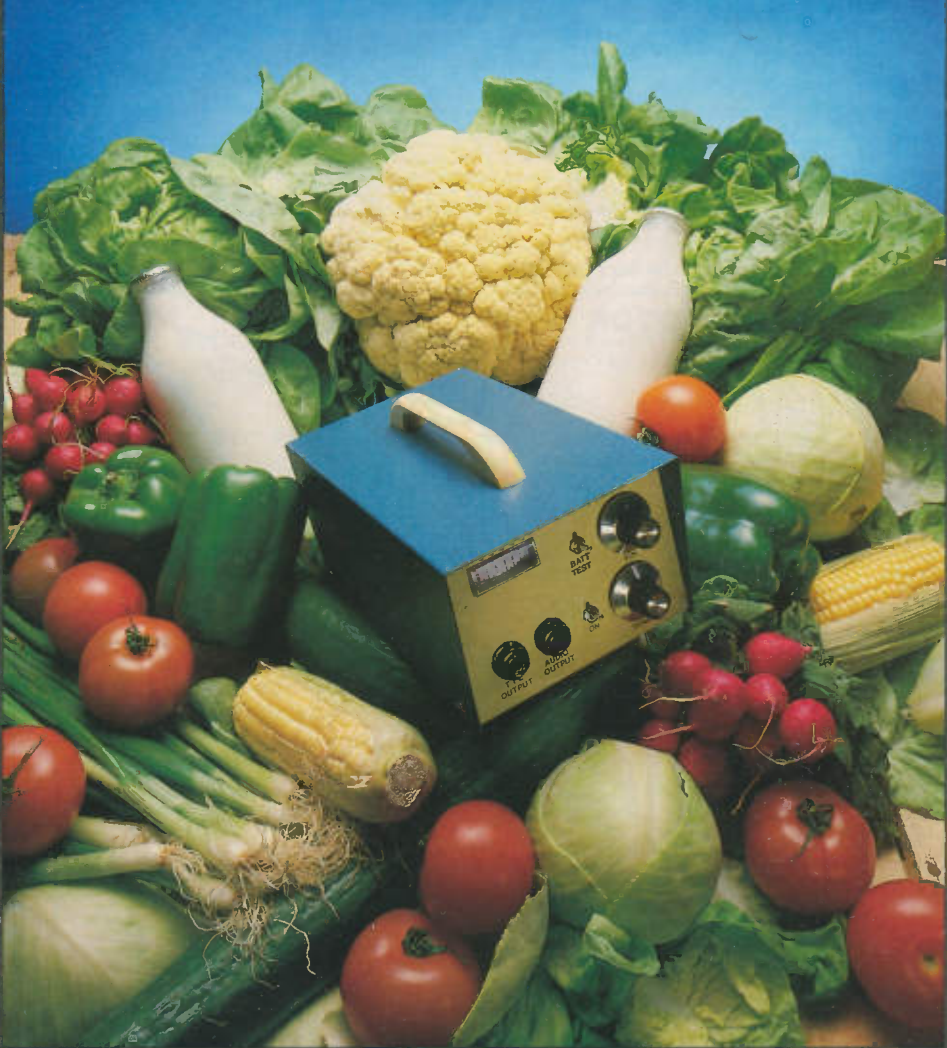
PRACTICAL AUGUST 1986 · £1·25

ELECTRONICS

SCIENCE AND TECHNOLOGY

BUILD A GEIGER COUNTER

WITH MICRO INTERFACE—CHECK IT OUT!



MICRO CHIP TESTER

RS232 OPTO DATA LINK

ADVANCED µP BOARD

HOBBY BUS FOR 6502s

PCB OF THE FUTURE

COMMENT SPECIAL– THE NUCLEAR ISSUE

The Atomic Energy Authority v The Friends Of The Earth

CAD-CAM & ATE– WE CAN PUT IT TO THE TEST

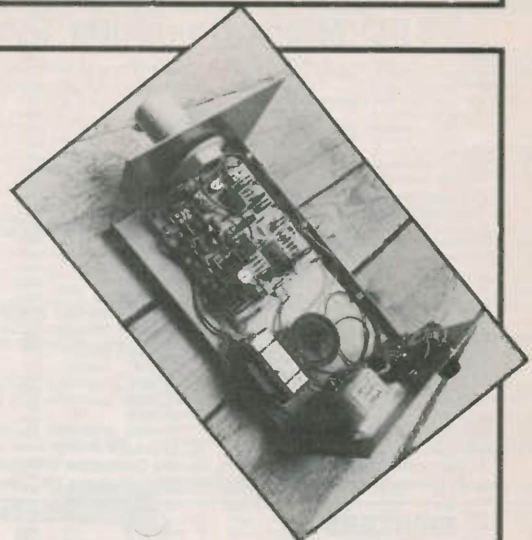
A practical look at computer aided engineering

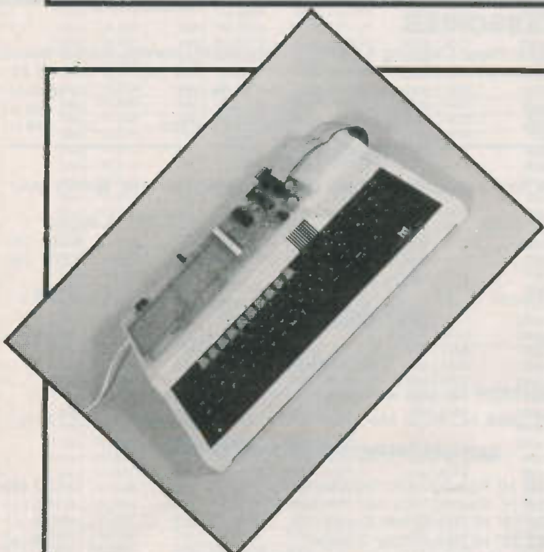
BATTERIES– BETTER USE OF SEALED NI-CADS

THE SCIENCE MAGAZINE FOR ELECTRONICS AND COMPUTER ENTHUSIASTS

PRACTICAL ELECTRONICS THE MAGAZINE FOR SERIOUS ELECTRONICS ENTHUSIASTS

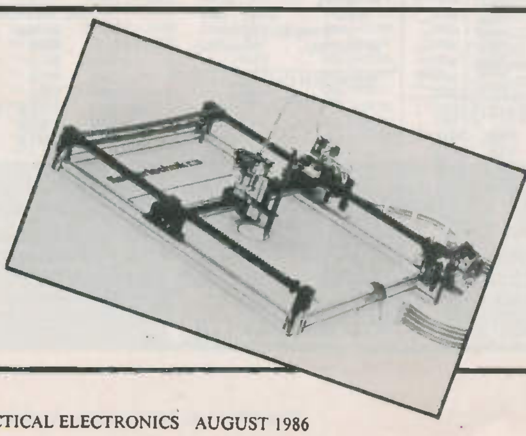
PROJECTS TO BUILD





SPECIAL FEATURES

REGULAR FEATURES



NEWS AND VIEWS

01-208 1177 TECHNOMATIC LTD 01-208 1177

BBC Micro Computer System

BBC Master Series
AMB15 BBC MASTER Foundation computer 128K .... £435 (a)
AMB12 BBC MASTER Econet computer 128K (only ANFS) .... £348 (a)
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)
Econet Bridge .... £174 (b)
File Server Level 1 .... £75 (d)
File Server Level II .... £210 (d)
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.

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 17/16" Single row .... £5.25 (d)
27/16" x 17/16" 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.

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 (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.

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)

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)
40T DS DD £12:75 (d)
80T SS DD £14.75 (d)
80T DS DD £16:00 (d)

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

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)

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 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

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	-

TEXTOOL ZIF

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

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	—

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).

MISC CONNS

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

AMPHENOL CONNECTORS

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

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

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

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

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

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

TECHNOLINE VIEWDATA SYSTEM

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

74 SERIES

7400	30p
7401	30p
7402	30p
7403	30p
7404	36p
7405	30p
7406	40p
7407	40p
7408	30p
7409	30p
7410	30p
7411	30p
7412	30p
7413	50p
7414	70p
7416	36p
7417	40p
7420	30p
7421	60p
7422	36p
7423	36p
7425	40p
7426	40p
7427	40p
7428	43p
7430	30p
7432	36p
7433	30p
7437	30p
7438	40p
7439	40p
7440	40p
7441	90p
7442A	70p
7443A	100p
7444	110p
7445	100p
7446A	100p
7447A	100p
7448	120p
7450	36p
7451	35p
7453	38p
7454	38p
7460	55p
7470	50p
7472	55p
7473	55p
7474	50p
7475	60p
7476	45p
7480	65p
7481	180p
7483A	105p
7484A	125p
7485	110p
7486	42p
7489	210p
7490A	55p
7491	70p
7492A	70p
7493A	55p
7494	110p
7495A	60p
7496	80p
7497	210p
74100	190p
74107	50p
74109	75p
74110	75p
74111	55p
74116	170p
74118	110p
74119	170p
74120	100p
74121	55p
74122	70p
74123	80p
74125	65p
74126	55p
74128	55p
74132	75p
74136	70p
74141	90p
74142	250p
74143	270p
74144	270p
74145	110p
74147	170p
74148	140p
74150	175p
74151A	70p
74153	80p
74154	140p
74155	80p
74156	100p
74157	80p
74159	175p
74160	110p
74161	80p
74162	110p
74163	110p
74164	120p
74165	110p
74166	140p
74167	400p
74170	200p
74172	420p
74173	140p
74174	110p
74175	105p
74176	100p
74178	150p
74179	150p
74180	100p
74181	340p
74182	140p
74184	180p
74185A	180p
74190	130p
74191	130p
74192	110p
74193	115p
74194	110p
74195	80p
74196	130p
74197	110p
74198	220p
74199	220p
74221	110p
74251	100p
74259	150p
74265	380p
74273	200p
74276	140p
74278	170p
74279	90p
74283	105p
74285	320p
74290	90p
74293	90p
74298	180p
74351	200p
74365A	80p
74366A	80p
7436A	80p
74367A	80p
74368A	70p
74376	180p
74390	110p
74393	112p
74490	140p

74LS SERIES

74LS00	24p
74LS01	24p
74LS02	24p
74LS03	24p
74LS04	24p
74LS05	24p
74LS08	24p
74LS09	24p
74LS10	24p
74LS11	24p
74LS12	24p
74LS13	34p
74LS14	50p
74LS15	24p
74LS20	24p
74LS21	24p
74LS22	24p
74LS24	50p
74LS26	24p
74LS27	24p
74LS28	24p
74LS30	24p
74LS32	24p
74LS33	24p
74LS37	24p
74LS38	24p
74LS40	24p
74LS42	50p
74LS43	150p
74LS47	80p
74LS48	90p
74LS49	100p
74LS51	24p
74LS54	24p
74LS55	24p
74LS73A	30p
74LS74A	35p
74LS75	45p
74LS76A	36p
74LS83A	70p
74LS85	75p
74LS86	35p
74LS90	48p
74LS91	80p
74LS92	55p
74LS93	54p
74LS95B	75p
74LS96	90p
74LS107	40p
74LS109	40p
74LS112	45p
74LS113	45p
74LS114	45p
74LS122	70p
74LS123	80p
74LS124/629	140p
74LS125	50p
74LS126	50p
74LS132	65p
74LS133	50p
74LS136	45p
74LS138	55p
74LS139	55p
74LS145	95p
74LS147	175p
74LS148	140p
74LS151	65p
74LS152	200p
74LS153	65p
74LS154	160p
74LS155	65p
74LS156	65p
74LS157	50p
74LS158	65p
74LS160A	75p
74LS161A	75p
74LS162A	75p
74LS163A	75p
74LS164	75p
74LS165A	110p
74LS166A	180p
74LS168	130p
74LS169	100p
74LS170	140p
74LS173A	100p
74LS174	75p
74LS175	75p
74LS181	200p
74LS183	190p
74LS190	75p
74LS191	75p
74LS192	80p
74LS193	80p
74LS194A	75p
74LS195A	75p
74LS196	80p
74LS197	80p
74LS221	90p
74LS240	80p
74LS241	80p
74LS242	80p
74LS243	80p
74LS244	80p
74LS245	110p
74LS247	110p
74LS248	110p
74LS249	110p
74LS251	75p
74LS253	75p
74LS256	90p
74LS257A	70p
74LS258A	70p
74LS259	120p
74LS260	75p
74LS261	120p
74LS266	60p
74LS273	125p
74LS279	70p
74LS280	190p
74LS283	80p
74LS290	80p
74LS292	900p
74LS293	80p
74LS295	140p
74LS297	£9
74LS298	100p
74LS299	220p
74LS321	370p
74LS323	300p
74LS324	320p
74LS348	200p
74LS352	120p
74LS353	120p
74LS356	210p
74LS363	180p
74LS364	180p
74LS365	50p
74LS366	50p
74LS367	50p
74LS368A	50p
74LS373	90p
74LS374	90p
74LS375	75p
74LS377	130p
74LS378	95p
74LS379	130p
74LS381	450p
74LS385	325p
74LS390	60p
74LS393	100p
74LS395A	100p
74LS399	140p
74LS445	180p
74LS465	120p
74LS467	120p
74LS490	150p
74LS540	100p
74LS541	100p
74LS608	700p
74LS610	1900p
74LS612	1900p
74LS624	350p
74LS626	225p
74LS628	225p
74LS629	125p
74LS640	200p
74LS640-1	300p
74LS641	150p
74LS642-1	300p
74LS643	250p
74LS643-1	300p
74LS644	350p
74LS645	200p
74LS645-1	400p
74LS668	90p
74LS669	90p
74LS670	170p
74LS682	250p
74LS684	350p
74LS687	350p
74LS688	350p
74LS783	£21

74S SERIES

74S00	50p
74S02	50p
74S04	50p
74S05	50p
74S08	50p
74S10	50p
74S11	75p
74S20	50p
74S22	50p
74S30	50p
74S32	60p
74S37	60p
74S38	60p
74S40	50p
74S51	45p
74S64	45p
74S74	70p
74S85	300p
74S86	100p
74S112	150p
74S113	120p
74S114	120p
74S124	300p
74S132	100p
74S133	60p
74S138	180p
74S138	180p
74S139	180p
74S140	100p
74S151	150p
74S153	150p
74S157	200p
74S158	200p
74S163	300p
74S169	550p
74S174	300p
74S175	320p
74S188	180p
74S189	180p
74S194	300p
74S195	300p
74S196	350p
74S200	450p
74S201	320p
74S225	520p
74S240	400p
74S241	400p
74S244	500p
74S251	250p
74S257	250p
74S258	250p
74S260	100p
74S261	300p
74S283	270p
74S287	225p
74S288	200p
74S289	225p
74S299	550p
74S373	400p
74S374	400p
74S387	225p

4000 SERIES

4000	20p
4001	24p
4002	25p
4006	70p
4007	25p
4008	60p
4009	45p
4010	60p
4011	24p
4012	25p
4013	36p
4014	60p
4015	70p
4016	36p
4017	55p
4018	60p
4019	60p
4020	60p
4021	60p
4022	70p
4023	30p
4024	48p
4025	24p
4026	90p
4027	40p
4028	60p
4029	75p
4030	35p
4031	125p
4032	100p
4033	125p
4034	250p
4035	70p
4036	70p
4037	110p
4038	100p
4039	250p
4040	60p
4041	55p
4042	60p
4043	50p
4044	60p
4045	100p
4046	60p
4047	60p
4048	55p
4049	36p
4050	35p
4051	65p
4052	60p
4053	60p
4504	80p
4055	80p
4056	85p
4059	400p
4060	70p
4063	85p
4066	40p
4067	230p
4068	25p
4069	24p
4070	24p
4071	24p
4072	24p
4073	24p
4075	24p
4076	65p
4077	25p
4078	25p
4081	24p
4082	25p
4085	60p
4086	75p
4089	120p
4093	35p
4094	90p
4095	90p
4096	90p
4097	270p
4098	75p
4099	90p
4501	36p
4502	55p
4503	36p
4504	95p
4505	360p
4506	90p
4507/4030	35p
4508	120p
4510	55p
4511	55p
4512	55p
4513	150p
4514	110p
4515	110p
4516	55p
4517	220p
4518	48p
4519	32p
4520	60p
4521	115p
4522	80p
4526	70p
4527	80p
4528	65p
4529	100p
4531	75p
4532	65p
4534	380p
4536	250p
4538	75p
4539	75p
4541	90p
4543	70p
4551	100p
4553	240p
4555	36p
4556	50p
4557	240p
4560	140p
4566	140p
4568	240p
4569	170p
4572	45p
4583	90p
4584	48p
4585	60p
4724	150p
14411	750p
14412	750p
14416	300p
14419	280p
14490	420p
14495	450p
14500	650p
14599	200p
22100	350p
22101	700p
22102	700p
40014/4584	
40106	48p
40085	120p
40097	36p
40098	48p
40100	150p
40101	125p
40102	130p
40103	200p
40104	120p
40105	120p
40106	48p
40107	55p
40108	320p
40109	20p
40110	225p
40114	225p
40147	280p
40163	100p
40173/4067	120p
40174	100p
40175	100p
40192	100p
40244	150p
40245	150p
40257	180p
40373	180p
40374	180p
80C95	75p
80C97	75p
80C98	75p

LINEAR ICs

AD7581	£15
ADC0808	1190p
AM7910DC	£25
AN103	3200p
AY-1-5050	110p
AY-3-1350	450p
AY-3-8910	450p
AY-3-8912	500p
CA3019A	100p
CA3028A	110p
CA3046	70p
CA3059	325p
CA3080	80p
CA3080E	70p
CA3086	60p
CA3089E	210p
CA3090AO	375p
CA3130E	90p
CA3130T	130p
CA3140E	45p
CA3140T	100p
CA3160E	100p
CA3161E	200p
CA3162E	200p
CA3189E	270p
CA3240E	150p
CA3280G	270p
D7002	£8
DAC1408-8	300p
DAC0800	300p
DAC0808	300p
DG308	300p
HA1366	190p
ICL7106	675p
ICL7611	95p
ICL7650	400p
ICL7660	250p
ICL8038	400p
ICM7216B	£22
ICM7217	750p
ICM7555	90p
ICM7556	140p
LC7120	300p
LC7130	300p
LC7137	350p
LF347	120p
LF351	60p
LF353	90p
LF355	90p
LF356N	110p
LF357	100p
LM10C	450p
LM301A	30p
LM307	45p
LM308CN	75p
LM310	225p
LM311	60p
LM318	150p
LM319	180p
LM324	45p
LM334Z	115p
LM335Z	140p
LM336	180p
LM339	40p
LM348	60p
LM358P	50p
LM377	300p
LM380N-8	150p
LM380	150p
LM381AN	170p
LM382	200p
LM383	325
LM384	220
LM386N-1	100p
LM387	270p
LM389	190p
LM391	180p
LM392N	110p
LM393	385p
LM394CH	400p
LM709	35p
LM710	48p
LM711	100p
LM723	60p
LM725CN	400p
LM733	65p
LM741	22p
LM747	70p
LM748	30p
LM1011	480p
LM1014	150p
LM1801	300p
LM1830	250p
LM1871	300p
LM1872	300p
LM1886	550p
LM1889	480p
LM2917	300p
LM3302	90p
LM3900	60p
LM3909	100p
LM3911	180p
LM3914	350p
LM3915	340p
LM3916	340p
LM13600	150p
M51513L	230p
M51516L	450p
MB3712	200p
MC1310P	150p
MC1413	75p
MC1458	45p
MC1495L	300p
MC1496	70p
MC3340P	200p
MC3401	70p
MC3403	65p
MF10CN	400p
MK50240	900p
MK50398	790p
ML920	500p
ML922	400p
MM6221A	300p
NE531	120p
NE544	190p
NE555	22p
NE556	60p
NE564	400p
NE565	120p
NE566	150p
NE567	125p
NE570	400p
NE571	300p
NE592	90p
NE5532P	150p
NE5533P	180p
NE5534P	150p
NE5534AP	150p
OP-07EP	500p
PLL02A	500p
RC4136	55p
RC4151	200p
RC4558	55p
S566B	220p
SAA1900	£16
SFF96364	800p
SL490	300p
SN76033N	300p
SN76489	400p
SN76495	400p
SP0256AL2	700p
TA7120	120p
TA7130	140p
TA7204	150p
TA7205	90p
TA7222	150p
TA7310	150p
TBA231	120p
TBA800	80p
TBA810	90p
TBA820	80p
TBA820M	75p
TBA920	200p
TBA950	225p
TC9109	500p
TCA940	175p
TDA1010	225p
TDA1022	400p
TDA1024	110p
TDA1170S	300p
TDA2002	325p
TDA2003	190p
TDA2004	240p
TDA2006	320p
TDA2020	320p
TDA2030	250p
TDA2593	500p
TDA3810	750p
TDA7000	350p
TEA1002	700p
TL081CP	40p
TL062	80p
TL064	90p
TL071	40p
TL072	70p
TL074	110p
TL081	35p
TL082	55p
TL083	75p
TL084	100p
TL094	200p
TL170	50p
UA759	320p
UA2240	150p
UAA170	170p
UCN4801A	550p
ULN2003A	75p
ULN2004A	75p
ULN2068	290p
ULN2802	190p
ULN2803	180p
ULN2804	190p
UPC575	275p
UPC592H	200p
UPC1156H	300p
UPC1185H	300p
XR210	400p
XR2206	400p
XR2207	375p
XR2211	575p
XR2216	675p
XR2240	120p
ZN409	190p
ZN414	80p
ZN419P	175p
ZN423E	130p
ZN424E	130p
ZN425E8	350p
ZN426E	300p
ZN427E	600p
ZN428E	450p
ZN429E8	225p
ZN447E	£9.50
ZN449E	300p
ZN450E	750p
ZN459CP	300p
ZN1034E	200p
ZN1040E	680p
ZNA134J	£23
ZNA234E	950p

VOLTAGE REGULATORS

FIXED PLASTIC

		+ve		-ve	
1A 5V		7805	45p	7905	50p
6V		7806	50p	7906	50p
18V		7808	50p	7908	50p
12V		7812	45p	7912	50p
15V		7815	50p	7915	50p
18V		7818	50p	7918	50p
24V		7824	50p	7924	50p
5V	100mA	78L05	30p	79L05	45p
8V	100mA	78L08	30p		
12V	100mA	78L12	30p	79L12	50p
15V	100mA	78L15	30p	79L15	50p

OTHER REGULATORS

Fixed Regulators		
LM309K	1A 5V	140p
LM323K	3A 5V	250p
78H05KC	5A 5V	575p
78H12	5A 12V	750p
Variable Regulators		
LM305AH		250p
LM317T	TO-220	150p
LM317K	TO3	240p
LM337T	3A+VAR	225p
LM350T	5A+VAR	400p
LM396K	10A+VAR	£15
LM723N		50p
78HGKC	5A+VAR	650
79HGKC	5A+VAR	675p
78GUIC	1A+VAR	225p
79GUIC	1A+VAR	250p
Switching Regulators		
ICL7660		250p
SG3524		300p
TL494		300p
TL497		300p
78S40		250p

COMPUTER COMPONENTS

CPU

1802CE	650p
2650A	1050p
6502	400p
6502A	450p
65C02A	£15
6800	250p
6802	300p
6809	650p
6809E	£8
68B09	£10
68B09E	£12
68000-LB	£36
8035	350p
8039	420p
80C39	700p
8080A	420p
8085A	300p
80C85A	900p
8086	£22
8088	1750p
8741	£12
8748	£16
TMS9980	£14.50
TMS9995	£12
Z80	250p
Z80A	290p
Z80B	550p
Z80CMOS (CMOS Z80)	750p

SUPPORT DEVICES

2651	£12
3242	800p
3245	450p
6520	300p
6522	350p
6522A	550p
6532	480p
6551	550p
6821	150p
68B21	300p
6829	£12.50
6840	375p
68B40	600p
6850	160p
68B50	300p
6852	250p
6854	650p
68B54	800p
6875	500p
8154	850p
8155	380p
8156	380p
8205	225p
8212	200p
8216	160p
8224	300p
8226	420p
8228	550p
8243	280p
8250	950p
8251A	325p
8253C-5	350p
8255AC-5	320p
8256	£18
8257C-5	400p
8259C-5	400p
8275	£29
8279	£11
8282	300p
8284	460p
8287	380p
8288D	950p
8755A	£16
TMS9901	£14
TMS9901	500p
TMS9902	500p
TMS9911	£18
TMS9914	£14
Z80PIO	240p
Z80APIO	250p
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Z80CTC	250p
Z80ACTC	275p
Z80BCTC	500p
Z80DART	650p
Z80ADART	700p
TMS4500	£14
TMS9901	500p
TMS9902	500p
Z80DMA	700p
Z80ADMA	750p
Z80ASIO-0/1/2/9	700p
Z80BP10	500p
Z80BCTC	500p
Z80DART	500p
Electrically programmable and erasable PROMS	
2816-30	£15
9306	450p

EPROMs

2516+5v	350p
2516-35	550p
2532	450p
2532-30	550p
2564	£11
2708	400p
2716+5v	350p
2716-35	550p
2732	450p
2732A-2	900p
2732A-35	£7
2764-25	200p
27C64-25	£10
27128-25	250p
27128-30	800p
27256	£5
TMS2716	500p

CRT CONTROLLER

CRT5027	£18
CRT5037	£12
CRTC6545	£9
EF9364	£8
EF9365	£25
EF9366	£25
EF9367	£36
MC6845	650p
MC6845SP	650p
MC6847	650p
SFF96364	£8
TMS9918	£15
TMS9928	£10
TMS9929	£10

INTERFACE ICs

AD558CJ	775p
AD561J	£20
AD7581	£15
ADC0808	1190p
AM25S10	350p
AM25LS2521	350p
AM25LS2538	350p
AM26LS31	120p
AM26LS32	120p
D7002	£6
DAC80-CB1-V	£28
DM8131	600p
DP8304	350p
DS3691	350p
DS8830	140p
DS8831	150p
DS8832	150p
DS8833	225p
DS8835	200p
DS8836	150p
DS8838	225p
MC1488	60p
MC1489	60p
MC3446	250p
MC3459	450p
MC3470	475p
MC3480	850p
MC3418L	990p
MC3486	250p
MC3487	250p
MC4024	550p
MC4044	550p
MC14411	950p
MC14412	750p
ULN2003	75p
ULN2004A	75p
ULN2068	290p
ULN2802	190p
ULN2803	180p
ULN2804	190p
75107	90p
75108	90p
75109	120p
75110	90p
75112	160p
75113	120p
75114	140p
75115	140p
75121	140p
75122	140p
75150P	120p
75154	120p
75159	220p
75160	500p
75161	350p
75162	400p
75172	300p
75182	90p
75188	60p
75189	60p
75365	150p
75450	50p
75451	50p
75452	50p
75453	50p
75454	70p
75480	150p
75491	65p
75492	65p
8T26	120p
8T28	120p
8T95	120p
8T96	120p
8T97	120p
8T98	120p
81LS95	140p
81LS96	140p
81LS97	140p
81LS98	140p
88LS120	300p
9602	300p
9636A	160p
9637AP	160p
9638	190p
ZN425E8	350p
ZN426E8	350p
ZN427E	500p
ZN428E8	450p
ZN429E	210p
ZN447E	900p

MEMORIES

2016-150	400p
2101	400p
2102	250p
2107B	500p
2111A-35	400p
2114-3L	250p
2147	400p
4116-15	200p
4416-15	300p
4532-20	250p
4816AP-3	300p
5101	370p
5514	450p
5516	550p
6116P-3	350p
6116LP-3	400p
6264-15	700p
6264LP-15	340p
6810	260p
74S189	225p
74S201	350p
74S289	225p
93415	600p
93L422	950p
93425	600p

ROMS/PROMs

28L22	400p
24S10	250p
18S030	200p
18SA030	200p
74S188	150p
74S287	225p
74S288	180p
74S387	225p
82S23	150p
82S123	150p

DISC CONTROLLER ICs

756A	£10
6843	£8
8271	£48
8272	£12
D765A	£13
FD1771	£20
FD1791	£20
FD1793	£20
FD1797	£22
WD2793	£27
WD2797	£27
WD1691	£15
WD2143	£12

CHARACTER GENERATORS

R03-32513	
UC	850p
LC	850p

KEYBOARD ENCODERS

AY 5 2376	1150p
74C922	500p
74C923	600p

BAUD RATE GENERATORS

MC14411	750p
COM8116	650p
4702B	750p

UARTs

AY-3-1015P	300p
AY-5-1013P	300p
COM8017	300p
IM6402	450p

UHF MODULATORS

6MHz UHF	375p
8MHz UHF	450p
Sound & Vision 12MHz	£12

CRYSTALS

32.768 KHz	100p
100 KHz	400p
1.00MHz	270p
Freq in MHz	
1.8432	225p
2.00	255p
2.45760	200p
2.5	250p
2.662	250p
3.12MHz	175p
10.00MHz	175p
3.275	150p
3.5795	100p
4.00	140p
4.194	150p
4.43	100p
4.608	250p
4.9152	200p
5.000	150p
6.00	140p
17.734	200p
7.00	150p
7.168	175p
8.00	150p
8.867	175p
10.50	250p
10.70	150p
11.00	300p
12.00	150p
14.00	175p
14.318	160p
14.756	250p
15.00	200p
16.00	225p
18.00	170p
18.432	150p
19.969	150p
20.00	175p
24.00	150p
48.000	175p
116	250p
PXO1000	£12

REAL TIME CLOCK

MC6818P	400p
MM58174AN	990p
MSM5832RS	350p

TELETEXT DECODER

SAA5020	600p
SAA5030	700p
SAA5041	£16
SAA5050	900p

Turned Pin Low Profile Sockets

8 pin	25p	22 pin	50p
14 pin	30p	24 pin	55p
16 pin	35p	28 pin	65p
18 pin	40p	40 pin	90p
20 pin	45p		

LOW PROFILE SOCKETS BY TEXAS

8 pin	39p	22 pin	22p
14 pin	10p	24 pin	24p
16 pin	11p	28 pin	26p
18 pin	16p	40 pin	30p
20 pin	18p		

WIRE WRAP SOCKETS BY TEXAS

8 pin	30p	22 pin	75p
14 pin	35p	24 pin	75p
16 pin	42p	28 pin	100p
18 pin	50p	40 pin	130p
20 pin	66p		

OPTO-ELECTRONICS

		MAN4640	200p
		MAN6610	200p
		NSB5881	570p
		TIL311	650p
FND357	100p		
MAN74/DL704	100p		
MAN71/DL707	100p	MAN8910	120p
MAN3640	175p		
TIL32	75p	TIL78	75p
TIL31A	120p	TIL81	120p
TIL100	90p	SFH305	100p

DRIVER

9368	350p

COUNTERS

74C925	650p
74C926	650p
74C928	650p
ZN1040	670p

OPTO-ISOLATORS

ILQ74	130p	TIL111	70p
MCT26	100p	TIL112	70p
MCS2400	190p	TIL113	70p
MOC3020	150p	TIL116	70p
ILQ74	220p	16N137	360p
		6N139	175p

LEDS

TIL209 Red	12p
TIL211 Green	15p
TIL212 Yellow	20p
TIL220 Red	15p
TIL212 Green	18p
TIL226 Yellow	22p
Bar Arrays	
Red (10)	225p
Green (10)	225p
RECT. LEDS	
Red, Green, Yellow	30p

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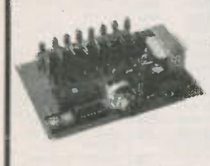


DON'T CHASE AROUND FOR ANOTHER SEQUENCER

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

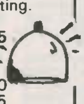
VERSATILE REMOTE CONTROL KIT

This kit includes all components to make a sensitive IR receiver with 16 logic outputs (0-15V) which with suitable interface circuitry (relays, triacs, etc—details supplied) can be used to switch up to 16 items of equipment on or off remotely. The outputs may be latched (to the last received code) or momentary (on during transmission) by specifying the decoder IC and a 15V stabilised supply is available to power external circuits.
Supply: 240V AC or 15-24V DC at 10mA. Size (excluding transmitter) 9 x 4 x 2cms.
The companion transmitter is the MK18 which operates from a 9V PP3 battery and gives a range of up to 60ft. Two keyboards are available MK9 (4-way) and MK10 (16-way), depending on the number of outputs to be used.

MK12 IR Receiver	£13.50
MK18 Transmitter	£6.80
MK9 4-way Keyboard	£1.90
MK10 16-way Keyboard	£5.40
601 133 Box for Transmitter	£2.60

HOME LIGHTING KITS

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



TDR300K Remote Control Dimmer		£14.95
MK6	Transmitter for above	£4.50
TD300K	Touchdimmer	£7.75
TS300K	Touchswitch	£7.75
TDE/K	Extension kit for 2-way switching for TD300K	£2.50

HOME CONTROL CENTRE

This kit enables you to control up to 16 different appliances by means of coded pulses in the mains wiring which may be decoded by special receivers anywhere in the house. The transmitter may be controlled manually or by the computer interface enabling your favourite micro to make your coffee in the morning, switch lights anywhere in the house, or your electric blanket in your bedroom. Just think of the possibilities – and no wiring!
This kit comprises a transmitter with pre-drilled box and two receivers.

XK112	£42.00
Additional receivers XK111	£10.00

ELECTRONIC LOCK KIT

With hundreds of uses in doors, garages, car anti-theft devices, electronic equipment, etc. Only the correct easily changed four-digit code will open it! Requires a 5V to 15V DC supply. Output 750mA. Fits into standard electrical wall box. Complete kit (excl. front panel)
XK101 £11.50
Electronic lock mechanism for use with the above kit. 70150 £14.95

DVM/ULTRA SENSITIVE THERMOMETER KIT

Based on the ICL 7126 and a 3½ digit liquid crystal display, this kit will form the basis of a digital multimeter (only a few additional resistors and switches are required – details supplied), or a sensitive digital thermometer (–50°C to +150°C) reading 0·1°. The kit has a sensitivity of 200mV for a full-scale reading automatic polarity and overload indication. Typical battery life of 2 years (PP3). £15.50

DISCO LIGHTING KITS

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

MK4 PROPORTIONAL TEMPERATURE CONTROLLER

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PE SCIENCE AND TECHNOLOGY

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Readers' Enquiries

All editorial correspondence should be addressed to the editor and any letters requiring a reply should be accompanied by a stamped addressed envelope. Please address editorial correspondence to: **Practical Electronics, 16 Garway Rd., London W2 4NH. Tel. 01-727 7010**

We regret that lengthy technical enquiries cannot be answered over the phone.

