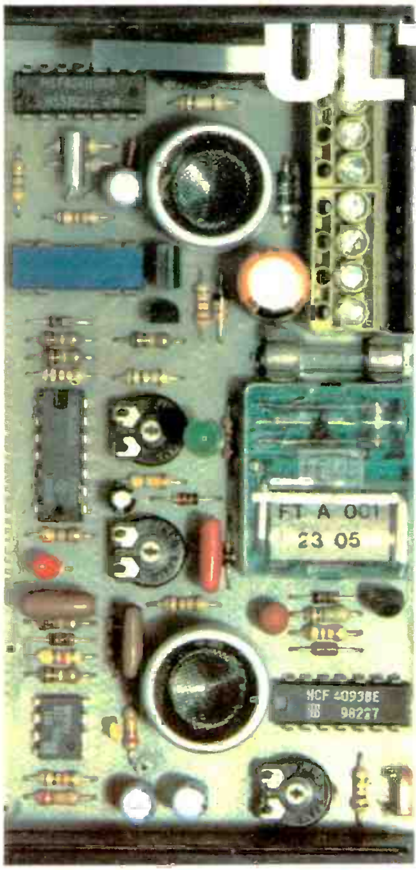
Australia $1.50 New Zealand $1.60 Malaysia $4.95 IR £1.23 (inc. VAT)

PRACTICAL ELECTRONICS

JULY 1983

85p



ULTRALIGHT

INTRUDER ALARM Plus AUTOMATIC LIGHTING

TIMER PROJECTS

UP/DOWN TIMER - TIMER CONTROLLER

Computing: Fairlight Music Computer explained

SPACEWATCH • SEMICONDUCTOR CIRCUITS • INDUSTRY NOTEBOOK

EXTRA! EDITORIAL PAGES EXTRA!

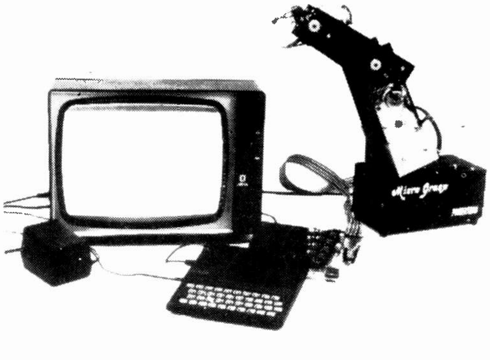
Get moving with these new developments in UK Robotics

— advanced electrohydraulic designs for education, industry and now available to the home constructor.

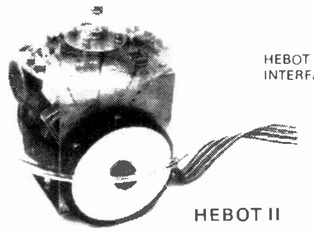
[illegible]

Robotic experience is becoming as essential a subject as computing. MICROGRASP provides the lowest cost means of acquiring that experience but despite its ultra low price the robot has considerable versatility. There are [illegible] servo motor and there is [illegible] arm movements. Control [illegible] by any computer with [illegible] bus, the ZX81 being particularly suitable. [illegible] with hardware [illegible] the interface board [illegible] BASIC [illegible] required. [illegible]

MICROGRASP [illegible]	£145.00
[illegible]	£48.50
[illegible]	£2.50
ZX81 [illegible] RAM pack [illegible]	£3.00

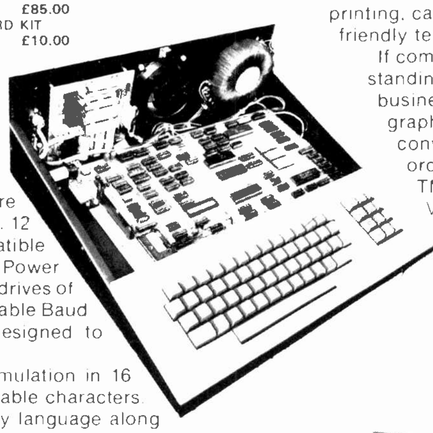


MICROGRASP, INTERFACE BOARD AND ZX81



HEBOT KIT	£85.00
INTERFACE BOARD KIT	£10.00

HEBOT II



Up to the nano-second hard, firm and software developments embodied in a complete system. 12 Mega Hertz 16 bit CPU, 64K upwardly compatible DRAM, separate 16K video DRAM and 24K TI Power Basic with overwrite. Supports up to four Disc drives of mixed type with 16 serial I/O ports. Programmable Baud rate and comprehensive E Bus interface designed to support real world applications.

Very high resolution graphics gives 3D simulation in 16 colours on 36 prioritised planes of user definable characters. Software FORTH coming includes this trendy language along with NOS C/PM.

Hardware components available separately with details in Nov, Dec, and Jan issues of ETI. Software features include, Real time clock, full renumber command, buffered I/O to free machine whilst printing, call to machine code routines, hexadecimal support and user-friendly textual error trapping messages.

If computers interest you then the Cortex will expand your understanding infinitely more than off the shelf machines. Use it in business, education, research or just play with the incredible graphics capability. At Powertran we are using these machines in conventional roles, in product control and R & D. We shall co-ordinate the Cortex user group and distribute software for the TMS 9995 CPU. Complete 16 bit 64K computer kit **£295.00** + VAT. Complete 16 bit 64K computer ready built **£395.00** + VAT

Top of the range is the Genesis P102 which has dual speed control, continuous servo operation and double acting cylinders for increased torque on the wrist and arm rotation joints. The microprocessor based control system has additional memory, position interrogation via the RS232C interface increasing the versatility of computer control and inputs are provided for machine tool interfacing.

[illegible] £1950.00

Example prices and specifications

Genesis S101
Base: 19.5" × 11" × 7.5"
Lifting capacity: 1500gm
Arm lift: 6 6"
Weight: 29Kg

4 axis model in kit form	£425
5 axis model in kit form	£475

Genesis P101
Base: 19.5" × 11" × 7.5"
Lifting capacity: 2000gm
Arm lengths between axles: 14.0"
Weight: 34Kg

6 axis model in kit form	£675

Complete Systems as shown in Photograph on right

Genesis S101

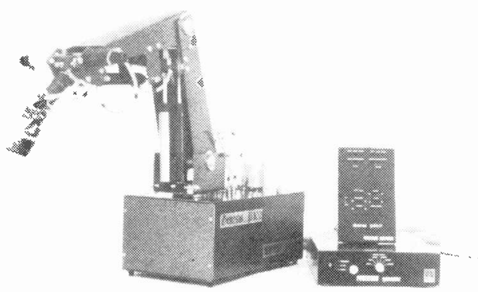
4 axis system in kit form	£681.50
5 axis system in kit form	£737.50
5 axis system Ready Built	£1450

Genesis P101

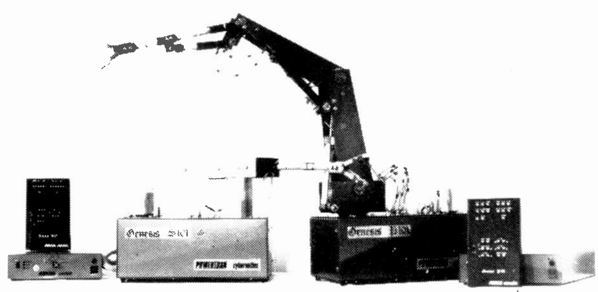
6 axis system in kit form	£945.00
6 axis system Ready Built	£1650

All prices exclusive of VAT

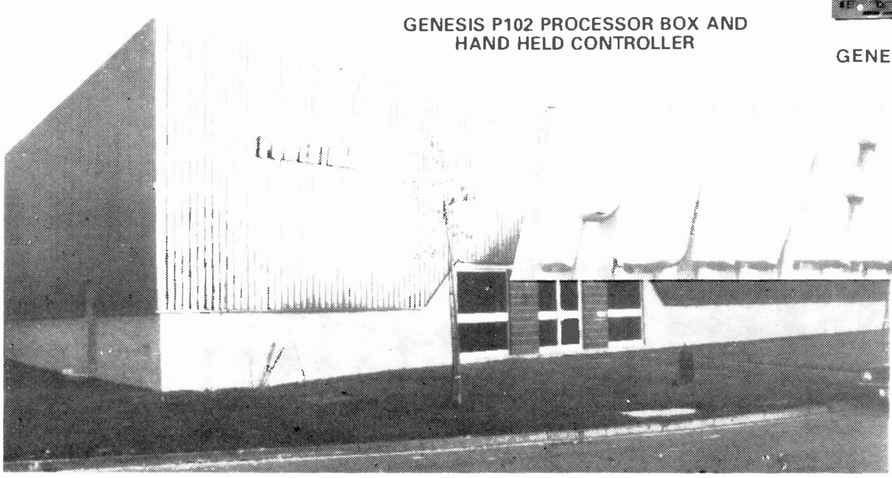
[illegible]



GENESIS P102 PROCESSOR BOX AND HAND HELD CONTROLLER



GENESIS S101 AND GENESIS P101 WITH PROCESSOR BOXES AND HAND-HELD CONTROLLERS



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(CYBERNETIC DIVISION)
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PRACTICAL
ELECTRONICS

VOLUME 19 No. 7 JULY 1983

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

SPECIAL SUPPLEMENT

OUR AUGUST ISSUE WILL BE ON SALE FRIDAY, JULY 1st, 1983
(for details of contents see page 39)

The sundial and hourglass shown on the cover were supplied by Seaway Chandlery, Poole.

SPEAKERS
8Ω, 0.3W, 2"; 2.25", 2.5", 3" — 80p
0.3W, 2.5" 40Ω; 64Ω or 80Ω — 80p

DIODES	
AA119	15
AA129	20
AAY30	15
BA100	15
BAX13	20
BY100	24
BY126	12
BY127	12
CRO33	250
OA9	40
OA47	12
OA70	12
OA79	15
OA81	20
OA85	15
OA90	8
OA91	8
OA95	8
OA200	8
OA202	8
1N914	4
1N916	5
1N4001/2	5
1N4003	6
1N4004/5	6
1N4006/7	7
1N4148	4
1N5401	15
1N5404	16
1N5406	17
1N5408	19
1S44	9
1S921	9
6A/100V	40
6A/400V	50
6A/800V	65

BRIDGE RECTIFIERS (plastic case)	
1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	46
2A/600V	65
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	298
25A/200V	240
25A/600V	395
BY164	56
VM18	50

ZENERS
Range: 2V7 to 39V 400mW — 8p each
Range 3V3 to 33V 1.3W — 15p each

VARICAPS	
MVAM2	165
BA102	30
BB105B	40
BB106	40

SCR's Thyristors	
0.8A-100V	32
5A/300V	38
5A/400V	40
5A/600V	48
8A/300V	60
8A/600V	95
12A/100V	78
12A/400V	95
12A/800V	188
BT106	150
BT116	180
C106D	38
TIC44	24
TIC45	29
TIC47	35
2N5064	38
2N4444	130

TRIACS	
3A/100V	48
3A/400V	56
3A/800V	85
8A/100V	60
8A/400V	69
8A/800V	115
12A/100V	78
12A/400V	82
12A/800V	135
16A/100V	103
16A/400V	105
16A/800V	220
25A/400V	185
25A/800V	295
25A/1000V	480
30A/400V	525
T2800D	120

DIAC	
ST2	25

SOLDERCON PINS
100 — 75p
500 — 370p

OPTO

LEDS price includes Clips

TIL209 Red 3mm	10
TIL211 Green 3mm	14
TIL212 Yellow	14
TIL220 .2" Red	12
0.2" Yel, Grn, Amber	14
Rectangular LEDs with two part clip. R, G & Y	29
Rectangl. Stackable LEDS	18
Triangular LEDs R&G	18
0.2" Flashing LED Red	56
0.2" Bi colour LEDs Red/Green	65
Green/Yellow	80
0.2" Tri colour LEDs Red/Green/Yellow	85
0.2" Red High Bright	59
LD271 Infra Red (emit)	46
TIL32 Infra Red (emit)	52
SFH205 (detector)	118
TIL78 (detector)	54
TIL38	45
TIL81	82
TIL100	90

7 Segment Displays

TIL321 .5" C.An	115
TIL322 .5" C.th	115
DL704 .3" C.Cth	99
DL707 .3" C.Anod	99
FND357 or 500	120
.3" Green C.A.	140
±1 .3" Red or Green	150
Bargraph 10 seg. Red	225
Bargraph NSM3914	500

0.5" LIQUID CRYSTAL DISPLAYS

3½ digit	495
4 digit	530
6 digit	625

BPX25	195
BPW21	295
IL74	45
ILD74	99
ILQ74	185
TIL111	75
OCP71	120
ORP12	78
2N5777	45
4N33	135
Pin diode	610
Schmitt Receiver	620

OPTO SWITCH
Reflective TIL139 — 170
Slotted similar to RS — 186

FERRIC CHLORIDE
Crystals 1lb
195p + 50p p&p

DALO ETCH RESIST
Pen plus spare tip — 100p

ALUM.BOXES

4×2¼×2"	85
4×2¼×2¼"	103
4×4×2½"	120
5×4×2"	105
5×2¼×1½"	90
5×2¼×2¼"	130
5×4×1½"	99
5×4×2½"	120
6×4×2"	120
6×4×3"	150
7×5×3"	180
8×6×3"	210
10×4½×3"	240
10×7×3"	275
12×5×3"	260
12×8×3"	295

COPPER CLAD BOARDS

	Fibre Glass Single-sided	Double-sided	SRBP 9.5"×8.5"
6"×6"	100p	125p	110p
6"×12"	175p	225p	

VEROBOARDS 0.1"

	Clad	Plain
2½×3¾"	85p	—
2½×5"	100p	—
3¾×3¾"	100p	—
3¾×5"	115p	95p
3¾×17"	390p	275p
4¾×18"	495p	—
Pkt. of 100 pins	55p	
Spot Face Cutter	150p	
Pin Insertion Tool	185p	

'VQ' Board	180
'DIP' Board	374
Vero Strip	144

PROTO-DECs

Veroblock	405
S-Dec	350
Eurobreadboard	520
Bimboard 1	695
Superstrip SS2	£13

VERO WIRING PEN and Spool — 350p
Spare Wire (Spool) 75p; Combs 6p ea.
Wire Wrapping Stakes 100 — 250p

VOLTAGE REGULATORS

1A T0220 Plastic Casing

	+ve		−ve	
5V	7805	40p	7905	45p
12V	7812	40p	7912	45p
15V	7815	40p	7915	45p
18V	7818	40p	7918	45p
24V	7824	40p		

100mA T092 Plastic Casing

5V	78L05	30p	79L05	60p
6V	78L62	30p		—
8V	78L82	30p		—
12V	78L12	30p	79L12	60p
15V	78L15	30p	79L15	60p

ICL7660	248	LM317K	320
78H05 5V/5A	550	LM317P	99
78H12 12V/5A	580	LM323K	500
78HG+5 to +24V 5A	599	LM337T	175
79HG −2.25V to −24V 5A	685	LM723	35
LM309K	120	TBA625B	75
		RC4194	375
		RC4195	160

SWITCHES

SLIDE 250V

1A DPDT	14
1A DPDT C/OFF	15
½A DP on/on/on	40

TOGGLE 2A 250V

SPST	33
DPDT	44
4 pole on off	54

PUSH BUTTON
Spring loaded

Latching or Momentary 6A	
SPDT c/over	99
DPDT c/over	145

SUB-MIN TOGGLE 2 amp

SP changeover	60
SPST on off	54
SPDT c/off	85
SPDT Biased	105
DPDT 6 tags	75
DPDT C/OFF	88
DPDT on/on/on	185
DPDT Biased	145
3 pole c/over	205

MINIATURE Non Locking
Push to make — 15p
Push break — 25p

ROTARY: (Adjustable Stop Type)
1 pole/2 to 12 way, 2p/2 to 6 way, 3 pole/2 to 4 way, 4 pole/2 to 3 way — 45p

ROTARY: Mains 250V AC, 4 Amp — 64p

DIL SWITCHES: (SPST) 4 way 65p; 6 way 80p; 8 way 87p; 10 way 100p; (SPDT) 4 way 190p.

★ SPECIAL OFFER ★

1 MEGABYTE DRIVES
Mitsubishi Slim Line, Uncased, Double track, Double density, 5¼". Track Density 96TPI, track to track. Access time: 3mSec.
Only £210.

EPSON RX80

Available from stock — £295

DIL SOCKETS

	Low profile	Wire wrap
8 pin	8p	25p
14 pin	10p	35p
16 pin	10p	42p
18 pin	16p	52p
20 pin	20p	60p
22 pin	22p	65p
24 pin	25p	70p
28 pin	28p	80p
40 pin	30p	99p

ZIF DIL SOCKET

16 way	475p
24 way	575p
28 way	850p
40 way	975p

DIL PLUGS (Headers)

Pins	Solder	IDC
14	38p	95p
16	42p	100p
24	88p	138p
40	195p	218p

RIBBON CABLE (price per foot)

Ways	Grey	Colour
10	15p	28p
16	25p	40p
20	30p	50p
26	40p	65p
34	60p	85p
40	70p	90p
64	100p	135p

ULTIMUM

WATFORD'S most versatile MICRO EXPANSION SYSTEM. Interfaces with: APPLE, ATOM, DRAGON, PET, RESEARCH MACHINE, SPECTRUM, SUPERBOARD, VIDEO GENIE, ZX81, etc. As published in P.E. starting from Nov., 1982.
Send SAE for details.

IDC CONNECTORS (Speed block type)

2 rows	PCB Male with latch Strt. Pins	Angle Pins	Female Header Socket	Female Card-Edge Connector
10 way	90p	99p	85p	120p
16 way	130p	150p	110p	195p
20 way	145p	166p	125p	240p
26 way	175p	200p	150p	320p
34 way	205p	236p	169p	340p
40 way	220p	250p	190p	420p
50 way	235p	270p	200p	470p

EURO CONNECTORS

	FEMALE SOCKETS Strt.	Angle	MALE PLUGS Strt.	Angle
DIN 41617 31 way	170p	—	—	175p
DIN 41612 2×32 way	275p	320p	220p	285p
DIN 41612 2-3×32 way	295p	340p	240p	300p
DIN 41612 3×32 way	360p	385p	260p	395p

'D' CONNECTORS:

Pins	9 way	15 way	25 way	37 way
MALE				
Solder	80p	110p	160p	240p
Angle	150p	210p	250p	355p
Strait	170p	160p	220p	310p
FEMALE				
Solder	105p	160p	200p	338p
Angle	165p	215p	290p	440p
Strait	175p	200p	300p	420p
COVERS	80p	75p	75p	90p

IDC 25 way Plg. 385p, Skt. 450p

TRANSFORMERS (mains Prim. 220-240V)
3-0-3V, 6-0-6V 100mA; 9-0-9V 75mA; 12-0-12V 75mA; 15-0-15V 75mA — 98p
6VA: 2x6V-.5A; 2x9V-.4A; 2x12V-0.3A; 2x15V-.25A — 220p
12VA: 2x4V5-1.3A; 2x6V-1.2A; 2x12V-.5A; 2x15V-.4A — 295p (35p p&p)
24VA: 6V-1.5A 6V-1.5A; 9V-1.2A 9V-1.2A; 12V-1A 12V-1A; 15-.8A 15-.8A; 20V-.6A — 330p (60p p&p)
50VA: 2×6V-4A; 2×9V-2.5A; 2×12V-2A; 2×15V-1.5A; 2×20V-1.2A; 2×25V-2A; 2×30V-0.8A — 465p (60p p&p)
100VA: 2×12V-4A; 2×15V-3A; 2×20V-2.5A; 2×30V-1.5A; 2×40V-1.25A; 2×50V-1A — 920p (60p p&p)

SIL Sock-Sockets 0.1"
20 way 65p
32 way 95p

EDGE CONNECTORS

	1"	.156"
2×10 way	—	135p
2×15 way	—	140p
2×18 way	180p	145p
2×22 way	199p	200p
2×23 way	170p	190p
2×25 way	225p	280p
2×28 way	210p	—
2×30 way	245p	—
2×36 way	295p	—
2×40 way	315p	—
2×43 way	395p	—
2×75 way	550p	—

JUMPER LEADS Ribbon Cable Assembly
DIL Plug (Headers)
Single Ended Lead, 24" long

Length	14pin	16pin	24 pin	40 pin
24"	145p	165p	240p	325p
Double Ended Leads				
6"	185p	205p	300p	465p
12"	198p	215p	315p	490p
24"	210p	235p	345p	540p
36"	230p	250p	375p	595p

IDC FEMALE RECEPTACLE Jumper Leads 36"

	20pin	26pin	34pin	40pin
1 end	160p	200p	260p	300p
2 ends	290p	370p	480p	525p

COMPUTER CORNER

- **SEIKOSHA GP100A** – Unihammer Printer, normal & double width characters, dot resolution graphics 10" Tractor feed, parallel interface standard. **FREE 500 Sheets** — **£175**
- **SEIKOSHA GP 250X** Printer — **£230**
- **ORIC-I. 48K** now available. — **£147**
- **JUPITER ACE** Microcomputer — **£78**
- **SOFTY – 2.** The complete Microprocessor development system. New powerful instructions. Accepts any 24 pin 5V single rail EPROM. Supplied fully built & tested. — **£169**
- **WEMON.** Watford's 4K Ultimate Monitor IC for Superboard & UK101. — **£10**
- **ZENITH 12" Hi-RES,** Green Monitor 40/80 column select switch, value for money. — **£75**
- **SANYO 14" colour monitor, RGB & V.H. sync. screened metal cabinet** — **£199**
- **MICROVITEC 14"** colour monitor. RGB input. Lead incl. — **£249**
- **TEX EPROM ERASER** Erases up to 32 ICs in 15-30 min. — **£33**
- **TEX EPROM ERASER** with the Solid-State 30 minute Electronic Timer. — **£43**
- **SOLID STATE** 30 minute Electronic **TIMER** for above UV Erasors — **£14**
- **Spare** 'UV lamp bulbs — **£9**
- **POWER SUPPLY** Regulated, Variable from +5V to +15V. 4A. Fully Cased — **£39**
- **MULTIRAIL PSU KIT.** Output: +5V/5A; +12V; +25V; −5V; −12V @ 1A. — **£40**
- 4 × 4 **matrix keypad** (reed switch assembly) — **£4**
- **C12 COMPUTER Grade BASF Cassettes** in Library Cases — **40p**
- **8½" & 9½" Fan fold paper** (1000 sheets) **£7 (150p)**
- **Teleprinter Roll** (no VAT) — **£3.50**

(P&P on some of the above items is extra)
Call in at our shop for demonstration of any of the above items. Be satisfied before you buy.

- **MICROLINE-82A.** 10" Tractor & Friction Feed. 9×9 matrix, 80 column, 120 CPS. Bi-directional
£320 (£7 carr.)

★ NEW ★

- **DP80 PRINTER.** 80CPS, dot matrix printer, 80 column, logic seeking, italics, graphic resolution, true decenders, Tractor/Friction feed. Carbon ribbon. Ideal with BBC Micro complete with paper rack. Introductory offer: **£299** (carr. £7)

- **EPSON FX80 10"** 160cps, Tractor/Friction, Bi-directional, logic seeking, 9 × 11 matrix, Hi-res bit image, normal, italic & elite char. Super & subscript. Proportional spacing. Underlining.
£395 (£7 carr.)

ANTEX Soldering Irons

C15W	495
G517W	495
G18W	520
XS25W	525
Spare bits	85
Elements	225
Iron stands	175
Heat Shunt	30

CRYSTALS

32.768KHz	100
100KHz	235
200KHz	268
455KHz	370
1MHz	275
1.008M	275
1.28MHz	392
1.5MHz	420
1.6MHz	395
1.8MHz	395
1.8432M	200
2.0MHz	225
2.4576M	200
2.5MHz	225
2.56250M	220
3.2768M	150
3.57954M	98
3.6864M	300
4.0MHz	150
4.032MHz	290
4.194304M	200
4.433619M	100
4.608MHz	200
4.80MHz	200
5.0MHz	160
5.185MHz	300
5.24288M	390
6.0MHz	140
6.144MHz	150
6.5536MHz	200
7.0MHz	150
7.168MHz	250
7.68MHz	200
8.0MHz	150
8.08333M	395
8.867237M	175
9.00MHz	200
9.375MHz	350
10.0MHz	175
10.5MHz	250
10.7MHz	150
10.24MHz	200
12.0MHz	175
12.528MHz	300
14.31818M	170
14.7456M	175
14.765MHz	250
15.0MHz	200
16.0MHz	200
18.0MHz	180
18.432M	150
19.968MHz	150
20.0MHz	200
24.0MHz	170
24.930MHz	325
29.695MHz	150
26.670MHz	325
27.125MHz	295
27.145M	190
27.648MHz	300
38.66667M	175
48.0MHz	175
55.5MHz	400
100MHz	350
116.0MHz	300
145.8MHz	225

AMPHENOL PLUGS

	IDC	Solder
24 way IEE	475p	450p
36 way Centronix	525p	485p

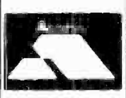
ASTEC UHF MODULATORS
6MHz — 325p
8MHz Wideband — 450p

BBC MICRO & UPGRADE KITS

- BBC Micro A **£299;** MODEL B **£399** (incl.)
- 16K MEMORY (8×4816-100ns) BBC1 — **£16.00**
- Printer User I/O Port BBC2 — **£6.98**
- Complete Printer Cable 36" — **£12.00**
- Disc Interface Kit incl. DOS — **£65.00**
- BBC Joysticks — **£12/pr**
- Analogue I/O Kit BBC4 — **£6.45**
- Serial I/O Kit BBC5 — **£6.70**
- Expansion Bus Kit BBC6 — **£6.10**
- Complete Upgrade Kit from Model A to B — **£42**
- Complete range of Connectors, Cables, Quality Software, Accessories, Books, etc. for BBC available. Send SAE for detail list.

DISC DRIVES (BBC Compatible) (12 months warranty on Drives)

- CS50A – TEAC Single Cased with PSU, 40 track, 5¼". Single sided, 100K — **£180**
- CD50A – TEAC Twin Cased with PSU, 40 track, 5¼". Single sided, 200K — **£350**
- CS50E – TEAC Single Cased with PSU, 80 track, 5¼". Single sided, 200K — **£250**
- CD50E – TEAC Twin Cased with PSU, 80 track, 5¼". Single sided, 400K — **£475**
- **MITSUBISHI** Slim line, Single Cased with PSU, 5¼". 80 tracks, D.S.D.D. 1 Megabytes (400K-BBC) — **£275**
- **MITSUBISHI** Slim line, Dual Cased with PSU, 5¼", 80 tracks, D.S.D.D. 2 Megabytes (800K-BBC) — **£550**



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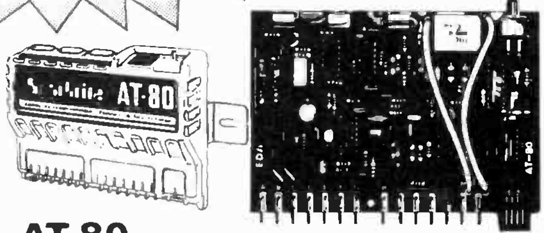
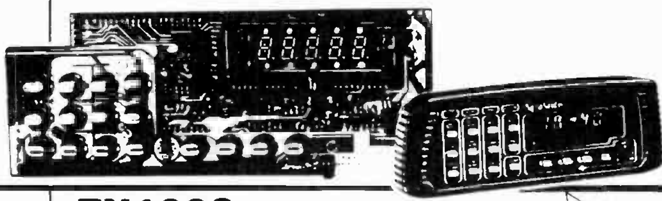
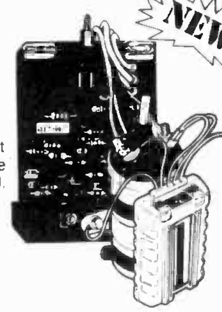
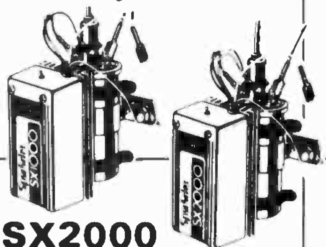
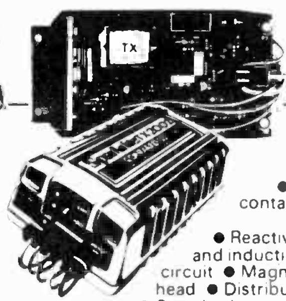
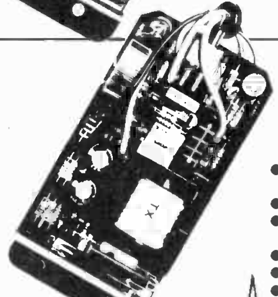


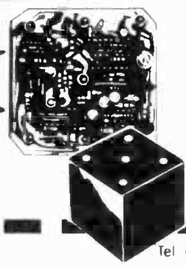












T.V. SOUND TUNER

BUILT AND TESTED

In the cut-throat world of consumer electronics, one of the questions designers apparently ponder over is "Will anyone notice if we save money by chopping this out?" In the domestic TV set, one of the first casualties seems to be the sound quality. Small speakers and no tone controls are common and all this is really quite sad, as the TV companies do their best to transmit the highest quality sound. Given this background a compact and independent TV tuner that connects direct to your Hi-Fi is a must for quality reproduction. The unit is mains-operated.

£24.95 + £2.00p&p.

This TV SOUND TUNER offers full UHF coverage with 5 pre-selected tuning controls. It can also be used in conjunction with your video recorder. Dimensions: 11¾"x 8½"x 3¼".

E.T.I. kit version of above without chassis, case and hardware. £12.95 plus £1.50 p&p.

PRACTICAL ELECTRONICS STEREO CASSETTE RECORDER KIT

COMPLETE WITH CASE

SPECIAL OFFER!

ONLY £31.00 plus £2.75 p&p.

• NOISE REDUCTION SYSTEM. • AUTO STOP. • TAPE COUNTER. • SWITCHABLE E.Q. • INDEPENDENT LEVEL CONTROLS. • TWIN V.U. METER. • WOW & FLUTTER 0.1%. • RECORD/PLAYBACK I.C. WITH ELECTRONIC SWITCHING. • FULLY VARIABLE RECORDING BIAS FOR ACCURATE MATCHING OF ALL TYPES.

Kit includes tape transport mechanism, ready punched and back printed quality circuit board and all electronic parts, i.e. semiconductors, resistors, capacitors, hardware, top cover, printed scale and mains transformer. You only supply solder & hook-up wire. Featured in April P.E. reprint 50p. Free with kit.

STEREO TUNER KIT

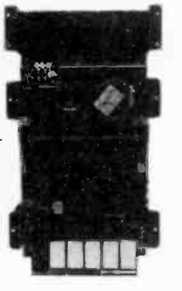
This easy to build 3 band stereo AM/FM tuner kit is designed in conjunction with P.E. (July '81). For ease of construction and alignment it incorporates three Mullard modules and an I.C. IF System.

FEATURES: VHF, MW, LW Bands, interstation muting and AFC on VHF. Tuning meter. Two back printed PCB's. Ready made chassis and scale. Aerial: AM-ferrite rod, FM-75 or 300 ohms. Stabilised power supply with 'C' core mains transformer. All components supplied are to P.E. strict specification. Front scale size 10½"x 2½" approx. Complete with diagram and instructions.

SPECIAL OFFER! £13.95 +£2.50p&p.

Self assembly simulated wood cabinet sleeve to suit tuner only. Finish size: 11¼"x8½"x3¼". £3.50 Plus £1.50 p&p.

STEREO CASSETTE DECK



Stereo cassette tape deck transport with electronics. Manufacturer's surplus — brand new and operational — sold without warranty.

£11.95
plus £2.50 p&p.

Just requires mains transformer and input/output sockets and a volume control to complete. Supplied with full connection details.

125W HIGH POWER AMP MODULES

The power amp kit is a module for high power applications - disco units, guitar amplifiers, public address systems and even high power domestic systems. The unit is protected against short circuiting of the load and is safe in an open circuit condition. A large safety margin exists by use of generously rated components, result, a high powered rugged unit. The PC board is back printed, etched and ready to drill for ease of construction and the aluminium chassis is preformed and ready to use. Supplied with all parts, circuit diagrams and instructions.

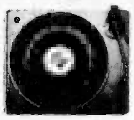
SPECIFICATIONS:
Max. output power (RMS): 125 W. Operating voltage (DC): 50 - 80 max. Loads: 4 - 16 ohm. Frequency response measured @ 100 watts: 25Hz - 20KHz. Sensitivity for 100w: 400mV @ 47K. Typical T.H.D. @ 50 watts, 4 ohms: 0.1%. Dimensions: 205x90 and 190x36mm.

ACCESSORIES: Stereo/mono mains power supply kit with transformer: **£10.50** plus £2.00 p&p.

KIT **£10.50** +£1.15p&p

BUILT **£14.25** +£1.15 p&p.

BSR RECORD DECK



Manual single play record deck with auto return and cueing lever. Fitted with stereo ceramic cartridge 2 speeds with 45rpm spindle adaptor ideally suited for home or disco.

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13"x 11" app.

SPECIAL OFFER! Replacement Stereo cassette tape heads — £1.80 each. Mono: **£1.50 each.** Erase: **£0.70 each.** Add 50p p&p to order.

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185,000	@	15V	71,000	@	40V
120,000	@	15V	60,000	@	40V

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p&p	1 or 2 capacitors	£1.00
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	6 + "	£2.00

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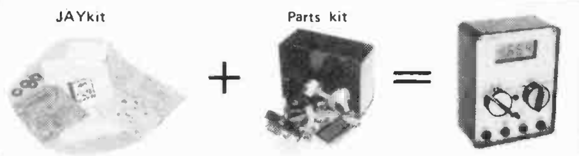
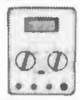
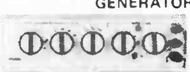


DM-2 DIGITAL MULTIMETER



* DCV to 1kV, ACV to 500V, DCI to 0.2A, R to 20M
* 3½ digit LCD
* Auto Low Battery indication
* Auto Polarity & Zero
* 1% accuracy (DC volts)

FG-1a FUNCTION GENERATOR



* 30mV to 10V pk-pk
* 1Hz to 100kHz
* Sine, Square & Triangle
* DC coupled
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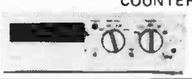
UC-1 UNIVERSAL COUNTER



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* 1Hz to 10MHz (input A), 1Hz to 2.5MHz (input B) @ sensitivity > 20mV rms
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* Takes plug-on Prescaler PS-1

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NEW

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☐ PS-1 JAYkit	£1.85
☐ PS-1 Parts kit (incl. box)	£10.76
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74LS10	12
74LS11	12
74LS14	23
74LS20	14
74LS30	12
74LS32	13
74LS37	14
74LS38	14
74LS42	28
74LS47	42
74LS51	14
74LS73	18
74LS74	16
74LS75	18
74LS76	15
74LS85	40
74LS86	15
74LS90	26
74LS92	30
74LS93	23
74LS107	20
74LS112	20
74LS123	34
74LS125	24
74LS126	25
74LS132	34
74LS136	18
74LS137	90
74LS138	27
74LS139	27
74LS145	60
74LS148	75
74LS151	32
74LS153	36
74LS155	30
74LS156	36
74LS157	27
74LS161	36
74LS163	36
74LS164	38
74LS165	50
74LS166	60
74LS173	55
74LS174	36
74LS175	40
74LS191	40
74LS193	39
74LS195	39
74LS196	40
74LS197	58
74LS221	45
74LS240	50
74LS241	55
74LS242	55
74LS243	58
74LS244	55
74LS245	75
74LS251	36
74LS253	30
74LS257	32
74LS259	55
74LS266	24
74LS273	60
74LS279	30
74LS299	150
74LS367	29
74LS368	33
74LS373	55
74LS374	55
74LS378	60
74LS393	48

7400

7400	11
7401	11
7402	12
7403	12
7404	13
7405	15
7406	20
7407	20
7408	14
7409	16
7410	15
7413	18
7414	24
7420	17
7430	17
7440	17
7442	32
7443	60
7444	60
7447	39
7448	36
7450	17
7451	16
7453	16
7454	17
7460	15
7470	24
7472	16
7473	24
7474	20
7475	25
7476	30
7480	35
7482	65
7483	38
7485	60
7486	19
7489	110
7490	24
7491	30
7492	27
7493	27
7494	35
7495	29
7496	40
74100	85
74104	37
74107	22
74121	24
74123	30
74125	29
74126	29
74141	35
74151	30
74154	55
74155	35
74156	35
74157	30
74190	45
74192	45
74193	45
74393	78

CMOS

4000	10
4001	10
4002	12
4006	48
4007	14
4008	36
4009	24
4010	22
4011	11
4012	14
4013	20
4014	40
4015	38
4016	20
4017	34
4018	42
4019	24
4020	40
4021	40
4022	30
4023	14
4024	32
4025	13
4026	75
4027	20
4028	36
4029	36
4030	15
4041	40
4042	35
4043	35
4044	35
4046	46
4049	21
4050	21
4060	45
4069	13
4070	13
4071	13
4072	13
4081	13
4082	13
4093	29
4510	40
4511	40
4511	85
4516	45
4518	45
4520	45

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ANALOGUE

709C5	55
709C14	44
723C14	36
741C5	57
741C8	16
741C14	47
747C14	65
748C8	35
1458C5	62
1458C14	40
7106	600N
7107	600N
555	18N
7555	80N
556	50
CA3046	70N
CA3080E	70N
CA3130E	90N
CA3140E	45N
LM301AN	25N
LM308N	60
LM317K	295
LM324N	32
LM348N	55
LM380N	66
LM380N8	80
LM381N	195
LM382N	45
LM3900N	50
LM3914N	200
LM3915N	200
NE555V	18N
NE556A	50
NE567N	104
RC4151NB	66
S041E	290
S041P	121
S042E	364
S042P	138
S89	11.23
S178BA	28.50
S187	11.95
S566B	214
S576A	235
S576B	235
S576C	235
S576D	225
S1469	468
SAB0600	302
SAB3209	425
SAB3210	311
SAB3211	168
SAB3271	329
SAB4209	497
SAB8256C	35.40
SAD1024	11.00
SAJ131	238
SAJ141	278
SAJ205	810
SAS231W	260
SAS251	142
SAS580	196
SAS590	196
SDA5680A	15.55
TAA761	104
TAA761A	49
TAA765A	62
TAA861	103
TAA865A	59
TAA2761A	72
TAA4761A	113
TAA4765A	120
TAB1041W	187
TBA120AS	62
TBA120U	72
TBA400	100N
TBA800	75
TBA10S	75
TBA820	75
TBB1458	62
TBB1458B	40
TCA105	120
TCA105B	108
TCA105G	140
TCA250A	185
TCA205K	200
TCA335A	66
TCA345A	109
TCA345W	177
TCA671	131
TCA780	211
TCA871	114
TCA955	228
TCA965	120
TCA965K	170
TCA971	92
TCA991	80
TCA991K	100
TDA2002	120
TDA2003	126
TDA2030	150
TDA4050B	144
TDA4290	169
TDA4600	184
TDA4700A	546
TDA4713A	435
TFA1001W	252
TL071CP	25N
TL072CP	45N
TL074CN	40
TL081CP	25N
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Buz 54A	TO3	1000	4.6	125	£20.45
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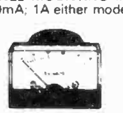

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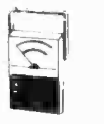

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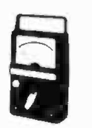
£16.45N



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Type CK – 1P/12 way, 2P/6 way, 3P/4 way, 4P/3 way **48p**; Min Toggles – S7101 SPDT **57p**; S7201 DPDT **80p**; S7301 3PDT **£1.64**; S7203 DPDT **96p**; PB min. 8531 mk 8533 br **62p**; 8225 DPDT **£1.34**.
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Ceramic Very small 1.8, 2.2, 2.7 etc. up to 1n, **5p each**. 1n5, 2n2, 3n3, 4n7, 6n8, 5p; 10n, 22n, **6p**; 33n, 47n, **7p**; 100n, **8p**.
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4.7/100	14	100/10	12	1000/25	36	6.8/16	16
6.8/40	9	100/16	12	1000/40	44	6.8/25	24
10/25	9	100/25	12	1000/63	76	10/6.3	16
10/40	11	100/40	15	2200/6	09	10/16	18
10/63	12	100/63	20	2200/16	44	10/25	18
10/100	15	100/100	27	2200/25	60	22/6.3	18
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47/3	03	220/100	42	**BEARS**		100/10	66
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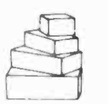

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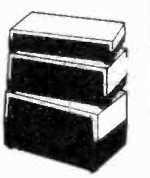

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PE7

PE VOLUME 19 No. 7 JULY 1983

MICROCHIPS AND MEDICINE

IN these days when we read so much about nuclear armaments and defence electronics and when so many electronics companies rely heavily on Ministry of Defence contracts, it is good to hear how British electronics is to the forefront in the medical world. We do not intend to look at the ethics of the engineer in the armaments industry. The subject of "Microchips and Megadeaths" has been well aired in *Wireless World* and indeed has made fascinating reading and provided plenty of food for thought. The multi-faceted subject will no doubt be discussed at even greater length around the world in the coming years—we hope so anyway.

