Australia $1.35 New Zealand $1.60 Malaysia $4.95 IR £1.14 (inc. VAT)

PRACTICAL ELECTRONICS

JUNE 1982

75p

Microsynth

MPG METER

Plus... SPECIAL SUPPLEMENT

SOUND SYNTHESIS TECHNIQUES

PRACTICAL
ELECTRONICS

VOLUME 18 No. 6 JUNE 1982

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

SPECIAL SUPPLEMENT

OUR JULY ISSUE WILL BE ON SALE FRIDAY, JUNE 11th 1982
(for details of contents see page 31)

SPEAKERS
8Ω, 0·3W, 2": 2·25", 2·5", 3" 80p
0·3W, 2·5" 40Ω; 64Ω or 80Ω 80p

DIODES

AA119	15
BA100	15
BY100	24
BY126	12
BY127	12
CRO33	250
OA9	40
OA47	12
OA70	12
OA79	15
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

Noise Diode
Z5J 195

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
BT108	150
BT116	180
C106D	38
TIC44	24
TIC45	29
TIC47	35
2N5062	32
2N5064	38
2N4444	130

DIAC
ST2 25

BRIDGE RECTIFIERS
(plastic case)

1A/50V	20
1A/100V	22
1A/400V	29
1A/600V	34
2A/50V	35
2A/200V	40
2A/400V	46
2A/600V	65
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	350
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
MVAM115	158
BA102	30
BB105B	40
BB106	40

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

SOLDERCON PINS
100 70p
500 325p

OPTO ELECTRONICS
LEDS including Clips

TIL209 Red 3mm	13
TIL211 Green 3mm	18
TIL212 Yellow	18
TIL220 ·2" Red	15
0·2" Yel, Grn, Amber	18
Rectangular LEDs with two part clip, R, G & Y	29
Stackable LEDs	18
Triangular LEDs R&G	18
0·2" Flashing LED Red	55
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)	91
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
DL747 ·6" C.Cathod.	180
·8" Orange C.A.	250
FND357 or 500	120
·3" Green C.A.	140
±1·3" Red or Green	150
Bargraph 10 seg. Red	225

FERRIC CHLORIDE
1 lb bag Anhydrous
195p + 50p p&p

DALO ETCH RESIST
Pen + Spare tip 90p

0·5" LIQUID CRYSTAL DISPLAYS

3½ digit	550
4 digit	650
6 digit	750

BPX25	95
IL74	45
ILD74	99
ILQ74	185
TIL111	75
TIL117	90
OCP71	120
ORP12	78
ORP61	85
2N5777	45
4N33	135

OPTO SWITCH
Reflective TIL139 170
Slotted similar to RS 186

ALUM. BOXES

3x2x1"	65
4x2½x2"	85
4x2½x2½"	103
4x4x2½"	120
5x4x2"	105
5x2¾x1½"	90
5x2¾x2½"	130
5x4x1½"	99
5x4x1½"	120
6x4x2"	120
6x4x3"	150
7x5x3"	180
8x6x3"	210
10x4½x3"	240
10x7x3"	275
12x5x3"	260
12x8x3"	295

COPPER CLAD BOARDS

	Single-sided	Double-sided	SRBP 9·5"x8·5"
Fibre Glass 6"x6"	90p	110p	95p
6"x12"	150p	195p	

VEROBOARDS 0·1"

	Clad	Plain
2½x3¾"	73p	52p
2½x5"	83p	—
3¾x3¾"	83p	—
3¾x5"	95p	79p
3¾x17"	325p	211p
4¾x18"	425p	—
Pkt. of 100 pins	50p	
Spot Face Cutter	118p	
Pin Insertion Tool	162p	

'VQ' Board	150
'DIP' Board	330
Vero Strip	144
S100 Board	£14

PROTO-DECs

Veroblock	375
S-Dec	360
Eurobreadboard	520
Bimboard 1	695
Superstrip SS2	£13

VERO WIRING PEN and Spool 310p
Spare Wire (Spool) 75p; Combs 6p ea.

SPECIAL OFFER

	1+	25+
NE555	16p	14p
2114L-3	87p	80p
2114L-2	87p	80p
2532	395p	365p
2716	200p	195p
2732	400p	375p
4116	80p	70p
6116-150ns	450p	420p
6520/21	150p	125p
6522	350p	320p

CUSTOMER: How can Watford sell full spec devices so cheaply?
WATFORD: It's simple. By bulk buying (direct from manufacturers where possible), low overheads and smaller margins which give us an edge over our competitors.

ANTEX Soldering Irons

C15W	410
CX17W	425
CCN15W	425
X25W	440
Spare bits	50
Elements	200
Iron stands	160
Heat Shunt	25

Buy with

Just phone your order through, we do the rest.

GAS & SMOKE DETECTORS
TGS812 & 813 575
Sockets 40

ULTRASONIC TRANSDUCERS
40KHz Transmitter & Receiver 395p/pair

DIL SOCKETS (TEXAS)

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

ZIF DIL SOCKET

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

DIL PLUGS (Headers)

Pins	Solder	IDC
14	44p	100p
16	49p	120p
24	88p	170p
40	250p	265p

RIBBON CABLE
(price per foot)

Ways	Grey	Color
10	12p	22p
20	25p	40p
26	35p	52p
40	55p	70p

WATFORD'S Ultimate Monitor IC.
A 4K Monitor Chip specially designed to produce the best from your: Superboard Series I & II, Enhanced Superboard & UK101. As reviewed by Dr. A. A. Berk in Practical Electronics, June 1981.
Price only £15.95 + 50p P&P.

IDC CONNECTORS (Speed block type)

	PCB PLUG with latch Pins Strt.	Angle	Header Free Socket	PCB Pins Strt.	Angle
2 x 5 way	90p	99p	85p	60p	65p
2 x 8 way	130p	150p	110p	70p	78p
2 x 10 way	145p	166p	125p	80p	92p
2 x 13 way	175p	200p	150p	95p	110p
2 x 17 way	205p	236p	169p	110p	135p
2 x 20 way	220p	250p	190p	125p	150p
2 x 25 way	235p	270p	200p	150p	175p

EURO CONNECTORS

	Plug	Socket	Angle Plug
DIN 41618	180p	195p	—
DIN 41612 2x32 way	250p	320p	325p
DIN 41612 2-3x32 way	260p	335p	350p
DIN 41612 3x32 way	280p	390p	420p

'D' CONNECTORS mini. (Cannon type) Solder Bucket

	Plugs	Sockets	Covers plastic
9 way	95p	125p	145p
15 way	135p	198p	150p
25 way	170p	230p	100p
37 way	290p	398p	185p
PCB Pins 25 way	200p	245p	—
PCB Pins (right angle) 25 way	210p	275p	—

TRANSFORMERS (mains Prim. 220-240V)
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
24VA: 6V-1·5A 6V-1·5A; 9V-1·2A 9V-1·2A; 12V-1A 12V-1A; 15-·8A 15-·8A; 20V-·6A 20V-·6A 330p (44p p&p)
50VA: 2x6V-4A; 2x9V-2·5A; 2x12V-2A; 2x15V-1·5A; 2x20V-1·2A; 2x25V-2A; 2x30V-0·8A 440p (60p p&p)
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2·5A; 2x30V-1·5A; 2x40V-1·25A; 2x50V-1A 920p (60p p&p)

Amphenol Plugs
24 way IEEE 575p
36 way Centronic Paralle 550p

EDGE CONNECTORS Two rows

	·1	·156
2x10 way	—	135p
2x15 way	—	140p
2x18 way	180p	145p
2x22 way	199p	200p
2x23 way	210p	—
2x25 way	225p	220p
2x30 way	245p	—
2x36 way	295p	—
2x40 way	315p	—
2x43 way	395p	—
2x75 way	550p	—

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

Length	14 pin	16 pin	24 pin	40 pin
24"	145p	165p	240p	380p
Double Ended Leads				
6"	185p	205p	300p	465p
12"	198p	215p	315p	490p
24"	210p	235p	345p	540p
36"	230p	250p	375p	595p

ID HEADER SOCKET Jumper Leads 24"

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

COMPUTER CORNER

- **VIC 20 MICROCOMPUTER.** Connects directly to a colour TV. 5K RAM expandable to 32K PET type graphics. **£165**
- **CASSETTE DECK** for VIC20 including a free 6 programme Cassette. **£39**
- **EPSON MX SERIES PRINTERS:** Full range available. Please phone for prices.
- **SEIKOSHA GP100A** – Unihammer Printer, gives normal and double width characters as well as dot resolution graphics 10" Tractor feed. Parallel Interface standard. **£195**
- **SOFTY–2.** As reviewed in PE September 1981. The complete microprocessor development system for Engineers & Beginners. New powerful instruction. Accepts any 24 pin 5V single rail EPROM. Supplied fully built, tested & enclosed in a black ABS case. Price incl. encapsulated plug in power supply. **£169**
- **VIDEO MONITOR** 9" fully cased. B&W. Fully guaranteed. Excellent value for money at only **£79**
- **TEX EPROM ERASER.** Erases up to 32 ICs in 15-30 min. **£33**
- **TEX EPROM ERASER** with integral 30 min. Electronic timer **£45**
- **Spare UV lamp bulbs** **£9**
- **5V/5A PSU** Ready built and tested **£25**
- Attractive Beige/Brown **ABS CASE** for Superboard/UK101 or Home Brew **£26**
- **Extra 4K of RAM** (8 off 2114L-300nS) **£7**
- **Space Invaders** for Superboard **£6**
- **Full ASC11** coded keyboard type '756' **£39**
- **4 x 4 matrix keypad** (reed switch assembly) **£4**
- **C12 Cassettes** in Library Cases **40p**
- **8½ Fan fold paper** (500 sheets) (no VAT) **£6**
- **9½" Fan fold paper** (500 sheets) (no VAT) **£6**
- **Teleprinter Roll** (no VAT) **£3.50**

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

VOLTAGE REGULATORS

1A	T03 +ve		–ve	
5V	7805	145p	7905	220p
12V	7812	145p	7912	220p
15V	7815	145p	7915	220p
18V	7818	150p		—
1A	T0220 Plastic Casing			
5V	7805	50p	7905	55p
12V	7812	50p	7912	55p
15V	7815	50p	7915	55p
18V	7818	50p	7918	55p
24V	7824	50p		
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

LM300H	170	LM309K	135
LM304H	160	LM317H	280
LM305H	140	LM317K	350
78H05 5V/5A	550p	LM317P	99
78HG+5 to +24V 5A	599p	LM323K	500
		LM326N	240
79HG –2.25V to –24V 5A	785p	LM723	35
		TBA625B	75

SWITCHES

SLIDE 250V		TOGGLE 2A 250V	
1A DPDT	14	SPST	33
1A DPDT C/OFF	15	DPDT	44
½A DP on/on/on	40	4 pole on off	54

PUSH BUTTON Spring loaded		SUB-MIN TOGGLE	
Latching or Momentary 6A		SP changeover	60
SPDT c/over	99	SPST on off	54
DPDT c/over	145	SPDT c/off	85
		SPDT Biased	105
MINIATURE Non Locking		DPDT 6 tags	75
		DPDT C/OFF	88
Push to make	15p	DPDT Biased	145
Push break	25p	3 pole c/over	205

ROCKER: 5A, 250V, SPST 28p
ROCKER: (white) 10A 250V SPDT 38p
ROCKER: With neon lights red when on. 10A 250V, DPST 85p
ROCKER: (White) 10A/250V DPDT 72p
ROTARY: Make your own Multiway Switch. Shafting Assembly accommodates up to 6 wafers. 90p
Break before make Wafers. Silver contacts. 1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6 pole/2 way 65p
Mains DPST Switch to fit 45p
Screen & Spacers 6p
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 58p
DIL SWITCHES: (SPST) 4 way 70p; 6 way 85p; 8 way 90p; 10 way 145p; (SPDT) 4 way 190p.

CRYSTALS

32·768KHz	150
100KHz	270
200KHz	295
455KHz	370
1MHz	295
1·008M	290
1·28MHz	392
1·6MHz	395
1·8MHz	395
1·8432M	220
2·0MHz	240
2·4576M	220
3·2768M	220
3·57954M	98
3·6864M	300
4·0MHz	150
4·032MHz	290
4·80MHz	200
4·194304M	200
4·433619M	120
5·0MHz	160
5·185MHz	300
5·24288M	390
6·0MHz	140
6·144MHz	225
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
10·7MHz	150
10·24MHz	200
12·0MHz	290
12·528MHz	300
14·31818M	170
16·0MHz	250
18·0MHz	180
18·432M	150
19·968MHz	150
20·0MHz	325
24·0MHz	170
24·930MHz	325
26·69M	150
26·670MHz	325
27·648M	330
27·145M	190
27·125MHz	295
38·66667M	175
48·0MHz	175
100·0MHz	375
116·0MHz	300

ASTEC UHF Modulators

6MHz	280
8MHz Wide-bandwidth	425

WATFORD'S UNIVERSAL MICRO EXPANSION SYSTEM

Designed by Watford Electronics, this extremely versatile and economical Expansion System as published in E.T.I., starting from Dec., 81 issue, offers a low cost flexible expansion facility for **ZX81, UK101, SUPERBOARD, ACORN ATOM, PET, TANGERINE, VIDEO GENIE, VIC 20.**
The Motherboard (Interfaces with the Computer) has capacity to accept up to five daughter cards and can be paralleled for even more daughter cards. All PCBs are of Computer grade finish and are supplied in Kit form.

Just look at the expansion possibilities:
MOTHERBOARD – Accepts up to five Daughter Cards **Full Kit: £36.50**
SOUND CARD – Utilising up to three AY-3-8910 Sound chips. (one supplied with every Kit) **Full Kit: £24.95**
PIO CARD – Using two 6520 PIA chips, this Board offers Centronics parallel printer driver, digital to analogue converter and a host of other out-put facilities. **Full Kit: £19.95**
PROM PROGRAMMER – This simple but extremely useful card can blow 2716 or 2732 single rail EPROMS. **Full Kit: £25.95**
EPROM CARD – This card houses 4x2716 or 2x2532/2732. **Full Kit: £11.80**
RAM CARD – 8K RAM card. Accepts 16x2114 RAMs. The Board is supplied fully populated. **Full Kit: £28.50**
Coming soon: Disc Interface Card, 32K Dynamic RAM Card Speech Card & High Resolution Colour Graphics Card.

(N.B. PCBs may be bought separately)

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NEW an exciting range of projects to build on the EXP300 breadboards.
NOW anybody can build electronic projects using "Electronics-by-numbers", its as "Easy as A, B, C with G.S.C!"

FREE project

MUSICAL DOORBELL OF THE 3RD KIND

You've seen the film, now haunt your visitors with the tune!
Each time the doorbell is pushed the eerie tune plays out, then switches off to conserve battery power.

HOW DO YOU MAKE IT.

Our **FREE** project gives you clear "step-by-step" instructions. For example "take Resistor No.1 and plug it into hole numbers B45 and B47".
"Take IC No.1 and plug it into hole numbers E35 to E42 and F35 to F42, (pin 1 on the IC goes into F35)"
"Take. . ." Well! why not "clip-the-coupon" and get your **FREE** step-by-step instruction sheet and your **FREE** 12 projects with each EXP300 bought and your **FREE** catalogue and. . . . .

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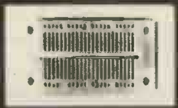
The largest range of breadboards from GSC.
Each hole is identified by a letter/number system
EACH NICKEL SILVER CONTACT CARRIES A LIFE TIME GUARANTEE.

All modular construction means that any Experimentor breadboard can be 'snap-locked' together to build breadboards of any size.

EXP325
The 'one-chip' breadboard
Takes 8, 14, 16 and up to 22 pin IC's
Has 130 contact points including 2 bus bars.



EXP350
The 'beginners breadboard'
For limited period you can have FREE 12 'Electronics by Numbers' PROJECTS

EXP300

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EXP600
The Hobbyist microprocessor' board

EXP650
The 'one chip microprocessor' board

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Exp 350	£ 4.48	
Exp 300	£ 7.76	
Exp 600	£ 8.39	
Exp 650	£ 5.00	
Exp 4B	£ 3.50	
PB 6	£11.73	
PB 100	£14.72	

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5

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DISCO LIGHTING KITS

DL 1000K
This value-for-money kit features a bi-directional sequence, speed of sequence and frequency of direction change, being variable by means of potentiometers and incorporates a master dimming control. Only £14.60

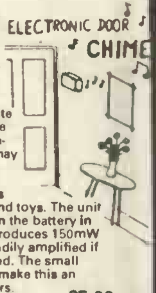
DLZ100K
A lower cost version of the above, featuring undirectional channel sequence with speed variable by means of a pre-set pot. Outputs switched only at mains zero crossing points to reduce radio interference to a minimum. Only £8.00

Optional opto input DLA1 .... 60p
Allowing audio ("beat")—light response.

XK102 3-NOTE DOOR CHIME

Based on a single integrated circuit (SAB0600), this kit comes complete with loudspeaker and drilled box (size: 95 x 71 x 35mm) and requires only a PP3 battery and pushbutton to complete.

The unit produces a 3-note harmonically related tone sequence when the push-button is operated and may be used to replace any doorbell or switched by logic in such applications as alarms, PA systems and toys. The unit draws less than 1uA from the battery in the standby mode and produces 150mW output which may be readily amplified if a louder sound is required. The small number of components make this an ideal project for beginners.



£5.00

DVM/ULTRA SENSITIVE THERMOMETER KIT

This new design is based on the ICL7126 (a lower power version of the ICL7106 chip) and a 3½ digit liquid crystal display. This kit will form the basis of a digital multimeter (only a few additional resistors and switches are required—details supplied), or a sensitive digital thermometer (−50°C to +150°C) reading to 0.1°C. The basic kit has a sensitivity of 200mV for a full scale reading, automatic polarity indication and an ultra low power requirement—giving a 2 year typical battery life from a standard 9V PP3 when used 8 hours a day, 7 days a week.
Price £15.50

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Vero products
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2114	.95	2732	4.80	8035L	5.50
2708	2.25	6810	1.25	M6802P(CPU)	3.85
2716	2.45	6821P	1.25	Z80ACPU	3.30
		6850P	1.50	Z80ACTC	2.90
		6852P	2.55	Z80AP10	2.90

74 LS TTL

LS00	.12	LS14	.48	LS42	40	LS93	.37
LS01	.12	LS15	.15	LS47	.42	LS95	.48
LS02	.13	LS20	.14	LS51	.15	LS107	.24
LS03	.13	LS21	.15	LS54	.15	LS109	.24
LS04	.14	LS22	.15	LS55	15	LS112	.24
LS05	.15	LS26	.18	LS73	.20	LS113	.24
LS08	.15	LS27	.15	LS74	.18	LS114	.24
LS09	.15	LS30	.14	LS75	.27	LS123	.51
LS10	.14	LS32	.15	LS76	.21	LS126	.29
LS11	.15	LS37	.17	LS85	.64	LS132	.44
LS12	.15	LS38	.16	LS86	.18	LS160	.40
LS13	27	LS40	.14	LS90	.32	LS161	.40

CMOS

4000	.14	4025	.18	4081	.22
4001	.14	4026	1.05	4093	.45
4002	.14	4027	.40	4501	.24
4007	.14	4028	.50	4511	.85
4011	.15	4040	.68	4514	1.80
4012	.17	4049	.30		
4013	.35	4050	.30		
4015	.70	4060	.90		
4016	.30	4069	.18		
4017	.85	4070	.24		
4019	.38	4071	.22		
4023	.22	4077	.24		

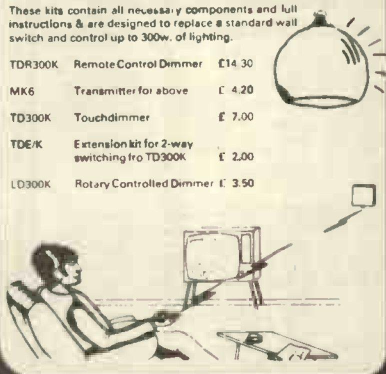
THE KEY TO YOUR SECURITY IS IN OUR LOCK

If the thought of car thieves, house breakers of people tampering with your electrical and electronic equipment upsets you, we have just the kit for you.
Our ELECTRONIC LOCK KIT includesa 10-way keyboard and a special IC which provides a 750mA output to drive a solenoid or relay (not supplied) when four keys are depressed in the correct sequence. This gives over 5,000 possible combinations! The sequence is prewired and may be easily changed by means of a small plug and socket. A "SAVE" function is also available enabling the open code to be stored (especially useful in a car when it is left in a garage for servicing as the open code need not be disclosed). Size: 7x6x3 cms. Power Consumption is 40uA at 5V to 15V d.c.
At only £10.50 + VAT, it will make a smaller hole in your pocket than a bunch of keys!
Electric Lock Mechanism £12.50
Suitable for use with existing door locks and above electronic lock kit.

HOME LIGHTING KITS

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

TDR300K	Remote Control Dimmer	£14.30
MK6	Transmitter for above	£ 4.20
TD300K	Touchdimmer	£ 7.00
TDE/K	Extension kit for 2-way switching fro TD300K	£ 2.00
LD300K	Rotary Controlled Dimmer	£ 3.50



REMOTE CONTROL COMPONENTS

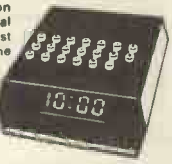
	£
LD271 IR Emitting Diode	.36
SFH205 Photodiode Detector	.90
SL480 IC Pulse Amp.	1.70
SL490 32 Command Encoder/transmitter	2.40
ML922 10-channel reciever + 3 analogue outputs	4.20
ML924 Programmable RC Receiver	1.95
ML925 A decoder designed for model/toy control, providing a 2-speed driver motor and three position latched steering system or a vehicle with momentary action steering and a third motor, eg gun turret, winch, etc Outputs also available for other facilities such as horn, turn indicators, headlights etc	2.10
ML926 16-channel receiver, 4 momentary binary outputs.	1.40
ML927 16-channel receiver, 4 momentary binary outputs.	1.40
ML928 16-channel receiver, 4 latched binary outputs	1.40

We have compiled a booklet on remote control, containing circuits, hints, data sheets and details of our remote control kits and components. So don't control yourself - Send us 30p and a stamped addressed envelope for your copy TODAY!

THE MULTI-PURPOSE TIMER HAS ARRIVED

Now you can run your central heating, lighting, hi-fi system and lots more with just one programmable timer. At your selection it is designed to control four mains outputs independently, switching on and off at pre-set times over a 7 day cycle, e.g. to control your central heating (including different switching times for weekends), just connect it to your system programme and set it and forget it—the clock will do the rest.

ONLY £45 WITH SO MANY EXTRA FEATURES.



FEATURES INCLUDE:-
- 0.5" LED 12 hour display.
- Day of week, am/pm and output status indicators.
- 4 zero voltage switched mains outputs.
- 50/60Hz mains operation.
- Battery backup saves stored programmes and continues time keeping during power failures. (Battery not supplied).
- Display blanking during power failure to conserve battery power.
- 18 programme time sets.
- Powerful "Everyday" function enabling output to switch every day but use only one time set.
- Useful "sleep" function—turns on output for one hour.
- Direct switch control enabling output to be turned on immediately or after a specified time interval.
- 20 function keypad for programme entry.
- Programme verification at the touch of a button.

THERE HAS NEVER BEEN A CLOCK CAPABLE OF SO MUCH AT SUCH A LOW PRICE—

(Kit includes all components, assembly and programme instructions & an attractive case).

24 HOUR CLOCK/APPLIANCE TIMER KIT

Switches any appliance up to 1kW on and off at present times once per day. Kit contains: AY-5-1230 IC, 0.5" LED display, mains supply, display drivers, switches, LEDs, triacs, PCBs and full instructions.

CT1000K Basic Kit	£14.90
CT1000K with white box (56/131 x 71mm)	£17.40
(Ready Built)	£22.50

Add 50p postage & packing +15% VAT to total.
Overseas Customers;
Add £1.50 (Europe), £4.00 (elsewhere) for p&p.
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LOOK

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.

Self-assembly simulated wood cabinet. £4.50 + £1.50 p+p.

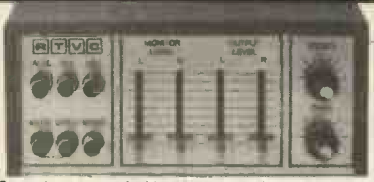
Featured in April issue Practical Electronics, reprint 50p - Free with Kit.

INTRODUCTORY OFFER – ONLY **£32·95** + £2.75 p&p.

P.E. STEREO CASSETTE RECORDER KIT

- 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 TAPES

STEREO AMPLIFIER KIT



- Featuring latest SGS/ATES TDA 2006 10 watt output IC's with in-built thermal and short circuit protection.
- Mullard Stereo Preamplifier Module.
- Attractive black vinyl finish cabinet, 9"x 8¼"x 3¾" (approx).
- 10+10 Stereo converts to a 20 watt Disco amplifier.