Advertisements

All correspondence relating to advertisements, including classified ads, should be addressed to: **The advertisement manager, Practical Electronics, 25 Glenhurst Avenue, Bexley, Kent DA5 3HQ. Tel. (0322) 521069.**

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MY BIT AT THE BEGINNING

Technology, *especially that of electronics, is vital to the development, advancement and improvement of the world in which we live. Regrettably, though, it is taken for granted. Better communication, video and hi-fi entertainment, electrical power and transport, computers, microwave cooking and advanced medical facilities (to name but a few) are now part of everyday life—unquestioned, unremarkable yet apparently essential.*

Why is it that so few take any interest, understand or even care about subjects so vitally important to us all? Why does it take disasters such as the American space shuttle failure and the Chernobyl nuclear accident in the Soviet Union to wake us up?

The answer lies in the transparent complexity of electronics. We are too used to seeing and benefiting from results. Press a button or two and as if by magic you get what you want: be it a TV programme, a perfectly cooked meal or the destruction of an army of alien space-invaders. The processes, ingenuity and technology behind the results seem to be irrelevant until something goes wrong.

They are not! Understanding and interest in electronics, science and technology is vital to the development of individual nations. Britain, for example, was once at the forefront of leading edge technology. Our engineers, scientists, education and research establishments were internationally renowned and respected. Our industries and products were in demand throughout the world. Now it seems, with little exception, we are nothing more than an international has-been—a situation that can and must change.

We've said it before and no doubt will say it again. Government, industry, the educational system and individuals can all play a part in bringing about this change. Indeed we have a collective responsibility to promote, educate and stimulate interest in the subjects which so dramatically affect our lives and the world in which we live.

As new editor of Practical Electronics, *I hope to continue in the tradition set by Fred Bennett, Mike Kenward and Nick Hampshire in playing a small but significant part in the promotion of technology. While continuing to include, in each issue, a range of excellent constructional projects, I will be looking for stimulating and interesting in-depth news, views, features and comments on a range of related subjects. I hope it's what you want.*

Electronics, science and technology are important to us all!

Richard Barron

DID YOU KNOW?

Since the mid-1970s the world market for electronic components has risen at an average annual rate of 12 per cent.

Last year almost 25% of electronic equipment incorporated surface mounted devices; by 1990 the figure will be over 50%.

According to a recent MORI poll, the most attractive applications of new technology are cordless and video telephones. Facsimile machines and word processors have much less appeal.

OUR SEPTEMBER 1986 ISSUE WILL BE ON SALE FRIDAY, AUGUST 1st, 1986 ***(see page 37)***

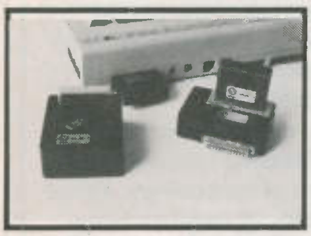
WHAT'S NEW. . .

POINTS ARISING
SBC PART 2

Due to problems with the SBC project design, we have decided to suspend the project pending further investigation. It appears that the circuit published in June is not STE compatible. Next month we will give details of some suitable software for the project but it is unlikely that we will produce a p.c.b. design.

Crafty Cartridge For Commodore

Much of the software available for the Commodore 64 and 128 home micros is available as a plug-in cartridge. The plug-in cartridge is simply a box containing semiconductor memory (a PROM) on a p.c.b. The memory block is mapped into the system and is thus much faster and easier to use than tape or disk. It is also very reliable.



Few Commodore owners seem to make use of the cartridge slot for developing and running their own software, but a new system from Sircal Instruments could change the situation. The EPILOG-1 cartridge system comprises a programmer unit which is plugged into the I/O port, a UV exposure unit, an operating system cartridge and a programmable cartridge.

The operating system is extremely user friendly and allows even the beginner to create cartridge based software, in basic or machine code. Once programmed, the software is permanently stored and can only be erased using the UV unit.

As well as obvious home user applications, the system could be efficiently and cost effectively used in industry as an alternative to disk based software. For example, simple production or test control software could be used ensuring system integrity and fool-proof operation. The complete system is available at £144.95 which is a reasonable price to pay for a reliable cartridge development system, but the additional 8K EPROM cartridges at £17.95 are a little expensive.

Also for the Commodore 64 and 128, the 64 Multimodem from Miracle Technology is now approved for use on the BT public network. It is entirely self-contained and like the Epilog System, plugs into the cartridge port. The software operating system is included in the package and offers facilities such as autodial/answer, automailbox edit and save and telesoftware downloading. The price is £98.50 plus VAT.

Light But Strong

The limiting factor in optical digital signal links is often the response time of the l.e.d. used in the transmitter circuitry. A new ultra-fast high efficiency l.e.d. from Texas Optoelectronics offering a rise-fall time of 6ns at 100mA drive current is now available from GCA Electronics.

Surface Cells

Photain Controls have recently launched a CdS photoconductive cell using surface mounted technology. Measuring only 10mm by 3mm by 0·5mm (approx), the photocells should find their way into a wide range of products.

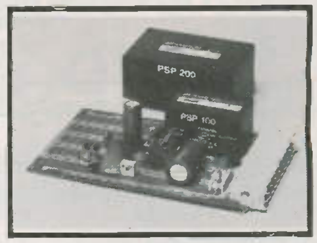
Energy Expenses Granted Response

In the days of soaring energy costs, large users of electricity are becoming increasingly aware of energy expense. Grant Instruments and the Response Company have got together to produce an electricity logging package which is able to monitor power consumption details of machinery or buildings for later analysis.

Called the squirrel, the system takes cumulative readings at pre-programmed fixed intervals between one minute and 100 hours. It can store up to 16,000 readings depending on memory size (there are several versions) which can be displayed on its own screen or passed to a computer for more detailed analysis.

Mode Switch

Switch mode power supplies are used extensively in hundreds of applications but as often as not are inefficient or prone to generation of RF interference. In many cases it is not cost effective to employ in-house designers on PSU design as maximising efficiency whilst maintaining low RF radiation is not easy, due to difficulties in optimising the oscillator, transformer and regulating circuits.



Powerline Electronics Ltd have made the problem of SMPSU design less daunting by producing a half-way design incorporating these circuits on a p.c.b. mounting package which needs no further heat sinking components. All that is required for a custom PSU is a suitable step down transformer, rectifier and filter capacitor.

The output of the supply is controlled simply by injecting a low current into one of the boards terminals. An op-amp can be used to derive the controlling current from the supply output rails.

Holiday Test Gear

TMK Instruments, the test equipment division of Harris Electronics Ltd, are offering to pay for your holiday by offering free vouchers with instruments. What a daft idea!

Anyway, the vouchers are not free because you have to buy some test gear to get them and they will only pay for part of your holiday, 5% maximum.

CATALOGUE CASE BOOK

Over the last month we have received the following catalogues:

The A to Z of **instruments and accessories** from AlphaOmega instruments Ltd., Unit 5, Linstock Trading Estate, Linstock Way, Wigan Road, Atherton, Lancs. M29 0QA. Tel (0942 873558).

TMK short form **test instrument** catalogue from: Harris Electronics, 138 Grays Inn Road, London WC1X 8AX. Tel. 01-837 7927.

Expanded short form catalogue of **components** from: Micro Power Systems, Orion House, 49 High Street, Addlestone, Surrey KT15 KTU. Tel. (0932) 57315.

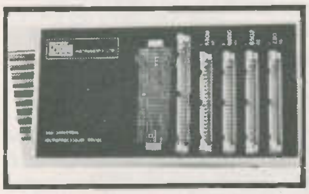
Thermalloy **Heatsink** catalogue from: MCP Electronics Ltd., 26-32 Rosemont Road, Alperton, Wembley, Middlesex HA0 4QY. Tel. 01-902 6146.

WHAT'S NEW...

Logical Additions

Two options for the 701 range of Zicon Logic Analysers are now available, the 803 Universal Microprocessor Probe and Remote Control Operation.

The 803 Universal Microprocessor Probe is actually four personality probes in one. Inputs for 6800, 6809, 6502 and Z80 allow direct connection to these microprocessors using the 40-way input cable and clip supplied without requiring a



different personality probe for each. A fifth input, which duplicates the input connections on the 701, enables the probe to be used as a buffered and protected extension for the Logic Analyser.

The remote control option for the 701 comes supplied with an EPROM for the BBC micro which contains machine specific routines to enable complete remote control over the Logic Analyser. The routines are fully interfaced to BBC Basic and will work with B+, Master series and second processors. Simple commands such as *SEND, *BINDUMP and *FORMAT, and routines for fast data dumps and memory comparisons enable programs to be written very easily in BBC Basic.

D.i.l. Diodes

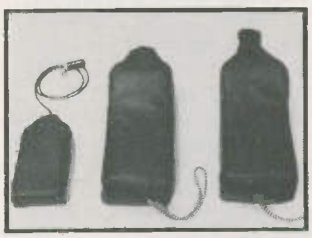
Most components, nowadays are available in packages compatible with automatic p.c.b. equipment. Iskra Ltd are now able to supply, on request, any type of DO-35 diode in 16-pin plastic packages, each of which contain eight independent diodes.

It Looks Good In Black

The success of the electronics industry has provided markets for hundreds of other areas of manufacturing, the most recent being that of the leather goods trade.

Castle Associates spent four years looking for a suitable supplier of a case of their sound meter products. They have now found one; Hobson De Niro Design Partnership of Scarborough. Their sound meters are now dressed in black doeskin.

Following on from this success, Hobson De Niro now offer a service to instrument suppliers of all kinds. They will take a pattern from any instrument and produce a sample leather case within 28 days. The initial pattern-making fee is deductible from the first order.



PC Upgrade

The IBM PC whilst being extremely popular, mainly due to its name, is not a particularly advanced computer. In fact by today's standards it is decidedly slow. To increase its performance, there are upgrade kits available but these are often expensive.

However, it is now possible, according to Mektronic Consultants, to increase performance by simply changing the existing 8088 and 8086 chips to newer versions. This can be done for as little as £35. The new versions are compatible with existing software.

Keeping Track Of Developments

There's more to changing channels on satellite TV than pressing a button—as on standard receivers. If you want to switch, say, from an Intelsat 5 channel to a programme on ECS, you have to re-position your dish.

A new auto antenna tracking device is now available from Greenwich Satellite, the UK distributor of NESAT equipment, which makes the job much easier. The dish is positioned using a motor which is linked by a cable to a microprocessor controlled digital tracker. An l.e.d. display shows the position of the dish which can be positioned simply by pressing a button. A remote control is optional.

FIRM CONTACT

Details of products, services and companies mentioned in News and Market Place can be obtained from the following sources:

Photain Controls Ltd., Ford Aerodrome, Arundel, West Sussex, BN18 0BE. Tel. (0903) 721531
Iskra Ltd., Redlands, Coulsdon, Surrey, CR3 2HT. Tel. 01-668 7141
British Standards Institution, 2 Park Street, London W1A 2BS. Tel. 01-629 9000
The Response Co. Ltd., 77 Wales Street, Winchester, Hampshire SO23 8EY. Tel. (0926) 67287
Grant Instruments, Cambridge Ltd., Barrington, Cambridge CB2 6QZ. Tel. (0762) 60811
Hobson De Niro, North Riding Passage, Queens Parade, Scarborough, North Yorks., YO12 7HU. Tel. (0723) 351515
BBC Engineering Information Dept, Broadcasting House, London W1A 1AA Tel. 01-927 5432
Global Specialities, Shire Hill Ind. Est., Saffron Walden, Essex CB11 3AQ Tel. (0799) 21682
GCA Electronics Ltd., Unit 2, Great Hasely Trading Estate, Great Hasely, Oxfordshire, OX9 7PF. Tel. (08446) 8861
Miracle Technology (UK) Ltd., St. Peters Street, Ipswich IP1 1XB. Tel. (0473) 216141
Powerline Electronics Ltd., 5 Nimrod Way, Elegar Road, Reading RG2 0EB. Tel. (0724) 868567
Fluke (GB) Ltd., Colonial Way, Watford, Herts, WD2 4TT. Tel. (0923) 40511
Metronic Consultants, Linden House, 116 Rectory Lane, Prestwich, Manchester M25 5DB. Tel. 061-798 0803
Sircal Instruments (UK) Ltd., 11 Southfields Court, Sutton Common Road, Sutton, Surrey SM1 3HJ. Tel. 01-644 0981
NEC Business Systems Ltd., Cambden Office, 35 Ocal Road, London NW1 7EA. Tel. (01) 267 7000
Sony Broadcast Ltd., Belgrave House, Basing View, Basingstoke, Hampshire RG21 2LA. Tel. (0256) 55011
Consumers Association, 14 Buckingham Street, London WC2N 6DS. Tel. 01-839 1222
RNIB, 224 Great Portland Street, London W1N6AA. Tel. 01-388 1266
Radamec Electronics, 22 Dukes Ride, Crowthorne, Berkshire RG11 6DS. Tel (0244) 775115
Rapid Silicon, Rapid House, Denmark Street, High Wycombe, Buckinghamshire HP11 2ER. Tel. (0494) 442266
Zicon Instruments, Hellesdon Park Road, Drayton High Road, Norwich, Norfolk NR6 5DR. Tel. (0603) 400093

WHAT'S HAPPENING . . .

A closer look at what is happening in the electronics world plus what present developments might bring in the future

Tape Trade To Take More

For years now the record industry has been beefing about loss of income through copying of pre-recorded music onto blank tapes for personal use or mass copying by pirates for financial gain. Both practices are currently illegal but it has become obvious that policing of the relevant copyright laws is totally impossible.

This and previous governments have been under pressure to legislate on this matter but, to date, little has been done. The present government has proposed a levy on blank tapes, which whilst not preventing illegal copying will, they claim, compensate the copyright holders. However, a survey carried out by NOP Market Research, commissioned by The Tape Manufacturers Group, highlights some very interesting statistics which indicate that the proposed levy would be very unfair to a large number of blank tape users. In addition, other groups such as the Royal National Institute For The Blind (RNIB) and the Consumers' Association are very unhappy about the situation.

Under proposed legislation a levy would be raised on all blank tapes which would be paid to copyright holders but would allow tape buyers to record broadcast or pre-recorded material. On face value this idea seems quite fair but according to the NOP survey, over 70% of tape buyers would be paying twice for the privilege. This is because over 50% of tape buyers record their own records and a further 18% record broadcast material on which copyright fee has also been paid.

If the proposed levy became law, according to Mr. Christopher Hobbs of the Tape Manufacturers Group, "copyright owners would be laughing all the way to the bank". In summarising the results of the survey, Mr. Hobbs said, "Under the Government's proposed tape levy scheme all tape buyers would be penalised on the basis that they are capable of infringing copyright and, therefore, should pay.

"Nowhere else in English law is this principle accepted, and no wonder—it would pave the way for parliament to impose a levy on all cars sold, to allow for parking offences the owner might commit in the future."

The RNIB claim that blind people would be penalised for using tapes which are necessary for their normal daily living—for notes, lists, recipes, etc. Although it is expected that certain users, probably including visually handicapped people, could be exempt from the levy, reclaiming the 10% imposed might prove to be difficult or extremely inconvenient.

Rosemary McRobert of the Consumers' Association, whilst speaking at an 'Anti Tape Levy' press conference, said of the proposed legislation:

"All in all it's a tacky, small minded device to do something—anything, rather than tackle the reform of copyright law which is outdated by modern technology."

Big Blue Listener

Effective speech recognition is fast becoming a reality. IBM researchers at the Thomas J Watson Research Centre, New York, recently demonstrated an experimental system which is capable of producing accurate documents in response to human speech. It is claimed that the system can correctly transcribe sentences from a vocabulary of 5,000 words with over 95% accuracy. They didn't say which words it got wrong.

IBM demonstrated its first large, real-time, speech recognition system two years ago—it needed a room full of electronics and computing power. The new version has been redesigned and integrated into their popular PC AT using two powerful subsystems each composed of three computer cards. At the heart of the system is an IBM digital signal processor capable of 30 million operations per second. The result is a transformation from large mainframe to desk-top in two years.

Probably the most important factor in this change is not the hardware, but the firmware and software programming techniques. Rather than attempting to model thousands of separate words individually or emulating human speech recognition methods, it works with a limited number of phonetic sounds or symbols.

As words are spoken, the system encodes the 'recognised' phonetics and then uses a statistical model drawn from an analysis of over 25 million words to determine the most probable word spoken. As the sentence progresses it can update the interpretation as the context becomes apparent. This method allows the system to distinguish between similar sounding words such as know and no.

It will be quite a time before a commercial model is available as intensive field trials have to be carried out first. Also, work is in progress on increasing the machine's vocabulary. Various problems such as background noise, interference and differing voice tones still have to be ironed out.

Even when the system is more reliable, versatile and adaptive to many different voices, the design team leader at IBM, Dr. Fredrick Jelinek, says:

"We need to understand how people in normal office settings will actually use it."

I don't mind being a guinea-pig—I've always wanted a perfect audio typist and secretary who doesn't answer back.

Plug into our network—we're just next door

Use of the mains electricity system for transmission of data, especially audio signals, has been around for years and has more recently been used for digital communication. The techniques are quite simple —just superimpose the required signal using inductive coupling via a 13A socket and you're in business.

Radamec Electronics have had a black-box type module for computer communication via the mains cable for some time now. The system offers a speedy method of setting up a computer network within a building without the need for extensive cabling. Each terminal, computer or peripheral uses its own isolating and conversion unit to transmit RS232 compatible serial data. Radamec have now introduced a bare-board version for use by OEM's to incorporate into finished equipment.

The idea seems good, but I can't figure out how they can possibly protect unauthorised use of the data. Because of the nature of mains distribution it is usual for several buildings or offices to use a common mains feed, thus with suitable equipment plugged into a socket, the data is anybody's. Admittedly, the data may need decoding, but in most cases this shouldn't prove too difficult. I'm not saying that the world is full of hackers, but I wouldn't like to think my bank or doctor was using a system of this kind.

Inmos continue to do well with their range of memory products, especially in the high performance static and dynamic RAM market of which they claim to be world leaders. The 256K, 60 nanosecond access time dynamic RAM from Inmos is the fastest in production. Mind you, they are produced under licence in Japan.

A new Inmos short-form catalogue detailing all their latest RAM devices is available from Rapid Silicon.

Meanwhile Inmos have announced a substantial range of additions to the transputer family which they say have been sold successfully throughout Europe, the US and Japan. They haven't, though, put any figures to these sales.

WHAT'S TO COME...

A Clear View To The Future

In 1970 it took an average worker 10 weeks to earn enough to buy the cheapest 22 inch TV set. Now it takes less than two weeks to buy the same sized set which offers better quality, reliability and facilities. The home entertainment business is one of the decades boom industries with developments of video players and recorders, flat screen TVs, cable TV and satellite networks.

A recent "Ideal Homes" survey carried out by MORI, shows no evidence that tomorrow's home-owners will be less reliant on the 'box' than their elders. Indeed, for first time home-owners, the most attractive technology developments are satellite television receivers and flat screen TVs.

A new development which Sony Broadcast claim will revolutionise both large and small screen entertainment is that of high definition TV (HDTV). HDTV is basically standard video technology using a 1125 line scan rather than the 625 lines which make up a typical PAL television picture.

It will be years before the benefits of HDTV are seen by the consumer, as existing broadcast facilities around the world are not capable of transmitting 1125 lines, due to the limited ability of existing cables to carry the necessary signals.

At present the main market in this area is that of advertising. Advertisers are able to film adverts using HDTV, the results of which can easily be used for the large or small screen. Obviously, when the recording is received by normal TV it will be back down to 625 line definition, but because the original was high quality, a marked improvement is realised.

In the future, HDTV will be a service offered to the consumer through the satellite TV stations. Obviously, suitable receiving equipment will be required together with a 'special' 1125 line TV. Meanwhile satellite TV is taking off in the UK slowly but surely. There are now about 6,000 households in the UK equipped to receive satellite broadcasts, from a range of channels offering a variety of services and programmes.

Revolution In Radio

The electronics hobby initially stemmed from the enormous interest and fascination in radio. Over the last half century or so, radio hams and electronics enthusiasts have conquered most of the technical problems of radio reception and hundreds of radio projects have appeared in the hobby press. In recent times, partly due to the cheaply available radio and hi-fi equipment in the high street, radio projects have lost their popularity.

Next year (August '87), however, things might change. A new service, Radio Data System (RDS) is to be offered by the BBC. RDS is a revolutionary system that, amongst other things, allows receivers to be automatically tuned in to a chosen programme.

The RDS signal is to be transmitted from the BBC's VHF-FM transmitters and will consist of an inaudible 57kHz sub-carrier added to each VHF transmitter. This signal is phase-shift keyed by a 1187·5 bits per second digital data stream which will carry a range of information which can be decoded by the new generation of RDS receivers which will no doubt appear on the market.

There are to be 14 possible functions and the BBC will start a basic RDS service using five of these to offer the following facilities:

Programme Identification (PI) This allows the receiver to find the strongest signal and identify the station.
Programme Service (PS) This consists of a code which may be displayed to show the station name, eg, 'Radio 3'.
Alternative Frequencies (AF) This consists of codes which inform the receiver of other frequencies for a particular station to which it can switch if a stronger signal is available.
Other Network Information (ON) This allows information about other stations to be monitored and could, for example, inform of an imminent weather forecast on another station.
Clock Time And Date (CT) An automatic, accurate time and date code.

These services will be expanded once the basic system has got off the ground and will be available throughout the UK. It is likely, also, that an international standard will be adopted thus allowing a British receiver to be used anywhere in the world for local information.

Obviously these developments beg for someone to produce one or more practical hobbyist designs, something Practical Electronics is already looking into—in anticipation. No doubt others will follow.

COUNTDOWN

If you are organising any electrical, computing, electronic, radio or scientific event, big or small, drop us a line. We shall be glad to include it here. Address details to Countdown, Practical Electronics, 16 Garway Road, London W2 4NH.
NOTE: some exhibitions detailed here are trade only. Please check details and dates before setting out, as we cannot guarantee the accuracy of the information presented here.

Instrumentation '87, Feb 25/26, Harrogate Exhibition Centre, March 25/26, Bristol, Crest Hotel.
British Laboratory Week, Sept 23–25, Olympia. **C**
ITAME, Sept 23–25. **C**
College. **B**
Milan Fair, Sept 4–8, Milan (Trade only).
Audio '86, Nov 12-15, Olympia 2.
Official Acorn User Exhibition, July 24–27, Barbican. **E**
Amateur Electronics Exhibition, July 12–20. Esplanade, Penarth. **A**

A B.A.E.C. ☎ 0222 707813
B Imperial College ☎ 01-589 5111
C Evan Steadman ☎ 0799 26699
D HPS ☎ 0494 40176
E Editionscheme ☎ 01-394 4667
F Amateur Radio Promotions ☎ 021-421 5516

Big Bang To Cause Minor Communications Boom

Under present regulations, there is strict segregation between stock brokers and stock jobbers at the stock exchange. Later this year under a deregulation process commonly known as "Big Bang", many small firms will combine leading to an increased demand for communications facilities in the City.

BT has responded by introducing 'Dealerinterlink', a low cost private network system. Over 40 major banks and dealing houses have already signed up for this service which enables private communications lines to be set up between two points within 24 hours.

British Telecom are of course in an ideal position to offer this type of service, having thousands of miles of existing cable and innumerable distribution points around the City, for the general telephone network. Very few, if any, other communications companies could respond to such a market quickly enough.

This situation may change. The telecommunications market is growing at a rate of 8% per year and since the relaxation of BT's monopoly in Britain firms such as Mercury are aiming to become credible competitors. Of course any competition would be aimed at the highly lucrative business service market which could easily affect the cost of residential telephone services. If BT has to compete in the business sector which subsidises residential services, things might get tough. Sir George Jefferson, Chairman of BT, speaking at the Communications '86 Exhibition at Birmingham said:

"Our track record has been very responsible and for the average domestic customer has resulted in no real increase in his bill. It would be BT's wish to continue with this policy."

Well, Sir George, it might be your wish and ours, but time will tell.

C.A.D.

BY CHRIS KELLY

In this the first of two articles on computer aided engineering we look at the techniques, applications and benefits of this relatively new technology. Much of the software used in industry is beyond the price range of the home constructor but the techniques used in cheaper packages are very similar. Next month in PE we will be taking a much closer look at the software available to the hobbyist which may be run on popular machines such as the BBC.

It may not be as much fun, but it's certainly more useful than Space Invaders!

For many years large computers have been used in the design of advanced technology products such as aeroplanes and cars. Also, powerful computers are used in the automation of factory processes, but generally the huge investment needed has limited this to a few mass-produced products. But now the dramatic fall in the cost of computers is giving more and more design and production engineers access to these new tools.

An industry has been spawned which has become generally known as *computer aided design* (CAD). It now extends beyond the design stage to link the design concept with computer-controlled manufacturing and testing which only a few years ago was beyond the scope of smaller industries. An all-embracing title of *computer aided engineering* (CAE) has been given.

To encourage developments in the fields of electrical and electronics the government launched CADMAT (yet another acronym!) which stands for *computer aided design, manufacture and testing.* This article presents some of the trends in computer aided engineering generally but, naturally, with an emphasis on analogue and digital electronics.

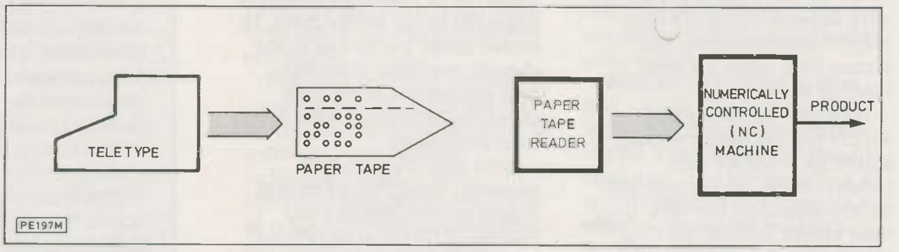


Fig. 1. *N.C. machine system*

MECHANICAL PRODUCTION

Machines for the automatic manufacture of mechanical components have been available at high cost since the early 1970s performing a number of tasks such as drilling, turning and milling. These are known as 'numerically controlled' or NC machines (Fig. 1).

The co-ordinates which control the machine's action are punched on paper-tape entered by the operator on a teletype. The paper-tape program is fed into the NC machine which then manufactures the item repeatedly: fast, precise and tireless. One human operator feeds many of these machines with new material and generally supervises to ensure that all is working well.

Now the design work can be done using an engineering design workstation which may be a self-contained computer or may be one of many terminals linked to a large computer. The computer converts the design concept into a list of co-ordinates which can be sent directly to a 'computer numerically controlled' or CNC machine (see Fig. 2). However, it is normal for the computer to first run a graphics simulation of the design. This verifies that nothing goes wrong in the actual production.

Some of the simulations show an imaginary tool profile working at the material in the same way as the CNC machine would move a real tool. Sometimes realistic sounds are used, including an awful clanging sound if the tool runs into the chuck! At this stage corrections and modifications are made until the design is satisfactory. This greatly reduces time in design and eliminates wasted materials in making prototypes.

Very advanced design drafting systems have become available. A 2D drafting system allows the designer to draw using conventional geometries and projections of the design. So the system is really an electronic drawing machine but often provides advanced facilities which include libraries of standard components stored on disc which can be included in a larger design, and a zoom facility so that fine detail can be put on the drawings.

Systems are available that can transform the 2D information into three dimensional isometric views from any desired angle. These can be as simple as 'wire-framework' models or as sophisticated as the Medusa package from Cambridge Interactive Systems which fills in details of colour and shading as if lit from a particular direction.

For this type of 3D modelling the speed of the processor must be very fast indeed and the working store enormous. Medusa is often run on the ultra fast VAX mini-computer through a local workstation.

Designing a component from a CAD drafting system is not the full story. Often a prototype must be made for testing its performance under the stresses of a working environment. A further development in design and research work is that of computer aided stress analysis involving a technique known as 'finite element analysis'.

This involves defining a physical component as thousands of tiny shapes or elements. The computer is programmed to analyse how each element would respond to forces caused by

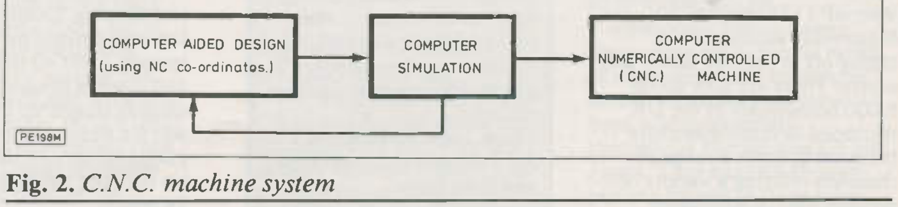


Fig. 2. *C.N.C. machine system*

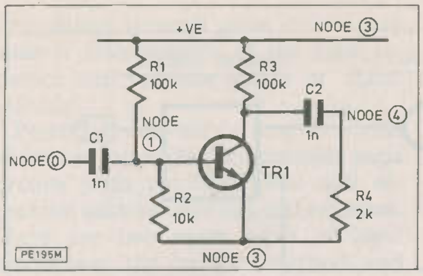


Fig. 3. *Simple CAD annotation*

stress, impact or even electrostatic forces. The response of each element can be predicted using mathematical relationships and after all the elements have been considered individually the changes taking place in the whole component can be understood.

ANALOGUE CIRCUIT DESIGN

Until recently an analogue circuit designer would breadboard the components of a new design, test and then modify the circuit extensively. Each modification required a new set of readings which could be very time consuming. Now with circuit design software packages of increasing sophistication, the designer can use a computer to simulate the action of a circuit and repeatedly alter the design until the required performance is achieved.

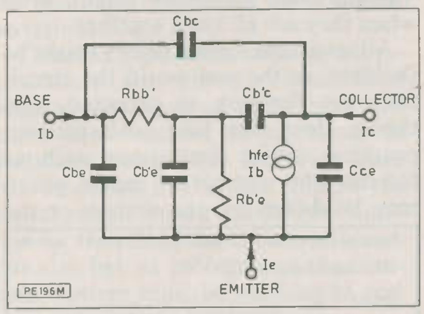


Fig. 4. *Simple CAD circuit*

For a number of years, programs have been available to assist in the calculations of circuit analysis. Most of them work on the principles of nodal analysis. That is, most circuits can be broken down into a number of nodes or numbered points and each component in the circuit is defined as being between two nodes. For example, in Figs. 3 and 4 for a simple amplifier circuit, the transistor is represented by a mathematical equivalent circuit so that its performance can be calculated using known circuit equations.

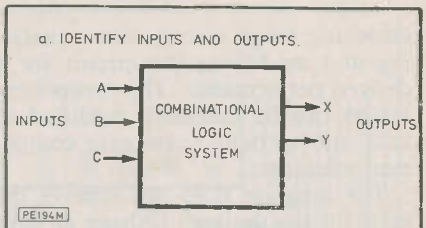
With older programs the designer would draw the circuit and label the nodes on paper before entering all the components and the nodes to which they are connected as a numerical list known as a 'net-list'. The computer would then expect to be told whether dc or ac or even transient analysis is required, the values it should calculate (eg gain, phase, input and output impedance) over what frequency range and how many steps it should take.

The results could be as simple as tables of figures from which the designer makes his own interpretation or, of more value, the results are presented as graphs. This type of program is simply an advanced type of calculator, making many thousands of calculations which would take the designer weeks to wade through with a pocket calculator.

Figs. 3, 4 and 5 show a simple example using a program called 'Analyser II' by Number One Systems which runs on the BBC Model B. Selections from a menu allow the user to create new circuits, modify, store circuit on disc, load old circuits from disc and, of course, analyse the circuit. Having made a choice, the user is then guided through options with a series of questions, most requiring a yes/no answer—no complicated procedure to remember.

For a new circuit, the designer sketches his design on paper and calculates the component approximate values using standard circuit techniques (the program cannot do this part for the designer). The circuit is then labelled with nodes (Fig. 3) and the component names, nodes and values are entered into the computer as a table (see Fig. 9). The circuit can have up to 27 nodes and 100 components.

The parameters of active devices such as bipolar transistors, FETs and operational amplifiers are stored in a data library on disc and for a circuit analysis only require to be referenced by a simple code and the nodes to which they are connected. The active devices are analysed using equivalent circuits. For example, a bipolar transistor equivalent circuit represents the operation of the transistor as a number of resistances, capacitances and a current source.



A	B	C	X	Y
0	0	0	1	1
0	0	1	0	1
0	1	0	1	0
0	1	1	1	0
1	0	0	0	1
1	0	1	0	0
1	1	0	1	0
1	1	1	0	1

$$X = \overline{A}.\overline{B}.\overline{C} + \overline{A}.B.\overline{C} + \overline{A}.B.C + A.B.\overline{C}$$
$$Y = \overline{A}.\overline{B}.\overline{C} + \overline{A}.\overline{B}.C + \overline{A}.B.C. + A.B.\overline{C}$$

Fig. 6. *Logic design*

The final information needed by Analyser is to identify the input, output and ground nodes. The program is then ready to compute. The user makes a selection from absolute gain or relative gain in either magnitudes or in decibels. The system also calculates phase, group delay, input and output impedances if required.

After specifying the frequency range over a number of steps, the program will compute a table of results and display these as a graph (Fig. 5) made up of alphanumeric characters which is adequate for most purposes.

I found Analyser very easy to use, taking little more than an hour to become familiar with it. I was soon

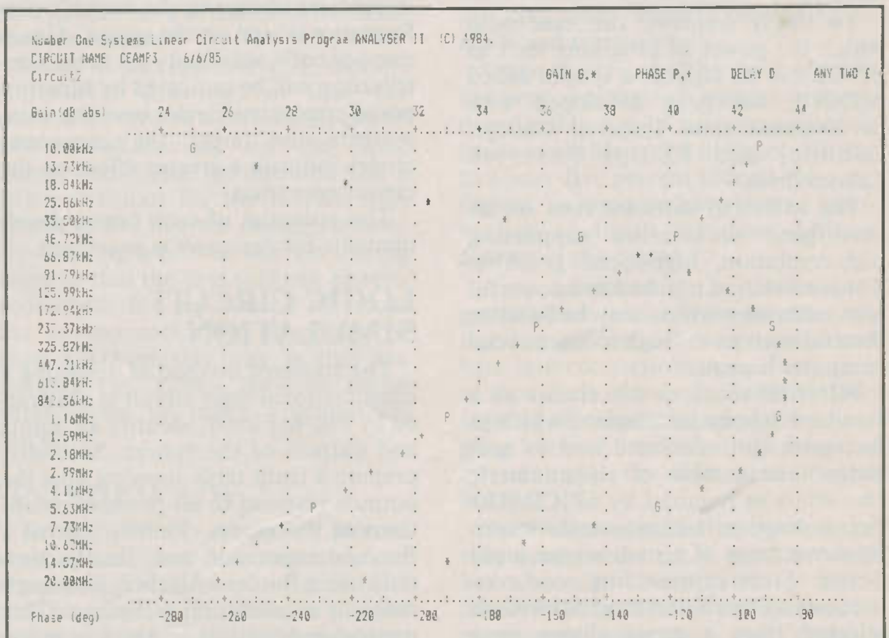


Fig. 5. *Computer generated graph*

sketching rough circuit ideas, analysing and modifying the circuit for a desired performance. The component values can be manually modified to take into account worse case component tolerances.