Much less controversial but just as important is the contribution electronics can make to the everyday lives of many who suffer from various illnesses. Most of us are well aware of the contribution to medicine of the X-ray scanner or ultrasonic sonar techniques, even of home dialysis machines, but next time you are in a hospital just take in the amount of electronics involved, starting with the doctor's bleeper and electronic notepad. It doesn't take long to realise that over the years just about every aspect of medical practice has been assisted by some form of electronics. For instance many G.P.s have been at the forefront of "real" applications for the microcomputer and now specialist systems and software are available just for them.

This spread of electronics is becoming apparent in our everyday lives. It is not unusual to find a pulse rate monitor in a sports centre or gym, a faradic massager or electrolysis unit in a beauty parlour, even electronic scales in our homes. They are all related to medicine—perhaps loosely—and demonstrate our acceptance of electronics in this area.

The application of electronics in research is also fascinating. Relaxometers are being used in cancer treatment and e.s.p. research, areas which are relatively new and controversial in the medical profession. (PE will be returning to this subject in future issues.)

Perhaps the best examples of applied electronics are those that assist patients to "treat themselves" and to lead normal lives instead of being hospitalised. This year two pieces of electronic equipment that do just that have been given Design Council Awards for outstanding British products in the medical field. Both items are relatively inexpensive, as medical equipment goes, and both have been designed for patient use.

The items are:

A portable syringe driver from Graseby Medical, designed to provide a continuous infusion of a drug from 1 to 99mm per hour. The unit is small enough to fit a normal pocket for ambulant patients.

A blood glucose monitor which enables diabetics to monitor their own blood glucose level. The unit has automatic calibration and temperature and humidity correction, is also pocket sized and has been designed by Hypoguard Ltd. to be easily used by the patient.

We would like to add our congratulations to these award winning companies and to the engineers behind the products. Perhaps this is one of the best applications of modern technology and therefore one of the most rewarding in which to work. It is an area of interest we will return to in the coming months.

Mike Kenward

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Components and p.c.b.s are usually available from advertisers; where we anticipate difficulties a source will be suggested.

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HYDRO-ELECTRIC GIANT

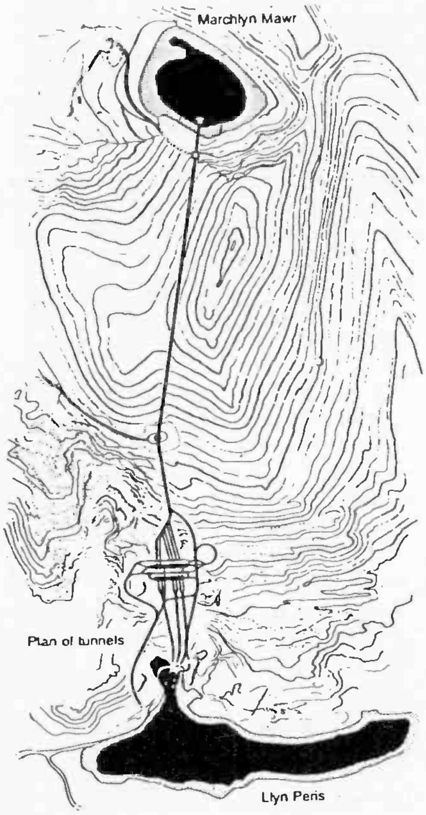
Around three million tonnes of slate have been excavated in North Wales to create a subterranean engineering marvel: the Dinorwig generator. The pump chamber which houses the main plant is in itself one of the largest man-made caverns in the world—twice as long and half as wide as a football pitch and higher than a 16 storey building.

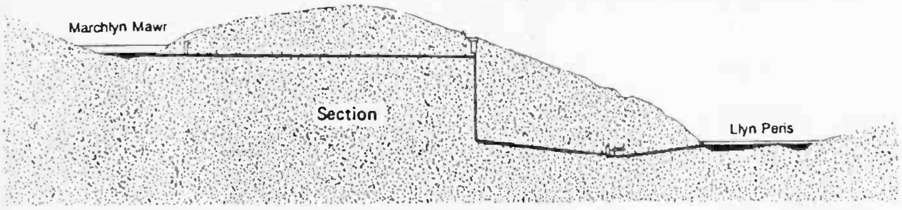
The Dinorwig pumped-storage power station is presently being commissioned by CEGB engineers in the Welsh mountains. Pumped-storage schemes are used to store 'potential electrical energy' in a massive body of water in the higher of two reservoirs. When electricity is needed by the national grid, the plant is used like an ordinary hydro-electric system. On its path from the higher to the lower reservoir the water drives six huge turbines which in this case can provide a constant output of 1,680MW over a five hour period.

It then uses cheap rate electricity to return the water to the higher level by reversing the role of the turbines and using them as motor pumps. Power for pumping is used only during 'off peak' periods. Generated power is used only at times of 'peak demand' and at lower cost than the old (and less efficient) power stations that would otherwise have to be brought into operation. Consequently, large sums of money can be saved—even though only three units of electricity can be generated for every four used in pumping.

Dinorwig will provide a faster, more reliable and cheaper 'immediate reserve' than that provided by steam stations. It will give the national grid greater flexibility and cheaper power at a price that could be approached in no other way. It is expected to save millions of pounds during each year of its operational life.

This project will be the subject of a detailed feature article to be published in PE later this year.





Surrogate Companion

Once upon a time children's story books were chunky, stiff-paged affairs, with cartoon pictures at the top of each page and a bold-printed storyline along the bottom. The scheme was that the words would be large in typesize, small in length, and most important of all, English! *Mum* or *dad* would *personally* teach their offspring to read with the help of the funny stories therein, and all would live happily ever after.

Now, in another decade it may not be uncommon to encounter youths who deliver their words with the intonation (or lack of it) of a voice synthesiser, and who can only read bar code. These will be the ones growing up now with the latest concept in twentieth century story books.

The photograph shows the Texas Instruments computerised storybook reader. To learn to read, the child simply runs a light pen across the bar code accompanying each picture, which instructs the voice synthesiser what to "say". Sound effects and music may also emanate from the "Magic Wand Speaking Reader" as it is called, making it a real boon to the tone deaf parent.

Does this teaching aid live up to the standard set by TI's excellent "Little Professor" and "Speak & Spell"? The spectre of the thoroughly modern family unit, in which Mr. and Mrs. Gizmo are wrestling over the cable TV selector, whilst junior tucks himself up in bed to the metallic voice of a silicon storyteller, is forming its first pixels, so to speak.

TOWERS

The fifth title in the series of Towers' Selectors now brings the list of these classic data books to: *FET, OP-AMP LINEAR IC, TRANSISTOR, MICROPROCESSOR,* and *DIGITAL IC Selectors*. The author, T. D. Towers MBE MA BSc CEng MIERE has created a handy "user-slanted" reference work covering the vast field of digital i.c.s. The latest selector includes a full introduction which describes the various i.c. technologies and types, followed by tabulations giving device descriptions and control specifications. Devices are listed in alpha-numerical order, and the contents are, as expected, international, covering products from the UK, USA, Europe, Eastern Europe and Japan. Current and obsolete devices are copiously described, pin compatible equivalents indicated, and cross-references included where common specifications between manufacturers occur.

The tables are supported by separate appendices to give pin-out and package information, and manufacturers' proprietary house codings. *Towers' International Digital IC Selector* measures 248 × 174mm, has 256 pages, and costs £9·95. Published by W. Foulsham & Co. Ltd., Yeovil Road, Slough, Berkshire.

MARKET PLACE

Prestel Experiment

Go on, you remember Prestel, don't you? *Interactive* Information Technology brought to your lounge. Okay, perhaps not to your lounge, but to your office, at least. No? Well, in the words of British Telecoms' Prestel supremo, Richard Hooper, the service "had the method of delivery but the package of information services was not right."

All has changed with the introduction of Club 403, an experiment designed to probe the potential of a mass market, and which scrolled into life in March this year. The pilot scheme is confined to the West Midlands, and returns with it the prospect of teleshopping from the chaise longue, if only for 2500 bargain rate subscribers. At the outset, about fifty vendors were seriously interested in participating at the business end, among them Curry's, DER and Radio Rentals. Citibank Savings cite the occasion as being a "valuable step towards home banking/shopping", whilst the marketing manager of Imperial Life Assurance of Canada says, of formulating personalised quotes, enquirers "can be *led through* an analysis of just what income they would need to exist in an emergency". Peugeot Talbot UK take test drive bookings through what is known as the "response frame."

The reality of life for Club 403 members is that they either have, or may look forward to, such services as a *swop-shop, electronic message board, local weather* and *road situation reports;* they may send flowers and gifts from stores like Lewis's and Rackhams (and video greetings), book theatre seats, and even enrol on local courses. The service includes what is claimed to be the world's first *electronic newspaper*. Might the Commons debates on shop opening hours become academic in the long term? Twenty-four hour electronic trading is quite legal.

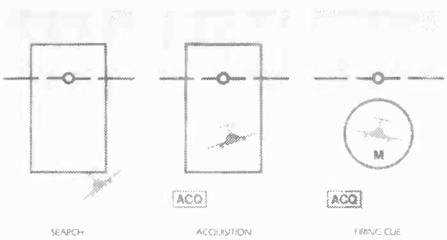
Of course, information about local entertainments and public transport timetables is included, but subscribers will, for example, find all restaurants listed by area and food type, rather than only those prepared to pay for advertising.

Club 403 is a service provided by Viewtel Services Ltd. (sister company of Birmingham Post & Mail) and Prestel. This pilot system combines the use of Ceefax, Oracle and Prestel, the latter providing the *interactive* database. Ultimately, telepurchasing of "low risk" goods—those which require no inspection prior to purchase—is envisaged. The customer's bank account would be automatically debited, and then the goods delivered to the door. The question is: would this require an army of delivery boys, or robots?

HEAD-UP DISPLAY

Soaring through the skies, duelling with laser-guided obliteration, where all that stands between a pilot and eternity is the wits to outmanoeuvre a tenacious air-to-air missile, split seconds have a currency few can appreciate.

The scientists and engineers who develop military hardware are very familiar



with the split second, particularly those involved with aviation; which is why HUD (Head Up Display) exists. Its purpose is to allow the pilot of a fighter aircraft to view his instruments without having to glance down at the instrument panel—a movement which costs living seconds. The HUD reflects the digital read-outs and such data as the artificial horizon, onto the cockpit glass, with focus at infinity. The pilot neither has to move his head, nor refocus his eyes from the horizon (or target) in order to assimilate flight/combat information.

Apart from a navigation mode, the HUD can also superimpose the weapons-aiming computer's cross-hairs, and other graphics, on the real target when attacking a surface or air alien. Ferranti's type FD4500 HUD (shown in the photograph) can control the entire weapons system, and will project a *drift-compensated bomb fall line* down the pilot's field of view during the run-in to a surface attack. In this, one of many modes of operation and display formats, elapsed time-to-bomb release is graphed as an uncoiling circle. If the target has already been entered into the computer as a waypoint, the attack can take place in the absence of visibility. The inertial navigator, laser rangefinder, computer and HUD combine to make a combat system which has a distinctly Starwars flavour.

Patents, Copyright, Trade Marks...

Laurence Shaw is the author of "The Practical Guide for people with a new idea", which explains the need for, and the ins and outs of, patents, copyrights and trade marks.

The purpose of the book is to show how the fruits of ingenuity can be protected, and innovation made profitable. Market research is explained, along with how to approach a manufacturer with an idea, the importance of design registration, patenting and the secret patent. The reader may discover how to search to check that his or her idea is original, and how much a patent will cost, and for how long its protection will last. The relationship between the UK and overseas patent is explored, and how to arrange licensed manufacture.

The work is easy to read; it puts its reader in touch with the correct terminology, and is peppered with entertaining facts. For example, did you know that the Rolls-Royce Silver Cloud was at first to be called the Silver Mist, until their German distributor pointed out that *mist* in German means *manure?* On a more serious note, did you know that if a patented invention is not put to use, its owner can be instructed to *license* a third party to use it, like it or not? Does something invented at work belong to the employer, or the employee? *The Practical Guide for people with a new idea* will show how to distinguish who is the rightful owner. Well worth reading.

The 98 page paperback (measuring 150 × 210mm) costs £5·95 post paid, and is available from Laurence Shaw, George House, George Road, Edgbaston, Birmingham B15 1PG.

Items mentioned are available through normal retail outlets unless otherwise specified. Prices correct at time of going to press.

...NEWS &

ELECTRONICS KIT

Midland Ross Cambion have produced a low cost experimental kit to help in the teaching and understanding of basic electronics in schools and for use by Training Officers responsible for training apprentices.

The kit, which offers 31 different experiments and applications complete with teachers' notes, has been developed and tested over the past two years before being introduced this Spring.

No soldering is required and each of the 31 experiments is produced on a hard wearing laminated card. To ensure that teachers have a regular supply of worksheets, photocopy masters are provided free of copyright.

Stage two of the kit will be launched in the Autumn of this year.

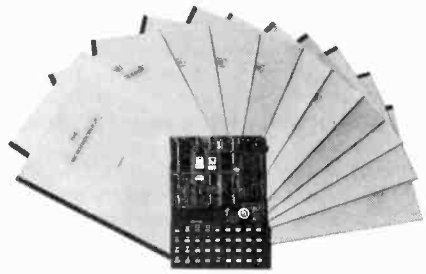
The full kit is priced at £35·21 including VAT and p&p. Part kits and replacement components are also available.

For further details contact Cambion Electronics Products Ltd., Castleton, Sheffield S30 2WR (0433 20831).

Postal Course

There are a number of postal tuition courses available from British companies and we are often asked, especially by overseas readers, if we can recommend them. We recently visited one of the companies involved and were impressed with the thoroughly professional approach and back up provided.

The British National Radio & Electronics School operate from Reading and provide a wide range of home study courses from basic electronics right up to City & Guilds Telecommunications Certificates. This long established company has just added a microprocessor course to its list.



The course is based on the well known Micro-Professor microcomputer equipment and the combination gives a complete theory and practical self study training programme in this field. The course comes complete with a Micro-Professor and provides a new four book user manual for the unit. Students have the advantage of having continuous contact with a specialised teacher who will guide them through the course and set a number of exercises to test knowledge at various stages.

Some of the courses are available in many different languages and the electronics course is also used in many industrial training schemes by firms in the UK and abroad. The School is recognised and approved by the Council for the Accreditation of Correspondence Colleges in the United Kingdom.

Full details from BNRES, 55 Russell Street, Reading, Berks or Tel: 0734 51515.

Silicon News Corner

Bulletins announcing new semiconductor devices arrive at PE daily, so it is possible only to describe them briefly. Details of how to obtain further information are included, however.

Intersil ▶ The ICL7135 is a precision 4½ digit, single chip A-to-D converter features multiplexed BCD output and digit drivers, combining dual slope conversion reliability with ±1 in 20,000 count accuracy. Auto-Zero to less than 10μV, zero drift of <1μV/°C, input bias of 10pA and rollover error < one count.

▶ IM6657/IM6658 are 8192-bit, fully decoded CMOS UV EPROMs. 550μW standby with 300ns access time, these TTL compatible memories are also fully compatible with Intersil's standard CMOS ROM/EPROM family.

▶ IM6716 is a 16,384-bit CMOS UV EPROM requiring a single 5V supply. Fully decoded, and organised as 2048 8-bit words, this device has TTL compatible tristate outputs.

▶ ADC0801-ADC0804 8-bit μP compatible A/D converters are MCS-48 and MCS-80/85 compatible on memory or I/O mapped basis. Conversion time is < 100μs. Incorporate on-chip clock generators, 0-5V input range, differential input, and no zero-adjust necessary. Will operate "stand-alone".

▶ A/D converter with direct drive multiplexed LCD output, is called the ICL7129. A 4-½ digit CMOS converter, it uses "successive integration" to obtain 0·005% FSR accuracy, and 10μV resolution. Draws 1mA at 9V, and has "Low Battery" indication. Intersil Datel (UK) Ltd., Snamprogetti House, Basing View, Basingstoke, Hants.

Mullard ▶ A high performance 14-bit hybrid DAC called the OM901 contains the nakid chip of the established TDA150, plus the peripheral components needed for a 14-bit DAC. Has high linearity and excellent S/N ratio (85dB typical). Can handle 16-bit signal if used with SAA7030 digital filter.

▶ Two new hybrid inductive proximity detector i.c.s from Mullard are the OM386 and OM387, for +Ve and −Ve supply voltages respectively. Small enough to fit M8 size Cenelec hollow stud, yet have direct relay drive O/P (400mA @ 10–30V). Detection range 1·5mm when used in M8 tube.

▶ The BU505 is a 1500V/2A transistor for CTV deflection circuits. This TO-220 transistor has 75W power and typical t_f of 0·7μs.

▶ Three new Schottky diodes: BA481, BAT81/82/83 and BAT85 are DO-34 glass encapsulated. These offer forward voltage similar to germanium and short recovery time, being majority carrier there are no storage delay problems.

▶ Three new high voltage, glass passivated n.p.n. switching transistors: BUW11/12/13. Plastic SOT-93 encapsulation, intended for power converters, inverters, switch-mode PSUs and motor control. Typical Vceo 450V, and power 125W.

▶ New AM/FM radio i.c. called TEA5570 is resistor programmable and of hi-fi quality. Has wide a.g.c. for car radios, and consumes only 6mA @ 6V (supply 2·7–12V) making it suitable for portable equipment. Can be diode tuned and works up to 30MHz.

▶ Electronic humidity sensor, type 2322 691 90001, offers 10%–90% relative humidity range. Works capacitively from 110pF to 150pF using metallised film. Worst case accuracy is 5% mid-range. Mullard Ltd., Mullard House, Torrington Place, London WC1E 7HD.

Laser Light

The light beam from a CO_2 laser is used in Ferranti's MF400 drawing system, which can precision cut quartz, paper, silica, rubber, thin gauge metal, plastic, fibre glass and ceramics—almost any sheet material, in fact, including carpet and cloth. The Dundee plant's workshop laser can cut out patterns, etch signs, weld, and bore holes. The pattern to be burned out is first digitised by the CNC (Computer Numerical Control) unit, reproduced on a graphics VDU, and then rescaled to any size.

MARKET PLACE

The advantages of laser cutting seem endless, and include improved speed of production, reduction in waste due to more efficient pattern nesting, precision repeatability (essential for inlay work), and low distortion of material from heat.

One of the interesting features of the MF400 is that it recirculates its gases, reconstituting them for re-use. Most CO_2 lasers waste their helium, nitrogen and carbon dioxide because once thay have passed through the laser resonator, the CO_2 decomposes into carbon monoxide, and the helium becomes contaminated. These unusable gases are consequently expelled into the atmosphere. The MF400's recirculation system cuts gas costs by a factor of ten.

Briefly...

Konica, the long-established Japanese photographic company, is this month entering the tape market with a range of audio and video cassettes. The tapes will be launched under the Konica brand name and will be available in a full range of lengths and formats. Konica have developed their tape technology in association with Ampex, a name long-associated with the highest standards in the tape market. The products stemming from this association are, according to Konica, of outstanding quality.

A truly "unbreakable" code has been developed, which is based on prime numbers. Professor Adi Shamir of the Weizmann Institute, who developed the code jointly with Leonard Adelman of the Massachusetts Institute of Technology, claims that this is an entirely novel concept in public communications. It should soon be widely used, particularly in the coming era of home banking, as security is one of the stumbling blocks to this. A prototype chip which can do the cryptographic computations is currently being tested.

● ● ● ●

Fairchild is withdrawing from the opto-electronics business, closing its Santa Clara and San Jose plants. The company is also pulling back from the MOS market.

● ● ● ●

Japan's Kyoto University has created an optical transistor that could become the basis of a completely optical computer. The device is a natural for optical fibre communications; once activated by a low voltage it can amplify a 50mW laser beam applied from beneath, with a gain of four. The device emits the amplified light from its upper surface. Signals below a threshold are not amplified, and the device has the potential to store data indicating which signals have been amplified, and which have not.

A toothbrush that uses ultrasonics to mix the toothpaste with water, without shattering teeth, has been developed by scientists at NASA. The resultant, mildly abrasive spray is directed at the teeth during brushing.

● ● ● ●

A low-cost, high-integrity edge connector which eliminates 'RAM-pack wobble' and allied problems on home computers has been developed by BICC-Vero Connectors. The new 908 Series uses a novel plating process that does not involve gold, thereby keeping the cost down, but the contact design ensures a retention force and reliability much higher than that of normal mass-produced types. The new connector is to be used in proprietary RAM-packs and Sinclair RAM-packs for the ZX range of computers.

POINTS ARISING...

INGENUITY UNLIMITED

Lighting Effects Unit April '83

In Fig. 2 a 1N914 diode should be inserted between VR101 and the junction of VR102 and C101 with the anode towards VR101.

Countdown...

Please check dates before setting out, as we cannot *guarantee* the accuracy of the information presented below. Note: some exhibitions may be trade only. If you are organising any electrical/electronics, radio or scientific event, big or small, we shall be glad to include it here. Address details to Mike Abbott.

The Computer Fair June 16–19. Earls Court. **Z1**
Compec North June 21–23. Belle Vue, Manchester. **Z1**
Transducer/Tempcon June 28–30. Wembley Conf. Cntr. **T**
Leeds Electronics Show July 5–7. University. **E**
Satellite TV & Cable TV July 5–7. Alex. Palace, London. **G4**
IBM User Show July 12–14. Wembley. **O**
Internoise (noise control conf.) July 13–15. **A7**
BAEC Amateur Electronics July 16–24. Shelter, Esplanade, Penarth, S. Glamorgan. **B9**
Laboratory Edinburgh July 18–20. University. **E**
Star '83 Aerospace July 21–24. RAF Greenham Common. **Z1**
Acorn Exhibition Aug. 25–28. Cunard Int. Hotel, Hammersmith, London. **J3**
BARTAG Rally (radio teleprinter) Aug. 29. Sandown Park, Esher, Surrey. **E2**
ElectroWest Sept. 6–8. Bristol Exhibition Centre. **Q**
Weldex Sept. 12–16. NEC B/ham. **I**
Testmex Sept. 13–15. Grosvenor House, Park Lane, London. **E**
Home Entertainment Spectacular Sept. 17–25. Olympia. **I2**
Personal Computer World Show Sept. 28–Oct. 2. London. **M**
Laboratory London Oct. 12–14. Barbican Centre. **E**
Drives/Motors/Controls Oct. 12–14. Leeds University. **E**
Computer Graphics Oct. 18–20. Wembley. **O**
PARC (computers in architecture, conf.) Oct. 18–20. Wembley. **O**
International Business Show Oct. 18–26. NEC. **T**
Business Efficiency Exhibition Oct. 22–26. Earls Court, London. **Z**
Electronics Hobbies Fair Oct. 27–30. Alex Pavilion, London. **Z1**
Electronic Displays Nov. 1–3. Kensington Exhibition Centre, London. **D4**
Compec Nov. 15–18. Olympia, London.
Northern Computer Fair Nov. 24–26. Belle Vue, Manchester. **Z1**
Intron Nov. 22–24. RDS Hall, Dublin. **V**
Automatic Testing/Test/Instrumentation. Dec. 13–15. Metropole, Brighton. **D4**

A7	Institute of Acoustics ✆ 031-225 2143
B9	Cyril Bogod, British Am. Elect. Club ✆ 0222 707813
D4	Network ✆ 02802 5226
E	Evan Steadman ✆ 0799 22612
E2	BARTG 89 Linden Gdns., Enfield, Middx.
G4	Intech Exhibitions, 55 London Rd., St. Albans
I	Industrial Trade Fairs ✆ 021 705 6707
I2	Alan Taylor ✆ 01-486 1951
J3	Computer Marketplace ✆ 01-930 1612
M	Montbuild ✆ 01-486 1951
O	Online ✆ 09274 28211
Q	Exhibitions for Industry ✆ 08833 4371
T	Trident ✆ 0822 4671
V	SDL Exhibitions ✆ Dublin 763 871
Z	BETA Exhibitions ✆ 01-405 6233
Z1	IPC Exhibitions ✆ 01-643 8040

ULTRALIGHT

INTRUDER ALARM Plus AUTOMATIC LIGHTING

G. DAVIES

THE Ultralight/Ultralarm system is designed to allow the detection of movement within a secure envelope to operate a light switch or trigger an alarm. Built into the attractive case specified it can be used to foil housebreakers, or simply to make the light come on in a room as soon as it is entered. An ambient light detector is inbuilt for this purpose. In the latter application the low-power consumption Ultralight is ideal for stairways and corridors, and may be adjusted in situ for the most appropriate sensitivity. Many as yet unthought of applications may be dreamed up for this movement detector.

CIRCUIT DESCRIPTION

Device IC1a, R1, R2, C2 and Xtal form a self starting 32·7kHz crystal oscillator, the output of which feeds a bridge buffer stage comprising IC1c,d,e and f to increase the drive voltage to the ultrasonic transmitter X1. R3 limits the loading on IC1. R4 and C1 decouple the oscillator stage from the 8V stabilised rail to lower the power consumption of the driver stage for low quiescent current—a major power saver in this circuit, and essential for direct mains operation with optional mains adaptor.

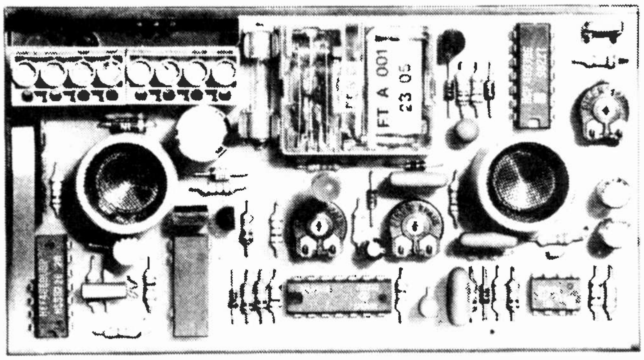
The output of the ultrasonic receiver X2 feeds IC2 via C4 whilst R5, R6, C3 and R7 form the bias for IC2, R9, R8 and C5 determine the gain at 32·7kHz. The output of this stage goes via R10 to the detector D1, R11 and C6 to remove the 32·7kHz and obtain the "Doppler" frequency produced from the 32·7kHz envelope. The resultant Doppler frequency is amplified by IC3a, the bias derived from the diode pump detector and the gain of the stage determined by the Range control VR1, R13, R12 and C7 before passing through R29 to the modified diode pump detector formed by IC3b, C8, D3, D2, R15, R14 and Sensitivity control VR2. The values of C8, C9, R14 and R15 and the setting of VR2 optimise the response of the detector for individual requirements, either responding to a half-step of movement or two steps to reduce the possibility of a false alarm considerably.

The output of the diode pump detector, which is a varying d.c. level with movement, feeds the comparator stages formed by IC3c and IC3d. R22, R17, R18 and IC3d form a Schmitt trigger driving RLA1 on via TR1 and drive resistors R19, R20 and D4 suppressing the back e.m.f. of the reed relay coil. IC3c inverts the output of IC3d before driving the Walk Test l.e.d. D5 via R23.

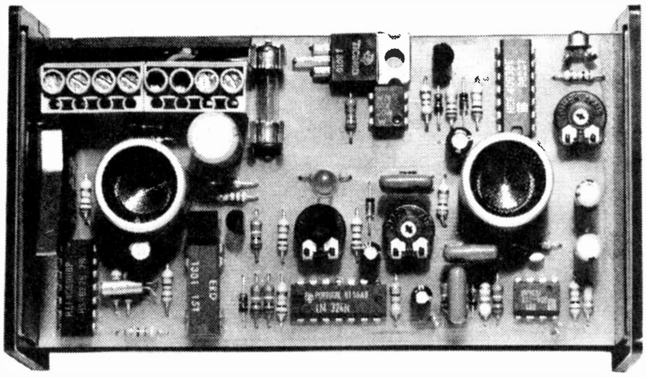
To prevent lead capacitance effects on long runs, R21 was included so as to prevent the reed relay contacts "sticking".

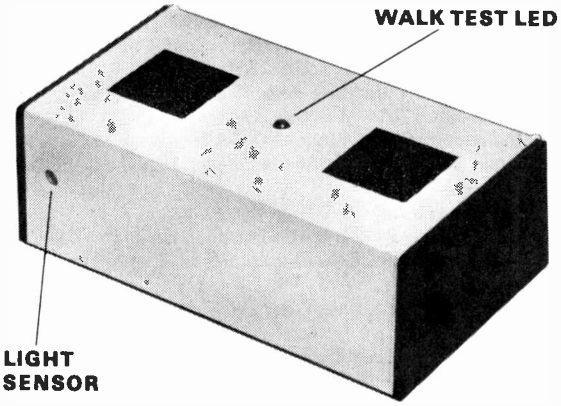
LIGHT LOGIC

In high ambient light conditions the l.d.r. is a low resistance pulling pin 6, IC5 high (dependent upon the setting of VR3 and value of R24). Initially IC5 pin 5 is high, causing IC5 pin 4 to be low, thus closing gate IC5a, and



The same p.c.b. layout will accept either the relay or the triac alternative output components





ULTRASONIC MOVEMENT DETECTOR

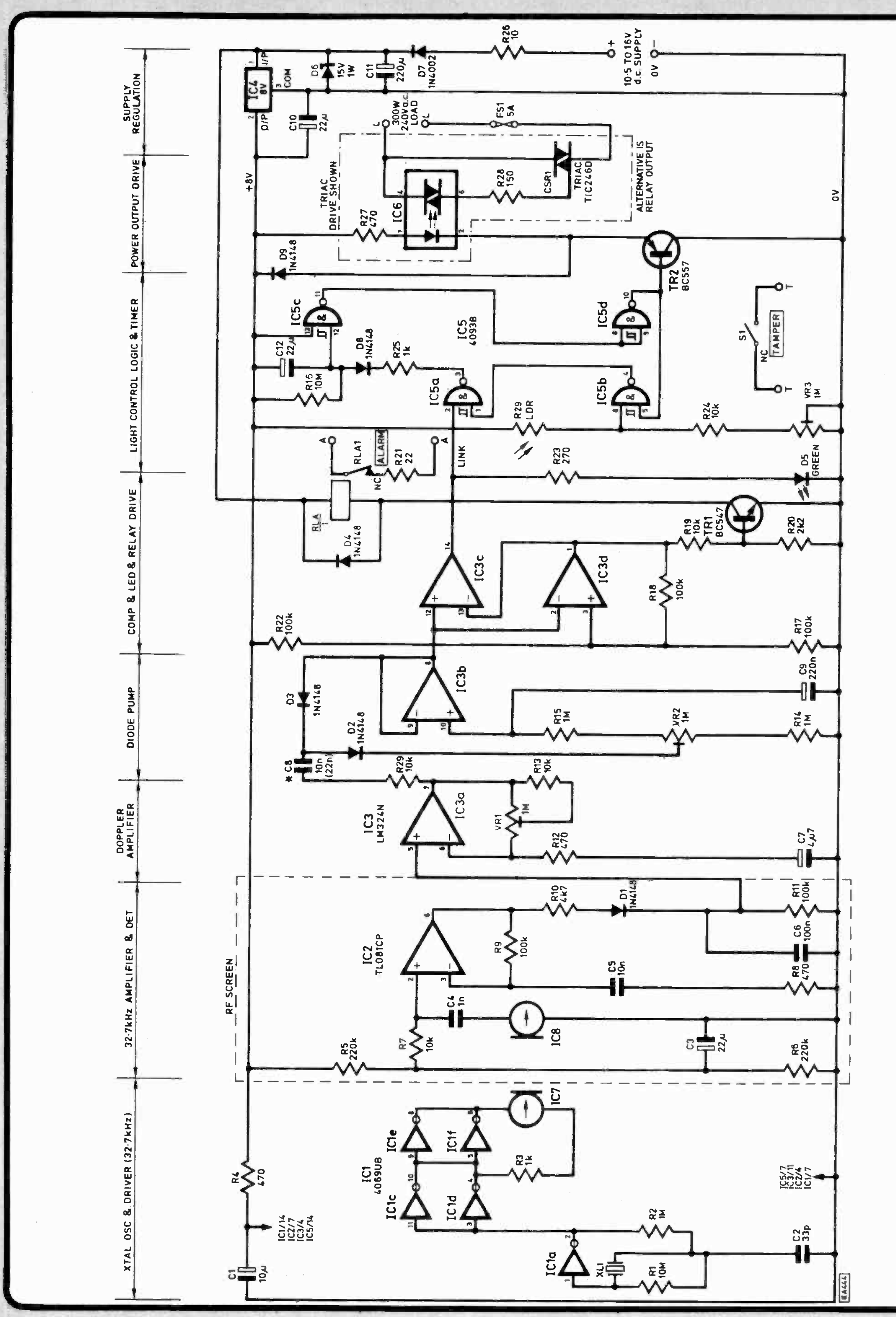


Fig. 1. Circuit diagram (showing triac output)

preventing the "movement" signal from activating this stage. If the ambient light level is low the input of IC5b pin 6 is low, the output on IC5 pin 4 is high, opening the gate IC5a, allowing the "movement" signal to cause IC5 pin 3 to go low. This passes through R25, D18 rapidly charging C12, causing IC5c pin 12 to go low, and the output on IC5 pin 11 high. IC5d inverts the signal and its output on pin 10, goes low, driving the emitter follower TR2 and opto coupled triac IC6, the current being limited by R27, causing the slave triac to fire the master triac, CSR1, via R28. FS1 is included for overload protection for CSR1. Note that this output stage is for *filament* lamps only.

Once CSR1 is on, the output of IC5d feeds IC5b pin 5 with a low signal to prevent the ambient lighting affecting

SPECIFICATION

Model	2000	2001	2002
Frequency	32·765 kHz		
Linear Range	8 metres		
Operating Temp	−10C to +40C		
Voltage	10·5 to 16V d.c. or 240V a.c. with mains adaptor (not 2002)		
Current	16mA quiescent		
Alarm	A normally closed contact rated 200mA at 30V d.c.		
Walk test	Green l.e.d.		
Controls	(a) Range pot 2m to 8m (b) Sensitivity pot ½ step to 2 step (normal)	(c) Light level control pot	
Controller Load		Triac 240V 300W	Relay 240V 1kW
Protection		Internally fused	
Dimensions	122 × 70 × 44mm		
Net weight	160 gm		
Colour	Black and white		

Compatibility
Both the alarm and tamper outputs are left uncommitted to enable the unit to match any alarm installation. The alarm section complies with BS4737 Part 3 Section 3.5.

RF Screening
An important feature of the unit has been to ensure that the sensitive electronics are screened from radio frequency interference. This can reduce false alarms considerably. (If screen can fitted as supplied in the kit.)

Crystal Control
By the use of crystal control precise setting of the stable operating frequency is achieved allowing a number of single units to be fitted in the same environment without mutual interference.

Walk Test LED Indicator
To simplify the installation the unit has a walk test l.e.d. which indicates the trip state of the detector.

COMPONENTS . . .

Resistors

R1, R16	10M (2 off)
R2, R14, R15	1M (3 off)
R3, R25	1k (2 off)
R4, R8, R12, R27	470 (4 off)
R5, R6	220k (2 off)
R7, R13, R19, R24, R29	10k (5 off)
R9, R11, R17, R18, R22	100k (5 off)
R10	4k7
R20	2k2
R21	22
R26	10
R23	270
R28	150
R29	CDS cell

All resistors ⅛W 5%

Potentiometers

VR1, VR2, VR3	1M hor. preset (3 off)

Capacitors

C1	10μ elect.
C2	33p ceramic
C3, C10, C12	22μ/25V elect. (3 off)
C4	1n ceramic
C5	10n poly
C6	100n poly
C7	4μ7 submin elect.
C8	22n poly
C9	220n submin
C11	220μ/16V elect.

Transistors & Diodes

D1-4, D8, D9	1N4148 (6 off)
D5	Green l.e.d. (5mm)
D6	15V 1W Zener
D7	1N4002
CSR1	TIC 246D triac
TR1	BC547
TR2	BC557

Integrated Circuits

IC1	4069UB
IC2	TL081CP
IC3	LM324N
IC4	78L08
IC5	4093B
IC6	MOC3020
IC7	T32-18
IC8	R32-18

Miscellaneous
D.i.l. reed relay (RLA)
XL1: 32·7kHz
Tamper switch: norm. closed μswitch
FS1: 5A plus clips
4-way p.c.b. mounting terminals (2 off)
Printed circuit board
Case
Screen can (optional)
AT Foam
Bracket
Relay (if used as alternative to IC6, CSR1, R28 & R27)
X1, X2: 32kHz ultrasonic transducers (2 off)

Constructors' Note
A complete kit is available for the ULTRALIGHT, from **GJD Electronics** 105 Harper Fold Road, Radcliffe, Manchester M26 0RQ.
The full kit is available at the special price of £24.50 +60p p&p plus VAT to *PE* readers.

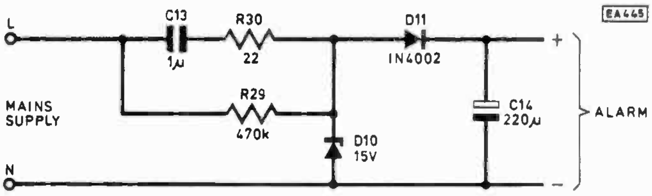


Fig. 2. PSU circuit diagram

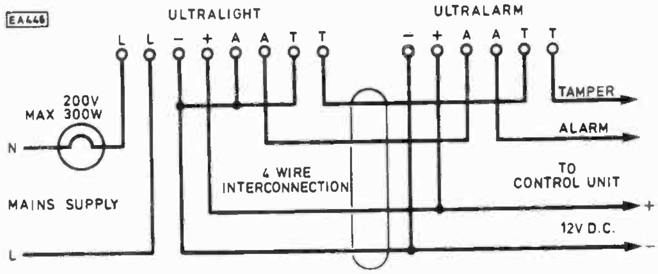
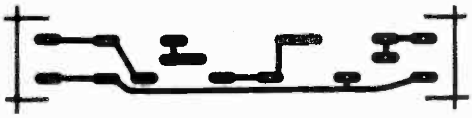


Fig. 6. Interconnecting the Ultralight

Fig. 3. PSU printed circuit layout (actual size)



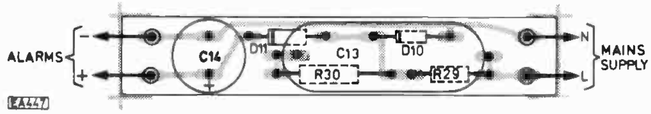


Fig. 4. PSU component layout

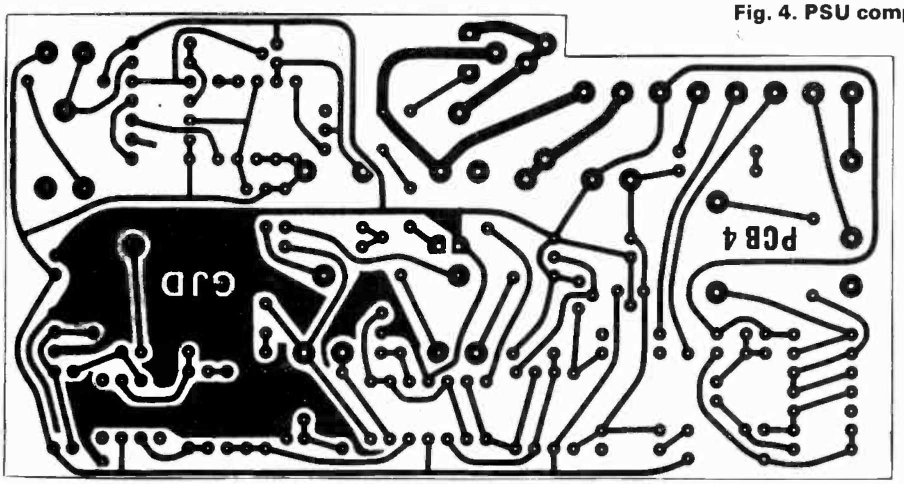
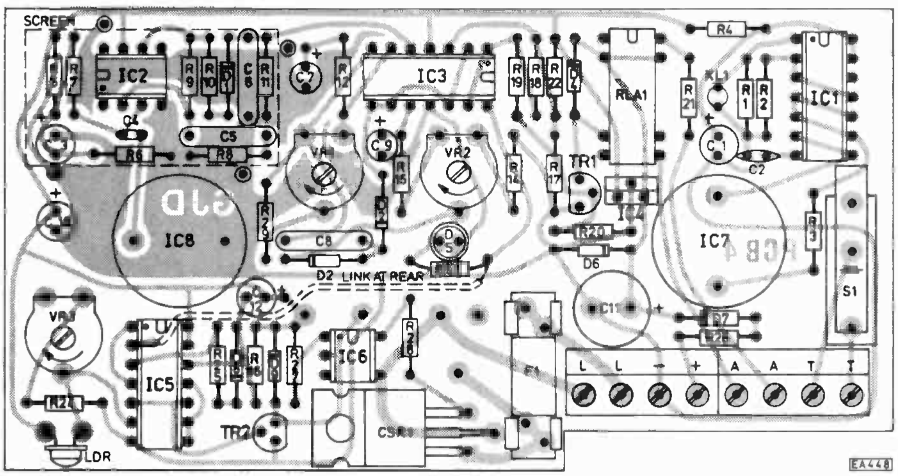


Fig. 5 left. Ultralight p.c.b. (actual size)



COMPONENTS . . .