To complete you just supply connecting wire and solder. Features include din input sockets for ceramic cartridge, microphone, tape or tuner. Outputs - tape, speakers and headphones. By the press of a button it transforms into a 20 watt mono disco amplifier with twin deck mixing. The kit incorporates a Mullard LP1183 pre-amp module, plus power amp assembly kit and mains power supply. Also features 4 slider level controls, rotary bass and treble controls and 6 push button switches. Silver finish fascia with matching knobs and contrasting cabinet. Instructions available, price 50p. Supplied FREE with kit.

£16·50 + £2.90 p&p.

SPECIFICATIONS:	Suitable for 4 to 8 ohm speakers
Frequency response	40Hz – 20KHz
Input sensitivity	P.U. 150mV. Aux. 200mV. Mic. 1.5mV.
Tone controls	Bass ±12db @ 60Hz Treble ±12db @ 10KHz
Distortion	0.1% typically @ 8 watts
Mains supply	220 – 250 volts 50Hz.

8" SPEAKER KIT Two 8" twin cone domestic speakers: £4.75 per stereo pair plus £1.70 p&p. when purchased with amplifier. Available separately £6.75 & £1.70 p+p.

125W HIGH POWER AMP MODULE

KIT: **£10·50** + £1.15 p&p BUILT: **£14·25** + £1.15 p&p.

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.

ACCESSORIES: Suitable mains power supply kit with transformer: £7.50 plus £3.15 p&p.
Suitable LS coupling electrolytic: £1.00 plus 25p p&p.

SPECIFICATIONS:
Max. output power (RMS): 125W.
Operating voltage (DC): 50 - 80 max.
Loads: 4 - 16 ohms.
Frequency response measured @ 100 watts: 25Hz - 20KHz.
Sensitivity for 100 watts: 400mV @ 47K.
Typical T.H.D. @ 50 watts, 4 ohms: 0.1%.
Dimensions: 205 x 90 and 190 x 36 mm.

HI-FI SPEAKERS AT BARGAIN PRICES

GOODMANS TWEETERS
8 ohm soft dome radiator tweeter (3¾"sq.) for use in up to 40W systems; with 2 element crossover.
£3.50 each (p&p £1) or **£5.95 pair** (p&p £2).

35 WATT MICRO 2-WAY SPEAKER SYSTEM
Unit comprises one 50w (4"app.) Audax soft dome tweeter HD100. And one 5" Audax bass/midrange 35w driver HIFIIJSM. Complete with 2 element crossover. Total impedance of system 4 ohms.

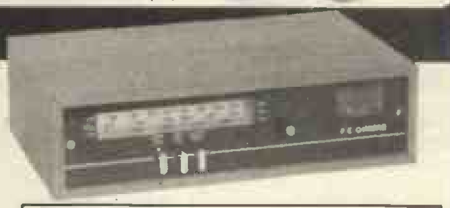
£7.95 PER SET + £2.70 p&p.

P.E. STEREO TUNER KIT

This easy to build 3 band stereo AM/FM tuner kit is designed in conjunction with Practical Electronics (July 81 issue). 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.

£17·95 Plus £2.50 p&p.

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



SPECIAL OFFER! TUNER KIT PLUS:
- Matching I.C. 10 watt per channel Power amp kit.
- Mullard LP1183 built pre-amp, suitable for ceramic pick-up and aux. inputs.
- Matching power supply kit with transformer.
- Matching set of 4 slider controls for bass, treble and volumes.

£21.95 + £3.80 P&P.

PRACTICAL ELECTRONICS CAR RADIO KIT SERIES II

2 WAVE BAND, MW – LW
- Easy to build.
- 5 push button tuning.
- Modern design.
- 6 watt output.
- Ready etched and punched PCB.
- Incorporates suppression circuits.

All the electronic components to build the radio, you supply only the wire and the solder, featured in Practical Electronics. Features: pre-set tuning with 5 push button options, black illuminated tuning scale. The P.E. Traveller has a 6 watt output neg. ground and incorporates an integrated circuit output stage, a Mullard IF Module LP1181 ceramic filter type pre-aligned and assembled, and a Bird pre-aligned push button tuning unit.

Suitable stainless steel fully retractable aerial (locking) and speaker (6"x4"app.) available as a complete kit. £2.50/pack + £1.50 p&p.

£12·95 + £2.00 p&p.

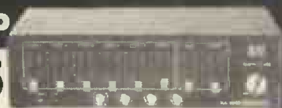
TV SOUND TUNER KIT

£11·45 + £1.50 p&p.

As featured in E.T.I. December '81 issue. Kit of parts including PCB, UHF tuner and selector switch with all components excluding case.

- Transformer £1.50 + £1.50 p&p (p&p free on transformer if ordered with kit).
- Ready built LP1183 Module for simulated stereo operation. £1.95 + 75p p&p.

MONO MIXER AMP



£39·95 + £3.70 p&p.

50 WATT Six individually mixed inputs for two pick ups (Cer. or mag.), two moving coil microphones and two auxiliary for tape, tuner, organs, etc. Eight slider controls – six for level and two for master bass and treble, four extra treble controls for mic. and aux inputs. Size: 13¼"x 6½"x3¾"app. Power output 50 watts R.M.S. (continuous) for use with 4 to 8 ohm speakers. Attractive black vinyl case with matching fascia and knobs. Ready to use.

BIRD AUDIO STEREO CAR RADIO BOOSTER

To boost your car radio or radio cassette to 15W r.m.s. per channel.

£9·95 + £1.50 p&p.

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Note: Goods despatched to UK postal addresses only. For further information send for instructions 20p plus stamped addressed envelope. All items subject to availablity. Prices correct at 31/1/82 and subject to change without notice. Please allow 7 working days from receipt of order for despatch.
ALL PRICES INCLUDE VAT AT 15%.

ALL CALLERS TO: 323 Edgware Rd, London W2. Telephone: 01-723 8432. Open 9.30 – 5.30pm. Closed all day Thursday. RTVC Limited reserve the right to update their products without notice.

RTVC

PE VOLUME 18 No. 6 JUNE 1982

AMALGAMATION

As we move towards the 21st century, it becomes noticeable that the various technologies are gradually amalgamating. No longer do we have individual mechanical, electrical or other pieces of equipment; eighty per cent of them also employ electronics. As the requirement for greater versatility, accuracy and reliability grows so does the electronic content.

It is difficult to think of many modern domestic appliances without electronic control systems and some—like the microwave oven—are simply straightforward applications of electronics with no "mechanical" counterpart. There are of course a few exceptions to the rule—the lawn mower being one that springs (no pun intended) to mind at this time. Though we doubt if it will be long before a programmable (robot!) version is readily available that can be shown how you like your lawn cut just once and will forever after mow to your satisfaction—unless of course you make a new flower bed without telling it! It could even go and empty its own grass box as necessary; just think of the hours that could be saved for sunbathing or something equally rewarding. Anyway, enough day dreaming; now what was the point of all this?

DESIGN!

What these developments mean is that the design engineer must be more able to understand the interface to other technologies. Be able to sort out the elements that require monitoring, the transducers needed and the relationships of the various resulting outputs. Only then can the control electronics and, if necessary, software be designed. As electronics moves ahead, the ease with which new devices can be applied to given situations is greatly improved and the design of electronics for specific applications is becoming little more than the selection and wiring of the appropriate chips.

The sort of "shop floor" design engineer is in danger of being replaced by a "systems engineer", with the true designer jobs increasingly back at the chip stage. The result of this progression will be a greater requirement for a jack-of-all-trades who can understand and interface electronics with a wide variety of appliances and equipments. Possibly even a jack-of-all-trades/programmer.

PROJECTS

It is noticeable that in particular areas our projects are also going this way; it is very often the ingenuity of applying a chip or the program that results in excellent new projects rather than the ingenious circuit design of yesteryear. This progression is enhanced by the falling prices of l.s.i. chips. Although a device may, in electronic design terms, be an overkill when applied to a particular requirement, if it is cheaper than a discrete alternative and has the added advantages of reliability and ease of use, it is an obvious winner.

Mike Kenward

EDITOR Mike Kenward
Gordon Godbold ASSISTANT EDITOR
Mike Abbott TECHNICAL EDITOR
David Shortland PROJECTS EDITOR
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Colette McKenzie SECRETARY

ADVERTISEMENT MANAGER D. W. B. Tilleard 01-261 6676
SECRETARY Christine Pocknell 01-261 6676
AD. SALES EXEC. Alfred Tonge 01-261 6819
CLASSIFIED SUPERVISOR Barbara Blake 01-261 5897
AD. MAKE-UP/COPY Ian Sweeney 01-261 6601

Editorial Offices:
Practical Electronics,
Westover House,
West Quay Road, Poole,
Dorset BH15 1JG
Phone: *Editorial* Poole 671191

We regret that lengthy technical enquiries cannot be answered over the telephone (see below).

Advertising Offices:
Practical Electronics Advertisements,
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Technical Queries
We are unable to offer any advice on the use or purchase of commercial equipment or the incorporation or modification of designs published in PE. All letters requiring a reply should be accompanied by a stamped, self addressed envelope, or international reply coupons, and each letter should relate to **one published project only**.

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

Back Numbers
Copies of most of our recent issues are available from: Post Sales Department (Practical Electronics), IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at 95p each including Inland/Overseas p&p.

Binders
Binders for PE are available from the same address as back numbers at £4·60 each to UK or overseas addresses, including postage and packing, and VAT where appropriate. Orders should state the year and volume required.

Subscriptions
Copies of PE are available by post, inland or overseas, for £13·00 per 12 issues, from: Practical Electronics, Subscription Department, Oakfield House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH. Cheques and postal orders should be made payable to IPC Magazines Limited.

...NEWS &

Edited by Jasper Scott

The IBA and Satellites...

On 4th March the Home Secretary announced the Government's intention to allocate the first two television channels for direct broadcasting by a British satellite in 1986.

The IBA fully appreciates the urgency of early decision-making in a field full of promise for export sales and job opportunities at home: and the commercial consortium building the British satellite system will need to be certain that there are broadcasting organisations committed to the use of two channels at the outset.

The Government believes that for this reason the right course is to authorise an immediate go-ahead with BBC proposals for the first two channels: the BBC is unhampered by the need for passing new legislation through Parliament which would be required for IBA involvement. The Government points out that the total number of channels on the satellite can be up to five as permitted by international allocation so that there will be future opportunities for Independent Broadcasting.

The IBA's position is that it has advanced at least as far as the BBC—and in some ways further—in its work and thinking on the development of Direct Broadcasting by Satellite (DBS): and until the Home Secretary's statement in March there had been no proper public debate on the many and important implications. The IBA in its submissions to the Home Office following the publication of the Government's study document on DBS last year has argued for the use of satellites to improve picture quality and for the need to have uniform standards in Europe in view of the overlap of satellite "footprints". It has also advanced examples of services which the IBA, in discussion with the ITV companies, could be equipped to run.

Meanwhile, the Authority has made significant progress with experiments in both the technical and the programming fields.

Its engineers have pioneered a transmission system for satellite broadcasting, called MAC or Multiplexed Analogue Component, to overcome problems of incompatibility between the different colour systems in Europe, providing a single 625-line system—with clearer pictures than anything at present available on television receivers and with multi-channel sound systems. It would lead to a single design of adaptor unit for the whole of Europe, with consequent advantages for production.

In May, the first experimental European television service via satellite is to be launched on closed circuit by the IBA and 13 other broadcasting organisations—the BBC decided not to participate—within the European Broadcasting Union, headed by an IBA co-ordinator. With full five-hour schedules daily, providing for up to four different language sound channels and the IBA's ORACLE teletext system for sub-titling, and continuing for five weeks, the experimental service will be transmitted using the IBA's own mobile dish transmitter via the European Space Agency's Orbital Test Satellite (OTS).

The first public pan-European television service is due to be launched in 1986: this will make use of another satellite in which British industry has a large share and into which the British Government has put many millions of pounds. The IBA submission to the Home Office suggested that the pan-European service could also be carried on the all-British satellite which is now being authorised to proceed. Another proposal was for a "best of British" service made up of programmes from all four existing services in the UK. And the Authority undertook further study by itself and the programme companies of the practicalities of organising a subscription service—for which, it has argued, the commercial experience of the Independent sector makes it a more suitable operator than the BBC who would ultimately pass the risk to the licence-payer.

A detailed plan for this IBA service could be submitted later this year, well before actual planning perparation for a 1986 service will need to begin in the second half of 1983 and without holding up the decision-making and contractual arrangements on the industrial side.

Clearly there is much still to be publicly debated in the months immediately ahead, espceially when, besides DBS, there are other exciting new possibilities in television broadcasting in the next decade: notably the expansion of cable services and the future use of re-engineered VHF Bands I and III. It would be wrong to make piecemeal decisions.

The IBA believes that the public debate should focus on the best sources of new programmes; on a realistic basis for funding fresh services; and on assurances to viewers that their services from the four terrestial channels continue to be as good as the the broadcasters can make them. Recognising the great opportunities which like in abundance of outlets for broadcasting, the aim must be to ensure that the quality which has been one of Britain's main claims to distinction during the past 50 years is maintained and indeed enhanced.

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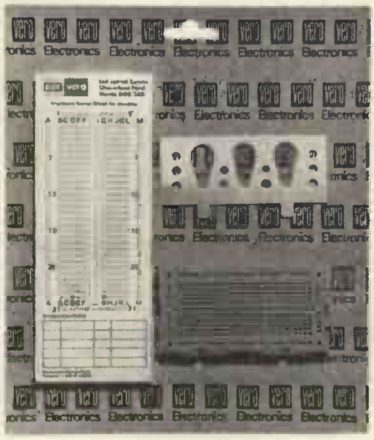
VERO KIT



Pictured above is Vero's latest addition to their range of products for the hobbyist, the Verobloc Kit which consists of one Verobloc breadboard, one component mounting panel and a design sheet pad. It is available from retailers, or direct from Vero at a price of £4.32 plus VAT (p&p on direct orders is free). The Verobloc Kit, along with other products is detailed in Vero's new newspaper-style catalogue, the Hobby Herald, which again is available from retailers or direct from Vero, on request.

Vero Electronics Ltd., Retail Department, Industrial Estate, Chandler's Ford, Hants SO5 3ZR (04215 62829).

MARKET PLACE

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

Briefly...

In News & Market Place, April '82, we featured a siren module from Riscomp, complementing their ultrasonic alarm module. The price we gave for the siren module was incorrect—it in fact costs only £2.57 plus VAT and 50p p&p, rather than £12.59 as originally stated.

Riscomp Ltd., 21 Duke Street, Princes Risborough, Bucks HP17 0AT (08444 6326).

• • • •

If you own a BBC Microcomputer, or are thinking of buying one, you may be interested to hear of 'Beebug'—which describes itself as the first Independent National User Group for the BBC Microcomputer.

Beebug produces a regular newsletter—devoted entirely to the BBC Micro—which contains new program listings, hardware and software hints, plus competitions and discount offers. Membership costs £8.50 per year, or £4.50 for 6 months.

For further details send a stamped self-addressed envelope to Beebug, 35 St. Julians Road, St. Albans, Herts.

• • • •

OK Machine & Tool have recently published their new Electroware catalogue, which features a selection of tools, hardware and various other goodies in the Electroware range, which is available from component and computer retailers, or direct from OK.

To obtain your copy of the Electroware catalogue, write to Electroware, Dutton Lane, Eastleigh, Hants SO4 4AA, enclosing a cheque or postal order for 30p to cover postage.

• • • •

Clive launches New Micro' . . .

A new microcomputer was launched by Clive Sinclair at the Earls Court Computer Fair on April 23rd. At the time of going to press we have few details, but understand that it features a significantly higher specification and price than the ZX81, and marks a major extension to Sinclair's range. A new range of software for the ZX81 has also been introduced.

TEACH YOURSELF DIGITAL

Any reader who wishes to learn about digital electronics will be pleased to hear that a practical and inexpensive means of gaining a basic knowledge of the subject is now available from Cambridge Learning Ltd.

For an inclusive price of £19.90, Cambridge Learning will send you a Superkit, which they describe as a Self-Instruction Digital Electronics Kit for beginners, and which consists of an instruction manual, breadboard and set of components, neatly contained in a plastic wallet.

The course covers boolean logic, gating, R-S and J-K flipflops, shift registers, ripple counters, half-adders; and teaches fault finding, improvisation and subsystem checking. The use of a breadboard means that no soldering is necessary, and all components can be used repeatedly.

Send your order or request for further information to Cambridge Learning Ltd., Unit 22, Rivermill Site, Freepost, St Ives, Cambs. PE17 4EP (0480 67446).

MICRO-PROF.

A new 'teaching computer' known as the Micro-Professor is now available from Flight Electronics Ltd of Southampton.

The Micro-Professor (model MPF-1) is a low cost Z80-based microcomputer which provides an interesting and economic method of understanding the world of microprocessors. It features 2K of RAM (expandable to 4K), 2K of ROM (expandable to 8K), a 36 key keyboard and a six-digit 13mm l.e.d. display. To facilitate experimentation and expansion, the MPF-1 also incorporates a wire wrapping area measuring 89 x 35mm.

Complete with power supply and 350 page manual, the MPF-1 is priced at £69.95 plus VAT and £2.95 p&p. It is available from Flight Electronics Ltd., Flight House, Quayside Road, Bitterne Manor, Southampton SO2 4AD (0703 34003).

We intend to publish a detailed review of the MPF-1 in a future issue.

MADE FOR MICROS

A recent introduction from Monolith Electronics is their new cassette recorder, the ECR81, which has been designed for use with personal computer systems.

Monolith say that the ECR81 (Enhanced Certified Recorder) represents a major advance in cassette recorder technology. It has been designed specifically as a storage medium for personal computer systems and incorporates a number of features which are lacking in machines designed for the audio market which have hitherto been used with such systems. The ECR81 consists of a high quality, proven cassette mechanism with certified tape tension, torque, speed and head alignment.

The ECR81 is supplied complete with mains lead, DIN connector and certification tape, and is priced at £47·50 including VAT, plus £2·50 p&p. It is available from Monolith Electronics Co. Ltd., 5-7 Church Street, Crewkerne, Somerset. (0460 74321).

NEW SHOP

A new electronic component shop serving hobbyists in the North London area has just opened.

Enfield Electronics is stocking a wide range of components, hardware and service aids, as well as a range of kits and books. The shop features a large self-service area for personal callers; a mail order catalogue will be available soon.

For further information contact Enfield Electronics, 208 Baker Street, Enfield, Middx. (01-366 1873). Personal callers will be pleased to note that opening hours are from 9 a.m. to 6 p.m., Monday to Saturday.

POINTS ARISING . . .

FREQUENCY METER (May '82)

The l.e.d. of Fig. 6 should return to pin 12 of IC3, *not* 0V. Similarly in Fig. 7, the diodes (from left to right) should return to pins 4, 6, 7, 12 of IC3, again *not* 0V. The second sentence in the caption of Fig. 11 should be ignored.

The recommended displays (FND 0238) are now obsolete. A directly compatible alternative is the FND 357.

IC3 in the component list of page 26 (Frequency Counter) should be specified as 7216**B**. Capacitor C3 should be included (39pF).

If difficulty is experienced in trimming the crystal to 10MHz, try changing C3 to 47p or 68p. Alternatively, increase the value of VC1.

Optional Prescaler: Re. 2nd paragraph. The 8660 is the *more* expensive device and will *not* work at such high frequencies, but does provide TTL compatible outputs.

FASCIAS...

L & B Electronic inform us that they now produce a range of fascia panels for their range of lighting modules, in addition to those already available for the Multi-4 and Program-8.

All the panels are anodised blue and finished with white lettering. They come complete with an illuminated rocker switch, black control knobs, and where appropriate, l.e.d.s for monitors.

Prices for the fascia panels are as follows: 41000SLC – £9.20; 31000SLC – £8.70; 31000SL – £7.70. All prices include VAT; p&p is 30p extra. L & B Electronic, 45 Wortley Road, West Croydon, Surrey. (01-689 4138).

Countdown . . .

Please check dates before setting out, as we cannot *guarantee* the accuracy of the information presented below.

HEVAC May 24–28. NEC Birmingham. **I**
International Word Processing May 25–28. Wembley Conference Centre, London. **Z**
CETEX (Consumer Electronics Trade) May 30–Jun. 2. Earl's Court, London
Electronic Hotel June 3–4. West Centre Hotel, London. **Z1**
Videotext June 4. Europa Hotel, London. **Z1**
Scotelex Jun. 8–10. Roy. Highland Ex. Hall, Ingliston, Edinburgh. **A1**
BEX Leeds Jun. 9–10. **K**
Compec North June 23–25. Belle Vue Hotel, Manchester. **Z1**
Transducer/Tempcon Jun. 29–Jul. 1. Wembley Conf. Centre. **T**
BEX Croydon Jun. 30–Jul. 1. **K**
Leeds Electronics Show Jul. 6–8. University. **E**
Video Revolution (symposium) July 12–15. Reading University **G1**
Internoise July 13–15, 1983. Edinburgh University **A7**
BAEC Amateur Electronics Jul. 17–25. Penarth Esplanade, S. Glamorgan. **B9**
BEX Manchester Sept. **K**
Personal Computer World Show Sept. 9–12. Barbican Centre, London. **M**
Laboratory London Sept. 14–16. Grosvenor Ho. Park Lane. **E**
Two Counties Fair Sep. 15–18. Plymouth Ex. Centre, Millbray, Plymouth, Devon. **T**
Microprocessors In Audiology Sept. 24 **A7**
BEX Cardiff Oct. **K**
Viewdata Oct. 12–14. Wembley Conf. Centre. **O**
Video Show Oct. 16–18. West Cntr. Hotel. **Z1**
Computer Graphics Oct. 19–21. London. **O**
Testmex Oct. 26–28. Wembley Conf. Centre, London. **T**
Compec Nov. 16–19. Olympia, London. **Z1**
Brighton Electronics Exhibition March 1983. **T**
INSPEX March 21–25, 1983. NEC. **Z1**
HEVAC London Apr. 26–28 1983. Barbican. **I**
Semlab June 1983. Olympia, London. **I**

A1	Institute of Electronics, Rochdale, Lancs.
A7	Institute of Acoustics. ✆ 031-225 2143
B9	BAEC, 26 Forrest Road, Penarth
E	Evan Steadman, Saffron Walden ✆ 0799 22612
G1	SERT, 8 Charing Cross Rd., London.
H1	Seminex Ltd. Tunbridge Wells ✆ 0892 39664
I	ITF, Solihull ✆ 021-705 6707
K	Douglas Temple, Bournemouth ✆ 0202 20533
L1	World Trade Centre ✆ 01-488 2400
M	Montbuild ✆ 01-486 1951
O	Online, Northwood, Middx. ✆ 0822 4671
T	Trident Tavistock ✆ 0822 4671
V	SDL ✆ Dublin 763871
Z	Beta Exhibitions ✆ 01-405 6233
Z1	IPC Exhibitions, Sutton ✆ 01-643 8040

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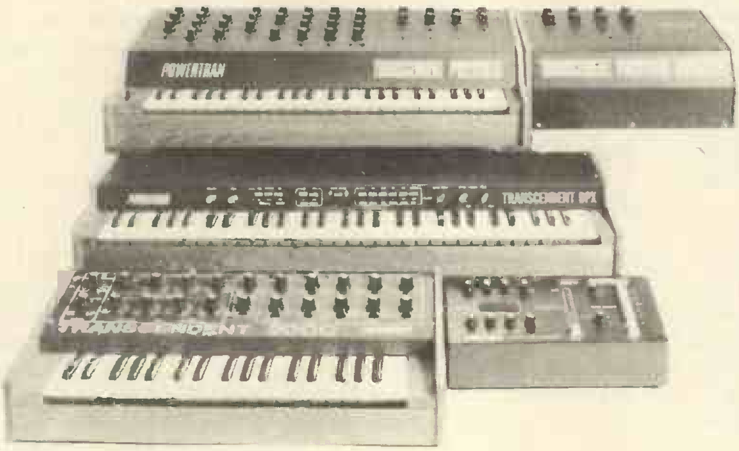

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Microsynth...

Part One

A.R. Bradford M.Sc.

ELECTRONIC sound synthesisers have become very popular over the last few years, with a wide range of ready built and do-it-yourself designs currently available. The problem is that they are all very expensive, although prices have been coming down slowly. Some manufacturers now produce small units for people not wishing to fork out several hundred pounds, but these all have drawbacks in terms of "cost-performance".

While "anything to anything else" patching (by matrix pin-patch or flying leads) is prohibitively expensive in small synthesisers, not to mention inconvenient, there is a tendency for simpler models to be rather limited in what they can do owing to the number of switched interconnections available. The Microsynth overcomes this limitation.

On the amateur constructor front, in the author's experience, there seems to be no limit to the complexity of existing designs, as if the designers' maxim were "never use simple circuits where something more complicated will do." This has resulted in an extensive re-think of what is required from the various units in a synthesiser with the emphasis on using as few and as cheap components as possible, while at the same time ensuring effective and reliable operation. Slide switches have been employed for the various interconnections; these work out just as cheap as flying leads and are a lot neater.

Ideally it should be possible to feed or modulate any part of the synthesiser from any other, but in practice many effects thus obtained are so dull or pointless as to be redundant. Consequently, much thought has gone into creating routing systems for audio signals and control voltages (the two may be the same) which is as versatile as possible, but which is greatly simplified by omitting the least useful connections, particularly where similar results may be obtained by more than one means. Having made sure of satisfying the experimenter, the author then consulted professional keyboard players in arriving at a panel layout which is both pleasing and ergonomic, that is, non-confusing and rapidly operated on stage.