The program does not remove the need for the designer to have an intimate knowledge of a particular circuit's operation—it simply and dramatically speeds up the process of design. Furthermore, the fully printed details of the circuit and graphical results are a tremendous advantage for filing or inclusion in a report.

Analyser is a very useful program with many 'user-friendly' qualities, but it is obviously limited by the speed at which the BBC can compute and the amount of available memory. A program called SPICE, however, was developed by the University of California at Berkeley to run on much larger and more powerful mini and mainframe computers.

SPICE can perform d.c. analysis where the voltage at any node is calculated, a.c. analysis using sinusoidal signals or transient analysis where variations in circuit response against time are computed for impulse inputs. There are many advanced features in the program which permit noise analysis, distortion analysis and affects due to temperature variation.

The price to pay for such analytical power is complexity. A user must follow quite complex procedures and protocol and to become proficient must be prepared to spend a great deal of time learning the system. Also the circuit has to be 'captured' manually by the user, tabulating all components and nodes which can become very painstaking and tedious for advanced circuits.

To vastly improve the ease with which the power of programs such as SPICE can be tapped, a system called MINNIE has been developed with involvement from Imperial College, London, and Philips Research Laboratories.

The MINNIE software runs on an intelligent workstation supporting high-resolution, high-speed graphics. The workstation is linked to a powerful host computer which may be local or distant, such as through a commercial computer bureau.

MINNIE captures the circuit as a standard schematic diagram which is far easier to understand and to spot errors than a table of alphanumeric characters as required by SPICE. The circuit diagram is drawn on the screen by movements of a mouse-type input device. Lines representing wire connections are positioned and devices are selected from a menu shown in a window. Components can be rotated or flipped to give a mirror image so

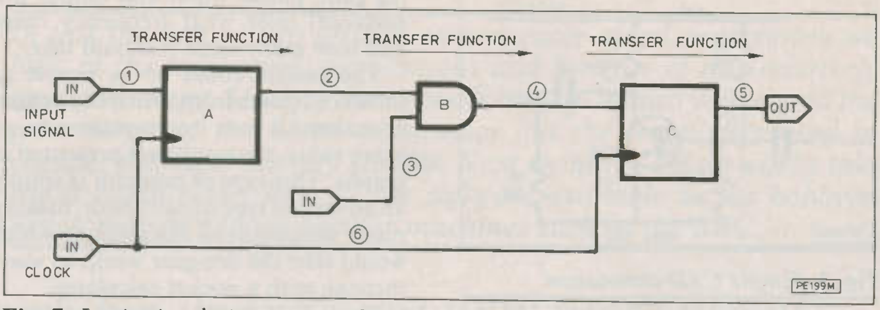


Fig. 7. *Logic simulation timing chart*

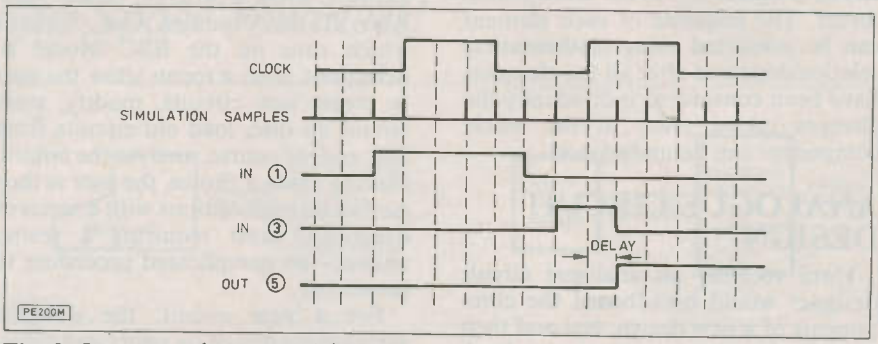


Fig. 8. *Logic simulation model*

that all device positions and orientation are available.

Values are then assigned to the components. MINNIE also allows circuits to be defined as 'black boxes' to be included in more complex circuits.

The user then specifies how the circuit is to be analysed by making selections from a menu. The circuit information is converted into data that the powerful analysis program can understand in the host computer. A further window displays the high-resolution plots of results.

A further important development planned for MINNIE is to provide dynamic results so that component values can be varied and an almost immediate change in the circuit's performance is seen on the screen. Also, a component's sensitivity or noise contribution will be indicated by superimposed concentric circles over the components—the larger the concentric circles indicate a greater effect on the circuit operation.

The potential of such future developments for designers is enormous.

LOGIC CIRCUIT SIMULATION

The standard method of designing a combinational logic circuit is illustrated by Fig. 6. Firstly, identify all inputs and outputs of the system. Secondly, prepare a truth table showing how the outputs respond to all possible conditions at the inputs. Thirdly, derive a Boolean expression and, finally, simplify using Boolean Algebra, Karnaugh maps or a tabulation technique. This method is described in detail in many electronics text books.

Apart from the tabulation methods of equation simplification, computer assistance is limited in this initial design work. However, once the simplified logic equation is known, the next step traditionally is to breadboard the circuit to verify its operation. Also, small subcircuits may work well individually but problems might arise when they are all hung together.

Although the logical theory might be faultless, in the real world the circuit may not function as expected. The theory does not take into account practical device limitations such as fan-out (the number of inputs which may be driven by one output) or the

Number One Systems Linear Circuit Analysis Program ANALYSER II (C) 1984

CIRCUIT NAME CEAMP3 6/6/85

Circuit2

Component list:

R1	1	3	100000			
R2	1	5	10000			
R3	2	3	100000			
C1	0	1	1E-9			
C2	2	4	1E-9			
R4	4	3	2000			
OA1(ZTX239)	1	2	3	300	5	300
P	0	4	5			

TEST RESULTS

Frequency	Gain(dB abs)	Phase (deg)
10.00k	25.04	-92.36
13.73k	27.75	-96.04
18.84k	30.42	-100.28
25.86k	33.00	-105.40
35.50k	35.44	-111.70
48.72k	37.67	-119.34
66.87k	39.57	-128.10
91.79k	41.07	-137.72
125.99k	42.15	-147.16
172.94k	42.84	-155.81
237.37k	43.26	-163.32
325.82k	43.49	-169.77
447.21k	43.60	-175.44
613.84k	43.63	-180.74
842.56k	43.58	-186.10
1.16M	43.45	-191.96
1.59M	43.18	-198.70
2.18M	42.70	-206.58
2.99M	41.92	-215.58
4.11M	40.74	-225.27
5.63M	39.13	-234.92
7.73M	37.13	-243.79
10.62M	34.84	-251.49
14.57M	32.35	-258.02
20.00M	29.73	-263.65

Fig. 9. *Example of computer generated table*

time delays through gates which may cause a discontinuity of the logic sequence and produce spikes or 'static hazards'.

Powerful software is now available which can simulate very complex logic circuits both combinational and sequential such as counters and registers. There are two main types of logic simulation: the 'epoch' method and 'event' method (Figs. 7 and 8).

The epoch method evaluates every logic state for every device at each sample period. The system may be programmed to check many times within a simulated clock pulse so that brief transients caused by propagation delays can be detected. For complicated circuits this can significantly slow the simulation and as each state is stored at each sample, large amounts of memory are required.

Event driven simulations start with initial logic states and record only changes that occur at each sample. This speeds up computing time and saves on storage.

In both systems the device inputs and outputs are specified in the overall system using nodes. Logic transfer functions represents the action of the devices and the user specifies where software probes are to display the logic states after a simulation. The output is very similar to a logic analyser showing the relationship between many digital waveforms.

Complex logic chips such as microprocessors are difficult to simulate because they have so many pins and many combinations of responses to particular instructions. It is often more convenient to link a real chip to the digital signals from a computer simulation for the rest of the circuit, although this also has its problems as the computer system must be working in real time rather than simulated time.

PCB DESIGN

When the functional design work of any circuit is complete, the next state is to manufacture the circuit and the first step in this is the printed circuit board design. This involves component allocation and layout on the board, routing tracks between component and then producing high quality artwork.

Even for skilled designers, producing the artwork can take typically two-thirds or the time. Computer systems are available for all stages of the design work, but a CAD drafting program used simply as a drawing tool gives the best return of time saved for investment. Systems which provide automatic positioning and routing of tracks save proportionately smaller amounts of design time yet they are vastly more expensive to buy.

Most CAD drafting programs can be used for p.c.b. artwork, starting with

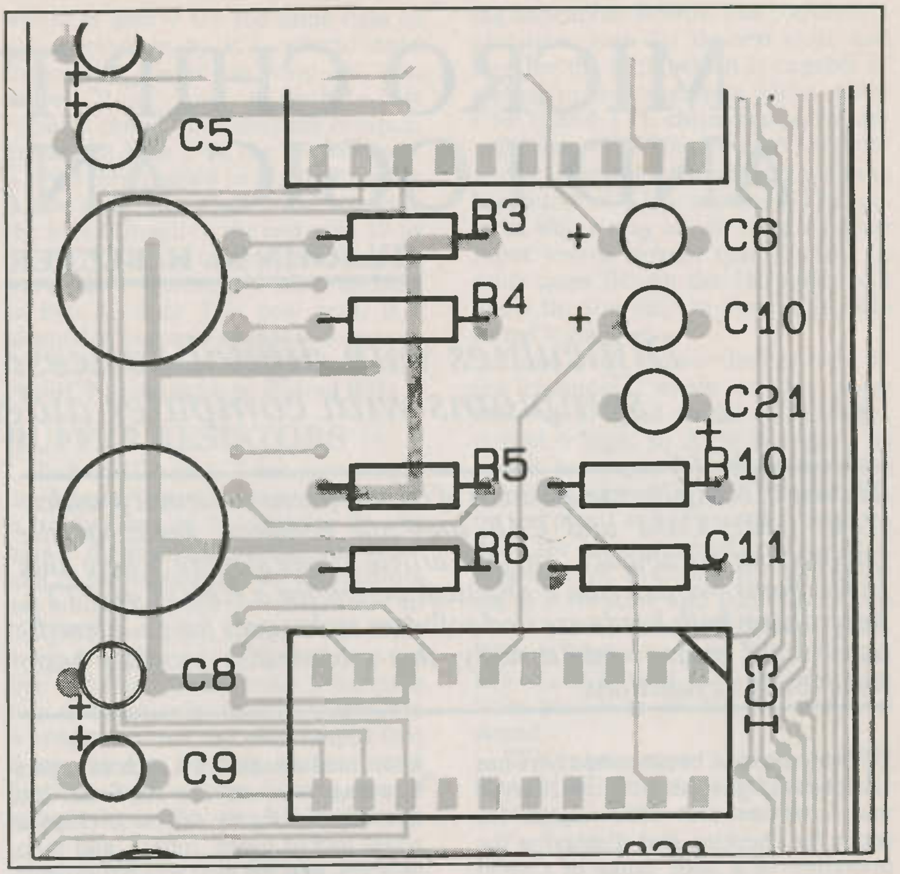


Fig. 10. *Computer generated p.c.b.*

generating a library of pad formats and sizes for the many types of component 'footprints'. A selection of these are called from the library and positioned by the designer on the screen using cursor controls with the simpler programs, and mouse or graphics tablet input devices for more expensive systems. Then tracks are routed one at a time between components, so the intelligent part of the process is done by the human operator, although the program does not permit tracks to be crossed for obvious reasons.

Some CAD systems can support multi-layer drawing, so that the artwork for double sided boards can be seen simultaneously on the same screen, one colour for one side and a different colour for the reverse side. This is rather like the designer manually drawing a second side on tracing paper so that the first side can be seen underneath for registration of tracks and components. The advantage of using CAD in this way is that the designer can switch between layers immediately to make amendments quickly.

FINISHED A/W

The finished artwork is best plotted at actual board size on an acetate sheet using special black pens, or sometimes even plotting directly onto the copper-clad board is possible. Cheaper programs sometimes use dot-matrix plotters in graphics double density mode and printing at twice or four times the actual board size. The printed artwork is then photographically reduced to become the p.c.b. mask.

Auto-routing PCB design requires a long procedure where the designer places each component using x-y co-ordinates, specifies the component footprint and then details the connections to be made between device pins and component legs. The program is then asked to find the best route, which can take many minutes depending on the board complexity.

Often the system falls short of making every connection without a cross-over, and a list of no-connections is made available to the designer. Ninety to ninety-five percent success rates are typical. So again we have human intervention to finish the most difficult aspects of the design.

Very advanced p.c.b. design programs which work out the most economical positions of components and best interconnections cost many tens of thousands of pounds. Some are also capable of calculating capacitive coupling between tracks for high-frequency analogue or high-speed digital boards.

Furthermore, industrial systems not only produce the p.c.b. mask artwork but also plot co-ordinates for automatic drilling of holes and automatic component insertion, and provide masks for flow-soldering! Anyone want to buy a soldering iron? PE

MICRO CHIP TESTER AND LOGIC ANALYSER

BY JOHN M. H. BECKER

Difficulties with digital devices? Sort out the symptoms with computer aided test gear

The use of computers in all areas of industry is now normal practice. ATE, CAD, CAM and CAE are now common words in the engineering vocabulary. In this article (there's more where this came from), we describe a practical design for a CMOS and TTL tester using both hardware and software techniques for i.c. identification and testing. Additionally, this project also provides basic logic analysis functions

THE project to be described here has been designed as a low cost, easy to use computer controlled digital i.c. tester for checking and displaying the operation of a wide range of CMOS and TTL logic families including standard TTL, LS, ALS, HC etc, up to 24 pins in size. It consists of a hardware board containing a multiplexed set of data latches and gates, which in response to control instructions from a computer allow automatic checking of the logic states of the integrated circuit pins under examination in the board's test socket.

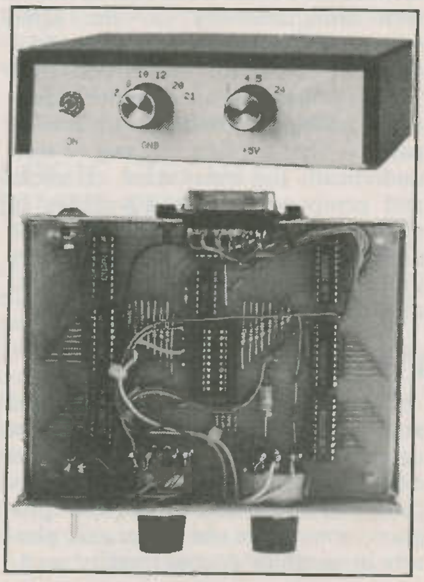
The controlling computer program has been written specifically for use with the BBC, C64, and PET series of computers of 16K upwards. The program is in BASIC and can be readily modified for use with other computers providing that they have a normal 8-bit parallel output socket, either as a User Port or IEEE 488 port.

THE PRINCIPLE

The functioning of the unit is based upon the principle that in most digital integrated circuits, the various input pins require the application of either high or low logic level voltages, and that in response to the correct combination of these, relevant output pins will also change their states between low and high logic levels. If they fail to do so then the chip can be considered faulty. This principle applies to devices such as gates, flip-flops, buffers, counters, encoders, decoders, shift registers, multiplexers, and arithmetic functions, and most chips within these categories can be checked and analysed. However the principle cannot be applied to some devices where additional components such as capacitors and resistors are required. Into this latter category fall such chips as phase locked loops, timers, and monostables, and the unit will not satisfactorily check these.

BYTE BLOCKS

Most computers available to the average electronics constructor use 8-bit technology, whereas most digital i.c.s have at least 14 pins, and probably more. Since in this unit, each pin of the chip under test is controlled by a single bit of data, the information exchange between the computer and the chip has to be split into two or three 8-bit blocks, any of which can contain data going to the chip or coming back from it. Consequently an onboard multiplexed system of data storage and retrieval is employed. (Fig. 1).



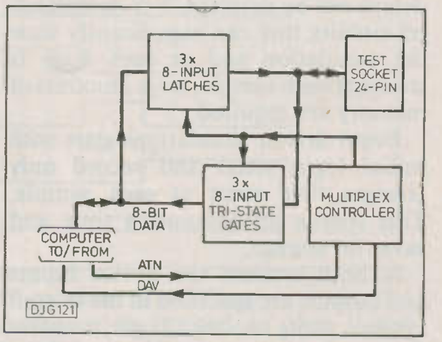


Fig. 1. *Block diagram*

Obviously for a correct assessment of the chip under test, all the relevant input pins must be simultaneously at the correct logic levels before output pin data is read. The data required to hold the inputs at their relevant levels is sent out as three separate bytes, each being stored in a data latch dedicated to the particular block of pins in question, in order of IC1 to IC3 respectively (Fig. 2). A synchronised controller opens or closes the relevant latches at the correct point (IC7 in conjunction with IC8). When all three bytes have been sent to the latches, the controller then successively opens three output gates, IC4 to IC6, so that the data on each set of eight pins can be sent in order back to the computer, which memorises the logic states received. At the end of the full test cycle, the computer, determines which pins have changed their states during the cycle and which have not. Taking into account that some pins such as power line pins do not need to change their state, the computer then shows which pins if any, have failed to comply. If some have failed it then signifies that it considers the chip under test to be faulty.

DATA CYCLE

Basically, the cycle for testing a 24-pin chip consists of six steps, send and store the questioning bytes 1 to 3, then gate and retrieve the answering bytes 1 to 3. However, as examination of the timing chart shows, the process actually needs 9 steps.

Each of these steps is activated by clocking the counter IC7. At the start of the test program, the computer will have sent out a succession of up-down signals to IC7 on the ATN line, until IC7 pin 3, output zero, goes high whereupon the DAV line coupled to this pin signifies that IC7 is reset. At this point all latches and gates are automatically held closed. The computer now switches to Data send mode on its 8-bit lines, and sends the first data byte relating to test pins 1 to 8. Having sent byte 1, the computer triggers the ATN line up and down stepping IC7 forward by one place so that output zero goes low, and output 1 goes high, allowing the data byte into IC1 by opening the control gate via its pin 11. The data passes straight through the latch gate to the test pins, but is not yet stored. ATN is again toggled, and IC7 steps to output 2, allowing output 1 to fall. As it falls, so IC1 closes its inputs and latches the data indefinitely at its outputs until the gate is again opened during the next cycle.

IC2 is the latch gate that receives the second byte. If this were to be opened at the same time that IC1 closes, it would of course see the same data as just latched in by IC1, which could incorrectly trigger the chip on test. Since IC2 only wants to see byte 2, it remains closed until after the computer has put byte 2 on the output lines. ATN is then toggled so that IC7 output 3 goes high opening IC2 and allowing the byte through to the test pins 17 to 24. ATN is again toggled stepping IC7 to output 4, so closing IC2 and latching in byte 2. Byte 3 is now sent, IC7 stepped to output 5 so that IC3 accepts the byte, and again ATN is clocked to step IC7 to output 6 so closing IC3.

BUFFER RESISTORS

Each of IC1 to IC3 has now stored the 3 data bytes, and where applicable, is holding any of the relevant 24 test pins at the required logic levels via R1 to R24 respectively. Since the resistors are buffers between the latches IC1 to IC3 and test pins 1 to 24, the logic levels on either side of the resistors are free to differ. Consequently if the latch side of a particular resistor is low, but is connected to a test chip output that is supposed to be high, the output is free to go high without distress since it regards the resistor as a 1K load drawing only about 0·5mA. The converse is also true, both for the test chip, and also for the latch which is capable of sinking or sourcing up to 35mA. Most CMOS and TTL chips can quite happily sink or source 0·5mA without undue logic level disturbance, with the exception of a few standard TTL devices which may ideally need a higher input source current than 0·5mA. In most cases though the 1K buffer will allow the test chip to assume its preferred logic level.

These levels can now be retrieved by the computer, which at this point switches to Read mode. IC7 still has output 6 high, so ATN is toggled to step it to output 7. IC8a inverts this level and opens IC4 via R25. The data on test pins 1 to 8 is passed to the data lines, the computer reads and stores it, toggles ATN, so closing IC4 and opening IC5 via IC8b and R26. Data from pins 17 to 24 is read and stored, again ATN is toggled to close IC5 and open IC6 via IC8c and R27, so that data from pins 9 to 16 can be read and stored.

ATN is once more toggled, stepping forward IC7 to output 9. Since this is connected to the reset pin of IC7, the

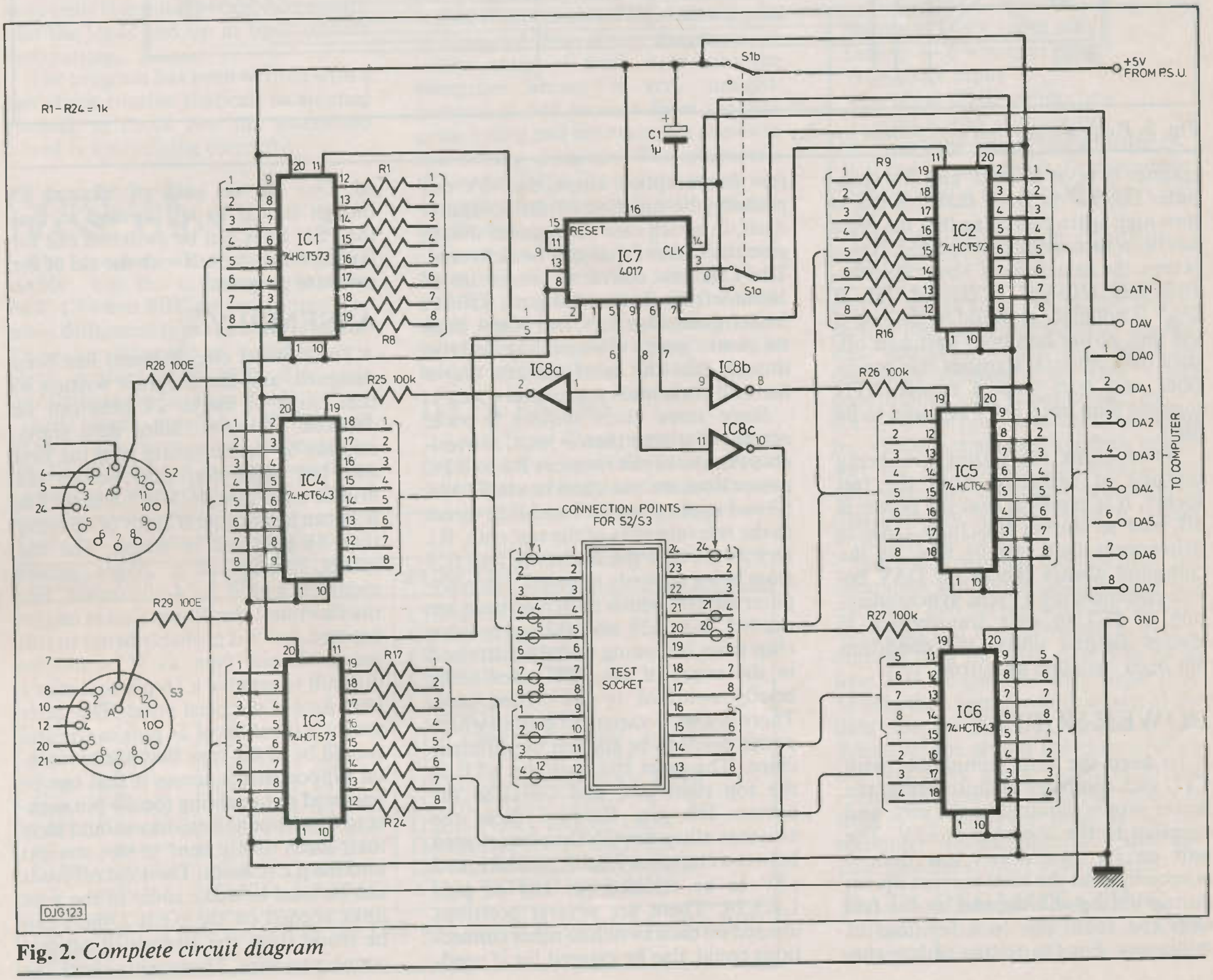


Fig. 2. *Complete circuit diagram*

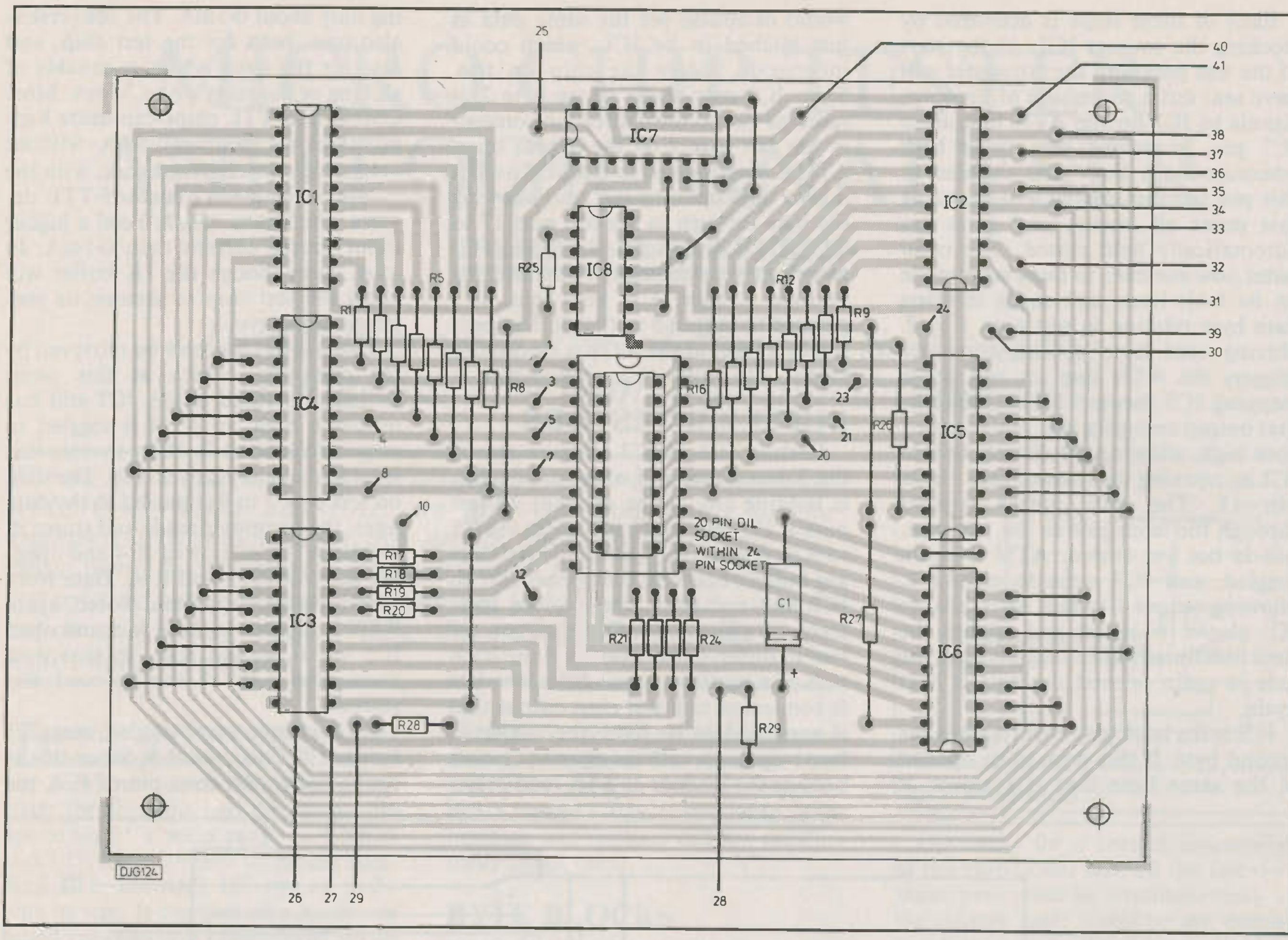


Fig. 3. *P.c.b. design and component overlay*

counter is reset to zero, and the computer checks via DAV that this pin is now high again signifying that the cycle has been successfully completed. If this is true, the next cycle of 3 byte transference and retrieval is carried out. If DAV is not high, as would be the case if the unit power had been switched off, then the computer signifies this condition, and goes into a repeat ATN toggling loop until DAV is found to be high.

When chips for testing are being inserted or extracted from the test socket, it is essential that the power is off, and so during this time DAV is deliberately held low by S1a. As the computer always checks for DAV before commencing a cycle, synchronisation of IC7 to data transference is always assured unless the condition has been signalled as untrue.

POWER SUPPLY

To keep the unit compatible with TTL and computer requirements, the power supply required by the unit, and supplied to the test chip is +5V. The unit on its own draws less than 1 microamp, but the total current drawn during testing will depend on the test chip and could rise to a few tens of milliamps. For the testing of low current consumption chips, the +5V can probably be supplied by the computer itself, in which case the manual should give the current that can be delivered. The C64 can deliver a maximum of 100mA from its cassette port, 450mA from its cartridge port, and 50mA from its user port. Commodore advise though that the total current drawn from all ports must not exceed 450mA.

Since some chips require a p.s.u. current of greater than 0·5mA, as available via any of the resistors R1 to R24, power lines are switched in via S2 and S3 and applied via R27 and R28 direct to the relevant pins of the test chip. R1 to R24 prevent the latches IC1 to IC3 from being adversely affected. The computer advises which switch settings are needed, but R28 and R29 prevent a chip from becoming unduly distressed in the event of the PSU lines being briefly switched to the wrong pins. There is a wide variety of pins to which power needs to be applied for different chips. The most common are +VE to the top right pin, and GND to the bottom left pin. Between them the switches allow for GND to be selected between chip pins 7,8,10,12,20,21, and +5V to be selected for any of pins 1,4,5,24. There are several positions unused on each switch so other connections could also be catered for if needed. One tag on each of S2 and S3 though should be left unused so that the PSU lines can be switched out for testing the unit itself with the aid of the software program.

ASSEMBLY

The printed circuit board has been designed, and the program written so that chips of up to 24 pins can be checked. However, since data transmission by the computer is to the first and last eight test pins before the middle eight pins, IC3, IC6 and R17 to R24 can be omitted if chips of no more than 16 pins will be tested. The test socket consists of a 20-pin socket mounted within a 24-pin socket. For the short unit the 24-pin socket can be omitted, but it is probably better to still use a 20-pin type as it would be difficult to remove a 16-pin socket at a later date if the need arose. The outer socket is for chips of 24 pins in size and should be of the type that has horizontal support struts across it that can be trimmed out enabling the 20-pin socket to fit within it. Resistors should have their leads neatly bent to slot straight into the p.c.b. holes. Their cut off leads can be used to make some of the wire links needed on the p.c.b. Others can be made from the strands of normal connecting wire. Thoroughly check the board after assembly for soldering inadequacies.

The p.c.b. has been designed to fit snugly into a 6in × 4·5in × 1·75in box. The front panel switch centres on the prototype were drilled 0·9in above the base at 1·85, 2·2 and 4·0in from the left respectively. When wiring up, also take a ground lead to the box, so that during CMOS testing, you can automatically discharge static electricity from yourself by touching the box first. The unit is intended to be used with the box lid off allowing ready access to the test sockets. If a fair amount of testing is anticipated, it may be worthwhile buying a chip inserter and extractor tool, they are not very expensive. Alternatively zero-insertion force sockets could be used in place of the normal d.i.l. ones, these have a lever on them that opens the pins so that the i.c. can be very easily slotted in without force, however, they tend to be expensive.

The computer connection socket shown in Fig. 4, is a 24-pin IDC socket, the wiring to this, or to other substituted sockets may be arranged to suit the computer lead with which the unit is to be used. You do not need to adhere to that shown if a different arrangement suits your computer better. Just ensure that the leads end up at their correct destinations.

The program has been written with a self check routine that can be stepped through to check that the assembled board is functioning correctly.

COMPUTER TRANSLATION

The program is written in PET BASIC, but the differences between PET, C64 and BBC are only minor, the main difference is in the control codes. These are arranged as variables in a block at lines 1560–1570. The code translations are listed in Table 1.

BBC users note that PEEK and POKE are expressed differently. 'POKEAT,DN' for example would be expressed as '?AT=DN', and 'D=PEEK(IN)' expressed as 'D=?(IN)'. Also, 'GETZ$' is expressed as 'Z$=INKEY$(0)'.

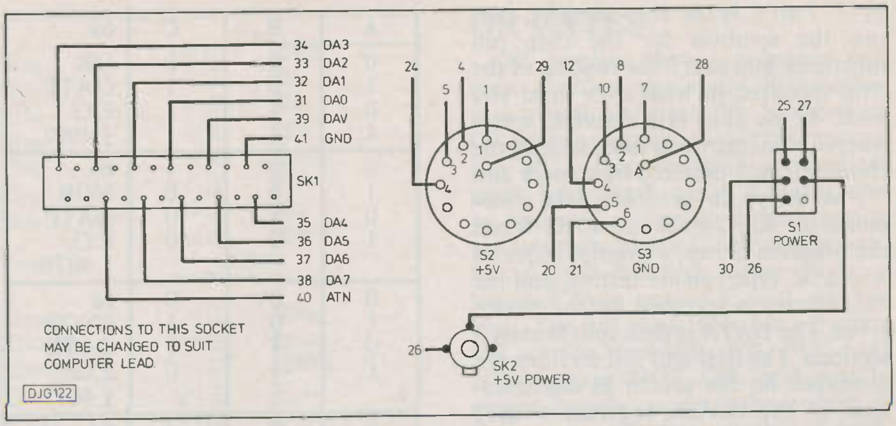


Fig. 4. *Wiring details and computer connections*

DATA LIBRARY

The program is very comprehensively written and will automatically perform a full permutation of all the tests needed to determine whether designated pins are toggling. The program includes a library of data for several commonly used chips. Other chips can have their data written into the program as data statements obtained from manufacturers data sheets or observed from circuit diagrams.

The entry of fresh data into the computer library is very straightforward as will be seen from the program listing and the examples shown in the timing diagram. The characters shown in Table 2 are used to tell the computer the primary function of particular pins.

From the '+' and '–' data the computer will advise which settings of S2 and S3 should be used. Do not use these two symbols for holding other pins high or low, otherwise you may be told to incorrectly set S2 and S3.