PSU

Resistors

R29	470k
R30	22 ½W
R31	4k7

Capacitors

C13	1μ/400V
C14	220μ/16V

Diodes

D10	15V 1W
D11	1N4002

Miscellaneous

Printed circuit board

NB. FOR MAXIMUM SAFETY ENSURE THE NEUTRAL OF THE MAINS IS CONNECTED TO THE "−" OF THE ULTRALIGHT —THE ALARM IS NOW OPERATING AT MAINS POTENTIAL AND THIS MUST BE CONSIDERED WHEN TESTING THE UNIT.

the control section which can now be repeatedly retriggered by movement only. After a period of no movement and the time-out of C12 and R25 the lamp will extinguish.

The d.c. power supply is fed via R26, reverse polarity protection diode D7 and overvoltage and transient suppression diode D6 before feeding the decoupling capacitor C12, IC4 stabilises the input voltage to 8V for the internal rail of the alarm and further decoupled by C12.

The unit can be powered directly from the mains supply whilst the alarm output and tamper switch contacts remain isolated. The 240V a.c. supply feeds the Zener diode D10 via R29, R30 and C13, the current being limited by the reactance of C13 at 50Hz, and any fast transients by R29. R31 is included to discharge C14 after disconnection from the supply for safety. The Zener diode clamps the positive half cycle to +15V and the negative half cycle to −0·6V. The positive half cycle goes via D11 and smoothed by C14. The 15V can then be fed to the d.c. supply of the unit.

ASSEMBLY/INSTALLATION

All resistors and diodes are on a 0·4inch pitch to ease assembly and all components are p.c.b. mounted. No securing holes have been included in the p.c.b. as guide slots are incorporated in the attractive two part case to make assembly, installation and service simple.

The outputs of all sections are left uncommitted to allow easy connection to existing lighting circuits and alarm systems.

Adjusting VR1 clockwise increases the detection range, VR2 increases the sensitivity to movement and VR3 increases the ambient light threshold for the light controller. ★

Space Watch...

THE SUN

From Russia there comes a new look at the Sun. The theory says that the Sun is in a 'special place' in the Galaxy. These conclusions could be very far reaching. They have been put forward by L. S. Marochnik of the USSR Academy of Science in Moscow. The home of the Solar System is in a spiral Galaxy more popularly called the Milky Way Galaxy. The new theory stems from some revision work that has been carried out in Russia. So far no details have been published outside the Soviet Union. The revision was directed at the rotation rate of the Galaxy. So far there has been no opportunity for the rest of the world to study the far reaching implications of Marochnik's extrapolations of the accepted state.

At present it is widely accepted that the spiral pattern formed by the stars of a Galaxy is produced by a density wave moving through the stars. The general view is that this density wave rotates around the Galaxy. The Solar System orbits the centre of the Galaxy at a distance of 32,500 light years and passes through the wave repeatedly. From this it is supposed that the repeated passes compresses the dust or presolar material until it collapses to form a system.

Marochnik does not agree with this. He rejects the view that the wave is a short wave mode coming from the periphery of the Galaxy inwards and claims that in fact it is a long wave mode and comes from the centre of the Galaxy outwards. This is not only a revolutionary thought but alters the whole conception, for it is in fact reversing the present thought. If this new picture is correct it means that the Solar System is at a place in the Galaxy where it would be rotating at almost the same speed as the wave. This is a special position in that a spiral Galaxy has only one co-rotation circle.

This produces a very unique situation and suggests that if it is so then a complete revaluation of the history of the Solar System will need to be written. The cloud of material of which the Solar System is formed would have taken something like 4·6 thousand million years to travel from one spiral arm to the next. Moreover it would have taken something of the order of several hundred million years for it to have passed through the highly compressed region of the spiral arm. This would mean that the whole geological history would have to be re-structured. This is the picture which has perhaps prevented Marochnik making any kind of drastic or dramatic statement. One possible conclusion might be suggested. If the co-rotation theory produces planetary systems then it would suggest that this is the most likely place to look for other life. This reduces speculation as to contact or indeed that invasion is imminent here.

LARGE SPACE TELESCOPE

The launch of this important piece of scientific equipment due to be put into orbit in 1985 may be delayed for as much as a year. This is rather sad news. There had been rumours of delays and minor problems but it would seem that the difficulties are rather more than minor. It is not confined to failures of the equipment or even of assembly snags and wider implications caused the NASA administrator to set up an enquiry. The administrator James Beggs has stated that at least two months will be necessary to reach a stage of report for study and then conclusions have to be drawn and the project restructured. From the Marshall Spaceflight Centre in Alabama the spokesman Tim Tyson stated that there were two types of problem. First there had been delays in installing the large mirror in its supporting ring in a 'strain free' condition. Because the telecope will be in orbit for many years it is vital that the mirror is free from deforming stresses. Allowance has to be 'guesstimated' as to what will take place in free space caused by temperature stresses alone, though much practical knowhow has been accumulated over the years. Also there have arisen some difficulties with the guidance systems that will affect pointing of the telescope as it moves in orbit. The Perkin Elmer Corporation who are dealing with the assembly of the telescope have met with technical problems. In addition to this there have been other delays and not least of these is Congress. Delays always seem to mean increased costs and therefore each successive delay results in escalation of costs.

Such has been the concern of all those involved that even the staff have been asked not to talk about the situation. This could well be necessary on more than one count. One very serious casualty of the delay in getting the vehicle operational relates to the closer look at the planet Uranus when the Voyager approaches it in 1986. The facility of the telescope to examine the situation and to redirect the spacecraft from Earth represents an opportunity that may not again be possible for decades. Some of the difficulties are not easily resolved because they are related to the loss of skilled personnel who have moved on, thus causing continuity breaks. Clearly it is again time for finger crossing. What would science do without such aids?

INTELSAT 5A MODIFICATION

A modification for the 14th and 15th spacecraft 5A is required to meet the needs of a Ku-band digital business communications service. The Board of Governors of the International Telecommunications Satellite Organisation awarded the contract worth 23·8 million dollars to Ford Aerospace. The contract is for a downlink capability in the 11·7 to 11·95GHz band allocated to fixed satellite service in North and South America. This implements the decision of the 1979 World Administrative Radio Conference.

This downlink will add to the facilities of the existing downlink 10·95 to 11·2GHz. There was also an allocation of three 72MHz spot beam transponders in the 11GHz band to begin operation in January 1984. The modified design plans will include in-orbit switching between two frequency bands in order to provide the flexibility needed to accommodate future interpretation of a conference ruling that restricts the 11·7 to 11·7GHz band to domestic or regional service in the Western Hemisphere. The business service will become available in the atlantic ocean region in 1985. It will include video teleconferencing, digitally compressed voice, electronic mail, highspeed facsimile and interactive computer networking. There are proposals under consideration which include the incorporation of similar modifications in the INTELSAT-6 design and the leasing of capacity on the British Unisat communications satellite.

THE EUROPEAN SPACE AGENCY PROGRAMME

This has come as a great disappointment to scientists and industry. Complaints have already been directed from some research groups because of what they regard as the neglect of planetary science. As usual it is lack of funds and not expertise that has reduced the programme. It seems too, that unless some revolution in funding takes place, much that was hoped for in this century must wait till the next. Certainly it does not seem that there will be the hoped for re-visit to Mars even unmanned for this is one of the items put back. Similarly the very important and worrying question of the oscillation of the Sun. Though intensive new work has been published on this subject (NATURE vol. 302, 28) it will not be supported by DISCO, the spacecraft which was one of the projects not qualified for a place. MAGELLAN for u.v. studies was not qualified and also X80, an X-ray telescope.

Those that are to go forward are the EXOSAT which is an X-ray satellite launched by NASA at the end of May this year. GHIOTTO—the probe to do a fly-past of Halley's comet, this is for launch in mid-1985. HIPPARCOS—for astrometry studies. ISO—the infra-red astronomical observatory satellite; this satellite is the successor to the IRAS infra-red satellite and is about 100 times more sensitive. It will have liquid hydrogen and liquid helium to 13°K. Its life will be determined by the speed of evaporation of the coolants, which in the light of experience with IRAS will be greater than the design anticipation. This telescope will complement the work of IRAS. It will be used to study extra-galactic objects.

Frank W. Hyde

PERCUSSION MICROSYNTH

Part Two

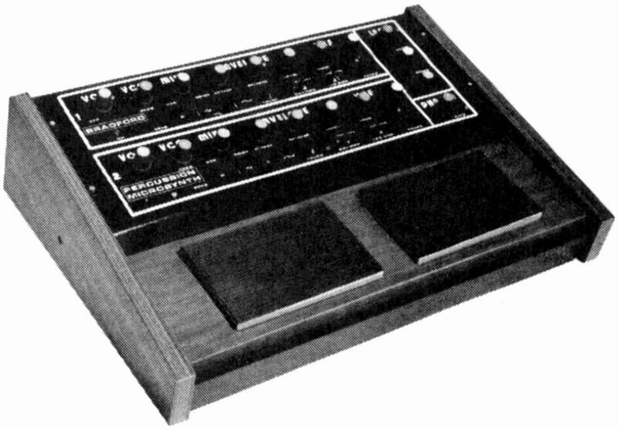
A.R. BRADFORD M.Sc.

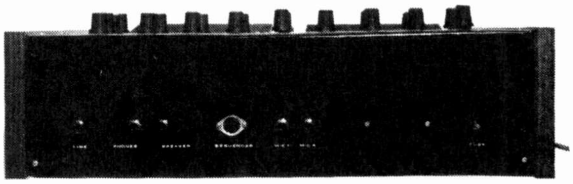
ALL components with the exception of the headphone attenuating resistors mount directly onto the p.c.b. (Fig. 6). This should be assembled in the usual manner, first soldering in all the through-board connection pins, checking very thoroughly that each has been soldered on both sides of the board. A lot of time and trouble can be saved later on by ensuring that none of these essential connections have been omitted. Next solder in the resistors, followed by semiconductors and capacitors. Mount the switches, pots and large capacitors last, or they will get in the way. Remember to cut the pot spindles to length before fixing and soldering to the pads on the p.c.b. Check construction against the component overlay and component schedule and double check against the circuit diagrams, then thoroughly scrub the underside of the board and check for solder bridges, etc.

Complete kits including cabinets, front panels and trigger pads are available from **Clef,** but for diehards and those wishing to customise units to their own requirements complete constructional details are given. One obvious modification is build two Percussion Microsynths into one cabinet making a four-channel unit; another is to make the control panel(s) 19 in long so that they can be rack mounted while free standing trigger pads for remote use could be devised for mounting on a drum kit, or whatever.

The cabinet used for the prototype was essentially the same as for the keyboard Microsynth, and details are shown in Fig. 8. The end cheeks are first cut from $\frac{3}{4}$in timber to the size shown and three battens screwed to the insides. The top two are cut from $\frac{3}{4}$in$\times\frac{1}{2}$in timber and support the trigger pad base plate and the front panel. The bottom one is made from $\frac{1}{2}$in square timber and provides fixing for the bottom of the cabinet, which is of $\frac{1}{8}$in plywood or hardboard. The lower battens should therefore be fixed to the end cheeks $\frac{1}{8}$in from the lower edge to allow clearance. The cabinet bottom is $13\frac{5}{8}$in$\times 17\frac{3}{4}$in, and the end cheeks should be fixed to the bottom panel next, leaving $\frac{1}{4}$in gap at the front and back edges. This leaves the frontispiece, and the back batten to which the metal back panel is screwed. These are each $17\frac{3}{4}$in long and should be chamfered on their lower edges as shown in Fig. 8. The bottom panel should be screwed to these, and the frontispiece and back batten themselves should be glued and/or bracketed to the end cheeks. This should give quite a strong construction, although ultimately an extremely rigid unit is obtained once the trigger pad base plate and the metal panel are screwed in place.

Many different designs of trigger pad have been tried, and tested under prolonged conditions ranging from severe (such as on stands at exhibitions) to positively brutal (namely heavy handed drummers on stage), and the end product of this research is shown in Fig. 9.





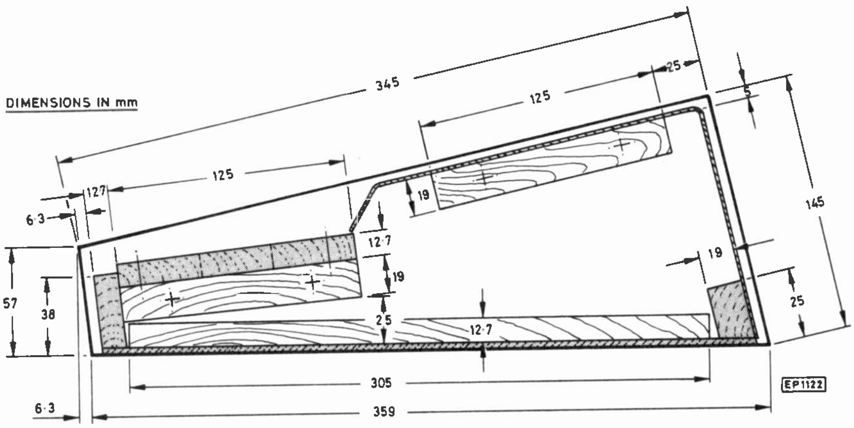


Fig. 8. Construction details for the cabinet

The transducers are crystal microphone inserts, bracketed onto a metal plate to provide a large hitting area. If heavy usage is expected, this plate should be steel. The bracket, which goes under the microphone capsule and holds it against the plate, is fixed to the plate with two M5 countersunk bolts. The wooden base plate provides a firm platform for the pads, but since there are two triggers, they must be mechanically isolated from each other to prevent cross-triggering. For this reason holes are cut in the base plate with plenty of clearance around the bracket and transducer, and a sandwich of foam rubber with a similar hole in the middle, is interposed between the wooden base plate and the metal hitting plate. Good quality foam rubber should be

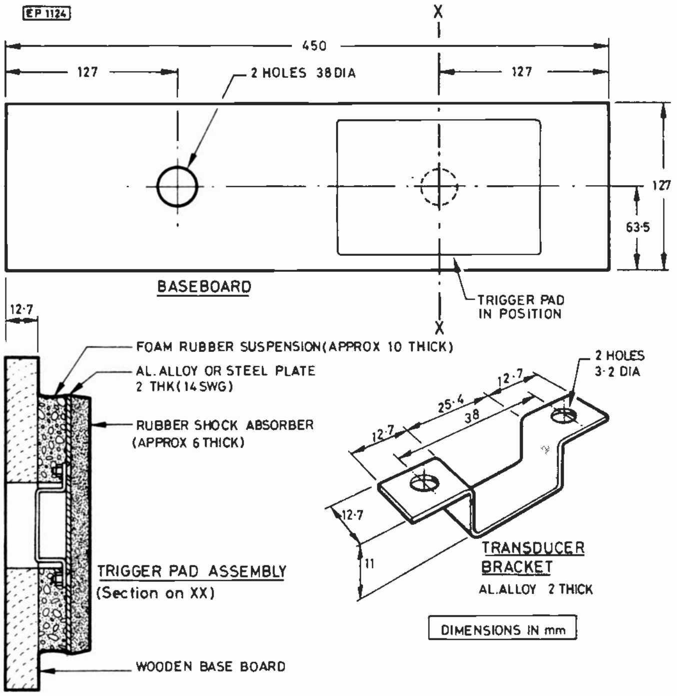


Fig. 9. Trigger pad assembly

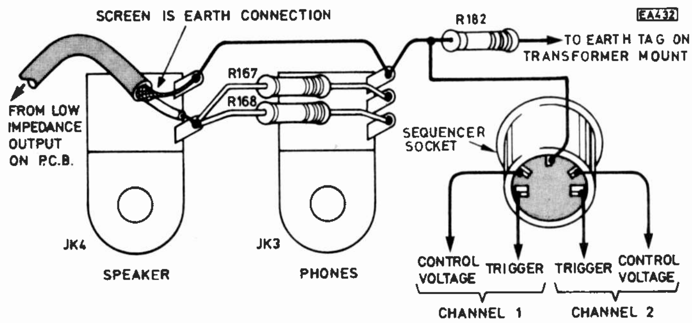
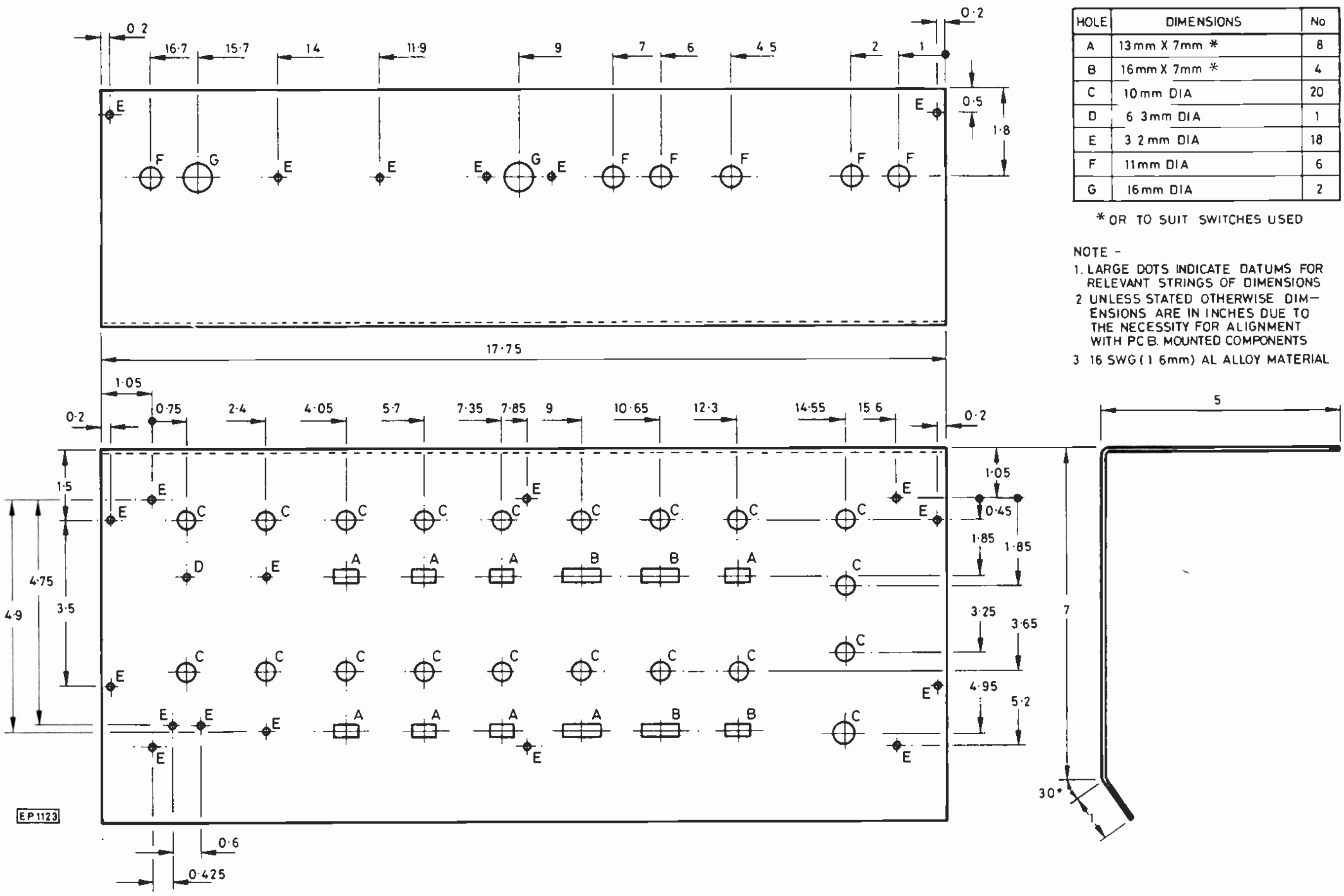


Fig. 7. Wiring diagram for the rear panel



HOLE	DIMENSIONS	No
A	13 mm X 7 mm *	8
B	16 mm X 7 mm *	4
C	10 mm DIA	20
D	6 3 mm DIA	1
E	3 2 mm DIA	18
F	11 mm DIA	6
G	16 mm DIA	2

* OR TO SUIT SWITCHES USED

NOTE -
1. LARGE DOTS INDICATE DATUMS FOR RELEVANT STRINGS OF DIMENSIONS
2 UNLESS STATED OTHERWISE DIMENSIONS ARE IN INCHES DUE TO THE NECESSITY FOR ALIGNMENT WITH PCB. MOUNTED COMPONENTS
3 16 SWG (1 6mm) AL ALLOY MATERIAL

Fig. 10. Front panel details

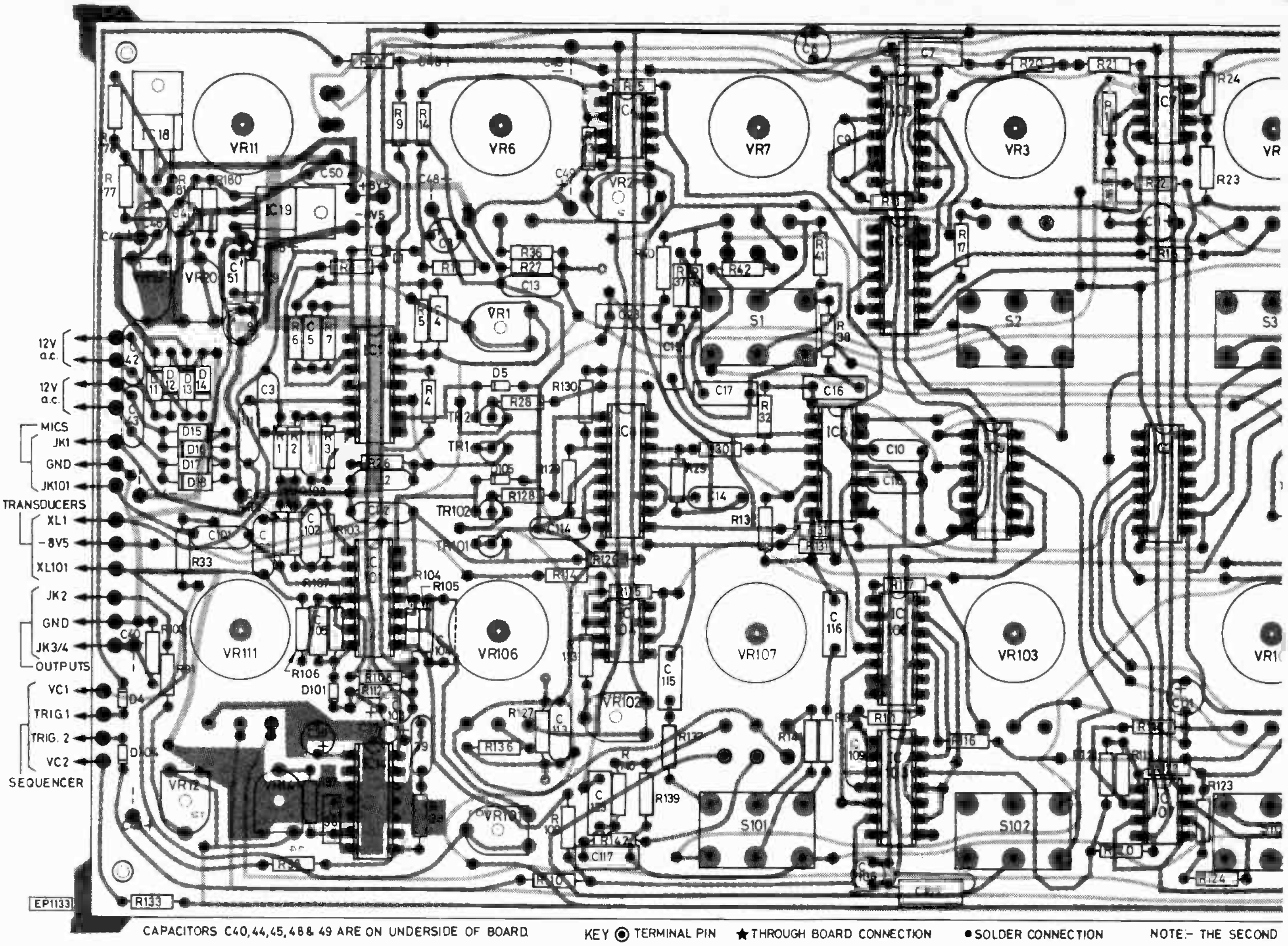


Fig. 6. Component layout for the p.c.b.

used here, as some types can be rather crumbly, and the sandwich should be assembled using a strongly bonding adhesive such as "Thixofix". To reduce shock to the transducer, as well as for appearances sake, a layer of rubber is glued to the top of the metal plate. Suitable rubber, as well as the foam rubber, can be obtained from craft or model shops.

As for finishing touches, the cabinet and the trigger pad base plate can either be covered with cabinet cloth, or veneered, or simply polish up the wood! Stick-on or screw-on cabinet feet are a nice addition too.

The front panel should be made from 16 s.w.g. aluminium as shown in Fig. 10. After drilling, filing and bending, the panel should be flatted with emery cloth and thoroughly cleaned with a Brillo pad taking care not to get any grease back onto the metal. It should then be sprayed with several coats of matt or gloss car paint, preferably flatting between each coat with fine wet or dry paper (used wet) and finally rubbing gently with car "cutting paste". This will ensure a sufficiently tough, lasting finish.

The lettering is applied with white Letraset or similar rub-down dry transfer lettering and the white lines with Letraline or similar 0·1in. striping. The completed panel should be sprayed with a clear matt or gloss fixative (available from good stationers or drawing materials shops) to prevent scratching of the lettering.

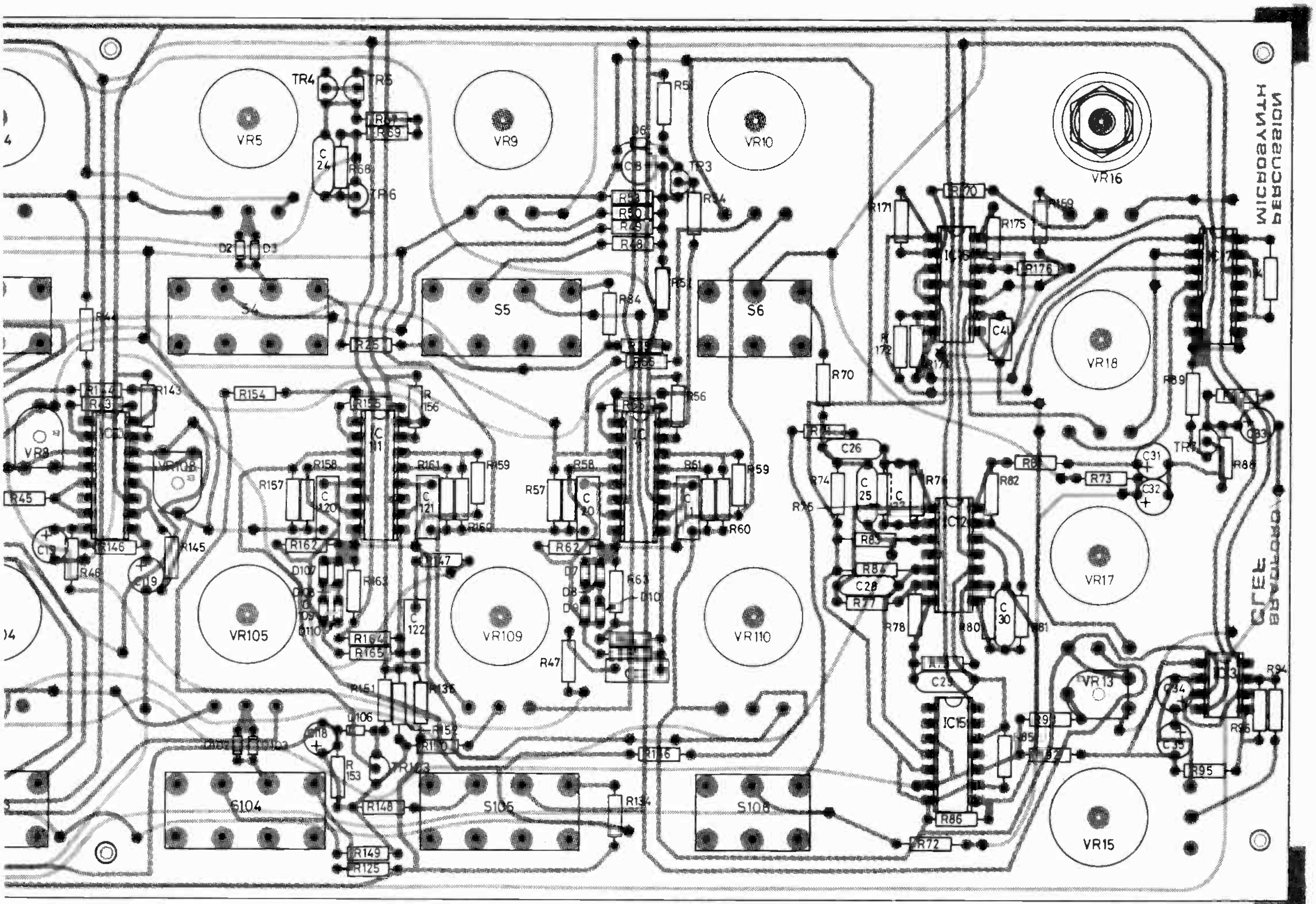
The p.c.b. bolts directly behind the front panel: use $\frac{3}{8}$in spacers and attach these to the six holes in the panel using 6BA nuts and bolts ($\frac{3}{4}$in). This will give the correct clearance for the slide switches. All other components, transformer, fuse, sockets, etc, fix to the rear of the panel.

Finally complete all the interwiring, including connections to the sequencer socket (see Fig. 7).

SETTING UP

First check the power supply, adjusting VR18 and VR19 to give +8·5V and −8·5V respectively. *Do not exceed these voltages: remember the CMOS is being run across both rails!* Connect power to the rest of the circuitry by installing the two wire links near VR11, and switch on while monitoring the supply voltages with a meter. If there is any drastic departure from the nominal ±8·5V switch off immediately and re-check the board for shorts, incorrect components, etc. When all is well re-trim VR18 and VR19.

With S3 and S103 off, the sensitivity presets at minimum resistance, short attack, medium release, and VCF and "Envelope Level" controls all set mid-way, check that striking the trigger pads produces a sound in the appropriate channel. Check that all the VCO outputs as well as noise are available in each channel, remembering to have the VCF Frequency controls turned up, otherwise you may filter out what you are trying to hear. VR8 (VR108) should be adjusted to give a clean start to the sound with minimum audible thump when the "Attack" control is at zero (fully anticlockwise). Now switch on the touch sensitivity and adjust VR2 (VR102) about its mid position to achieve the desired range



GANG OF DUAL POTS SHOULD BE CONNECTED TO THE PINS PROVIDED.

of effects. The best way to do this is with a positive modulation from the envelope (level control clockwise from its mid position) switched into the VCO (to give typical disco style descending pitches — see also the section on test programs). The highest pitch from the VCO should then be proportional to the force with which the pad is struck.

Selecting the noise signal only ("Mix" control fully clockwise) and maximum release time, and with VCF "Frequency" fully up, "Q" (resonance) fully down, switch one channel into the Phaser. Adjust VR13 for a symmetrical phasing effect. Check that the other channel also phases. The output level presets VR12 and VR14 are adjusted to taste; if you find some of the sounds distorting, it may be that the relevant preset is set too high.

TEST PROGRAMS

The following selection will serve both to demonstrate the range of effects that can be achieved, as well as to check that everything is functioning correctly. Put all switches to the left between programs.

Disco

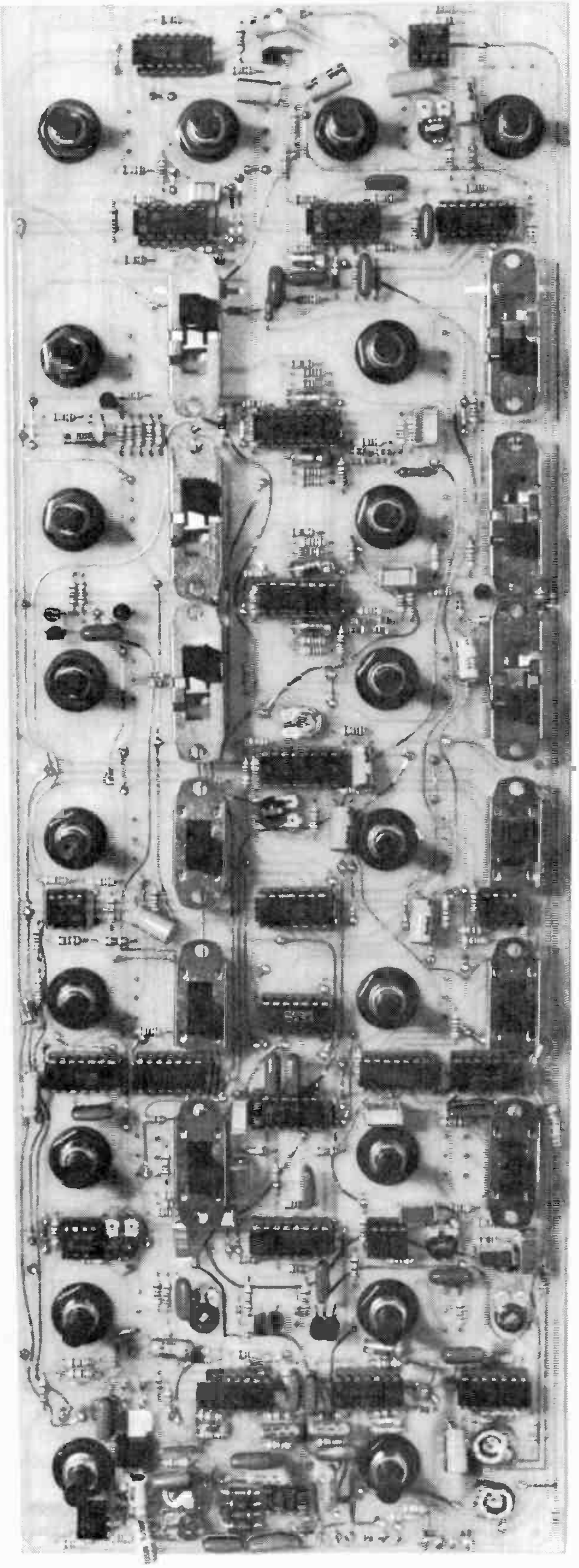
This is the effect that first brought drum synthesisers to the public's attention. Select a triangle waveform with the VCO "Frequency" knob one third turn clockwise, the "Mix" control fully anticlockwise. "Attack" fully anticlockwise and "Release" three quarters clockwise. Switch the "Envelope Modulation" to "VCO" and set the envelope "Level" knob clockwise. Hitting the pad will now produce a descending pitch. Now move the "Touch" switch to "On". A gentle tap on the pad will produce a sort of "boo" sound, and as the pad is struck harder both the sweep in VCO pitch and the duration of the sound will increase. We are already beyond the capability of a simple percussion synthesiser, so let's see how we can further extend the effect. Setting the "Attack" control mid way, the "Release" control to zero and the envelope "Level" control fully anticlockwise creates a curious effect where the pitch still descends, but the sound starts quietly, gets louder and stops abruptly. Next try using a square wave of low frequency together with the sub octave. Switch the "Envelope Modulation" to "VCF" say with the "Attack" one third clockwise, Release at zero and envelope "Level" nearly fully clockwise. This will produce a bassy sound like a croaking frog. All you need now for the complete disco treatment is some hand-claps.

Hand-claps

A short pulse of noise will generally be mistaken for a hand-clap, and this is the principle on which most hand-clap synthesisers work. To get this effect turn the "Mix" control right round to noise, with zero "Attack", very short "Release", and with the VCF "Frequency" about two thirds clockwise and "Q" (resonance) at zero.

Bells

Turn the "Mix" control right round to "VCO" and select a



triangle waveform at a frequency to taste. Set "Attack" at zero and "Release" three quarters clockwise. Switch the LFO "Modulation" to "VCO", with LFO "Rate" one third clockwise, "Shape" mid way and "Level" one quarter turn clockwise. Switch on the Phaser with its "Rate" control fully clockwise for a more reverberant quality.

Next turn up the VCF "Q" knob so that the VCF itself oscillates, and tune in the VCF to the VCO using the VCF "Frequency" control. With the VCO and VCF nearly at the same frequency or some harmonic interval, the sound will be fairly mellow, while de-tuning them will create a harsh, metallic sound. Mix in a little noise and turn up the LFO "Rate" and "Level" for the "dustbin lid" sound. The sub octave can also be used to good effect with the bell programs, by having the resonance fairly high and tuning the VCF to pick out the fundamental of the sub octave. A slight negative modulation (that is, anticlockwise from the vertical) from the envelope to the VCF may be effective here.

CONVENTIONAL DRUM SOUNDS

Cymbal

Select "Noise" only and set "Attack" one quarter clockwise and "Release" two thirds clockwise. With the VCF "Frequency" knob at maximum advance the "Q" control until the VCF is just short of oscillating. Phase the sound at a fairly brisk rate if required. Mix in a small amount of high frequency VCO modulated by a fast triangle from the LFO for added zest.

Hi hat

As for Cymbal but with the "Attack" at zero, the VCF "Frequency" slightly lower and the "Touch" switch on. Hitting the pad hard and soft will give an open and closed hi hat respectively.

Snare

As above, but shorten the "Release" time further, set VCF "Frequency" two thirds clockwise and "Q" to zero.

Tom toms

Use VCO triangle waveforms alone, at minimum frequency, perhaps with a very slight negative modulation from the envelope.

Bass drum

Use noise only, with a very short "Release", VCF "Frequency" at zero and "Q" mid way.

It should be emphasised that the above programs are suggestions only as the best effects are a matter of personal taste. Finally try anything and everything, keeping a note of all useful programs. ★

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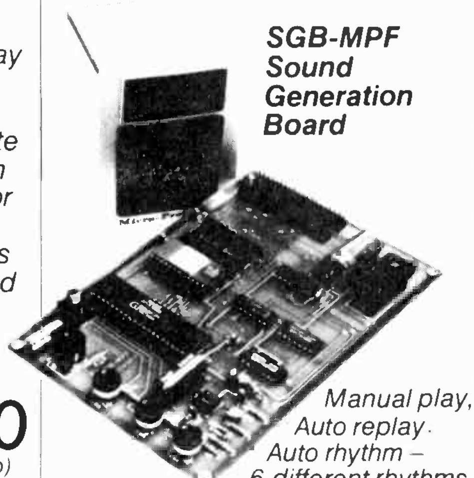

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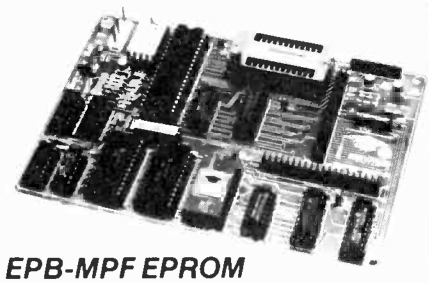

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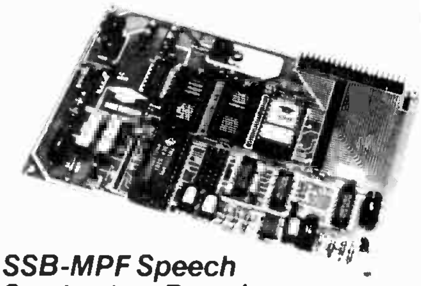

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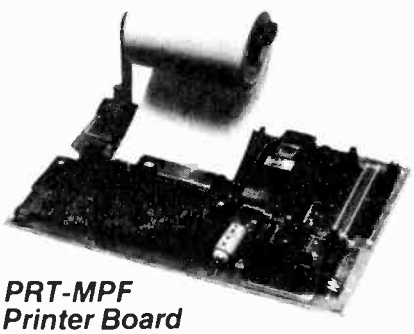

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Fairlight Music

ALTHOUGH microcomputers are particularly good at music making, the first microcomputer package dedicated solely to music production did not appear until 1980. It was developed in Sydney, Australia, and was named 'The Fairlight'—after a hydrofoil that skims its way across Sydney harbour.