Whilst the circuits employed in the Microsynth will obviously not compare with the most expensive instruments available, they will hold their own against many professional machines and are equally suited to domestic, stage and studio use. Most importantly, the Microsynth is completely insensitive to changes in temperature, that is, it will not go out of tune.

The result is a synthesiser which is tremendously versatile yet simple to operate, reliable, and above all cheap enough to bring the tremendous potential of electronic sound creation within the reach of most peoples' pockets!

PERFORMANCE

The Microsynth operates in two modes depending on the configuration of VCO2, as shown in the block diagrams (Figs. 1 and 2).

In the first mode both VCOs run at audio frequencies and manual modulation of pitch, etc, is available via the thumbwheel. In the second mode, VCO2 is configured as a low frequency oscillator (LFO) and can be used to modulate the keyboard, filter, VCO1 mark/space, etc, trigger the envelope shaper, and so on. The thumbwheel can be used to introduce LFO modulation manually.

A notable feature of the Microsynth is that with VCO2 switched to "RM" or ring modulator mode, it still runs at audio frequencies and tracks VCO1 very accurately, but its output is via the modulation routes only. Thus instead of being added, the waveforms from the two oscillators are multiplied together producing sum and difference tones. This, together with the sub-octaves, underlies the remarkably rich sounds that the Microsynth can produce.

Having VCO2 switchable in this way is not a drawback as it may at first seem. In a unit as compact as the Microsynth it was felt that it was impractical to have a second VCO and an LFO and do justice to both, and so the switchable VCO is felt to be a reasonable compromise. Even with only one VCO operating the sub-octaves can be used to give rich harmonic structures, while waveform modulation or other effects are created by the LFO. Pitch bending can be introduced manually with the thumbwheel. With both VCOs running at audio frequencies the lack of a separate LFO makes little difference — the thumbwheel allows expression of various sorts to be imparted manually, while vibrato may be created by setting the two VCOs slightly apart to give a slow beat.

One feature of the Microsynth which is sadly lacking from many commercial designs is that all modulation routes enable the device being modulated to be swept over its entire range, enabling extreme effects to be produced. Another feature which is unusual in smaller synthesisers but which is very powerful, is the inclusion of a separate sample and hold (or analogue memory). This samples the waveform from VCO2 each time the envelope shaper completes a cycle and can be used to create either staircase or random

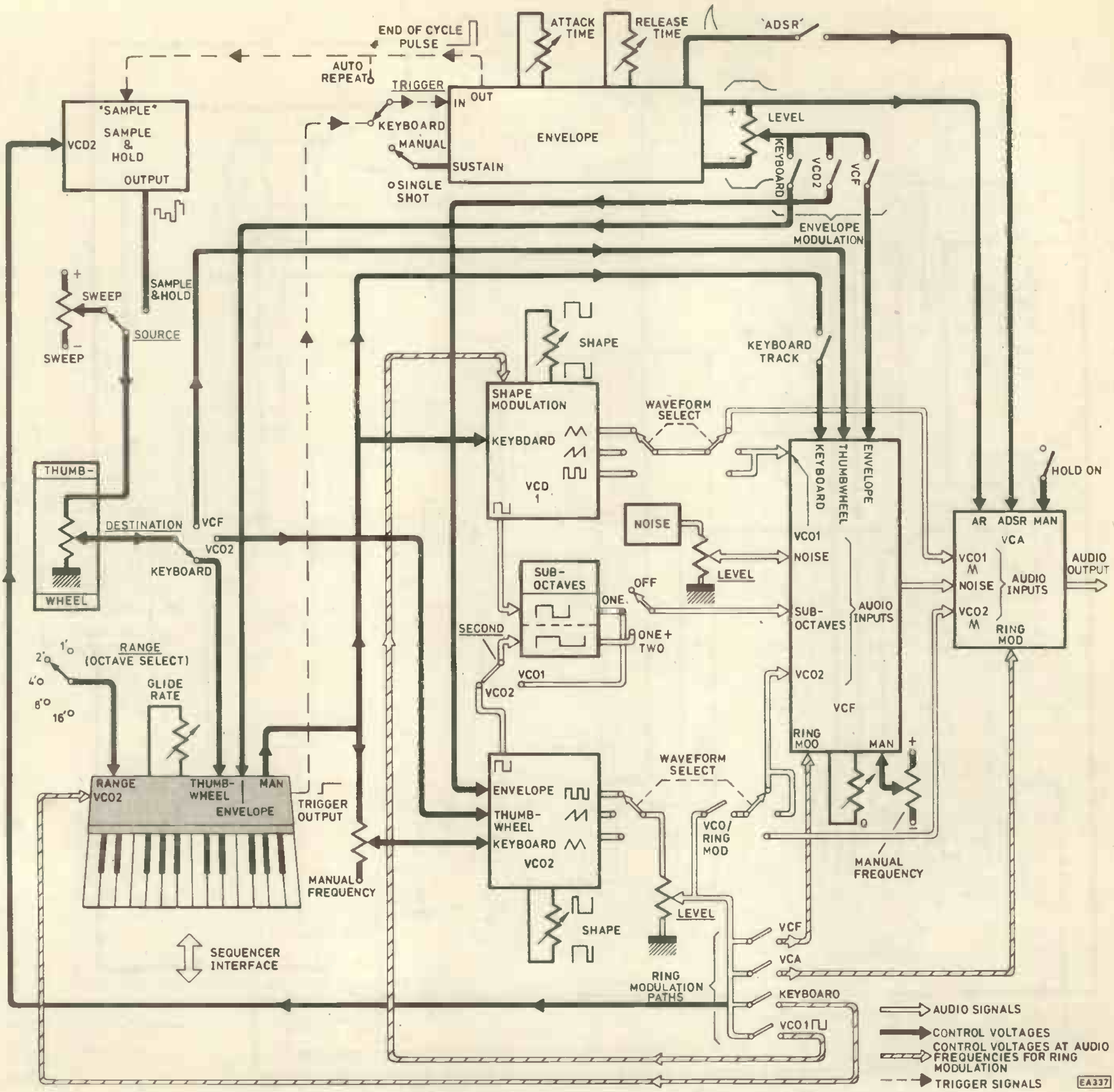


Fig. 1. Effective 2–VCO configuration of the Microsynth

changes in pitch or timbre. This enables the Microsynth to generate sophisticated rhythms or sequencer type patterns using the oscillators and/or filtered noise, which again far belie the complexity of the instrument.

KEYBOARD CONTROLLER

The keyboard resistor chain is in the feedback loop of IC1b, which acts as a constant current source giving highest note priority. The keyboard itself is provided with three contacts (made from short lengths of gold wire) under each key. As a key is pressed a sequence of two events occurs: first the selected point in the keyboard resistor chain makes contact with the keyboard bus bar which transfers the appropriate voltage to the sample and hold circuit IC4a, C1 and IC5a. A moment later the trigger bus is connected to the keyboard bus and switches on comparator IC1a, debounced by R28 and C2. As IC1a output goes high the CMOS analogue switch IC4a is turned on and the keyboard voltage is sampled. As the key is released the trigger bus is disconnected first, so IC1a goes low, IC4a is switched off and the sampled voltage is stored on C1, buffered by high impedance op-amp IC5a. Finally the keyboard bus is disconnected.

IC1c and IC1d are wired as comparators of opposite polarity; each time the voltage from IC5a changes up or down, even by a semitone, this change in voltage is differentiated by C4 and R51 to give a spike, and this spike makes either IC1c or IC1d go high momentarily, depending on its direction. Thus a positive pulse appears on the far side of D2, D3, and this pulse enables the envelope shaper to be retriggered each time a new key is pressed, even if the preceding key has not been released. This circuit comes into its own when fast runs are being played with a percussive attack.

The voltage from IC5a is summed along with an offset

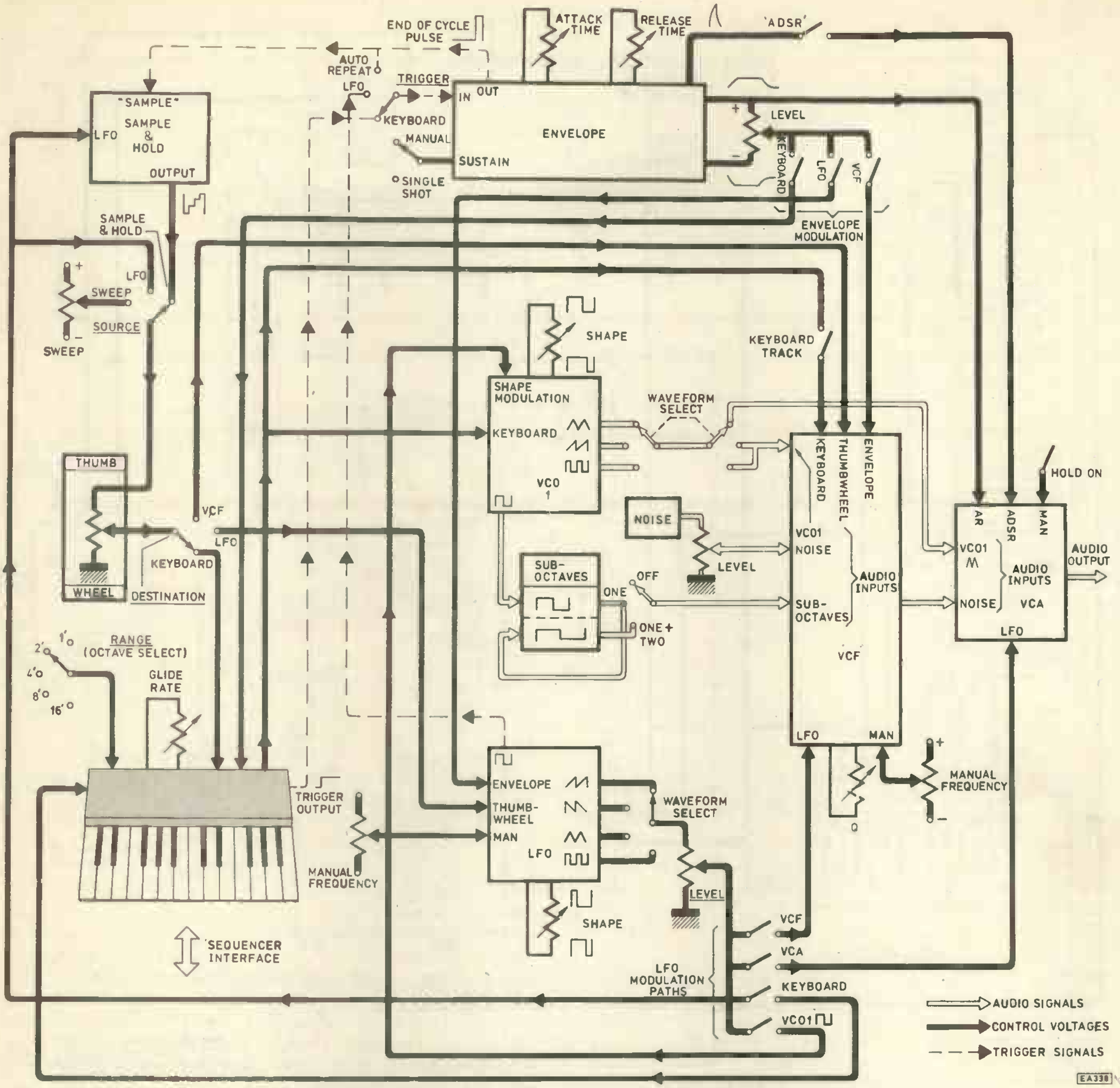


Fig. 2. Effective operation with VCO2 configured as an LFO

and various incoming modulation voltages by inverting amplifier IC2a. The voltage from the "Tune" preset VR1 is also fed in at this point. VR2, C5 and IC6 form a slew rate limiter providing glide rates from a few milliseconds to several seconds depending on the setting of VR2. Inserting the slew limiter at this point means that the transition to a new note will be completed even if the key is released prematurely.

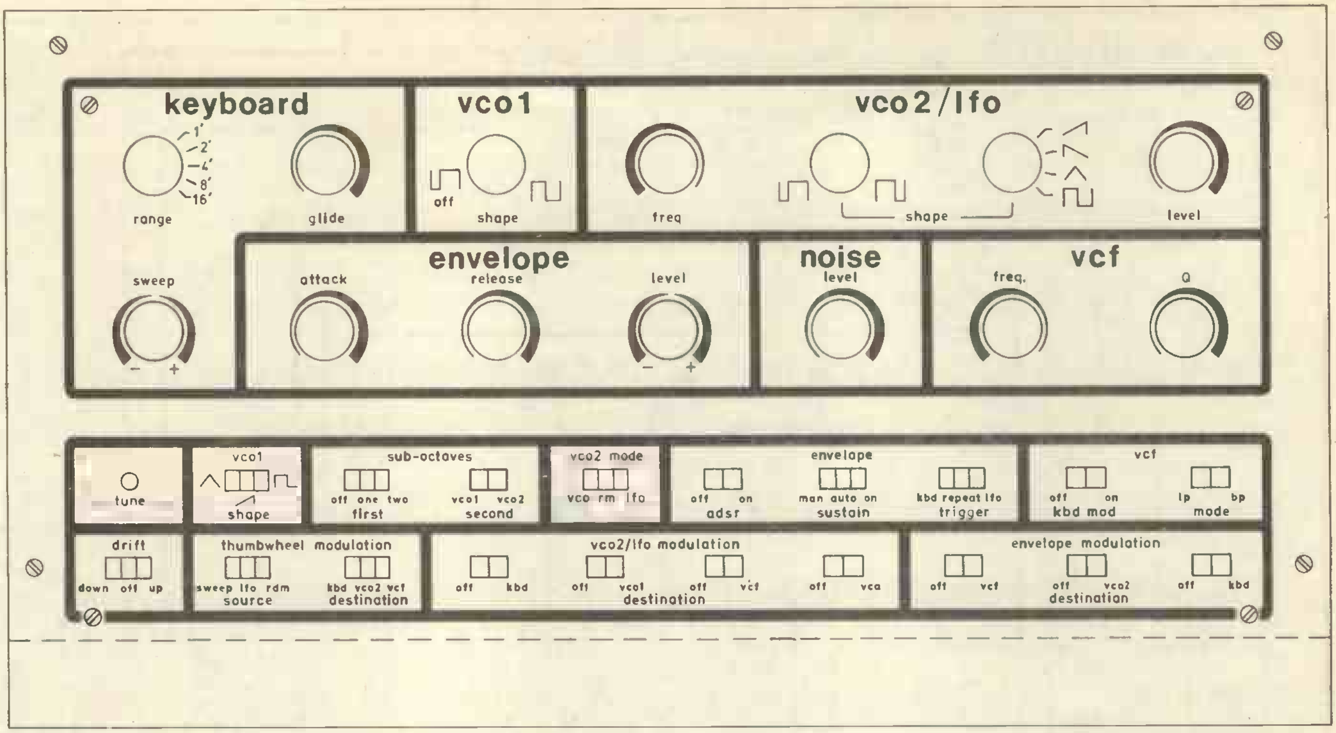
The keyboard circuitry thus far generates a law of about 0·35 volt per octave. This is smaller than is commonly used in synthesisers for reasons which will become apparent.

EXPONENTIAL CONVERTER

This is the most important part of the synthesiser and will be discussed in some detail.

Positive going control voltages from the preceding circuitry are attenuated by VR3, R38, R39 and R40, so that every 0·35 volt increment in input voltage results in an 18mV increment at the base of TR2, which in turn doubles the current flowing in TR2. The emitter of TR2 is held at −0·6 volt so that any positive voltage at its base will cause it to conduct. This reference voltage is generated by a temperature compensating transistor TR1, buffered by IC2b. As temperature rises the current in TR1 increases, raising the reference voltage and so lowering the current in TR2, and vice versa. D1 prevents zenering of TR1 and consequent damage. TR1 and TR2 are glued together for intimate thermal contact and a piece of polystyrene packing pushed over the two transistors ensures that they remain at the same temperature. In practice it has been found unnecessary to use specially matched transistors unless violent changes of temperature are anticipated.

The current to V_{be} relationship of TR2 is also temperature dependent affecting the relative tuning of the keyboard, or



EA336

"span", as it is otherwise known, and so R39 and R40 are a combination chosen for a temperature coefficient which cancels out this effect.

The prototype Microsynth has been used for over a year both on stage and in the studio and invariably one finds that it is other, conventional instruments such as guitars that drift and require tuning, rather than the synthesiser. The prototype has also held its own against two expensive commercial machines—a Moog and an ARP. The circuit used here has advantages over other designs as the temperature stabilisation requires no tedious setting-up, there is no warm-up time (as with transistor ovens, heated chips, or whatever), and the musical scale is simply adjusted by VR3.

The current in TR2 is converted back into a voltage by IC7. This arrangement has been chosen so that more than one VCO can be driven from the same exponential converter. Thus only one converter is needed, reducing cost, and the musical scale of the instrument is adjusted only once. Another important advantage is that because both VCOs are driven from the same exponential converter, they will track each other perfectly over the entire range of the keyboard providing triangle/square wave VCOs are used, which unlike relaxation oscillators do not suffer from reset time problems. (Here it is worth noting that a defect of triangle oscillators is put to good use in the Microsynth, namely, a tendency to lock on to each other's harmonics). Octave switching is simply achieved by switching the gain of IC7 to multiply the exponential up and down. Thus the most accurate part of the exponential is always used. The octaves are tuned using VR4 to VR7, while VR8 trims out the offset in IC7, which must function linearly down to very low voltages.

DRIFT

One novel feature of the Microsynth is the "Drift" function. Moving S1 to the left or right means that once a key is released the held voltage (C1, IC5a) will drift up or down as C1 charges or discharges via R31 or R32 respectively. This offers a neat way of synthesising "seagulls", "frogs", "alarm" tones, etc, not to mention the sort of irritating noises heard on many disco records!

ENVELOPE

As previously described the envelope shaper is triggered each time a key is pressed, by IC1a. It can also be retriggered by pressing another, higher, key via IC1c and IC1d.

Moving S9 to the "LFO" position means that the envelope will be triggered by the square wave output from a slow-running VCO, for rhythmic effects. However the gating of IC3a and IC3b ensures that this only happens as long as a key is depressed. As the envelope output goes low the centre of the Schmitt trigger built around IC3c and IC3d goes high, and selecting the centre "Repeat" position of S9 sends this positive voltage back to the trigger input of the envelope shaper. Thus the whole thing is turned into an oscillator, retriggering itself every time it completes an attack and release cycle.

With "Sustain" switch S8 in the "Manual" position, pressing a key turns on IC4b while inverter TR3 holds IC4c off, so C12 charges up to about +8V via the attack pot VR9. Releasing the key reverses this arrangement: IC4b turns off and IC4c closes allowing C12 to discharge to −8V via the release pot VR10.

With S8 switched to "Auto", the set-reset flip-flop IC8c and IC8d is triggered as a key is pressed so that pin 10 of IC8 goes high, turning on IC4b and intitiating the attack cycle. VR11 is adjusted so that when the envelope output (IC10 pin 6) reaches about +7V, the flip-flop is reset and C12 discharges via the release pot. The complete envelope cycle time is thus the sum of the attack and release times and one cycle occurs each time a key is pressed. IC9 and IC10 provide negative and positive going envelopes respectively. The positive going envelope is fed directly to the VCA, while "Level" control VR12 cross fades between negative and positive envelopes and controls the degree of modulation fed to the VCF, VCO2, etc. Diodes D8 and D9 provide a dead band in the centre of VR12, corresponding to 0 volts or "no modulation".

Each time the envelope shaper is triggered, by whatever means, the flip-flop built around IC8a and IC8b is set, charging up C11, and then reset by the voltage on C11 a short

COMPONENTS . . .

Resistors

R1		10k
R2		680
R3 to R26 (2%)		56
R27		1k2
R28		1M
R29		33k
R30		1k
R31, R32		10M
R33, R34		15k
R35		180k
R36		390k
R37		1M
R38		22k
R39	wire wound	870
R40	metal oxide	130
R41		39k
R42		22k
R43		47k
R44		100k
R45		180k
R46		390k
R47 to R50		10k
R51		15k

R52	100k
R53, R54	100
R55, R56	100k
R57	4k7
R58	33k
R59	100k
R60, R61	10k
R62, R63	10M
R64, R65	47k
R66	470k
R67	1M
R68	100k
R69	33k
R70	10k
R71	8k2
R72	4k7
R73	10k
R74	1k
R75	10k
R76	3k9
R77	470k
R78	1M2
R79	1M
R80, R81	470k
R82	10
R83	1M

R84	10k
R85	8k2
R86	4k7
R87	10k
R88	1k
R89	10k
R90	15k
R91	1k
R92	220
R93, R94	1M
R95	1k8
R96	100
R97, R98	47k
R99	5k6
R100	82k
R101	47k
R102	5k6
R103	33k
R104	1k
R105	220k
R106 to R108	12k
R109, R110	100
R111	10k
R112, R113	100
R114, R115	10k
R116, R117	4k7

R118		10k
R119, R120		47k
R121		1k
R122		33k
R123		3M9
R124		6k8
R125, R126		47k
R127		33k
R128, R129		100
R130		220k
R131		1M
R132, R133		10k
R134, R135		68k
R136		150k
R137, R138		1k
R139		100k
R140, R141		10k
R142		39k
R143		15k
R144		2R7
R145, R146	0·5W	470
R147		4k7
R148		2k2
R149		10k
R150		1M
R151		6k8
R152		56k

Potentiometers

VR1	preset	100k
VR2	pot log	2M
VR3	cermet preset	22k
VR4	cermet preset	10k
VR5	cermet preset	10k
VR6	cermet preset	47k
VR7	cermet preset	47k
VR8	preset	10k
VR9	pot log	1M
VR10	pot log	2M
VR11	preset	100k
VR12	pot lin	100k
VR13	preset	10k
VR14	pot lin	100k
VR15	preset	100k
VR16	pot lin	1k
VR17	preset	10k
VR18	pot lin	100k
VR19	preset	100k
VR20	pot log	10k
VR21	pot lin	100k
VR22	preset	100k
VR23	pot lin	1k
VR24	pot log	10k
VR25	preset	100k
VR26	pot log	10k
VR27	edge pot log	4k7
VR28	pot lin	1k
VR29	preset	10k
VR30	preset	10k

Switches

S1, S3, S4, S6, S8, S9, S12, S13 are p.c.b. mounting slide switches 2-pole, 3-position (8 off)

S4, S5, S7, S10, S11, S16 to S20 are p.c.b. mounting slide switches 2-pole, 2-way (11 off)

S2, S21 are rotary switches, 2-pole, 6-way (2 off)

Capacitors

C1	polycarbonate	1µ
C2	polyester	22n
C3	p.c. elec 25V	100µ
C4	polyester	100n
C5	polycarbonate	470n
C6	polyester	10n
C7	polyester	100n
C8	polyester	10n
C9, C10	polyester	10n
C11	p.c. elec 25V	1µ
C12	p.c. elec 25V	4µ7
C13	polyester	10n
C14	polyester	100n
C15	polyester	10n
C16	polyester	15n
C17, C18	polyester	10n
C19	polyester	15n
C20	polyester	10n
C21	polyester	100n
C22, C23	polystyrene	680p
C24	polyester	220n
C25	polyester	100n
C26 to C28	polyester	220n
C29	p.c. elec 10V	4µ7
C30	p.c. elec 35V	4µ7
C31	p.c. elec 10V	4µ7
C32	p.c. elec 25V	4µ7
C33	polyester	100n
C34	p.c. elec 25V	470µ
C35, C36	polyester	100n
C37, C38	p.c. elec 25V	200µ
C39, C40	p.c. elec 25V	10µ
C41, C42	p.c. elec 25V	1000µ