DATA ENTRY

Apart from Clock inputs, the computer assumes equivalent status for all other inputs in the test sequence and these are toggled high and low in a permutated sequence. Where a chip has several identical sections within it, as in say the 4 × 2 input NAND gate 4011, each of the sections are tested independently and so each is given a different set of alphanumerics. In the case of the 4011, the first NAND gate has pins 1 and 2 as inputs, and pin 3 is their resultant output. Pins 1 and 2 are symbolised each by '1', and the output as 'A'. The next set of input pins are 5 and 6, so, as they are in the second section they are symbolised by '2', and their output pin 4 as 'B'. And so on for the other sections. The p.s.u. GND goes to pin 7, and is symbolised by '–'. P.s.u. +5V is pin 14 and is symbolised by '+'. Do not allocate symbols of any sort for the unused test socket pins otherwise the computer will believe that the chip is larger than it is and misdirect the data.

Since this chip has only 14 pins, the computer will automatically split the data into two halves, with the data for 4011 pins 1 to 7 being treated as byte 1, and the data for 4011 pins 8 to 14 as byte 2. If the test chip were larger than 16 pins then byte 3 would consist of the data for test socket pins 9 to 16. Whatever the size of the chip, providing you have given the data in the correct sequence of chip pin numbers from 1 to however large it is, the computer will automatically split the data into the correct byte pattern.

DATA PERMUTATING

The chip information held as DATA statements is in three parts separated

Table 2. *Character definitions*

Numbers 1–9 = input pins
Letters A–Z = output pins
'&' = clock input
'–' = p.s.u. GND connection
'+' = p.s.u. +5V connection
'#' = no connection, but additionally it can be used to let the computer believe that a pin should always be low
'↑' can be used to hold a particular pin high

Table 1. *Computer code translations*

CODE	PET	C64	BBC	FUNCTION
CU	145	145	11	CURSOR UP
CD	17	17	10	CURSOR DOWN
CL	157	157	8	CURSOR LEFT
CR	29	29	9	CURSOR RIGHT
CC	147	147	12	CLEAR SCREEN
CH	19	19	30	CURSOR HOME
DN	205	195	14	SET ATN LINE LOW
UP	237	199	206	SET ATN LINE HIGH
SET	2	16	16	DETECT +VE OF DAV LINE
DAV	59469	56589	&FE6D	DATA VALID LINE
DRT	59459	56579	&FE62	USER PORT DIRECTION
IN	59457	56577	&FE60	DATA INPUT REGISTER
OUT	59471	56577	&FE60	DATA OUTPUT REGISTER
AT	59468	56576	&FE6C	ATN (ATTENTION) LINE

Code 59467 is only needed by the PET and should be omitted for the BBC and C64.

by '/'. Part 1 is the chip identity, part two the symbols for the chip pin functions, and part 3 the funtion of the chip specified in what ever form you want. If the chip is a counter, somewhere in this part you must specify the counter length prefixed by a space and '*', as shown in program data statements for 4017, 4024 and 4040. When the program is run, a prompt requests which i.c. type you are testing, and the data library is searched for the device given. The DATA is then split into its 3 sections. The first and 3rd sections are displayed on the screen as confirmation of the device, together with 3 skeleton outlines of the correct size of chip. Part 2 is then analysed for pin functions and a test sequence is calculated.

This primarily consists of establishing the number of permutations of high and low that are required by the number of inputs of a particular chip section. In the instance of the 4011 there are 2 inputs so the computer establishes that there are 4 permutations of high and low. As far as it is concerned the combinations can be expressed in binary as 00, 01, 10, 11, and it knows that 'A' is the output pin for this section. It then searches for the next set of pins having identical numbers, in this case 2 pins of '2'. It does not matter whether the pins are next to each other or well apart, they will be found. A test sequence for these inputs is now calculated, which in this instance is the same as before, but it may not be, depending on the number of input pins for that section. With an 8-input gate for example the number of combinations for a full test sequence is 2 to the power of 8 = 256. If that same chip also had a two input gate as well, the test sequence would consist of 256 tests for the first part and 4 tests for the second part. It would perform these consecutively resulting in 260 separate tests for the complete cycle. For the 4011, a sequence of 16 tests is generated.

Whilst it is calculating test instructions, the computer displays its answers in the skeleton outlines. The top one shows the input pins, the bottom the outputs, and the centre the function of all the pins.

TEST RUNNING AND DISPLAY

When the instructions have been calculated, and it does not take very long, the computer pauses for your next instruction. You can now select whether you wish the test sequences to be carried out repeatedly without interruption, at about 2 tests per second, or whether you wish to step them through one at a time, holding between each until the keyboard space bar is pressed. Which ever mode is selected, the computer will run through its calculated data, sending the input pin data out to the chip being tested, and receiving back the information on the state of all the chip pins.

This information is displayed as a constantly updated graphic display in the relevant skeleton outlines. You can thus watch the screen to see what is happening at the chip. (Photograph). This is of use not only in checking a suspect chip, but equally important, you can actually analyse the logic behind a particular chip with which you are unfamiliar. This is a highly advantageous facility of use not only to designers, but also for educational purposes since a computer simulation of what a chip does is far more readily understandable than having to wire up a test board for logic analysis. Whereas a hard wired test would take some considerable time to set up, and probably need a whole bank of instruments to simultaneously monitor all of the chip pins, by using this project with a computer, a comprehensive analysis of all pin states can be readily observed.

RECORD KEEPING

Whilst the computer is sending and receiving data, it is keeping a record of the state of the pins under test. It is looking for at least one transition between low and high or high and low for each designated pin. If the chip is functioning, then during the full test sequence, each designated pin will do this at least once. If it does not change state, the chip is probably faulty. The automatic analysis does not check that the number of transitions is correct according to a truth table as to set up such a ultimate test could consume considerable amounts of memory. At the end of the cycle sequences, if some pins have not toggled then the delinquent pins will he highlighted in the lower skeleton outline. The computer will carry on through the checking sequence repeatedly, each time displaying the analysis result. If no fault is found the skeleton outline will show the normal information of high or low.

At any time during the test sequences the computer can be requested to go into step and hold mode, normal

A	B	C	6a
0 1 0 1	0 0 1 1	0 1 1 1	OR GATE E.G. $\frac{1}{4}$ 4001
0 1 0 1	0 0 1 0	1 0 0 0	**6b** NOR GATE E.G. $\frac{1}{4}$ 4070
0 1 0 1	0 0 1 1	0 1 1 0	**6c** EXOR GATE E.G. $\frac{1}{4}$ 4077
0 1 0 1	0 0 1 1	1 0 0 1	**6d** EXNOR GATE E.G. $\frac{1}{4}$ 4081
0 1 0 1	0 0 1 1	0 0 0 1	**6e** AND GATE E.G. 4081
0 1 0 1	0 0 1 1	1 1 1 0	**6f** NAND GATE E.G. $\frac{1}{4}$ 4011

```
10101110      174
00110111   OR 55
10111111  =  191

10101110      174
00110111  AND 55
00100110  =   38
```

Fig. 8. *Simplified OR, AND arithmetic*

Fig. 7. *8-bit binary logic (AND)*

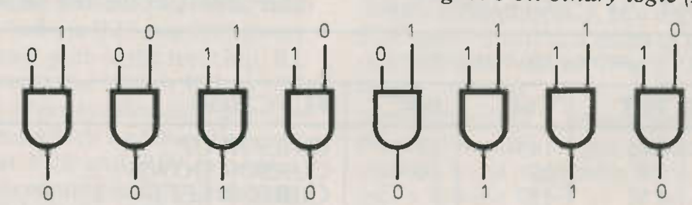


Fig. 6. *8-bit binary logic (OR)*

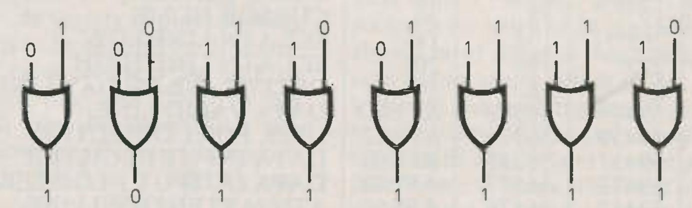
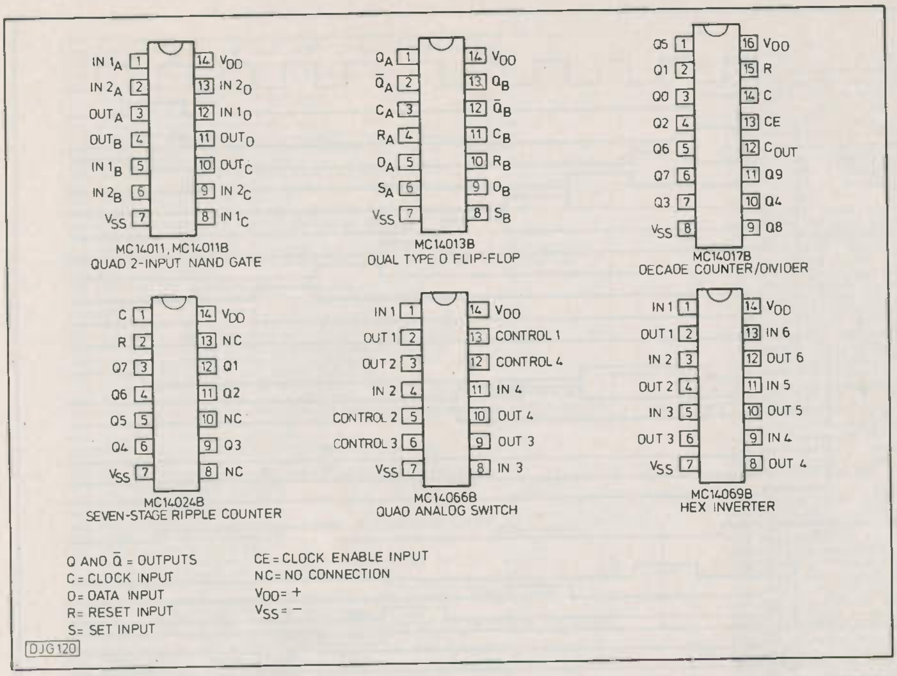


Fig. 5. *Basic 2-input gate truth tables*



PIN NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
4011	1	1	A	B	2	2	–	3	3	C	D	4	4	+		
4013	A	A	&	1	1	1	–	2	2	2	&	B	B	+		
4017	F	B	A	C	G	H	D	–	I	E	J	K	1	&	1	+
4024	&	1	G	F	E	D	–	#	C	#	B	A	#	+		
4066	1	A	B	2	2	3	–	3	C	D	4	4	1	+		
4069	1	A	2	B	3	C	–	D	4	E	5	F	6	+		

NUMBERS = CHIP INPUTS } SAME CHARACTER IS REPEATED FOR
LETTERS = CHIP OUTPUTS } RELATED INPUTS OR OUTPUTS
& = CLOCK INPUT
# = NO CONNECTION (see below)
– = PSU GND SUPPLY PIN
+ = PSU +VE SUPPLY PIN
#AND ↑ MAY ALSO BE USED TO DELIBERATELY HOLD PIN LOW OR HIGH RESPECTIVELY

CONTROL INPUTS SUCH AS "SETS" OR "RESET" MAY BE TREATED EITHER AS ORDINARY INPUTS OR HELD AT REQUIRED STATIC LEVEL WITH # OR ↑

TABULATED DATA IS ENTERED INTO THE COMPUTER AS FOR EXAMPLE:
2000 DATA 4011/11AB22–33CD44+/QUAD 2-INPUT NAND
2010 DATA 4024/&1GFED–#C#BA#+/7-STAGE COUNTER*128:REM 128=COUNT

Fig. 9. *Pin assignments to data statement conversion*

running, reset to start of sequence, or have the test chip type changed. Prompt codes are displayed on the screen throughout testing.

LOGIC ANALYSIS

An enormous quantity of digital chips are gates of some sort, all of which respond to predictable rules. Consequently, the original intention was to have the program also check chips against predetermined truth tables. However, it soon became apparent that this would be highly memory consuming, and that aspect of automatic checking was abandoned. The rules though for truth table checking of most digital chips are very straightforward and in most cases follow normal Boolean logic. In its simplest form this is really very easy to understand, and through it a more detailed logic analysis can be visually determined from the pin states displayed on the screen. From this, truth tables can be readily compiled, or even printed out on paper if a suitable command is entered into the program.

A very simple table for the inputs of a two input gate has already been shown above for part of the 4011, namely 00, 01, 10, 11. The output truth in response to input variations of this sort will depend upon the function of the gate. Essentially there are 6 types (ignoring the number of inputs and exotic variations), OR, NOR, AND, NAND, Exclusive OR and Exclusive NOR.

OR GATES

OR implies that a response will occur if either one input OR the other is in a particular state. Fig. 5a shows an OR gate truth table, in this case part of the 4071 that contains 4 identical gates. Each has 2 inputs, A and B, and an output C. Normally if both inputs are low then output C will also be low, but if A OR B is high, either singly or together then output C will also be high. The full truth table for a 2 input OR gate is thus 000, 101, 011, 111. NOR means NOT OR, and simply means that the output is the inverse of that for an OR gate, so that if both inputs are low then the output will be high. If A OR B is high, either singly or together then the output will be low. Fig. 5b.

EXCLUSIVE GATES

The principle for Exclusive OR and Exclusive NOR is similar to the above, in as much that if either A OR B is high, then the output will also be high. However, if both inputs are high, OR both inputs are low, then the output will be low. The answer is only true if the table Excludes either A OR B (Fig. 5c). As with a NOR gate, an Exclusive NOR gate inverts the output (Fig. 5d).

AND GATES

The implied truth here is that if A AND B are both high then the output will also be high. In any other input combination, the output C will remain low (Fig. 5e). NAND, (NOT AND), is simply the inverse again, with output C normally high until both A AND B are high together to force C low (Fig. 5f). The same principle applies whether a gate is an 8-input one or has just 2 inputs, the only difference is that the truth table is longer since the number of input permutations of high and low is greater. You can observe this with any of these gates in the test socket whilst stepping the program through separate cycles.

Even with multiple input counters these truths can be observed, though in a somewhat more complex fashion since some of the inputs are probably SET, RESET, INHIBIT inputs as well as CLOCK. The Truth will be in the total response of all outputs, and the total number of permutations will be related to the number of control inputs against the total number of outputs. With a 4017 decade counter, this amounts to 2 control inputs (4 combinations), 10 main outputs, a change-over bit at the end of each count, and a clock input that has two combinations, high or low for each other input combination. The total combination is therefore $4 \times 10 \times 2 + 4 = 84$ variations to the full permutated cycle.

8-BIT BINARY GATES

From a basic understanding of simple OR and AND gates, it then becomes easy to comprehend the extension to 8-bit binary logic for OR and AND. As you should be aware, 8-bit binary logic is frequently used by computers and deals with binary numbers 8 bits long, with each bit related to a power of 2, so representing decimal numbers between 0 and 255. Zero is thus represented by 00000000, 1 by 00000001, 2 by 00000010, etc. up to 11111111 for 255. In the control program for this chip tester, computing AND and OR are heavily relied on for determining the state of the pins under test, since each pin is controlled by the relevant binary bit. Pins 1, 9 and 24 are controlled by bit 1, pins 2, 10 and 23 by bit 2, etc. By ANDing or ORing the current test result with previous results the state of each pin can be assessed.

8-BIT OR

8-bit ORing can be regarded as applying equivalent bits of the numbers being checked, to 8 pairs of 2-input OR gates (Fig. 6), and recording the state of the 8 output bits. For the project this method is used to check that all bits have been high at some point in the test sequence. At the start of the sequence a memory store is set to zero, and at each test the result is ORed with the store, and restored. At the end of the full sequence, all bits should be high if the chip is satisfactory. If a zero occurs anywhere in the binary number, that pin has not changed state and so a fault exists. The binary number can also in effect, be turned upside down by subtracting it from 255. This can be used as a computing equivalent of NOR. In either state it is straightforward to define precisely which pins are faulty. In Fig. 6, if 191 was the actual answer at the end of a sequence, since bit 7 is zero then this pin has produced a faulty response.

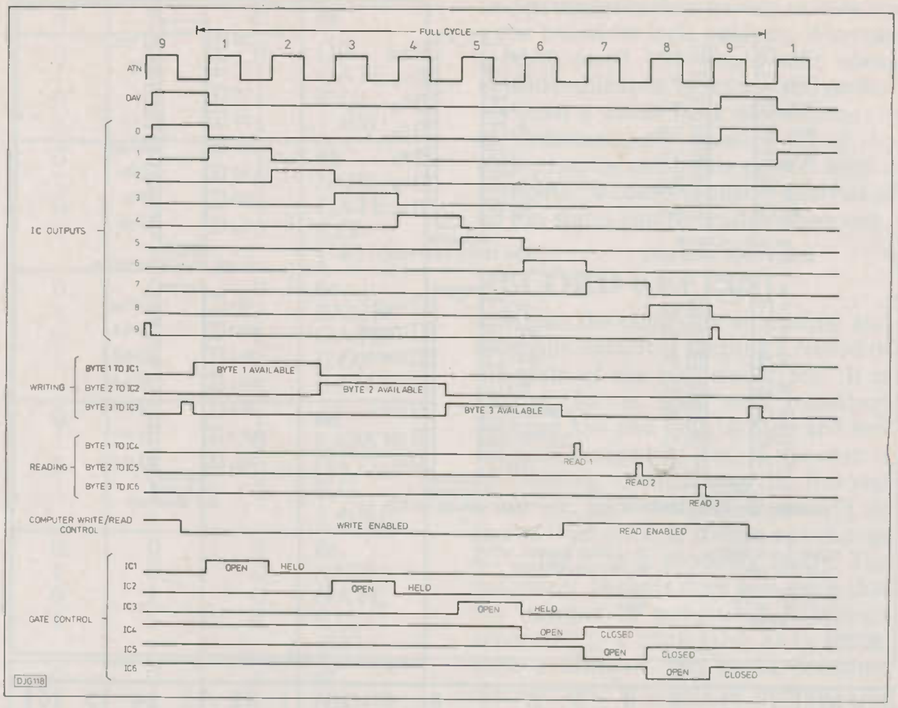


Fig. 10. *Micro Chip Tester timing chart*

8-BIT AND

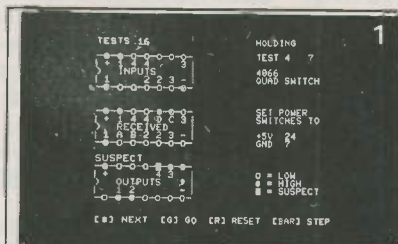
This can be regarded as 8 separate 2-input AND gates (Fig. 7). For the unit this is used to check that pins have been low at some point. At the start of the sequence, a memory store is set to 255, then each test is ANDed with the store, and restored. At the end of the sequence, all bits should be low, and if they are not the faulty pins can be defined. In Fig. 8, if 38 was a final answer, pins 2, 3 and 6 would not have toggled. A computing equivalent of NAND is for example, 255–(174 AND 55) as this simply inverts the answer.

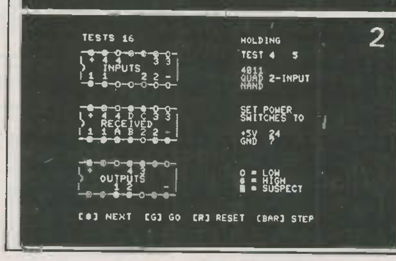
Fig. 8 shows how OR and AND can be expressed as an arithmetic layout. A decimal to binary chart needs to be used for the numeric conversion, though observant readers will see a program section towards the beginning (Binary File Creation) that can be converted to do the job automatically.

Note that you do not need to understand or use binary and truth tables in order to use this chip tester. The understanding of such principles though will give a greater insight into the functioning of digital chips.

IN CONCLUSION

This unit will be of considerable value to any constructor much involved in digital electronics, whether it is for checking chip failure, or analysing logic behaviour. The latter facility will also be of interest to anyone involved in basic electronic education, for not only is an easily readable display given, but also chip parameters can be changed within the data statements so that logic analysis functions can be further explored.





About The Author

John M. H. Becker has had a varied career, but has spent most of his working life in film making and electronic design. After leaving the film industry he set up business as "Phonosonics", now known as Becker Phonosonics. This move enabled him to devote his time to his main interest in life—music and electronics. He has designed a wide range of electronic musical instruments, effects units and lighting systems as well as a host of other electronic goodies, many of which have been featured in *PE*.

COMPONENTS . . .

RESISTORS

R1–R24	1k (24 off)
R25–R27	100k (3 off)
R28,R29	100 (2 off)

All resistors ¼W 5%

CAPACITORS

C1	1µ 63V electrolytic

SEMICONDUCTORS

IC1–IC3	74HCT573 (3 off)
IC4–IC6	74HCT643 (3 off)
IC7	4017
IC8	4069

SWITCHES

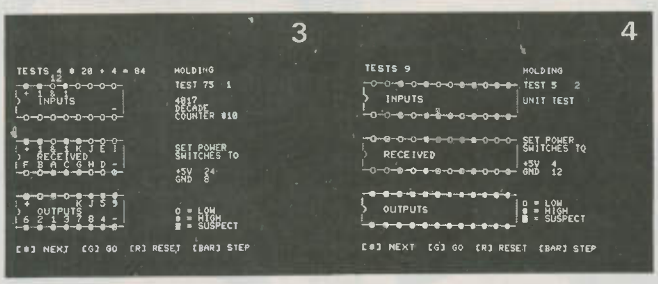
S1	min d.p.d.t.
S2,S3	3p–12W (2 off)

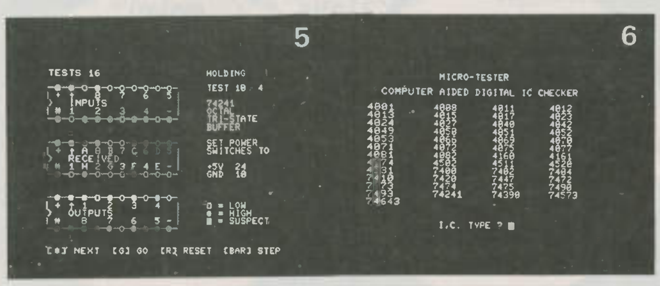
MISCELLANEOUS

P.c.b. clips (4 off); Knobs (2 off); p.c.b. available from Becker Phonosonics; 20-pin i.c. socket (7 off); 14-pin i.c. socket; 16-pin i.c. socket; 24-pin i.c. socket; 3·5mm jack socket; wire, cable, etc.

```
100 REM P.E. IC TEST PROG258 23MAY86 - SEE NOTES AND TEXT BEFORE TYPING IN ***
110 GOSUB1540 DIMA(2),L(2),H(2),B(2),C(2),J(2),S(8),V(2),W(2)
120 DIMQ%(256,2),I(1,2),B$(255),R$(15),D$(15),A$(24),K$(3),T$(6),C$(24,1)
130 S$="************************" C$="  " FORA=1TO4 C$=C$+CHR$(CL) NEXT
140 R$=CHR$(CR) U$=CHR$(CU)+CHR$(CU)
150 FORA=1TO15 D$(A)=D$(A-1)+CHR$(CD) NEXT H$=CHR$(CH)+D$(2) V$=CHR$(CH)+D$(1)
160 K$(1)="INPUTS" K$(2)="RECEIVED" K$(3)="OUTPUTS" T$(0)="SETTING UP"+D$(1)
170 PRINTD$(3);TAB(7);"CREATING BINARY FILE" FORA=0TO15 A$="" D=A B$=""
180 FORB=3TO0STEP-1 E=2↑B W=D/E IFW<1THENA$="—O"+A$ B$=R$+"▒"+B$ GOTO200
190 D=D-E A$="—●"+A$ B$=R$+R$+B$
200 NEXT A$(A)=A$ R$(A)=B$ NEXT C=0 FORA=0TO15 FORB=0TO15
210 B$(C)=A$(B)+A$(A)+"—" C=C+1 NEXT NEXT L$=LEFT$(B$(0),16)+LEFT$(B$(0),9)
220 FORC=0TO15 A$(C)="" NEXT
230 REM INPUT STAGE
240 RESTORE GOSUB1590 PRINTD$(4);TAB(6);"[*] UNIT TEST  [M] MENU" FORB=0TOH
250 FORA=1TOV Q%(A,B)=0 NEXT C(B)=0 J(B)=0 I(0,B)=0 I(1,B)=0 W(B)=0 H(B)=0
260 V(B)=0 B(B)=0 NEXT
270 PRINTD$(2);TAB(11); INPUT"I.C. TYPE ";A$ T$=A$+"/" IFA$<>"M"THEN320
280 GOSUB1590 PRINT
290 C=4 READA$ IFA$="*"THENRESTORE PRINT GOTO270
300 IFMID$(A$,C+1,1)<>"/"THENC=C+1 GOTO300
310 PRINTLEFT$(A$,C), GOTO290
320 L=LEN(T$) IFA$<>"*"THEN350
330 T$(1)="UNIT TEST" PRINTTAB(50);"COMPILING DATA" H=2 V=9 P=24 T=1 N=1
340 FORB=0TO2 FORC=1TO8 Q%(C,B)=2↑(C-1) NEXT Q%(C,B)=0 I(1,B)=255 NEXT GOTO500
350 READB$ IFB$="*"THEN240
360 IFT$<>LEFT$(B$,L)THEN350
370 A$(4)="" B$=B$+"/" E=L+1 D=0 FORC=ETOLEN(B$) IFMID$(B$,C,1)<>"/"THEN390
380 D=D+1 A$(D)=MID$(B$,E,C-E) E=C+1
390 NEXT T$(1)="*" T$(2)="#" FORB=1TO2 IFLEN(A$(B))>3THENT$(B)=A$(B) GOTO430
400 READB$ IFB$<>T$(B)THEN400
410 FORC=1TOVAL(A$(B)) READB$ NEXT C=3 IFVAL(B$)>9THENC=4
420 T$(B)=MID$(B$,C)
430 NEXT Q$=T$(1) T$=T$(2)+" "+A$(3)+" " T$(2)=""
440 REM SCREEN FORMAT
450 T$(1)=A$ E=1 N=1 T=2 FORC=1TOLEN(T$) IFMID$(T$,C,1)<>" "THEN490
460 IFLEN(T$(T))+C-E>12THENT=T+1 T$(T)=""
470 IFMID$(T$,C+1,1)="*"THENN=VAL(MID$(T$,C+2))*2
480 T$(T)=T$(T)+MID$(T$,E,C-E+1) E=C+1
490 NEXT P=LEN(Q$) H=INT(P/17)+1 IFP=14THENB(0)=128 B(1)=128
500 PRINTCHR$(CC),D$(1) FORA=0TOT PRINTTAB(26);T$(A) NEXT T$(A)=""
510 PRINTV$ FORA=1TO3 PRINTLEFT$(L$,P+1) PRINT"| ";TAB(P+1);"| "
520 PRINT")  ";K$(A);TAB(P+1);"| " PRINT"| ",TAB(P+1);"| " PRINTLEFT$(L$,P+1)
530 PRINT PRINT NEXT PRINT"[*] NEXT  [G] GO  [R] RESET  [BAR] STEP"
540 IFT$(1)="UNIT TEST"THENU=P-16 P=16 GOTO1040
550 REM STANDARDISE DATA
560 Q$=LEFT$(Q$,P/2)+LEFT$(S$,24-P)+RIGHT$(Q$,P/2) A$(0)=LEFT$(Q$,8) A$(1)=""
570 FORB=17TO24 A$(1)=MID$(Q$,B,1)+A$(1) NEXT A$(2)=MID$(Q$,9,4)
580 FORC=16TO13STEP-1 A$(2)=A$(2)+MID$(Q$,C,1) NEXT U=P-16 IFU<1THENU=1
590 IFU<2ANDU>14THEN610
600 FORC=4TO(U/2)+1STEP-1 B(2)=B(2)OR2↑(C-1) NEXT B(2)=B(2)+(B(2)*16)
610 X=0 Y=0 FORC=1TOLEN(Q$) IFMID$(Q$,C,1)="+"THENY=C
620 IFMID$(Q$,C,1)="-"THENX=C
630 NEXT Q$=A$(1)+MID$(A$(2),5,4)+A$(0)+LEFT$(A$(2),4) PRINTCHR$(CH);D$(9)
640 FORC=1TO24 IFC=13THENPRINTD$(1)
650 IFMID$(Q$,C,1)="*"THENPRINTR$;P$; GOTO670
660 PRINTR$;MID$(Q$,C,1);
670 NEXT PRINT
680 REM TRUTH TABLE CALC
690 Q$=A$(0)+A$(1)+A$(2) L=16 IFH=2THENL=24
700 FORC=1TOL A$(C)=MID$(Q$,C,1) NEXT G=0 FORC=1TOL IFA$(C)=""THEN910
710 IFVAL(A$(C))=0THEN810
720 C$(C,0)=A$(C) S=1 S(1)=C FORD=C+1TO(L)
730 IFA$(D)=A$(C)THENS=S+1 S(S)=D C$(D,0)=A$(D) A$(D)=""
740 NEXTD FORF=1TO2↑S D=F-1 G=G+1 FORB=0TOH Q%(G,B)=0 NEXTB
750 FORA=S-1TO0STEP-1 E=2↑A W=D/E IFW<1THEN770
760 D=D-E B=INT((S(A+1)-1)/8) K=S(A+1)-(B*8) Q%(G,B)=Q%(G,B)OR(2↑(K-1))
770 NEXTA FORB=0TOH J=Q%(G,B) I(0,B)=I(0,B)ORJ PRINTV$ IFB=0THENPRINTD$(3)
780 IFB<2THENPRINTLEFT$(B$(J),P) PRINT GOTO800
790 PRINTTAB(16),MID$(B$(J),9,U);TAB(176);LEFT$(B$(J),U)
800 NEXTB NEXTF GOTO910
810 A$=A$(C) B=INT((C-1)/8) K=C-(B*8) M=2↑(K-1) A=240 IFB=1THENA=0
820 IFB=2THENA=176 IFK>4THENA=16
830 IFA$="-"ORA$="#"THENC$(C,0)=A$ C$(C,1)=A$ B(B)=B(B)ORM GOTO910
840 IFA$="+"ORA$="↑"THENC$(C,0)=A$ C$(C,1)=A$ B(B)=B(B)ORM H(B)=H(B)ORM GOTO910
850 IFA$<>"&"THEN880
860 C(B)=C(B)ORM J(B)=K*2-2+A C$(C,0)="&" IFN=1THENN=2
870 GOTO910
880 IFA$<"A"ORA$>"Z"THEN910
890 I(1,B)=I(1,B)ORM E=ASC(A$)-ASC("A")+1 IFE>9THENC$(C,1)=A$ GOTO910
900 C$(C,1)=STR$(E) IFLEFT$(C$(C,1),1)=" "THENC$(C,1)=MID$(C$(C,1),2)
910 A$(C)="" NEXTC IFP>16THENP=16
920 FORB=0TOH FORC=1TOG Q%(C,B)=Q%(C,B)ORH(B) NEXT NEXT
930 FORC=0TO1 FORB=0TOH PRINTV$ IFC=1THENPRINTD$(13)
940 I(C,B)=I(C,B)ORH(B) IFB=2THEN990
950 IFB=0THENPRINTD$(3)
960 PRINTLEFT$(B$(I(C,B)),P) IFB=0THENPRINTU$;
970 E=8*B FORD=1TOINT(P/2) IFC$(D+E,C)=""THENPRINTR$;
980 PRINTR$;C$(D+E,C); C$(D+E,C)="" NEXT PRINT GOTO1030
990 PRINTTAB(16);MID$(B$(I(C,B)),9,U);TAB(176);LEFT$(B$(I(C,B)),U) PRINTU$;
1000 PRINTTAB(16); FORD=17TO24 IFD=21THENPRINTU$;CHR$(CU) PRINTTAB(16);
1010 IFC$(D,C)=""THENPRINTR$;
1020 PRINTR$;C$(D,C); C$(D,C)="" NEXT PRINT
1030 NEXTB NEXTC V=G IFV=0THENV=1
1040 PRINTCHR$(CH);"TESTS";V; IFN>1THENPRINT"*";N;"+";V;"=";V*N+V
1050 PRINTD$(8) PRINTTAB(26),"SET POWER" PRINTTAB(26),"SWITCHES TO" PRINT
1060 IFY=0THENPRINTTAB(26);"OFF";D$(4) GOTO1080
1070 PRINTTAB(26);"+5V ";Y PRINTTAB(26);"GND ";X,D$(3)
1080 PRINTTAB(26);"o = LOW" PRINTTAB(26);"● = HIGH" PRINTTAB(26);"▒ = SUSPECT"
1090 PRINTH$;TAB(26);"TEST 0    " GOSUB1480 L=1 Y=0 IFZ$="*"THEN240
1100 Z$="" FORB=0TOH H(B)=B(B) D(B)=255-B(B) L(B)=D(B) NEXT
1110 REM TESTING SEQUENCE
1120 X=0 W=0 PRINTH$;TAB(34);Y FORK=1TOV X=X+1 IFLTHEN1140
1130 GETZ$ IFZ$=""THEN1190
1140 IFZ$="*"THEND=PEEK(IN) GOTO240
1150 IFZ$=" "THENL=1 GOTO1180
1160 IFZ$="G"THENPRINTCHR$(CH),TAB(26),"        " L=0 GOTO1190
1170 IFZ$="R"THENFORB=0TOH W(B)=0 NEXT K=V Y=0 Z$="" GOTO1120
1180 IFL=1THENGETZ$ IFZ$=""THENPRINTCHR$(CH),TAB(26),"HOLDING" GOTO1180
1190 FORB=0TOH IFC(B)=0THEN1230
1200 W(B)=W(B)+1 IFW(B)>NTHENW(B)=0 W=0 GOTO1230
1210 W=W+1 IFW(B)AND1THENQ%(K,B)=Q%(K,B)ORC(B) GOTO1230
1220 Q%(K,B)=Q%(K,B)AND(255-C(B))
1230 POKEOUT,Q%(K,B) POKEAT,UP POKEAT,DN POKEAT,UP POKEAT,DN NEXT
1240 IFB=2THENPOKEAT,UP POKEAT,DN POKEAT UP POKEAT,DN
1250 REM ERROR DETECTION
1260 POKEDRT,0 FORB=0TOH A(B)=PEEK(IN) H(B)=H(B)ORA(B) L(B)=L(B)ANDA(B)
1270 POKEAT,UP POKEAT,DN NEXT IFB=2THENJ=PEEK(IN) POKEAT,UP POKEAT,DN
1280 REM SCREEN PRINT
1290 PRINTH$;TAB(32);C$,X IFN=1THEN1320
1300 FORB=0TOH IFC(B)THENPRINTV$;TAB(J(B)+2),C$,W(B)
1310 NEXT
1320 PRINTH$;LEFT$(B$(Q%(K,1)),P);MID$(B$(Q%(K,2)),9,U)
1330 PRINTD$(3);LEFT$(B$(Q%(K,0)),P),LEFT$(B$(Q%(K,2)),U)
1340 PRINTD$(2);LEFT$(B$(A(1)),P);MID$(B$(A(2)),9,U)
1350 PRINTD$(3);LEFT$(B$(A(0)),P);LEFT$(B$(A(2)),U) IFWTHENK=K-1
1360 POKEDRT,255 IFPEEK(DAV)ANDSETTHEN1380
1370 GOSUB1480 K=V FORB=0TOH W(B)=0 NEXT Y=Y-1 IFZ$="*"THEN240
1380 NEXT Y=Y+1 FORB=0TOH C=H(B)AND(255-L(B)) IFC=V(B)THEN1460
1390 B%=C/16 A=C-(B%*16) PRINTCHR$(CH);D$(15) ONB+1GOTO1430,1440,1400 *
1400 PRINTTAB(16);MID$(B$(I(1,B)),9,U) PRINTCHR$(CU);TAB(16) LEFT$(R$(B%),U)
1410 PRINTD$(3);TAB(16);LEFT$(B$(I(1,B)),U)
1420 PRINTCHR$(CU);TAB(16);LEFT$(R$(A),U) GOTO1450
1430 PRINTD$(3)
1440 PRINTLEFT$(B$(I(1,B)),P) PRINTCHR$(CU);R$(A);R$(B%)
1450 PRINTCHR$(CH),D$(15);"         " IFC<255THENPRINTCHR$(CU);"SUSPECT"
1460 H(B)=B(B) V(B)=C L(B)=D(B) NEXT GOTO1120
1470 REM COMPUTER CONTROL
1480 A=0 POKEDRT,255 D=PEEK(IN) POKEAT,DN POKEAT,UP POKEAT DN
1490 IFPEEK(DAV)ANDSETTHEN1530
1500 GETZ$ IFZ$="*"THEN1530
1510 A=A+1 IFA>10THENPRINTCHR$(CH);TAB(26);"POWER NOT ON!" L=1 A=0
1520 D=PEEK(IN) POKEAT,UP POKEAT,DN GOTO1490
1530 PRINTCHR$(CH);TAB(26);"              " A=0 D=PEEK(IN) RETURN
1540 REM PET CURSOR & CONTROL CODES - SEE END FOR C64 & BBC EQUIVS
1550 REM AND SUBSTITUTE FOR THE NEXT TWO LINES
1560 CU=145 CD=17 CL=157 CC=147 CH=19 CR=29 DN=205 SET=2 UP=237 DAV=59469
1570 DRT=59459 IN=59457 OUT=59471 AT=59468 POKE59467,0
1580 POKE59467,0 REM DELETE THIS LINE FOR BBC AND C64 USE
1590 PRINTCHR$(CC);TAB(51);"MICRO-TESTER"
1600 PRINTTAB(42);"COMPUTER AIDED DIGITAL IC CHECKER" RETURN
1610 REM LIBRARY
1620 DATA4001/1/3/NOR,4008/1111111-&ABCDE1+/ADDER 4-BIT
1630 DATA4011/1/3/NAND,4012/3/1/NAND,4013/AA&111-222&BB+/8/DUAL D
1640 DATA4015/&HCBA12-&DGFE34+/DUAL 4-BIT SHIFT REG *4
1650 DATA4017/FBACGHD-IEJK1&1+/6/,4023/4/2/NAND,4024/&1GFED-#C#BA#+/5/*128
1660 DATA4027/AA&1111-2222&BB+/8/DUAL J-K,4040/LFEGDCB-A&1IHJK+/5/*4096
1670 DATA4042/DAA1&↑2-BBCC34D+/12/,4049/2/9/,4050/2/HEX BUFFER
1680 DATA4051/EG&HF1#-111DABC+/11/8 CHAN,4052/BB&BB1#-11AA&AA+/11/DUAL 4 CHAN
1690 DATA4053/BBC&C1#-111AA&&+/11/TRI 2 CHAN,4066/1AB223-3CD441+/QUAD SWITCH
1700 DATA4069/5/9,4070/1/3/EXCLUSIVE OR,4071/1/3/OR,4072/3/1/OR
1710 DATA4075/4/2/OR,4077/1/3/EXCLUSIVE NOR
1720 DATA4081/1/3/AND,4082/3/1/AND,4160/6/6,4161/6/5/*16
1730 DATA4174/&A12B3C-&D4E56F+/8/HEX D,4502/CC1&A2B-D4E#5F6+/9/STROBED
1740 DATA4511/11↑↑#11-EDCBAGF+/10,4520/&1ABCD1-&2EFGH2+/7/*16
1750 DATA4531/1112222-A&33331+/12 BIT PARTITY TREE
1760 DATA7400/11A22B-C33D44+/3/NAND,7402/A11B22-C3C44D+/3/NOR,7404/5/9
1770 DATA7410/11222B-C333A1+/2/NAND,7420/11#11A-B22#22+/1/NAND
1780 DATA7447/11↑↑111-↑↑↑↑↑↑↑+/10,7472/##111A-A222&#+/8/J-K
1790 DATA7473/&11+&22BB2-AA1/8/DUAL J-K,7474/11&1AA-BB2&22+/8/DUAL D
1800 DATA7475/A12&+34DDCC-&BBA/12,7490/&↑##+#↑CB-DA#&/6
1810 DATA7493/&11#+##CB-DA#&/5/4-BIT *8
1820 DATA74241/#1H2G3F4E-5D6C7B8A↑+/4/BUFFER,74390/&1A&BCD-HGF&E2&+/7/*10
1830 DATA74573/#12345678-↑HGFEDCBA+/4/LATCH
1840 DATA74643/↑12345678-HGFEDCBA&+/4/BUFFER
1850 DATA#,1/11AB22-33CD44+,2/+A1B2C3-4D5E#6F#,3/A1111#-#2222B+
1860 DATA4/11222B-1AC333+,5/1A2B3C-D4E5F6+,6/1&####↑-↑↑DCBAE+
1870 DATA#,1/DUAL 4-INPUT,2/TRIPLE 3-INPUT,3/QUAD 2-INPUT
1880 DATA4/OCTAL TRI-STATE,5/BINARY COUNTER,6/DECADE COUNTER *10
1890 DATA7/DUAL COUNTER,8/FLIP FLOP,9/HEX INVERTER,10/BCD 7-SEGMENT DECODER
1900 DATA11/ANALOGUE MULTIPLEXER,12/QUAD LATCH
1910 REM 'RESET' OPTION ONLY RESETS TEST SEQUENCE,DOES NOT RESET COUNTER CHIPS
1920 REM ****************************************
1930 REM C64 CURSOR & CONTROL CODES
1940 CU=145 CD=17 CL=157 CC=147 CH=19 CR=29 DN=195 SET=16 UP=199 DAV=56589
1950 DRT=56579 IN=56577 OUT=56577 AT=56576
1960 REM ALTERNATIVES FOR C64 - DN=4, UP=251
1970 REM ****************************************
1980 REM BBC-2 CURSOR & CONTROL CODES
1990 CU=11 CD=10 CL=8 CC=12 CH=30 CR=9 DN=14 SET=16 UP=206 DAV=&FE6D
2000 DRT=&FE62 IN=&FE60 OUT=&FE60 AT=&FE6C
2010 REM BBC USERS ALSO NOTE THE FOLLOWING -
2020 REM THE BBC USES '?' INSTEAD OF 'PEEK' AND 'POKE'
2030 REM THUS 'POKEOUT,Q%(K,B)' WOULD BECOME '?OUT=Q%(K,B)'
2040 REM FOR 'PEEK' THE '?' CAN BE SUBSTITUTED DIRECTLY
2050 REM THUS 'D=PEEK(IN)' WOULD BECOME 'D=?(IN)'.
2060 REM 'GETZ$' BECOMES 'Z$=INKEY$(0)'
2070 REM WHEN TYPING IN, NORMAL BBC REQUIREMENTS FOR A SPACE BETWEEN
2080 REM STATEMENTS SHOULD BE OBSERVED
```