There are now about ten systems manufactured in the world which might reasonably be described as dedicated music computers. The Fairlight has now been surpassed in some areas, but the system, in common with all 'soft' packages, is under constant revision and it has certainly become the most widely-played computer musical instrument (CMI) in the world. As a result, there is now a considerable amount of user feedback available.

POLYPHONIC SYSTEM

The Fairlight was the end product of five years of research by Peter Vogel, Kim Ryrie and Tony Furse. Vogel and Ryrie were, and still are, precocious young Australian designers with a talent for electronics and a love of music. Furse was a computer engineer of 20 years' standing who in 1974 brought to the partnership a monster machine, already capable of producing digital music. The team then developed a system called the Qasar M8 which was an eight channel polyphonic system. The unusual element in this machine was the 'dual processing' carried out by two microprocessors working in tandem. Whilst one controlled information exchange with the human users, the other saw to it that the hardware did what was necessary. The Qasar was a large expensive system and as improved microchips became available, the team redesigned the package making it both smaller and cheaper.

The Fairlight is a 'digital ear' on the world of sound. It is markedly different to most other musical instruments in that it is capable of 'listening' to the external world, storing what it hears and reproducing that sound as music. The symphony of windows breaking is a reality with the Fairlight. This ability was developed from Tony Furse's original system of digital music production. Rather than opting for FM index synthesis, or any of the other methods of sound production, he worked with digitally produced waveforms, a system that later allowed information to be entered from the outside world.

The Fairlight is larger (in total RAM terms) than most microcomputers. Its total RAM of 208K—coupled with dual processing capacity—almost brings it up to the minicomputer, although *processor* RAM (excluding that used for waveform storage) is currently the regular 64K. The concept, successfully developed in the Qasar, of running two microprocessors as independent but linked central processing units, became a central part of the Fairlight design. There have long been problems in running two, linked microprocessors and gaining maximum speed from both—one tends to take on capacity work leaving the other partly idle. The Qasar development provided the answer.

Software may reliably be regarded as the really clever part of dedicated computer design and the Fairlight system contains the end product of six years of solid work by several programmers. The present program, in 'assembler language', occupies over 300K of memory space and understandably the team are now

Ray Hammond

Computer

looking to move towards a high level language, such as 'C', now that major improvements in hardware memory capacity are on the horizon.

HARDWARE

Despite this insistence on the importance of good software, it is fair to say that the Fairlight incorporates some very dedicated hardware indeed. The system arrives with one or two musical keyboards (at the purchaser's option), the VDU housing the central CPUs and the eight voice modules, a dual disc drive and the main operating software language stored on an 8 inch disc. The VDU is fitted with another Furse development, a 'light pen' to assist in graphics work. It was the team's intention to display musical sounds and wave shapes. The monitor was built to the Fairlight company's own design because commercially available units didn't have sufficiently high resolution graphics. Some of the electronic components in the circuit have been deliberately overrated in an attempt to offer the user some protection against mains fluctuation—a phenomenon that has been known to occur on concert stages from time to time. The twin floppy disc storage system operates on DMA (direct memory access), a refined high-speed information retrieval system. Disc systems found with most home computers and many professional machines, operate under the control of the CPU (central processing unit) which requires an interruption in the task in hand for the CPU to monitor the disc system during loading. The DMA system requires a signal from the CPU when information is required but thereafter the transfer takes place without CPU involvement, until the CPU senses the end of the information load. In practical terms this allows the musician to program a piece of music which calls for voices to vary during the performance, and the CPU will cue the disc to load the required voices when necessary without being interrupted in its task of controlling pitch, waveshape or any other parameters.

The disc drives are unimportant to the theoretical system design, but are vital in practice. Despite the expense of a Fairlight system and its relative bulk and complexity, the makers are certain that the Fairlight will become a fully-fledged transportable instrument. Several world tours have been undertaken with the system being shipped from concert to concert—in most cases without any provision for back-up, spares or systems being made—and the system has performed without trouble.

Fairlight financed their seemingly insane decision to build a dedicated music computer by producing business computers that Remington Office Machines of Australia shipped out as business machines under their own brand label. The hostile business environment showed up the weaknesses of available disc drive systems and the company heaved a sigh of relief when, shortly before the first Fairlight was produced, a Japanese company marketed a drive significantly more reliable than anything previously available.

A Fairlight (along with some of the other dedicated instruments mentioned later) represents the most flexible and powerful type of musical instrument available to mankind. But it has no sound of its own. When it arrives the memory spaces are empty and at no stage will a characteristic 'Fairlight sound' develop.

Fairlight Instruments provide a starting disc on which a wide variety of digitally-stored sounds are pre-recorded. These may be loaded into the Fairlight by inserting the disc into the right-hand disc drive and issuing the appropriate command via the alphanumeric keyboard—the left-hand drive contains the system disc. The sounds may also be loaded into RAM via the calculator-type keypad on the musical keyboard and via the light pen and screen. After loading, any one of the sounds is instantly available under the musical keyboard and can be played in real-time, i.e. the response time of the Fairlight is rapid enough to allow instant recall of sound when a key is depressed.

VISUAL INFORMATION

The operating software of the Fairlight is 'menu-driven' throughout. On powering up and loading the system disc containing the operating software, and a disc containing sounds, an index appears on the screen. This index lists a total of 12 pages (menus) that the user may go to and several new pages are due to be added. Page 1 is the index itself. Page 2 is Disc Control, a menu for the store of voices and for the disc-control system which will create space for a new voice or file. Page 3 is Keyboard Control and this menu allows the playing parameters to be set, such as tuning, scale, etc. Page 4 is Harmonic Envelopes which will allow the user to draw envelopes on the screen and hear the result, and so on.

While using any of the pages except Page C (Composition) described later, the user may request 'Help'. This command clears the screen temporarily and lists operating instructions which should solve the user's problem. The page currently in hand is restored when the help page is no longer needed.

The musician selects the page required—perhaps Page 2—to load a voice or an 'instrument' (an instrument is a generic name for a set of keyboard controls). The musician may then start to work with these. Page 2 is also the page that allows the storage of new voices or instruments to take place and the transfer of information, e.g. from one disc to another. It is the disc control page.

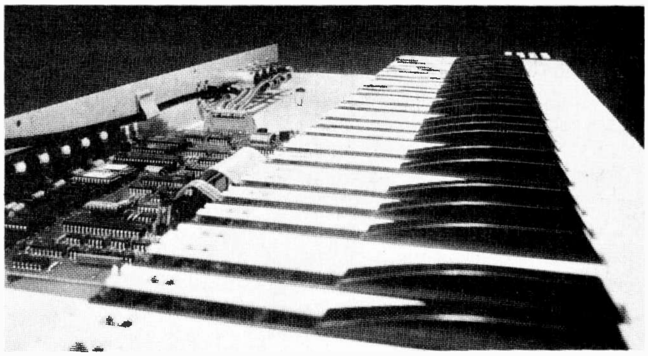
At any time during the user's work on a voice, a sequence or during the creation of a sound, the user may call up any of the pages necessary and issue the next command without the risk of losing any work completed.

Most users I have spoken with say that although the system seems daunting initially, basic understanding arrives after two days of experimentation, and fluency develops after a few weeks. All, however, complain that the operating manual is inadequate and poorly written, although like all aspects of the Fairlight, this is (and will remain) under constant revision.

CONCEPT

The concept of the Fairlight is—as a soft instrument the owner will never have to replace the system, the company has promised that it will never produce a Mark II which makes the Mark I obsolete. Improvements in software will be supplied on disc, and improvements in hardware will be supplied as plug-in cards for the user to fit. Kim Ryrie, Fairlight's Managing Director, estimates that the cost to the Fairlight owner of keeping a system up to date would be 'one thousand dollars a year'.

The keyboard unit in the Fairlight package is itself 'intelligent'. A microprocessor is installed in the keyboard unit and this pre-processes key-strokes and control information. External controls such as pedals may be plugged into this unit and in a performance situation the VDU can be replaced by a 16 button control panel and small alphanumeric display which interfaces with the keyboard. The input commands are simplified using these buttons and long strings of pre-programmed sounds can be accessed in a shorthand form through this separate keypad. This adapts the unwieldy Fairlight package to a format as close to performance requirements as possible.



The master keyboard with its own processor can calculate the velocity of any key depression

OPTIONS

Performance is an area that the Fairlight engineers are currently studying. Plans are afoot to provide the instrument with several new performance aids. Amongst these will be dynamic pitch-bend controls and other analog-type controls. Bob Moog—the father of modern analog synthesis, is working on a new keyboard for the company which will be pressure sensitive. It will be an expensive optional extra. It is also possible that the Fairlight will become the first dedicated music computer to offer input from a guitar-type instrument. At the time of writing a London company working in association with Fairlight, was developing a guitar-type instrument that could replace the musical keyboard. This type of input device would open up the world of the real-time music computer to the millions of guitarists who can't play a note on a keyboard.

The Fairlight CMI is an expensive musical tool. The price at the time of publication was hovering around £18,000 in the UK, plus or minus £3,000 depending on options purchased. This market position is unlikely to change. As micro-power becomes cheaper, Fairlight will opt to improve the package, rather than reduce the price of the existing system.

The eight voice modules installed in a standard Fairlight allow eight-voice polyphony or simultaneous playing of up to eight sounds. Sound can be inserted into the Fairlight's memory banks in several ways. The pre-recorded sounds may be loaded from disc. Most users with whom I have discussed the subject agree that the pre-set sounds are useful at the beginning, but are rapidly replaced by sounds created by the user. Another method of creating a sound for the Fairlight is to sample an external sound—the Fairlight has an input line which will accept signals from a microphone, mixer or any other line carrying sound signals. Inside the hardware an A to D converter changes the sound into digital form which is stored for later use.

The A to D converter in the Fairlight samples sound waves at a rate determined by the user up to a maximum of 32K. In practice the optimum rate will depend on the nature of the sound to be recorded. The duration of sample that the Fairlight is capable of taking is one area where the system has been surpassed by its rivals (although any disadvantage in this fast-moving field is likely to be temporary). The duration depends on the frequency of the sound to be sampled. A bass drum may be sampled for about four seconds, whereas a high harmonic spectrum sound will be sampled for about one second. To overcome the shortage of sample, the waveform is looped so that it may be sustained indefinitely. Some of the pitfalls of this sampling system may be overcome by setting internal high and low-pass filters to narrow the frequency bandwidth that the computer has to sample. The limitation with this system is that some fidelity of reproduction is lost, particularly at high frequencies. The reason for this is logical—the higher the frequency, the more rapid the soundwave and the more information there is to be measured.

COMPARISONS

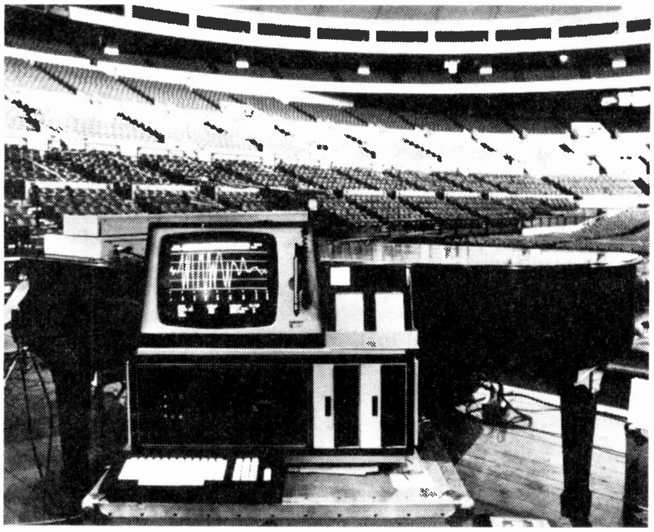
If a middle C from a Steinway grand piano is captured using a high quality microphone and the note is sampled by the Fairlight, the sound may be stored on a disc as a voice. The voice may be recalled (from Page 2), stored in the 16K RAM voice modules and reproduced at will by the user. In raw terms the user may choose the sound to be reproduced at middle C and the 'piano' sound that is reproduced is virtually indistinguishable from the original acoustic instrument. Any alteration to the sound will come from loudspeakers and their enclosures, but remember that if recording is the goal, the acoustic will suffer equally when a recording of it is replayed through loudspeakers.

Without any further modification the user may then play the grand piano sound back at any pitch, using the musical keyboard. In raw terms, the digits representing the timbre and envelope of the middle C remain unchanged, but the digits governing frequency are those of upper C. Thus a sound like a top C is produced but it doesn't sound like a grand piano. The reason is that the envelope and amplitude of the top C on the piano changes as well as the frequency, but the digital store did not have this information.

One answer available is to take several samples from the grand piano keyboard, from top to bottom. The Fairlight has eight voices, each may receive a sample from the grand piano. Now the computer has a store of information from a range of sounds. This store may be organized so that the nearest appropriate sample may be used to generate the piano note required. Thus A above middle C would draw its envelope and amplitude from the sample of C above middle C—its nearest sample source. This is far more accurate, and for some purposes will produce a sound acceptably close to the grand. But in filling up all eight voices with separate samples, the polyphony has been used up and thus the object is defeated.

A better option would be to take the eight samples and then ask the computer to work out what percentage of which sample should be applied to the note called for. Software changes are now becoming available which will compute these changes but the reduction in polyphony still remains directly proportionate to the number of samples taken.

I have deliberately picked the piano as an example as it is one of the few instrument sounds that the Fairlight, and its rivals, find impossible to reproduce accurately. It is important to say that no musician would use a computer to reproduce a piano, it would be far better to use the original instrument. In a survey of users, Fairlight discovered that the single most important feature on the instrument was its ability to capture natural sounds and place them on the music keyboard, the computer's ability to reproduce conventional instrument sounds was rated as a low priority.



Entire musical scores can be fed into the computer via the VDU's alphanumeric keyboard

CPU UPDATE

However, the problem of inaccurate reproduction should be solved when the promised new hardware is available for the Fairlight. This is scheduled to appear towards the end of 1983. Although this new hardware will fit all Fairlights, it is quite a major revision. The central 6800 CPU is to be replaced with the new (but related) 6809 which works internally as a 16-bit processor and offers a RAM of 256K as opposed to the existing 64K. This major jump, accompanied by similar upward leaps in individual voice card RAM capacity, will end most of the limitations now affecting the Fairlight. Sampling rate will go up to around 40K and this will make possible every kind of natural sound sampling. Currently the Fairlight has difficulty sampling long sounds, such as running water, because of limited RAM storage in voice channels. With the new capacity, quite long sounds—six seconds for example—may be captured. The bandwidth will jump from its present low-ceiling cut-off to the point where almost perfect fidelity will be possible. With this combination of new hardware and software the eight voices from the grand piano discussed in our hypothetical example will be stored in just one of the eight voices available. Accurate sound and full polyphony will be the result.

The Fairlight software offers the user absolute control over the musical scale in use—this is accessed from Page 3, Keyboard Control. The default setting that the software specifies is the equal-tempered scale, and a few key strokes alters this scale at the user's will. The grand piano can become perfectly tuned for the first time in its life.

It must be pointed out that although the perfect reproduction of a grand piano or any conventional instrument is a highly useful tool, particularly for recording and composing, to use the Fairlight exclusively for this purpose would be to miss a major advantage.

All sound produced by conventional musical instruments is artificial. The only reasonable definition of musical sound is sound which is pleasing and the Fairlight, and some others in its class, allows the composer and artist to use sounds from our environment in a musical way. Thus a sample of a chain saw, a canary's song or an explosion, may be taken at its naturally-occurring frequency and stored digitally, allowing the mighty-micro control of all its elements.

Much of the music that is now produced with computer aid still 'apes' conventional instruments, but this is changing. The composer is required to shake free from mental prejudice about musical sounds and start experimenting with sound itself all over again.

ABSTRACT COMPOSITION

Experimentation with the essence of sound is at the centre of the philosophy that is behind the design of the third system for entering sound into the Fairlight's memory banks. This system allows the user to create sound by a variety of abstract methods. The best known of these is additive harmonic synthesis which is based on Fourier transforms, which are a series of formulae creating a bridge between the dimensionally complex relationships of frequency and time. The human ear hears sound and the mind notes the frequency, but when stored the time elapsed must also be recorded and stored. The Fourier mathematical principle shows that all repeating waveforms can be resolved into sine-wave components, consisting of a fundamental and a series of harmonics at multiples of the frequency.

In use, additive synthesis allows sounds to be built up one harmonic layer at a time. Arbitrary waveform synthesis is also possible, demanding the maximum from the user, and a system unique to Fairlight allows sounds to be drawn on the screen with a light pen.

This last method of creating abstract synthesis is particularly intriguing. The light pen may be used to draw harmonic envelopes or actual waveforms on the VDU—from Page 4 (Harmonic Envelopes). The light pen is also able to adjust index information on the screen and a total of 128 waveforms may be created and loaded in the waveform memory of each voice module.

When shaping harmonic envelopes with the light pen, up to eight may be shown at a time, the fundamental harmonic being shown in bold, although recent software revisions allow the 'energy' and 'duration' profiles to be displayed bringing the total envelopes that may be shown on the screen at one time up to 34. The desired harmonic number is selected by the light pen and the pen may then be used to modify an existing envelope or draw a new one.

An alternative method of abstract sound creation is offered from Page 5, Waveform Generation. Here the musician is presented with a graphic representation of 32 'faders' such as might be found on a mixing desk. These faders each represent a harmonic in a sound. A light point on each represents the level of volume in each harmonic. This level may be altered by the light pen or by using the alphanumeric keyboard. A voice must be either loaded from disc or newly created before this page can operate. On 'start-up' this page displays the appropriate amplitude plot of the voice held in RAM. This voice may be modified as described and then saved.

Page 6, Waveform Drawing, allows sound to be created by drawing waveforms. As might be expected, sounds are saved via the control page, Page 2. With this facility, waveforms are put directly into waveform memory by drawing waveshapes on the screen. A plot function ensures the light pen is followed no matter how complex the route, and 'Join' allows the user to input dots at various stages on the wave, the Fairlight computes the gaps and joins them up. The main advantage this method has over methods such as additive synthesis is that the harmonics involved are automatically computed as the wave shape changes. Joining up separate wave shapes is also made easy, with the Fairlight guessing the correct bridging shapes under the 'Merge' function.

Page 7, the control page, is loaded whenever a voice is loaded into RAM. This page allows the musician to specify the limits of such events as sustain, level, filters, attack and vibrato depth etc—the sort of controls found for voice-shaping on an analog synth. A new software modification will marry this page into individual voice files.

Sound samping is controlled from Page 8 and the sequencer section of the Fairlight is accessed from Page 9. The sequencer is programmed by playing the music keyboard in real-time. Key velocity information and foot pedal movements etc are automatically recorded. Sequence lengths are limited by the space available on the disc—an empty disc will store about 50,000 notes. Discs are the subject of much research in Sydney—the hard disc, an advanced version of the floppy disc, allows huge amounts of information to be stored and retrieved rapidly, typically two or three million bytes against 500,000 on a standard 8 in. floppy—but the systems are too fragile for road use and Fairlight's declared policy of making the Fairlight 'performance proof' currently excludes their great storage power.

Up to eight separate parts may be overdubbed, each having its own voice. Page 9 requires control decisions such as a name for the sequence and speed for playback. A sequence is recorded by using the light-pen to select 'record'; the part is then played. To play back the sequence, the musician uses the light pen to select 'replay'. The speed of replay must also be selected. Parts using the same voice may be merged and all settings may be stored on disc along with the sequence.

Page L is the Disc Library. This allows the updating of a list of files, voices, control, instrument files, etc. Whenever a new voice or other file is saved it can be added to the library list.

LANGUAGE

Page C loads the Music Composition Language that Fairlight have developed to aid composers and provide musicians who cannot play keyboards with a way to play their compositions on the Fairlight. It is also true that someone who cannot play 'any' musical instrument but who understands the theory of music can compose and play with this system. This software opens up the world of music to those with imagination and a little theoretical knowledge but who have not mastered the discipline of a musical instrument—singers for example. This is likely to prove a very exciting development. The Fairlight survey also revealed that 70% of users who 'can' play a keyboard still choose to use MCL for some purposes.

John Lewis, a London film-music and jingle writer, at his Fairlight CMI

Fairlight describe MCL as being a tree-structured language operating on several levels of hierarchy. Top of the tree is the 'Piece', followed by the 'Part' and finally the 'Sequence'. These are all terms musicians are familiar with and throughout MCL, musical language is adopted wherever possible.

A piece consists of up to eight parts to be played simultaneously and each part consists of up to 32 sequences which are played sequentially—although a larger number of sequences may be written and the overflow stored on disc. Fairlight suggest the analogy of parts representing independent musicians, each playing their own instruments through written sequences. Each part is independent although capable of playing at the same time.

Continuing Fairlight's imagery; the piece is the conductor, instructing each part when to come in. The system has the power to allow chords inside each individual part, and each part may be played by a different voice. Each sequence may be between 1 and 2,000 notes long and individual sequences may be used by individual parts independently.

To the question 'what's the longest piece of music I can compose and have played back at one time?' Fairlight respond, 'that depends'. The final answer is that it is adequate for most purposes. Certainly piece lengths of 30 minutes or an hour usually present no problem.

In use, the composer has to write a program for his music. It is this hurdle that some manufacturers believe musicians are unwilling to try. Substantial sales of the Fairlight over the last few years indicate that some musicians are prepared to learn a simple programming language, but Fairlight also think that this requirement is a barrier to expression for some users and have just produced a software revision which adds a new option to the system 'page R', described later.

It takes a little time to learn the Music Composition Language and like any learning task in life, success depends upon motivation. The motivation appears to be intense when absolute control over music is the goal.

The MCL program includes a 'debugger', a self-diagnostic device that tells the user if any errors have occurred during the writing of the program. Writing programs can be tedious and it is all too easy to misspell a command. The usual result is that the program execution stops, or 'hiccups' over the command. In the MCL program, the software locates the line written incorrectly and prints it on the screen for the user to amend.

WRITING MUSIC

To write a piece of music into the Fairlight the composer opens a 'piece file' (top of the tree) and specifies how many parts there will be: part A, part B, etc. The composer then opens one of the 'Part Files'—Part A for example—and specifies how and what the sequences will play: sequence One will play keyboard area number One and sequences Two and Three will play keyboard areas number Two and Three etc.

The composer then opens the first sequence file. It is here the user starts to write musical notation. Although the sequence of events calls for a specification of numbers of parts and sequence allocation before getting down to writing the dots, these decisions may be altered endlessly during composition.

Typically a composer might always start by deciding to write four parts, each of four sequences and all sequences to play on one keyboard. That might be considered the composer's 'default' setting. Only as the part progresses might the composer decide to add more parts or to change around the allocation of sequences to different voices. The composer can go back and do this at any stage.

Working with a computer means endless decision making and the first notation decisions the Fairlight composer has to make are as follows—BEAT: this is the number of sub-divisions within each time unit. Setting a value of 16, means each beat has a sub-division of 16 available. The GAP specifies the time between the end of the current note and the start of the next note and it is calculated in beat units. OCTAVE specifies in which keyboard octave the note falls. TRANSPOSITION adds an offset to the note requested; e.g. a note which is a specified number of keys up or down is played instead of the original note.

VELOCITY specifies the key velocity used when playing the note and the data is used exactly as if it had come from an actual keystroke on the musical keyboard. KEY SELECTION allows the key to be set, i.e. amount of sharps, flats and naturals. Most of these control options have default values and the composer will be able to settle for these on many occasions.

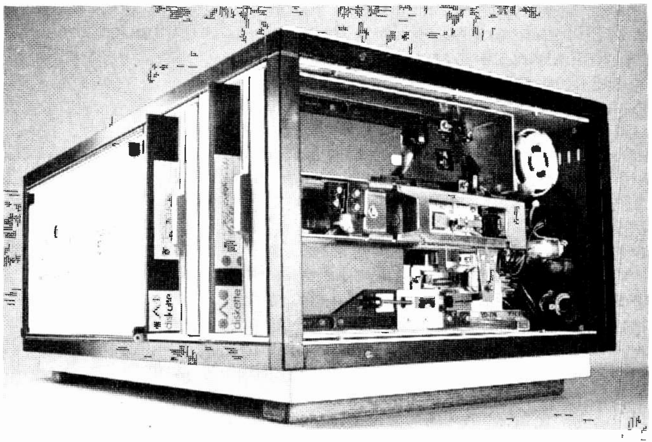
Once these parameters are established the entering of the notation may begin. Each note may be fully specified by Pitch, Velocity, Time and Gap. For Pitch the name of the note is typed in: A, D or F for example. Any accidentals may precede it, overriding the key signature set up in the sequence specification.

Each individual note may have its own velocity specified and each note will have its time expressed in the number of beats. The gap, between the conceptual 'key release' and the start of the next note, will also be set. In practice the pitch of the note must always be set, in other instances the controls for Time, Velocity and Gap may be default settings taken from the information entered when the sequence controls were specified. Rests may be entered by an 'R'. Notes to be played together as chords are grouped in brackets.

In this way, and with quite a few other control specifications, music may be entered. The procedure becomes rapid with practice and several composers insist it is a very efficient way of writing music.

PROGRAMMING MADE EASY

Fairlight have produced Page R so that musicians may compose on the Fairlight without having to learn MCL. Kim Ryrie describes this system as 'working rather like a Linn drum machine, but with the ability to add melody and expression' and the system allows the composer to build bars which constantly repeat. The composer can play notes in real-time which are read by the Fairlight and appear as notation on the screen. Adding another few bars builds up a sequence. Instruments may then be added to that polyphonically. Each pattern created can be linked together and the Fairlight user has up to 250 patterns to link together. Any eight patterns can be linked together to form up to 26 sections (labelled from A to Z). Patterns and sections can be mixed during linking to create a complete piece.



The all-important high quality disc unit

Software is being developed to make Page R and Page 9 (the real-time sequencers) act as real-time input sources for MCL. The music created through these pages in real-time will write itself as MCL in the Fairlight memory. For editing the musician can then refer to the MCL read-out and edit through this language—a precise and easy-to-use system. With the new high-level language that has been created in these software updates, Fairlight have overcome the requirement for the musician to learn programming techniques. As microprocessor memory capacity increases, so the demands made upon the musician's non-musical abilities will further diminish.

The ultimate goal for the Fairlight team is to develop the CMI so that it is totally software based. Such a system would have an analog-to-digital converter at one end, a massive amount of RAM and some super-high-speed processors in the middle and a few A to D converters at the output end. This system will arrive within a few years. Once this happens, hardware development is effectively at an end and the software teams will then have no limit to the programs they can write.

With its ability to 'listen' to the sounds of the outside world and then place them under the musician's control, the Fairlight represents the current 'state of the art' in commercial computer musical instruments. ★

Ray Hammond has recently completed a book which takes an in-depth look at music electronics, entitled 'The Musician and the Micro'. It is published by Blandford Press at £4.95 (paperback).

Patents Review

Copies of Patents can be obtained from:
the Patents Office Sales, St. Mary Cray, Orpington, Kent. Price £1.60 each.

US DISC ALTERNATIVE

Although Compact Disc, the digital audio sound system, is already on sale in Japan, Britain and the USA, some Americans still have faith in the Soundstream digital audio recording card.

Soundstream, based in Utah, is already known for its digital audio tape recordings. Many of the vinyl records on sale today were made from digital masters, recorded with Soundstream equipment. Three years ago Soundstream was bought out by the Digital Recording Corporation of Connecticut. The result was Audio File, an optical card that can store computer data or hi-fi stereo. The difference between Audio File and Compact Disc, is that the Audio File card remains stationary while tracked by a moving laser beam, whereas Compact Disc rotates over a notionally stationary beam.

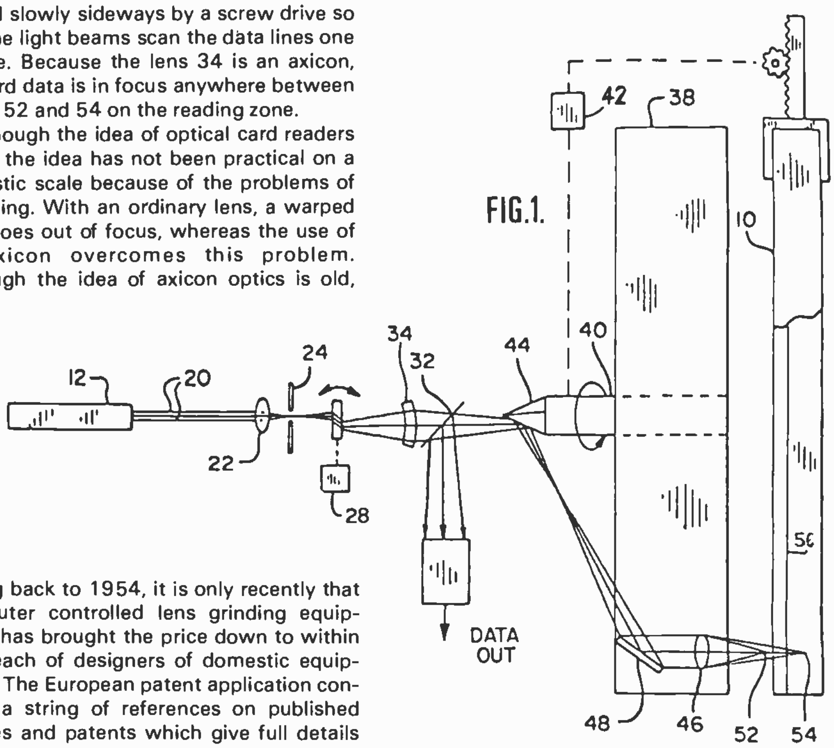
Soundstream and DRC have been cagey about technical details, preferring simply to quote the sampling frequency at 50kHz and quantization as 16 bit linear. But patents are now beginning to issue on the technology. Although more details will doubtless follow in later patents, the first three give useful basic information. US patent 4320488 was issued in March 1982, but dates back to an application made in March 1975. US patent 4321700 was issued in the same month, but dates back to an even earlier application, filed in October 1974. European patent application 0056683, dates back to January 1981 and is still in the pending stages.

This patent application is however the most interesting to read. Fig. 1 shows the basic system. The beam from laser 12 is focussed by lens 22 through pinhole 24 and directed under galvanometer control 28 onto lens 34. This lens is an axicon, which has the special optical characteristic of focussing light rays not in a single spot, but along a line in a common plane.

The line-focussed beam passes through prism 32 onto a five sided pyramid mirror 44 mounted slight off-axis on a shaft 40 which is rotated by motor 42. The shaft also rotates scanning wheel 38 which carries five prism and lens arrangements 48, 46. Because the pyramid 44 is offset slightly from the axicon lens axis, it distributes a light beam to the five sets of lenses 46, one at a time. As a result the scanning wheel traces a series of horizontal lines over the surface of a flat card 10. This card carries a digital audio recording on the surface as microscopic pits of data 56 arranged in a raster of lines. The card 10 is moved slowly sideways by a screw drive so that the light beams scan the data lines one by one. Because the lens 34 is an axicon, the card data is in focus anywhere between points 52 and 54 on the reading zone.

Although the idea of optical card readers is old, the idea has not been practical on a domestic scale because of the problems of focussing. With an ordinary lens, a warped card goes out of focus, whereas the use of an axicon overcomes this problem. Although the idea of axicon optics is old, dating back to 1954, it is only recently that computer controlled lens grinding equipment has brought the price down to within the reach of designers of domestic equipment. The European patent application contains a string of references on published articles and patents which give full details of axicon technology.

FIG.1.



PE micro-file

R.W.Coles

FILESHEET 8 8086

WITH their 8 bit designs behind them, and sales taking off nicely, the leading microprocessor manufacturers recognised that the next prize would be awarded for the introduction of a powerful new generation of 16 bit devices, able to compete directly with the big mini-computers in business, science, and engineering applications.

First on the scene was the 9900 from Texas Instruments, but although this chip was a true 16 bit processor, it lacked memory addressing range and in performance terms was not much better than some 8 bit designs. Worse still, the 9900 was too expensive to be used in applications where its 16 bit architecture was not absolutely essential, and in the mid 1970s there were very few system builders ready to take the plunge into full-blown 16 bit microcomputers because memory was still very expensive, and you needed a lot of it to do justice to a 16 bit machine. The lessons of the 9900 were not lost on the other chip manufacturers. They could see that before 16 bit processors could take off in a big way they would need to be many times more powerful than their 8 bit predecessors and they would also have to have access to lots of cheap memory. In effect, they had to design a microcomputer for the 1980s and not for the 1970s.

The 8086 was the first of the "second wave" of 16 bit processors, and its introduction in 1979 fitted in well with the rock-bottom price of 16K dynamic RAMs and with the promise of 64K just around the corner. Unlike the 9900, the 8086 fell on fertile ground, and almost at once it was being designed into a multitude of powerful new systems for both data processing and control tasks. To ensure that their new design was up to the job, Intel had to pack 29,000 transistors onto a small 225 mil square chip, and to achieve that they used a new high resolution NMOS process called HMOS to get the gates smaller and the speeds higher. The result is a processor which is at least ten times more powerful than the 8 bit 8080A.

Whereas the previous generation of 8 bit processors had used a primitive low performance version of the architecture employed by mini-computers, the 8086 set out to *beat* the minis on the basis not only of price, but of performance too. With the investment many users already had in 8080/8085 software, however, it was also considered necessary for the 8086 to be compatible with its 8 bit predecessors to the extent that 8080 assembly language programs could be easily converted to run, albeit inefficiently, on the new processor.

Inside the 8086 there are actually two processing blocks operating in parallel. One, the Bus Interface Unit (BIU), is responsible for address calculation and the fetching of instructions and operands from main memory. The other, the Execution Unit (EU), receives a stream of instructions from the BIU and interprets these to execute the intended program. Because the Fetch and Execute activities have been separated in this way, the processor can operate very efficiently. The BIU maintains a "queue" of pre-fetched instructions for the EU, and will attempt to top up the 6 byte queue by performing a word fetch whenever it sees a minimum of 2 bytes free. Since the BIU can operate independently of the EU, it can be fetching the next or the next but one instruction while the current instruction is executing, a technique known as "pipelining". This system falls down when the executing instruction is a JUMP of course, because the BIU is not clever enough to anticipate the need to fetch the next instruction from the destination address, but the need to clear the queue on these occasions is not a serious penalty, because in the average program most time is spent executing in-line code rather than JUMPs.

To overcome the limitations of the 9900 and its 32K word address space, the 8086 uses a 20 bit address which can reach 1 megabyte. To avoid the need for a large expensive package, Intel have chosen to multiplex the address and data bus onto sixteen pins so that a cheap 40 pin unit can be used. The sixteen bits of address available on these pins will only reach 64K bytes of memory by themselves, of course, and so four other pins are used to provide the most significant address bits A16 to A19. To make the most of the small 40 pin package, Intel have provided an MN/$\overline{\text{MX}}$ pin which can be used to put the 8086 into either a "Minimum" or a "Maximum" mode by changing the function of package pins 24 to 31. In Maximum mode the 8086 interfaces to the rest of the system using an 8288 bus controller chip which decodes the S0 S1 and S2 status lines to generate memory and I/O control signals. In this mode the 8086 is capable of operating in large multiprocessor systems, and has an expanded set of control facilities provided on pins 24, 25 and 29 to 31.

In Minimum mode, pins 24 to 31 provide the memory and I/O control signals without the need for an 8288. To gain these extra facilities on-chip however, the multiprocessing features of Maximum mode are lost, so Minimum mode is mainly intended for applications which fit onto a single circuit board. The full 1 megabyte address range is available in either mode.

As mentioned in the 6809 file article, Intel never attempted to produce a "super" 8 bit processor to compete with the Z80 and the 6809. Instead they concentrated on the high performance 8086 so that they could be the first with a "second wave" 16 bit device which would give them a higher profit margin than direct competition in the cut throat "super-8" market.

Having captured the high ground with the 8086 however, Intel were quick to see the advantage of producing an 8086 derivative which would not incur the high system costs which follow inevitably from using a 16 bit data bus. The resulting 8088 variant is really an 8086 with full 16 bit performance *inside* but with a modified BIU so that the data bus is only 8 bits wide *outside*.

When executing, say, a 16 bit register addition, the 8088 is just as fast as the 8086. When 16 bit instruction or data words are fatched from memory, however, the 8088 takes twice as long as the 8086, but this disadvantage is offset by the much lower cost of byte-wide memory and peripheral circuitry for small to medium sized systems.

What Intel had done was to produce a stepping stone from 8 bits to 16 bits, a processor which could compete for the high end of the 8 bit market and the low end of the 16 bit market. A wise move for a company which was already doing well at the low end of the 8 bit market (8085, 8048) and at the high end of the 16 bit market (8086)! The advantages of a processor family with instruction set compatibility from the lowly 8080A, through the 8085 and 8088, to the 8086 and beyond was not lost on many system designers, and, needless to say, Intel have done very well indeed.

Many of the so-called 16 bit personal computers like the IBM PC and the ACT SIRIUS actually use the 8088, and it would appear that many more 8088s are currently finding sockets than are 8086s. When the quest for still higher performance drives these and other manufacturers to move up to full 16 bit bus operation, they can do so without changing so much as a full stop in their software, a very important consideration!

To cope with the challenge from the Zilog Z8000 and the Motorola 68000 which are (arguably) better 16 bit processors than the 8086, the fast moving Intel design team have now come up with a two pronged attack which leapfrogs the competition. Soon to be available will be the 80186 which is an 8086 with most of the necessary system "glue" parts, such as a clock generator, interrupt controller, memory decoder, bus controller, a DMA controller and three 16 bit timers, integrated on to the same chip as

8086 REFERENCE FILE SHEET

GENERAL

The NMOS 8086 from Intel was the first of the "second generation" 16 bit microprocessors arriving just in time to take advantage of rapidly falling memory prices and to capture a large share of the expanding 16 bit market. The 8086 is not a partioularly elegant microprocessor and does need several additional chips to form a practical system but the Intel track-record of aggresive innovation has made it very popular. The 8088 8 bit bus version of the 8086 is used in many popular computers.

REGISTERS

THE 8086 HAS A SET OF FOURTEEN 16 BIT REGISTERS, SOME OF WHICH HAVE DIRECT EQUIVALENTS IN THE 8080/8085 PROCESSORS. THE GENERAL REGS CAN BE USED FOR 8 OR 16 BIT DATA ITEMS WHILE THE POINTER AND SEGMENT REGS HOLD 16 BIT ADDRESS INFO.

POINTER & INDEX REGS

STACK POINTER	SP
BASE POINTER	BP
SOURCE INDEX	SI
DEST. INDEX	DI

GENERAL REGS

AH	AL	AX
BH	BL	BX
CH	CL	CX
DH	DL	DX

SEGMENT REGS.

CODE SEG	CS
DATA SEG.	DS
STACK SEG.	SS
EXTRA SEG.	ES

PROGRAM/COUNTER REGS.

INSTRUCTION POINTER	IP
FLAGS	

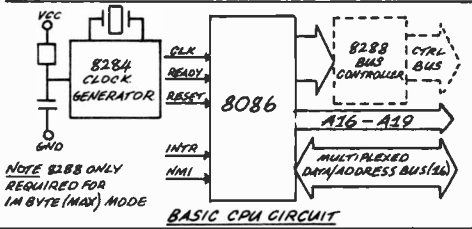
☐ = 8080A/8085 COMPATIBLE REGS

FLAGS

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
				O V F.	D I R.	I N R.	T R A P	S I G N	Z E R O		A U X C Y		P A R I T Y		C A R R Y

INSTRUCTION SET AND SOFTWARE

Aimed at applications making extensive use of high level languages, the 8086 instruction set has been optimised for efficient compilation from typical HLLS such as BASIC and PASCAL. Although the 8086 has some code compatibility with the 8080, there are many new instruction types and addressing modes to facilitate high speed operation in both data processing and controller applications. Well supported with software running under CP/M86, MSDOS and UNIX derivatives.