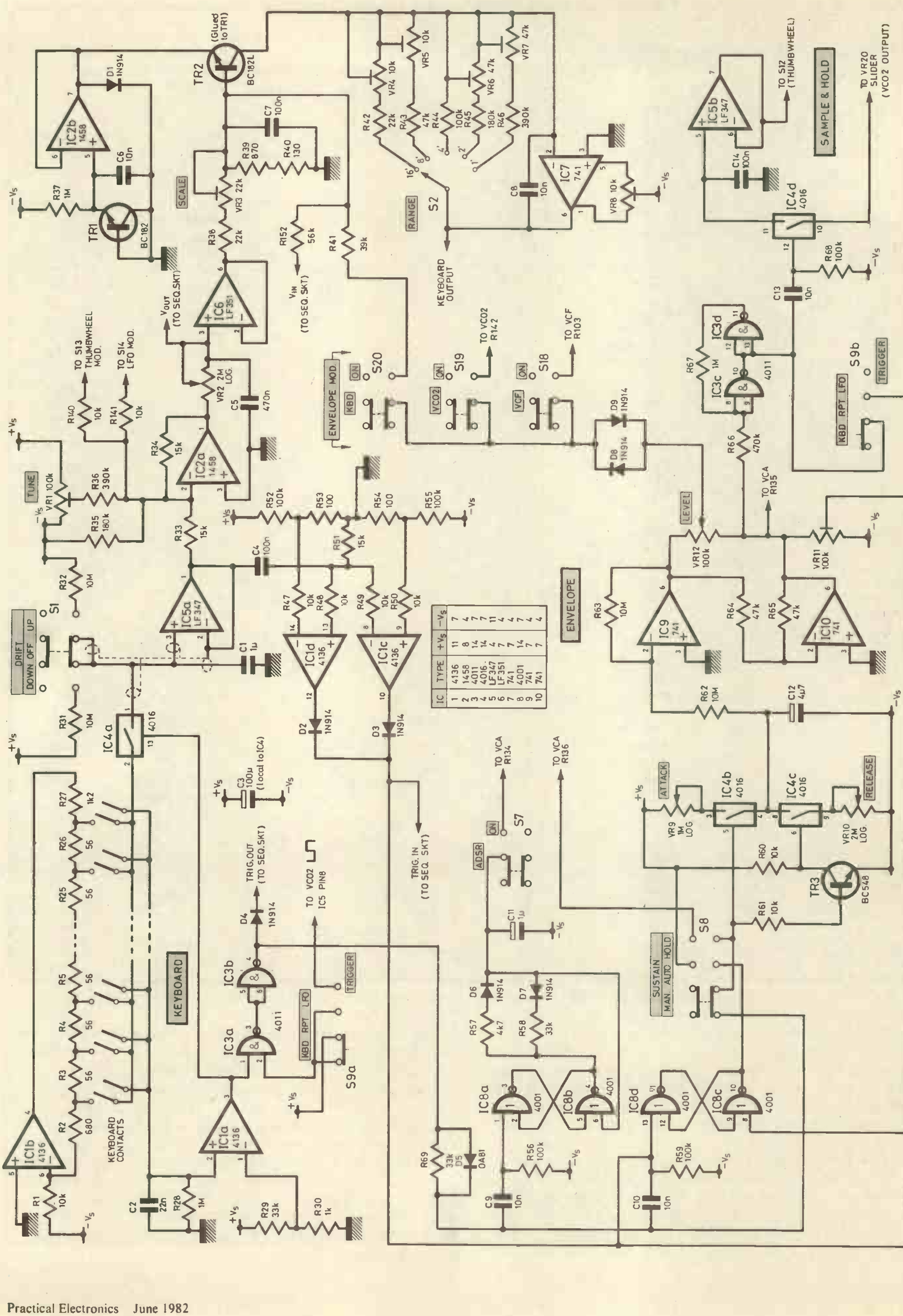
Semiconductors

TR1, TR2	BC182L
TR3	BC548
TR4, TR5	BC212L
TR6 to TR9	BC548
TR10, TR11	TIP41
D1 to D4	1N914
D5	0A81
D6 to D11	1N914
REC1, REC2	W005
IC1	4136
IC2	1458
IC3	4011
IC4	4016
IC5	LF347
IC6	LF351
IC7	741
IC8	4001
IC9 to IC13	741 (5 off)
IC14	4016
IC15	LF351
IC16 to IC19	741 (4 off)
IC20	LM13600
IC21	CA3080
IC22	4013
IC23	LM380
IC24, IC25	µA78MGU1C

Parts available from **Clef Products Ltd., 44a Bramhall Lane South, Bramhall, Cheshire, SK7 1AH.**

Miscellaneous

Transformer 0-12V, 0-12V 500mA, solder tag, Microsynth p.c.b. A (main board), Microsynth p.c.b. B (power supply and power amp), 25 note, flat fronted keyboard, Microsynth front panel, Microsynth socket panel, Microsynth cabinet, push-on knobs plus colour coded push in caps to taste, R.S. type (15 off), large edge wheel (at least 31mm dia), Microsynth keyboard, p.c.b. gold contact wire (3m), mono jack socket open, stereo jack socket open, Din latch socket 5-pin A, min mains cable to suit, mains cable grommet ($\frac{3}{8}$" dia), mains plug with 1A fuse, 2m of 4-way ribbon cable, Min screened cable (approx 0·5m), 6BA bolts $\frac{3}{4}$in (10 off), 6BA nuts (10 off), 6BA threaded spacers $\frac{1}{2}$in (6 off), 6BA threaded spacers $\frac{1}{4}$in (4 off), domed-headed self-tap screws $\frac{1}{2}$in (4 off), cabinet feet plus self-tapping screws to suit (4 off), strap handle.



IC	TYPE	$+V_s$	$-V_s$
1	4136	11	7
2	1458	8	4
3	4011	14	7
4	4016	4	11
5	LF347	7	4
6	LF351	7	4
7	741	14	7
8	4001	7	4
9	741	7	4
10	741		

Fig. 4. Controller, shaper and sample and hold elements of circuit

SPECIFICATION

Keyboard	2 octave, may be stepped through 5 octave range from 16′ to 1′ using the "Range" switch. Debounced contacts. Max drift rate about ten minutes per semitone. "Drift" switch allows selected note to drift up or down once a key is released at about 1 octave per second. "Glide" variable 0 to 5 seconds. Front panel screwdriver adjustment "Tune" allows tuning of the synthesiser relative to other instruments over $\pm\frac{1}{2}$ octave. Modulation by any or all of Sweep, VCO2/LFO, Envelope, Sample and Hold. High note priority.
VCO1	10Hz to 10kHz nominal range, hardwired to keyboard. Triangle output to VCA, ramp and squarewave outputs to VCF. Duty cycle of squarewave variable from 50% to 10% either manually or by VCO2/LFO. May be switched off, allowing VCO2 or Noise to be used alone.
VCO2/LFO	VCO mode: 10Hz to 10kHz nominal range. Frequency may be manually set to any multiple of VCO1 frequency. Accurate tracking over entire range of keyboard. Triangle output to VCA; rising ramp, falling ramp or squarewave to VCF. Squarewave duty cycle manually variable from −10% through 50% to +10%. Level control on output. Ring mod mode: Switch disconnects audio outputs but LFO modulation switches allow frequency modulation of keyboard, VCO1 shape, VCF, VCA. In either mode, independent modulation allows pitch bending relative to VCO1 by any of sweep, envelope, sample and hold. LFO mode: 0·1Hz to 30Hz nominal range, manually variable. Manual level control, triangle, rising ramp, falling ramp and squarewave modulation via output switches to keyboard, VCO1 shape, VCF, VCA. Modulation of LFO frequency by sweep, envelope, sample and hold.
Sub Octaves	Two divide-by-two circuits may be used to provide either an octave below VCO1 frequency and an octave below that, or an octave below each of VCO1 and VCO2, switchable. Outputs: squarewave to VCF.
Noise	White noise source with level control. Output to VCF.
Envelope	Attack and release times variable 0 to 10 seconds. ADSR switch adds additional percussive attack. Triggered either from keyboard, or LFO as long as a key is depressed. Repeat switch causes the envelope shaper to retrigger itself, with a repeat time equal to the sum of the attack and release times. Sustain operates in three modes: "Manual" means the envelope attacks and remains high as long as a key is depressed (like an organ); "Auto" puts it into single shot mode so that depressing a key produces one attack and release cycle. The envelope is then only retriggered by re-pressing the same key or depressing a higher key; "Hold" produces a continuously audible output about half maximum volume—pressing a key then adds the envelope shape to this constant level bringing the output of the VCA up to maximum. The positive-going envelope is hardwired to VCA; positive and negative envelopes are available via the level control for modulation of any or all of keyboard, VCO2/LFO, VCF.
VCF	State variable filter with manual control of roll-off frequency. Outputs: switchable low pass or band pass to VCA. Manual "Q" control adjusts size of resonant peak at roll-off frequency. Min roll-off: 6dB per octave; max roll-off: 50dB per octave. Modulation of roll-off frequency by keyboard, envelope, sweep, VCO2/LFO, sample and hold.
VCA	Controls output volume of synthesiser. Max attenuation: −60dB min. Max output level 100mV into 10kΩ, via master volume control on rear panel.
Sample and Hold	Analogue memory samples instantaneous output voltage from VCO2/LFO each time envelope ends. Output to thumbwheel.
Sweep	Manual control producing variable positive or negative d.c. control voltage with zero dead band at centre. Output to thumbwheel.
Thumbwheel	Manual level control. Modulation depths may be preset using sweep and VCO2/LFO level controls, then introduced manually using the thumbwheel. Inputs: sweep, VCO2/LFO or sample and hold. Output to keyboard, VCO2/LFO or VCF.
Power Amp	Output 2 watt into 8 ohm nominal.
Sequencer Socket	Keyboard output voltage 0·35 volts per octave. Trigger output voltage 9 volts positive. Input requirements 0·35 volts per octave to keyboard, 9 volts positive trigger to envelope.

time later. In this way a pulse, shaped by R57, D6, R58, D7, is produced. Closing S7 adds this pulse into the VCA, giving an added percussive attack, and simulating a full ADSR envelope. While this is a bit of a cheat to keep costs down, one finds in practice that if one goes to the trouble of building an ADSR envelope shaper, most of the time it will be used to create precisely this sort of envelope, with only the sustain and release times being altered.

SAMPLE AND HOLD

The remaining f.e.t. op-amp from IC5 (pins 5, 6 and 7) is used to form a separate hold circuit. Each time the envelope shaper completes a cycle, the positive pulse from IC3c (pin 10) passes via D10, C13 and R68, and closes CMOS switch IC4d for a few milliseconds. In this way the selected waveform from VCO2/LFO is sampled and held on C14, buffered by IC5b.

The output from the Sample and Hold can be fed into the keyboard via the thumbwheel in order to produce "random" or "staircase" changes in VCO pitch depending on the frequency of VCO2/LFO relative to the sampling frequency. That is, a slow waveform from the LFO, sampled fairly quickly, will give a staircase effect. If VCO2/LFO frequency is considerably faster than the sampling time, then the changes in pitch will be apparently random. Alternatively with VCO1 off, and VCO2 running as an LFO, noise being fed into the VCF and the VCF tracking the Keyboard, similar effects can be achieved with filtered noise.

NEXT MONTH: VCOs, VCF, VCA, power amplifier and power supply.

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MPG METER

LIONEL TAYLOR

THE PE MPG Meter is an accurate method of measuring the instantaneous fuel consumption of a car. The unit has been designed to employ either:

1) A rev counter as a dual purpose instrument reading MPG or RPM as selected.

2) A custom designed l.e.d. bargraph instrument. Both systems can be easily constructed, installed and calibrated; they have been designed to be effective, inexpensive and accurate.

This system is suitable for virtually all vehicles except those with diesel or fuel injected engines which cannot be modified in order to fit a single flow meter.

The theory of an MPG meter is simple: a flow meter measures the fuel flow (GPH), a speed sensor measures the speed (MPH) a suitable circuit divides MPH by GPH and the answer is miles per gallon; *and that is what concerns most motorists who pay for their own petrol.*

PRACTICAL DESIGN

The practical application of the theory is rather more complex.

The fuel system of a car can produce severe fluctuations in flow rate which do not bear any relationship to the true fuel consumption at that instant.

The carburettor valve for example, is affected by vibration and movement of the car and can easily shut off the flow completely, regardless of the demand of the engine. At that moment your MPG would be infinitely high. Conversely, the needle valve will frequently open too wide, permitting a higher flow rate than the engine is demanding.

Things are further complicated by the inevitable presence of petrol vapour and/or air in the fuel line. When a bubble of gas reaches the carburettor needle valve, it passes through the orifice much faster than petrol and increases the instantaneous flow rate by a factor of perhaps 20 or more.

Add to these effects, flow pulsations due to the fuel pump (particularly the mechanical type most commonly used), pressure fluctuations, flow reversals, wide temperature and viscosity variations, high ambient temperature, a hostile electrical environment and the extent of the problem becomes apparent.

The flow sensor provided for the PE MPG meter has been specifically developed to cope with such adverse conditions and produce an accurate measurement of the true flow rate.

It is not enough, however, to measure the flow rate accurately; it must be presented to the driver in a readily readable form, *so for this purpose any sort of digital readout is useless.* Even under completely steady driving conditions the reading will fluctuate, and flickering digits cannot really be read while driving a car. Obviously the time constant could be increased to 4, 5 or more seconds to give a slightly steadier display but this would introduce a totally unacceptable delay between driver action and instrument reaction.

ANALOGUE

The only practical answer is an analogue display. The analogue presentation of both instruments (bargraph or rev counter version) has been chosen specifically so that it will:

1. Enable fuel consumption to be observed at a glance.
2. Show the direction of any change in consumption.
3. Show the rate of change.

There are two basic versions of this design; one of which uses the car's standard rev counter as a switchable RPM/MPG meter, the other uses a 20 l.e.d. bargraph display with a custom designed housing. This incidentally has a dual scale, reading in miles per litre as well as MPG.

Two additional options have been incorporated in the design, allowing the constructor to take the speed input from the ignition pulses. This saves the cost of the speed sensor, as well as the time to fit it, but means that the MPG indicated is true only when in top gear. In practice this is not a serious drawback. A speed sensor can of course be fitted at a later date if desired.

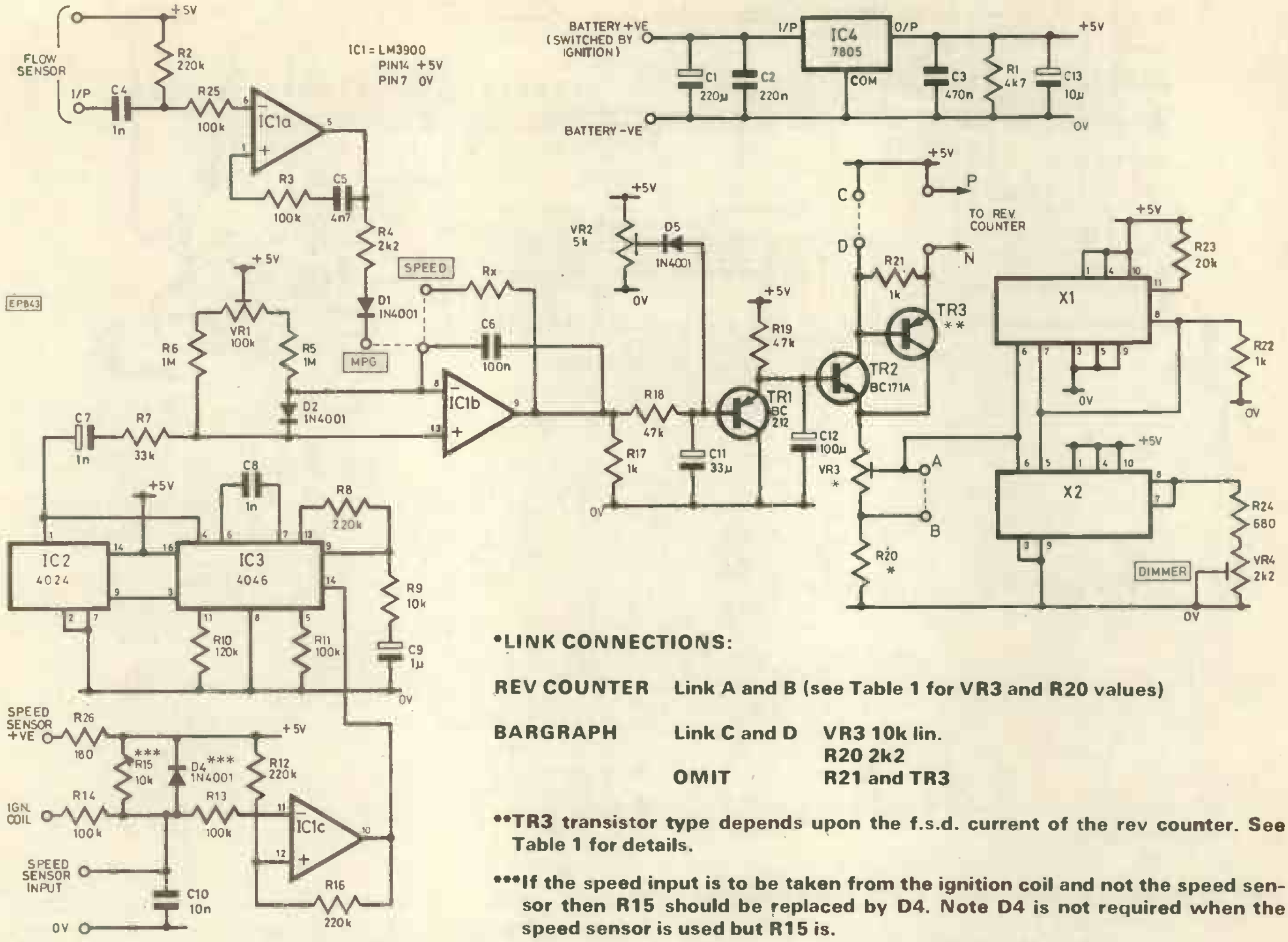
CIRCUIT

The basic circuit (Fig. 1) is a quad op. amp, LM 3900 in which the speed input generates a ramp which is reset to zero by every flow pulse. This requires that the speed pulses occur at a higher rate than the flow pulses.

To do this, and make it possible to use ignition pulses as the speed input, or to make use of a readily available speed sensor, a multiplying circuit consisting of a 4046 and 4024 has been incorporated. This multiplies the speed pulses by 8 and ensures that a suitable ratio is maintained for accurate operation.

The capacitor C7 sets the height of the ramp and since any variation in its value will directly affect the output, it should be a good quality polyester or polystyrene component.

The ramp output is fed to TR1 which acts as a peak detector. Capacitor C12 is charged through R19 and discharged through TR2 which is the final output to the bargraph. This arrangement is incorporated so that the final output is differentially controlled, ensuring that the reading drops at a faster rate than it rises. When a rev. counter is used as the



***LINK CONNECTIONS:**

REV COUNTER	**Link A and B (see Table 1 for VR3 and R20 values)**	
BARGRAPH	**Link C and D**	**VR3 10k lin.**
		R20 2k2
	OMIT	**R21 and TR3**

****TR3 transistor type depends upon the f.s.d. current of the rev counter. See Table 1 for details.**

*****If the speed input is to be taken from the ignition coil and not the speed sensor then R15 should be replaced by D4. Note D4 is not required when the speed sensor is used but R15 is.**

Fig. 1. Complete circuit diagram of the MPG Meter. Note: VR4 can be any suitable potentiometer mounted in the side of the case for dimming the display.

indicator, a third transistor (TR3) is incorporated to provide the necessary drive. (See Table 1.)

There are many occasions when, with the throttle closed, the car is doing 100 or even 200 MPG.

The instrument will naturally try to indicate this, and charge up the damping capacitors accordingly. When the throttle is then re-opened, there would be some delay while the capacitor discharges.

To minimise this delay, a preset, VR2 is incorporated which is set to limit the circuit output to a little over full scale deflection. This ensures that the meter rapidly adjusts to the correct reading, while at the same time giving the optimum damping of the needle or the bargraph display. Experience has shown that the response rate of this instrument is very much a matter of personal taste, therefore capacitor C12, which mainly decides the damping function, may be changed as desired.

CONSTRUCTION

This is straight forward, but normal care is needed in handling the two CMOS chips, 4024 and 4046.

The main p.c.b. contains all the options which are as follows.

1. Rev counter display (f.s.d. 1mA to 80mA). Speed input from ignition pulses.
2. Rev counter display. Speed input from speed sensor.
3. Bargraph display. Speed input from ignition pulses.
4. Bargraph display with speed sensor input.

It is suggested that the voltage regulator and a suitable heatsink are fitted first, followed by the wire links. Fit the two CMOS chips last, apart from the two display units.

These should be connected using 2 to 2½ inch lengths of thin flexible insulated wire so that the displays may be readily mounted on the stepped pegs moulded on the back of the front moulding. The red filter should be carefully cemented in place taking care not to smear the vital area. Check the displays for alignment with the slot, and secure with a suitable adhesive (instant glue is ideal), or carefully melt over the pegs with a soldering iron.

SETTING UP

1. Each flow sensor is allocated a number when it is calibrated, which is directly related to its K-factor (pulses per gallon). It is expressed as a resistance and is the value of Rx which should be built into the circuit. By this means, the circuit is calibrated for the particular flowmeter supplied. As a rough guide, a 4 per cent error in Rx will produce a 1 per cent error in calibration.

2. Set the SPEED/MPG link to "MPG". Connect a 12V supply and with no inputs, adjust VR1 so that the rev counter needle or bargraph display moves off zero and floats between zero and approximately full scale.

3. Connect a frequency source (if available) to the speed input. A simple generator as shown in Fig. 4 is quite adequate. Adjust VR3 to give more than f.s.d. then adjust VR2 to bring the needle or bargraph to exactly full scale. Then

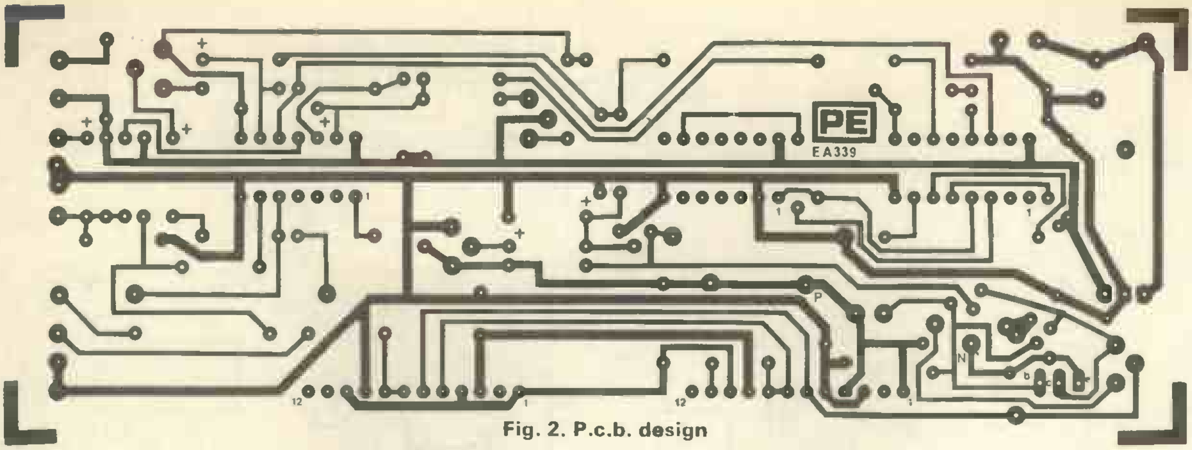


Fig. 2. P.c.b. design

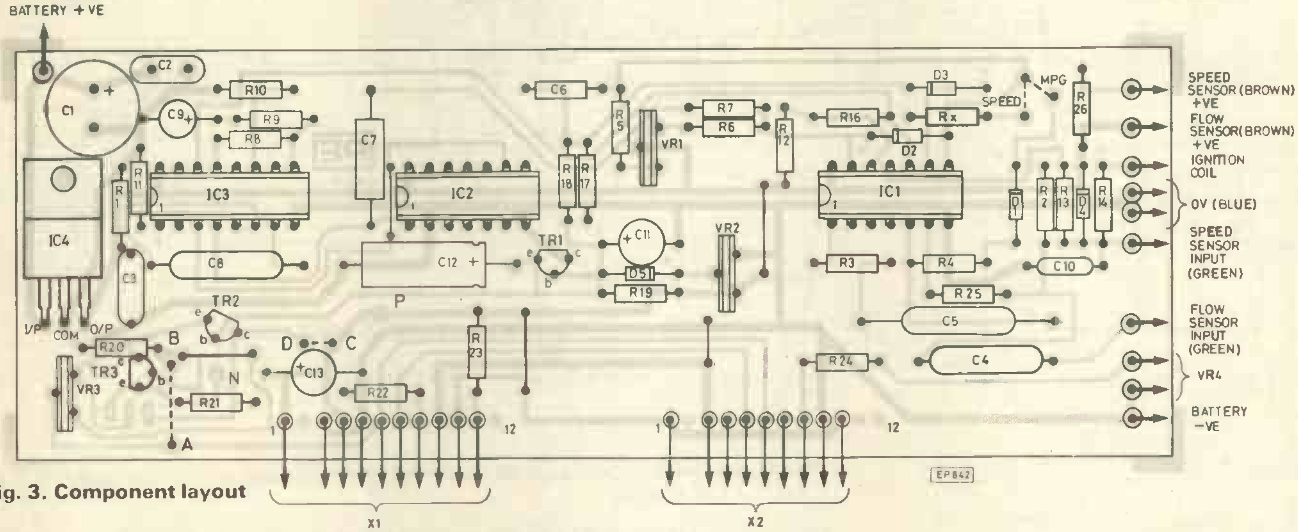


Fig. 3. Component layout

move it back so that it limits at about 10 per cent more than full scale. A voltmeter in parallel with the output would enable this to be done, with greater certainty.

CALIBRATION

The final calibration is done in the car WITH THE AID OF AN ASSISTANT.

Set the SPEED/MPG link to "SPEED", and drive the car at a steady 30 to 45 MPH. Your assistant should then adjust VR3 so that the rev-counter (switched of course to MPG) or bargraph display, reads the same speed as the car speedometer. Reset the SPEED/MPG link to "MPG" and the instrument is then calibrated. The circuit can then be finally fitted into its housing (in the case of the bargraph) or tucked away behind the dashboard in a thick polythene bag if the rev. counter is being used.