Fig. 11. *Complete demonstration software listing*





Screen dump photos:
1 *14-pin gate;* **2** *16-pin gate;* **3** *16-pin counter;* **4** *20-pin gate;* **5** *Unit self-test;* **6** *Existing library file*

KIT AND PCB SERVICE

AUDIO EFFECTS

		Unboxed	Boxed
Blow Box	SET 214	£24.83	£29.33
Flanger	SET 153	£23.95	£28.45
Frequency Changer	SET 172	£40.06	£45.56
Frequency Doubler	SET 98	£10.80	£15.30
Fuzz (Smooth)	SET 209F	£15.08	£19.58
Guitar Modulo	SET 196	£19.06	£23.56
Guitar Overdrive	SET 56	£23.54	£29.04
Hand Clapper	SET 197	£22.19	£26.69
Multi-Processor	SET 189	£53.53	£61.33
Reverb – Stereo	SET 203	£32.04	£36.54
Rhythm Generator	SET 240	£54.49	£59.99
Ring Mod (Simple)	SET 179	£19.40	£23.90
Storm Effects	SET 154	£18.10	£23.60
Tom-Tom Synth	SET 190	£14.87	£19.37
Tremolo	SET 136	£11.12	£15.62
Vibreto	SET 137	£23.55	£29.05
Wah (Auto & Manual)	SET 140	£18.86	£24.36
Wah (Triggered)	SET 58	£14.34	£18.84

PE & EE KITS

		Unboxed	Boxed
Chorus Flanger (PE*)	SET 235	£54.49	£59.99
Cybervox (EE*)	SET 228	£39.26	£44.76
Disco Light Control (PE*)	SET 245F	£57.00	£62.50
Echo-Reverb (PE*)	SET 218	£52.16	£57.66
Mixer 4ch Mono (PE*)	SET 229M	£44.45	£49.95
Mixer 4ch Stereo (PE*)	SET 229S	£82.15	£89.95
Noise Gate (PE*)	SET 227	£22.11	£26.61
Phaser (PE*)	SET 226	£36.86	£42.36
Reverb – Mono (EE*)	SET 232	£22.85	£27.35
Ring Modulator (PE*)	SET 231	£40.08	£45.58
Signal Gen (PE*)	SET 233	£41.46	£46.96
Thunder & Lightning (PE*)	SET 250T	£26.00	£29.50
Wind & Rain Storm (PE*)	SET 250W	£26.00	£29.50

*** = Kit as Published**

GEIGER COUNTERS

PE Geiger, audio & meter output—Unit 264

with heavy duty box as published	£69.50
with normal black steel box	£59.50
without box	£55.00

EE Simple Geiger, audio only output—Unit 265 with steel box **£49.50**. Unboxed **£47.00**

PCB SERVICE

Chorus Flanger (Jan 85) PCBS 235A-B	(SET)	£9.06
Dig Delay-MCS (June 85) PCBS 234A-E	(SET)	£29.50
Disco Light (Dec 85) PCBS 245A-B	(SET)	£7.17
Echo-Reverb (Sep 84) PCBS 218A-B	(SET)	£8.14
Mini Sampler (Jun 85) PCBS 234A-B	(SET)	£11.00
Mixer (Jan 86) PCB 229A	(EACH)	£3.10
Noise Gate (May 85) PCB 227A		£4.35
Phaser (Oct 84) PCBS 226A-B	(SET)	£7.44
Ring Mod (Dec 84) PCB 231A		£5.27
Scope Simul (Dec 85) PCB 247A		£3.33
Signal Gen (Feb 85) PCB 233A		£4.53
Storm Effects (Jun 86) PCB 250A	(EACH)	£6.07
Geiger counter (PE Aug 86)		£4.53
Chip tester (Aug 86)		£6.56

CONTROLLERS

Bass Boost	SET 138B	£9.12	£13.62
Compander	SET 238	£18.49	£22.99
Envelope Shaper	SET 174	£20.70	£25.20
Fader (Voice Op)	SET 167	£17.72	£22.22
Graphic Equaliser	SET 217	£20.83	£25.33
Guitar To Synth	SET 173	£35.91	£41.41
Headphone Amp Mono	SET 156M	£13.57	£18.07
Headphone Amp Stereo	SET 156S	£22.15	£26.65
Hum Cut	SET 141	£12.31	£16.81
Microphone Pre-amp	SET 144	£10.43	£14.93
Mixer 4 channel Mono Simple	SET 256	£15.49	£19.99
Mock Stereo	SET 213	£19.87	£24.37
Sustain	SET 222	£20.81	£25.31
Tone Control	SET 139	£15.51	£21.01
Treble Boost	SET 138T	£9.12	£13.62
Vocoder	SET 152	£72.15	£79.95
Vodalek Robot Voice	SET 155	£13.81	£18.31

COMPUTER PROJECTS

'Scope Simulator (PE*)	SET 247	£39.00	£44.50
Dig Delay & Mcs (PE*)	SET 234	£162.00	£198.50
Mini Sampler (PE*)	SET 246	£69.50	£75.00
Rhythm Gen (Computer)	SET 185	£29.14	£34.64
Synth To Computer	SET 184	£21.65	£26.15
Chip tester— 24 pin (PE*)	SET 258F	£35.80	£39.30
Chip tester— 16 pin (PE*)	SET 258S	£29.00	£32.50
Mini Music Tuner (EE*)	SET 259	£19.00	£22.50

PARTS & CATALOGUE

Boxes – Linkafex Robust Diecast, SET 234 19 inch steel rack, others Black Steel & Aluminium. All kits include PCBs, parts, instructions. Free wire & solder with boxed sets. Further details in Catalogue of over 70 kits – Send 9 × 4 S.A.E. (Overseas Catalogue send £1.00 or 5 IRCS).

ORDERS & POST

Mail order, CWO, CHQ, PO, Access, Visa. Details correct at press, E&OE. Add 15% VAT. Add P&P – unboxed kits £1.00 each, SET 234 £3.50. Other boxed kits £1.50 each. PCBS add 70p total regardless of qty. Insurance 50p per £50. Overseas P&P in catalogue.

Text photocopies — DDL-MCS £1.50, others 50p each. Send large stamped envelope.

OTHERS

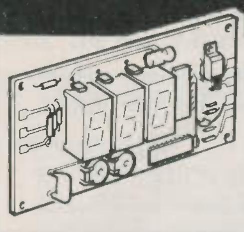
Metronome	SET 143	£16.85	£21.35
Roger (2-Gong)	SET 126	£12.13	£16.63
Roger (Single)	SET 127	£9.41	£13.91
Sirens (Drum Trig)	SET 199	£19.25	£23.75
Sirens (Multi)	SET 151	£16.66	£21.16
Voice Op Switch	SET 123	£15.91	£20.41

FOOT PEDALS

Linkafex Chorus	SET 204	£37.26	£42.96
Linkafex Delay	SET 206	£36.39	£42.09
Linkafex Equaliser	SET 216	£19.73	£25.43
Linkafex Flanger	SET 207	£29.22	£34.92
Linkafex Fuzz	SET 209L	£17.54	£23.24
Linkafex Modulo	SET 211	£19.71	£25.41
Linkafex Overdrive	SET 215	£19.43	£25.13
Linkafex Phaser	SET 205	£28.68	£34.38
Linkafex Sustain	SET 223	£20.77	£26.47

PHONOSONICS, DEPT. PE68
8 FINUCANE DRIVE, ORPINGTON,
KENT BR5 4ED.
Tel: ORPINGTON 37821
(STD 0689, LONDON 66)

DIGITAL VOLTMETER MODULE
WITH HIGH BRIGHTNESS LED DISPLAY



- High accuracy ± 0.1% + 1 digit.
- Operates from single supply 7-12V.
- Reads - 99mV to 999mV which is easily extended.
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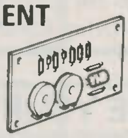

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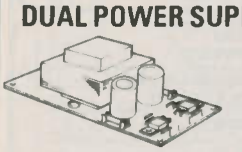

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ROBOTICS REVIEW

BY NIGEL CLARKE

A NEW name is finalising plans to enter the robot market in Britain in the autumn. Spectravideo, already well known in this country for its computer peripherals is to give its low-cost arm an official launch at this year's Personal Computer World Show in September.

It has four axes, being the base, shoulder, elbow and wrist roll, with three clip-on end effectors. It is supplied with a forceps gripper, a shovel and a magnet.

Powered by four batteries it can stand alone being controlled by two joysticks which activate any of the five motors needed to achieve the required movement. It is intended to be used as a peripheral and an interface already exists for the MSX series of micros. Work is in hand to develop interfaces for the usual Spectrum, BBC and Amstrad machines with IGR building the hardware and writing the software for the Spectrum and Logotron writing the software for the BBC.

Made of plastic and using d.c. motors with no feedback, it is strong enough, the makers claim, to lift something like the weight of a coffee mug with an accuracy that is good enough for the arm to be used in the classroom.

It is expected that the arm will sell for a little less than £50 with the joysticks being extra. Richard Sekula, sales manager for Spectravideo said that he expected the machine to appeal to home computer enthusiasts who would be likely to have at least one joystick already. The machine has been built to accept the standard nine-pin D-type joystick.

As the interfaces and software are still being developed no prices have been fixed, however Sekula said that for the education market a package was being put together with the arm, BBC interface and a version of Logotron's Control Logo for about £100.

Later on there are plans for a C64 interface and it is hoped to be able to develope a mains supply system providing extra power through the interfaces.

The arm, which was developed by Spectravideo's research department in Hong Kong is said to have been attracting interest from all parts of the world but the UK is being used as a test market with other areas such as Europe and the States being considered later.

ANOTHER ONE!

Another new arm has been introduced by Fischertechnik, the model kit maker. It is much more complex than the Teach-in arm which can be built from the company's Computing kit, having three axes, two of which are pivotted and a gripper.

It is driven by four new servos, more powerful than previously used in Fischertechnik kits. The base uses the same system as the Teach In, being controlled by a potentiometer but the other two axes are new developments being driven by worm screws and controlled by digital encoders. When in use the wrist is kept at a constant angle to the horizontal by mechanical compensation.

It is possible to alter the shape of the gripper, with a number of extra parts being supplied for this.

All four motors may be driven at the same time and the makers say that the model has good positional accuracy.

Britain is still lagging behind in Robotization. During 1985 the number of Robots used in West Germany rose by 33% and in the US by 54%—meanwhile the efforts of British Industry produced an increase of just 22%.

The kit can be controlled by the BBC B using the Fischertechnik interface and software is available from Economatics, the main Fischertechnik distributor in Britain. It consists of the same driver routines for the Computing kit with extra routines for the digital encoders, which it is possible to adjust, and robot learning and experimenting programs.

Other robotics and control technology concepts are dealt with by Fischertechnik's other new model, the plotter/scanner. The movements along the X and Y axes are driven by stepper motors and there is a pen up and down mechanism for the pen holder. There is an alternative simple sensor device for scanning and picture digitising.

The makers claim an accuracy of less than 1mm.

Again it can be controlled from the BBC B using the interface and the software allows the working of the steppers to be examined as well as giving a comprehensive set of plotter instructions such as absolute and relative moves, circle drawing, lettering and scaling.

As with the arm the software can easily be incorporated into the user's own programs.

CARing ROBOTS

Most robots in the UK are found in the motor vehicle industry, used for injection moulding, cost, on average, the least of those installed in the major industrial countries and are mostly to be found in the West Midlands.

Those are a few of the conclusions to be drawn from the British Robot Association's annual collection of statistics about robot use in Britain.

The car industry is by far the biggest user with a total of more than a 1,000 installed, almost double the next major user, rubber and plastics. During the year it added a further 151 machines, against 141 in the rubber and plastics industries.

The figures also show that Britain is falling further behind its main trading partners, West Germany and the States, in the use of robots. At the end of the year Britain had a total of 3,208 an increase of 22 per cent during the year, whereas West Germany had 8,800, a rise of 33 per cent and the US had 20,000, a rise of 54 per cent.

Most of the British robots, with about 30 per cent of them being supplied by UK companies, were at the cheaper end of the range at less than £10,000. Both Europe's and Japan's purchases were in the £20,000 to £35,000 region with American machines more likely to be more than £35,000.

Because of the tight definition used by the BRA a large number of the robots used in Britain do not count in the figures, particularly the small arms and turtles used in education.

The Second European Personal Robot Congress is going ahead with a two-day conference being organised at the Institute of Electrical Engineers in Savoy Place, London in mid-July. The two days of lectures and demonstrations will look at many aspects of personal robots particularly their uses in education and problems associated with their development. Many of the leading names in the industry will be speaking including Dave Bukley of IGR, John Reekie of Reekie Technology and John Billingsley of Portsmouth Polytechnic. I have also been asked to speak on the commerical nightmare of being a personal robot supplier. The Micromouse finals will also be held together with the Robat competition. PE

MOULDED WIRING BOARDS

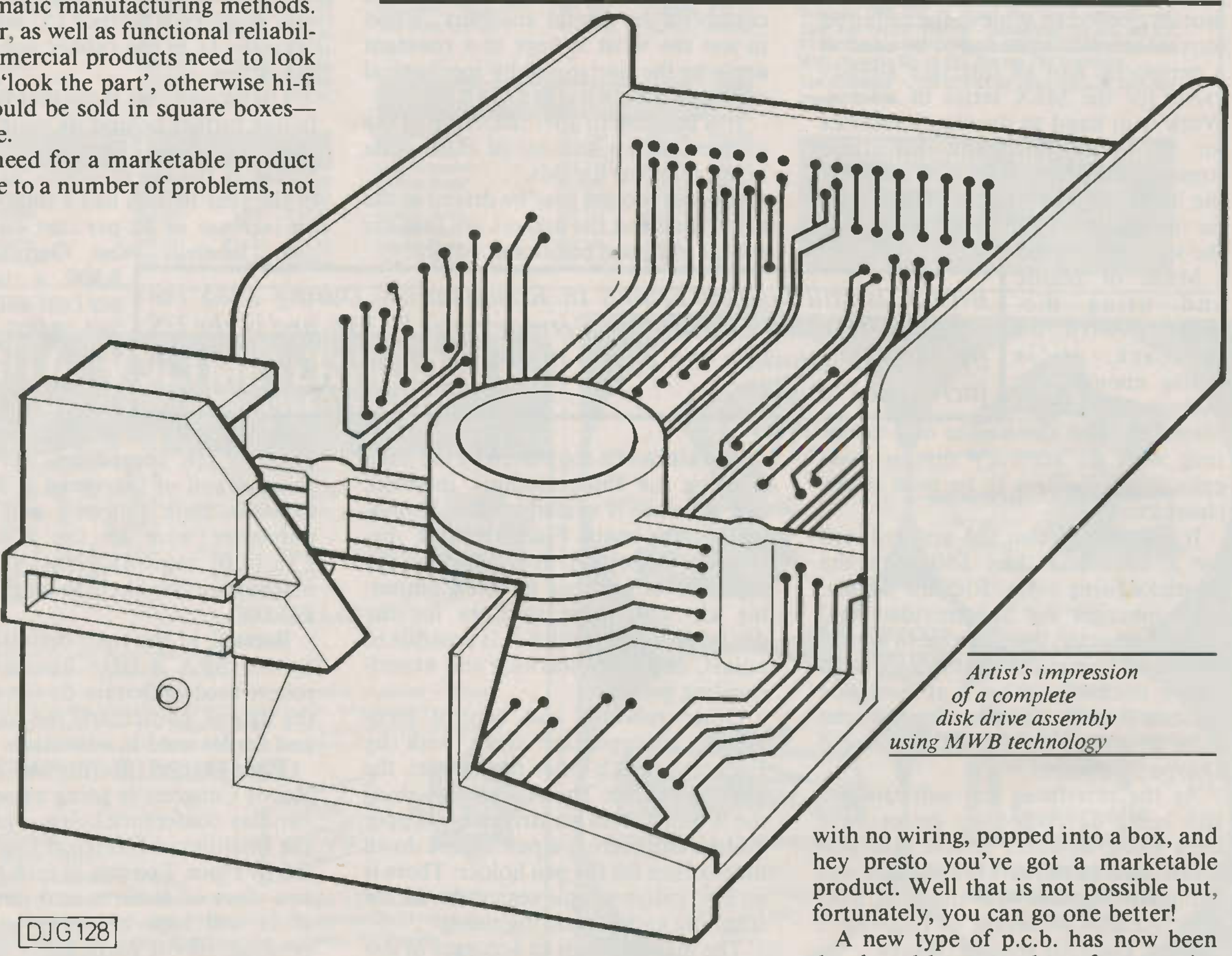
BY RICHARD BARRON

And On The Eighth Day—The Pcb Was Invented

With electronics came problems—masses of tangled wires made production and testing of electronic products a nightmare. Tag boards helped but things didn't really change much until mass produced i.c.s. and p.c.b.s. came on to the scene. Further improvements came quickly with thin and thick film technology, SMDs and multi-layer p.c.b.s. Now comes Moulded Wiring Boards (MWBs), the p.c.b technology of the future.

ADVANCES made in the techniques used for electronic goods production have been encouraged by the need to reduce manual labour input and to improve reliability by reducing the number of electrical connections beteen components or modules. Some products are now assembled entirely by automatic manufacturing methods. However, as well as functional reliability, commercial products need to look good or 'look the part', otherwise hi-fi units would be sold in square boxes—some are.

This need for a marketable product gives rise to a number of problems, not least being that of production. Many electronic devices such as tape recorders, disk drives, and printers contain a large proportion of mechanical parts. Even televisions, radios and computers have to have switches conveniently positioned for the user. In order to maintain compactness, the electronics are often designed around the mechanics. This usually means a number of electronic modules (p.c.b.s) connected by plugs, sockets and wires to various switches and other mechanical devices.



Artist's impression of a complete disk drive assembly using MWB technology

Now suppose you could cut and bend one large p.c.b. into any shape you want allowing you to connect all your switches and mechanical components to this single p.c.b. Wouldn't this provide a neat solution to reliability and production problems? The p.c.b. could be completely assembled with no wiring, popped into a box, and hey presto you've got a marketable product. Well that is not possible but, fortunately, you can go one better!

A new type of p.c.b. has now been developed by a number of companies which looks set to revolutionize electronic product design, the Moulded Circuit Board (MCB) or Moulded Wiring Board (MWB). It is a three dimensional plastic structure which is able to carry all necessary electrical connections, allow standard and SMD chip insertion, passive device insertion and in addition form part of the structure of the final product. The possibilities are enormous.

THERMOPLASTICS

The key to MWBs is modern thermoplastic technology. New improved resins now available, which can withstand high temperatures while flowing in a molten state, can be moulded into any shape for later addition of electrical tracks and components. They can be single or double sided and should prove to be extremely reliable and mechanically sound. I say *should* because as yet they have not stood the test of time.

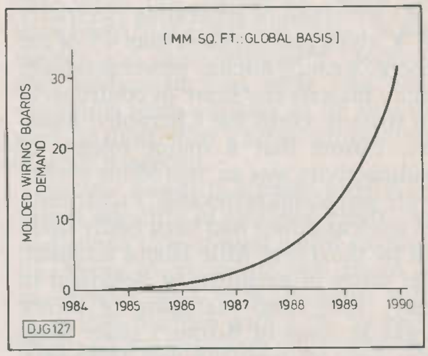
There are several methods which can be used to produce MWBs, all based on similar technology but employing slightly different techniques. One method is to use a plastic resin which has been combined with a catalytic filler making it receptive to copper-plating. It is moulded to form a substrate with a raised circuit pattern. Following this it is 'overmoulded' with a non-catalised plastic which fills in the non-circuit elements of the board. An adhesive promotion agent is then applied which allows only the circuit track to be built up with copper.

To date, there are few companies using this technology but interest is expected to rise dramatically over the next decade. Leading industrial experts predict that MWB technology will account for a large proportion of p.c.b. production by the end of this decade. A recent survey carried out by Phillip Townsen Associates Inc. in the US shows that by 1990 injection moulded thermoplastic substrates will create a demand for thirty million square feet of p.c.b.s. This represents a world consumption of nearly 14 million pounds of thermoplastics.

With potential sales this high, many leading multinational companies are getting their foot in the door now, ready to take advantage of the market. ICI, General Electric, Du Pont and Union Carbide are just a few. Whilst at present the market is only worth about £8 million per year, by 1990 it could be as high as £300 million.

"By 1990 injection moulded thermoplastic substitute will create a demand for 30,000,000 square feet of p.c.b.s."

MWBs can, obviously, be only cost effective in fairly high volume production as initial tooling costs are high. This makes the price per board much higher than the traditional p.c.b. but this disadvantage is far outweighed by cheaper assembly and testing. MWBs, though, offer other advantages over traditional p.c.b.s, in that they are more suited to hostile environments, high frequency response is better, and they lend themselves to total computer aided design. With suitable software, because the electronics form part of the mechanical structure of the finished product, the whole thing could be computer modelled.



Future demand of Moulded Wiring Boards

COME ON!

By the way, I've got to mention it—most of the research into MWBs is being carried out in Japan and the US, with very little in Europe and even less in the UK. I'm sure that this needn't be the case; even if we are behind in electronics, we know enough about plastic!

As a method of generating electricity which provides less than 4% of the energy we buy, nuclear power produces more than its fair share of controversy in Britain. Until the Chernobyl disaster, claims that a major release of radioactivity was an 'incredible event', were just about believable. Public faith in nuclear power had been badly shaken by the Three Mile Island accident, the series of accidents at Sellafield in early 1986, and the spate of minor leaks at some of Britain's older Magnox reactors over the past few years. After Chernobyl, however, things will never be quite the same. Public opinion polls have shown an acceleration of a trend over the past 6 years which has shown that a large majority of the British population now wants to see a phase-out of the use of nuclear power in this country.

Government support for nuclear power has been consistently strong over the past 35 years. The current Government is no exception to this, with the Prime Minister recently describing the nuclear industry as 'one we can be justifiably proud of', and which had 'an absolutely superb safety record'. Closer investigation of Britain's nuclear programme reveals a rather different picture. Britain has tried three types of nuclear reactors and each in turn has failed, either on technical or economic grounds, to provide a cheap and reliable alternative to coal-fired power stations.

The 11 Magnox reactors have never produced electricity cheaper than large coal stations and are an inefficient power reactor system. They were replaced by the Advanced Gas Cooled reactors, all of which have suffered from serious cost and construction overruns ranging from 20 to 265%. Up until now, they have yet to produce cheaper electricity than large coal-fired stations, though the CEGB confidently expect then to do so in the future. After a brief affair with the Steam Gas Heavy Water reactor, a further 2 AGR's were commenced in 1978. The CEGB has now decided to try a fourth type of reactor, the Pressurised Water Reactor (PWR). The case for the PWR, initially at Sizewell, was tested during a long public inquiry in Suffolk. The economic case for the PWR, is at best dubious—at worst it promises to take us down yet another technological cul-de-sac posing yet another drain on public resources. It also poses safety risks of a fundamentally different nature to that of our British reactors. In the USA, home of the PWR, the reactor still has many safety issues which have yet to be resolved. There is much dispute over the risks of a serious PWR accident, but a widespread acceptance of the consequences of such an accident. At Sizewell, a PWR meltdown which released radiation into the environment for between $\frac{1}{2}$ to 10 hours, could lead to at least 3,500 cancer and leukaemia deaths, the evacuation of Ipswich for 12 months, and clean-up costs of £15 billion. The official calculations may have to be completely reassessed following Chernobyl where radioactivity escaped into the environment for over 6 days and the effects were felt thousands of miles away. In the USA meanwhile, in a market place less cossetted by Government, and lack of competition amongst electrical utilities, there has not been a single PWR order since 1978 and at least two utilities are signing contracts to convert nuclear stations to run on coal.

There are a number of risks associated with nuclear power. These include the thorny problem of nuclear waste, particularly the long-lived high-level waste, and the problems of what to do with the old nuclear reactors when they come to the end of their life. No full decommissioning has yet taken place with a large commercial reactor in the world, and a great deal of research and development is required to solve this particular problem. Nuclear reactors, of course, produce fissile materials which can be used in nuclear weapons. The British nuclear power programme grew out of the British nuclear weapons programme in the 1950s and still has a number of links to this, particularly at Sellafield and Capenhurst where military work is carried out side by side with civil work. There has now been a frank admission by the current chairman of the CEGB that prior to 1967, civil plutonium was used for military purposes. It is clear that the motivation for developing nuclear power in many countries around the world is linked to this capacity to develop nuclear weapons.

Both Brazil and Argentina have made no secret of their wish to acquire nuclear weapons in this way, and both South Africa and Israel have the ability to produce nuclear weapons as a result of their involvement in nuclear power research and development. The sheer scale of the problem is immense—it takes only 5kg of plutonium to produce a nuclear weapon on the size that devastated Hiroshima, yet we, in Britain, have a stockpile of plutonium approaching 32 tonnes. Large nuclear power stations have the capacity to produce plutonium for 5 nuclear weapons every year. The International Atomic Energy Authority has tried vainly to control this problem but its 100-strong group of inspectors are fighting a hopeless cause. There are no other sources of electricity which pose such significant risks of this type.

The Chernobyl disaster has, of course, shown that the 'incredible' can actually happen. The reassuring statistics provided by the nuclear industry that such accidents would happen only once in 1 million years have been blown to the wind. Such figures are clearly based upon a limited database and operational experience, and even with improved safety systems, the industry cannot guarantee that such an accident will never happen again. A single accident which has the capacity to lead to at least 10,000 additional long-term cancers throughout Europe should have no place in Britain's energy strategy.

In the aftermath of Chernobyl, the confidence of nuclear advocates has been badly shaken. A front cover of the Economist shortly before Chernobyl read 'The Charm of Nuclear Power'. Recent editorials in this journal have indicated that the Editor has at least realised the folly of comparing the risks from nuclear power with those from working in a chocolate factory. A major reassessment of the energy options available to us is now being carried out both by politicians and the general public. Unthinkable questions are now being asked—could we live without nuclear power?, why have the alternatives to nuclear power not been developed?, how quickly could nuclear power be phased out?

We in Britain are in an enviable position in that we are awash with a whole range of options for our energy usage. We have extremely large reserves of coal which, given the use of improved pollution control equipment and newer combustion technology, could provide the backbone of our energy supply system well into the 22nd century. We have large North Sea oil and gas reserves which unfortunately are being used at present at a rapid rate. A more sensible utilisation of

COMMENT

THE NUCL

Chernobyl is now history but the debate
argument to this important issue, Practic
The UK Atomic Energy Association and
spite our insistence upon a maximum nu
sides had equal say, The Friends Of The
Since we agreed not to edit their text, we h
so they still have a lot to say.
The views expressed on these pages
Electronics, but are personal comments,
tive of the organisations to which they be
Let battle commence. *On my left is Stuar*
on my right is Bill McMillan of The UK A
however, leave us on the fence. Taking eve
the benefits of nuclear energy far outwei

these could ensure thair continued usage well into the next century. We also have the huge potential resources of renewable energy sources such as solar, wind, tidal, wave and geothermal energy.