NOTE 8288 ONLY REQUIRED FOR (MAX) MODE

BASIC CPU CIRCUIT

PERFORMANCE DATA

	8086
MEMORY ADDRESS RANGE :–	1Mb
I/O ADDRESS RANGE :–	64Kb
CLOCK FREQUENCY :–	5MHz*
POWER SUPPLIES :–	5V
INTERRUPTS :–	NMI, INTR

*NOTE: 8 AND 10 MHZ VERSIONS ALSO AVAILABLE

BENCHMARKS	8086
ADD REGISTER TO ACCUM	0.6μS
O/P ACCUM TO PORT	2.0μS
MOVE FROM MEMORY TO MEMORY	4.0μS①

① DIRECT ADDRESSING MODE VIA ACCUM. (QUEUE ASSUMED FULL IN EACH CASE)

8086

Signal	Pin	Pin	MAX (MODE)	MIN
GND	1	40	VCC	
AD14	2	39	AD15	
AD13	3	38	A16/S3	
AD12	4	37	A17/S4	
AD11	5	36	A18/S5	
AD10	6	35	A19/S6	
AD9	7	34	BHE/S7	
AD8	8	33	MN/MX	
AD7	9	32	RD	
AD6	10	31	RQ/GT0	(HOLD)
AD5	11	30	RQ/GT1	(HLDA)
AD4	12	29	LOCK	(WR)
AD3	13	28	S2	(M/IO)
AD2	14	27	S1	(DT/R)
AD1	15	26	S0	(DEN)
AD0	16	25	QS0	(ALE)
NMI	17	24	QS1	(INTA)
INTR	18	23	TEST	
CLK	19	22	READY	
GND	20	21	RESET	

OTHER FAMILY MEMBERS

8088	8 BIT DATA BUS VERSION FOR LOW COST SYSTEMS. DIRECTLY COMPATIBLE BUT SLOWER.
80186	HIGHLY INTEGRATED 8086 WITH ONCHIP CLOCK, INTERRUPT CTRL, D.M.A., TIMERS AND MEMORY DECODER.
80286	BIG SYSTEM 8086 FOR 1 GIGABYTE VIRTUAL MEMORY MULTI-USER, MULTI-TASKING APPLICATIONS.
80188	HIGHLY INTEGRATED VERSION OF 8088 (LIKE 80186) COST COMPETITIVE WITH 8 BIT PROCESSORS.

MANUFACTURERS

ORIGINATOR :- INTEL.

2ND. SOURCES :- AMD, FUJITSU, NEC, SIEMENS.

CMOS VERSION :- HARRIS (80C86).

SUPPORT CHIPS

8086 and 8088 REQUIRE 8284A CLOCK GENERATOR. 8288 BUS CONTROLLER ALSO REQUIRED FOR MAX MODE (MULTI BOARD SYSTEMS). BOTH CHIPS CAN USE 8080 PERIPHERAL FAMILY AND 8088 CAN USE 8085 SPECIALS SUCH AS 8155 AND 8755. POWERFUL NEW 8086/8088 CO-PROCESSORS INCLUDE 8087 ARITHMETIC SUB-SYSTEM, AND 8089 I/O PROCESSOR.

INSTRUCTION SET

GENERAL PURPOSE	
MOV	Move byte or word
PUSH	Push word onto stack
POP	Pop word off stack
PUSHA	Push all registers on stack
POPA	Pop all registers from stack
XCHG	Exchange byte or word
XLAT	Translate byte
INPUT/OUTPUT	
IN	Input byte or word
OUT	Output byte or word
ADDRESS OBJECT	
LEA	Load effective address
LDS	Load pointer using DS
LES	Load pointer using ES
FLAG TRANSFER	
LAHF	Load AH register from flags
SAHF	Store AH register in flags
PUSHF	Push flags onto stack
POPF	Pop flags off stack

ADDITION	
ADD	Add byte or word
ADC	Add byte or word with carry
INC	Increment byte or word by 1
AAA	ASCII adjust for addition
DAA	Decimal adjust for addition
SUBTRACTION	
SUB	Subtract byte or word
SBB	Subtract byte or word with borrow
DEC	Decrement byte or word by 1
NEG	Negate byte or word
CMP	Compare byte or word
AAS	ASCII adjust for subtraction
DAS	Decimal adjust for subtraction
MULTIPLICATION	
MUL	Multiply byte or word unsigned
IMUL	Integer multiply byte or word
AAM	ASCII adjust for multiply
DIVISION	
DIV	Divide byte or word unsigned
IDIV	Integer divide byte or word
AAD	ASCII adjust for division
CBW	Convert byte to word
CWD	Convert word to doubleword

MOVS	Move byte or word string
INS	Input bytes or word string
OUTS	Output bytes or word string
CMPS	Compare byte or word string
SCAS	Scan byte or word string
LODS	Load byte or word string
STOS	Store byte or word string
REP	Repeat
REPE/REPZ	Repeat while equal/zero
REPNE/REPNZ	Repeat while not equal/not zero

LOGICALS	
NOT	"Not" byte or word
AND	"And" byte or word
OR	"Inclusive or" byte or word
XOR	"Exclusive or" byte or word
TEST	"Test" byte or word
SHIFTS	
SHL/SAL	Shift logical/arithmetic left byte or word
SHR	Shift logical right byte or word
SAR	Shift arithmetic right byte or word
ROTATES	
ROL	Rotate left byte or word
ROR	Rotate right byte or word
RCL	Rotate through carry left byte or word
RCR	Rotate through carry right byte or word

FLAG OPERATIONS	
STC	Set carry flag
CLC	Clear carry flag
CMC	Complement carry flag
STD	Set direction flag
CLD	Clear direction flag
STI	Set interrupt enable flag
CLI	Clear interrupt enable flag
EXTERNAL SYNCHRONIZATION	
HLT	Halt until interrupt or reset
WAIT	Wait for TEST pin active
ESC	Escape to extension processor
LOCK	Lock bus during next instruction
NO OPERATION	
NOP	No operation
HIGH LEVEL INSTRUCTIONS	
ENTER	Format stack for procedure entry
LEAVE	Restore stack for procedure exit
BOUND	Detects values outside prescribed range

CONDITIONAL TRANSFERS	
JA/JNBE	Jump if above not below nor equal
JAE/JNB	Jump if above or equal not below
JB/JNAE	Jump if below not above nor equal
JBE/JNA	Jump if below or equal not above
JC	Jump if carry
JE/JZ	Jump if equal/zero
JG/JNLE	Jump if greater/not less nor equal
JGE/JNL	Jump if greater or equal/not less
JL/JNGE	Jump if less/not greater nor equal
JLE/JNG	Jump if less or equal not greater
JNC	Jump if not carry
JNE/JNZ	Jump if not equal/not zero
JNO	Jump if not overflow
JNP/JPO	Jump if not parity/parity odd
JNS	Jump if not sign
JO	Jump if overflow
JP/JPE	Jump if parity/parity even
JS	Jump if sign

UNCONDITIONAL TRANSFERS	
CALL	Call procedure
RET	Return from procedure
JMP	Jump
ITERATION CONTROLS	
LOOP	Loop
LOOPE/LOOPZ	Loop if equal/zero
LOOPNE/LOOPNZ	Loop if not equal/not zero
JCXZ	Jump if register CX = 0
INTERRUPTS	
INT	Interrupt
INTO	Interrupt if overflow
IRET	Interrupt return

the CPU to reduce system cost. For those who want more performance and never mind the cost, Intel will be offering the powerful 80286 which has six times the processing power of the basic 8086 together with big-system features such as memory protection and the on-chip management of a virtual memory space extending to one thousand megabytes!

In all the foregoing text I have used actual device part numbers, but to avoid confusion I should point out that some whizz kids in the Intel marketing department have decided to complicate things by using an alternative terminology based on the i APX prefix (meaning Intel Advanced Processor or something). In this scheme i APX 86 equals 8086, i APX 286 means 80286 and so on, but suffixes may be added to denote a combination of devices e.g.:

i APX 86/10 = 8086 alone

i APX 86/20 = 8086 + 8087

To quote from the Intel manual, "This improved numbering system will enable us to provide you with a more meaningful view of the capabilities of our evolving microsystems"!

REGISTERS

The 8086 has a set of fourteen 16 bit registers divided into three files of four registers each and two specials, namely the Instruction Pointer (Program counter) and the Flag register.

The General Register File can be accessed as either four 16 bit register pairs or as eight individual 8 bit registers, and is intended for use as temporary data storage and counters. Although the nomenclature is different, all of the 8080A data registers have an equivalent in this file. For example the 8080A accumulator is represented here as AL, and the register pair H and L now becomes DH, DL, all done in the interests of software compatibility. In general these registers can be used interchangeably in the arithmetic and logical operations of the 8086, and unlike those of the 8080A, are general purpose in nature. There are still a few instructions, however, which use these registers in a dedicated role.

The Segment Register File holds the key to the wide address range of the 8086, and introduces the new concept of segmented addressing. To address 1 megabyte the processor has to generate a 20 bit address, but to keep the chip reasonably simple, the data paths, registers, and arithmetic unit all handle 16 bit quantities only. To solve this conflict the required addresses are generated by adding together two 16 bit quantities in such a way that a 20 bit result is formed. One of the segment registers is always used as one operand in this addition, but the other operand can come from the Program Counter, Stack Pointer, Index Register, General Register, or memory, all of which provide 16 bit data.

If there was only *one* segment register in the 8086, then it would only be possible to address a single 64K slice of memory at any one time without changing the contents of the segment register by issuing an explicit instruction. Fortunately, the 8086 has *four* segment registers, and so the 8086 programmer can gain simultaneous access to 256K bytes of memory at any given time, and 1 megabyte by reloading one or more of the segment registers. Each of the four segment registers has a specific function so that it may be automatically used to form an appropriate address. Instruction fetches always access the "code" segment of memory and so use the Code Segment register, while stack operations always use the separate Stack Segment register, for example. Data memory can be accessed using either the Data Segment or the Extra Segment register, giving a 128K byte range.

No doubt you have already spotted the fact that 16 bits from the segment register tacked on to 16 bits from elsewhere would give 32 bits, or if you added them, a maximum of 17 bits. What actually happens is that the 16 segment bits are effectively "left-shifted" by four bits before the addition is carreid out, giving the required 20 bit result. But there are still some loose ends. Why, for example, use 16 bit segment registers when 4 bit registers would give the required 1 megabyte range (sixteen 64K byte segments possible)? Well, by using 16 bit registers, the start address of any given segment can be defined with a resolution of 16 bytes, and the four segments available can be overlapped in any desired manner.

The third register file contains memory pointers and index registers. The Stack Pointer (SP) is quite conventional, although it is joined in the 8086 by a new companion called the Base Pointer (BP) which is also used to generate addresses in the Stack Segment of memory. Also here are the Source Index register (SI) and the Destination Index register (DI) which are both used to generate addresses in one of the two data segments. We have seen in previous file articles just how important it is to have two index registers available for accessing tables of data stored in memory.

One of the new flags, OVF, is a very useful addition which provides an indication of a signed arithmetic overflow condition, the other three are used to control processor operation. INTR is used to enable or disable interrupts, TRAP puts the processor into a single step mode, and DIR specifies auto increment or auto decrement during string manipulations.

INSTRUCTION SET

With the advent of microprocessors with a 1 megabyte (or greater) address range like the 8086, and with the availability of cheap 64K bit dynamic RAMs and 8K byte EPROMs, it has become inevitable that future software will mainly be written in a High Level Language (HLL) such as PASCAL or PL/M. Certainly no one in their right mind would sit down and compose a one megabyte program in Assembly language, since using an accepted rule of thumb of ten lines of debugged code per day, *whatever* the language, this gargantuan task could take one programmer the best part of a century!

This simple fact of life was not lost on the designers of the 8086 instruction set, and they have done a creditable job in ensuring a good registration between what the HLL compiler *needs* and what the machine *provides*.

Anyone used to the 8080A or the 8085 will recognise quite a number of familiar landmarks when taking a walk through the 8086 instruction set, and this is not surprising when it is considered that a direct equivalent for most 8080A instructions is to be found there. Despite these occasional similarities however, the 8086 is really a totally new machine with many new instructions and operating modes. New features of particular note are:

Signed and unsigned multiply and divide.

Bit tests.

String (block) operations.

Word/byte translation instructions.

Multiprocessor co-ordinating instructions.

Like the 6809 and the 9900 the 8086 uses the concept of general purpose instruction types which are modified by qualifiers and operand expressions to give a large number of machine code possibilities from relatively few basic mnemonics. There are in fact about 100 mnemonics in the 8086 set, which keeps life tolerable for the assembly language programmer. (Yes, some programs, or parts of programs, will still use assembler.)

Being a 16 bit processor, the 8086 uses an instruction format which can nominate two operand locations, and it does not therefore suffer from the 8 bit limitation of implied sources and/or destinations. Unlike the 9900 however, the 8086 generates an address which can uniquely specify a single *byte* not just a single 16 bit *word*, and this makes it possible to use instructions which are a minimum of one byte, and a maximum of six bytes in length. An example of a one byte instruction is CLC (clear carry) which has no operands, and an example of a six byte instruction is ADD FRED, OFFFOH which adds the immediate data FFFOH contained in bytes 5 and 6 of the instruction to the memory location FRED which is specified by bytes 3 and 4. The use of single byte encoding for instructions with no explicit operands is an efficient way to speed up processing and to reduce memory requirements, but remember that the 8086 BIU will always fetch two instruction bytes at a time from memory, because a 16 bit wide data bus is used. Byte encoding is of course particularly beneficial to the 8088, which does fetch data a byte at a time.

The 8086 instruction set can be divided into major groups:

DATA TRANSFER GROUP: which includes word or byte transfers to or from registers, memory, and I/O ports and all stack operations.

ARITHMETIC GROUP: which includes addition, subtraction, multiplication and division of signed, unsigned, and decimal numbers as well as increments, decrements and decimal-adjust instructions.

BIT MANIPULATION GROUP: which adds the ability to non-destructively test bits in registers or memory (like the Z80) to the 8080A-like logical operations, shifts, and rotates.

STRING GROUP: which with single instructions can search, compare, or move, byte or word organised "strings" of up to 64K bytes. These are similar to the Z80 "block" instructions but with some nice extra facilities.

PROGRAM TRANSFER GROUP: which includes the usual jump, call and return instructions together with the new facility of interrupt instructions which can generate standard interrupts without external stimulation. A very versatile form of the 6800 software interrupt.

PROCESSOR CONTROL GROUP: which combines 8080A style flag manipulations and the NOP instruction with a new group for synchronising the 8086 with external events. Of particular note here is the ESC instruction which allows an associated processor (such as the 8087) to obtain a 6 bit opcode from the 8086.

To complement the capable, if not exactly elegant, instruction set of the 8086 there is of course a wide choice of addressing modes which may be used to specify the Effective Address (EA) of an operand. Unlike the simpler 8 bit processors which usually specify an EA by means of explicit data contained in a register or following the opcode in instruction memory with only minimal computation possible, the 8086 is capable of performing considerable arithmetical gymnastics to compute an operand address by summing up to three 16 bit quantities. Since the resulting 16 bit EA is really just an offset from the start of a memory segment, yet another addition is performed in the BIU to create the final 20 bit address before the operand can be accessed.

Addressing modes are: REGISTER, IMMEDIATE, DIRECT, REGISTER INDIRECT (which are conventional) and:

BASED in which the EA is computed by summing a displacement value contained in the instruction with the contents of the BX or BP register. If the BP register is specified, access to data on the stack is gained without the need for POP instructions. If BX is specified, the result is similar to indexing as applied to the Z80 IX register for example.

INDEXED in which the EA is computed by summing a displacement with the contents of register SI or DI. In this case it is usual to use the displacement value as the "base" address of a table, and the index register value as the table pointer. Arithmetic manipulation or incrementing of the index register can then be used to step through the table.

BASED INDEXED in which the EA is generated by the summation of a base register, an index register and a displacement. Since two separate address components, the base and the index, can be varied at run time, this mode is useful for accessing two dimensional arrays of data.

STRING is really a cop-out since it is not possible to use the above modes with string instructions. Instead, the index registers are implicity used as source (SI) and destination (DI) pointers.

I/O PORT DIRECT which uses an 8 bit direct address to access one of 256 I/O ports.

SOFTWARE

It is probably fair to say that the 8086 will not make a significant impact on the hobby scene until about 1985, and even then it may be in the form of the 80186 which should be cheaper. The 8088 is already here however, or at least it is in the shape of personal computers like the IBM PC and the ACT SIRIUS, and it should be remembered that there is not a jot of difference in software terms between the 8086 and the 8088 variant.

Thanks to 8080 compatibility it should be possible to convert the 8 bit CP/M DOS for use on the 8086, but this would not be a very effective way of using a powerful 16 bit processor and fortunately it is not necessary because Digital Research have come up with a brand new CP/M called CP/M86. CP/M86 is written in 8086 code, and is already available from Intel in the form of the 80150 16K byte ROM complete with an I/O control package for driving standard Intel peripheral chips. We can expect that CP/M86 will gain a big following and that plenty of cheap software will become available in due course, an important consideration when choosing a microprocessor for a data processing application! In the past CP/M has had the market pretty much to itself, but this is no longer true for the 16 bit CP/M86. Strong competition will come from MSDOS, designed by Microsoft and used on the IBM PC, or even from VENIX and XENIX which are versions of the very popular UNIX operating system widely used in universities.

Already available from Intel for use under their own ISIS DOS is a compiler for PLM/86, an assembler (ASM86), and an 8080A to 8086 converter programme (CONV86). For real time applications they also have a useful piece of software called RMX86 (Real-time Multi-tasking eXecutive) which provides a skeleton on which communicating software modules can be hung.

Intel software is very good but it *is* expensive, so go for CP/M86 or MSDOS for hobby applications!

INTERFACING

The 8086 is a 5 volt NMOS device and is therefore easy to hook up. Most hobby applications will use it in its MINIMUM mode, doing away with the need for an 8288 bus controller, but an 8284 clock generator will be required until the 80186 is widely available.

The bus connections are straightforward and are patterned after the 8085 model, which is not surprising since the 8086 needs to be compatible with the popular Intel MULTIBUS which is used for inter-card communication. Using the MULTIBUS it is possible to build systems with multiple CPU boards employing the 8080A, 8085, 8088, and 8086 all acting in consort, because the original specifiers of the bus had the foresight to make provision for 16 bit as well as 8 bit processors.

The use of a 16 bit data bus does put more of a strain on the system designer because EPROMs for example are only 8 bits wide and so it is necessary to use two of them in parallel. This is why many designers have plumped for the simpler system interconnections of the 8088!

The 8086 data and address buses are multiplexed like those of the 8085, so it is necessary to use an external address latch built from two or three TTL 8 bit latches to do the demultiplexing. Like the 8085, the 8086 generates a special Address Latch Enable (ALE) strobe to synchronise this feature.

Rather than design a new souped-up interrupt scheme, Intel decided to stick with the original 8080A concept, which used external hardware in the shape of the 8259 interrupt controller to take care of prioritisation and vectoring. This keeps the CPU simple but does require the use of yet another external package. This problem is overcome by the 80186 which puts the interrupt logic on the CPU chip.

Thanks to the family compatibility built in by Intel, all the 8080A peripheral chips such as the 8255 PIO and the 8251 USART can be used without modification. In addition, the 8088 can be usefully teamed with the two 8085 "combo" chips, the 8155 RAM, TIMER, I/O and the 8755 EPROM, I/O. These will interface directly to the multiplexed 8088 bus and permit the assembly of complete 16 bit controller systems using only 4 to 5 devices.

Although compatibility with pre-existing peripheral devices was a definite advantage, Intel have not left it at that. To multiply the power of their 8086 and 8088 still further, Intel have introduced a number of co-processor devices which unload some of the more onerous chores from the 16 bit CPUs.

Even with hardware multiply and divide available on-chip, the execution times of a software based floating arithmetic library are disappointing to say the least, and to boost performance in this area Intel have introduced the 8087 numeric co-processor which can perform a wide variety of arithmetic and trigonometric operations at very high speed.

Also available is the 8089 I/O processor which is really a separate 16 bit microprocessor in its own right, but one which has an instruction set optimised for input/output operations. The 8089 can be used to control high speed DMA transfers, and to buffer and control complex peripheral devices such as disc drives by virtue of its two external I/O channels each capable of 1·25M bytes per second transfer rate. The 8089 executes programs stored in memory shared with the main CPU, and is directed to a particular program by the 8088 or 8086 which passes Control, Parameter, and Task blocks using a simple communication scheme.

APPLICATIONS

The 8086 is unlikely to be chosen for hobby projects due to the complexity of the hardware required to use it effectively, but the 8088, and, in the future, the 80186, are worth considering where 16 bit power is needed.

The 8086 instruction set and architecture are both equally suited to data processing and controller applications, and anyone with an 8088 based personal computer can be satisfied that they have one of the best price/performance combinations currently available.

NEW SERIES

SEMICONDUCTOR CIRCUITS

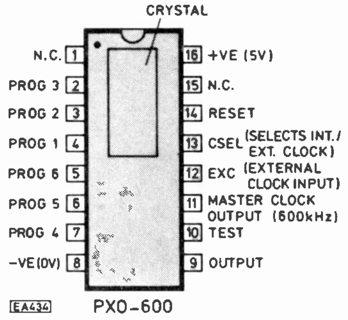
TOM GASKELL B.A.(Hons)

PROGRAMMABLE CRYSTAL OSCILLATOR (PXO–600)

THIS month we feature a brand new, and very unusual, semiconductor device. The PXO–600 is a 16 pin i.c. from the American Statec Corporation, which contains a complete programmable crystal oscillator, including the crystal itself! Internal programmable dividers allow for the production of frequencies between 0·005Hz and 600kHz, all with the same stability and accuracy as the basic crystal oscillator itself. The internal circuitry is based on CMOS technology, so the complete i.c. consumes very little power.

Fig. 1 shows the pin-out of the PXO–600, with the crystal fixed at the pin 1/pin 16 end of the package. A transparent window is provided in the top surface of the i.c., so the crystal is clearly visible. The internal block diagram is shown in Fig. 2. The crystal oscillator runs at a fixed frequency of 600kHz, and its signal is always available at pin 11. Following this, a selection circuit allows for either this internal clock, or an external one, to be fed into the rest of the circuitry. Programmable dividers then divide the frequency down to provide the final output from the i.c. Fig. 3 shows the different division ratios possible, which are selected by providing the required logic levels on pins 2 to 7. (As usual, '0' is a low level, or 0V, and '1' is a high level, or +5V.) The overall division ratio is a combination of the first programmable division (1/1 to 1/12) and the second (1/1 to 1/10^7). The complete table of output frequencies is shown in Fig. 4; note that the output is a square wave except where indicated. The specifications for the PXO–600 are shown in Fig. 1, and are largely self-explanatory. Unlike many CMOS circuits, the maximum supply voltage is +6V, so normally the i.c. should be run from a 5V supply. As we shall see in the applications circuit, the i.c. is capable of driving LS TTL inputs as well as CMOS.

Fig. 1. PXO–600 pin-out with specifications set out below



Characteristic	Notes	Minimum	Typically	Maximum	Units
Supply voltage	(All specs measured at +5V supply)	4·0	5·0	6·0	V
Quiescent current	60kHZ selected		0·7	1·0	μA
Temperature range		−10		+70	°C
Crystal calibration		−100		+100	ppm
Frequency stability	(Does not include calibration tolerances) −10°C to +70°C	−0·015		+0·015	%
Ageing	In first year			10	ppm
Maximum external oscillator frequency				1·25	MHz
Output current	High level (Logic 1)			+1·0	mA
	Low level (Logic 0)			−1·6	μA
Input voltage	For Logic 1	4·0		5·0	V
	For Logic 0	0		1·0	V
'Reset' input current	High level (Logic 1)			+0·5	μA
	Low level (Logic 0)			−15	μA
All other input currents	High level (Logic 1)			+15	μA
	Low level (Logic 0)			−0·5	μA
Output rise time	Loaded with 15pF		70		ns
Output fall time			30		ns

ppm = parts per million

EXTRA FACILITIES

Various extra facilities are provided in this i.c. to add a little flexibility to the way that it can be used.

Test (Pin 10)
Setting this pin to a high level (logic 1) multiplies the output frequency by 1000, except when the division ratio is already less than 1/1000 (i.e. 1/10^3). This enables quick testing of some of the very low frequencies.

Exc (Pin 12)
This is the external clock input to the i.c., allowing the programmable dividers to be used to divide down any suitable external clock.

Csel (Pin 13)
Setting this pin high (logic 1) causes the divider to operate on the external clock, rather than the internal crystal oscillator.

Reset (Pin 14)
Setting this pin low (logic 0) resets the dividers and sets the output to logic 0.

All the inputs except EXC have pull up/pull down resistors, as appropriate, fitted internally to the i.c. Hence, leaving any of these inputs open circuit will cause that facility to be non-operational, removing the necessity for many external resistors.

APPLICATIONS CIRCUIT

The PXO–600 is such a compact and ver-

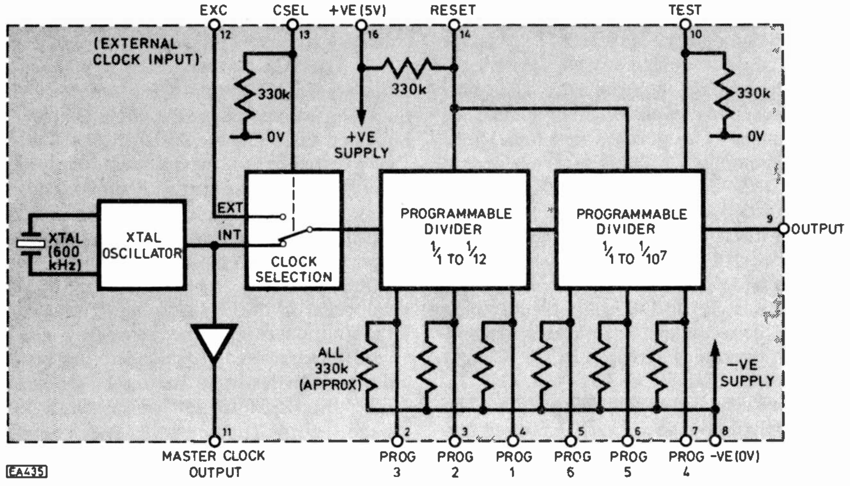


Fig. 2. Block diagram

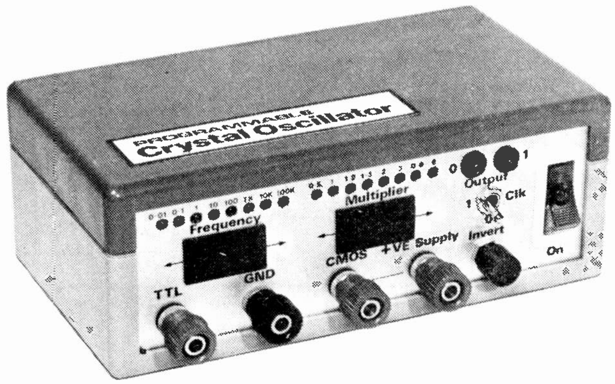
Prog 1	Prog 2	Prog 3	Dividing Ratio	Prog 4	Prog 5	Prog 6	Dividing Ratio
0	0	0	1	0	0	0	1
0	0	1	$\frac{1}{10}$	0	0	1	$\frac{1}{10}$
0	1	0	$\frac{1}{2}$	0	1	0	$\frac{1}{10^2}$
0	1	1	$\frac{1}{3}$	0	1	1	$\frac{1}{10^3}$
1	0	0	$\frac{1}{4}$	1	0	0	$\frac{1}{10^4}$
1	0	1	$\frac{1}{5}$	1	0	1	$\frac{1}{10^5}$
1	1	0	$\frac{1}{6}$	1	1	0	$\frac{1}{10^6}$
1	1	1	$\frac{1}{12}$	1	1	1	$\frac{1}{10^7}$

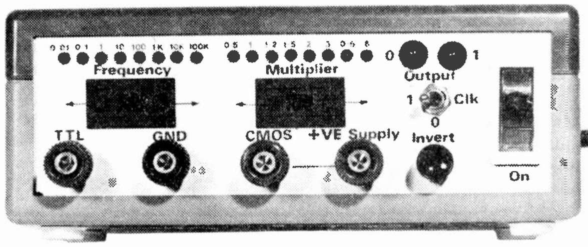
Fig. 3. Programmable dividing ratios

Prog pins		4 5 6	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
1	2	3								
0	0	0	600k	60k	6k	600	60	6	0·6	0·06
0	0	1	60k	6k	600	60	6	0·6	0·06	0·006
0	1	0	300k	30k	3k	300	30	3	0·3	0·03
0	1	1	★ 200k	20k	2k	200	20	2	0·2	0·02
1	0	0	150k	15k	1k5	150	15	1·5	0·15	0·015
1	0	1	★★ 120k	12k	1k2	120	12	1·2	0·12	0·012
1	1	0	100k	10k	1k	100	10	1	0·1	0·01
1	1	1	50k	5k	500	50	5	0·5	0·05	0·005

★ = 33% DUTY CYCLE
★★ = 40% DUTY CYCLE

Fig. 4. Output frequencies





satile device that a rather more sophisticated circuit than usual has been provided to fully exploit its potential! Crystal oscillators have inherently high accuracy and stability, and this, combined with the ease and flexibility of frequency selection, allows us to construct a high accuracy signal generator for both digital and analogue circuit use, with a very wide range of available frequencies. Fig. 5 shows the circuit diagram of a complete programmable crystal oscillator, which will prove to be ideal for general purpose test and measurement use.

The output frequency is selected by S1 and S2. These are miniature 'push-push' thumbwheel type switches, with a hexadecimal, or "hex" code. These switches display a number, or letter, through a small window in the front of the switch; because this is irrelevant in our application, these should be painted over with ordinary black paint. The 'common' pins of these switches are connected to 0V, rather than the more usual +5V, with R1 to R6 acting as pull-up resistors. This is exactly what is needed to provide the correct binary codes into the PXO–600, IC1. To give us an indication of the frequency being generated, IC2 and IC3 (both TTL i.c.s) decode the binary codes from the switches into a decimal, or 1-out-of-8 code. The outputs of these i.c.s are inverted; when they are turned on, they sink current to 0V, turning on the l.e.d.s in question. Note that 'ordinary' TTL should be used for these two i.c.s, not LS TTL, because of the current sinking requirements. The result of all this circuitry is an arrangement whereby one thumbwheel programs in the basic frequency selected, 0·01Hz to 100kHz, and the second thumbwheel programs in the 'multiplier' of this basic frequency, x0·5 to x6.

OUTPUTS

ICs 4, 5, and 6 provide us with the output driving circuitry, and a little control over the output states of the instrument. S3 is a 3 position centre-off toggle switch, which selects the outputs to be either fixed at logic 1, fixed at logic 0, or clocking, i.e. fed from the oscillator. In any of these three conditions, the output can be inverted momentarily, while S4 (a momentary action, single pole changeover pushbutton switch) is pressed; hence, a logic 0 level becomes logic 1, and vice-versa. S4 is 'debounced' by the flip-flop, or latch, formed by IC4c and IC4d, with the signal inversion being controlled by the EX-OR gate IC5c. This ensures that the signal inversion is done with no contact bounce or spurious pulsing. IC6a and IC6b are used to drive the logic 1 and logic 0 output l.e.d.s, which monitor the state of the outputs, while IC6c and IC6d are connected in parallel to increase the drive capability of the TTL output signal. IC6 should be a 7400, not a 74LS00, to ensure that sufficient output drive is available.

The CMOS output is provided in rather a different manner. IC4 is an 'open collector' LS TTL i.c., which means that it can only sink current to 0V; there is no pull-up circuitry provided within the i.c. For IC4a, c and d we have to use a 1k pull up resistor on the gate output to +5V; these are R15, R18, and R9 respectively. IC4b provides the CMOS output of the instrument. If the 'CMOS +ve supply' terminal is left unconnected externally, D5 and R12 provide the pull-up to ensure a full voltage swing from IC4b, hence the CMOS output is a square wave with an amplitude of +4·5V maximum. If the CMOS circuit under test is run from a higher voltage, up to +18V, then by connecting the +ve supply to the 'CMOS +ve supply' terminal on the instrument, the CMOS output is now pulled up by R13 (via D6) to this higher supply rail, which matches the square wave amplitude to the circuit under test. At very high frequencies, typically above 100kHz, this output will be a little rounded in shape, which is caused by the discrete time taken for R12 or R13 to charge up stray capacitance and any capacitive loading on the CMOS output. This will not normally cause any problems, but should be borne in mind. If faster edges were found to be necessary, and the CMOS supply rails were to remain fixed, then a 4049 CMOS buffer i.c. could be added to the circuitry as a permanent feature, with extra power supply components being added as necessary.

IC7 is a 5V regulator i.c. mounted on a small heatsink. D1 to D4 rectify the incoming a.c. from the secondary of the mains transformer, with smoothing provided by C1. C2 and C3 ensure the stability of IC7, with C4, C5, and C6 (all disc ceramic capacitors) providing extra supply decoupling, a very important factor when dealing with TTL i.c.s.

CONSTRUCTION

Two Veroboard layouts are provided this month, Fig. 6 and Fig. 7. The power supply and the main circuitry have been separated for convenience. If the choice of mains transformer is made carefully, the whole instrument, including power supply, will fit into a very small Verobox: type 212 (Vero part number 202–21041C). Naturally, any box larger than this nominal 155mm x 85mm x 60mm will be able to accommodate the circuitry with even greater ease. The l.e.d.s have their legs bent *very* carefully to fit onto the edge of the Veroboard. Treat them with care, because it's very easy to crack and destroy the l.e.d. body when bending the legs. The front panel should have its holes marked and drilled very carefully, too, as any inaccuracy at this stage will result in the l.e.d.s on the Veroboard and the front panel holes not meeting up when the case is assembled. Remember, the board is designed to fasten to the *top* of the case; in other words, if fastens upside down in the case, with the components pointing downwards.

Due to the fairly high cost of the PXO-600, it is a good idea to mount this in an i.c. socket (use a good one) so that the correct wiring of power supplies to the i.c., etc., can be checked before the i.c. itself is inserted. Note that the PXO-600 fits into the board the opposite way round to all the other i.c.s; pin 1 of

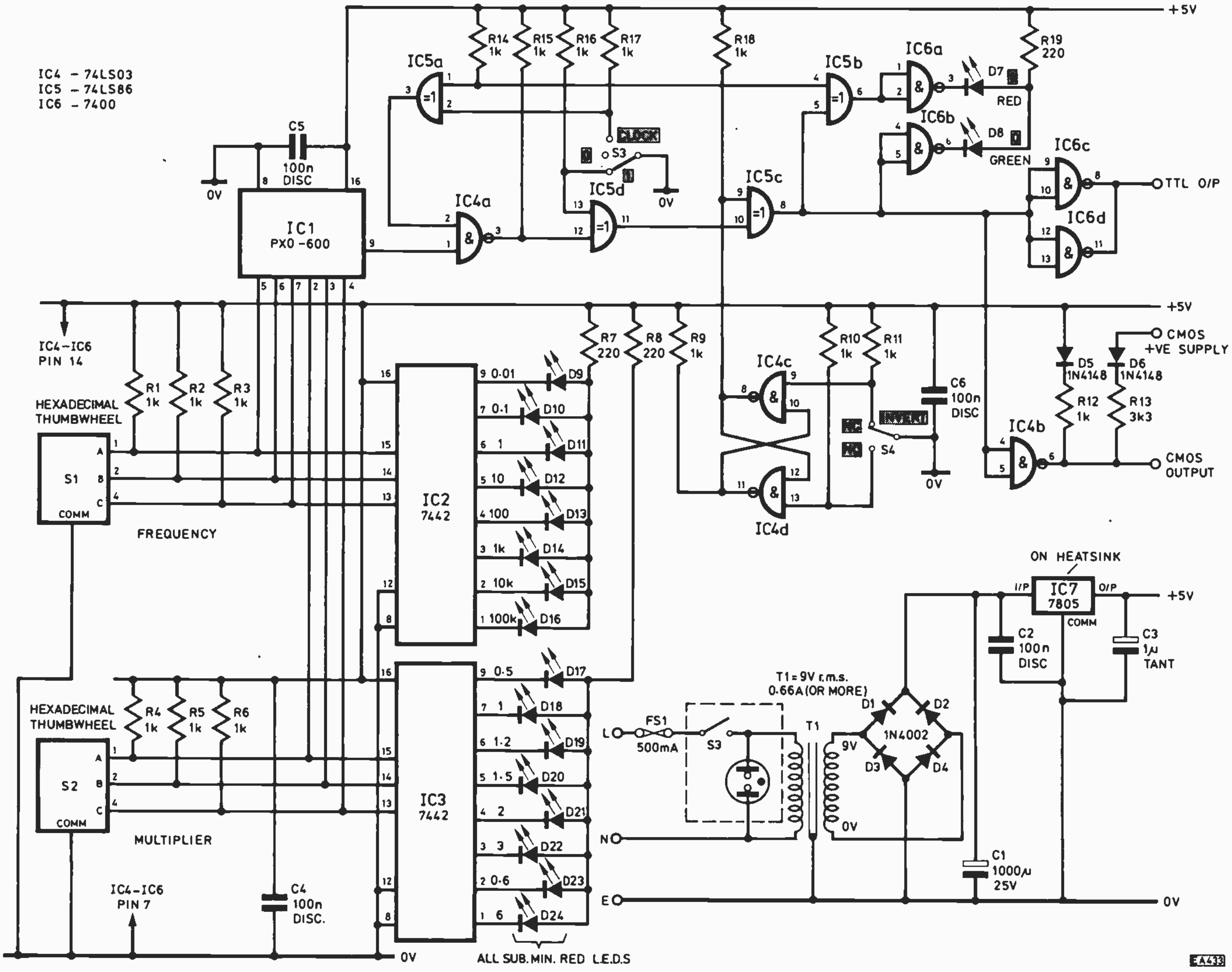


Fig. 5. Circuit of programmable crystal oscillator

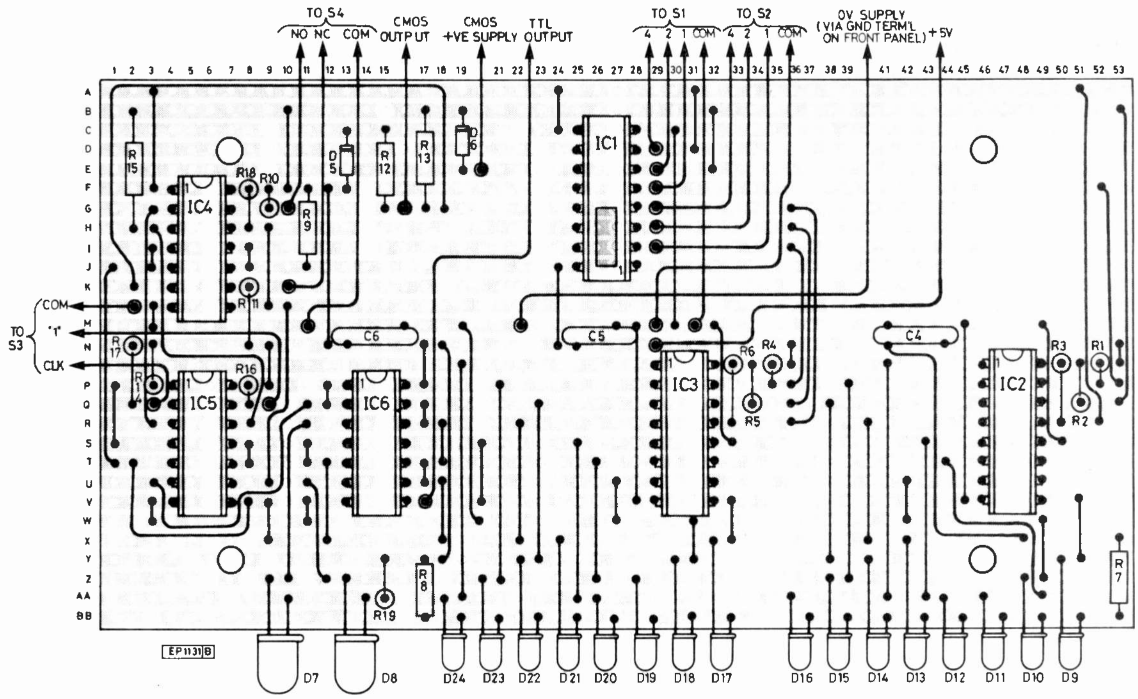


Fig. 6. Veroboard layout for the Crystal Oscillator

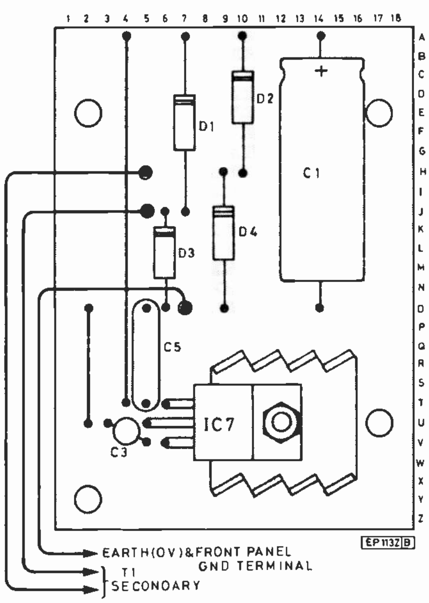


Fig. 7. Veroboard layout for the Power Supply

Internal view

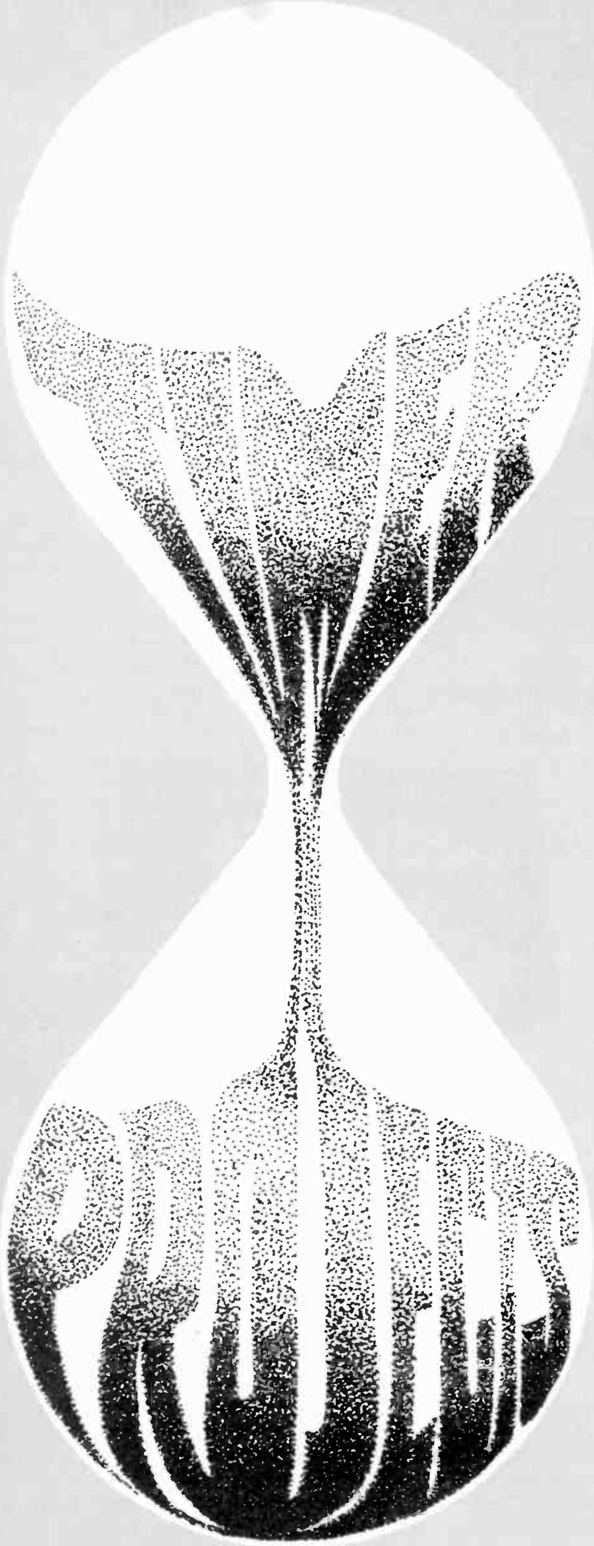
the PXO–600 faces the front panel, whereas pin 1 on all the other i.c.s faces the back panel. When wiring up the thumbwheels, use only pins A, B, and C, along with the common pin; do not use pin D. These may be marked 1, 2, and 4, with the common pin marked C.