FITTING THE FLOW SENSOR

The flow sensor is fitted in the fuel pipeline between pump and carburettor and after the fuel filter, with the arrow pointing in the direction of flow. (See Fig. 5.) Ideally the flow sensor should be mounted with the arrow pointing upwards, but if it has to be horizontal, it is preferably fitted with the fuel passage above the detector housing.

The fuel line, which may be metal, plastic or rubber must be cut or parted to insert the flow sensor. In the case of a flexible hose it is simply necessary to slacken the hose clamp and fit the flow sensor with the aid of the flexible pipe and clamps supplied. With a metal pipe it is probably better to remove it from the engine before cutting it in order to avoid any swarf entering the carburettor. If no filter is present, it is

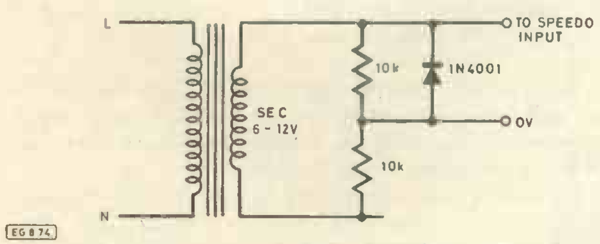


Fig. 4. Frequency generator

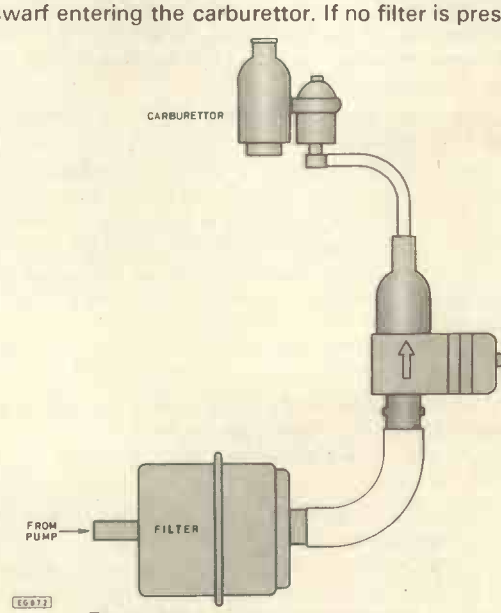


Fig. 5. Flow sensor connections

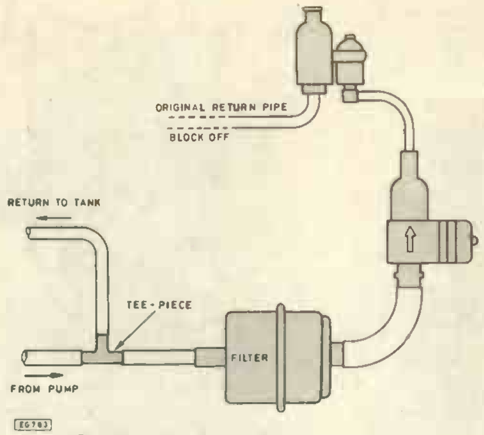


Fig. 6. Tee-piece connections

strongly recommended that a standard type of in-line paper element fuel filter be fitted, immediately ahead of the flow sensor.

If your car has a return flow to the tank from the carburettor this calls for a little modification using the special restricting T-piece supplied.

Fit the T-junction into the fuel line (Fig. 6) between the pump and flowmeter, making sure that the return to the tank is fitted to the leg of the tee, since this contains a restrictor to limit the return flow. Block off the original return outlet from the carburettor.

If a car already has a 'T' or 'Y' junction between pump and carburettor, the flow sensor must be fitted between that and the carburettor.

It is essential to check all fuel lines and joints for leaks immediately after the engine is first started and again after a few hours driving.

The possibility of fuel spillage will be lessened if the fuel tank is reasonably empty before the fuel line is disconnected or cut.

PLEASE NOTE: THE FLOW SENSOR CANNOT BE USED WITH FUEL INJECTION OR DIESEL SYSTEMS.

MODIFYING THE STANDARD REV COUNTER

Most rev. counters have movement sensitivity of between 6mA and 10mA. f.s.d. Some older instruments however, require about 80mA and some modern meters may require only 1 to 2mA.

To cope with such variations, the final adjustment preset, VR3, its series resistor R20, and the transistor TR3 should be selected as follows:

Meter f.s.d.	VR3	R20	TR3
1mA	2k2	470	BC212
2mA	1k	220	BC212
10mA	220	47	BC212
80mA	100	10	BD132

TABLE 1

Ideally the rev. counter should be removed from the car (after first disconnecting the battery). It should be dismantled with care to gain access to the instrument movement. The two thin leads (usually red and black) connected directly to the meter movement, should be de-soldered from the rev. counter circuit noting their polarity for reconnection later. They should then be carefully joined to a pair of suitably fine flexible leads, the joints insulated, and firmly fixed to some part of the meter casing or movement, to avoid tearing away the delicate wires in subsequent handling.

At this point the meter f.s.d. should be checked. Connect the movement in series with a milliammeter, a 5k or 25k pot. and a power supply (a $1\frac{1}{2}$ volt dry battery will do). Adjust the pot. to give full scale deflection on the rev. counter, and read off the current on the milliammeter. If a suitable potentiometer is not available, use a fixed resistor, say 10k and calculate the f.s.d. accordingly. E.g. if the rev. counter indicates $\frac{2}{3}$ f.s.d. and the current is 5mA, then the f.s.d. is 7·5mA. Please note, this figure is not critical, but merely a guide to the selection of VR3, R20 and TR3.

Now return to the rev. counter circuit and connect two flexible leads to the two output points, noted when meter

COMPONENTS . . .

Resistors

R1	4k7
R2, R8, R12, R16	220k (4 off)
R3, R11, R13, R14, R25	100k (5 off)
R4, R27	2k2 (2 off)
R5, R6	1M (2 off)
R7	33k
R9, R15	10k (2 off)
R10	120k
R17, R21, R22	1k (3 off)
R18, R19	47k (2 off)
R23	20k
R24	680
R26	180
R20	see text and Table 1
Rx	see flow sensor

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

Capacitors

C1	220μ 50V elect. p.c.b. type
C2	220n ceramic
C3	470n ceramic or nylon film
C4, C8	1n ceramic (2 off)
C5	4n7 polyester
C6	100n polyester
C7	1n polyester
C9	1·0μ 10V elect. p.c.b. type
C10	10n ceramic
C11	33μ 10V elect. p.c.b. type
C12	100μ 10V elect.
C13	10μ 10V elect. p.c.b. type

Potentiometers

VR1	100k lin. min. preset
VR2	5k lin. min. preset
VR3	see text and Table 1
VR4	2k2

Transistors and Diodes

D1 to D5	IN 4001 (5 off)
TR1	BC212
TR2	BC171A
*TR3	BC212 or BD132

Integrated circuits

IC1	LM3900
IC2	4024
IC3	4046
IC4	7805 5V reg.
Bargraph array X1, X2	NSM 3914 (2 off)

* See Table 1

Constructor's Note

The case, p.c.b., flow and speed transducers are available from **Moray Engineering Ltd., Quayside Road, Bitterne, Southampton.** Flow sensor, connecting kit and p.c.b. (£18.82). Speed sensor (£5.38). Housing for baragraph display (£3.75). (State scale req. 0-60 MPG or 0-80 MPG — rec. for 1500cc and under.) Total price £26.45 inc p&p.

The other components are available from **Watford Electronics, 33/35, Cardiff Road, Watford, Herts. (0923 40588).**
Approx. price £15.00.

movement was disconnected. These wires and the two from the meter movement should be about 12 to 18 inches long. The two from the meter movement are connected to the two centre contacts of a d.p.d.t. switch and the two from the rev. counter circuit to two of the outer contacts. The remaining two contacts are connected (observing correct polarity of course) to the two output points from the p.c.b. labelled 'P' and 'N' (positive and negative respectively).

In order to bring the four leads outside the rev. counter housing, it may be necessary to drill a small hole through which they can pass. Great care should be taken to prevent swarf contaminating the meter movement during this operation.

FITTING THE SPEED SENSOR

a) Disconnect the cable from the speedometer and withdraw the inner cable. Select a suitable position for the sensor, which may be just behind the dashboard, or just on the engine side of the bulkhead.

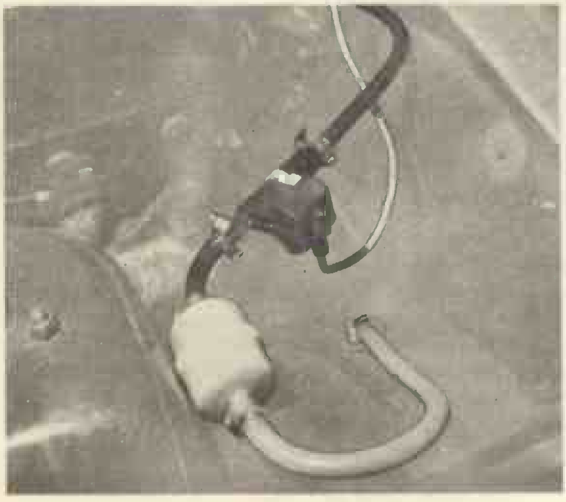
b) Cut through the outer sheath of the cable with a fine tooth hacksaw, at the selected position for the sensor.

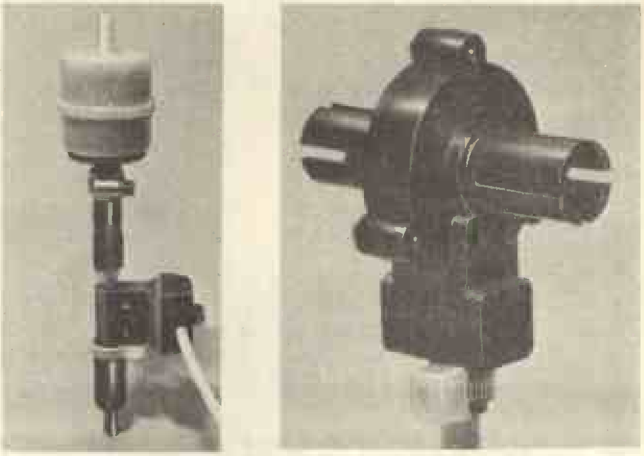
c) Make a second cut exactly $\frac{1}{2}$ inch in from one of the ends and discard that piece. Carefully remove any burrs from each cut end of the outer sheath and try to prevent any swarf entering the outer cable.

d) Slide a clamp over the speedo and gearbox ends of the outer cable then fit the end of the speed sensor with the screwheads towards the speedo. If the outer cable is very small in diameter, it should be built up with a few layers of PVC or similar tape. Push the outer cable fully into the speed sensor and lightly tighten the clamp.

e) Feed the inner cable through the centre flexible grip of the speed sensor and when a few inches have passed through, start inserting the inner cable into the gearbox portion of the sheath. Then slide the sensor over the outer sheath and keep feeding the inner cable through until it reaches the gearbox. At this point the inner cable will have to be rotated slightly in either direction to enable it to enter the cable drive housing. This will be obvious when it is no longer free to rotate.

f) Push it fully home and fully tighten the clamp on the lower (gearbox) side of the speed sensor. Now slide the top edge of the sensor about $\frac{1}{16}$" down (away from the speedometer). This should centralise the rotating disc in the centre of the speed sensor. Finally tighten the two clamps fully.





Flow sensor with filter and the speed sensor

g) Before refitting the cable to the speedometer, it is as well to drive, or move the car a short distance to check that the inner cable is rotating freely. Now connect the speed sensor cable to the p.c.b.

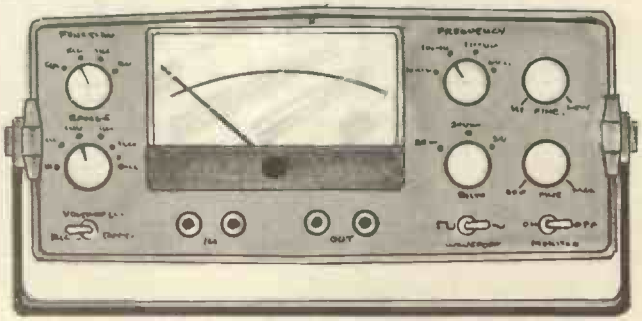
SPEED INPUT FROM IGNITION PULSES

Since 90 per cent of the distance travelled by the average motorist is in top gear, the use of ignition pulses as the speed input is not a serious disadvantage.

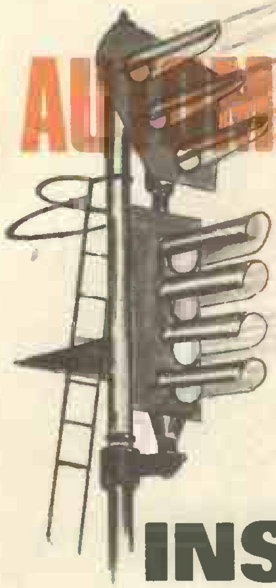
All that is required is to connect the point marked IGN. on the p.c. board to the contact breaker terminal on the coil. THIS IS SUITABLE FOR NEGATIVE EARTH SYSTEMS ONLY. Although the current carried is negligible, a physically tough grade of cable should be used, to withstand the temperature and possibility of damage against hot metal or sharp edges in the engine compartment. ★

next month...

AUDIO TEST SET



Frequency meter, peak and r.m.s. voltmeter, sine and square wave generator and a monitor amplifier all neatly housed in one unit. Designed specifically for testing and setting up a wide range of audio equipment this accurate, easily constructed instrument should meet many needs.



AUTOMATIC SIGNAL SWITCHING

AUTOMATIC DIAMOND CROSSING CONTROL

Two designs to assist with the automation of model railway layouts.

INSTRUMENT TUNER

Covering five octaves this device will produce any desired note for tuning comparison. It's simple to build and accurate.

Plus . . . ACTIVE SPEAKER SYSTEM

PRACTICAL

ELECTRONICS

JULY ISSUE ON SALE FRIDAY, JUNE 11th

AUTO FLASH SLAVE

R.A.Penfold

AUTOMATIC flashguns are more convenient than manual types for most types of photography, and this has made them deservedly popular. They have a built-in light sensor which measures the light coming back off the subject, and when the correct amount of light for the film speed/aperture combinations indicated on the exposure calculator has been received the flash is terminated.

One weakness of this system is that results can be a little unpredictable if more than one flashgun is used, which makes the use of automatic flash rather pointless. The problem is simply due to the fact that the sensors on the guns will respond to the light from both guns, rather than each sensor only responding to light from its own gun. In an extreme case with one flash mounted on each side of the camera and the two guns roughly aimed towards each other, it is possible that the sensor on one gun will directly receive light from the other gun. This results in the flashgun giving its minimum flash duration and consequently probably having no significant effect whatever.

As the use of a single flashgun is apt to produce rather harsh shadows and is considerably less than ideal for many types of photography it was decided to investigate the possibility of dual automatic flash using a system which would prevent any interaction between the exposure control systems of the two flashguns. The obvious way of achieving this is to have the flashguns triggered at different times so that there is no overlap of the two light pulses, and a simple way of doing this is to fire one flashgun from the camera and the other from a flash slave unit that triggers as the light from the main flashgun decays. A normal flash slave triggers at the beginning of the light pulse from the main flashgun, and the two flashes therefore largely overlap as a flash slave operates very rapidly.

In practice a flash slave which triggers as the light pulse from the main flashgun ceases seems to give perfect reliability and no interaction whatever between the exposure control systems of the two guns. The simple flash slave unit described here can be used in this mode, or it can be used as a conventional slave unit. It has good sensitivity and is not easily saturated by high ambient light levels.

THE CIRCUIT

In Fig. 1 S1 is the mode switch and it has three positions: "Off", "Auto", and "Normal". In the "Off" position of S1 power is removed from the circuit by S1d. In the "Auto" position S1a to S1c effectively connect photo-transistor TR1 in the common emitter mode with R1 as its collector load and C2 taking the output from TR1's collector. The base terminal of TR1 is left unconnected, and it is the change in collector to emitter impedance caused by changes in the light level received by TR1 that are of importance here. The higher the light level, the lower the collector to emitter impedance of TR1.

The output of TR1 goes negative at the beginning of the light pulse, producing a positive going output from TR2 which is used as a simple common emitter amplifier. TR3 is also used as a common emitter amplifier and this drives the gate of CSR1 via current limiting resistor R8. TR3 is normally biased below the threshold of conduction by R6 and R7 so that CSR1 is not triggered, and the positive pulse from TR2 via C3 simply reduces the bias on TR3.

As the light pulse decays, TR1 produces a positive going output which undergoes a phase inversion through TR2 to give a negative signal to the base of TR3. This switches on TR3 which in turn triggers CSR1 and fires the flashgun.

With S1 switched to the "Normal" mode TR1 is effectively connected as an emitter follower with R2 as its emitter load. It therefore produces a positive output pulse on the rising edge of the light pulse, giving a negative pulse from TR2 so that TR3 is switched on and the flashgun is fired by CSR1.

The current consumption of the circuit is only a little in excess of 1ma. and a PP3 size 9 volt battery is an adequate power source.

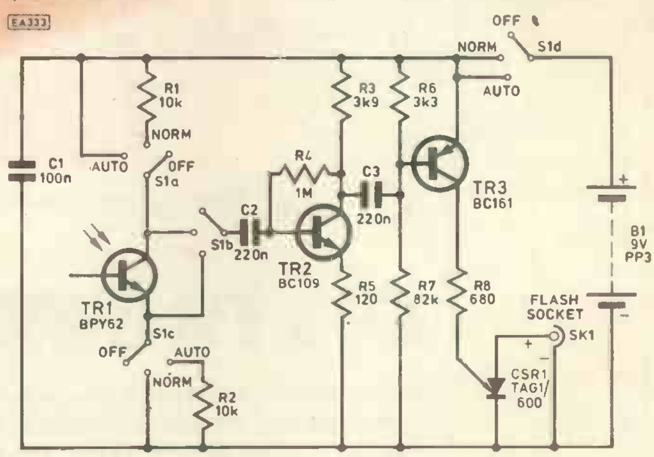


Fig. 1. Circuit of slave

CONSTRUCTION

A suitable case for this project is a plastic box having an aluminium front panel and outside dimensions of 85 x 56 x 35mm. Here the printed circuit board slots into guide rails moulded into the case.

The component layout and copper track for the printed circuit board are shown in Fig. 2. The completed board is fitted vertically in the case using the second set of guide rails from the left. The component side of the board faces towards the left of the unit, and a hole is drilled in the side of the case adjacent to TR1 so that light can pass through. This can be fitted with a grommet to give a neater finish.

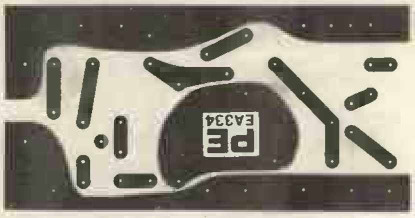


Fig. 2(a). P.c.b. etching detail

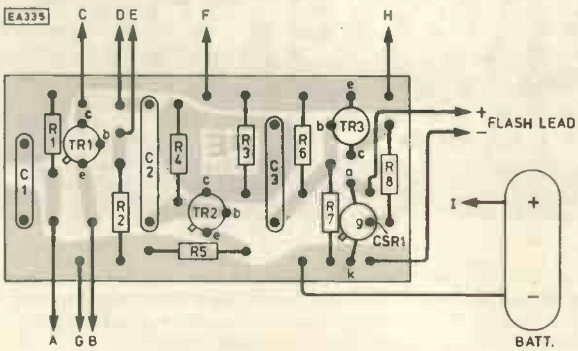


Fig. 2(b) Assembly details

The leads to S1 cannot be taken from the component side of the board and over or under the board as there is insufficient space and it would not be possible to fit the front panel in place properly. The same is true of the negative battery lead and the flash lead. Pins should therefore be used at the appropriate points on the printed circuit board so that the off-board components can be easily connected to the underside of the board.

S1 is mounted at the centre of the front panel and Fig. 3 shows the wiring to this component. It is possible to obtain flash sockets from some photographic accessory stockists, but flash extension leads are more readily available and can easily be used to make the connection to the flashgun. Cut off the unwanted plug, thread the lead through a hole drilled in the top of the case, and connect the lead to the printed circuit board with the correct polarity. A multimeter to a high d.c. voltage range (250 volts f.s.d. or more) can be used to check the polarity of the lead, or the correct method of connection can be found empirically.

IN USE

The BPY62 transistor has a built-in lens which makes the unit quite directional. Normally when the unit is used indoors this will not be of any significance, and it should operate reliably when aimed in any direction. When used out-of-doors there are no walls and ceiling to reflect light from the primary flashgun top TR1 and the aim of the unit becomes more critical. Reliable operation should be obtained with the unit aimed at either the main flashgun or the subject, and a range of about 10 metres or more should be possible even using light reflected from the subject. However, the exact range obtained obviously depends on the power of the primary flashgun and the reflectivity of the subject. If possible it is always advisable to do a test firing to ascertain that the flash is triggering properly.

A simple way of giving the "Auto" mode a quick check is to first set up the secondary flashgun so that almost the full flash duration is produced and the gun takes a few seconds to recycle if triggered manually. The same result should be obtained if the flashgun is triggered by way of the flash slave in the auto mode with the main flashgun aimed at the light

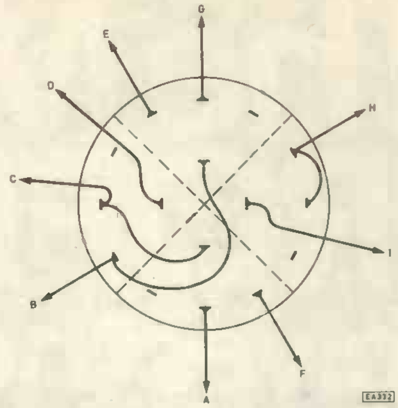


Fig. 3. Wiring details of S1, the panel mounted switch, to the board shown in Fig. 2

sensor of the secondary gun. Switching the flash slave to the "Manual" mode will almost certainly result in the secondary flashgun producing a very brief flash and recycling almost immediately if it is triggered in this way.

If the sensor of the flash slave receives very strong light from the gun it controls it is possible that multiple triggering of the flash will occur. This can only occur with flashguns which have thyristor power saving circuitry, and is unlikely to happen in a practical setup. The flashgun will only fire once while the camera's shutter is open, and so this is of no practical importance anyway.

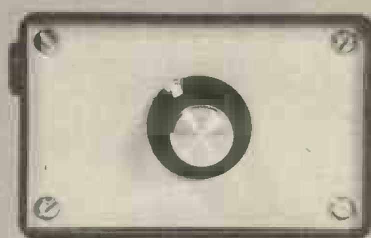
When photographing a fast moving subject it is possible that the use of the unit in the "Auto" mode might give less sharp results than using simultaneous triggering of the flashguns, although this could only make a marginal difference and it is not something that will not normally be of any consequence. When using powerful flashguns that have a long maximum flash duration it should be borne in mind that using the slave unit in the "auto" mode effectively doubles the flash duration, and may reduce the fastest shutter speed that can be used, but this is not something that applies to normal amateur flash and camera equipment. It only applies to professional flash equipment and cameras having leaf shutters. ★

COMPONENTS . . .

Resistors

R1–2	10k
R3	3k9
R4	1M
R5	120
R6	3k3
R7	82k
R8	680

All $\frac{1}{2}$W 10% carbon



Capacitors

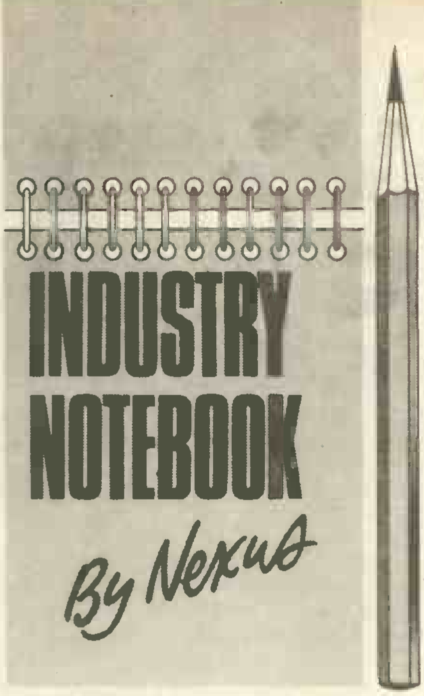
C1	100n polyester
C2–3	220n polyester

Semiconductors

TR1	BPY62/111 (Electrovalue)
TR2	BC109
TR3	BC161
CSR1	TAG1/600 (M.E.S.)

Miscellaneous

B1 PP3 9V; S1 3 way 4 pole rotary; SK1 Flash socket or extension lead (see text); PP3 connector; Printed circuit board; Case 85 × 56 × 35mm (Maplin-type M4003); Control knob; Wire, solder, pins, etc.



Confidence

In the few weeks since the budget it has become clear that industrial morale has improved. Not that the event itself induced unduly high spirits. There was the ritual procession of supplicants before the budget, each holding his begging bowl. The CBI, the TUC, charities, various pressure groups, plus possible, but largely unrealistic, alternative economic strategies submitted for consideration by the opposition parties.