So far these have been starved of investment and regarded as 'an insurance policy' in case of major disruptions of energy supplies. The scientists who have been charged with controlling the research programme and who are based at Harwell, have tended to look for the problems rather than the solutions. This has been the reason for the demise of the wave energy research programme in this country at the same time as the Norwegians are developing the world's first commercial wave power station. Most environmentalists realise that there are many problems in developing renewables in order to make them a commercial and dependable source of energy . . .

Stewart Boyle, BSc, DMS (Friends Of The Earth).

SPECIAL...

LEAR ISSUE

continues. In order to provide a balanced
cal Electronics invited comment from both
l The Friends Of The Earth. However, de-
umber of words in order to ensure that both
e Earth submitted far too much material.
had no option but to chop off the end. Even

are not necessarily those of Practical
by the two authors, which are representa-
elong.
rt Boyle of The Friends Of The Earth and
Atomic Energy Association. This does not,
erything into account, we (PE) believe that
igh the disadvantages.

NEEDS MUST . . .

It is too early to assess the aftereffects of the Chernobyl disaster but the event has undoubtedly brought nuclear electricity to the attention of a whole lot of people who did not realise that they've been using it for the past 30 years.

If there is any hesitation over decisions about the future of the nuclear electricity industry it is because it is seen as a major source of energy that can delay the demise of oil and coal.

About 20% of UK electricity comes from nuclear power stations, providing not only a steadying influence on prices but also some diversity of supply. Memories of the 3-day week in 1973/74 and the nail-biting period of last winter still linger and reinforce the need to have our energy supply eggs in more than one basket.

Nuclear electricity continues to grow. There are now 374 reactors producing electricity in 25 countries, with another 150 under construction. Not everyone is as well endowed with fossil energy supplies as the UK!

The biggest user is the USA, which has just brought its 100th nuclear power station on stream. The Three Mile Island accident and the fall in electricity demand due to the recession stopped new orders for nuclear—and coal—power stations but the prospect of an upturn in the economy is forcing a re-think on the power station building programme. Here in Britain electricity demand is again rising.

The first priority in the wake of Chernobyl must be to provide any help that may be needed by the Russians in ameliorating the health and environmental consequences of the accident. The second is to learn as much as possible about what went wrong and re-examine the safety of nuclear plants elsewhere in the light of this knowledge. The Comet aeroplane crashes and the Flixborough and Seveso chemical plant accidents are just a few of the many examples of tragedies that have led to major improvements in safety. Perhaps even the 2500 fatalities at Bhopal may produce positive information which will improve safety in the chemical industry.

The potential benefits of nuclear power in the coming decades remain enormous. In spite of the current oil glut, the world will need new sources of energy. Half the world's energy today comes from oil—a quarter of the annual oil production is still burned each year to generate electricity. At current levels, each year's total oil consumption represents about one-fortieth of proven reserves. Natural gas is also limited. There is far more coal, but this will eventually be needed for conversion into gas, into liquid fuels for transportation, and as a raw material for chemicals, fertilisers, plastics and textiles.

World population is growing, and growing most rapidly in the developing countries. There will be 6,500 million people needing energy by the year 2000 compared with 4,600 million today. There is a close link between standards of living and energy consumption—life expectancy, infant survival, literacy, health, all tend to be higher in countries that have access to plentiful energy. The availability of energy does not necessarily lead directly to these benefits, but as countries improve their standards of living, their energy consumption tends to increase.

So the world's demand will be growing, as a result of population growth and third world aspirations, just at a time when the sources on which we have relied in the past will be becoming scarcer and more expensive. Renewable sources such as solar cells and windmills seem unlikely to be able to provide more than a small proportion of what is needed.

Nuclear power is already providing nearly one-fifth of Britain's electricity and about 15% of total world electricity. Many countries are well ahead of us—France with 65%, Belgium with over 50%, Sweden with 45%, Switzerland and Finland with over 30%, W. Germany and Japan with over 20%. Nuclear electricity is proving cheaper than coal-fired electricity in country after country, the only major exception being parts of North America where coal-fired stations are sited near to large sources of easily extracted coal. Further substitution of nuclear power for imported oil in developed countries could make cheaper oil available for the developing countries.

But however strong the case for nuclear power on economic or energy resource grounds it must also be acceptable on environmental grounds. No energy source is environmentally entirely benign. Atmospheric pollution caused by burning fossil fuels is being blamed for the acid rain problem. The case is not proven but many countries are investing large sums in clean-up equipment. More serious in the long term may be the "greenhouse effect", that is the possibility of climatic change resulting from the increase of carbon dioxide concentrations in the atmosphere. Large hydro-electric schemes are being opposed by environmental groups in Sweden, Austria and elsewhere. Dam failures can have disastrous consequences. The Vaiont dam failure in Italy in 1963 killed 2,000 and the Gujarati dam failure in India in 1979 killed 15,000.

Part of the nuclear industry's problem is that it is a relatively young industry, One can only imagine how other, older energy industries would fare if they were starting up today, under the negative scrutiny of the single-issue protest groups and the media. What an outcry if someone seriously suggested piping an explosive, poisonous, suffocating and highly flammable gas into every house in the country—with easy access to it, and boxes of matches, by tiny tots and rheumatic pensioners!

We must learn any lessons that there are to be learnt about safety from Chernobyl, because there is an undoubted long-term need for a major, proven energy source to provide us with electricity and to save our coal, which is too valuable to burn.

William McMillan,
Director of Information Services,
U.K. Atomic Energy Association.

PORTABLE GEIGER COUNTER WITH TTL-COMPUTER INTERFACE

BY JOHN M. H. BECKER

Designed exclusively for Practical Electronics at a time when it matters most!

Seriously, not wanting to be called a scare-monger or instil panic into those intelligent, rational and logical minds of yours, it does seem that, in the present climate, a Geiger counter is an interesting —if not useful—project. Whilst it is unlikely that such a device will ever become a common household gadget, demand for them has risen dramatically in recent times. Apart from the obvious applications, there is plenty of scope for experimentation, especially in a controlled 'learning' enivronment.

THE nuclear accident at Chernobyl has highlighted the disastrous consequences of mishandled nuclear power. It has reaffirmed more emphatically than any demonstration or official statement, the need for public awareness of the nature of high technology energy production. As the worst accident in the history of nuclear power, it follows in the wake of numerous reported incidents at other power stations. Small wonder that enquiries about Geiger counters are at their present level.

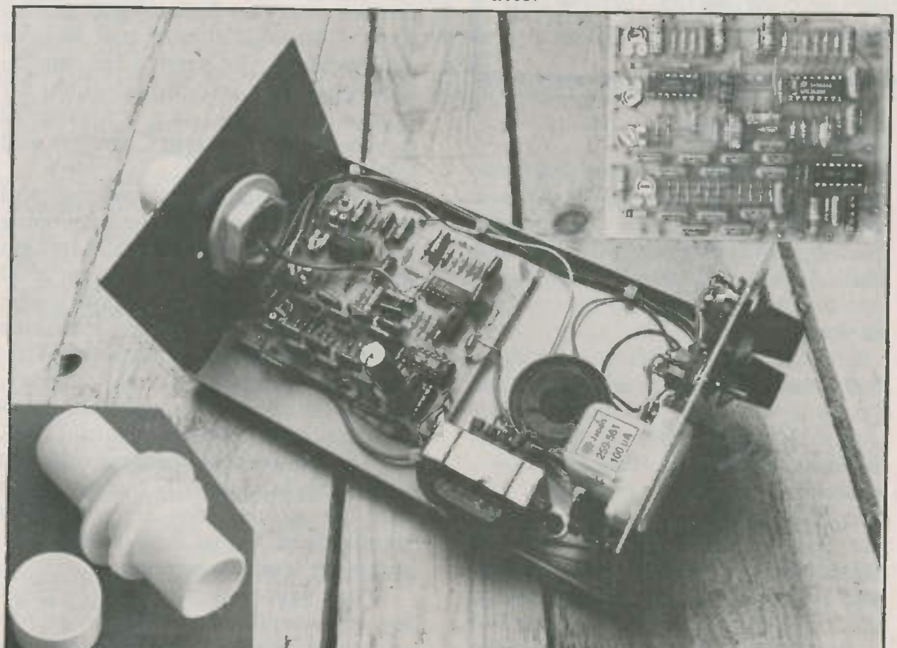
We are assured by Government authorities that in Britain there is no need for undue concern about radiation levels, whether they originate from Chernobyl, or even Sellafield. There is no reason to doubt these assurances, but none the less, demands for information about the nature of radiation and its consequences continue to be expressed.

On other pages of this month's *PE*, the viewpoints of both the Atomic Energy Commission and the Friends of the Earth are put forward. This article briefly states how radiation occurs, and describes a simple constructional project that will illustrate how it is detected.

NATURAL MATTERS

The material from which we and everything around us is made can be divided into smaller and smaller pieces. Ultimately, the smallest part that can be recognised as a substance in its own right is an element, of which there are over 100. Some occur naturally, such as hydrogen, copper, uranium. Others, such as plutonium, einsteinium and curium, only occur when specially created. The smallest part of an element that can exist is the atom. This too can be sub-divided, into three basic sections.

The core of the atom is its nucleus, composed of positively charged protons and one or more chargeless neutrons. Rotating around the nucleus are electrons, and these are negatively charged. The energy potential of an atom is relative to the combined forces holding it together. In most atoms the energy levels are in a state of balance, and the number of electrons held determines the element that exists. By definition an atom with only one electron around it is known as hydrogen, one with 79 around it is known as gold, and one having 92 is called uranium, and so on throughout the full table. In chemical reactions, the energy binding the electrons to the nucleus is released, and atoms of different types can combine to form compounds, such as oxygen and hydrogen combining to form water.



RADIATION

The number of protons, though, can vary without the element type changing and so under the appropriate conditions, different forms, or isotopes of the same element can be produced. Most natural elements are mixtures of several isotopes. Hence such materials as uranium 235 and uranium 238, the numbers being the quantity of neutrons in the nucleus.

Most atoms are normally stable, but uranium is the only naturally occuring element that is not. By applying sufficient force from a free neutron, the nucleus of an unstable atom can be split into two roughly equal parts releasing 2 or 3 more free neutrons and other particles which fly off at incredible speeds. This is known as fission and the radiated energy is categorised in three main groups.

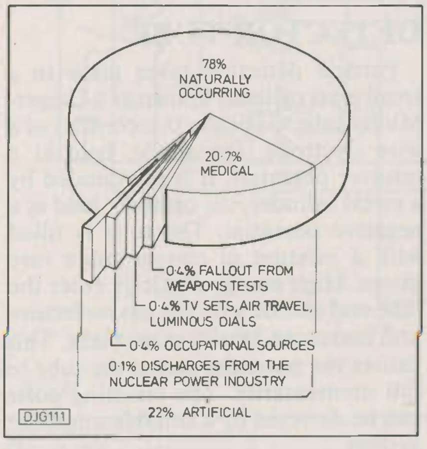
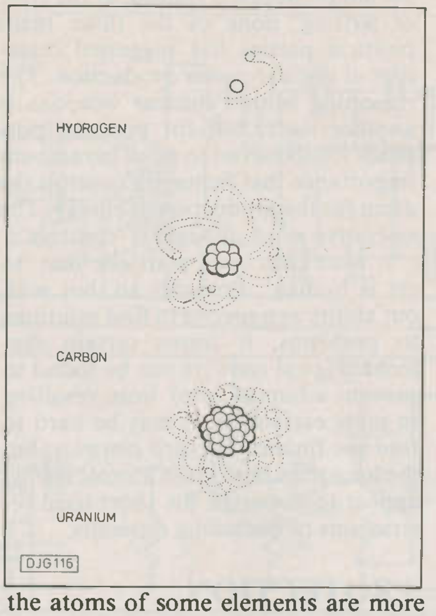


Fig. 1. *Radiation origination*

Firstly, there is alpha radiation of small particles each consisting of two protons and two neutrons. This is very short lived, travelling in air to only a few centimetres from the source, and is readily stopped, even by paper, clothing and skin. Beta radiation is streams of free electrons. These also lose their potency easily, travelling only a few metres in air, and aluminium or glass can readily be used as a blocking shield. More common are gamma and X-rays, which have similar properties to each other, and are capable of passing through considerable thicknesses of less dense matter. Hence the use of X-rays in medical applications, though gamma-rays are more energetic and will penetrate further. Both can be stopped by lead, or sufficiently thick amounts of concrete.

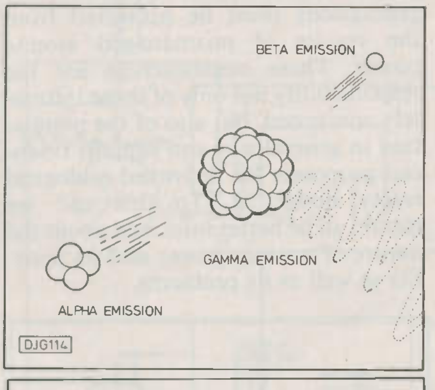
EFFECTS

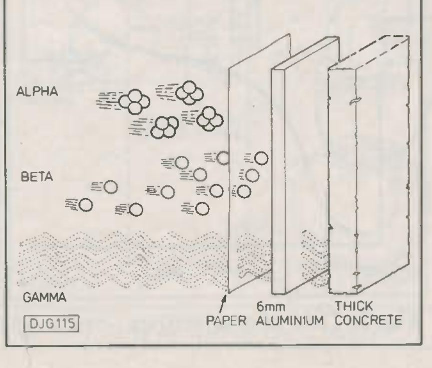
Should particles collide with another unstable atom, that too may be split and additional particles fly off, to collide with yet more atoms, which in turn are shattered. This is the so-called chain reaction. As each particle is kicked out, so energy is released. Since



the atoms of some elements are more stable than others, these can be used in the path of the radiation to reduce the reaction rate. Given the right mixture of stable and unstable atoms, the reaction can be controlled to manageable levels, and the resulting energy harnessed as heat. This can be used to generate steam to drive turbines and so produce electric power.

However, another effect exists. Instead of an atom breaking apart when the collision occurs, a particle can be captured by it. In this case the element is transformed into another isotope. Should this atom be part of a complex substance, such as that making up a plant or animal, the structure of the substance will be changed, and possibly become unstable. The nature, and thus the well-being, of that plant or animal depends on the correct balance





of the various substances of which it is composed. Small changes may make no difference. Function-sustaining substances are constantly being absorbed, changed or excreted throughout the organism's life. However, given sufficient changes in its make-up, the balance becomes seriously disturbed. The results of this may remain dormant for years after the event, or they may appear within hours. It is this disturbance, and its consequences that make radiation such a hazard when received in large doses.

In nature, random collisions and resulting radiation are occuring constantly. Some are beneficial. Probably our existence as human beings is a direct result of some random collision in the past resulting in the mutation of one gene into another. With enough favourable mutations it is understandable how life-forms have progressively changed across generations; from fungus to tree; pterodactyl to bird; primate to Man.

Adverse changes, though, can kill. In the worst immediate situation, the creature afflicted will die from its bodily changes. Of more sinister long-term consequence, is the possibility of undesirable changes in its reproductive system, resulting in malformed off-spring. Some unfavourable mutations are self-eliminating; that is, the mutant creature cannot reproduce, or is unfit to withstand the pressures of its environment, and so eventually the strain dies out. Others can result in hereditary defects affecting shape, ability, resistance to disease and so on, being passed from generation to generation. It is thus obvious that not only for our own individual welfare, but also for our future inheritors, exposure to adverse radiation levels must be avoided.

HALF-LIFE

Danger from nuclear events is not confined to the duration of the accident. Isotopes can remain unstable for considerable periods later. The duration depends on the isotope concerned, and its original intensity. The unity by which decay rates are measured is known as the half-life. This is the time taken for the intensity to fall to half its original value. It varies between isotopes, and can range from fractions of a second to billions of years. Given sufficient half-life reductions, radioactive isotopes will virtually disappear. Radioactive iodine, mentioned in relation to Chernobyl, has a half-life of only about 8 days, and so decays rapidly. The other likely by-product of that disaster is radioactive caesium. This has a half-life of thirty years. Uranium, though, has a half-life of four and half billion years, the age of the Earth.

COMPONENTS . . .

RESISTORS

R1,R2,R24, R25	4k7 (4 off)
R3,R13,R17, R18,R21,R27, R29	10k (7 off)
R4,R5,R8, R30	47k (4 off)
R6	200k
R7	2M4
R9,R12,R14, R19,R20,R23	100k (6 off)
R10,R11,R15, R16,R22,R28, R31	1k (7 off)
R26	5Ω6

All resistors ¼W 5%

CAPACITORS

C1	15n polyester
C2–C4, C22, C28	22μ 16V electrolytic (5 off)
C5–C18,C23, C24,C26,C27,	100n polyester (19 off)
C19	1n polystyrene
C20,C25	4μ7 63V electrolytic (2 off)
C21	470μ 10V electrolytic
C30	180p polystyrene

POTENTIOMETERS

VR1	50k skeleton
VR2–VR4	100k skeleton (3 off)
VR5,VR6	25k mono rotary (2 off)

SEMICONDUCTORS

D1–D11, D14–D16	1N4148 (15 off)
D12	4V7 400mW zener
IC1	324
IC2	LM13600
IC3	380

SWITCHES

S1,S2	min d.p.d.t. (2 off)

MISCELLANEOUS

Battery clip; p.c.b. clips (4 off); Geiger-Muller tube (see text); knobs (2 off); meter 100μA f.s.d.; p.c.b. available from Phonosonics; 14-pin i.c. socket (2 off); 16-pin i.c. socket; mono jack sockets (2 off); speaker 8 ohms; 6V transformer, 2 × 3VA secondaries, 240V primary.

ESSENTIAL CONTROL

Although it is natural to be antagonistic towards intentionally producing radiation for commercial processes, or military defence, the author does not believe that the use of atomic power should be stopped. Indeed, at the time of writing, none of the three main political parties has suggested cessation of nuclear power production. The reasoning behind nuclear weapons is another issue, but for peaceful purposes it is believed to be of paramount importance that humanity controls the atom for the production of energy. The operative word, though, is 'controls'.

It is an over used platitude that 'to err is human'. Probably so, but with our ability as a species to find solutions to problems, it seems certain that technological answers can be found to prevent a human error from resulting in mass extinction. It may be hard to find the finance for such controls, but the long-term benefits of atomic energy appear to outweigh the short-term restrictions of budgeting economy.

PROTECTION

It is argued that we do not need atomic energy to supply our requirements for power and that other forms of production exist. Indeed, they do, and they should be exploited. Solar power; wave energy; harnessing the wind; all laudable projects that should be encouraged enthusiastically. But so far as fossil energy sources are concerned there is a finite limit to what can be extracted from a small planet. Our outlook must be on a grander scale than just concern for stocks in plentiful supply for the next two or three generations. Where alternatives exist, they should be used, and this includes nuclear power. Conservation of irreplaceable resources must be maintained for the welfare of generations yet to come in the far distant future.

Simultaneously, of course future generations must be protected from the results of mismanaged atomic power. These consequences are the responsibility not only of those intimately concerned, but also of the population in general who can support financial proposals for improved ecological safety budgeting. To this end we should all be better informed about the nature of nuclear power and its benefits as well as its problems.

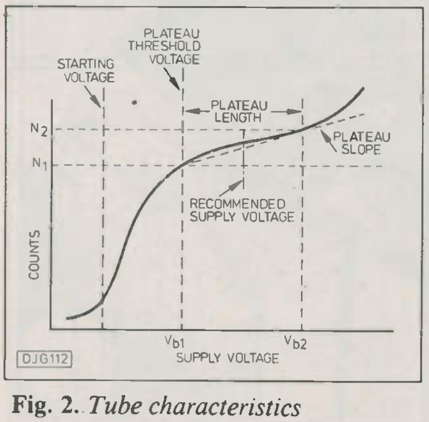


Fig. 2. *Tube characteristics*

THE PROJECT

The following project is intended as a contribution to encourage interest and understanding of nuclear activity. It will illustrate by practical use that radiation exists in natural forms all around us, whether it be from the luminous dial of a watch, the emission from a TV tube, or the background from archaeological remains and ancient geological systems. In both latter disciplines a Geiger counter is a common tool through which the age and make-up of rocks and biological remains can be assessed from the strength and type of radiation emitted. The detector described here is not a precision counter, but is a low-cost unit suitable for the average interested user. For those with a need for greater accuracy, commercially made units costing from about £120 upwards are available from various sources.

DETECTOR TUBE

Particle detection takes place in a small glass cylinder known as a Geiger-Muller tube. Basically this consists of a wire electrode, the anode, held at a positive potential. It is surrounded by a metal cylinder, the cathode, held at a negative potential. The tube is filled with a mixture of one or more rare gasses. High energy particles enter the tube and collide with the gas molecules and ionisation briefly takes place. This causes the potential across the tube to fall momentarily. The resulting pulse can be detected by a suitable amplifier system.

There are many varieties of tube available, each having different degrees of sensitivity to suit the type of particles to be detected. Typically, they operate with a recommended anode potential of between 450V and well over 1000V. Individual tube types have a fair amount of latitude in the applied voltage. When the potential is increased from zero, no events will be detected until the starting voltage of about 400V is reached. The count detection rate then increases rapidly as the voltage is raised, until the Geiger threshold point is approached. The detection rate levels off as the voltage is raised above the threshold, and a plateau slope develops. The plateau length usually extends across a range of about 100V, and the ideal operating point lies around the middle of the slope. As anode potential is increased above the plateau range, count rates increase, but linearity suffers, the tube becomes unstable and oscillations occur. Tube life expectancy is also decreased. Under optimum operating voltages, though, a minimum life of 5×10^{10} pulses can be expected. In sophisticated Geiger counters, it is also possible to assess the relative pulse levels detected, and to measure the radiation

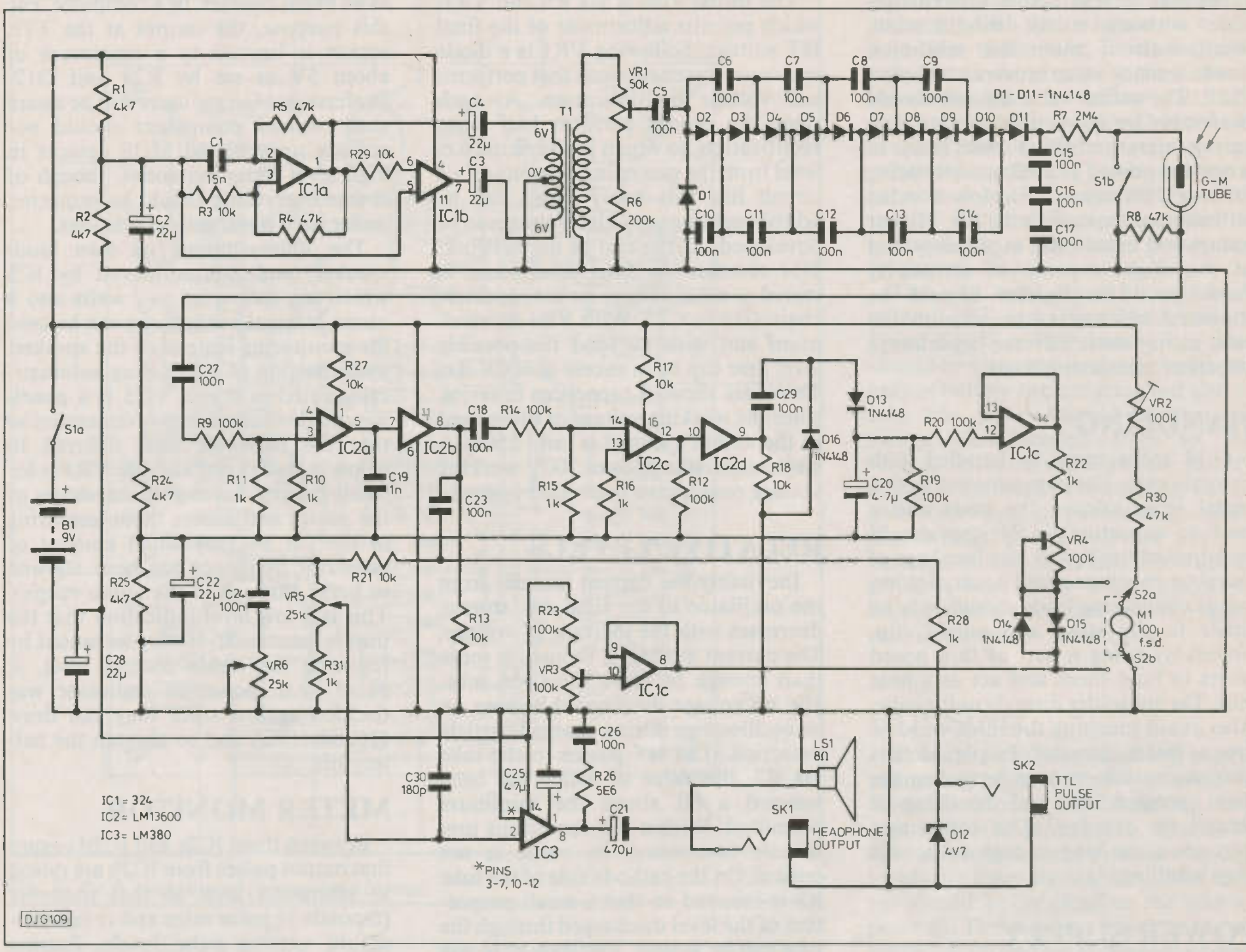


Fig. 3. *Complete circuit diagram of the Geiger Counter*

spectrum as well as the incident rate. Such detectors need highly stabilised power supplies and precision setting of the operating levels. For general purpose units, it is only the count rate that is detected, and simple power sources are adequate.

Once ionisation has been initiated, no further particles will be detected until it has been quenched and the anode potential restored. The quenching rate is partly determined by the gas used, and by the anode resistance value. This period is known as the dead time, and with Mullard G-M tubes this varies amongst different types between 11µS and around 220µS. For domestic purposes this is probably unimportant, as count rates at that frequency would imply conditions highly unfriendly to human life!

The unit here has been designed for use with the Mullard ZP1300 or ZP1310 G-M tubes. There is little significant price difference between them, but the latter has a greater gamma sensitivity, quoted at 1200 counts per minute, compared with 180 for the ZP1300. The respective operating voltages are 550V and 575V. The

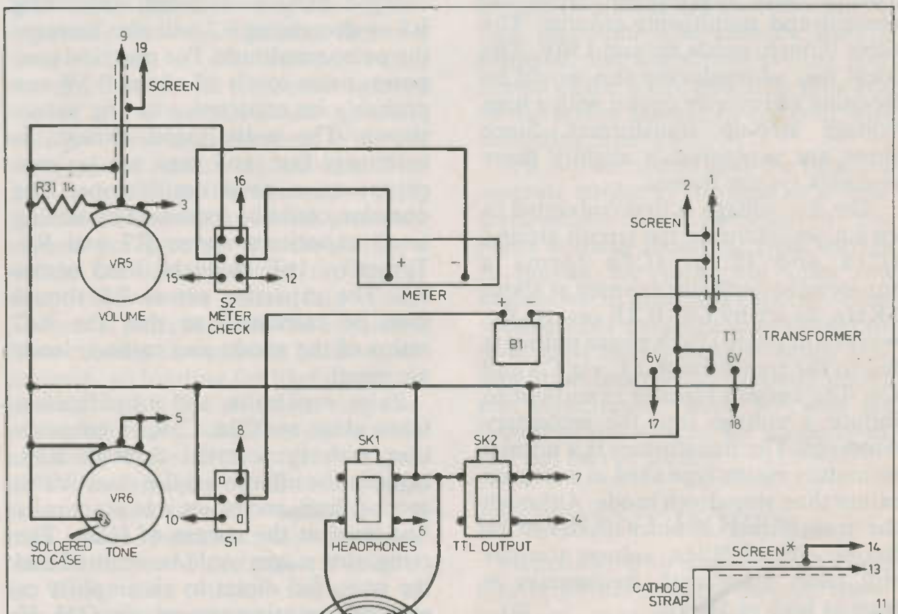


Fig. 4. *Wiring details of the Counter*

tubes may be regarded as interchange-able without circuit modification. With both of them the minimum anode resistor value must not be below 2M2. The actual value chosen should preferably be above this as manufacturing tolerance factors could result in a resistor quoted as 2M2 actually being 10% or 20% below. Too low a value will shorten expected tube life. Higher values will extend life expectancy, but at the slight expense of sensitivity reduction. The resistor should be mounted as close as possible to the tube to minimise adverse capacitance effects of connecting leads.

HANDLING

G-M tubes must be handled with extreme care. They are supplied with a metal strap around the body and a push-on mounting pin. Neither should be adjusted too tightly else breakage of the glass envelope could occur. Soldering of connecting leads should only be made to the strap and anode clip, preferably using a pair of thin nosed pliers to hold them and act as a heat sink. Do not solder directly to the tube. Also avoid touching the mica window area as this is extremely fragile. Mica is also susceptible to long-term damage from perspiration and handling it should be avoided. The connecting tabs are quite long enough to permit easy handling.

POWER SUPPLY

Since the unit has been designed to be portable, it runs from 9 volt battery. This directly supplies power to the control and monitoring circuits. The tube, though, needs around 550V. The ideal way of producing this would be by using an inverter circuit with a high voltage step-up transformer. Since these are expensive, a slightly more complex system is used.

The d.c. voltage is first converted to an a.c. waveform in the circuit around IC1a and IC1b. IC1a forms a squarewave oscillator running at about 5KHz, as set by C1. IC1b inverts the waveform phase. Each phase output is fed to the transformer T1, via C3 and C4. The current transfer is suffient to induce a voltage into the secondary windings. The transformer is a normal miniature mains type used in a step-up rather than step-down mode. Although the transformer is normally used for frequencies of 50Hz, voltage transfer still takes place with frequencies at least as high as 5KHz.

The output at the primary is related to the winding ratios and the load current drawn. With no load on the output, a stepped-up voltage of around 100V a.c. will exist. The actual voltage experienced will fall as the load is increased.

The initial load is via R6 and VR1, which permits adjustment of the final HT voltage. Following VR1 is a diode and capacitance network that performs a.c. voltage multiplication. At each stage the diodes perform half wave rectification, to which is added the a.c. level from the preceding capacitor. In a circuit like this many stages can be added enabling very high voltages to be developed. At the end of the network, D11 rectifies the final level which is stored as a d.c. voltage on the capacitor chain C15 to C17. With VR1 at maximum and with no load the possible level here can be in excess of 600V d.c. The chain shows 3 capacitors in series, since the working voltage of those used in the author's model is only 250V. A single capacitor of over 700V working voltage could have been used instead.

RELATIVE LEVELS

Inevitably the current transfer from the oscillator to the final d.c. storage decreases with the increase in voltage. The current available, though, is more than enough to drive the G-M tube, and no voltage drop could be seen on an oscilloscope during charged particle detection. The HT passes to the tube via R7, the value of which has been selected a bit above the minimum permitted. Within the conditions previously mentioned, its value is not critical. On the cathode side of the tube R8 is inserted so that a small proportion of the level discharged through the tube can be sensed. The level here will depend on the ratio of R7 to R8, the anode voltage, and the velocity of the charged particle detected. Increasing R8 or decreasing R7 will also increase the pulse amplitude. For practical purposes, pulse levels of about 0·5V can probably be expected with the values shown. The pulse speed, though, is extremely fast, and may not be seen except on a good oscilloscope. The duration could be increased by adding small capacitors across R7 and R8. Typically, 1pF could be used across R7. The capacitor across R8 should then be calculated so that the R-C ratios of the anode and cathode loads are equal.

Pulse expansion and amplification takes place at IC2a. C19, in conjunction with the current through R27, extends the effective pulse duration to around 2mS, and raises it to practically line level at the output of IC2b. The remaining stages could be omitted and the pulse fed direct to an amplifer or external counting system, via C23. In the unit as shown it is split in three directions.

TTL OUTPUT

Pulse counting and display can be carried out by external equipment such as an event counter, or a computer. For this purpose, the output at the TTL socket is limited to a maximum of about 5V as set by R28 and D12. Professional Geiger users will be aware that external equipment should not contain unprotected MOS devices in high level radiation zones, though of course everything should be protected under such hazardous conditions.

The unit contains its own loudspeaker, and this is driven by IC3 which can deliver up to 2 watts into 8 ohms. Normal headphones can be used for monitoring instead of the speaker, and insertion of a jack plug automatically switches it out. VR5 is a panel-mounted volume control, connected so that the indicator tone referred to below is always just audible. VR6 is for treble cutting, muting the harshness of the pulses and makes them less tiring to the ear. A very small amount of oscillator frequency has been allowed to break through to the audio output. This is a low level indication that the unit is functional. It may be muted by reducing the treble control level. A panel l.e.d. power-on indicator was decided against since they can draw around 10mA and so shorten the battery life.

METER MONITOR

Between them IC2c and IC2d ensure that output pulses from IC2b are raised to saturation level so that metering responds to pulse rates and is indifferent to varying pulse levels. Passing through C29, the pulses are rectified in conjunction with D16 and D13 to charge C20. The level to which it charges depends on pulse rates, set against the discharge rate via R19. C20 will charge to a higher level as the pulse rate increases. IC1c acts as a buffer between C20 and the meter. R22 and VR4 control the maximum current delivered to the meter, and should be set for the desired needle deflection for expected pulse counts. It is sensitive enough to register individual pulses. D14 and D15 are current shunts to protect the meter from overload under incorrectly set conditions. Meter zeroing is carried out via IC1d. Its output can be varied up and down by VR3 so that in the absence of a count, the reading is zero. S2 is included for battery level checking, using VR2 to set the deflection for a fully charged battery.