When wiring up the mains supply take great care and use sleeves and insulators over all mains connections. An old film transparency box lid, cut up and fixed on with "sticky fixers", makes a good cover for transformer connections. A few holes in the case should be provided to allow ventilation around the transformer and the heatsink for IC7, both of which can get quite warm. The operation of the 5 volt regulated supply should be checked out before it is connected to the rest of the circuitry.

For simplicity, and to keep the size down, this project has not included the extra facilities of the PXO–600 such as external clock, reset, and test. These could easily be added to the instrument if required, however. Other circuit configurations are also possible; by connecting the output (pin 9) back to the CSEL input (pin 13) we can make the device 'freeze' itself after half a cycle of its output. Using reset (pin 14) to trigger the device then effectively gives us a crystal controlled, wide range, one shot timer or monostable. Versions of this i.c. are also available which use different base frequencies. the PXO–768 has a base frequency of 768kHz, which provides outputs of 0·0064Hz to 768kHz, and the PXO–1000 has a base frequency of 1MHz, providing outputs of 0·0083Hz to 1MHz.

These different i.c.s, with their common programming and controlling facilities, offer an ideal solution to many high accuracy timing and controlling problems, all in a 16 pin package! The PXO series of i.c.s is just now becoming readily available. They can be obtained from:

I.Q.D. Ltd.,
29, Market Street,
Crewkerne,
Somerset TA18 7JU



Stephen Ibbs

Introduction...

ALL the timer projects shown here use the Intersil ICM 7217 4-digit up/down counter. This is a very versatile, presettable counter, which it is worthwhile understanding in more detail. The pin-out is given in Fig. 1 for the 7217A and 7217C, both of which drive a CC (common cathode) type display, the difference being the A version counts up to 9999 and the C up to 5959 (useful for clock type circuits). There is also a 7217 and 7217B, but these drive a CA (common anode) display, and have a different pin-out, so are not used here.

The carry/borrow pin provides the facility for direct cascading of counters, by connecting it for example to the count input of another 7217 to give an 8-digit counter.

The $\overline{\text{zero}}$ output, normally high, goes low when the counter reaches zero. This is useful for triggering alarms, controlling the input pulses etc. N.B. The bar over the word indicates a low level status, i.e. it goes low at zero.

The $\overline{\text{equal}}$ output is similar except that it assumes a low state when the counter is equal to the amount preset in the register. This will be explained in more detail when pins 11 and 12 are described.

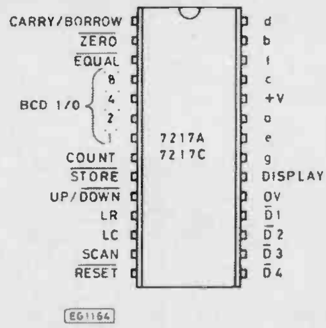


Fig. 1. Pin configuration of the 7217A and 7217C

Pins 4, 5, 6, 7 are BCD coded in/out pins and can be used either as inputs to load data, or as BCD outputs, giving the code of the counter level. Pin 4 = '8', 5 = '4', 6 = '2', 7 = '1'.

Pin 8 is the count input pin and is provided with a Schmitt trigger as protection against noisy input signals. The input frequency is guaranteed to at least 2 MHz.

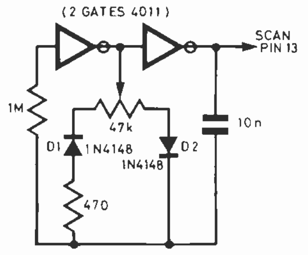
The $\overline{\text{store}}$ input will hold the display output latches with the last count and as will be shown later this can be used to give a simple frequency meter (or tachometer).

The up/$\overline{\text{down}}$ pin 10 is self explanatory and decides whether the i.c. counts up, with the pin positive, or down, with pin 10 at 0V.

Pins 11 and 12 are really clever, each having 3 states: high, low and floating (which is the normal level for operation). When either pin is taken high, the register or counter respectively is loaded with the data contained on the BCD pins. Thus if for example the register (pin 11) was preset with 1000, and the counter (pin 12) with 1500, and pin 10 (up/down) was low, the $\overline{\text{equal}}$ (pin 3) would go low after 500 input pulses. The counter section does not affect the data loaded in the register so if pin 11 was loaded with 2400, and the $\overline{\text{equal}}$ output used to reset the counter, a simple 24 hour clock with BCD output is provided. When pin 11 or 12 is low, the BCD pins assume a high impedance state, and various other functions are disabled. Diodes have to be included to isolate the BCD pins from each other when using BCD switches.

Pin 13 is the scan pin, used to over-ride the multiple scan oscillator, and using the circuit in Fig. 2, will provide a brightness control. This is a square wave oscillator with the duty cycle made variable by the 47kΩ preset controlling the charging and discharging rates through D1 and D2.

Pin 14 resets the counter to zero when pulled low. This can be done with a push to make switch, or automatically using the circuit in



EG1165

Fig. 2. 'Scan' circuit for brightness control

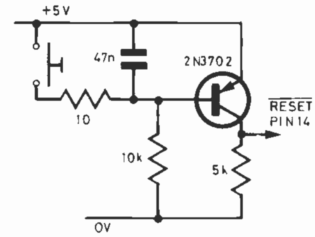


Fig. 3. Reset circuit

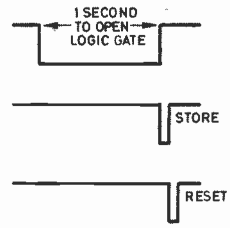


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Fig. 4. Timing diagram

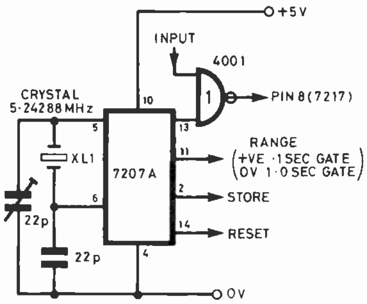


Fig. 5. 7207A circuit

Fig. 3 containing a manual button as well. Pins 15–18 are the digit drivers to control the l.e.d. display (common cathode). Pin 15 = D4, pin 18 = D1.

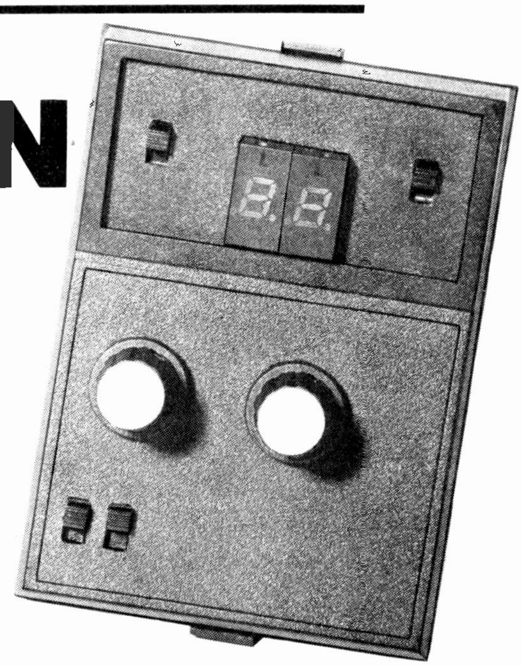
Pin 19 is connected to 0V, and pin 20 is another tri-state pin, controlling the display. It is left floating for normal operation, but when pulled high the display is turned off. When, however, it is pulled low, the leading zero feature of the i.c. is disabled. Apart from pin 24, connected to 5V, all the other pins to drive the display segments are multiplexed. The maximum supply voltage is 6V, so all the projects incorporate a 5V regulator.

If the count, store and reset pins are considered, it is possible to build a 4-digit frequency meter by counting the pulses, for e.g. one second, storing the result and displaying it, then resetting the counter ready for the next 'one second package' (Fig. 4). However, these controlling pulses have to be very carefully timed and this can be achieved using CMOS i.c.'s, but a much neater solution is to use the ICM7207A (crystal controlled) to give the desired pulse sequence with the necessary accuracy (Fig. 5).

For timing circuits the usual requirement would be for a 1 second and a 1 minute pulse. This can be produced easily in at least two ways, using either a 555 oscillator with its output divided by 60 (switchable), as used in the two handhelds, and the darkroom timer (which only has a 1Hz oscillator), or by using the ICM 7213 oscillator as used in the kitchen timer. More details are given in the individual circuit diagrams.

The BCD I/O pins interested the author most because some new BCD p.c.b.-mounting switches have been introduced, and these are used in three of the projects to preset the counter, as they enable easy programming of the counter; in fact it's so easy that the counter would prove useful for blind people. However, the fact that the pins can be used as outputs as well means that if a BCD decoder is used, other devices may be driven from the master i.c. . . . hence the two l.c.d. counters. These use the BCD outputs (inverted) which are fed into an ICM 7211 BCD to l.c.d. decoder/driver i.c. This provides a real opportunity for simple battery-powered timers because the displays consume such little current.

HAND HELD 2 DIGIT DOWN COUNTER



THIS project uses the presettable capability of the 7217A to provide a 2 digit counter capable of being preset to any number of seconds or minutes up to 99, producing an alarm when the counter reaches zero. Because it uses an l.e.d. display that has quite a high current drain, a switch is included to blank the display, whilst not upsetting the counter. The project uses the case given free by PE some time ago, and these are still available from the editorial offices at Poole (50p inclusive). The p.c.b. mounting switches solve many construction problems and the result is a highly useful timer, e.g. for parking meters, or (as the author does) as a fuel timer for radio controlled aircraft, to avoid landings with no fuel . . . a well known cause of ulcers, and increased profits for model shops.

HOW IT WORKS

The circuit diagram of the 2 digit down-counter is shown in Fig. 1. The oscillator is a 7555, selected for its low current drain, connected in its astable mode, and adjusted to 1Hz by VR1, which together with R1 and C1 provide the time constant. The output is switched either into the counter via the switching logic or into two 4017s, the first connected as a divide-by-ten, the second as a divide-by-six, to provide a pulse every 60 seconds. These dividers have to be reset at power-on to ensure the 'O' outputs are high, and this is accomplished by R2/C2, and R3/C3, providing a brief reset pulse to pin 15 of each i.c. The output from IC3 is inverted, otherwise because of the various logic levels involved, a spurious count would result after 10 seconds. IC4d is a gate controlled by the 'zero' output of the 7217, allowing pulses to go through until zero is reached when the gate closes.

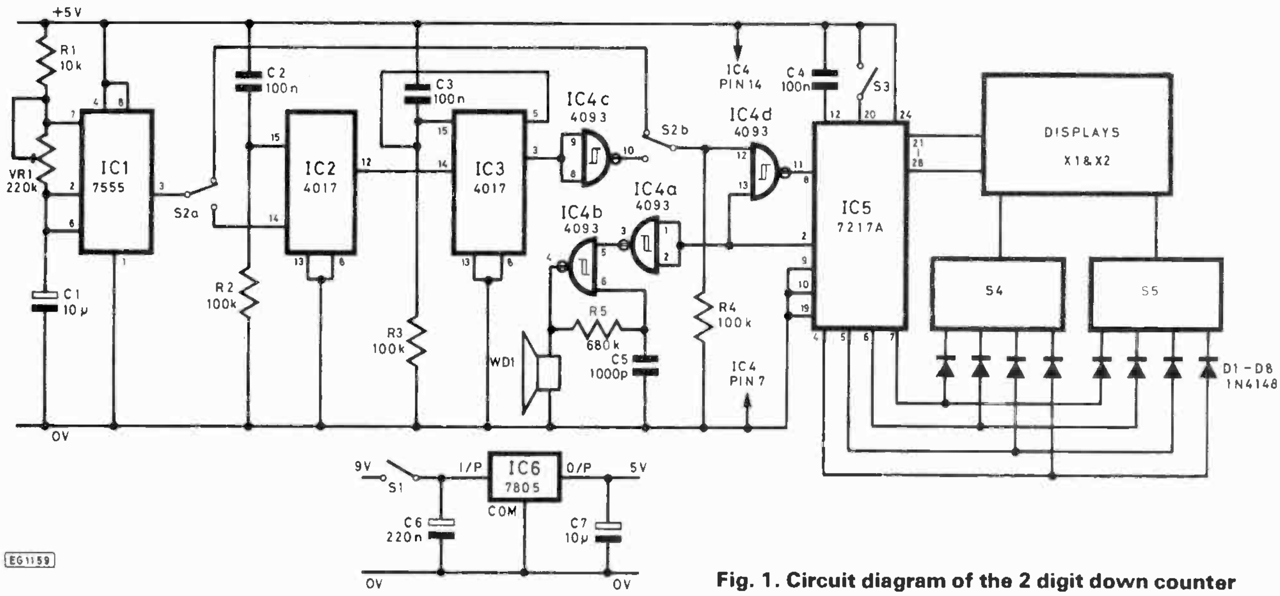


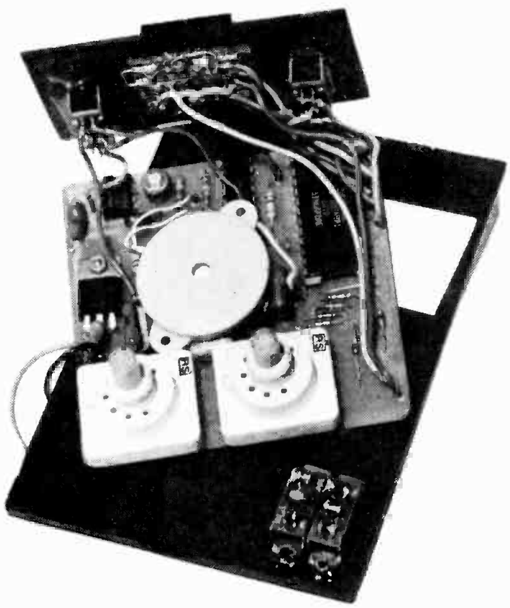
Fig. 1. Circuit diagram of the 2 digit down counter

This is necessary otherwise the counter would continue through zero and switch the alarm off. The 'zero' output also controls the gated audio alarm, driving a piezo transducer, and please note that a 4093 quad NAND Schmitt trigger is used for IC4. A 4011 will not work because it requires two gates to produce an oscillator, and there was not one spare.

The inclusion of a capacitor between pin 12 (IC5) and +ve needs explanation. It was felt by the author that to include yet another switch to manually load the counter would clutter up the appearance, and make the unit more cumbersome to use. Experiments were carried out for various ways of loading data, and it was found that a capacitor provided the necessary high pulse whilst not tying the pin high or low. Thus the counter is automatically loaded at 'switch-on', and immediately starts counting down. This results in a very simple-to-use unit.

CONSTRUCTION

Provided care is taken, necessary because of the restrictions due to the size of the case, no problems should be experienced. However the use of a p.c.b. is highly recommended, and a suggested design is given in Fig. 2. Mount all the components, including the BCD switches which should have all their unnecessary pins clipped short according to Fig. 3. All components should be mounted as close to the board as possible, with the capacitors bent over flush. A piece of black plastic was cut to fit the case aperture, and two slide



COMPONENTS . . .

Resistors

R1	10k
R2, R3, R4	100k (3 off)
R5	680k
VR1	220k sub-min cermet

All resistors $\frac{1}{4}$W 10% carbon

Capacitors

C1, C7	10µ tant (2 off)
C2, C3, C4	100n polyester (3 off)
C5	1000p ceramic
C6	220n tant

Semiconductors

D1 to D8	1N4148 (8 off)
IC1	7555
IC2, IC3	4017 (2 off)
IC4	4093
IC5	*7217A
IC6	7805

Miscellaneous

X1, X2: CC displays (2 off) DL-704
BCD switches (RS type 327-939) (2 off)
Slide switches 2-pole min (3 off)
Battery clip
PB 2720 piezo transducer (Ambit)
p.c.b.
Case

***Constructor's Note**

Care must be taken to obtain the correct switches and main i.c. The 7217 is available from many stockists but the version may not be the correct one, and the pin-out will be wrong. The 7217A is available from Ambit, and is the version required for this project. They can also supply the subminiature cermet preset, needed because of its small size. Ambit (0277 230909).

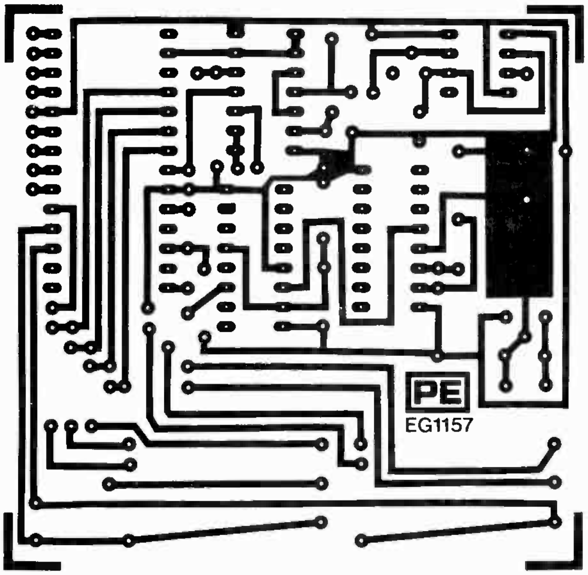
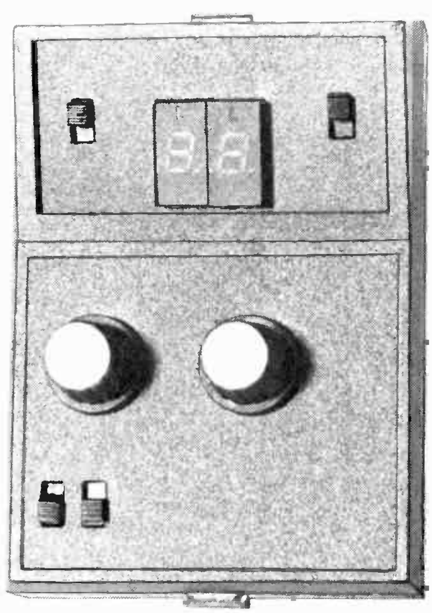


Fig. 2. P.c.b. design

switches were mounted either side of the display using epoxy resin. Holes were drilled for the display pins which were then mounted through the plastic onto the display board (Fig. 4). The piezo transducer was stuck on top of IC2 and IC3 and small lengths of insulated lead used to make the necessary interconnections. The third switch was mounted on the edge of the battery compartment. (Please ignore the 4th switch in the prototype. This was included for other purposes and not used.)

Two holes were drilled in the case for the BCD switches and constructors should make the holes large enough for the threaded bushes which by good fortune protrude to exactly the right height. The unit is then calibrated simply by switching on, with the 1Hz rate selected and adjusting VR1 until the display counts down at the correct rate. Do not forget to load some data in, otherwise the counter will load itself with zero! In use the counter is loaded and the count rate selected before the unit is turned on. A separate start switch could be included, as could a load button, reset button etc, but it would make construction more difficult.



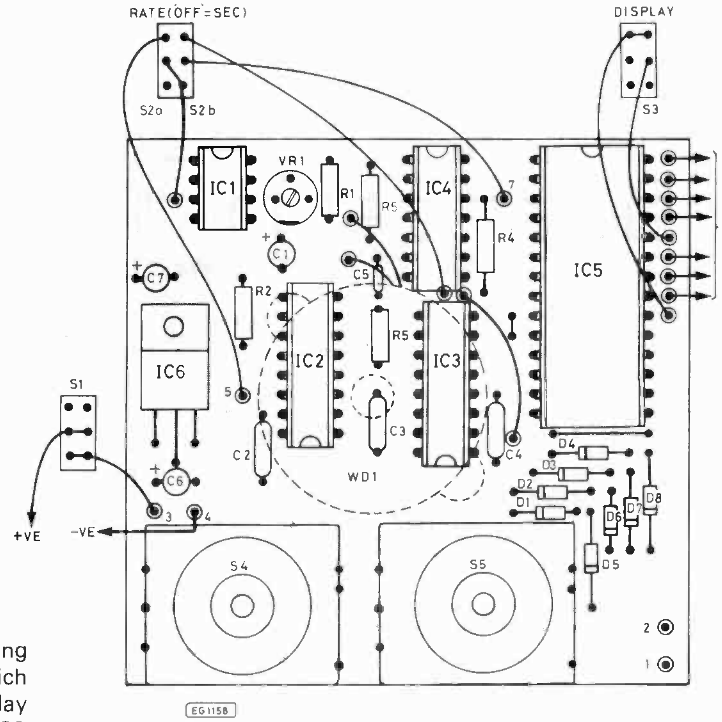


Fig. 3. Component layout

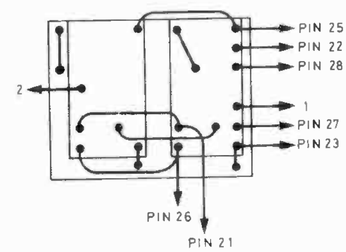


Fig. 4. Display wiring

Because of the space limitation, various desirable decoupling capacitors could not be built in, so do not change the rate switch whilst a count is in progress because it may cause the unit to 'jump' a digit. The unit is then clipped together, the switch nuts tightened down, and two knobs added. With all the digit segments lit the prototype consumed 53mA; however this dropped to 4mA with the display blanked. Thus it is wise to blank the display whenever possible, or arrange a mortgage to cover battery costs.

Constructors will note that pin 10 is connected to 0V via a wire link to make the i.c. count down. For those who intend to leave it like that, the wire link can be omitted, and pin 10 permanently connected to 0V by altering the p.c.b. slightly. However, if a 4th switch is included, placed for example as in the prototype, with pin 10 running to the centre contact, with +ve and 0V on the other two, the unit becomes a switchable up/down counter. However, it would not be able to start from zero because the input gate would be closed; thus the circuit would require a simple modification. This can be done most simply by breaking the connection between pin 2 and the input gate, pin 13, and running a wire from the zero output to the one contact of the second pole of the 4th switch, with pin 13 to the centre, and pin 12 to the final contact. The effect of this is to join 12 and 13 together when counting up, the gate being permanently open, and 13 and the zero pin together when counting down. Make sure the connection between pin 2 (IC5) and pins 1 and 2 (IC4) is maintained. ★

HAND HELD 4 DIGIT LCD UP COUNTER

THIS project demonstrates the ease with which a low power portable counter can be built using the 7217C. As with the 2-digit counter, constructors can make the unit count up or down, but no alarm is included. It uses a handheld case (RS 507-983), painted black to match the l.c.d. display bezel, and although the prototype is not presettable, suggestions are given as to how further facilities can be added, to make the unit more versatile.

HOW IT WORKS

The circuit diagram of the unit is shown in Fig. 1, and the input circuit attacks the problem of getting a 1Hz and 1/60Hz pulse in a different way. The 1Hz is again generated by a 7555, but instead of going into two 4017s, the signal is fed into a 4024 ripple binary counter. This i.c. produces outputs that are related in a binary manner to the input. This means that, e.g. pin 4 (2^6) produces a square wave 1/64 of the input frequency, i.e. it will go high after 32 pulses, low after 64 etc. Similarly pin 5 will go high after 16, pin 6 after 8, and pin 9 after 4 pulses. If these four pins are ANDed together, a 'high' will occur after 60 pulses. This 'high' is then used not only to clock the main counter, but also to reset the 4024, repeating the process ad infinitum. The second AND gate of the 4082 can be controlled by the 'zero' output for those readers who want a down option, or all the pins are connected together and it acts as a buffer. The pulses direct from the 7555 are fed via an inverter to achieve the right logic state at switch on.

As was explained in the introductory article to this series, it was decided (for various reasons) to use the A and C versions, and because of this, four inverters are needed between the digit output lines and the 7211, because the levels are the wrong way round. The BCD data is fed into pins 27-30, and the segment pins connected direct to the display, with the backplane of the display connected to pin 5. It was felt that a colon might be useful and this is most easily done by connecting two diodes between the 3b and 3c segments and the colon pin 28. One or both of b or c are always active, and the diodes prevent them from interacting with each other. However, a better and cheaper way is to connect the backplane to the input of the final inverter of the 4049 (pin 3) and connect the output (2) to the colon pin 28.

CONSTRUCTION

This is not difficult as there is plenty of room inside the case. Mount the components onto the p.c.b. according to Fig. 3, taking care not to forget the wire links. The aperture in the case needs enlarging slightly for the display bezel, by far the most convenient way the author has found of mounting l.c.d. displays. Short lengths of ribbon cable connected the switches and display to the board (Fig. 5).

After the usual check to confirm that there are no solder joins, track breaks, or components in the wrong way round, switch the unit on, with the 'seconds' rate selected via S2. Calibrate to a 1Hz rate by adjusting VR1. The unit can then be mounted in the case.

There is space below the display to mount a second p.c.b. and with care it should be possible to incorporate 4

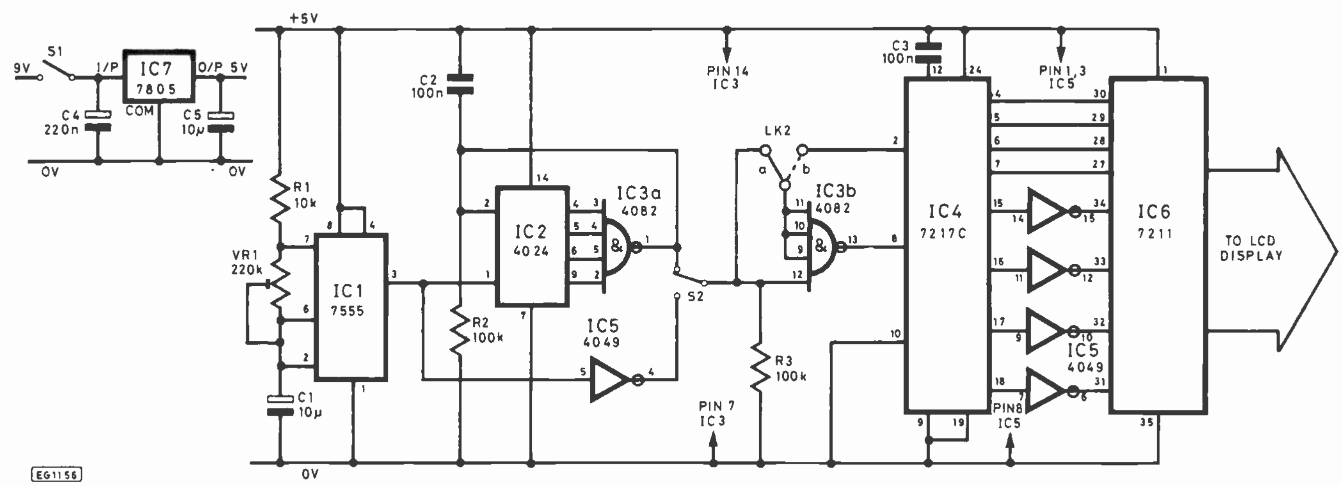


Fig. 1. Circuit diagram of the 4 digit LCD up counter

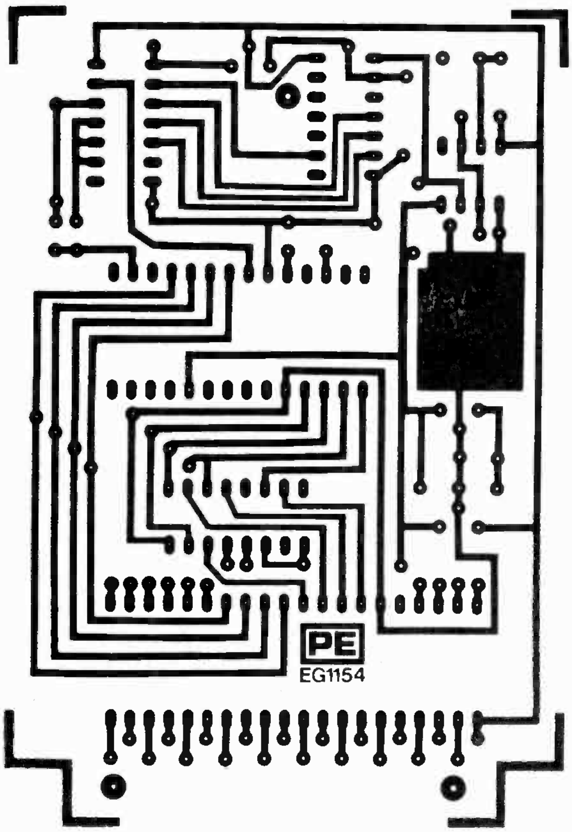


Fig. 2. P.c.b. design

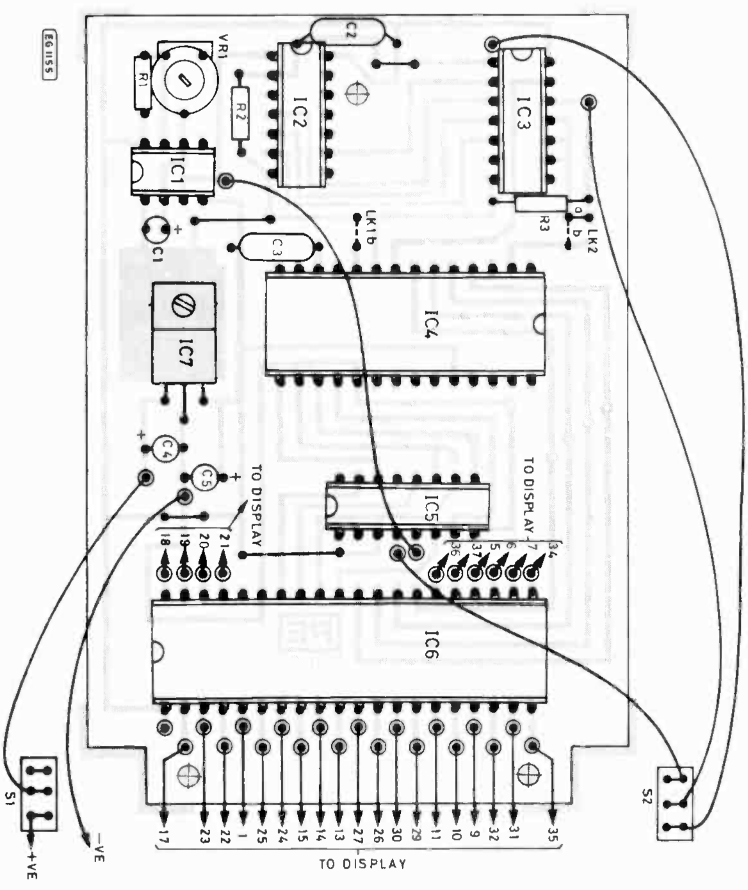
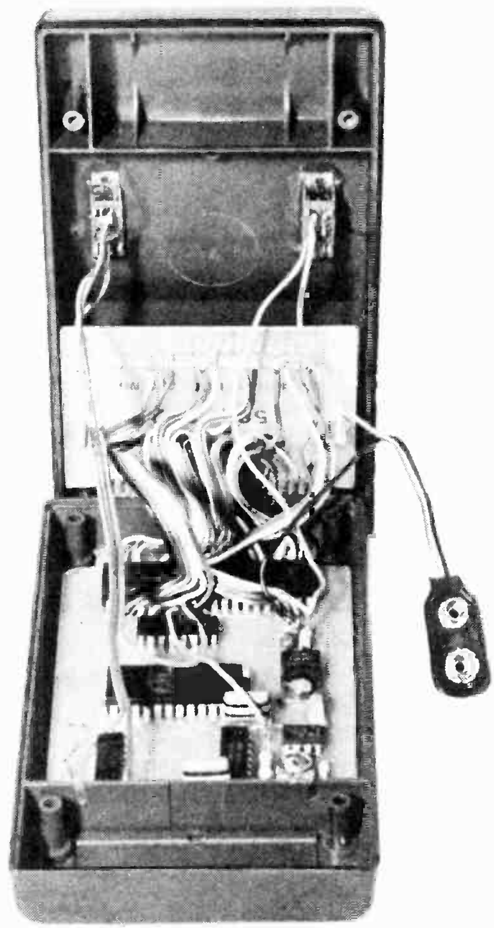


Fig. 3. Component layout



COMPONENTS . . .

Resistors

R1	10k
R2, R3	100k (2 off)
VR1	220k min hor preset

Capacitors

C1, C5	10μ tant (2 off)
C2, C3	100n polyester (2 off)
C4	220n tant

Semiconductors

D1, D2	1N4148 (2 off)
IC1	7555
IC2	4024
IC3	4082
IC4	7217C
IC5	4049
IC6	7211
IC7	7805

Miscellaneous

4-digit l.c.d. (RS type 587-305)
Display bezel (RS type 587-282).
If RS bezel is purchased
the p.c.b. EG1162 is included.
Case (RS 507-983)
Battery clip
Switch s.p.s.t.
Switch s.p.d.t.

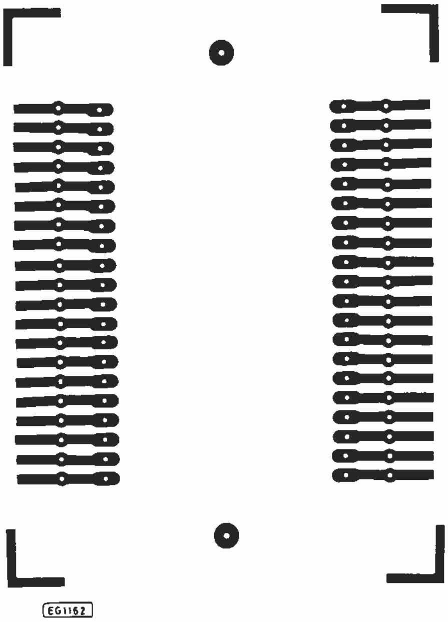


Fig. 4. Display p.c.b.

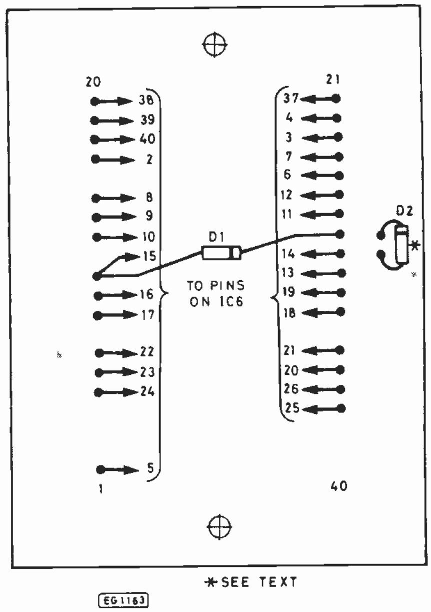


Fig. 5. Display board wiring

miniature BCD switches (which provide a screwdriver slot adjustment). The circuit would be similar to that used in the 'kitchen timer', and it is for this reason that spare pads are provided on the BCD and digit lines on the p.c.b., and why wire links are included around the logic gate and 'zero' output, as they enable the input circuit to be modified as suggested in the 2 digit counter. To count up, omit link 1b and insert link 2a. To count down, insert link 1 and link 2b ★

4 DIGIT LED DOWN COUNTER/ CONTROLLER

THIS project is a development from the 2 digit counter, and uses a 555 gated by a 4093. However, because its prime purpose is as a photographic timer it was felt unnecessary to include the divide-by-60 section because 59 mins 59 secs is long enough for almost any photographic process. The unit has two output devices, the first being a relay that switches on at the start of the timing cycle, and off when the counter reaches zero, the second being an alarm. Thus the relay could be used to control the enlarger, whilst the alarm will be useful for the various development processes. A switch is included to power the relay manually, independent of the counter, e.g. for focusing etc. It was decided to use three p.c.b.s, the main one carrying the timer circuitry, alarm and the display (soldered direct to the board). This makes mounting and interwiring extremely easy, and produces a very neat result. The second p.c.b. carries the BCD switches, as used in the 2 digit counter, with the unused pins cut off, and the diodes, and is mounted in the top of the case. The third and final p.c.b. carries the mains supply, relay, and its associated switching circuitry. Parts of this board are at mains potential, so extreme care must be taken.

Two fuses are included, a 250mA for the unit itself, and a fuse incorporated in the relay output line, whose value should be chosen to match the enlarger etc. The transformer is p.c.b. mounting to make construction easier and safer. A switch is also included to blank the l.e.d. display, useful when timing colour print exposures.

HOW IT WORKS

The circuit (Fig. 1) needs little explanation if the introductory article has been read. The output from the 555 is controlled by one gate of the 4093, gated by the 'zero' output, which also gates the audio alarm, and the output uses the final gate of the 4093 as an inverter with the piezo transducer connected across it to greatly increase the power. The 'zero' output is also used (it's kept very busy!) to switch on a relay via R3 and TR1, using unregulated d.c. supply to ensure enough voltage to drive the relay. When the count is over, pin 2 goes low, switching off the relay, turning on the alarm, and shutting the input gate. Please note that a second pair of relay contacts are provided to control, e.g. the safelight.