Predictably nobody got what they asked for but the bias, however modest, in favour of industry managed to inspire confidence that the worst was over provided there was no rocking of the industrial boat. Unhappily there is little that can be done to counter external storms, the unforseen upheavals such as OPEC quadrupling the price of oil which started the world recession, or the revolution in Iran which lost industry some very large contracts. More recently who would have imagined an oil glut so large as to force prices down, or that gold would be half the price it was only a year ago? Or that Poland and Romania would be bankrupt, threatening default on payment of interest due?

The Chancellor has remained prudently cautious. The 'dash for growth', an exercise once favoured as a vote winner near election time, is now discredited. Short-term gain, experience tells us, results in long-term loss. Slower but consistent growth is more sensible and as long as we can further improve our competitive position in world trade and minimise self-inflicted wounds at home there is every reason for hope, if not certainly, that the way forward is up.

DBS

The TV industry seems to need periodical shots-in-the-arm to maintain momentum. In the past the big boom events were the expansion of London and Birmingham-based transmission into a nationwide network, the switch from 405 to 625 lines, the introduction of colour and, on the programme side, ITV and increases in programme channels.

The next, and welcome, shot is DBS (Direct Broadcasting by Satellite) and the go-ahead for a British system is good news for both the consumer and capital goods sectors of the industry. The latter will benefit first because the space component will need to be in orbit before the consumer can receive anything.

As the Home Secretary was announcing his approval of DBS, industry also stated that a consortium was being planned for engineering and operating the system. Members are British Aerospace, GEC-Marconi and British Telecom.

Marconi's Satellite Division has been enjoying a flurry of activity. It is their communications package which is flying on the Marecs A satellite platform (built by British Aerospace) over the Atlantic Ocean providing ship-to-shore communications for the International Maritime Satellite Organisation (INMARSAT). A similar Marconi package has gone into Marecs B which, as we go to press, should be taking up an orbital station over the Pacific Ocean.

In addition Marconi has just won the contract for the business communications package on the European Space Agency's L-SAT programme and to give some idea of the magnitude of business in space technology this contract alone could ultimately be worth £20 million. And now Marconi is to be aboard DBS. As a result the company is urgently planning to double the staff in Satellite Division over the next two years.

At ground level the individual receivers will each need small dish aerials, frequency converters, decoders, all generating new business. An alternative is a group receiving station serving, for example, a housing estate with signal distribution by cable. Existing TV cable companies will naturally be in on the act with Rediffusion as one of the leaders likely to benefit. In fact the 'wired city' is one step nearer and the Government, by encouraging such new developments, is helping to keep Britain in the front rank of space-age electronics.

Meantime earth-bound business continues. Companies like Crow of Reading Ltd are quietly toiling away supplying professional broadcast-equipment. They recently supplied the switching system for Kenextel, the Kenya earth station which is Africa's major gateway into the Intelsat network. This contract was worth £750,000 and Crow have just had a follow-on order from Kenya worth £100,000 for TV equipment to be used in the Kenya Education Media Service. Recent Marconi orders included £2 million worth of TV transmitters to be installed in Ondo State, Southern Nigeria.

Anniversaries

Now that the electronics industry has reached maturity we can expect a spate of anniversary celebrations. Sixty years of regular broadcasting is one example. It was in 1922 that Captain P. P. Eckersley of Marconi started his weekly half-hour programmes from the company experimental station at Writtle, Essex. Eckersley wrote, produced, presented and performed in the programmes and later became the first chief engineer of the BBC.

Fifty years ago a component company was set up in a disused chicken run. Its then young proprietor called it Advance Components. During the war the company started making instruments and after the war changed its name to Advance Electronics and became a publicly quoted company. In 1974 it was acquired by the US company Gould Inc and is now known as Gould Instruments Division. Many of the Advance old-timers are still with the company and you can bet they continue to think of it by that name. Old habits die hard.

Change, however, is endemic in the industry. Here from memory are some radio receiver brand names famous 30 or 40 years ago. Alba, Bush, Columbia, Cossor, Decca, Dynatron, Ekco, Ferguson, HMV, Marconiphone, Mullard, Murphy, Philco, Philips, Pilot, Pye, RGD, Roberts, Sobell, Zenith. Most are long since dead. Of the survivors only one or two are still with the original owners.

Robots

I read that at the Massachusetts Institute of Technology 1982 is the Year of the Robot and where a new concentration of top brains, both academic and industrial, is expected to provide the impetus for a quantum jump in the technology.

And from a Tokyo source I read that the Japanese are having second thoughts on steel-collar workers. Once welcomed for the relief they gave from dangerous, dirty or boring repetitive work, they have now become so sophisticated that they are a threat to skilled workers, now fearful for the safety of their jobs. Japan is said to employ 100,000 robots with a robot population explosion adding some 24,000 a year. No wonder the Japanese unions are getting edgy (robots don't pay union dues) and the government is apprehensive that for the first time they may have to face an unemployment problem.

CADMAT

The Department of Industry has launched a £9 million support programme to promote the use of CADMAT (Computer Aided Design Manufacture And Test) in the electronics industry. This programme is additional to the CADCAM (Computer Aided Design-Computer Aided Manufacture) programme which is for mechanical design in engineering. Electronics CADMAT is to be promoted through the IEE and the Electronic Engineering Association (EEA) the latter dealing directly with industry.

Awareness programmes, seminars, courses and demonstrations are being organised to get the techniques and their advantages more widely known. The advanced technology companies are already using CADMAT. Smiths Industries, for example, who have just won the first production contract (worth £800,000) for the supply of head-up display units for the U.S. Marine Corps AV-8B Harrier jump-jets.

CADMAT is claimed to increase designer productivity by a factor of five and to reduce design time by up to 50 per cent.

Readout...

At long last, Bazaar

Sir—With reference to your new feature 'BAZAAR', this fills a long felt want, for me at least. At 74, with an interest in things electronic going back nearly 60 years, you can imagine I have accumulated a large quantity of components, books, etc., which I hesitate to put into the dustbin.

One of the fascinations of the hobby is—like Meccano—being able to dismantle and rebuild with the same basic components in a different arrangement. When it came to disposing of old magazines, I spent several days sorting out the ones I may need for reference. You will be pleased to know, I'm sure, that the pile of 'Practical Electronics' in this category was so large in comparison to the throwaways that I decided to keep the lot.

Regarding the coupon provided for the Bazaar feature, I think you should try to print this on a page backed by non-technical material. We don't all have access to a photocopier: especially those of us who have now retired from our previous occupations. For example, I have no immediate interest in your series on Robots, but you never know, in the future I could have.

Anyway, thank you for a most interesting and useful magazine which has given much pleasure over the years, and not a little frustration when something didn't work first time—usually my own fault!

A. D. Jones,
Ross-on-Wye.

Thanks for your letter, we don't need a photostat of the Bazaar coupon—just copy out the essential bits on a sheet of paper and send it in with a cut off corner. Perhaps a PE Robot could save your legs when you get older?—Ed.

Better than BR

Sir—In PE April 1982 in the Industry Notebook, it is stated that "one single-track line in the north of Scotland" is the only part of the system to have a radio link on moving trains in the UK.

I was on the first train going north from Dublin after the January 1982 snowstorm had closed road and rail traffic down for two days. Not only did Northern Ireland Railways hold two trains for several hours so that passengers going north and west from Belfast could make their connections, but the conductors on these trains used their train-to-station radios to ensure that taxis were waiting at every station for those passengers who required them, even though it was between one and two a.m.

Perhaps we do enjoy the best combination of technology and courtesy in our railway, and this is in a much maligned part of the UK.

However, having enjoyed in the USA many years of *itemised* phone-bills and unlimited local calls for $7.80 per month, I can find nothing to recommend BT or System X—if it ever arrives!

G. T. Best,
Portstewart,
Co. Londonderry.

Keeping Stocks

Sir—In response to Dr. N. J. D. Jacobs' letter in which he expressed his frustration at not being able to obtain certain devices described in "Semiconductor Update", I would like to offer some help to him and other readers in the same situation.

The AD7581 8 channel A to D chip which he quoted as an example, along with many other relatively new I.C.s, is available from many hobby shops who buy from large distributors who themselves buy direct from the I.C. manufacturers.

Farnell Components, for example, have stocked the AD7581 since Autumn 1981 and they deal with many electronics hobby shops in addition to selling to industry.

It may of course be that Dr. Jacobs' local hobby shop was not aware of this source of supply, although the manufacturer should be able to assist the shop with this information, in which case a different or larger shop could have helped.

R. C. Muriel,
Analog Devices Ltd.

BAZAAR

UK101 cased, programmable sound generator, 3D/A converters £200. Transcendent 2000 synthesizer, computer interface, excellent condition £180. D. Mortimore, Edgware. Tel: Middx 01-958 4885.

I WANT any ZX81 hardware (circuit diagrams) especially I/O port sound boards, etc. I may send payment if poss. Andres Howley, 16 Chesham Ave., Castleton, Rochdale, Lancs.

WANTED ultrasonic transducer 25 kHz or 40 kHz, digital frequency meter also books on ultrasonics. Mr. A. Bouskill, 129 Lyminster Road, Sheffield, S. Yorks. Tel: 0742 311191 after 4 pm.

PRINTER and keyboard, Creed 7B, paper, new motor, partially completed interface and software for UK101 £25 o.n.o. Chris Swift, Crowthorne. Tel: 03446 77426.

ZX81 16K RAM (Sinclair built) manual power supply, etc. and five books, £105. Kevin Davies, 14 Twickenham Gdns, Greenford, Middx. Tel: 01-902 2166 after 4 pm.

OSCILLOSCOPE wanted, broken condition type telequipment dual trace. State bottom price (DS2). Mr. David Neely, 19 Clanbrassil Drive, Portadown, Co. Armagh, N. Ireland.

AKAI stereo receiver AA-8080 35W+ 35W r.m.s. price £35. Tel: 01-573 8921.

EROS electric guitar, immaculate, black with accessories including strap lead tutor book £70. Tel: 03954 5679.

3BP1 CRT (Unused) plus base and mu metal screen. Also assorted components £15 to clear. A. C. Fieldsend, 61 Troydale Lane, Pudsey, Leeds.

ELECTRIC organ, Baldwin single manual, mike, head.ph., 13 note rhythm 37 note solo vibrato drums full orchestra £250. Mr. C. Mason, 225 Pype Hayes Road, Erdington, Birmingham B24 OLP.

SELMER 60 note keyboard in heavy teak case with legs. No electronics. £12 plus carriage. Tel: Brighton 0273 737076.

BARGAIN stirling sound the Mark II crosshatch generator. Used several times. Offers invited. Mr. L. Kozlowski, 38 Moreland Ave., Hereford. Tel: 0432 4553.

WANTED secondhand VHS video recorder, preferably Ferguson 3292. Should be in good working condition. Joseph Echefy, 52 Sandyvale Lawn, Headford Road, Salway, Rep. of Ireland.

UK101 24K RAM, 32 x 48 screen, cased, joystick, cegmon, Wemon monitors, software including invaders, startrek, etc. £170. David Rose, 104 Longfellow Road, Straits, Dudley, West Midlands. Tel: Sedgley 74804.

WANTED AVO type EM272. Tel: 01-451 3093.

PRACTICAL Electronics March 66 April 73. Practical Wireless November 65–April 73 and December 76–September 78 £20. Buyer collects 190 issues. D. P. Quinn, 37 Sandford Green, Banbury, Oxon. Tel: 0295 53813.

PE microprocessor evaluation system as described in May 1979 £30. With port I/O. Tel: Bolton 382796.

EXCHANGE my set of 20 encyclopedias for a functional suitable computer system. Mr. A. Jenkins, 55 Ash Grove, Craigshill, Livingston, W. Lothian.

ET–3200 Heathkit digital design experimentor; EE–3201 Ring Binders on Digital Techniques; suit electronics student £75 o.n.o. Mr. H. Pye, 3 Thornfield Crescent, Worsley, Manchester M28 6RF.

0·2" l.e.d. green 11p each. Mr. C. Lau, 10 Peebles Close, Lindley, Huddersfield.

SWAP Acorn Atom 12K RAM 8K BASIC books and software for good class 3 head cassette deck. Stephen Sparkes, 4 Fanshawe Ave., Barking, Essex.

FOR sale, MES 53 organ with MES 55 auto rhythm 49 note keyboards, any offers. J. M. Robbins, 73 Berwick Road, Rainham, Essex. Tel: Rainham 55259.

30, MULLARD ZM1171 nixie tubes, brand new. Very short pins (pluggable), £7.50 the lot. Mr. R. M. King, Malgre' Tout, Ruette des Corneilles, Cobo, Guernsey, C.I.

18W soldering iron £5. For Compukit—PE I/O board £22, Sound Board £10. Tel: 0742 745027.

24GHz rank precision slotted line SWR meter including dial gauge, boxed instruction, £92. Wanted. Tel: Eddystone 880.

ITT 2020 48K, palsoft, colour paddes manuals £350. Two apple disk drives, with controller £180 each. G. Mason, 67 Feeches Road, Prittlewell, Southend-on-Sea, Essex.

TINS transistors, resistors, capacitors, plugs, sockets, portable aerials, bank switches, many grommets, £35. Will separate. J. Williams, 5 Fern Road, St. Leonards, E. Sussex.

VIDEO tapes Umatic type, VCA60 new. Three for £21. Tel: Fleet 02514 28895.

UNWANTED stereo cassette module G/W electronics new. Unused for £9. 32 Common Approach, Benfleet, Essex.

HAVE 23 obsolete radio valves 1930s. Used but workers. £10 the lot. H. Lawrence, Greenacre Somersham, Nr. Ipswich, Suffolk.

PHILIPS stereo generator PM6456. Separate L and R signals carrier frequency 100MHz ±1% RF o/p 3mV pk–pk little used, bargain at £200. Mr. E. O. Rice, 68 Vernon Drive, Stanmore, Middx.

SPECIAL SUPPLEMENT

Sound Synthesis

A.R. BRADFORD

THIS is an introduction to sound synthesis and synthesisers for beginners and presents the basics necessary to quickly understand and use synthesisers.

THE CASE FOR AND AGAINST SYNTHESISERS

In the two creative areas of synthesis, namely music and sound effects, synthesisers are often used to provide imitations of things not readily to hand. For example if you require a tape of a "seascape", live in Birmingham, don't have the right BBC sound effects record and are in a hurry, then it is very easy to knock up quite convincing surf and seagull sounds on a synthesiser. Other examples that come to mind are aeroplanes, motorbikes, horns, sirens, bells, dawn choruses, crickets and various other animals, wind, rain, running water, explosions, etc. On the other hand, while it is quite possible to synthesise the sound of two dustbin lids being banged together, unless you are a synthesiser freak with lots of equipment, the time involved and complexity of the task may make it a rather pointless exercise especially when it is easier, cheaper and probably more fun to get two dustbin lids and simply bang them together!

On the musical front, synthesisers can frequently produce close copies of conventional instruments, and it is this latter facility that polarises peoples' attitudes to them quite markedly. There are those, generally non-musicians, who think it marvellous to play a keyboard and have it sound like a clarinet rather than sweat for several years over a real clarinet. Then there are those, generally musicians, who feel that synthesisers shouldn't be allowed, because they can become a ticket for persons lacking any real ability to cheat their way into the domain of real musicians. Arguments rage interminably but I do not wish to dwell overmuch on this, except to say that as with any creative activity the question should not concern whether synthesisers are being used, but rather *how* they are used.

Even accomplished musicians are often grateful for the imitative capacity of synthesisers when they wish to add a particular instrument's sound to a piece of music, but have neither the instrument to hand or anyone to play it. For example, have you tried getting your hands on a fairground engine? In live work, many bands use synthsisers to provide a wide variety of voices where it would be impractical to actually use all the appropriate instruments.

This aside, the real potential of synthsisers lies not in their capacity to sound like conventional instruments, but in creating unique voices that cannot be achieved by conventional means, which can then be used to complement the more traditional instruments. Many fine examples of this have been produced in recent years.

MONOPHONIC KEYBOARDS

Before we get down to the nitty-gritty, one popular misconception about synthesisers must be cleared up. This is that just because they tend to have keyboards and look like pianos or organs, they should be expected to operate like pianos or organs in that more than one note may be played at a time. They do not. Most synthesisers costing up to several hundred pounds are monophonic, that is only one key may be pressed at a time. In this respect they are more akin to wind instruments, and the keyboard is there merely as a convenience to operating them. In general if more than one key is pressed then either the highest, or the most recent, note selected will sound.

FROM MECHANICS TO ELECTRONICS

All sounds are of course vibrations carried in the air, and all vibrations originate in an oscillator of some sort. In conventional instruments, the oscillators are vibrating strings, reeds or diaphragms which are variously excited by bowing, plucking, hitting or having air blown over them. The vibrations are amplified and transferred to the air by the body of the instrument, witness old fashioned needle and horn gramophones. In this respect the instrument body acts as a mechanical transformer, converting the small, high energy vibrations of the oscillator into large, low energy vibrations of the surrounding air. The size, shape and mechanical properties of the body of the instrument also has a dramatic effect on the character of the sound. Metal or wooden tubes or boxes act as mechanical filters, removing certain harmonics and emphasising others. The way in which the oscillator is excited (blowing, hitting, plucking, bowing, etc.) also determines the sound character. These processes are all entirely mechanical.

In the middle ground we have the electric instruments, most notably the electric guitar. Here although the oscillators are still vibrating strings, very little mechanical sound is produced, the vibrations being detected by coils, amplified electronically and reproduced through loudspeakers. The analogy here is that of a modern record player, which electronically amplifies the vibrations of a stylus, but the sound originates in the record grooves and not in the electronics. Having said that, just as a record player has tone controls, the electronics used to amplify electric guitars generally permits the character of the sound to be changed. Often a whole array of electronics is employed to change the sound quality dramatically, the best known being the use of an overdrive or fuzz unit to generate new harmonics, followed by various electronic filters to modify the resulting harmonic spectrum, such as waa-waa pedals, flangers, and the like. Here we are getting into the realms of sound synthesisers: since the body of the instrument is solid to avoid damping the vibrations of the strings (that is, to give good sustain) and so contributes virtually nothing to the sound character, most of what is heard is arguably due to the electronics. The strings remain as a means of selecting groups of notes, bending the pitch, introducing vibrato, and so on. Whether the strings are plucked or bowed (as in electric violins) still affects the sound character.

Purely electronic instruments go the whole way and replace the mechanical oscillators as well. The oscillators are now electronic circuits generating fluctuating (a.c.) voltages. The resulting waveforms may be similar, but unlike their mechanical counterparts they oscillate continuously as long as the power is switched on.

VOLTAGE CONTROLLED OSCILLATORS

The oscillators used in synthesisers generate five basic waveforms (Fig. 1 a-e) at a frequency (pitch) set by the d.c. voltage applied to their voltage control inputs. With mechanical oscillators, the waveform is a picture or graph of how the string or diaphragm moves with respect to time, while the waveform from electronic oscillators is a picture of how the output voltage changes with time, and the shape is inherent in the design of the circuit. These pictures are all very well, but what do they sound like? The first one, the sinusoid, is a pure tone, that is, only one frequency is present and no harmonics. It sounds very bland or flat, and is also rather irritating to listen to on its own. The other waveforms all sound different (and more interesting) but to understand why we must digress and examine what we mean by the harmonic structure of a sound.

HARMONIC SPECTRA

Imagine that we have the sine wave of Fig. 1a, and we add another, smaller sine wave to it at three times the frequency (Fig. 2a). Quite a different waveform is produced. Now let us add another sine wave, smaller still, to the resulting waveform at five times the frequency of the first sine wave (Fig 2b). Already the resultant waveform is beginning to look more like the square wave of Fig. 1d. In fact this process need only be continued a little further to produce a very good square wave.

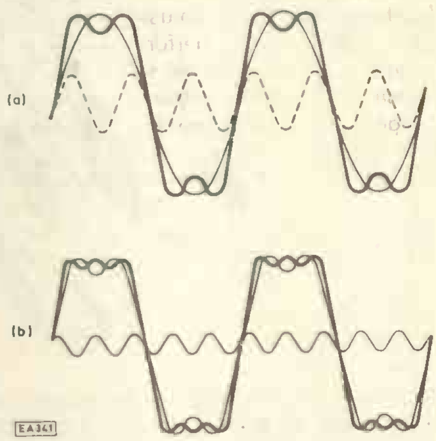


Fig. 2 Showing how the progressive compounding of the constituent sine waves go to make a square wave
(a) Sine wave with a reduced amplitude component at three times fundamental
(b) Sine wave with a reduced amplitude component at five times fundamental

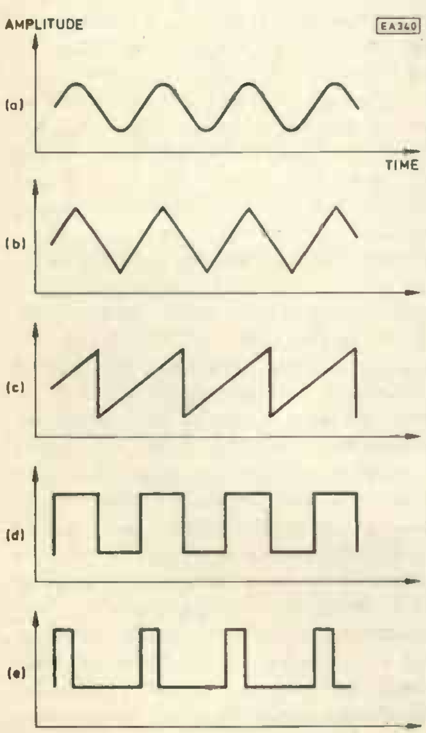


Fig. 1 Showing the five oscillator waveforms

(a) Sine

(b) Triangle

(c) Ramp

(d) Square

(e) Pulse

Now then, if adding lots of pure tones together in this manner can create a square wave, then it follows that a square wave sounds like a mixture of pure tones. In fact it consists of a pure tone called the fundamental which is at the same frequency as the square wave, plus another one third as big at three times this frequency, another pure tone one fifth the size of the fundamental at five times the frequency and so on. This can be represented graphically as in Fig. 3, where each sine wave is represented by a vertical line. The hortizontal position of each line denotes its frequency while the heights denote the relative contributions to the overall sound. A diagram of this sort is called a frequency spectrum, and gives a visual representation of what a particular waveform sounds like. Now we can go back and look at our oscillator waveforms. Fig. 4a-e shows the waveforms and their spectra.

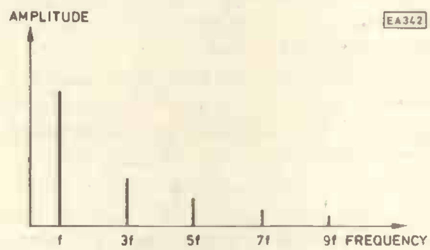


Fig. 3 Frequency spectrum for a square wave

The sine wave as we have said, sounds pure (because it is) and bland. The square wave contains odd harmonics which are odd whole-number multiples of the fundamental frequency, and has a rich, fruity sound. The triangle also contains odd harmonics but a much smaller proportion so it sounds more like a pure sine wave, but warmer. The ramp, or sawtooth, contains both odd and even harmonics and so is an even richer sound than the square wave, but one that is harsh and rasping. The rectangular waveform has a greater proportion of higher frequency harmonics. It is also a rasping sort of sound but rather thinner than that of the sawtooth.

Now we can compare these with some typical spectra of conventional instruments, whose sound we are familiar with (Fig. 5a-c). Notice that the waveforms give little clue as to the character of the sound, but analysis of their frequency spectra reveals the harmonic structure which underlies these widely differing sounds. Bear in mind that these are spectra of continuous tones—the harmonic content also changes with volume and the way instruments are played generally.

Frequency analysis of time dependent waveforms is a fairly advanced branch of mathematics known as Fourier analysis. Simple oscillator waveforms such as those of Fig. 4 are easy enough to analyse if you have studied mathematics to university degree level but sorting out more complex waveforms requires sophisticated computer programs. But don't worry, no one has to know the first thing about mathematics in order to use synthesisers! The reason is that your ears and brain perform Fourier analysis for you every time you listen to a given sound. Not mathematically, but by sensing the relative volumes in many different frequency ranges. It should be no surprise that this sort of spectrum analysis can also be carried out electronically.

Next we must look at how the spectra from our electronic oscillators can be modified so as to change the character of the sounds they create, but before we move on there is one other important source of sound used in synthesis, and this is called "white noise".

Just as white light can be split into all the colours of the rainbow using a prism, white noise consists of a mixture of equal sized sine waves of every conceivable frequency. It sounds like a high pressure jet of steam, or blast of wind, or tumultuous applause (minus the cheering). White noise is the one case where the time dependent waveform looks like the frequency spectrum and vice versa (Fig. 6).

VOLTAGE CONTROLLED FILTERS

A filter, as you might expect, lets some frequencies through but not others. There are four basic types (Fig. 7a-d) and all are characterised by a particular frequency called the roll-off (sometimes cut-off) frequency, beyond which remaining frequencies are increasingly attenuated. The low-pass filter (Fig. 7a) lets through frequencies lower than the cut-off frequency but removes higher frequencies, while the high-pass version (Fig. 7b) does exactly the opposite. Band-pass filters only allow frequencies through which are close to the centre frequency and notch-filters have the inverse response. The rate at which frequencies beyond the cut-off frequency are attenuated is referred to as the slope or roll-off.