SETTING UP

Ensure that the power supply is functioning correctly before connecting the G-M tube. First, check that the junction of R1 and R2 shows a voltage of about 4·5V. The oscillator and the audio monitor can be checked simultaneously by temporarily connecting the signal input end of VR5 to the

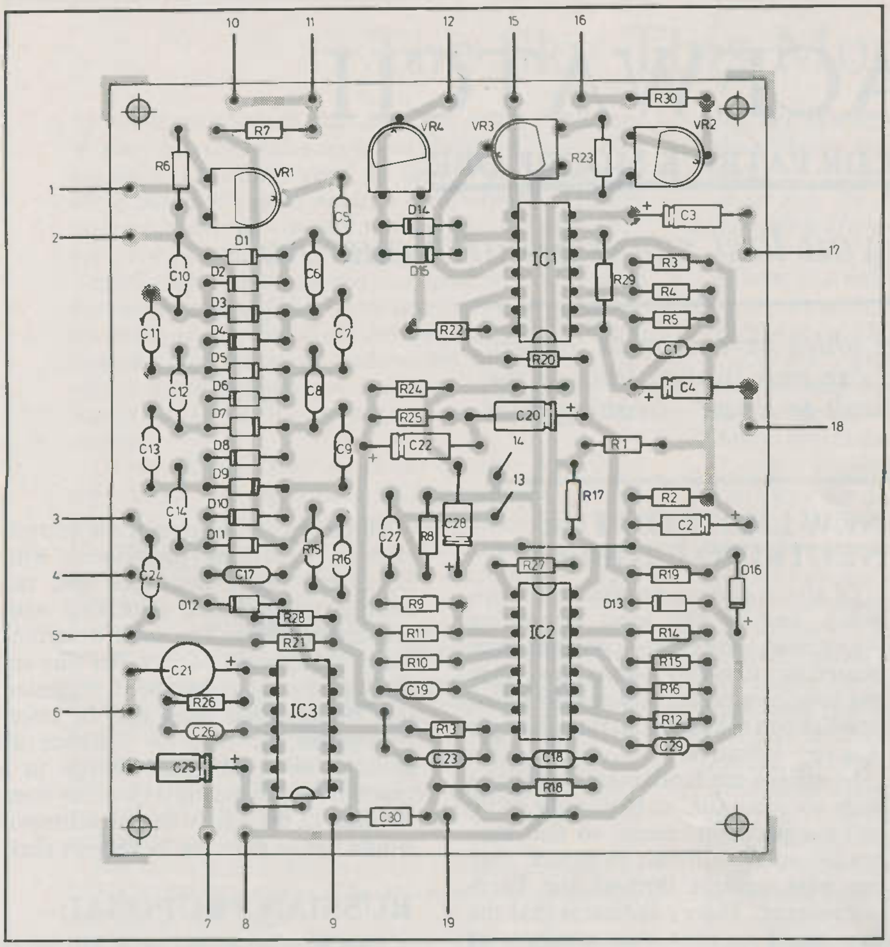


Fig. 5. *P.c.b. design and component layout*

outputs of C3 and C4 in turn. A high frequency note will be heard. A voltmeter is needed for the next step. This should be of as high an impedance as possible, and at least 20K per volt. Start off with VR1 turned fully anticlockwise. Check that about 75V a.c. is at the junction of VR1 and the transformer. It is permissible for the voltage to be a bit to either side of this level. Now monitor the wiper of VR1 and adjust it for approximately 65V a.c. Switch the meter to the d.c. range of at least 600V and probe the connection of D11 and C15. Avoid touching exposed wires in the voltage multiplier with any part of your body. It will not harm if you do, but it could surprise you a little, in the same way that a static shock can surprise. This is why S1b has been included so that the charge on C15 is allowed to drain away when the battery is switched off, allowing convenient working on the board. The author knows the value of this facility! Check the d.c. level at D11, and adjust VR1 until it is at the working voltage needed by the tube. Since the presence of the meter will add a load to the circuit, favour the low side of the optimum level. Once satisfied, switch off and carefully connect the G-M tube, ensuring that it is the correct way round, as shown in the drawing. Providing the voltage across the tube is about the correct level, particles will be detected without further setting up.

Probably the easiest way of confirming this is to use the luminous face of a wrist watch as the source. Note, though, that not all luminous watches use an active particle discharge material for their luminescence. With the right type of watch held within half an inch or less from the tube active face, periodic clicks will be heard, probably several per second. On the author's watch, the hands emitted the fastest count rate via the plastic face cover. The metal parts shielded the emissions from passing through the back. Alternatively, go hunting for likely sources, starting with a TV set (observing normal safety rules), which may give some emission if the EHT is greater than 10KV. In localities of reasonably high natural radioactivity, emissions of high speed particles may be heard while outside. At the author's locality in Kent, the counter responds to natural particles when inside and near to windows, but only at a very slow rate.

The setting of the meter depends on the amount of activity to be expected, and can really only be adjusted in the light of experience. In the test model, with VR4 at minimum resistance, the sensitivity resulted in a deflection of about one-fifth with a luminous watch held close to the tube, individual particle events showing as slight kicks in the needle. VR4 has sufficient latitude to set the sensitivity to within a wide range of counts. More precise setting can be achieved using a pulse generator connected to R8 with the tube removed. Meter deflection can then be ajdusted for a particular pulse rate frequency.

The unit only draws about 15mA without IC3, and about 34mA with it. Using a PP6 or PP9, battery life time should be long, but in the interests not only of battery conservation but also of tube life, power should be kept off except when needed. Even so, the voltage delivered will fall as the battery charge is depleted. It is probably advisable, therefore, to periodically check the settings of the relevant presets. Once the battery level falls below about 8V it is best to fit a new one. For indoor use, a stabilised power supply can, of course, be substituted.

HOUSING

The latter is a 2·5cm diameter plastic plumbing-pipe connector with a threaded mount and matching end cap, as in the photograph. The G-M tube is inserted in the pipe surrounded by plastic foam for stability. The tube tip should be as close to the end as possible. The cap goes over the end to protect it, though for greater sensitivity to some low level sources it could be removed, allowing closer proximity. Connecting leads are soldered on before insertion. The cathode lead is screened, but the screen is only connected at the p.c.b. end. The tube end of the screen should be covered with insulating tape.

If it is preferred to have the tube as a separate probe at the end of a lead, three points should be observed. The probe housing should be rigid enough to protect the tube, but offer low impedance to incoming particles. Connecting leads should have an insulation of at least 600V, and the anode lead should be unscreened to avoid undue self capacitance. Both R7 and R8 should be installed in the probe head, and not on the p.c.b.

INHERENT HOPES

Hopefully, this simple project will inspire greater interest in, and knowledge of, nuclear activity. It is an inescapable product of both the natural and technological world in which we exist. For the benefit of generations to come, its use must be handled responsibly. Until we inhabit other solar systems, this planet is the only home we have. PE

SPACEWATCH

BY DR PATRICK MOORE OBE

When did you last see a Solar Neutrino?

Neutrinos are fundamental particles which have no mass (or very little) and no electrical charge. They can pass straight through the earth unhindered and are very difficult to detect—cleaning fluid provides the solution!

THE uncertainty over the future of the Royal Greenwich Observatory continues; most astronomers will hope that any move from Herstmonceux can be prevented—it would be a scientific tragedy, since once an establishment of this sort is destroyed it can never be restored. Meanwhile, Dr. Russell Cannon of Edinburgh has been appointed Director of the Siding Spring Observatory in New South Wales, taking over from the acting director, Dr. David Allen.

Radio astronomers at Arecibo, in Puerto Rico—home of the 1000-foot radio telescope built in a natural 'bowl' in the ground—have made an interesting discovery, that of another millisecond pulsar. Pulsars are neutron stars, spinning round very quickly and sending out pulsed radio waves; the best-known example is in the Crab Nebula (the remnant of the supernova of 1054). Most conventional pulsars have periods of a few seconds or less, but in 1982 came the discovery of a pulsar apparently 'pulsing' at 642 times a second—so that clearly it came into a different category. In 1983 came the second object of the type, pulsing at 163 times every second. Now D. Segelstein and his team at Arecibo have identified PSR 1855 + 09 in Aquila, which has a pulse-rate of 186 per second. It now looks as though these very fast pulsars are members of binary systems. The neutron star pulls material from its larger, normal companion, and as this material rains down on the neutron star it contributes to its angular momentum, increasing the spin-rate. No doubt many more millisecond pulsars await discovery.

Also at Arecibo, astronomers have been studying an unusual galaxy, UGC 12591, which is a massive spiral of the 14th magnitude. It seems to be rotating very rapidly, at a speed of some 500 kilometres per second. If the measurements are accurate (and there seems no reason to think otherwise), UGC 12591 must be about ten times as massive as our own Galaxy.

NEW LIGHT ON THE NEUTRINO PROBLEM?

Of all the current problems in astronomy, one of the most interesting—and most important—concerns solar neutrinos. Recently some new work has been carried out which may throw new light on the problem, though as yet it is very tentative.

Neutrinos are fundamental particles with no mass (or, at best, very little) and no electrical charge, so that they are extremely difficult to detect; they can pass straight through the Earth unhindered. Theory indicates that the Sun ought to emit vast numbers of them, and for some twenty years experimenters in the United States have been trying to measure them. Deep in the Homestake Gold Mine in South Dakota, Dr. Ray Davis and his team have placed 'detectors'—a mile below ground, to shield the equipment from cosmic rays. The main detector consists of a tank of 100,000 gallons of tertachloroethylene, or cleaning fluid. This contains chlorine, of which some 25% is the isotope with an atomic weight of 37; the nuclear contains 17 protons and 20 neutrons. If a neutrino scores a direct hit, it can convert one of the neutrons into a proton, and the result is an argon nucleus of 18 protons and 19 neutrons. This is unstable, and after about 34 days the protons interact with one of the orbiting electrons to combine and make a neutron once more, emitting energy in the process. Therefore, the numbers of argon produced give a clue to the numbers of neutrino hits, and Davis has perfected the technique to the extent of being able to detect single atoms.

Yet the numbers of neutrons detected are surprisingly small—about one-third the expected rate. There is nothing wrong with the equipment, so that something is wrong with the theory. If the Sun's core is cooler than usually believed, the neutrino flux fits in; but this would cause other complications, and astronomers have been casting round for an alternative explanation.

Three types of neutrinos are known: electron neutrinos (associated with electrons), muon neutrinos and tau neutrinos, which are associated with heavier particles. The solar neutrinos are of the electron variety, but why are they so sparse? It has been suggested that the neutrino types may be interchangeable, so that for instance an electron neutrino could change to a muon neutrino during its journey from the Sun to the Earth. Muon neutrinos would not be detected by Davis's tank.

RUSSIAN PROPOSAL

Two Russian scientists, S. Mikheyev and A. Smirnov, have now proposed that electron neutrinos are converted to muon neutrinos while still inside the Sun—because the solar interior contains electrons but no muons (at least so far as we can judge). But nearer the Sun's surface the density of the material decreases quickly, so that the change-over would become possible. It may also be that only electron neutrinos below a certain critical energy can escape from the Sun unconverted—and these lower-energy electron neutrinos would also escape Davis's net.

At the moment proof is lacking, but these new ideas do at least hold out some hope of resolving what has become an embarrassing anomaly. It is of special importance, because as yet we have little definite knowledge of what neutrinos are really like. If they have even a tiny amount of mass (and it must be very tiny indeed), their vast numbers might mean that there is more 'mass' in the universe than appears at first sight—and this could even make the difference between an ever-expanding universe and a universe which will eventually contract once more before a new 'big bang'.

We may find out in the foreseeable future. New types of detector are being planned, mainly using gallium instead of cleaning fluid; the increased sensitivity may clear the matter up. Theorists devoutly hope that this will be the case! PE

The Sky This Month

THIS is positively the last month in which I will have any observational notes about Halley's Comet! This has been the 'Halley year', in view of the revelations about the nature of its nucleus; certainly it has taught us more about comets than seemed possible, but it has not been spectacular at any time. It is now in the constellation of Sextans, but has faded so much that it has become very difficult to see except with an adequate telescope; it has moved out beyond the orbit of Mars, though it is still closer-in than Jupiter. By the end of the month it will have become inconveniently close to the Sun in the sky—so if you want to see it, now is your last chance.

Of the planets, Mercury is out of view, but Venus remains an evening object above the western horizon after sunset; it passes just north of Regulus on the 10th. Its phase is still well over 60 per cent; dichotomy (half-phase) will not be reached until mid-August. Mars comes to opposition on the 10th, and this is a fairly favourable apparition insofar as distance is concerned; the apparent diameter reaches 23 seconds of arc, and the magnitude is −2·4, slightly superior to Jupiter. Unfortunately the declination is −28 degrees, so that to British observers the planet is very low in the sky. Jupiter rises before midnight; Saturn, magnitude 0·5, remains visible in the south-west after sunset. The rings are wide open, so that from this point of view Saturn is at its glorious best.

The Earth is at aphelion on the 5th, at a distance of 152,000,000 kilometres. The Moon is new on the 7th and full on the 21st.

Several meteor showers are due. The Capricornids last throughout much of July and August, with three maxima, but the ZHR is only about 6. (The ZHR, or Zenithal Hourly Rate, is the number of meteors that a naked-eye observer would expect to see per hour under ideal conditions, with the radiant at the zenith; in practice, of course, these conditions never apply, so that the real rate is always less than the ZHR.) The Delta Aquarids last from July 15 to mid-August, with a peak about July 29; ZHR may be as high as 20. The Piscis Australids (July 15 to mid-August maximum July 11) have a ZHR of only about 5. However, the Perseid shower, the most spectacular of the year, begins well before the end of July, though it does not reach its peak until August 12/13.

The starry aspect is dominated by what I have called the Summer Triangle (a nickname which has come into general use!), made up of Vega in Lyra, Altair in Aquila and Deneb in Cygnus. Vega, the lovely blue star, is almost overhead during evenings in July. Low in the south look for Antares in the Scorpion; it is identifiable because of its strong red colour, which has led to its name (Ant-Ares the Rival of Mars, Ares being the Greek god of war and the virtual equivalent of the Roman Mars). Scorpius is a magnificent constellation, but is inconveniently low as seen from Britain, and even in South England the 'sting' barely rises; it is interesting to look for, but you will need clear skies and a dark horizon, and you will have to be south of London. The sting is marked by two stars close together, Shaula and Lesath; Shaula is only just below the first magnitude (its official designation is Lambda Scorpii). Following Scorpius is Sagittarius, the Archer, with the superb star-clouds which indicate the direction of the centre of the Galaxy. Sweeping this area with binoculars is very rewarding. The Great Bear is to the west, the W of Cassiopeia to the east; Arcturus is dropping in the west, and Capella, in the north, is so low that it will probably not be seen at all. During winter, of course, Capella is at the zenith during evenings. If you see a bright star overhead from British latitudes, it can only be either Capella or Vega, but the two are not alike; Capella is decidedly yellow.

IN NEXT MONTH'S ISSUE:

EXPERIMENTAL ELECTRONICS—A new series of articles dealing with tried and tested electronics experiments and projects

OPTICAL DATA LINK (should have been in this issue but there was no room—sorry!) Optical RS232 communications project for micros

PLUS—all our regular features, projects and news

BETTER USE OF BATTERIES

PART 3 BY ROD COOPER

The secrets and failure mechanisms of dry NiCd batteries

This article, the third in the series, looks at the technical details of sealed NiCd batteries and methods which may be used to increase efficiency without compromising safety

IN CONTRAST to the traditional vented Nickel-Cadmium cell which can have a life of up to 20 years, the sealed Nickel-Cadmium type often has a very short and unsatisfactory life expectancy, despite using the same basic materials in its construction. Often the failure of a sealed cell is a complete mystery to the user, who may not realise he has done anything wrong. This article throws some light on the four basic failure mechanisms.

The chemical reaction inside a NiCd cell is shown below:

The chemical reaction inside a NiCd cell is :-

$$2NiOOH + Cd + H_2O \rightarrow 2Ni(OH)_2 + Cd(OH)_2$$

(NiOOH: Positive electrode; Cd: Negative electrode; H_2O: from electrolyte)

Don't be put off by the chemistry—the only point of showing this equation is to demonstrate that water is used in making the reaction work. It is often thought that the water is merely a convenient solvent for dissolving the various chemicals used in the electrolyte, but in fact it's vital to the reaction. No water, no reaction!

Unfortunately there is very little water inside a sealed cell because there has to be a clear space in between the two electrodes so that oxygen gas can freely diffuse from one electrode to the other. This is a fundamental difference between the sealed cell and the traditional vented type. The reason is as follows.

In any rechargeable cell, the simplest way of ensuring a full charge is to overcharge slightly. In a traditional cell, this results in the water of the electrolyte being split into hydrogen and oxygen by simple electrolysis, and this results in the well-known gassing effect. There is so much water around in a traditional cell's electrolyte that the small amount gassed off is not important, there is still plenty left for the water of reaction. In any case, this water loss can easily be replaced by topping-up. However, in a sealed cell there can be no topping up, so a different method of allowing overcharge without gassing must be used, and this is where the clear space between the electrodes comes in.

It is sometimes said that during overcharge in a sealed cell, the oxygen generated combines with the hydrogen to re-form water, but this is *quite untrue*. In sealed cells the evolution of hydrogen is suppressed. Oxygen is still evolved at the Nickel positive electrode, but then diffuses across the Cadmium negative electrode, where it combines with the Cadmium. An excess of Cadmium is provided by the manufacturer over and above that needed to make the cell work, at the negative plate. But the Cadmium is not used up—this would obviously limit the amount of overcharge that was possible. Instead, the oxygen and cadmium recirculate. For those who want to know the chemistry, here are the reactions, in three steps.

Step 1

$$2Cd + O_2 + H_2O \rightarrow 2Cd(OH)_2 + HEAT$$

(Cd: at neg. electrode; O_2: from pos. electrode; H_2O: electrolyte)

Step 2

$$2Cd(OH)_2 + 4\ electrons \rightarrow 2Cd + 4(OH)^-$$

(electrons: from charge current)

Step 3

$$4(OH^-) \rightarrow 2H_2O + O_2 + 4\ electrons$$

(O_2: migrates to cadmium electrode)

The nett result of steps 1 and 2 is that the cadmium that is oxidised to the hydroxide state is converted back to cadmium metal by the charge current, with the evolution of heat and excess hydroxyl (OH^-) radicals. The OH^- radi-

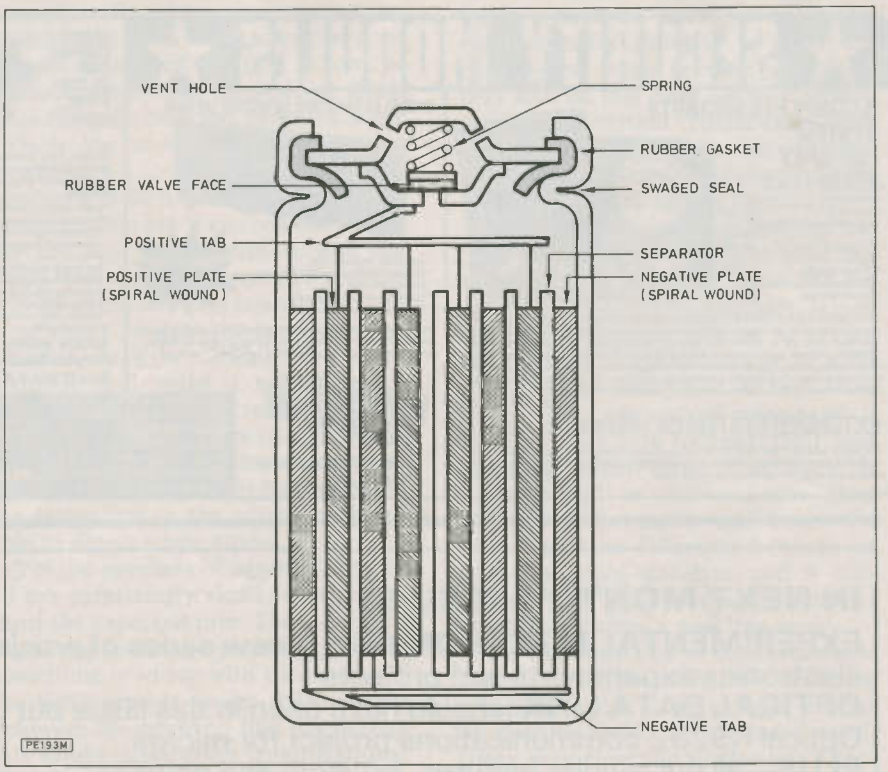


Fig. 12. *Typical Ni-Cad construction*

cals are converted back to water and oxygen at the nickel positive electrode just as in a straightforward electrolysis;

You will notice the whole thing balances out; the only result of overcharge current flowing is heat. Notice that hydrogen never enters into the reaction; the evolution of hydrogen has been "designed out".

It should now be clear why there has to be no obstruction to the free passage of the oxygen from the positive electrode (where it is released) to the negative electrode (where it is recombined). If the cells were filled with water, there would be no clear space. If you split a sealed NiCd cell open you will see that it is barely damp, for this very reason.

There is a big disadvantage to this otherwise excellent system of permitting overcharge in sealed cells; because there is so little water, removing even a very small quantity of it will result in a drastic reduction in cell capacity, because as we have already seen the water is absolutely necessary to take part in the cells's basic reaction shown in the formula. There are two main ways in which water can be accidentally removed from the cell, and usually this water loss takes place without the user realising it has happened.

REVERSE CHARGING

Of course, no-one charges an exhausted NiCd cell in the wrong direction on purpose! However, it is often done unknowingly.

In any battery of NiCd cells, there is bound to be a cell (or perhaps more than one) which has a slightly lower capacity than the other cells. Cells are rarely exactly equal in capacity even when new, and there are many ways in which these small differences can arise in service. Now, if the battery is used to the point where it shows signs of becoming "flat", the cell with slightly less capacity will be exhausted first. It will then be driven *in reverse* by its neighbouring cells which still have capacity left, and this results in the water of the electrolyte being split into hydrogen and oxygen. On most NiCd cells there is a resealable safety valve so that any water decomposed like this cannot build up too much pressure, so hydrogen and oxygen are vented off to atmosphere. A permanent reduction in cell capacity results. When the battery is next recharged and discharged, it will be this cell which is the prime candidate for more reverse-charging because of the further reduction in its capacity. This is clearly a classic case of a vicious circle, and eventually results in a battery of, for example, six good cells and one completely dead one. It is an unfortunate fact that NiCd batteries are not only used up to the point of going flat, but beyond, and sometimes when equipment is accidentally left on, to complete exhaustion. This is a sure way to cause permanent damage, and is very common.

HOW TO AVOID REVERSE CHARGING

There are three methods. The most common in the past was to use a voltage cut-out, which disconnected the battery when the voltage fell to a certain point. These were not very effective, because if the cut-out was set to operate at 1V per cell (i.e. near the exhaustion point) the battery could still be reverse-charging a cell without the cut-out sensing it. Clearly, if a 7-cell battery of nominal 8·75V was set to cut out at 7V, the voltage sensing unit would be unable to distinguish between this and a battery of six healthy cells at 1·25V each and a dead cell being reverse-charged at −0·4V. Also, these cut-outs had a nasty habit of cutting off the battery at the most inconvenient times. It's no consolation to know that your NiCad battery is being protected against reverse-charging if your radio goes dead in an emergency, or if your handlamp goes out when you're in the cellar!

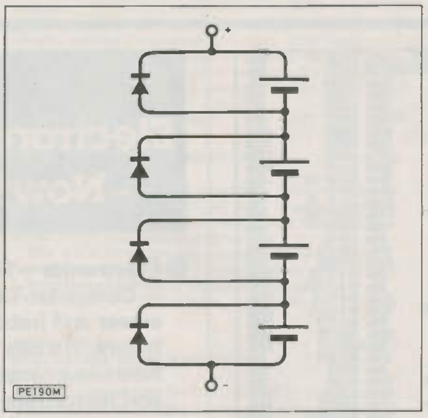


Fig. 13. *Protecting a battery of NiCd cells with reverse-biased Schottky diodes to stop reverse-charging of any one particular cell by its neighbours. The rating for the diode depends on the maximum likely discharge current. Up to 1 amp, use inexpensive wire-ended Schottky devices.*

This type of protection is not needed if you use a single cell and dc/dc converter to step the voltage up.

Another method is to use protection diodes as shown in Fig. 13. If a reverse current tries to flow through any one particular cell, the diode provides an alternative path for the current. This works well at high currents if you use Schottky diodes with a low V_f. Ordinary silicon diodes are no good. This technique works well if the cell has an anti-polar mass, which is a small amount of cadmium put by the manufacturer onto the nickel electrode so that the oxygen-recombination process already described can take place in both directions. This works reasonably well at low currents, but the penalty paid for this protection is a reduction in the effectiveness of the nickel electrode, i.e. less capacity. So a combination of an antipolar mass cell (good at low reverse currents) and reverse-charge Schottky diodes (good at higher currents) should give good all-round protection, and has the advantage of a slow fade-out rather than an abrupt one.

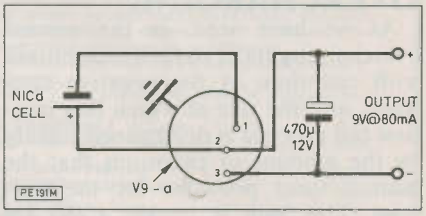


Fig. 14. *Simple step-up circuit*

There is some difficulty in actually attaching diodes to NiCd cells (try it and you will see why) and it is also expensive if you have many cells in a battery as Schottky diodes are not cheap.

Probably the best method of avoiding reverse-charging is not to use batteries at all if you can help it. An easy way of achieving this is to use a single NiCd cell and step the voltage up to—for example—9V using a dc/dc converter. The circuit for the Verkon V9-a (which gives 9V at 80mA) in Fig. 14 shows just how easy it is:

The Verkon V9-a is specifically designed for use with a single NiCd cell, and the output is inherently clean —none of the "nasties" found in the output of some types of converter.

If you use only one cell, there is only one set of rubber seals to go wrong (see Fig. 4) whereas in a battery there always seems to be at least one cell that leaks. You will also find it cheaper. For example, a NiCd PP9 costs £13 for 10·4 watt-hours but a super-F cell gives 12·5 watt-hours for only £9. After conversion losses, the super-F gives about the same amount of useful energy but costs 25% less. Of course the cost of the converter (£6.32) must be taken into account, but as the converter will outlast several NiCd cells the real cost will be spread over a long period.

A single cell is more mechanically robust than a string of interconnected cells, the weak link (particularly with button cells) being the electrical connections, and this can be important in portable gear, which often takes unfair punishment, like being dropped!

There are several other converters in the Verkon range giving from 6V up to 18V and current ratings from 50 to 200 mA.

Alternatively, you could design your circuit to work from just 1·25V, but this is fraught with difficulty, not least being the scarcity of devices which operate at this voltage, and the impossibility of getting such components as l.e.d.s, f.e.ts and relays to work.

EXCESSIVE OVERCHARGING

As we have seen, in the normal overcharging state, oxygen recombines with cadmium at the negative electrode, and the rate at which this reaction can proceed is determined mainly by the amount of cadmium that the manufacturer provides for the purpose. This rate is usually C/10 for standard sintered sealed cells and C/100 for button cells, where C is the capacity of the cell in amp-hours. Fast-charge cells have more cadmium to give protection even at C/3 rates of charge.

However, this rate is for temperature of around 20°C, and as the temperature falls the reaction goes more slowly, until at about 0°C there is a danger of more oxygen being released than can be recombined. Pressure builds up, and the safety vent will eventually open to release the pressure to atmosphere. This represents a permanent loss of water, and thus a reduction in capacity.

Many people (myself included) recharge their NiCd cells in an outbuilding, such as a garage, during the night. This is a good idea for safety reasons, but not such a good proposition during the winter months because the temperature can easily drop below freezing inside an outbuilding. It is quite easy to damage cells by continuing to charge below freezing at a supposedly safe charge rate, without even realising that damage is taking place. A simple answer is to fit a low-temperature cut-out to your charger, to stop the charger giving any further charge at, say, 4°C. A more expensive answer is to heat the outbuilding, or you could bring the charger indoors. However, there is a fire risk with electric appliances of this type being left unattended overnight, and so bringing the charger inside is not recommended if you recharge overnight.

Some users of NiCd batteries recharge standard cells at more than C/10, so that the battery can be returned to service quickly. Model engineering enthusiasts do this in order to cut down on the expense of extra batteries which they would otherwise have to carry. Rates of up to C are used. This is asking for trouble because sooner or later you are certain to cause damage by venting. There are designs of fast-charger which make use of the slight rise in temperature at the end of charging and the onset of overcharging to operate a cut-out and so prevent venting and these are notorious for damaging standard cells. This is because the rise in temperature lags behind the onset of overcharging, so some electrolyte decomposition precedes the rise in temperature. If you want to recharge quickly, then it is best to use only special fast-charge cells, like those made by Sanyo.

So much for damage caused by water loss. Part Four deals with a further two ways in which NiCds can meet with a premature end.

Next Month: The Death Of A NiCad

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THE LEADING EDGE

BY BARRY FOX

Surface mounted technology and patent p.c.b.s

The secrets of patents-pending are available to all—just go to the Patent Office, pay 50p and tell them what you want.

SURFACE mount technology has been much in the news recently. SMT is what makes camcorders, Walkman and pocket tv sets possible. It has brought the price of compact disc players down to below £200. It's a way of cramming more components on a smaller circuit board. All the major electronics firms around the world are now using SMT. A private inventor recently claimed that he held the master patent on the idea. So will he be rich beyond dreams? The short answer is, almost certainly, NO.

Firstly, what is SMT? A lot of people talk about it but don't actually understand the technology.

SMDS AND SMT

SMD stands for a surface mounted device. SMT is the technology of surface mounting. Until recently components like resistors and capacitors were mounted on a printed circuit board, by pushing their wires through holes in the board and soldering on the other side. An SMD is a component with metal pads at each end which is soldered direct onto the top of the board. In this way one board can hold components on both sides. The difficult part is to solder the pads without destroying the components. There are several ways of doing this.

A pattern of solder paste is screen printed on a ceramic or fibre insulating board. The tiny SMD components (often small enough to pass through the eye of a needle) are then put in position and the whole board heated. This can be done either by bathing in infra-red radiation or lowering into a vapour phase chamber. VP is the current favourite. Mullard in the UK, a subsidiary of Philips, is one of the leaders in this field. A bath of inert material, 3M's Fluourinert, is heated to create a heavy blanket of hot inactive gas. The SMD board is lowered into this gas blanket. It is very quickly heated by latent heat of condensation. Because Fluourinert costs £500 a gallon, another layer of cooler inert gas is is used over the top to prevent losses. Mullard notes that there is a lot of nonsense talked about creating a thermal gradient through which the SMD board is lowered. In fact the condensation heating is sudden, like putting your hand in the steam from a kettle. Without the right know-how this causes what is known in the trade as "tombstoning" or the "Manhattan effect". Instead of laying flat, the components pop up like skyscrapers.

The alternative approach, used when SMDs are mixed with ordinary components, is to pass the board through a wave soldering machine. The trick is to prevent the solder swamping the components. It's usually done with two waves, one violent and one smooth.

With the right know-how, an SMD machine can insert 150,000 components an hour. The speed will soon be half a million an hour. This is what makes those £199 compact disc players possible. If any one person held a master patent on the SMD idea, it would be quite literally priceless. If some newspaper reports are to be believed a private inventor called Stanley Bracey owns that patent. Certainly Bracey was granted a patent on SMT. But what is it worth? The SMD industry had not been beating a path to his door!

First some background which may well be useful to anyone in the electronics industry facing a claim from someone wielding a patent . . .

Even though the "new" British patent laws are now nearly ten years old, surprisingly few people have woken up to the most important change which the 1977 Patents Act introduced. This is that patent applications are published in Britain while they are still pending.

This used to happen only in a few foreign countries. That was how details of Sir Clive Sinclair's top-secret flat screen tv tube leaked out literally years ahead of any formal announcement. They had been published in a French language patent application. Now nothing stays secret in Europe for more than eighteen months. Although American patent applications are secret while pending, if the same case is filed in Europe, the inventor's secret becomes public.

It isn't just pending patent applications which are published. The whole file of correspondence between the inventor and Patent Office is there for the public to read. All you have to do is go to the Patent Office building at State House in High Holborn, pay 50p and give the search room the number of the patent. They will bring you a full file wrapper. (It may take 24 hours so phone first on 831 2525). The file wrapper hides nothing. Patent Office examiners are even obliged to make written notes of any telephone calls made by the inventor!

COVER ALL

Stanley Bracey's new British patent 2 109 629B apppears at first sight to cover the basic idea of surface mount technology. Bracey's credentials are not in dispute. Nor are his developments. But the wording in his patent, and the content of the file on public view at the Patent Office, put a large question mark over the real value of his legal claim.

The file on 2 109 629B shows that Bracey made a potentially disastrous tactical error when he filed his SMT application in March 1981. He did not employ a patent agent—the equivalent of a solicitor in other legal matters. As a result the technical description filed with the application was inadequate. The case was passed through a series of Patent Office examiners and they all bent over backwards to help Bracey put his case in order for grant. In mid-1982 Bracey tried to add the kind of technical description which he should have filed in the first place. But the Patent Office examiners were obliged by law to reject this as "new subject matter". It is a canon of British patent law that no new technical material can be added to a patent application once it has been filed.

After a lengthy correspondence, in which Bracey criticised a consultant who had helped him with the application, and pleaded unemployment and shortage of cash, the Patent Office examiners helped the inventor concoct a wording which was formally acceptable. So a patent was granted. On the face of things this patent claims a monopoly so broad that it covers all SMT work. But by the same token it may equally well cover old ideas, such as the pre-p.c.b. technique of soldering components on the top of a tag board. It is another canon of British law that a patent claim which covers an old idea is worthless. The normal legal tactic then is for the inventor to fall back on other claims to more specific and genuinely new technology. But that's what Bracey cannot do. Because the patent application is so thin on technical detail, there isn't any room for legal manoeuvre, thus engineers at the sharp end of SMT manufacture aren't taking Bracey's patent too seriously.

UNIVERSITY USAGE

At a recent Digital Information Exchange seminar, part-sponsored by Sony to spread the digital word, Dave Parker of the Department of Acoustics at Salford University and Dr. Trevor Lamb of the Department of Physiology told how they were using cheap Sony PCM processors to record laboratory results which would normally be captured by an industrial data recorder. Parker has modified a Sony PCM processor and domestic video recorder, with additional coupling capacitors, so that it can record signals down to a frequency of below 0·06Hz. Parker uses the system, costing under £2,000, to log explosions, which require accurate response over the range of 0·1Hz to 15kHz. The wide dynamic range of this digital system, makes it able to handle both very quiet and very loud sounds, so it is ideal for monitoring blast noise propagation.

Trevor Lamb uses a similar system to record the very small electrical output from rods and cones taken from a salamander's eye. The tissue is held in saline, exposed to light and the response signals converted into digital code for recording onto domestic video tape. At York University, David Mallam is using a domestic digital processor to record the output of a digital music synthesizer which the university's electronic music studio has built. This has a 24 bit design, which enables it to mix up to 48 separate 16 bit signals without degrading the output signal to below 16 bit standard. Mallam's processor is capable of handling 10 million instructions per second.