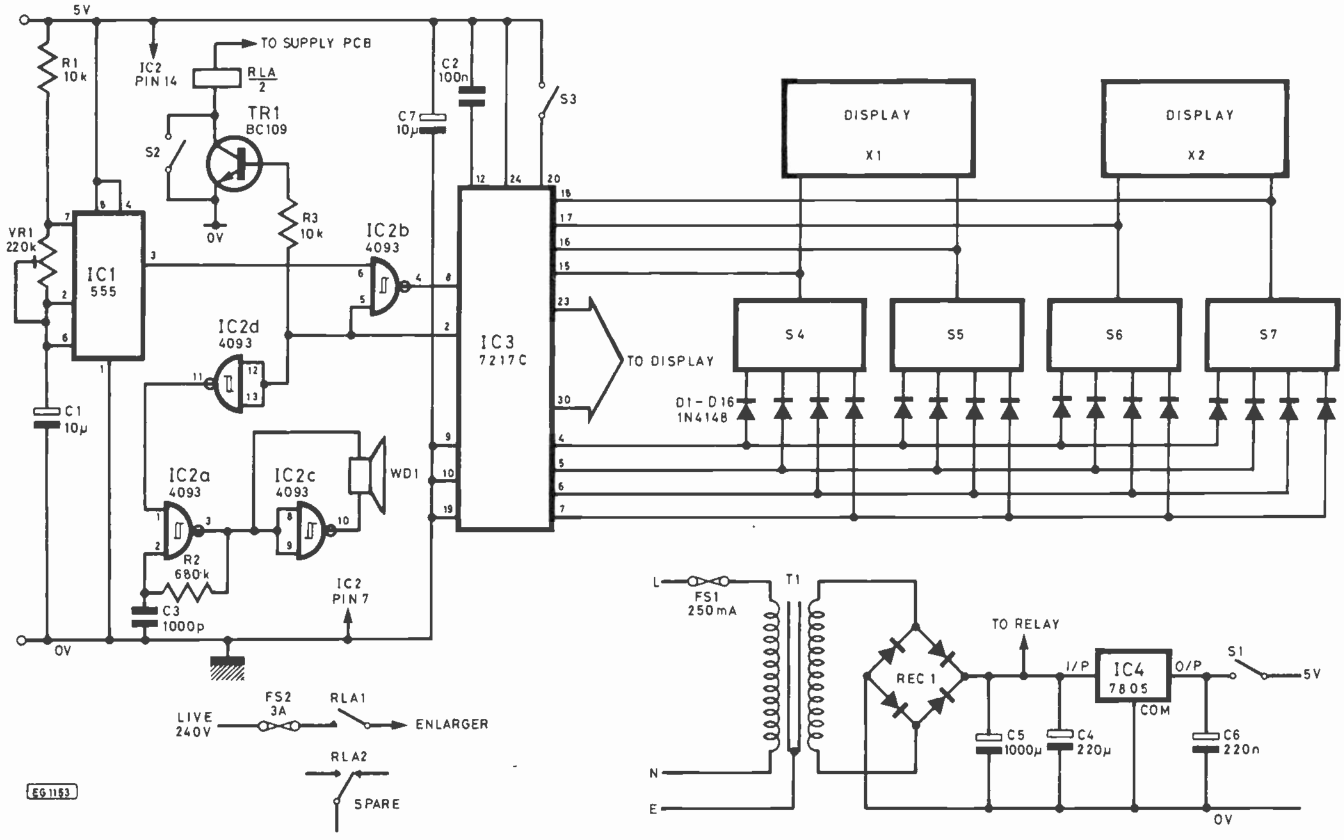
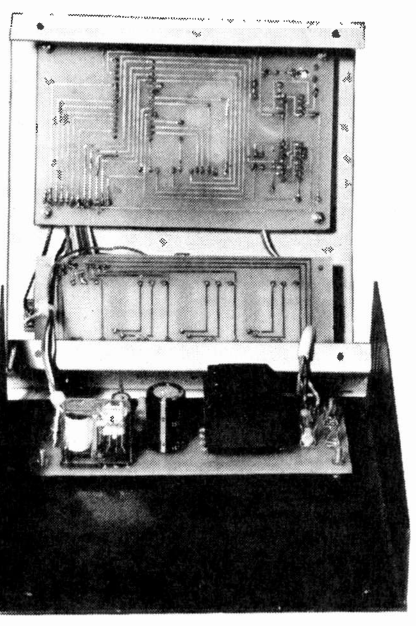


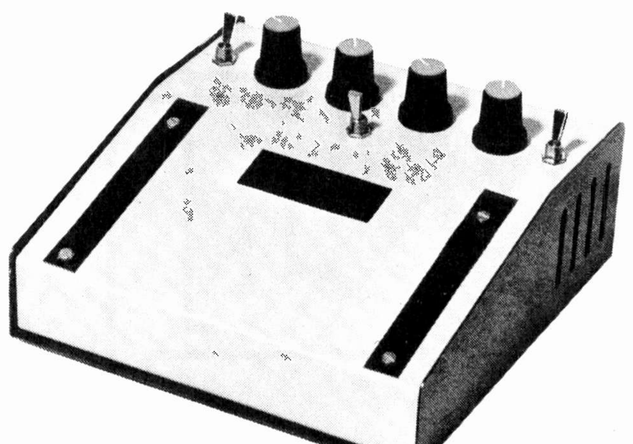
Fig. 1. Circuit diagram of the 4 digit LED down counter/controller

CONSTRUCTION

Printed circuit boards make the construction very easy, and the p.c.b. designs are shown in Figs. 2, 3 and 4 with the component layouts shown in Figs. 5, 6 and 7. Please refer to the components list carefully to ensure that the correctly fitting components are purchased. Construct the main board, not forgetting the three wire links, and make sure the capacitors and i.c.s are inserted the right way round. The display is stuck on top of the p.c.b. with its edge holes lined up over the appropriate p.c.b. hole. With small pieces of tinned wire then solder the two boards together. This method of mounting also ensures that the display is absolutely central on the p.c.b., useful when mounting the board in the case. The piezo transducer is also stuck onto the p.c.b., with its leads connected to pins 9 and 10 of IC2.



Eight way ribbon cable joins the BCD and digit lines to the switch board which is constructed next. Only switch pins B,D,F,I,J,N are used so all the other contacts should be clipped off. Mount the diodes, ensuring the correct polarity, otherwise some weird BCD data will be loaded, then mount the switches, and join the ribbon cable from the main p.c.b. Switches 4 and 6 should have a stop inserted in each to prevent them going past position 5. The author slightly cut down two Veropins and inserted them into the appropriate holes. These will then be held in place when the switches are



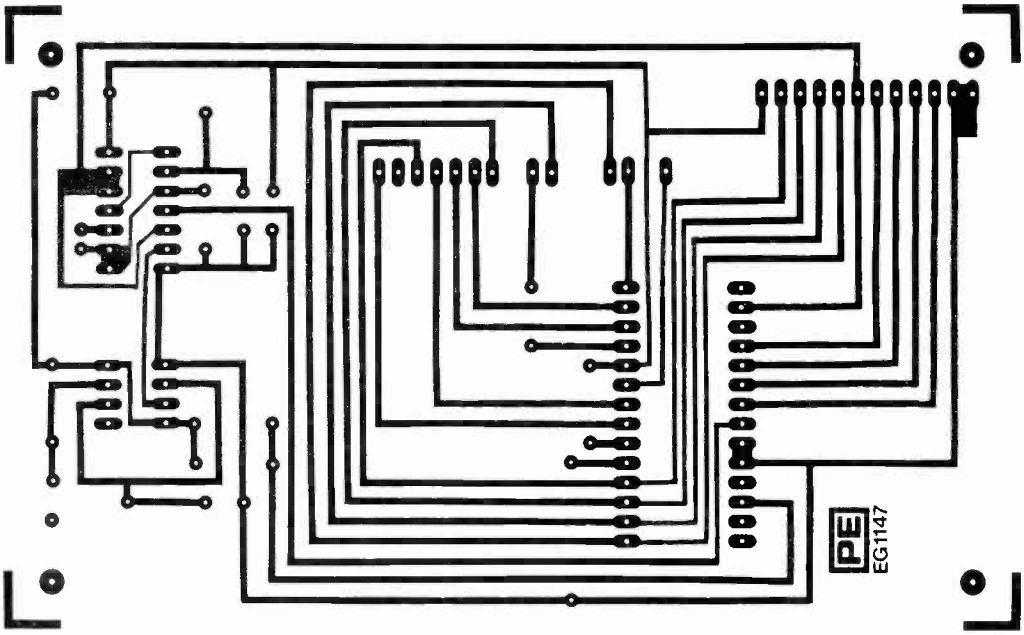


Fig. 2. P.c.b. design for the main board

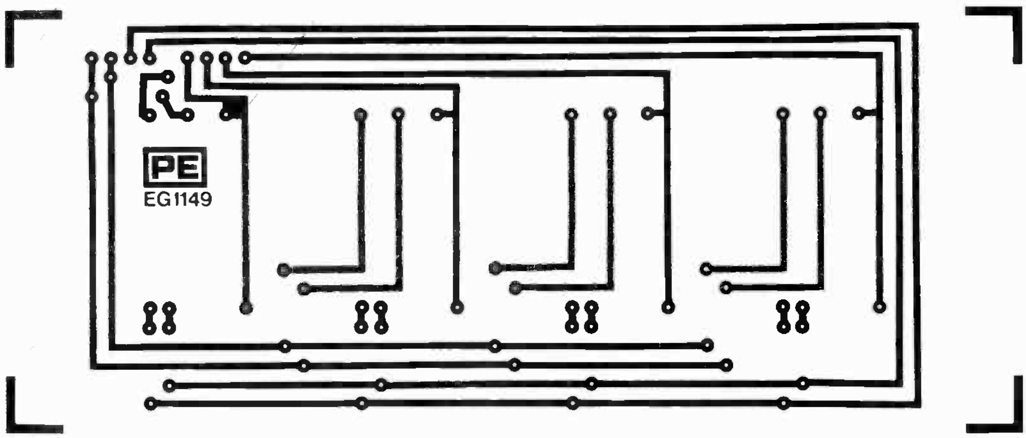


Fig. 3. P.c.b. design for the switch panel

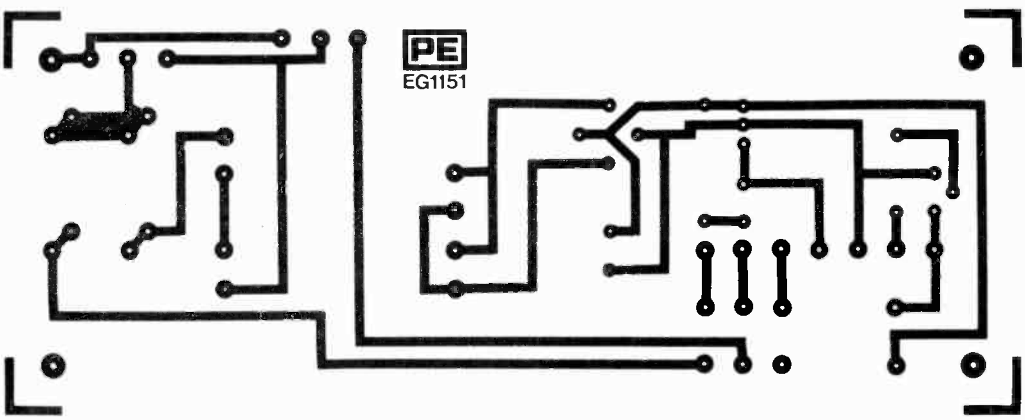
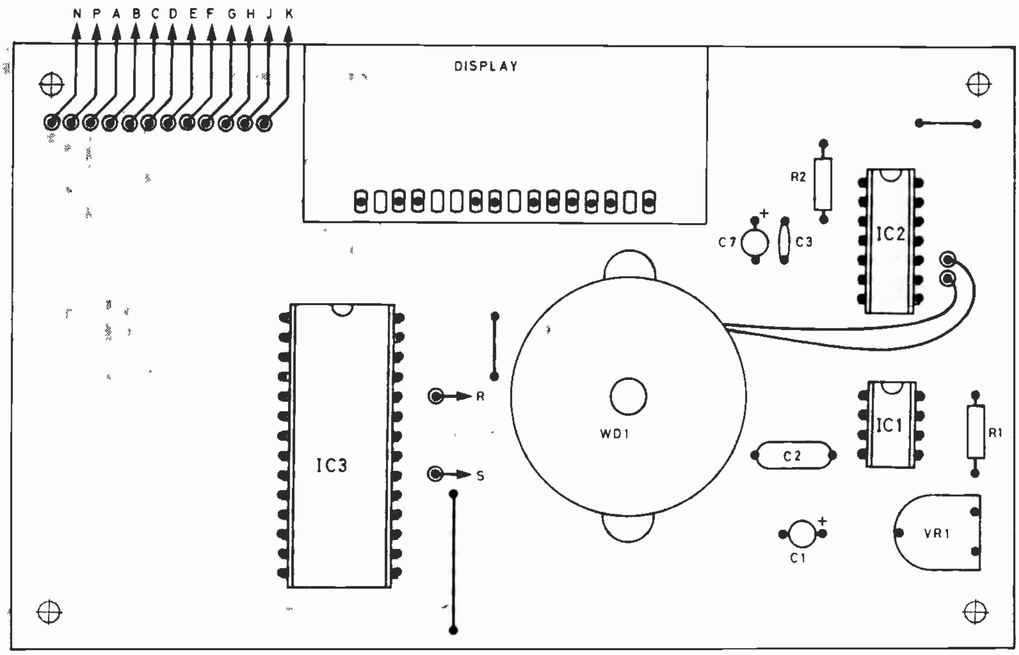
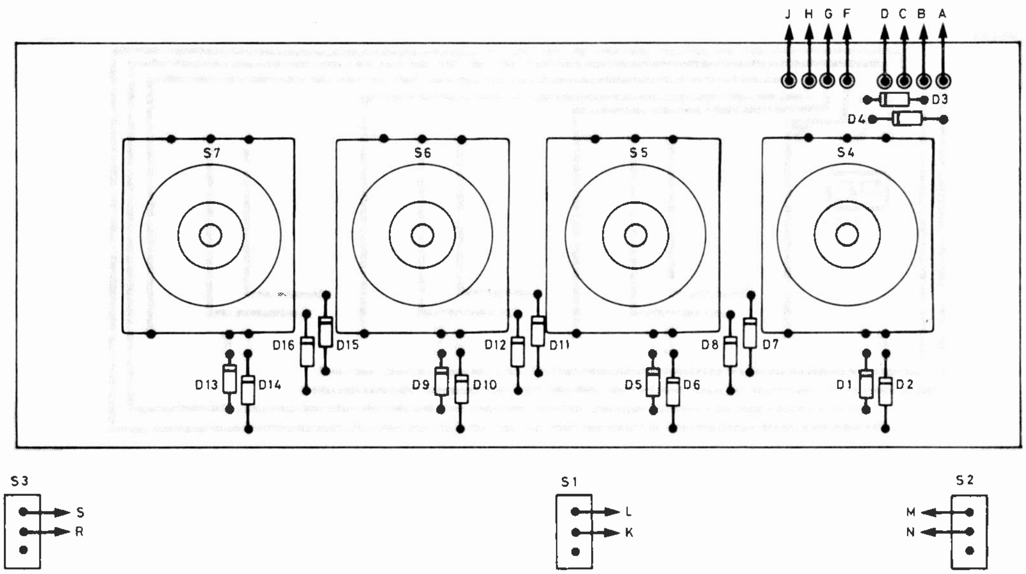


Fig. 4. P.c.b. design for the p.s.u.



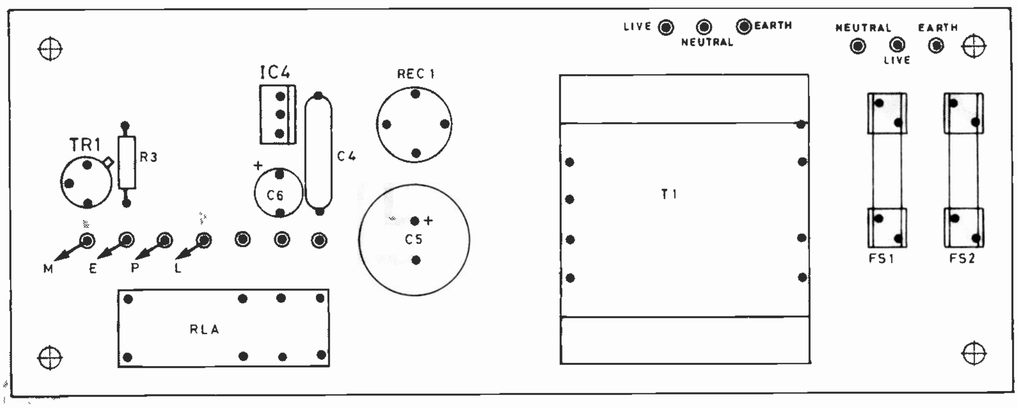
EG1148

Fig. 5. Component layout for main board



EG1150

Fig. 6. Component layout for switch panel



EG1152

Fig. 7. Component layout for p.s.u.

COMPONENTS . . .

Resistors

R1, R3	10k (2 off)
R2	680k
VR1	220k min hor preset

Capacitors

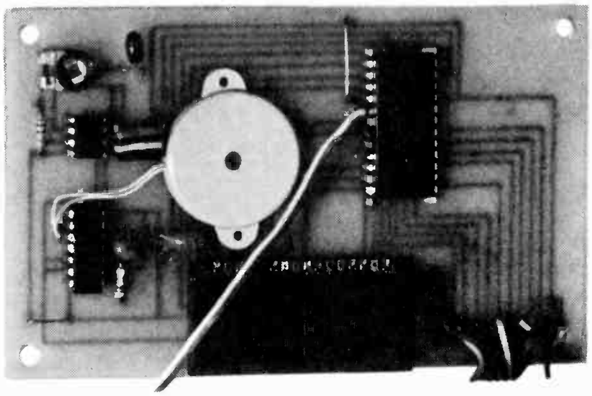
C1, C7	10μ tant (2 off)
C2	100n polyester
C3	1000p
C4	220μ elect
C5	1000μ elect
C6	220n tant

Semiconductors

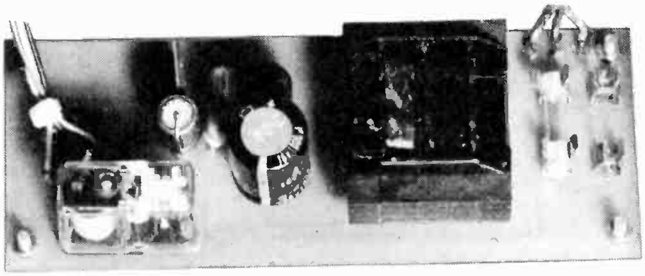
D1 to D16	1N4148 (16 off)
TR1	BC109
IC1	555
IC2	4093
IC3	7217C
IC4	7805

Miscellaneous

4-digit CC multiplexed display (RS type 587-507)
Transformer 6V 3VA p.c.b. (RS type 207-829)
Relay 6V 2-pole changeover (RS type 349-642)
Bridge rectifier 50V 1A
BCD switches (RS type 327-939) (4 off)
Fuseholder p.c.b. type (2 off)
Ribbon cable
Piezo transducer
Case (RS type 508-194)



Main board



P.s.u. board

mounted in the case. The power supply p.c.b. is constructed last and tested first, to check that 5V is coming from the output of the regulator. Insert Veropins for the various wire links, and then mount the board in the base of the case checking that a good earth contact is maintained. Drill a hole in the rear of the case for the mains strain relief grommet. A second hole will also need to be drilled for the output lead from the relay. Drill the four holes in the top of the case for the switch p.c.b., and mount the board which is held in place by the switch nuts. Though holes were drilled into the prototype p.c.b. for mounting bolts these are totally unnecessary and can be ignored. The sloping front panel is prepared as shown in the photographs, and care must be taken to make sure that the holes line up properly. The p.c.b. is then mounted using nuts, bolts and sufficient spacers to make the display just protrude through the aperture, taking care not to short its contacts onto the back of the front panel. However, it is obviously necessary to calibrate the unit as described for the 2 digit counter, before mounting the main board. Give the unit a final check, particularly with regard to the mains connections, before bolting the case together. ★

4 DIGIT LCD DOWN COUNTER/ CONTROLLER

FOR greater accuracy than can be achieved with a 555 oscillator, this version of the counter uses an ICM7213, designed specifically for the purpose of providing a 1Hz and 1/60Hz pulse, derived from a crystal oscillator running at 4·194304MHz (divided by 2^{22} to give 1Hz). This requires a commonly available crystal and 2 capacitors to pins 5 and 6. Because this i.c. is happier at a lower voltage, two diodes, each with a forward voltage drop of approx 0·6V, are included to provide approx 3·8V to the 7213. Once power is supplied the 7213 is self starting and this causes a problem in the overall design because when the counter is finally activated by the user, there may not be, for example, 60

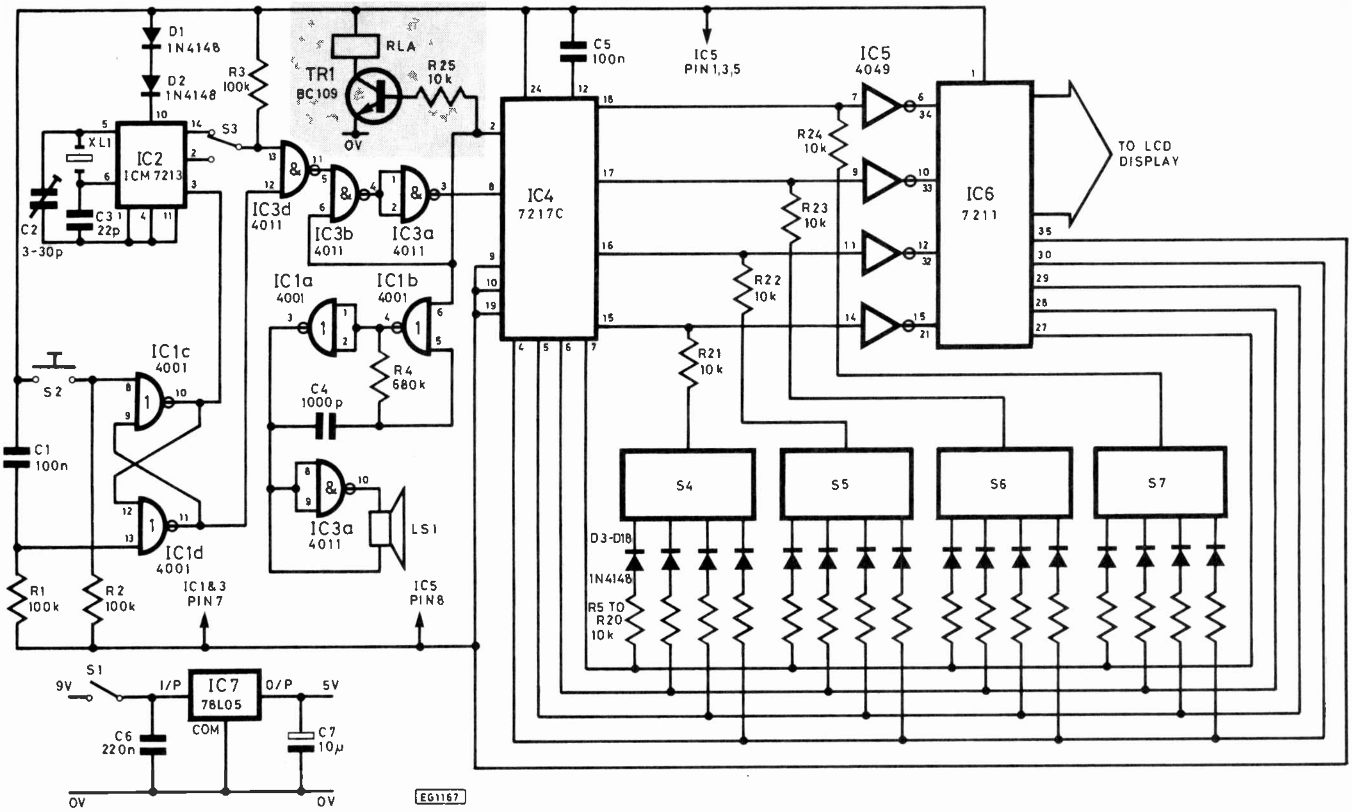


Fig. 1. Circuit diagram of the 4 digit LCD down counter/controller

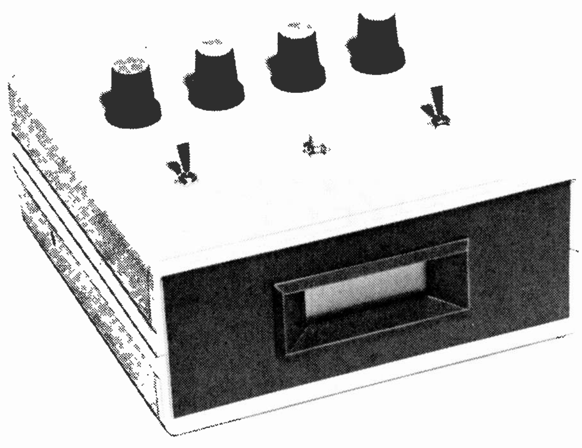
seconds remaining before the next pulse arrives, causing a spurious count. This can be overcome (Fig. 1) using a 'flip-flop', constructed around IC1c and d. At 'power-on', a pulse is fed to pin 13 to ensure that pin 10 is high and 11 low. This achieves two things. First, the logic gated IC3d is closed, and the Inhibit pin 3 (IC2) is high, stopping the oscillator. When the start button is pressed, the flip-flop changes state, the gate opens and the INH pin goes low, enabling the oscillator to run, and the interval from this point to the first pulse arriving, whether 1Hz or 1/60Hz, will be accurate to $\frac{1}{4}$ sec. Thereafter it should be accurate to the tolerance of the crystal. The two rates are selected by S3, and R3 is necessary to ensure the correct voltage swing from the oscillator. The resulting pulses are controlled by another gate using the 'zero' output, and the signal is then inverted to achieve the correct logic status prior to entry into the counter. The rest of the circuit should be self explanatory if the introductory article has been read, being very similar to the 4 digit l.e.d. version. Provision has been made on the p.c.b. for a relay output, but if constructors wish to use this option it is advisable to build a mains supply unit. Without the relay, the circuit draws less than 1mA from a 5V supply, even with the alarm running, and this rises to only 3mA when powered from a 9V battery with a 5V regulator.

IC1a and b provide the gated audio alarm, and the output is connected to the spare gate of IC3 to boost the output power. Also note that resistors are included on the switch board. These help to isolate the switches during the BCD output.

CONSTRUCTION

The project uses two p.c.b.s, designs for which are given in Figs. 2 and 3 with their respective component layouts shown in Figs. 4 and 5. Insert the diodes and resistors onto the switch p.c.b. before mounting the switches themselves, which should have the unnecessary pins clipped short. Construct the main board, not forgetting the links, and ensuring that the components are inserted the correct way round. If the relay option is not required simply omit R25, TR1 and the relay. Insert Veropins for the necessary interconnections. The front panel and case top should be cut and drilled and the display mounted using the bezel and associated hardware. Ribbon cable is used to make the necessary connections, and to make this easier for the display, the two rows of p.c.b. pads closest to IC6 go to the bottom set of display pins, whilst the two rows further away from the i.c. go to the top set. Fig. 7 should make the interwiring more clear.

Two diodes are again used to drive the colon, as with the 4 digit l.c.d. up counter, being connected to 3b and 3c as shown below but as was stated in the hand held counter ar-



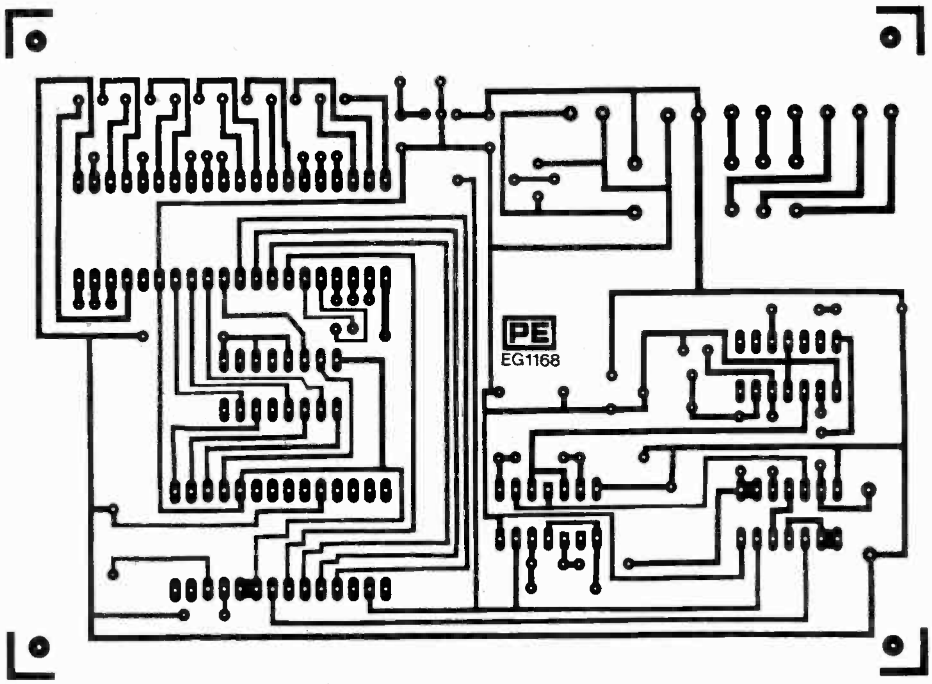


Fig. 2. Main p.c.b. design

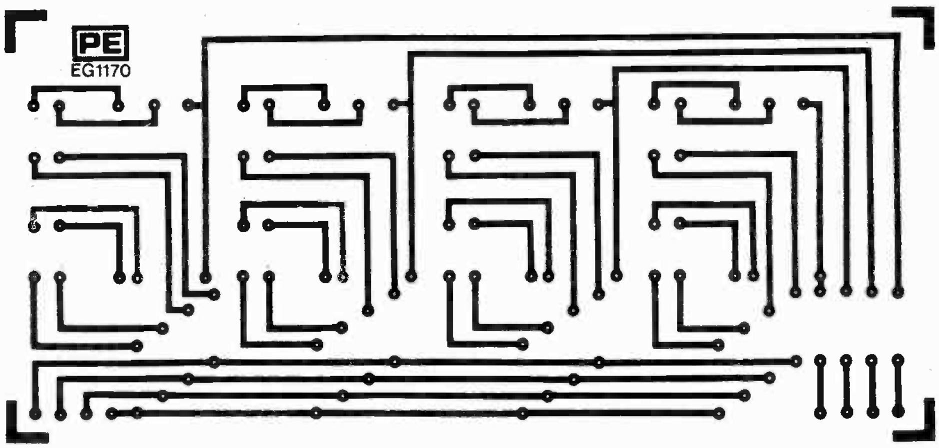


Fig. 3. Switch p.c.b. design

COMPONENTS . . .

Resistors

R1, R2, R3	100k (3 off)
R4	680k
R5 to R24	10k (20 off)

Capacitors

C1, C5	100n polyester (2 off)
C2	3-30 trimmer
C3	22p ceramic
C4	1000p ceramic
C6	220n tant
C7	10μ tant

Semiconductors

D1 to D20	1N4148 (20 off)
IC1	4001
IC2	ICM7213
IC3	4011
IC4	7217C
IC5	4049
IC6	7211
IC7	78L05

Miscellaneous

4-digit l.c.d. (RS type 587-305)
Display bezel
Piezo transducer PB2720
Switch s.p.d.t. (3 off)
Battery clips
Crystal 4·194304
BCD p.c.b. switch (RS type 327-939) (4 off)
*R25 10k
*TR1 BC109
*Relay d.p.c.o. (RS type 349-642)
*See text

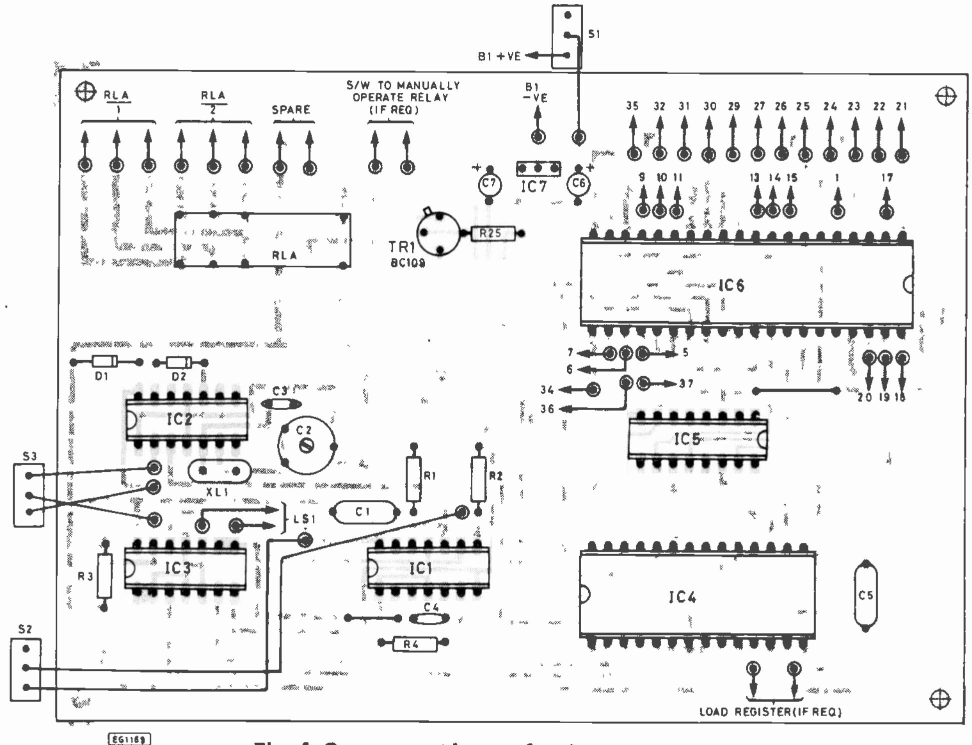


Fig. 4. Component layout for the main p.c.b.

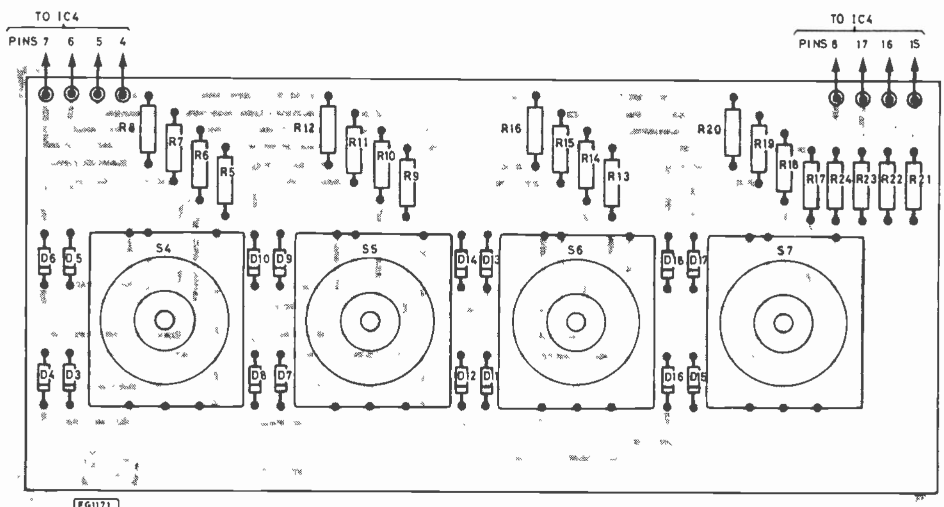


Fig. 5. Component layout for the switchboard

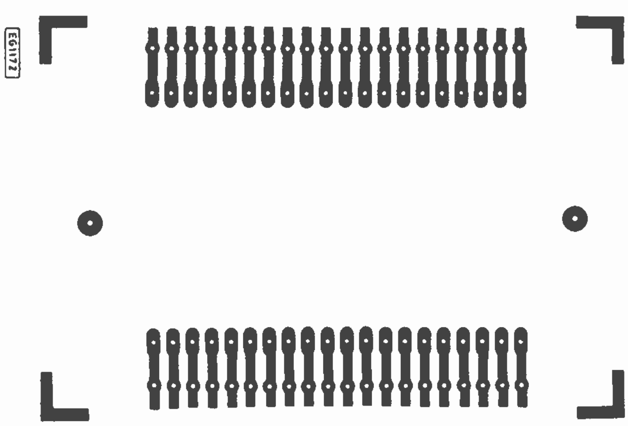


Fig. 6. Display p.c.b.

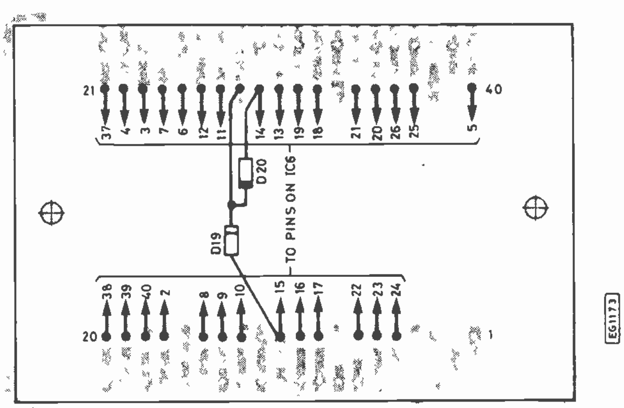
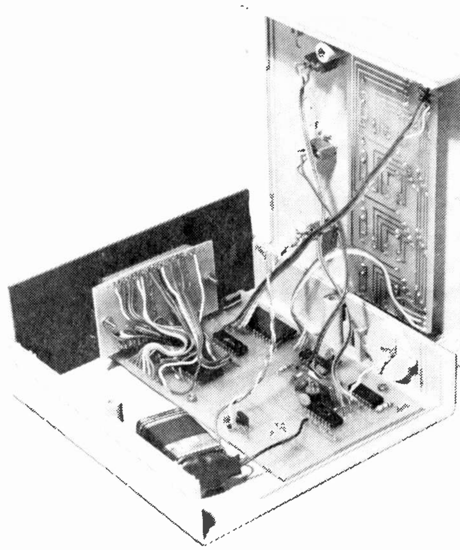
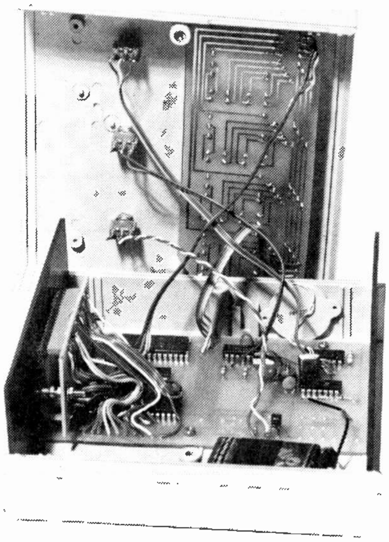


Fig. 7. Display wiring





ticle, it is better to connect the backplane to the input of one of the spare inverters (pin 3, 4049) and connect the output (2) to the colon (28). Connect up the switches and after a final check switch on and adjust the trimmer capacitor if necessary.

CONCLUSION

As mentioned in the introductory article, the ease with which the counter can be set up, by counting the switch clicks, makes it especially useful for people with poor or no sight. The display can simply be omitted, and a useful piece of equipment still remains. ★

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IN *Who's Who* that brilliant humorist, Frank Muir, lists 'staring blankly into space' as one of his recreations. A few pages further on in the same volume, his equally gifted sidekick, Denis Norden, confesses to a liking for 'loitering'.

What splendid fellows they both are. Can you think of anything more eminently sane than, when matters press and the toils of this troublesome life build up, to shut off the outside world and simply stare and mentally loiter? It's therapy at its best.

One of the fringe benefits of drifting into this beautiful state is that the mind tends to move backwards into calmer times. The other day, emulating these two top-class gurus, I underwent one of these journeys into times past. Mind you, I was ripe for a bit of wandering. I'd just returned from a hefty farewell lunch for a colleague who was going out to Saudi Arabia to work as a consultant in electronic engineering for some gullible sheik. His first project, I understand, was to design a microprocessor-controlled system for ensuring that the ladies of the harem all got their fair share of attention in an orderly way. Some guys have all the luck.

Anyway, as I sat there, restoring mokka in hand, my mind began moving in a backward direction to a couple of hundred years earlier when I was a boy. In those days we lived in a large house, the heart of which was the front parlour. It was an impressive chamber, full of dark and heavy furniture and floored with green linoleum. An ornate Japanese screen stood in the fireplace and cheap reproductions of Stag at Bay and The Light of the World brooded down upon us from the walls. It was in this impressive tomb of a room that we celebrated the usual Christian festivals, knocked back our birthday teas and mourned the passing of Uncle Charlie.