Introducing some positive feedback into the filter increases the gain in the region of the cut-off frequency (or centre frequency) and produces a peak in the frequency spectrum as shown in Fig. 7a-c. It can be seen that making this peak bigger also has the effect of increasing the slope. The two other types of basic filter are shown in Fig. 7e-f. These are multiple notch and multiple band-pass respectively.

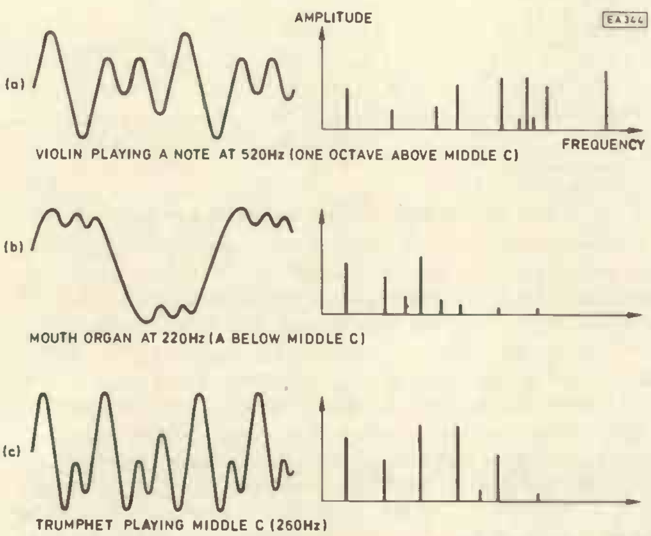


Fig. 5 Waveforms and spectra of (a) Violin note of 520Hz (b) Mouth organ at 220Hz (c) Trumpet at 260Hz

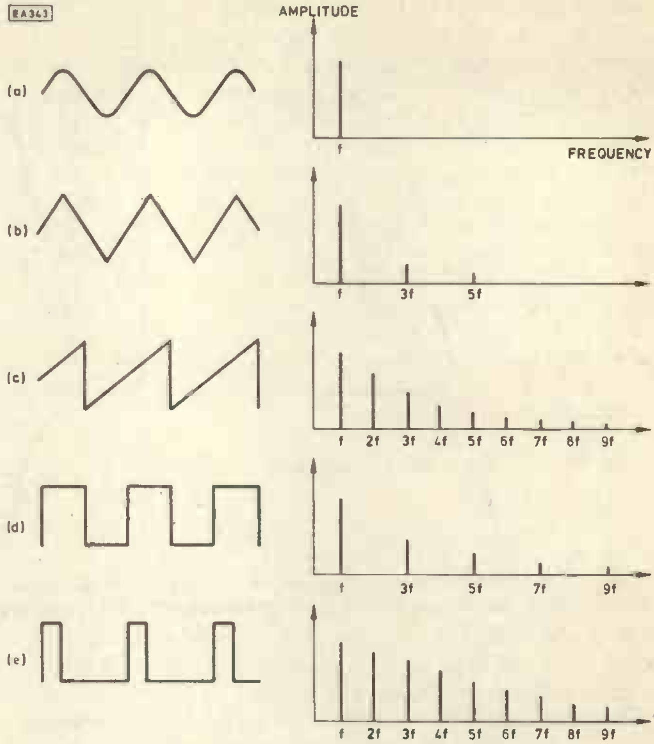


Fig. 4 Oscillator waveforms with spectra

In the case of VCFs (the sort used in synthesisers), the roll-off frequency is movable and where it is depends on the d.c. voltage applied to the VCF control voltage input. As with VCOs, the frequency can usually be varied manually or automatically by a voltage from another part of the synthesiser. Generally the degree of feedback, that is the size of the resonant peak is manually variable, though in more sophisticated synthesisers this function may also be voltage controlled. Either way, the function is variously referred to as "feedback", "resonance", "slope", or "Q".

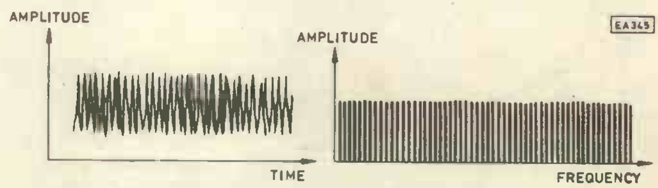


Fig. 6 Noise waveform and spectrum

ENVELOPES

We can, by using different waveforms, adding them together, and filtering, create virtually any sound spectrum we like, and change it around at will using voltage controlled devices. But so far we have been talking about continuous sounds. Some sounds of course, such as the sea, the hubbub of a city, politicians talking, etc are continuous, but joking aside, almost all sounds whether from instruments or the environment have one thing in common. They start and they stop. And in between they may fluctuate in volume (and also harmonic content). The graph of volume versus time is called the envelope of a sound, and some typical envelopes for various instruments are shown in Fig. 8a-d. Strings for example, when struck or plucked have a very sharp peak at the start of the note, after which the volume dies away much more slowly. A bowed string gives a more gradual increase in volume, but stops vibrating fairly abruptly when the bow stops moving. Removing the bow in a smooth continuous motion would of course leave the strings vibrating though

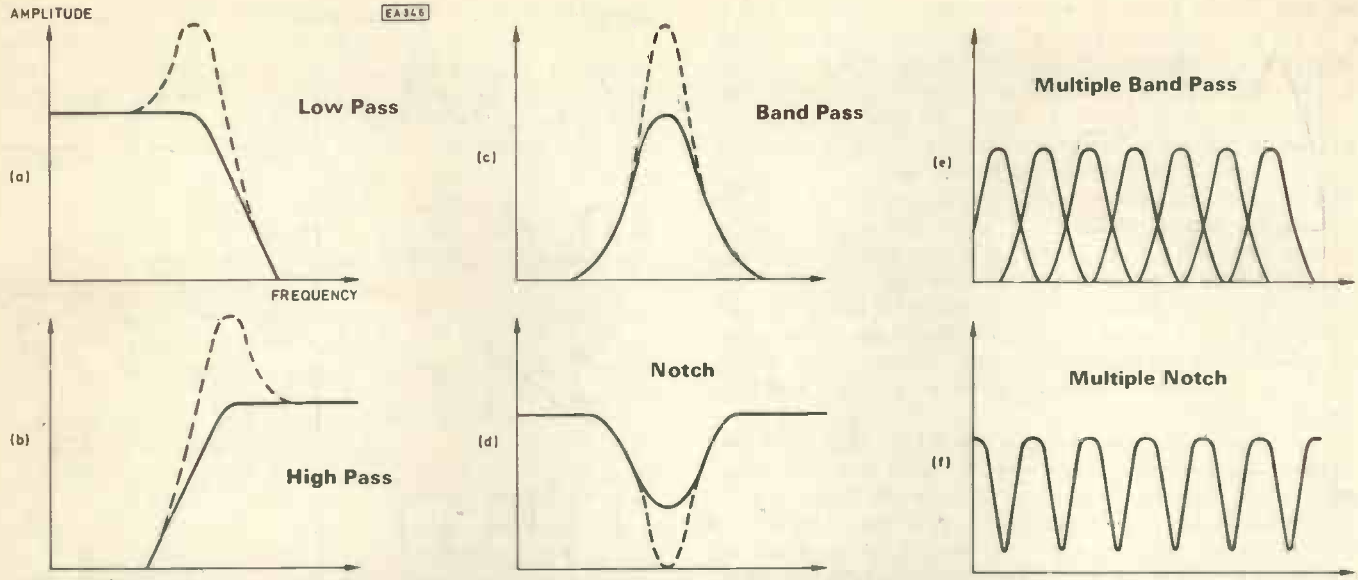


Fig. 7 A filter lets some frequencies through but not others. Introducing some positive feedback into the filter increases the gain in the region of the cut-off frequency and produces a peak as seen in Figs. 7 (a–c).

less fiercely and the reduced sound would then die away slowly like the plucked string. Wind instruments vary quite widely in their envelopes, but generally start more slowly than plucked strings, and die away rapidly. Organs, whether pipe or electronic both start and stop abruptly. Pipe organs often appear to die away slowly, but this is due to reverberation time of the room they are in. In other words although the direct sound from the pipes stops suddenly at the end of each note, the quieter residue of the sound already in the air reflects around the room for some time, gradually diminishing. Reverberation can also be created electronically using delay lines, either electro-mechanical or solid state, through which the sound signal is repeatedly passed.

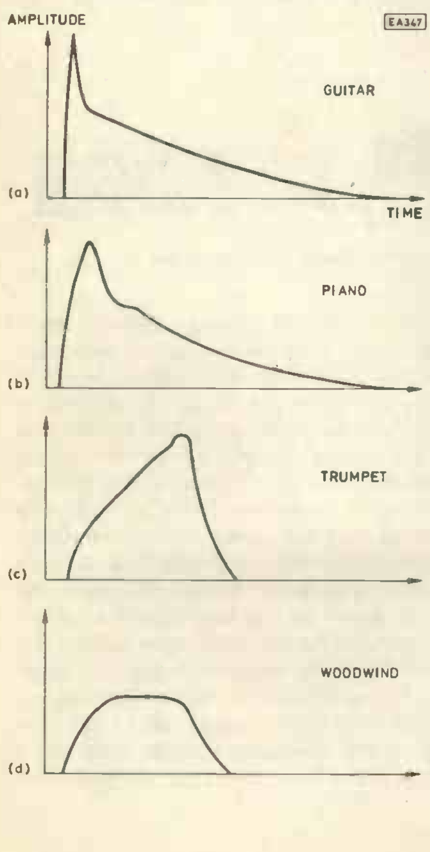


Fig. 8 Showing typical instrument sound envelopes. The guitar and piano have quite sharp peaks at the start of the note after which the volume dies away slowly

The trumpet and woodwind instruments start more slowly than strings but die away rapidly

VCAs AND ENVELOPES SHAPERS

Voltage controlled amplifiers vary the sound level coming out of the synthesiser from zero to maximum, depending once again on the d.c. voltage applied to their voltage control inputs.

Envelopes shapers generate, on demand, a changing voltage reproducing the shapes of Fig. 8, the actual shapes being set by the controls on the envelope shaper (manually, or in sophisticated machines, also by voltage control).

The simplest sort are known as "Attack-Sustain-Release" (or "A-R" for short) and operate as follows. When triggered, for example by pressing a key on the keyboard, the output voltage rises from zero at a rate set by the "Attack" control until it reaches maximum (or the key is released). The output remains at maximum for as long as the key is depressed and then when the key is released the output voltage falls back to zero at a rate set by the "Release" control. Varying the attack and release times as well as the key depression time enables a continuous variety of envelope shapes to be produced (Fig. 9). Comparing these with Fig. 8 shows that

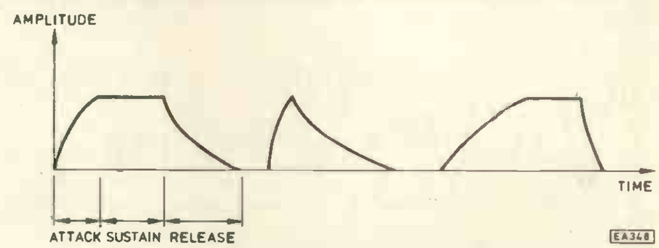


Fig. 9 Simple electronic envelope shapes

many instruments may be approximated with an A-R shaper, but not the more percussive instruments (meaning guitars, harpsichords, etc., as well as more obvious forms of percussion). A more versatile envelope shaper in common use is known as an A-D-S-R, "Attack-Decay-Sustain-Release", which gives full control over the parameters shown in Fig. 10. Even more complex envelope shapers are found on the most expensive synthesisers, but simple envelopes can always be added together to produce elaborate shapes.

For added realism envelope shapers are usually provided with a "single-shot" mode of operation, where one complete cycle is produced each time a key is pressed. To get another one the key must be re-pressed, corresponding to pianos, guitars, etc.

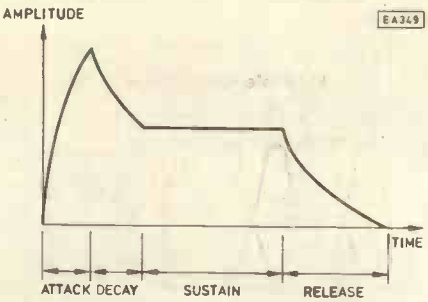


Fig. 10 More complex envelope shape

Note that the voltage output shape from an envelope shaper is also referred to as a waveform, but should not be confused with "audio waveforms" from oscillators. Audio waveforms fluctuate at audible frequencies, namely from about 10Hz to 10kHz (that is tens, hundreds or thousands of times per second), while envelope voltages change far more slowly, sometimes taking as much as several seconds to complete one cycle.

DYNAMIC FILTERING

As was hinted earlier, another feature characterising a particular instrument's "voice" is that not only does the volume of the sound change with time, but the harmonic structure of the sound can also change within the duration of each note. The sound of a trumpet, for example, becomes richer in harmonics as it gets louder. A plucked string is characterised by a burst of harmonics at the start, but decays to a pure tone as the sound dies away.

Now here voltage control really comes into its own. Not only can the envelope voltage be used to control the volume of the sound, but it can also be fed into the filter to vary the harmonic structure with time. This can either be the same envelope which is controlling the VCA so that the harmonic structure is related to the volume of the sound, or a different envelope from another envelope shaper, so that the changes in sound quality are unrelated to changes in volume.

The most obvious example of dynamic filtering is that of using the envelope to sweep the resonant peak of a filter through the harmonics of the sound, producing a waa-waa effect as notes are played. The next most obvious thing to do is to turn the envelope upside down for an inverted waa-waa, and most synthesisers generate both positive and negative envelopes for this reason — the possibilities become endless.

So far we have seen the four basic elements used in sound synthesis, namely:

VCO Generates various audio waveforms at a pitch proportional to the applied control voltage (generally in the range 10Hz to 10kHz).

VCF Modifies the harmonic content of oscillator spectra or white noise spectrum, depending on the applied control voltage, the type of filter and the degree of resonance.

Envelope Generates a cycle of relatively slowly changing voltage on demand, for modulating the voltage controlled devices.

VCA Modifies the sound level according to the control voltage applied from the envelope shaper.

Now let's put a synthesiser together. The most basic set up is shown in Fig. 11. One thing that has not been mentioned until now is the keyboard. Clearly something has to provide the control voltages for the VCOs, and for a harmonic spectrum to remain constant regardless of the VCO pitch, this same voltage must also be used to control the cut-off frequency of the VCF. VCOs and VCFs are generally adjusted so that they all track each other, that is, the same change in control voltage produces the same change of frequency in all the voltage controlled units. This control voltage is often derived from a chain of resistors in the keyboard, but it need not be. Guitar synthesisers convert the pitch of the notes played on a guitar into a control voltage in order to control the VCOs and VCFs, so that the synthesiser tracks (accompanies) the guitarist.

Drum synthesisers have neither, but use the envelope shaper or other oscillators to control VCO pitch, resulting in the strange noises commonly heard in disco and reggae music. The envelope shapers are triggered either by hitting a special pad, or by a microphone placed next to an existing drum, while in the case of the guitar synthesiser, the trigger signal is derived from the amplitude of the signal from the guitar.

Guitar synthesisers then, provide accompaniment for solo guitarists, while drum synthesisers are generally used to augment a conventional drum kit, and so both are, as it were, dedicated, unlike keyboards synths.

Back to keyboard synthesisers; in order to play a musical scale on an electronic keyboard, the keyboard voltage must cause the VCOs (and VCFs) to double in frequency as ascending octaves are played. In other words a linear change in voltage from the keyboard must be converted into an exponential (or as people will insist on calling it, a "logarithmic") change in voltage in order to control the VCOs. This may either be done in the keyboard itself and multiplied up and down in the VCOs, or alternatively the conversion may be carried out independently in each VCO and VCF. The new generation of digitally controlled synthesisers generate the exponential numerically in digital circuits, but however the musical scale is produced, the basic idea is the same.

PORTAMENTO

A simple circuit determines the rate at which the keyboard voltage may change. Thus instead of jumping from one note to the next, a control is provided to enable the VCOs to glide smoothly between pitches.

LOW FREQUENCY OSCILLATORS

These produce similar waveforms to the VCOs, but are not intended to be heard, rather to produce control voltages for other devices. The output frequency is variable from about twenty cycles per second down to one cycle every ten seconds or so, and may be either manually or voltage controlled. The size of the output voltage is variable between zero and maximum.

LFOs have numerous applications. For example, feeding a small amplitude sine or triangle wave at a frequency of a few Hz into a VCO generates a vibrato, while feeding the same thing into a VCA gives tremolo. Feeding a slow, large amplitude triangle into a VCO will give a siren effect, while the same thing controlling a VCF filtering a white noise input can be used to create sea or wind effects, depending on the resonance setting of the VCF. A fast, descending ramp waveform fed into a VCO will give birdsong. A squarewave into a VCO will give a two-tone, police car effect.

A slow running LFO can also be used to repeatedly trigger an envelope shaper, for rhythmic effects. For example, fairly rapid envelope shaping of a VCO tone can be used to create mandolin type effects, while the same technique applied more slowly using white noise as the sound source can produce steam trains or marching feet and the like.

RING MODULATON

Thus far we have only considered adding waveforms together, which simply results in the harmonics of one

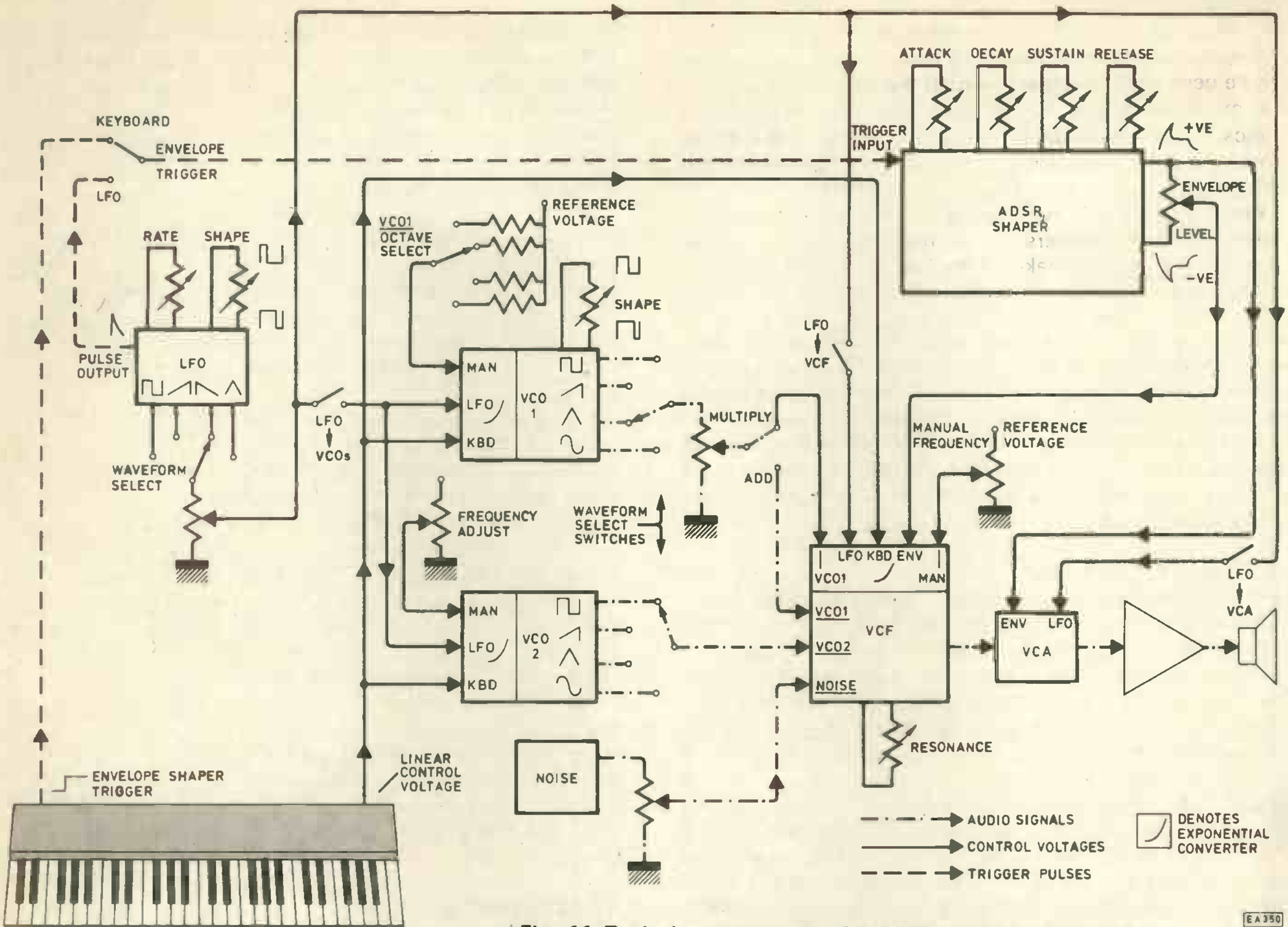


Fig. 11 Typical arrangement of a basic voltage controlled synthesiser

waveform being added to those of the other. Using the audio output of a VCO as a control voltage for a VCA which is determining the size of the signal from a second VCO, has the effect of multiplying the two waveforms together. This process generates entirely new harmonics. Taking the simplest case of two sine waves, frequencies A and B, basic trigonometry tells us that:

$$\cos A \times \cos B = \tfrac{1}{2}\cos(A+B) + \tfrac{1}{2}\cos(A-B)$$

so the resultant is two new sine waves, respectively the sum of and the difference between the two original frequencies. Multiplying other waveforms results in more complex spectra, and if the one frequency is not an integral multiple of the other, that is not in tune, then the harmonics generated are also no longer integral multiples of one another. This can be very useful, for example, close inspection of Fig. 5a reveals that the harmonics of a violin are not integral multiples of the fundamental. This arises from the "stick and slip" action of the bow on the strings, which creates a "non-Fourier" mixture of harmonics.

If the two VCOs are set at some musical interval apart, but very slightly off, bell-like tones are generated, while detuned VCOs give rise to metallic sounds, once suitably envelope-shaped. Using a VCF instead of a VCA as the multiplier facilitates the creation of tremendously rich sound structures.

SAMPLE AND HOLD

This is an analogue memory, that is, when triggered it instantaneously samples the output voltage from an oscillator or envelope shaper or noise source and then stores that voltage until it is next triggered. The output voltage from the sample and hold therefore moves in a series of steps. The sampling is usually triggered by a pulse from an envelope shaper or a slow running LFO, or by pressing a new key on the keyboard. For example, repeatedly sampling a slow ramp waveform from an LFO results in an arpeggio scale when the sample and hold output controls a VCO. Alternatively sampling the voltage from a noise source or a fast running VCO means that the sample and hold output voltage will change apparently at random. This can be used for such varied effects as random filtering and syncopation.

SEQUENCERS

A sequencer is a digital memory note storage system, programmed either manually or directly from the synthesiser keyboard, a voltage corresponding to each note being entered sequentially into a separate memory location.

On playback the memory locations are stepped through in turn by an internal LFO, and the resulting sequence of output voltages is used to control the synthesiser VCOs. Thus any sequence of notes, from a simple repeating arpeggio pattern to an entire piece of music can be stored in the memory and replayed automatically at any time via the synthesiser. The memory also stores trigger pulses in order to trigger the envelope shapers at appropriate times in the sequence. An entertaining analogy is that of the old automatic pianos, which were played by a roll of punched paper drawn through a mechanical control mechanism by a clockwork motor.

The advantages of modern sequencers however, is that they are useful for composition since notes can be entered and edited at any time, at the musician's leisure, and since the replay speed can be set to any desired tempo, sequences can be generated which are beyond the capacity of any normal musician to play in real time. Furthermore, the electronics can take over the drudgery of playing repetitive patterns while the musician concentrates on more inventive lead playing.

While we are on the subject of memories, the latest generation of synthesisers contain memory storage systems for a different reason. Make all the functions of a synthesiser voltage controllable, including envelope shaper time constants, VCF resonance, portamento, etc, and it follows that all the relevant voltages can be stored in a memory, in other words, all the information about VCO pitches, harmonic spectra, envelope shapes, as well as all the intermodulation between the various synthesiser units. In practice then, a complete voice can be set up using the front panel controls in the normal way, then push a button and the whole program is stored. Repeat this any number of times, and any of the stored voices can be recalled, also at the touch of a button.

POLYPHONICS

As stated at the beginning, most synthesisers are monophonic which means, complexity of voice aside, only one note may be played from the keyboard at a time. Pressing a new key before the envelope from the previous key has died away simply re-triggers the envelope shaper and changes the VCO pitch—conventional chording is out!

Electronic organs and pianos are fully polyphonic, that is, chords may be played, since there is effectively an oscillator and an envelope shaper for each key. However, variability of the envelope shapes is strictly limited, filters of switchable characteristics are tacked on the end, so the advantages of dynamic filtering, portamento and complex sound creation via ring modulation and the like are lost. Many instruments which retail for a few hundred pounds claim to be polyphonic synthesisers, but in reality are just glorified electronic organs, generally with one VCF responding to the latest envelope to be triggered.