Perhaps most interesting, York is now using video technology cassettes to record large quantities of computer data at very low cost. A domestic video cassette is used as a bulk store for the output of a DEC PD-11. A single £5 tape can store 40 gigabits of data, which is equivalent to 5 gigabytes or 5000 million text characters. PE

PE HOBBY BUS

PART FOUR BY R. A. PENFOLD

Computer connection details and programs for BBC, Oric, VIC and Commodore machines

This concludes the constructional and basic connection details of the PE Hobby Bus (PEHB) and over the next few months its versatility will become apparent. Already it can be connected to more home micros than any other hobby bus offering the same facilities and in many cases much fewer. Several authors and electronics designers have built prototypes of the PEHB and are now working on a range of exciting, useful and interesting peripherals. Also many add-ons designed for specific machines may be connected to the Hobby Bus with the minimum alteration. A typical example of this is the Micro Chip Tester featured in this issue. Simply put a DIN connector (64-way a+c) on the project connector cable, modify the software, connect it to the bus and away you go!

HAVING dealt with connecting the Hobby Bus to a number of popular Z80 based computers in the previous article, we now move on to consider its operation with several machines which are built around the 6502 or one of its derivatives. The Hobby Bus has good compatibility with 6502 based computers in most respects, and the only significant difficulty is in providing the separate read ($\overline{RD}$) and write ($\overline{WR}$) lines for the 8255 PIA. The Z80 microprocessor provides the necessary control signals, but the 6502 has only a single read/write (R/$\overline{W}$) line. The R/$\overline{W}$ line, like the $\overline{WR}$ line, goes low during write operations, and the two are roughly comparable. The Hobby Bus is designed to synthesise the read line by inverting the R/$\overline{W}$ line, and this gives a signal which is obviously roughly comparable to the required one. Unfortunately, the timing of the pulses from the write line is crucial to the correct operation of the 8255, and while the synthesised $\overline{RD}$ signal seems to be perfectly satisfactory, the $\overline{WR}$ signal is not adequate in all cases. There is a simple solution to the problem, though, and we will consider this in more detail shortly.

BBC MODEL B

The buses of the BBC model B computer are available at the "1MHZ Bus". The BBC machine actually has the 2MHZ version of the 6502, but some of the internal peripheral devices are standard 1MHZ devices, and the clock is effectively slowed down to a rate that is satisfactory for these when they are accessed. The same is also true for the 1MHZ Bus and devices which connect to it. The eight least significant lines of the address bus are available, but the eight most significant address lines are absent. Instead, two so called page select lines are included ($\overline{NPGFC}$ and $\overline{NPGFD}$), and these are decoded from the upper address lines so that they pulse low when any address in page &FC and page &FD (respectively) is accessed. This gives some 512 input/output addresses, but many of these are reserved for use with Acorn add-ons, and these must be avoided if compatibility with Acorn peripherals is to be preserved. The area from &FCCO to &FCFE is free for user and add-ons, and obviously provides a more than adequate address range for the Hobby Bus project (which occupies thirty-two addresses).

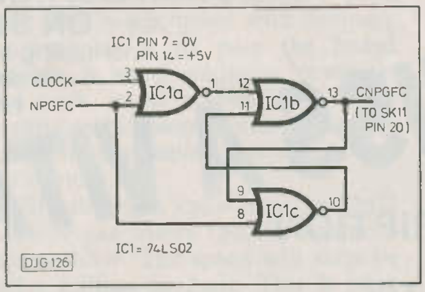


Fig. 1. *NPGFC de-glitch.*

Table 1 shows the recommended method of connection for the BBC machine (and the other computers), while details of the required DIP switch settings and link wires are shown in Tables 2 and 3 respectively. In Table 3 "0V" indicates that the link of the 0V rail is required, and "X" means that no link at all should be included. As can be seen from the slot address table (Table 4), the Hobby Bus is placed at addresses from &FCCO to &FCDF.

There is a slight problem with the BBC computer's 1MHZ Bus in that there are glitches on the page select lines. The basic circuit for removing these is the simple gate and flip/flop arrangement shown in Fig. 1. This circuit does not remove all the glitches, and it leaves one fairly large pulse which follows on shortly after the main pulse. This can sometimes cause devices connected to the 1MHZ Bus to malfunction, but in this case it actually seems to be beneficial rather than a problem. The additional circuit is easily wired up on the spare pads left on the board specifically for use with any

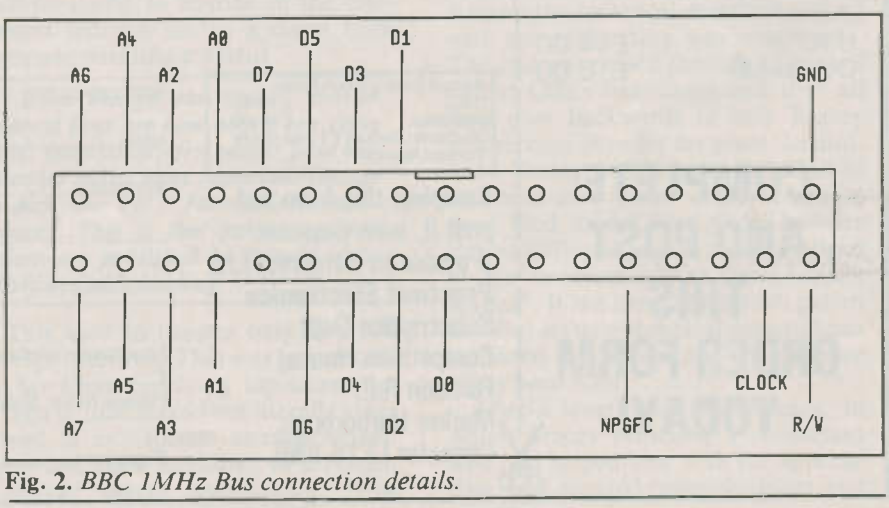


Fig. 2. *BBC 1MHz Bus connection details.*

signal processing circuits that might be required. The $\overline{NPGFC}$ line is brought in on the normally unused pin 13 of SK11, and the signal for the processor circuit is tapped off from here. One other modification is required in order to give good reliability, and this is to drive pins 9 and 10 of IC6 direct from the R/$\overline{W}$ line of the 1MHZ Bus rather than via IC3. The signal to these pins is carried via a through-pin situated right alongside them on the board, and it is a matter of omitting this (or removing it if it has already been fitted), and then wiring these pins to pin 2 of SK11.

Connection details for the 1MHZ Bus are shown in Fig. 2, and a 34-way IDC header socket is required. It is not practical to have a 34-way IDC socket at one end of the lead and a 40-way d.i.l. IDC type at the other, as apart from the different numbers of ways the two connectors do not match up pin for pin, or anything approximating to it. Probably the easiest way of making up a suitable lead is to obtain a 34-way IDC socket fitted with about 0·5 metres or so of ribbon cable (preferably the "rainbow" type), and to wire this to a "solder" type 40 pin d.i.l. socket.

The test program for the BBC computer is shown below, and this should flash D2 on and off if the unit is functioning properly. It also reads S2, printing "0" or "4" on the screen depending on S2's setting, and provides pulses on the seven slot select outputs of IC8.

BBC Test Program

```
5 REM BBC TEST PROG
10 ?&FCC3 = 147
20 ?&FCC2 = 0
30 ?&FCC4 = 0
40 ?&FCC8 = 0
50 ?&FCCC = 0
60 ?&FCD0 = 0
70 ?&FCD4 = 0
80 ?&FCD8 = 0
90 ?&FCDC = 0
100 PRINT ?&FFC2 AND 4
110 ?&FCC2 = 64
120 FOR D = 1 TO 100:NEXT
130 GOTO 10
```

Table 1. *The suggested methods of connection.*

SK11 Pin No.	BBC Model B	Oric Atmos	VIC-20	CBM 64	Master 128
1	A4	A4	A4	A4	A4
2	R/W	R/W	R/W	R/W	R/W
3	A0	A0	A0	A0	A0
4	A3	A3	A3	A3	A3
5	A1	A1	A1	A1	A1
6	A2	A2	A2	A2	A0
7					
8					
9					
10					
11					
12					
13	NPGFC	IO CONT.			
14					
15					
16					
17	A5	A5			A5
18	A6	A6			A6
19	A7	A7			A7
20	See Text	$\overline{IO}$	IO3	IO2	NPGFC
21					
22					
23					
24					
25	GND	GND	GDN	GND	GND
26					
27	D0	D0	D0	D0	D0
28	D1	D1	D1	D1	D1
29	D2	D2	D2	D2	D2
30	D3	D3	D3	D3	D3
31	D4	D4	D4	D4	D4
32	D5	D5	D5	D5	D5
33	D6	D6	D6	D6	D6
34	D7	D7	D7	D7	D7
35					
36					
37	Clock				
38					
39					
40					

Table 2. *The required settings for S3 to S10.*

Switch	BBC B Master 128	Oric Atmos	VIC-20	CBM 64
S3	CLOSED	CLOSED	CLOSED	CLOSED
S4	OPEN	OPEN	CLOSED	CLOSED
S5	CLOSED	CLOSED	CLOSED	CLOSED
S6	OPEN	OPEN	CLOSED	CLOSED
S7	CLOSED	OPEN	CLOSED	CLOSED
S8	CLOSED	CLOSED	CLOSED	CLOSED
S9	CLOSED	CLOSED	CLOSED	CLOSED
S10	CLOSED	CLOSED	CLOSED	CLOSED

MASTER 128

Interfacing the Hobby Bus to the new Master 128 computer is basically the same as for the original model B machine, but the required modifications to the board are somewhat different. This difference is brought about by the inclusion of clean-up circuits within the computer which render the external circuit unnecessary. However, this brings a second problem in that the totally clean page select lines result in incorrect timing for the 8255 PIA, and this is something that occurs when using the Hobby Bus with practically any computer based on the 6502 (or any 6502 bus compatible type).

The heart of the problem seems to be quite simple, and it is that the 6502 peripherals use a clock transition to latch data into devices, and it is for this reason that 65** and 68** peripherals all seem to have a clock input, even when the clock signal seems superflous to the operation of the device. With the 8255 it is the $\overline{WR}$ line returning to the high state that latches data into the device. When used with a 6502 based computer the write pulse is too long in duration, resulting in no data being written to the device. The solution to the problem is to either lengthen the enable pulse slightly (which is effectively what happens with the BBC model B), or to shorten the write pulse.

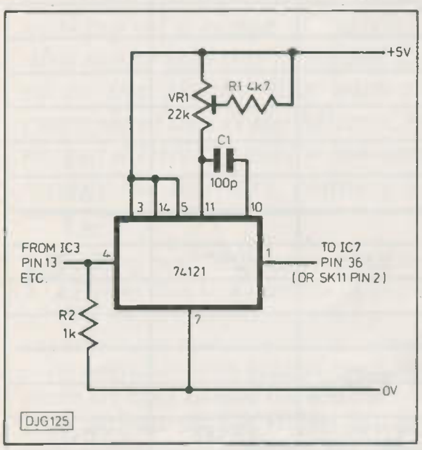


Fig. 3. *6502 write generation.*

The recommended way of doing things is to use the circuit of Fig. 3 to act as a pulse shortener to generate a suitable write pulse. The circuit is just a basic 74121 monostable type which triggers on the leading (negative going) edge of the input signal from the $\overline{WR}$ lined. The pulse duration is controlled by C1, R1, and VR1. This circuit should be used with all computers having a 6502 microprocessor with the only exception of the BBC model B. The Master 128 requires a slightly different method of connection to SK11 in that $\overline{NPGFC}$ can be brought straight into pin 20, rather than via pin 13 and the clean-up circuit. The R/$\overline{W}$ line can also be fed to IC6 via IC3 rather than direct. There should not be too much difficulty in wiring up the monostable circuit on the spare pads on the board. One slight modification to the board is required, and this is to cut the track leading into and out from pin 36 of IC7. A short piece of insulated wire is then used to bridge the break in the track, and the output from the monostable can then be connected to the otherwise unconnected pin 36 of IC7.

An unexpected problem was that of IC6c failing to provided the required ouptut signal, with the input tending to stay in the high state, driving the $\overline{RD}$ input of IC7 continuously low. This can be overcome by adding a 2k2 resistor between pins 9 and 10 of IC6 and the negative supply rail. This modification is not required with the BBC model B where IC6c is driven direct from the R/$\overline{W}$ line. It is required with the other 6502 computers though.

Table 3. *Details of the required links.*

LINK No.	BBC B Master 128	Oric Atmos	VIC-20	CBM 64
1	X	X	0V	0V
2	X	X	0V	0V
3	X	X	0V	0V
4	X	X	X	X
5	0V	0V	0V	0V
6	0V	0V	0V	0V
7	0V	0V	0V	0V
8	0V	0V	0V	0V
9	X	X	X	X

The test program for the Master 128 is the same as the one for the BBC model B. With the program running, VR1 in the monostable is adjusted to give reliable flashing of D2. If preferred, VR1 can be replaced with a fixed resistor of about 12k in value, but it might be necessary to experiment a little with various values in order to find one that gives satisfactory operation.

ORIC ATMOS

The Oric Atmos and the original Oric machines are all interfaced to user add-ons in exactly the same way. There is more than one way of tackling the problem, but the most simple method of interfacing is to place the add-on at the top of page 3. The internal hardware is at the bottom of page 3, and Oric add-ons are designed to use the space immediately above this. Oric therefore recommend that user add-ons should be placed at the top of page 3, working downwards as more are added, so that the possiblity of conflict between Oric and user add-ons is minimised. Accordingly, the recommended method of connection for the Hobby Bus places it at the adresses from 3E0 to 3FF.

The Oric machines have an output ("I0") which is roughly comparable to the page select lines of the BBC computers, and it pulses low when an address in page 3 is accessed. As the internal hardware resides in page 3, it is essential for any user add-on which is mapped into the same page, when it is accessed, to disable the internal hardware. This can be accomplished by taking "I0 CONT" low, and this input would normally be driven from the output of the address decoder. The latter must process "I0" plus some of the eight least significant address lines. In this case "I0 CONT" is brought in on the usually unused pin 13 of the d.i.l. connector, and pin 13 of SK11 must therefore be wired to pin of 3 of IC6 (pin 19 of IC5 is probably the most convenient place to tap off this signal). Note that the signal should not be taken direct from pin 6 of IC2 as the output pulse here is of the wrong polarity. Of course, the monostable circuit and the additional 2k2 resistor at the input of IC6c are required.

Like the BBC machines, the connections to the Oric expansion port are made by way of a 34-way IDC header socket, but the connections to the Oric's port are totally different, as shown in Fig. 4. The Oric test program is shown below. With the VR1 set correctly D2 should flash on and off,

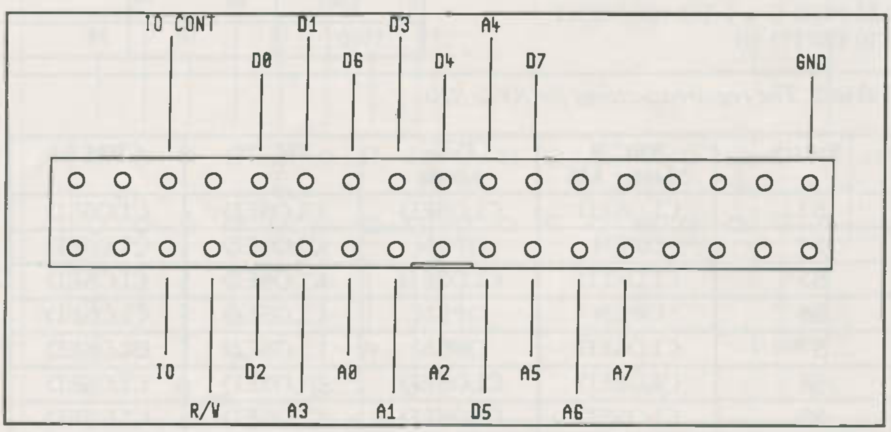


Fig. 4. *Oric connection details.*

and the value printed down the left hand side of the screen should be either 0 or 4 depending on the setting of S2. Pulses are provided at slot select outputs of IC8.

ORIC Test Program

```
5 REM ORIC TEST PROG
10 POKE #3E3,147
20 POKE #3E2,64
30 POKE #3E4,0
40 POKE #3E8,0
50 POKE #3EC,0
60 POKE #3F0,0
70 POKE #3F4,0
80 POKE #3F8,0
90 POKE #3FC,0
100 POKE #3E2,0
110 PRINT PEEK(£3E2) AND 4
120 FOR D = 1 TO 100:NEXT
130 GOTO 10
```

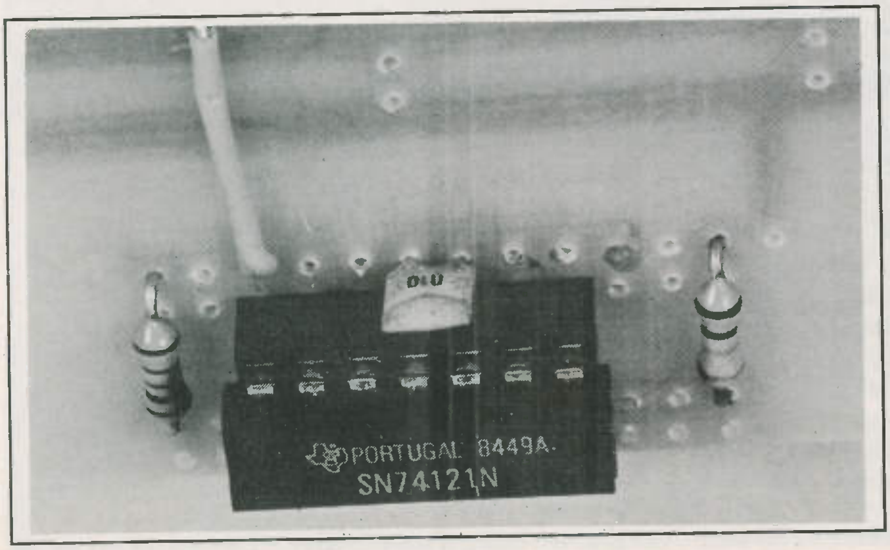
COMMODORES

The Commodore 64 and VIC-20 computers both have their buses available at the cartridge port. Although these are called the cartridge ports by Commodore and are only utilized as such by most users, they are in fact intended for general expansion purposes. They even have decoded page select lines which are comparable to those of the BBC machine. In the case of the Commodore 64 the line most suitable for user add-ons is I02, which pulses low when any address in page &DF (57088 to 57383) is accessed. The equivalent for the VIC-20 is I03, which is activated when any address in the range 39936 to 40959 is accessed (which is actually a four page block, or 1024 addresses in other words).

The suggested method of connection merely feeds I02 or I03 (as appropriate) to the address decoder of the Hobby Bus, with none of the address lines being decoded. As a result of this the Hobby Bus appears as echoes throughout the relevant address ranges. Obviously some of the address lines could be decoded in order to place the Hobby Bus at the required position within the block of available addresses, but unless some other user add-on is also connected to the cartridge port this is not worthwhile.

Table 4. *The slot addresses for the various 6502 computers.*

Device	BBC B Master 128	Oric Atmos	VIC-20	CBM 64
8255 (A)	FCC0	3E0	39936	57088
8255 (B)	FCC1	3E1	39937	57089
8255 (C)	FCC2	3E2	39938	57090
8255 (Cont)	FCC3	3E3	39939	57091
SLOT 1	FCC4	3E4	39940	57092
SLOT 1	FCC5	3E5	39941	57093
SLOT 1	FCC6	3E6	39942	57094
SLOT 1	FCC7	3E7	39943	57095
SLOT 2	FCC8	3E8	39944	57096
SLOT 2	FCC9	3E9	39945	57097
SLOT 2	FCCA	3EA	39946	57098
SLOT 2	FCCB	3EB	39947	57099
SLOT 3	FCCC	3EC	39948	57100
SLOT 3	FCCD	3ED	39949	57101
SLOT 3	FCCE	3EE	39950	57102
SLOT 3	FCCF	3EF	39951	57103
SLOT 4	FCD0	3F0	39952	57104
SLOT 4	FCD1	3F1	39953	57105
SLOT 4	FCD2	3F2	39954	57106
SLOT 4	FCD3	3F3	39955	57107
SLOT 5	FCD4	3F4	39956	57108
SLOT 5	FCD5	3F5	39957	57109
SLOT 5	FCD6	3F6	39958	57110
SLOT 5	FCD7	3F7	39959	57111
SLOT 6	FCD8	3F8	39960	57112
SLOT 6	FCD9	3F9	39961	57113
SLOT 6	FCDA	3FA	39962	57114
SLOT 6	FCDB	3FB	39963	57115
SLOT 7	FCDC	3FC	39964	57116
SLOT 7	FCDD	3FD	39965	57117
SLOT 7	FCDE	3FE	39966	57118
SLOT 7	FCDF	3FF	39967	57119



Both the cartridge ports are rather awkward as far as actually making the connections is concerned, as they both require male edge connectors. In each case it is 2 by 22-way type that is needed, but the connector for the Commodore 64 must have a pitch of 0·1 inches whereas that for the VIC-20 must be a 0·156 inch pitch type. Neither are likely to be available ready made, and it will therefore be necessary to build one from a piece of double-sided copper laminate board. This is not too difficult as rub-on edge connector transfers are available, making it easy to produce a good quality board. However, take due care to ensure that the two sides of the board match up correctly, and note that the VIC-20 connector must have a pitch of 0·156 inches and not 0·15 inches (which is also a standard size). Connections can be made direct to the tracks of the male edge connector, but there would be a strong risk of the tracks being pulled away from the board, and a much better way of doing things is to make the connector a double-ended type. The connections to it can then be made via a female edge connector of the appropriate size. 2 by 22-way 0·1 inch and 0·156 inch female edge connectors are both readily available. Mark the top and bottom edges of the female connector as such so there is little risk of it being fitted the wrong way up. The two ports have virtually identical methods of connection, as can be seen from Fig. 5.

Both computers require the monostable circuit and the additional 2k2 resistor at the input of IC6c. When the Hobby Bus was first tried with the VIC-20 it failed to work properly, and the reason for this seemed to be double triggering of the monostable which effectively prevented a suitably short write pulse from being generated. The

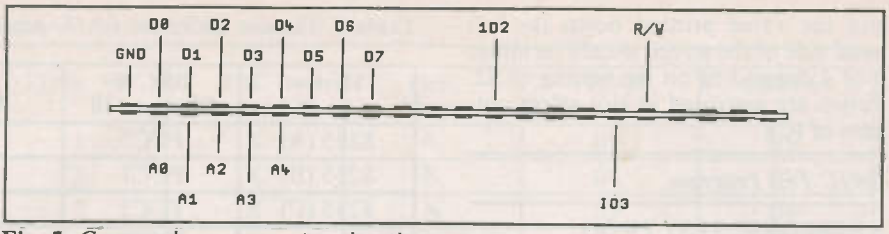


Fig. 5. *Commodore connection details.*

simple solution to this is to take the input signal for the monostable direct from pin 2 of SK11 rather than via IC3. No problem of this type was experienced with the other computers, but obviously this modified method of

```
5 REM CBM64 TEST PROG
10 POKE 57091,147
20 POKE 57090,64
30 POKE 57092,0
40 POKE 57096,0
50 POKE 57100,0
60 POKE 57104,0
70 POKE 57108,0
80 POKE 57112,0
90 POKE 57116,0
100 POKE 57090,0
110 PRINT PEEK(57090) AND 4
120 FOR D = 1 TO 100:NEXT
130 GOTO 10
```

connection can be tried with any 6502 based machine if adjustment of VR1 proves to be ineffective. The test programs for the Commodore computers are provided below, and once again VR1 should be adjusted to give reliable flashing of D2. The program provides the usual pulses at the slot select outputs of IC8, and repeatedly prints the value read from S2 on the screen.

```
5 REM VIC-20 TEST PROG
10 POKE 39939,147
20 POKE 39938,64
30 POKE 39940,0
40 POKE 39944,0
50 POKE 39948,0
60 POKE 39952,0
70 POKE 39956,0
80 POKE 39960,0
90 POKE 39964,0
100 POKE 39938,0
110 PRINT PEEK(39938) AND 4
120 FOR D = 1 TO 100:NEXT
130 GOTO 10
```

Details for setting up the 8255 PIA for the required operating mode were given in the previous article, and will not be repeated here. PE

INDUSTRY NOTEBOOK

BY NEXUS

Facts, figures and the people behind them —from humble beginnings

Possibilities of one of the biggest ever takeover deals in the world of electronics and the people behind the names and the names behind the people

HOME HELP FOR PHILIPS

CONSUMER electronics is proving one of the few bright spots in the current trading of Philips, the Dutch multinational electronics/electrical group. For the first quarter of 1986 the firm reports good sales of compact disc players, records, video recorders, in-car entertainment and colour tv sets. This sector is mainly responsible for a 5% increase in sales volume of the whole group, relative to the corresponding quarter of 1985.

But this improvement in consumer electronics did not compensate for continuing losses in electronic components—following last year's trend —and slight falls in other product areas. As a result both sales and income in this first quarter were lower than in the corresponding 1985 period. Sales in terms of money were 8% lower. Income was 5·6% of sales, compared with last year's 6.5%.

It's good to hear that the company's expansion in some areas of consumer electronics—mainly CD players, video recorders and flat square colour tv tubes—has generated a few more jobs. Since the beginning of this year 3,100 additional employees have been taken on, largely in this sector.

Looking at the latest Philips annual report (for 1985), I see that consumer electronics accounts for about 28% of the company's total sales revenues of approximately 60 billion guilders p.a. (about £16 billion). Electronic components contributes about 13%, while the remainder is largely made up of lighting, domestic electrical appliances and, totalling about 29%, a wide range of professional equipment including telecommunications, office systems, mobile radio and broadcasting and medical equipment. In that year consumer electronics sales grew by 11% while components sales fell by 6%.

RCA AND GE MEET AGAIN

If the proposed merger in the USA of RCA Corporation with General Electric actually goes ahead it will be one of the biggest takeover deals ever in the world of electronics. GE has agreed to buy RCA for $6.23 billion (about £4 billion) or $66.50 per share. The boards of both companies have agreed to the merger, but at the time of writing there are still problems being sorted out by various national bodies in the USA.

Both firms are well known as manufacturers of electronic components and equipment. RCA, incidentally, also owns the broadcasting company NBC. What is perhaps less well known is that the two giants also had a significant business encounter in the days when the electronics industry hardly existed. In fact GE was involved in the very birth of RCA, originally called the Radio Corporation of America.

This happened because Britain's Marconi Company had a subsidiary in the US called Marconi Wireless Telegraph Company of America, founded in 1899. Both GE and this American Marconi Company were strong in the radio technology of the early 20th century. Because their systems were complementary rather than competitive, the two firms thought that a merger would be advantageous to all concerned, and this was proposed.

But the US government of that time didn't like the idea. It insisted that any new company should be entirely American owned and not connected with any foreign organization. The British parent Marconi Company was in too bad a position financially to build up its American subsidiary and go it alone in the USA, so it reluctantly agreed to sell its holdings there. As a result the Radio Corporation of America came into being in October 1919. However, RCA acquired rights to all the fundamental Marconi patents, as well as many other important radio patents including some of GE's, and thus started from a very strong position technically and commercially.

David Sarnoff was the man mainly responsible for expanding RCA throughout the first half of this century. He arrived in the USA in 1900 as a child immigrant from Russia and got started in our industry when he joined the American Marconi Company as an office boy at the age of fifteen.

GOING PUBLIC

Although the computer sector of the industry has recently lost much of its appeal to the financial world, two more firms are offering themselves to the share-buying public on the stock market. One is in hardware, the other in software.

Rodime, the manufacturer of disk drives for personal and other small computers, has rapidly increased its sales over a short period to £75.9 million in the year ending September 1985. Profits have risen from £5.1 million two years ago to £14.8 million last year.

Package Programs, which specializes in software packages for business applications, has put about 30% of its equity on the stock market. It has done this to raise approximately £3 million, needed for expansion. Over the past five years its sales have risen to about £9 million, while pre-tax profits have increased from £68,000 to £735,000.

Meanwhile, in other ownership deals, Thorn-EMI has concentrated itself more on electronic/electrical products by selling off its Screen Entertainments film division. And STC has raised some much needed cash by divesting itself of the main systems building business of IAL (International Aeradio Ltd) to British Telecom for £22 million plus £2 million a year in royalties. Thus BT goes even further into manufacturing.

NEW MEN

A lot of people are intrigued by the surname of the man who this year bought up the computer interests of Sinclair Research for a mere £5 million—Alan Sugar, the head of Amstrad. Is it pronounced the same as the stuff we put in tea and coffee? Is the spelling perhaps just accidental, the result of modifications in earlier centuries?

Apparently Mr Sugar's great-grandfather was a Polish immigrant. He may have worked in a sugar-beet factory in his homeland and on arrival here told the authorities his name was Sugar.

I refer to the Sinclair purchase as a "mere" £5 million because Alan Sugar, not yet 40, is reported to have amassed a personal fortune about sixty times that amount. Amstrad, as everyone knows, has been a phenomenal business success, thanks to Sugar's great skill in marketing consumer electronic products. Last year it's pre-tax profits were £20 million, and a substantially higher figure is predicted for this year. I don't know whether Mr Sugar has been to the Harvard Business School, like some of our industry bosses, but he has certainly learned a lot somewhere since he was a street trader in Hackney, the borough with London's highest level of unemployment.

Another tough, competitive man fairly new to the electronics industry is Sir James Blyth, the recently appointed managing director of Plessey. What makes him particularly interesting to the industry, apart from his own achievements and career, is that he is not only the *first* managing director of the company but also a recruit from outside, having been on the board for only three months.

DOMINANCE

For the whole of its sixty years' existence, Plessey has been dominated by the Clark family, very autocratically to begin with. The most recent member of this family, in the post of chief executive, is Sir John Clark, who is sixty this year. Now the company has brought in the 'outsider' Blyth because it feels it needs fresh blood at the top to help cope with the takeover bid from GEC among other things.

Aged 45, Sir James is a Scotsman and a history graduate of Glasgow University. His first job was with Mobil Oil and he had a string of senior managerial appointments after that, including General Foods, Mars, Lucas and the Ministry of Defence. Like Sir Raymond Brown, now on the STC board (see April PE), he was knighted for his MoD overseas sales work. Plessey, of course, makes a lot of military equipment for the MoD. PE

REGULAR FEATURE

READERS' LETTERS

Dear Sir,
RE: Solar Challenge

The May 1986 issue of your journal contains details of the above competition. In the section marked 'Awards' there is a sentence, "If in the opinion of the judges any of the ideas are commercially exploitable then the sponsors of this challenge will undertake to assist the inventor in either patenting or registering the idea and will then assist the inventor to organise manufacture of the product under licence." I would like to give you a word of warning about this sentence before some inventor loses his patent rights.

Unless the entry to your competition is sent in confidence then its submission will be 'publication' under United Kingdom patent law and the invention will cease to be novel. A patent application filed after such publication will not be valid. I enclose a copy of my Institute's booklet 'Inventors, Patents and Patent Agents' which emphasises this point on the third page; I have highlighted the section.

The wording you have used may have originated from the United States (see US spelling of 'licence') where the patent law is substantially different and a patentee can, in some circumstances, file a valid patent application up to a year after a non-confidential disclosure of an invention.

Your regular correspondent Barry Fox is most experienced in patent matters and can probably assist you in rewording the section.

Apart from this small point I am delighted to see the competition. It is more than likely that I shall submit an entry.

Your faithfully,
Guy Selby-Lowndes, Chartered Patent Agent

Dear Mr. Lowndes,

Thank you for your information regarding the patent problem. Having given the 'Awards' some further thought, I have decided that all entries to the competition will indeed be submitted to the judges in confidence and will not be published until after any patent application has been made.

We look forward to receiving your entry.
Yours, The Editor

Dear Sir,

I have bought the magazine since its inception (apart from when my newsagent lets me down) and I think it is maintaining the standards and looks even better than before. Please keep the general articles, we don't all play with PCBs and soldering irons!

Yours sincerely,
G.R. Morris

Dear Mr. Morris,

Thank you for your kind words. We will always produce plenty of constructional articles, and, yes, we will keep up the general articles.
Yours, The Editor

P.C. BOARDS

Printed circuit boards for certain PE constructional projects are now available from the PE PCB Service, see list. They are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for overseas airmail. Remittances should be sent to: **PE PCB Service, Practical Electronics, Practical Electronics Magazines, 16 Garway Road, London, W2 4NH.** Cheques should be crossed and made payable to Intrapress.

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

Readers are advised to check with prices appearing in the current issue before ordering.
NOTE: Please allow 28 days for delivery. We can only supply boards listed here.

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Scope solartron CD1212 valve, heavy 40MHZ single beam manual XI Probe, £40 o.n.o. Buyer collects. D. Wilson, Woodfield House, Berrymoor Road, Norland, Sowerby Bridge, W. Yorks. Tel: HX 839769.

Will pay £8 for someone who will help find disc interface ZX81 s/hand. Appreciate user contact, postage reimbursed and offer utilities. J. Motte, 16 Quai de Biestebroeck 1070 BXL, Belgium.

For sale: C.B. two-channel transceiver, 27 MHz FM waveband. Still boxed as new, £18. F. Miah, 263 Elland Road, Leeds LS11 8TV. Tel: Leeds 719782.

Wanted: BBC model A, damaged considered or cheap model B. State price. L. S. Fisher, 5 Cadnam Close, Canterbury, Kent CT2 7SD. Tel: 0227 454204.

Wanted: passive infra-red detector circuits, information, price. J. R. Atkins, 82 Willow Way, Hurstpierpoint, West Sussex. Tel: 0273 834470.

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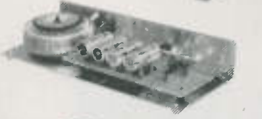

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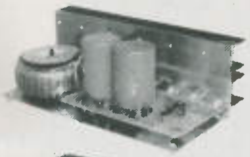

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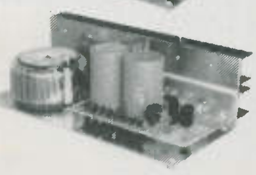

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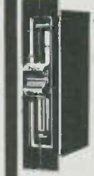

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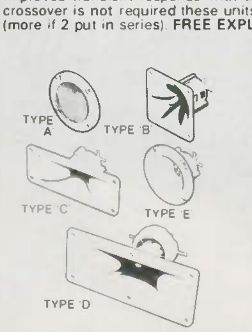

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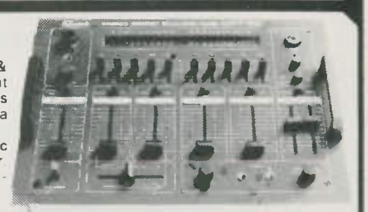

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