In one corner of the room stood a handsome wind-up gramophone. Its magnificent brass horn was regularly polished with the kind of devotion only a doting wife and mother can administer. Technically it was utterly reliable, except when the motor ran down in the middle of some Caruso aria. This, of course, would transform the great tenor into a bass of the greatest profundity. For us it was a plus-point rather than a defect and we would roll about the floor whenever it happened.

My father, a progressive if ever there was one, later invested in a crystal radio set. He'd spend hours setting it up before it would emit so much as a squawk. We'd sit there round the table, firmly lashed to a jack plug, serving as a kind of umbilical cord, waiting for the entertainment. Then one of us, forgetting our attachment, would cough or jog and the whole business would have to start all over again.

The day our first loudspeaker radio arrived was an occasion ranking in importance with the Delhi durbars the British monarch used to hold in the days of the Raj. Father bore the thing aloft like a dish of rare spices and the rest of the family processed in his train to the parlour. Our new possession utilised all the advantages of then modern technology, including an accumulator and an eliminator. What they accumulated and eliminated was something of a closed book. All this was gradually made clear as we eventually cottoned on.

As one innovation followed another over the years, so our range of domestic entertainment broadened. After the war, in a fit of d.i.y., my father built the family a TV receiver. It took about six months to produce, put the parlour almost permanently out of bounds and when finished looked like an elephant's coffin. It contained enough components to stock a set-maker's service department and sufficient wiring to stretch from Winchester to Wick. The picture tube had been nicked from a 'scope, measured six inches in diameter and, of course, glowed a *mal de mer* green.

On opening night, Ally Pally was putting out some ungripping play which involved passages of complete darkness while the hard-pressed riggers changed the scenery. The Trent brood, which by now had swelled its numbers (though I never know how the old man found the time with all his other hobbies) grouped themselves enthralled round the narrow viewing aperture. To the casual observer we must have looked like huskies huddling together for warmth until the arctic blizzard abated. We had great fun out of that set until we found the intense heat it generated was warping the furniture. So it had to go.

All these ramblings add up to one inescapable truth: In those days of yore the inventiveness of the entertainment industry never tried to swamp us with advances and refinements to the point where we became bemused. Technology moved forward with dignity and consideration for those whom it sought to serve. We were given time to understand and appreciate each new marvel before the next was sprung upon us. Whether this was by design or not I don't know. It could have been that research and development was a bit gropier than it is today.

Now, of course, we're in a vastly different situation. If you've got money to spend on home entertainment, you've immediately got problems. You're faced with a jungle of systems, units, add-ons, accessories, adjuncts and options. It turns fun into a chore.

Take TV. You can get a monochrome set in a whole range of sizes. The same goes for colour. You can choose a table model or a portable (and some of them palpably aren't). You can opt for a standard model or one able to receive teletext. And if you're a real informaniac you can put yourself in hock by purchasing a receiver that will bring Prestel into your sitting room as well.

For the complete home, you'll need a VCR—or risk the contempt of the neighbours. And those who haven't a comprehensive selection of video games had better keep their mouths shut.

What can one say about video games? Well, I suppose it's a matter of taste. Do you prefer playing tennis by the fire or on a sun-baked hard court? Do you prefer whacking leather with a stick of willow on the village green to doing so by pressing a button indoors? Are you content to let invading creatures from outer space walk calmly into your home, or are you British enough to go out and slay them as soon as they land?

Sometimes I pine like a puppy deprived of his mother for the days of the wind-up gramophone and all that it stood for. So much that is regrettable has been perpetrated in the audio field. Today you don't go out and buy some simple mechanism on which to play a disc for pleasure. No, you do one of two things: You swing on the bank manager's ear for a loan to purchase a battery of hi-fi equipment of near professional standard. Or you treat yourself to a music centre—the early 1980s equivalent of plastic ducks streaking across the chimney breast or an illuminated picture of a dusky maiden from Asia.

Take up the first option and you take up anxiety. Instead of leaning back in your armchair, sipping Remy Martin and sopping up a bit of Bach, you're worrying about other things. Surely that tweeter should be tweeting a bit more actively. Is that woofer falling down on the job? Has Dolby taken the night off? And you haven't even paid the first instalment on the bank loan.

Plump for a music centre and you risk becoming like the owner of a many-gadgeted car. Instead of using the thing as the manufacturer intended, you'll find yourself in no time at all hopping from disc to tape, tuning across the scale in all wavebands and generally behaving like a small boy with his first toy sweet shop or bus conductor's outfit.

All in all, the quality and reliability standards of most home entertainment equipment are uniformly high. And as circuitry and component counts are all very much the same, it doesn't matter much which brand you go for, so long as the manufacturer is reputable.

This situation means that competition for your money is of a high order. The manufacturers meet it by hiring wordsmiths to think up deathless names and phrases which imply that their product has something the others wish they had too. This, in turn, creates another decision-taking state of affairs for the consumer.

"Can I," he asks himself, "afford to do without 'Poke-at-It' instant channel selection? Is it fair to my children that they should have to watch Metal Mickey on a set that hasn't a picture that's 'Acid Drop Sharp'?"

During the coming months I will be touring the UK, speaking at various public halls (see your local Press for details) as part of my campaign for a nationally-concerted return to the days of the front parlour and the wind-up gramophone.

If you're the kind of readers I think you are, then I'm sure I can count on your unstinted support.

Ultimum Computer Interface Part 9

WILLIAM EDWARDS WATFORD ELECTRONICS

FOR interfacing a computer to the real world, analogue input and output devices are always required, this being an analogue world we live in. Even a TV or monitor can be considered as an analogue device; the optical information as presented is modulated on carriers and expanded in space. And who said that a computer graphic was worth a thousand words? This month's Ultimum card offers analogue facilities in the more generally accepted sense, with bandwidths up to about 500kb/s (one byte every sixteen microseconds). This is about the limit of capability of the average microcomputer anyway, so there is little point in paying extra for faster devices than the ones used here. The facilities provided by the card are:

1) Four analogue input channels with 10-bit resolution and 5 millisecond conversion time (8-bit, 2ms software controllable option);
2) One analogue input channel with 8-bit resolution and 15 microseconds conversion time;
3) Four analogue output channels with 12-bit resolution and 2·5 microsecond theoretical minimum time between successive outputs (not achievable by most micros).

Eleven locations of address space are used by the card. The unused ones of the block of sixteen have been positioned to allow efficient integration with other Ultimum system components (e.g. the motherboard and a speech card). The full-scale value of all analogue inputs and outputs is approximately 2·55 volts.

HARDWARE

The only novel part of the address decoding for this card is the final stage. A dual two-to-four line decoder (IC14 in Fig. 9.1) is used to decode the block of sixteen locations selected by ICs 10–13 into four groups of four, and one of those into individual locations. One of the single and one of the groups of four locations are not used by the card and may be assigned to other devices on the same motherboard.

The four slow analogue input chanels are handled by IC1. This device, the UPD7002, was originally designed as a 12-bit converter but the manufacturers have not been able to attain this accuracy and have had to modify their catalogue entry on the device (a new 12-bit device is apparently under development). BBC owners take note! The 7002 does all the conversion work internally and the only points of interest on the hardware are the guard ring on the integrating capacitor, and the separate analogue and digital grounds. This means that the signal ground does not carry large currents, thus reducing noise, and is a common feature of many types of interfacing system.

Fast conversion on a single analogue input channel is done by IC2, a ZN427. This uses the successive approximation method of conversion which gives a complete eight-bit result in only nine cycles of its input clock. This effects a considerable time saving over the integration methods of conversion used by ADC's such as the 7002. The 427 includes a voltage reference which is used by all the converters on the card, thus providing compatibility between the analogue voltages. The data output enable is driven by TR1, which combines RD and a single decoded address location, and the start conversion input is provided from an adjacent single location.

Digital-to-analogue conversion is provided by IC3, an AD7542. This is a 12-bit D-to-A requiring only an op-amp buffer on its output. The conversion time is negligible as the internal operation consists of twelve switches on an R,2R ladder. The first op-amp provides an inverted signal, from zero to −Vref; this is again inverted by the second half of IC4. IC5 performs the switching function (controlled by IC7, 8) for four sample-and-hold channels C6, 7, 8, 9, IC6. Note the guard rings run from the outputs of IC6. These ensure very small voltage gradients across the p.c.b. next to the protected lines, thus reducing leakage. IC5 uses CMOS switches, IC6 has f.e.t. inputs, and low-leakage types have been specified for the capacitors. All these details help to extend the hold time of the sample-and-hold circuits to more than one-tenth of a second for one least-significant bit drift. IC7 is simply a data latch defining the sample-and-hold channel. IC8 controls the switch, closing it after the channel has been defined, and opening it when the DAC is next written to.

Finally, IC9 provides clock signals for the two analogue-to-digital converters.

CONSTRUCTION

No problems should be encountered building this card. Try not to spread too much flux around the guarded lines and, if greasy fingers have been around them, swab them with a light non-deposit solvent. Switches S1–S12 should be set up to the corresponding address bit A15–A4 of the required location, noting that a closed switch selects a zero bit. Link options should be chosen and fitted according to Table 9.1. To finish, before powering the board for the first time, check all the component positions, orientations and joints once more.

SOFTWARE

The 7002 has three registers (Table 9.2) which are accessible to the user at consecutive locations starting at A+4,

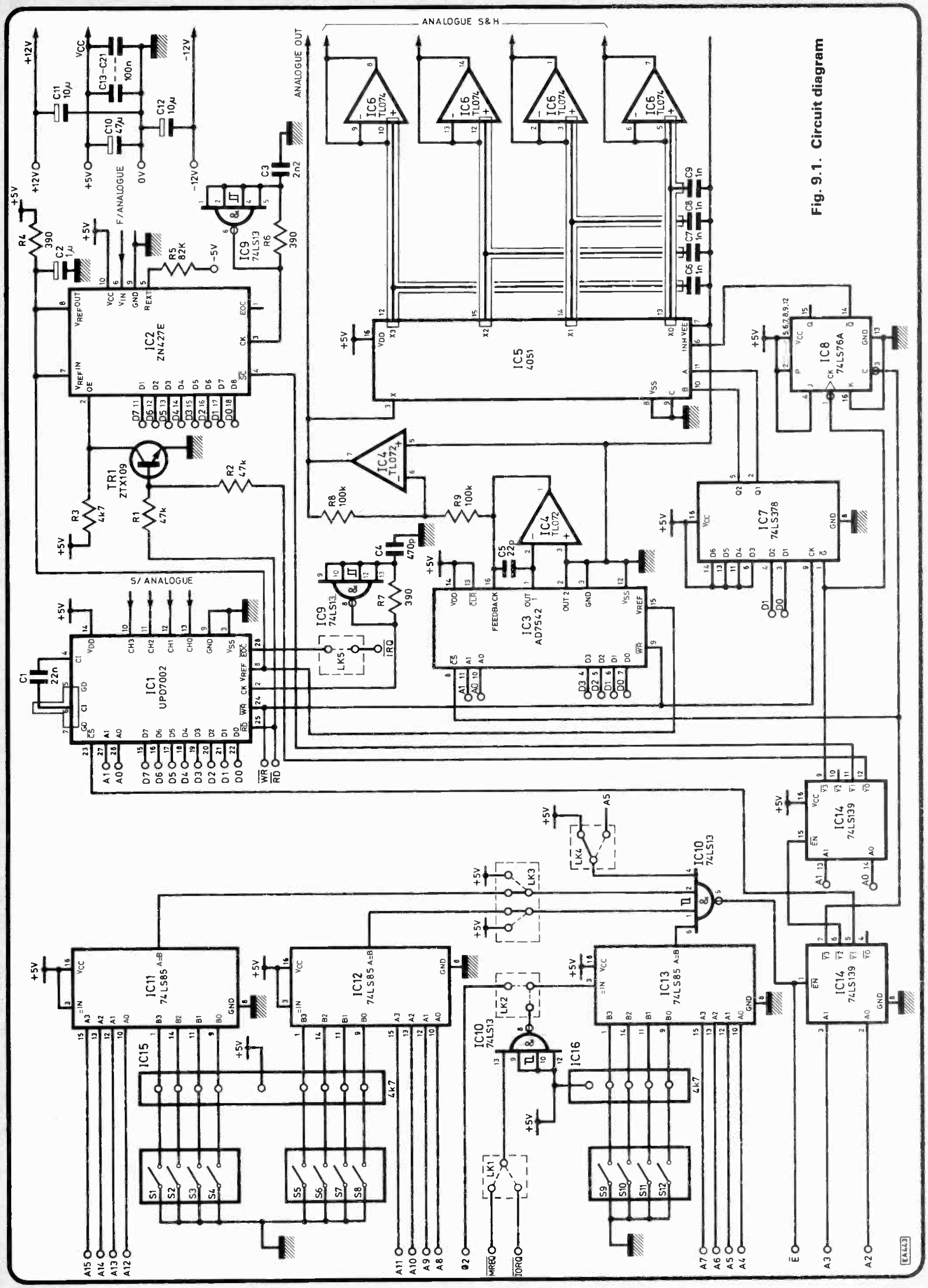

Fig. 9.1. Circuit diagram

Link 1	Memory mapped/IO mapped	No default position
Link 2	Z80/6502	No default position
Link 3	Memory mapped/IO mapped	
Link 4	Default—permanent. Alternative—mappable	
Link 5	Interrupt connection for slow conversion	

Table 9.1. Links

		bit 7	6	5	4	3	2	1	0	
A+4	R/W	$\overline{\text{EOC}}$	BUSY	*MSB	*2nd MSB	10/$\overline{8}$	Not used	CHANNEL		Command/ status
A+5	R	(MSB)		DATA HIGH						Data
A+6	R	Low Data		Not guaranteed			Not used			Data

Table 9.2. 7002 registers

		7 6 5 4 3 2	1 0	
A+11	W	Not used	CHANNEL	Channel
A+12	W	Not used	Data	Low nibble
A+13	W	Not used	Data	Mid nibble
A+14	W	Not used	Data	High nibble
A+15	W	Not used		Convert

Table 9.3. D/A registers

where A is the card base address. Use consists of writing the required channel number and resolution to the control & status register, reading it until the end of conversion is signalled, and then reading the result from the two data registers.

The 427 is accessed through two address locations on the card. Conversion is initiated by a read (or write) of location A+9. The data is meaningless in either case. The converted value is available on a read of A+8 after 15µs. We felt that this was fast enough for an end-of-conversion signal to the processor not to be justifiable. A very short no-op loop in machine code is sufficient. High-level languages will rarely need to be slowed down at all.

The digital-to-analogue subsystem uses five address locations (Table 9.3). Operation consists of three basic steps. First, the data should be loaded (into A+12,13,14) in four-bit nibbles. The low half of the data byte is used, the high part ignored. Any order of writing may be used and any nibble may be left unchanged from a previous write. Second, A+15 must be written to for the 7542 to convert the value previously loaded. The data written is ignored. If only one output channel is required, the analogue value is now available on the un-demultiplexed output from the board. The third operation, selecting the channel, consists simply of writing the desired channel number to location A+11. Each channel in use requires refreshing at least once every 100ms to retain full 12-bit accuracy, though this time may be increased proportionately if a lower accuracy is being used. Writing in all cases may be done at the full speed of the Ultimum bus.

The board as a whole may be most conveniently tested by connecting the outputs of the D-to-A on to the inputs of the A/D converters.

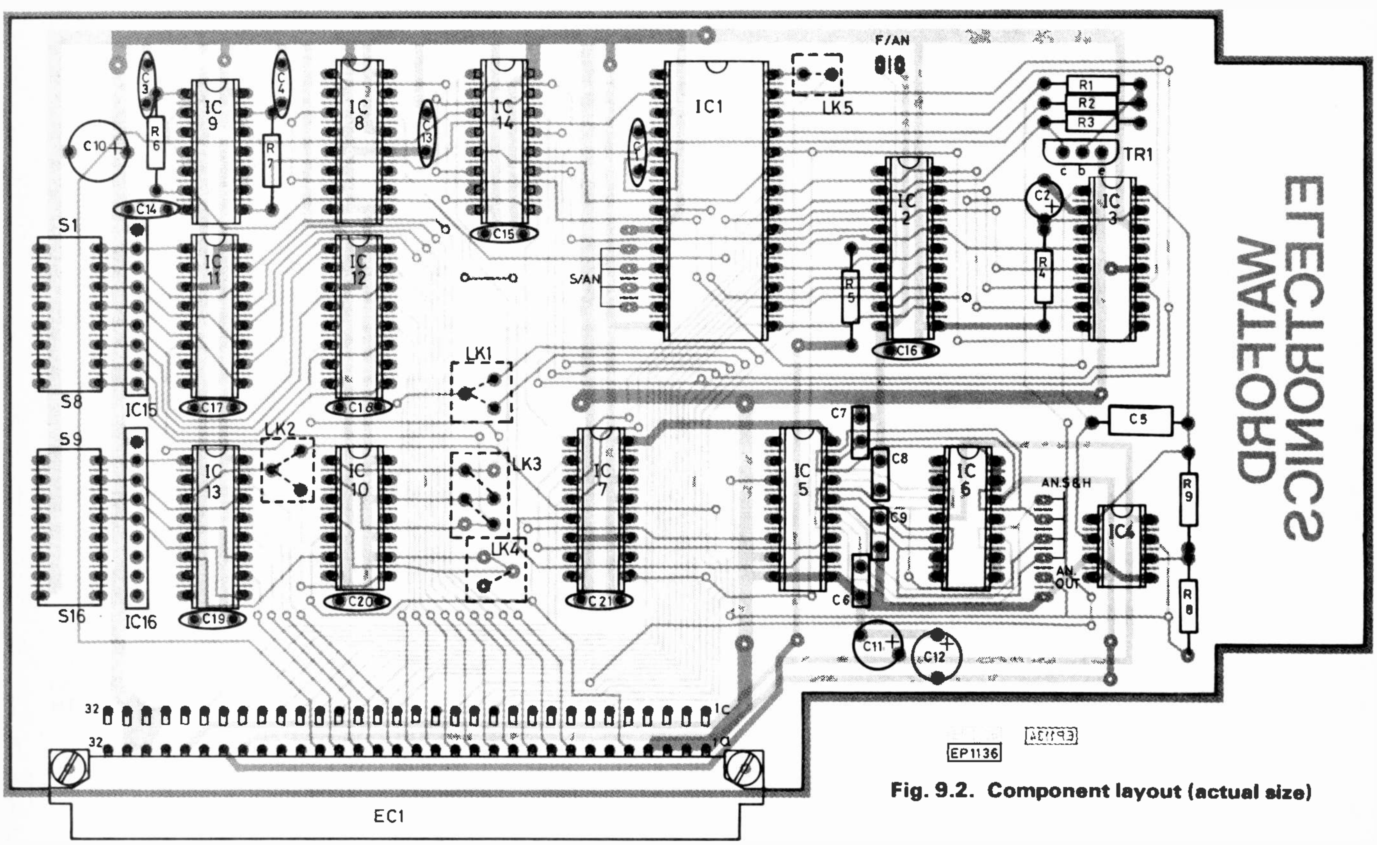

Fig. 9.2. Component layout (actual size)

COMPONENTS . . .

Resistors

R1, R2	47k (2 off)
R3	4k7
R4, R6, R7	390 (3 off)
R5	82k
R8, R9	100k 2%

Capacitors

C1	22n
C2	1µ/16V tant. bead
C3	2n2
C4	470p
C5	22p
C6–9	1n metal plate (4 off)
C10	47µ/16V tant.
C11, C12	10µ/16V tant. (2 off)
C13–21	100n disc cer. (9 off)

Semiconductors

IC1	UPD7002
IC2	ZN427E
IC3	AD7542
IC4	TL072
IC5	4051
IC6	TL074
IC7	74LS378
IC8	74LS76A
IC9, IC10	74LS13 (2 off)
IC11–13	74LS85 (3 off)
IC14	74LS139
IC15, IC16	8 × 4k7 s.i.l. resistor pack (2 off)
TR1	ZTX109

Miscellaneous

Printed circuit board
D.i.l. switch pack (S1–8)
14 pin d.i.l. socket (2 off)
16 pin d.i.l. socket (6 off)
18 pin d.i.l. socket (1 off)
8 pin d.i.l. socket (1 off)
28 pin d.i.l. socket (1 off)

Constructors' Note

Send S.A.E. to **Watford Electronics** for price list of all available boards

CONCLUSION

As stated throughout this series of articles, the Ultimum interface system will include a number of *intelligent* plug-in cards in addition to those cards already published in PE. These latter interfaces require the development of extensive m/c software, and therefore cannot be completed to meet a monthly publication cycle. From this point on, details of new boards will be announced in PE as and when they are fully designed and debugged. ★

BAZAAR

TRS–80 Model 1 Level II 16K complete with monitor manuals, etc. Tel: 01-595 6675. G. Bowen, 107 Cartwright Road, Dagenham, Essex.

ZX Spectrum working £75. L.C.D. Multimeter £29 other gear. Tank t.v. game wanted, s.a.e. no callers. D. Martin, 29 St. Johns Close, Leatherhead, Surrey.

UK101 16 × 48 Cegmon and handbook guaranteed working ok. Upgrading to 32 × 48 £12. Phone: Stoke on Trent 550684.

MICROTAN 65 + Tanex extension, 4K RAM, XBug Assembler/Disassembler, Mini-Motherboard uncased no keyboard, fully working + manuals £60 o.n.o. N. J. Counihan, 19 Robertson Road, Grantham, Lincs NG31 8AQ.

SYKES 8″ Drive Commstor II 22K RAM 4K RAM 3 Ports EIA R232 S100 Bds. IBM 3740 ASC II Conv. available. Forms entry variable length £200. Tel: 0532 579387. 8 Kent Crescent (M. S. Smith) Pudsey, Nr. Leeds LS28 9EB.

VDU case attractive steel construction fits 14–15″ screen £30 matching keyboard case £12. Norman Simons, 01-969 6150.

UK101 for (reluctant) sale. 8K MON 2, invaders etc. Must sell. Only £125. Tel: (024282) 274 (Evenings). Mr. J. P. Hawkes-Reed, Cotehax Farm, Brockhampton, Cheltenham, Glos. GLS 5TH.

UK101 24K colour, sound, Ohio S/Disk drive tape. Printer Ports, disk, tapes, software £350. Steve Gifford, 20 Lime Street, Nelson, Lancs. Tel: 692388.

COMPUKIT 8K, Wemon, 1/2MHz, 300/600 Baud, Sound, improved p.s.u., cassette relay, manual and software £120 o.n.o. Mr. A. Burns, 3 St. Andrews Road, Spalding, Lincs. Tel: Spalding (0775) 3197.

WANTED supplier for electronic inverter using 12V d.c. battery output 220V. a.c. Eng. Magued G. Helmy, 159 El-Fosha St. Saint Stefano Alex. Egypt.

HARVARD 40 Channel hand-held C.B. with rechargeable batteries and charger, £40. Hardly used. Tel: (0343) 820217 (evenings). John Smith, 50 High Street, Fochabers, Moray 1V32 7DU.

SIEL HB490 organ, £150 o.n.o. Buyer collects. Tel: Southampton 694856, after 4p.m. Mr. J. Brier, 19 Grangewood Gardens, Fairoak, Eastleigh, Hants SO5 7ER.

COMMODORE PET 4016 with cassette deck, toolkit and MIKRO assembler chips, manuals and cover. Offers. M. Thompson, 25 Impington Lane, Histon, Cambs CB4 4LT. Tel: Histon 3014.

AMSTRAD 5050 tuner/amp. Good condition, £35, or exchange computer or w.h.y. Mr. C. Shaw, 123 Ironside Road, Hemsworth, Sheffield S14 1FL. Tel: 657898.

APPLE 11 Europlus printer, communications and colour cards. 80 col printer, software. Books. £695. A. P. Smith (0602) 211601 (evenings).

MICROTAN. Tanex. BASIC. X-Bug. Tanbug. Separate Qwerty keyboard fitted in cabinet. Documentation. £200. Bargain. T.V. £50. Tel: 01-764 0839. M. Goonewardane, 241 Norbury Crescent, London SW16 4LF.

RESISTANCE bridge set. Section aerial 25ft. Mobile 432MHz aerial. Various meters etc. Offers/exchange, will split. J. M. Hill. Tel: (06462) 78497.

NON-WORKING ZX80/81 and other computers wanted for cash, new components, also PE back issues wanted. Bimal Jain, 17 Taylors Lane, London NW10 9JH. Tel: 01-459 2553.

UK101 wanted. Bare p.c.b. or unfinished kit or complete non-working unit. Mr. M. Lancaster, Boundary Cottage, West Dean, Salisbury, Wilts SP5 1JL. Tel: Lockerley (0794) 40718.

PE '71 Gemini stereo amp boards, power supply made up working, transformer included £25. p&p £5. L. T. Hill, 14 Rothesay Terrace, Bedlington, Northumberland.

QUAD 22 pre and power amps (valve). One amplifier defective £50 o.n.o. or swap for ZX81. C. Wallace, 9 Wilton Grove, Leeds LS6 4ES. Tel: 0532 740300 evenings.

COLOUR cartridge TV game with 4 cartridges pair joysticks £30. Will swop part-exchange for ZX 81. Alex Lindsay, 16 Dalziel Dr., Glasgow G41 4PT. Tel: 041 423 8440 (evenings).

DOUBLE beam scope 15MHz 8 × 10cm display 4kV tube with manuals excellent condition. £100, s.a.e. for datasheet. J. S. Hind, 7 Carlyle Road, West Bridgford, Nottingham.

WANTED AVO meter for spares also output transformer for Impact 60 watt valve amp. R. Kelsall, 58 Queen Street, Leek, Staffs. Tel: Leek 0538 372198.

WANTED SE3A c.r.t. and Telequipment S32 circuit diagram. J. Glover, 1 Bryony Cottages, Hambledon, Godalming, Surrey GU8 4HJ. Tel: Wormley 4649.

SUPERBOARD Series 2 16K Cegmon, Basic 4, Basic 5 ROMS. Cassette relay control £60. Afternoon only. Mr. R. Hall, 22 Stilwell House, Barncroft Close, Hillingdon, Uxbridge, Middlesex UB8 3JN.

INDUSTRY NOTEBOOK

By Nexus

Tiddlers

Doom-watchers have had an enjoyable time during the recession. Never have we had it so bad. Just look at the monthly list of company bankruptcies, and this was true back in 1980. There were some new start-ups but they failed to stem the tide. Firms going out of business exceeded the newly established by some 2,000. The doomsters still point out the failures but today with far less conviction. And they avoid any good news such as by 1981 there was a surplus of some 15,000 start-ups over close-downs. Last year's final figures are not available as I write but are forecast to be even better.

The vast majority of new starts are inevitably small businesses. They seldom get publicity and therefore great credit must go to the Daily Telegraph and the National Westminster Bank for sponsoring an enterprise award for small businesses. From an entry of 228, a short-list of 20 was finally whittled down to four. And it comes as no surprise that two of the four finalists are in electronics. The other two are in chemicals and in plastic throw-aways for hospitals.

Outright winner of the £10,000 prize was Noblelight of Cambridge manufacturing krypton lamps mainly for use in lasers. The electronics runner-up was Laser Scientific Services of Huntingdon in the industrial laser business.

The popular myth that all high-tech businesses need huge capital backing is now exploded. Both Noblelight and Laser Scientific were launched on capital resources of £1,000. In today's money values this is far less than the £100 with which Ray Brown (today Sir Raymond) and the late Calder Cunningham started the Racal Group empire some 30 years ago.

At the time of the award Noblelight employed 13 people, Laser Scientific one person less. Tiddlers, both of them, as indeed at one time were Hewlett-Packard, IBM, GEC and all the present big fish in the electronics sea. These new tiddlers are anything but parochial in outlook or ambition. They are busy in the competitive export markets of the United States, West Germany and Japan. But perhaps the most surprising fact that emerged is that none of the four finalists had used any of the government schemes intended to help small businesses. With good products, bright ideas and plenty of hard work they seemingly had little difficulty in convincing their local bank managers they were worth backing.

Losers

Against the success stories must be balanced the losers, by no means all in the old-fashioned heavy industries. Aero engines are high-tech but this didn't stop Rolls-Royce losing money at over £2 million a week in the past year. This one nationalised company has had £364 million in government aid over two years. Then there is the mystery of government-backed De Lorean, set up to make up-market autos. Accountants are still unravelling where all the money went. There are still millions of losses in coal-mining, steel, ship building, railways and airlines, on a weekly, often daily, basis. Even BL cars now with two winners in the stable and expecting soon to break even may yet stumble over labour disputes.

After allowing for difficult trading conditions it is hard to stomach such massive handicaps on the overall economy. Much has been achieved in eliminating waste but much clearly remains to be done.

AB Electronics

AB Electronics has had a history of ups and downs. Well known as a components and sub-assembly manufacturer, largely dependent on consumer electronics, it is no wonder that the company's fortunes have varied over the years. But it was one of the first to get into mass-produced thick films and now, like any electronics company wishing to succeed, has demonstrated its flexibility by taking on the manufacture of Acorn computers and later this year will be producing PRESTEL and TELETEXT adaptors for the Acorn ready for broadcast and phone-line software availability.

It is quite extraordinary that in a period of so-called recession there should be so much spare cash available to buy personal minicomputers as well as video tape recorders. A recent survey (Mintel Publications) suggested that the immediate market in the UK is for at least a further 1·25 million home computers. Longer term the market will be much larger.

AB, making the Acorn, has been fortunate in having all the publicity afforded by the BBC courses. Even so, the product still has to be made successfully. Investors in AB have had the satisfaction of seeing the share price rocket from 200p to nearly 700p over a nine-month period on very solid prospects of dramatically increased profits.

One appeal of the home computer is its versatility. Thus, we discover that the Christian Church, ancient in tradition, is not backward in computer use. One of a 200-strong Church Computer Users Group is the appropriately named Rev. Peter Goodlad who has used his to assist in redesign of his church and meeting hall interiors. The good lad has also bumped up his Sunday School attendance with video games based on existing games but with software modified to depict Biblical stories. From the report on this development I understand that the software has been 'doctored' so that good inevitably triumphs over evil. More generally, church computers are used for accounts and parish records. Any reader interested in the computer as a spiritual and moral teaching aid can find the Rev. Peter Goodlad at the United Free Church, Seven Kings, Essex. I add my congratulations on his originality.

First Hundred Thousand

Whatever the merits of competing claims on who 'invented' radar there is no dispute on Britain being first to install an effective defensive radar network against air attack and, once the war was over, in exploiting radar commercially. Among the first to get going was Decca Radar who had considerable success in popularising marine radar.

The first ship to be fitted by Decca 34 years ago in 1949 was the 'Ocean Monarch', a luxury liner on the New York–Bermuda millionaires run. The order came from Furness Withy. I am always suspicious of startling coincidences but this time I give the PR department the benefit of the doubt. Yes, you've guessed correctly. The hundred thousandth marine radar order is for another Furness Withy ship, this time a 38,000 dwt container vessel.

Decca Radar in the meantime has become Racal Marine Radar but the Decca name and reputation live on in the designation of the set as the Racal-Decca 1629C. Over the years the company has collected five Queen's Awards for technological achievement.

Learning Putonghua

It used to be called Mandarin. Now it's called Putonghua, literally in Chinese 'common language' and the official dialect of the People's Republic. At Cable & Wireless head office in London members of the newly established Far East Business Unit have been giving up their lunch breaks in favour of a crash course in Chinese. All in preparation, of course, for the big telecommunications drive in the Far East.

Such enthusiasm understandably terrifies Post Office Engineering Union employees fearful of both loss of monopoly and eventually privatisation. So on the one hand the POEU is trying to black connection of the Mercury network in the UK (in which C & W is involved) and on the other stopping maintenance on selected government computer networks so that the work of government will be eventually halted. As in all such cases there is the pious rider that there will be minimum inconvenience to the public or private sector business. If government departments are affected everyone is affected. The POEU should be looking forward, not backwards. They might start by updating their own name.

MICRO-BUS

Compiled by DJD.

Appearing every two months, Micro-Bus presents ideas, applications, and programs for the most popular microprocessors; ones that you are unlikely to find in the manufacturers' data. The most original ideas often come from readers working on their own systems; payment will be made for any contribution featured.

THIS month Micro-Bus presents a puzzling miscellany of programs, related only by the fact that their behaviour will be left unexplained until the next Micro-Bus. All the programs were originally written on a BBC Microcomputer (model A or B), but most of them could equally well be run on other machines with similar BASICs.

NUMBER TRICK

The first mysterious program, shown in Fig. 1, performs a number trick in which the spectator is asked to select from one of 60 random numbers displayed on the computer screen. The computer then displays selections of these numbers and asks in each case whether the chosen number is present. Finally, the computer discovers the spectator's number!

After first displaying the selection of 60 numbers, the computer waits for the spectator to type a key. Then, for each subsequent selection of numbers the spectator should either type "Y" or "N" to indicate whether the chosen number is present.

The problem in this case is to explain how the trick works; having solved this you may also like to consider whether the trick can ever fail, and if so, why?

```
 10 DIM A(60)
 15 CLS
 20 PRINT"THINK OF A NUMBER:"
 30 FOR N=1 TO 60: A(N)=RND(1000)
 32 PRINT A(N);
 33 NEXT
 35 PRINT ''"READY?": A=GET
 40 T=0
 50 FOR M=1 TO 6: CLS: T=T*2
 60 FOR N=1 TO 60
 70 IF (N DIV 2^(6-M)) MOD 2 THEN PRINT A(N);
 80 NEXT N
 90 PRINT''"IS IT SHOWN HERE?"
100 A$=GET$
110 IF A$="Y" OR A$="y" THEN T=T+1
130 NEXT M
140 PRINT "I THINK IT'S ";A(T)
```

Fig. 1. Number Trick program in which the computer guesses a spectator's number

MYSTERIOUS SEQUENCE

The puzzling program shown in Fig. 2 sets up an array of 100 numbers, initially all FALSE (i.e. with value zero) and then manipulates them. The statement "A(J)=NOT A(J)" is simply a way of converting TRUE values to FALSE, and vice-versa. Finally, the program prints out those elements of the array that end up with the value TRUE (i.e. non-zero). The puzzle is to explain why those particular values, and no others, are printed out!

```
10 DIM A(100)
20 FOR N=1 TO 100
30 FOR J=1 TO 100 STEP N
40 A(J)=NOT A(J)
50 NEXT J: NEXT N
60 REM
70 FOR N=1 TO 100
80 IF A(N) THEN PRINT N;
90 NEXT N
```

Fig. 2. Mysterious Sequence program prints out a puzzling sequence of numbers. Why?

NUMBER TRAILS

The next program, shown in Fig. 3, first asks you to type in a number; it then takes each digit of the number you typed in, squares them, and adds the squares together to give a second number. This is then taken as the new starting number, and the process is repeated. Finally, when a stable result is reached, the result is printed out. For example, starting with 7 we obtain: 7^2 = 49, 4^2 + 9^2 = 97, 9^2 + 7^2 = 130, 1^2 + 3^2 + 0^2 = 10, and 1^2 + 0^2 = 1.

The sequence then repeats 1, and so this is the value finally printed out. Similarly, starting with 19 again ends up with 1.

The question is, do all starting values end with 1? If not, can you predict where a particular number will end, without actually following it?

If you find this problem interesting, you may like to investigate the behaviour when you take the cube of each digit before adding.

```
10 INPUT T
15 REPEAT S=T
20 A$=STR$(S)
25 T=0
30 FOR N=1 TO LEN(A$)
40 J=EVAL(MID$(A$,N,1))
45 T=T+J^2
50 NEXT N
60 UNTIL S=T
70 PRINT T
```

Fig. 3. Number Trails program starts with a given number, and follows it until a stable result is obtained

DECIMAL TO HEX

The main part of the program shown in Fig. 4 is the function definition FNHEX which takes a decimal number, DEC, and converts it into hexadecimal (i.e. base 16). The program uses a string DIGITS$ to contain a list of the 16 hexadecimal digits, and it looks up the relevant digit using the mid-string function MID$.

The rest of the program uses FNHEX to print out the hexadecimal equivalents of the decimal numbers which form the series 1, 11, 111, 1111, etc. These numbers are constructed using the STRING$ function, which repeats a string (in this case "1") any specified number of times. The results are shown in Fig. 5.

The puzzle in this case is to explain why, for numbers in this series beyond 111, their hexadecimal equivalent appears always to end in the digit "7". Is this a coincidence? In answering this question you may also be interested in trying other series, such as 2, 22, 222, 2222 . . . etc.

```
10 DIGITS$="0123456789ABCDEF"
20 PRINT"   DECIMAL"," HEX"
30 FOR N=1 TO 9
40 J=EVAL(STRING$(N,"1"))
50 PRINTJ;"=";FNHEX(J)
60 NEXT: END
70 DEF FNHEX(DEC)
80 IF DEC<16 THEN =MID$(DIGITS$,DEC+1,1)
90 =FNHEX(DEC DIV 16)+FNHEX(DEC MOD 16)
```

Fig. 4. Decimal to Hex program uses the FNHEX function

```
>RUN
    DECIMAL HEX
          1=1
         11=B
        111=6F
       1111=457
      11111=2B67
     111111=1B207
    1111111=10F447
   11111111=A98AC7
  111111111=69F6BC7
```

Fig. 5. Decimal numbers 1, 11, 111, etc. converted into hex. Why do they tend to end in "7"?

RECURSIVE FUNCTION

The last program, shown in Fig. 6, prints out the first 10 values of a mystery function FNH which is defined in the last three lines of the program; the values generated by this program are shown in Fig. 7. The function appears to behave in a somewhat erratic way, increasing unsteadily in value. In fact, the function is a very interesting one, and poses some intriguing questions: For example, is FNH(N) always smaller than N? And, what does the curve of FNH(N) look like?

TWICE FUNCTION

As a final challenge to those who like con-

```
 5 FOR N=0 TO 10: PRINT N,FNH(N): NEXT
10 DEF FNH(N)
20 IF N<2 THEN =1
30 =FNH(N-FNH(N-1))+FNH(N-FNH(N-2))
```

Fig. 6. Recursive Function program explores the function FNH

structing functions in BBC BASIC, write a function FNTWICE which will perform any given function twice in succession. It should have two arguments, the first being the function name, and the second being the argument. Thus:
PRINT FNTWICE("SQR",256)
will print 4, the fourth-root of 256, and:

```
>RUN
 0    1
 1    1
 2    2
 3    3
 4    3
 5    4
 6    5
 7    5
 8    6
 9    6
10    6
```

Fig. 7. First ten values of the function FNH

PRINT FNTWICE("LOG",100)
should print 0.3010.

ANSWERS

For the best brief solutions to these problems we will be giving away a VIEW word-processing ROM for the BBC microcomputer, and some subscriptions to Practical Electronics. Solutions should be sent to the Editor of PE at the Poole office, to arrive before June 24.

The solutions to all of these problems, with explanations, will be published in the September Micro-Bus, and the names of the readers who contributed the best solutions will be published in the November issue.

BAZAAR

WANTED ZX81 assm/kit + accessories in exchange of new components FND-500, MM5314, 1N4002-7, TTL and linear I.C. etc. Dr. R. Aviney, P.O. Box 404, Hedera 38103, Israel.

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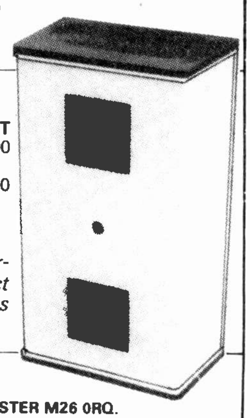

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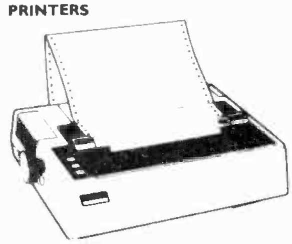

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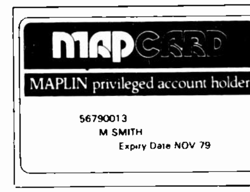

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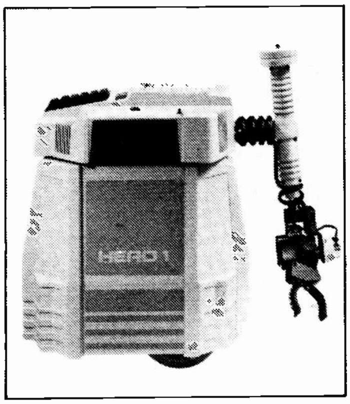

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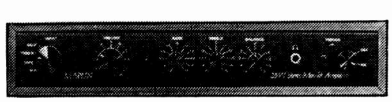

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