It is apparent then, that a truly polyphonic synthesiser would consist of a complete synthesiser for every key on the keyboard. In practice this is unnecessary, as one can get away with four, eight, or at the most sixteen being assigned in rotation to particular keys as they are pressed, this task being performed by digital circuitry scanning the keyboard at a very high frequency looking for pressed keys. Even so polyphonic machines generally cost several thousands of pounds to buy.

EXPRESSION PATHS

A criticism often levelled at synthesisers is that their preprogrammed, nature renders them rather mechanistic, perhaps soulless, from the musician's point of view, which (even the antagonists usually concede) is a pity in view of their tremendous potential. Indeed, with the current headlong rush towards digital waveform synthesis and control, wherein sounds can be dreamed up and music composed all from the alphanumeric keyboard of a computer terminal, even the knob-twiddling element is removed, so what price emotion and spontaneity now? Is the beauty of an instrument expressing the subtleties of innermost moods and feelings to be replaced by the aesthetic elegance of mathematical equations and the efficiency of subroutines?

This is, of course, overreacting. Computerisation of music has its own appeal and its own place just as any other human endeavour, but nevertheless, the lack of direct involvement in the control of synthesised sound has led to something of a counter-revolution in which designers go out of their way to give the musician back the ability to interact with his instrument, manually, as it is being played, which thus far has been lacking in synthesisers. It is ironic, by the by, that similar objections have never been raised during the several centuries that pipe organs have been around. These elaborate mechanical precursors of modern electronic synthesisers, while being able to chord and sound quite orchestral on their own owing to the number of spectra simultaneously available, lack any of the expression paths associated with other conventional instruments.

Such expression paths include breath control of pitch, volume and harmonic content in wind instruments, the way the guitarist can bend strings to control pitch and glide from one note to the next—as can the violinist and cellist, etc., but with bowed instruments the way in which the bow is applied to the strings also dramatically changes the sound. In keyboard instruments such as the piano and harpsichord the force with which the keys are pressed not only affects the volume and the resulting spectra but also, by virtue of the vibrations of each string being transmitted through the framework to the other strings, the keyboard controls the degrees of waveform multiplication. The pedals also give considerable control over the envelopes either by increasing sustain or damping out the oscillations and their resultant harmonics.

The point of all this is that no matter how sophisticated electronics becomes it will never out-class the human brain as a pattern-recognising feedback control system (for the implication would be one of replacing human beings altogether!) So to come back down to earth again, what can be done to provide the same degree of manual control over electronic synthesisers?

OPTIONS

Many options are available. Pedals are one obvious choice. Another is the provision of thumbwheels next to the keyboard; joysticks similarly. A more modern device in use consists of a sandwich of conductive foam between thin metal strips, which changes its resistance according to where it is pressed along its length. This is known as a ribbon controller.

Electronic pianos are usually touch sensitive in that the size of the envelopes increase the harder you press the keys, though it is generally key velocity that is measured rather than the force of impact. A more recent innovation is that of force sensitivity, a device unique to synthesisers. Here the keys are depressed in the normal way, but pressing harder on a key that is already depressed forces a spring-loaded metal bar downwards (alternatively the entire keyboard may move downwards!)

Whatever methods are employed, the result is the generation of control voltages proportional to the physical movements. The big advantage over conventional instruments is that these control voltages may be used to control any chosen parameter of the synthesiser: pitches, filter responses, envelope shapes, LFO speeds and amplitudes, etc.

One modern invention called the "Variphon" has gone one step further. It is a synthesiser right enough, but it is a wind instrument in that it is blown! There is a mouthpiece and electronic sensors around the reed generate the control voltages, in other words, a synthesiser with complete breath control.

The "Kaleidophon" is a pseudo stringed instrument. Again it is a synthesiser, but the control voltages are generated in the strings, thus giving the synthesist back some of the advantages that a guitarist has.

Semiconductor UPDATE...

FEATURING MK3824/3821 RC4191 27128

R.W. Coles

PIN MISER

What do you do if you want to hook additional I/O or memory on to your single chip microprocessor design, and you don't have sufficient I/O pins available to transfer the data and address information? Well, mainly you have to whistle, because for most parallel I/O devices and memories you need 8 pins for data transfer and several more for the address information. Some designers who just had to have lots of I/O from a limited number of pins have created their own special multiplexing systems using several external CMOS logic packages and a software driver, but the more usual course has been to make do or to use an all-singing all-dancing bus orientated microprocessor with an attendant increase in system cost.

Now Mostek have recognised this "pin-famine" problem and have come up with an ingenious scheme to solve it that will please not only single-chip users but also those who are feeling the pinch in bus orientated systems with a limited number of I/O lines. What Mostek have done is to build a family of I/O and memory devices which do not need parallel data and address busses because they have internal serial to parallel conversion logic and can work from a simple serial bus.

The serial bus is so simple that it hardly deserves a special name, but Mostek have given it one anyway and are calling it the "Microcomputer Data Link" (MDL)! All this link consists of is three wires, one to carry the serial data in or out, one to act as a clock, and one more to act as a chip select for the external MDL compatible devices. The clever bits are inside the peripheral chips themselves. Each device has a serial shift register which accepts 8 bits of data from the bus under the control of the microprocessor generated serial clock. The first byte to be transferred is always the Command/Address byte which consists of a start bit which is always zero, a Read/Write select bit, and then six address bits which can select up to 64 separate registers or memory locations within the peripheral device. All data transfers require 16 clock cycles, 8 to catch the Command/Address information, and 8 more to shift a data byte into or out of the processor depending on the Read/Write selection made.

The MDL compatible family of peripherals will all have at least one chip select input to allow for more than 64 locations if required, and those which have less than 64 internal locations will have hard-wired address inputs so that their own particular group of locations can be mapped into the 64 available without conflicting with any other similar device on the bus. The end result is a flexible system which requires only three CPU or I/O lines and requires much less board space than a conventional system because the peripheral circuits can be housed in small packages such as 8 pin mini-DIPs which also keeps the cost down. The only penalty (there has to be a catch!) is that the transfer of one byte takes at least 16 processor cycles instead of the 1 required by most parallel schemes. In many systems this is not a serious problem.

The first two devices available are the MK 3824 64 byte RAM array and the MK 3821 three channel Analogue to Digital converter, but Mostek promise parallel I/O ports, keyboard encoders, and display drivers will be along soon.

POWER MISER

Normal linear voltage regulators such as the ubiquitous 7805 are great for systems where the input voltage is only slightly above the required output voltage, or where their inefficiency is not a problem because power comes from the mains, but they do waste an awful lot of power when there is a large input-output voltage difference, and this can be a big problem for battery powered equipment. If you run your 5 volt logic from a 7805 supplied by a 12 volt battery then about 60% of the power used goes to keep the 7805 warm, a terrible waste. A better scheme is to chop the higher voltage up into a squarewave and then control the ON/OFF ratio so that exactly the right d.c. output voltage is developed across a reservoir capacitor on the output side. With a transistor or an f.e.t. as a switch, efficiency can be high and the chopping frequency can be several kHz so that only a small capacitor is needed to reduce the ripple to a respectable level.

The "Switching Regulator" technique is not new, but the circuitry is more complex than that required for a linear regulator and this has resulted in it being used only for relatively high power applications where its high efficiency has been essential. This is about to change, thanks to Raytheon who have just introduced a series of micropower switchers in low cost 8 pin packages which are designed to make the best use of battery supplies. Their new switcher family uses only 135 microamps quiescent current and can achieve up to 80% efficiency. Devices are coded RC 4191 to RC 4193 and all will work from a wide input range either 2·5 to 24 volts or 2·5 to 30 volts. The series transistor is capable of switching up to 150 milliamps and the control circuits provide excellent regulation against variations in the load current or the input voltage. Also on the chip is a logic controlled remote shut-down which can be used to turn the output ON or OFF, and a low battery detector circuit which will provide a signal when the battery is nearing the end of its life.

Because the Raytheon devices are true switchers, you don't have to restrict them to step-down applications either; by adding diodes and an inductor you can step-up or invert the polarity of a supply. I think we will be seeing a lot more of these devices in the near future.

BIT STUFFER

Still using steam powered 2708 EPROMS? Or old fashioned 2716s? Think you are bang up to date with your 2732s? Well think again, because 2732s with their measly 4K bytes of storage will soon be outgunned not only by the one year old 2764 but also by the giant new Intel 27128 which stores no less than 16K bytes (That's 131,072 bits folks!) in its 28 pin package. With that many bit cells, the chances are that some of them won't work properly, but Intel have thought of that and added a further 128 bytes to act as spares which they can patch in when they test the chip after manufacture. In most other respects the 27128 is similar to its predecessors and can date its family tree back to the 2716 when single 5 volt supply operation was first introduced. Programming requires the application of a 21 volt supply and a 50mS pulse for each byte, so you will have to wait quite a while for the whole array to be programmed!

The sheer size of this device makes it suitable for the distribution of software such as language compilers or interpreters, and no doubt the price will eventually drop to next to nothing from the present level of about 25 millipennies per bit!

AVAILABILITY

Devices featured in Semiconductor Update should, under normal circumstances, be available from good component retailers, but bear in mind that retailers will often not receive stocks of a device until some time after it has been featured in 'Update. However, when a high demand from hobbyists is not anticipated, you may need either to contact the manufacturer or a specialist distributor. The following three companies stock a wide range of devices, and all say that they will supply one-off orders: Rapid Recall Ltd., Rapid House, Denmark Street, High Wycombe, Bucks (0494 35634); Analog Devices, Central Avenue, East Molesey, Surrey (01-941 0466); Semiconductor Specialists (UK) Ltd., Premier House, Fairfield Road, West Drayton, Middx. UB7 8EX (08954 46415).

EXPERIMENTERS BREADBOARD
WITH POWER and PULSE GENERATOR

A BREADBOARD of this type is an invaluable piece of equipment to experimenters and students who wish to work with i.c.'s. The breadboard itself is easily obtainable, using GSC Quick Test Solderless Breadboard Elements in its make-up. Prototypes can be built easily, and after their completion, the components re-used. Two separate but identical power supplies were built into this breadboard to cater for future development. The use of a 0–9V 0–9V transformer, giving a possibility of 18V a.c. and simple voltage regulators makes a versatile power supply, which once built will have many and varied uses.

Pulse Generation is obtained by the use of two i.c.'s (see Fig. 1). The 50Hz pulse is made up from a Schmitt Trigger ($\frac{1}{2}$ IC1), this being tapped from the 9V a.c. supply via R1, D1 and D2 to the inputs. The output is a square wave at 50Hz. The 1Hz pulse is the other Schmitt Trigger in the same package ($\frac{1}{2}$ IC1). The charging resistor is R3, C7 the timing capacitor and TR1 the transistor switch. Together, these components give a pulse duration of approximately one second positive and one second negative for "slow motion work". Finally, the manual pulse is constructed by using a pair of NAND gates in IC2. This circuit alleviates contact bounce in S1 and is found to be of great value in the checking of i.c.'s stage by stage.

This pulse board, being constructed from three separate stages, can give either separate or multiple pulses at one time.

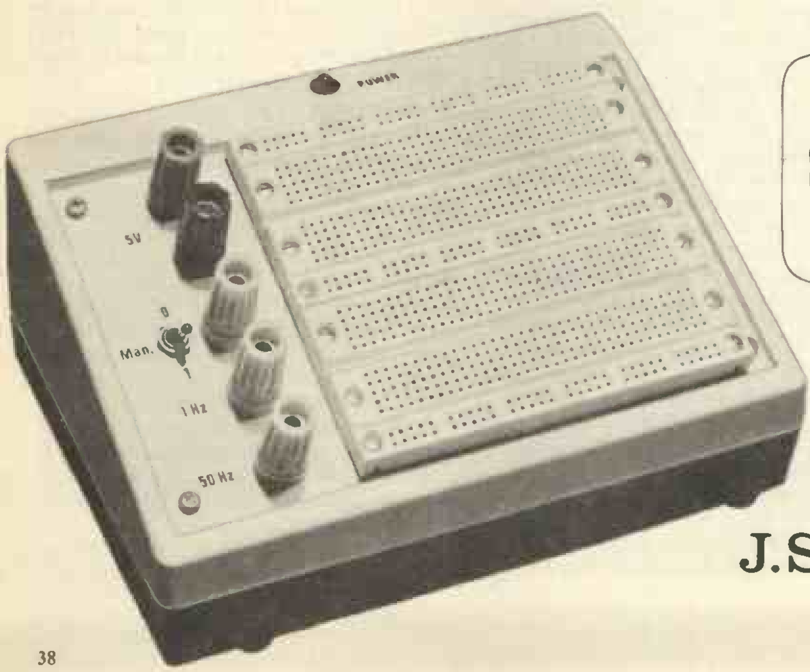
CONSTRUCTION PRIOR TO WIRING

Take one piece of 0·1 inch stripboard and cut to size for the Pulse Generator Board (15 copper strips x 31 holes). See Fig. 2. Drill mounting centres at 5-H and 27-H, also the mounting centres of the Power Board at 8-M and 33-M, using a 4mm bit. See Fig. 3. The Heatsinks should now be drilled along with the board to take IC3 and IC4 and also the transformer baseplate, 4BA clearance. On the base diagram, no dimensions are given; this is because it is felt far easier to position the two boards, transformer and air vent matrix to give clearance one from the other by eye. As space within the case is at a premium, every effort should be made to obtain the specified components.

When you are satisfied these are correct, mark and drill the base. 5mm for fixing centres of boards.

The mains input grommet is directly in line with the left-hand transformer mounting. From the bottom of the base, countersink both transformer holes to take bolts and also board fixing centre holes to take type 'B' standoffs. Make up the wire clamp from 2·5mm perspex 19 x 44·5mm (outer). Two smaller pieces are glued to this to form a groove through which the screened cable passes to the power output terminal posts. A hole to take the ventilation grille should be cut in the rear; the dimensions for this are given. Drill out to take D3 mounting clip centred on horizontal part of this section. Prior to the insertion of D3, it should be made up as shown, with the anode sleeved from the cathode and a final sleeve to make it more durable. These can be glued in place along with the ventilation grille.

The GSC Breadboard can be assembled and mounted on the aluminium section of the Vero box. The two holes for the wire clamp are countersunk from the anodised side, all these holes are 6 BA clearance. Drill to take terminal posts and switch, all dimensions given. Graphics can be added by the use of letter transfers and the whole board covered with Transpaseal, cut corners as seen in diagram and fold under the board. This will give the lettering protection and the breadboard a professional look.



FEATURES

Breadboard supply	**5–12V 500mA d.c.**
Pulse generator	**50Hz 2V p.p.**
	1Hz 0–4V d.c.
	Manual 0–4V d.c.

J.SLACK

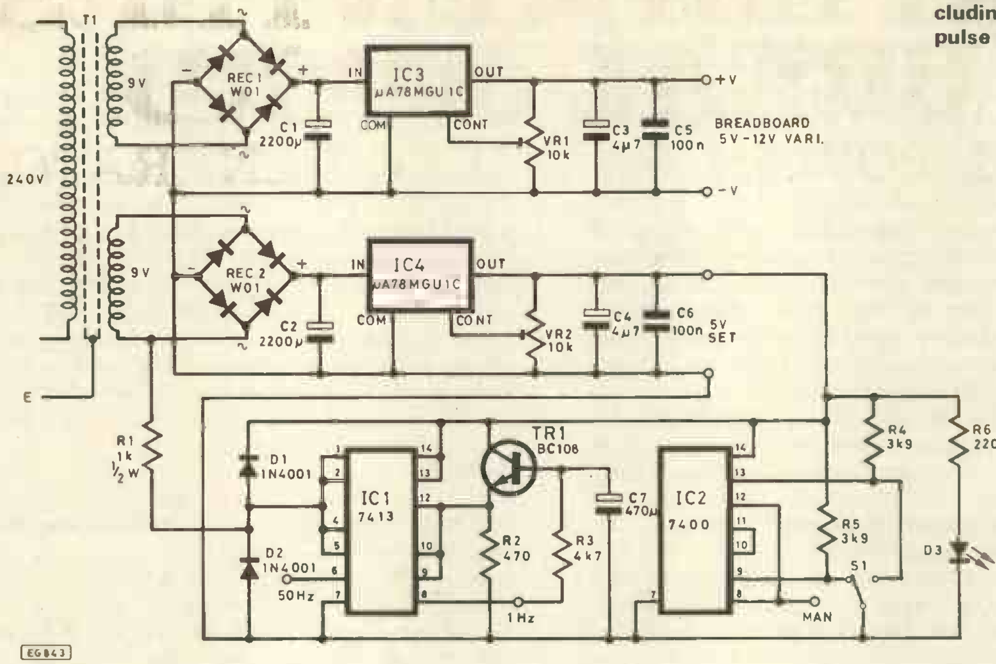


Fig. 1. Circuit diagram of the breadboard system, including power supply and pulse generator

COMPONENTS . . .

Resistors

R1	1k½W
R2	470
R3	4k7
R4, R5	3k9 (2 off)
R6	220
R7, R8	330 (2 off)

All ¼W 5% unless otherwise stated.

Capacitors

C1, C2	2,200 μ 40V axial elect. (2 off)
C3, C4	4n7 63V p.c. elect. (2 off)
C5, C6	100n disc (2 off)
C7	470 μ 16V p.c. elect.

Potentiometers

VR1, VR2	10k hor. sub-min. preset (2 off)

Semiconductors

REC1, REC2	WO1 p.c. Bridge Rect. 100V 1A (2 off)
IC3, IC4	μA78MGU1C (2 off)
IC1	7413
IC2, IC5	7400 (2 off)
TR1	BC108
D1, D2	1N4001 (2 off)
D3	Standard red with Plastic Clip
D4, D5	Sub. Min. red (2 off)

Miscellaneous

S1	S.P. Changeover, Sub. Min. Toggle
T1	0–9V 500mA 0–9V 500mA Output

Red terminal posts 4 mm top socket (5 off)
Case 217 202-21033A 171 × 121 × 75/37·5mm (Vero)
Boards 0·1″ 10346 95 × 63mm 24 × 37 holes (2 off)
Standoffs Type 'B' Short 6mm (4 off)
Pins 0·1″ Double and Single ended
Heatsinks 22 × 19 × 19mm (2 off)
D.i.l. 14 Pin Sockets (2 off)
Ventilation Grille (cut out 142 × 35 mm)
Lightweight screened cable, ribbon cable, 750W mains cable, 4BA and 6BA ½″ countersunk bolts, nuts and locking washers, Grommet, PVC sleeving, etc.
QT–35B breadboard (3 off)
QT–35S breadboard (2 off)
Supplied by **Global Specialties Corporation (UK) Ltd.,** Unit 1, Shire Hill Industrial Estate, Saffron Walden, Essex.
Letraset—12pt Univers Bold Condensed
Transpaseal, Cyanoacrylate Glue from any good Stationers or Drawing Office Supplier.
Transformer Base Plate 3⅜″ × 1″ × ⅛″ Aluminium
Wire Clamp 2·5mm × 19mm Perspex strip
Cling Plastic coated self-adhesive foam draught excluder

Wiring

On the component layout for power and pulse boards, only the wiring is shown.

Horizontal wiring is by copper strips, vertical by wire links. Half pins were used for all input and output terminals. Under board wiring is achieved by the use of full pins, these being trimmed off on the component side of the board. Work from small to large components, the link wires being inserted first. The four tags of each regulator were bent through 90° to insert into holes 24. These were fitted last because of their delicacy. Connect wires to input of power board and ribbon cable to output of pulse board before mounting in the base, this is because of the inaccessibility of these pins. Connect screened cable to output of power board (IC3 side) and to red and black terminal posts. The ribbon cable to appropriate yellow terminal posts and switch. The centre tag of S1 is connected to the black terminal post.

As the power and pulse boards have only two fixing centres, it was necessary to mount these on foam rubber strips to give stability. "Cling" plastic coated self adhesive foam draught excluder was found to be excellent for this use. Stick three strips to the base across the width of each board, taking care not to foul underboard wiring.

Mount the boards and complete wiring. The mains cable earth is connected to the transformer mounting by either crimped or soldered tag. The mains live and neutral lines are soldered, sleeved and the sleeving glued into position for safety when adjusting the voltage regulators at a future date. The circuit has a 3 amp fuse in the 13 amp plug.

Fig. 2. Stripboard layout of pulse generator section

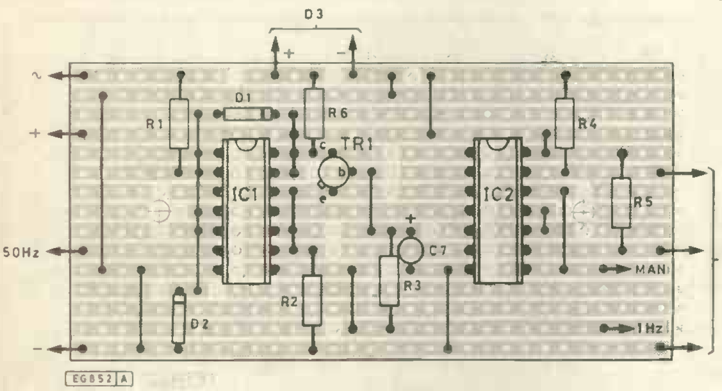
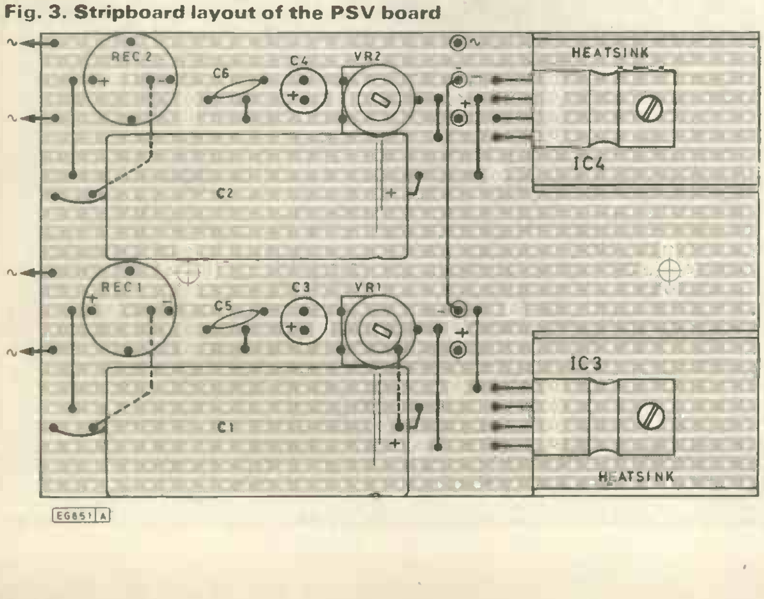


Fig. 3. Stripboard layout of the PSV board



TESTING

Turn both VR1 and VR2 fully clockwise and connect to mains supply. With a multimeter connected to the pulse board outputs, turn VR2 anti-clockwise until the voltage reaches 5V. This sets the power for the pulse board and D3 should be lit. With the multimeter connected to the power board outputs, turn VR1 anti-clockwise to any voltage from 5–12V (5V suggested at this stage).

To test pulse board outputs, a probe is necessary and a circuit for one is given in Fig. 4. Make this up on your completed breadboard. Connect the input of this probe to the Man. terminal and operate S1. If the 1's l.e.d. should glow when S1 is in the 0 position and vice versa, reverse the outer connections to S1. Next, connect the input to the 1Hz terminal, the 1's and 0's l.e.d.'s should glow alternately (one second each approximately). Finally, connect the input to the 50Hz terminal, both l.e.d.'s should glow but because of the pulse ratio, the 1's l.e.d. will be dimmer than the 0's l.e.d.

BOOKS

The author would like to recommend the following books:

The 555 Timer Applications Sourcebook With Experiments by Howard M. Berlin.
Published by Howard W. Sams & Co. Inc., 4300 West 62nd Street, Indianapolis, Indiana 46268, U.S.A.

50 Circuits Using 7400 Series IC's by R. N. Soar.
Published by Bernard Babani (Publishing) Ltd., The Grampians, Shepherds Bush Road, London W6 7NF.

From the latter was gained the initial inspiration of pulse circuits.

The author would also like to thank Mr. I. Roebuck and Mr. I. Wright for their help in the design and building of this project. ★

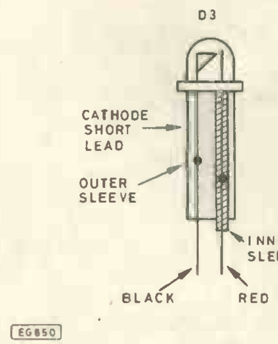
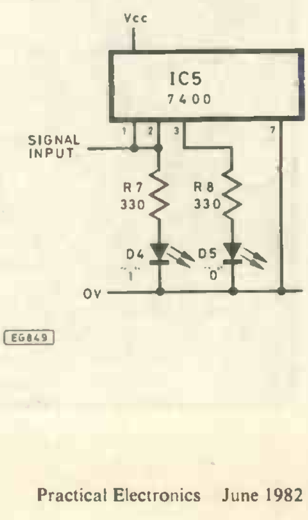
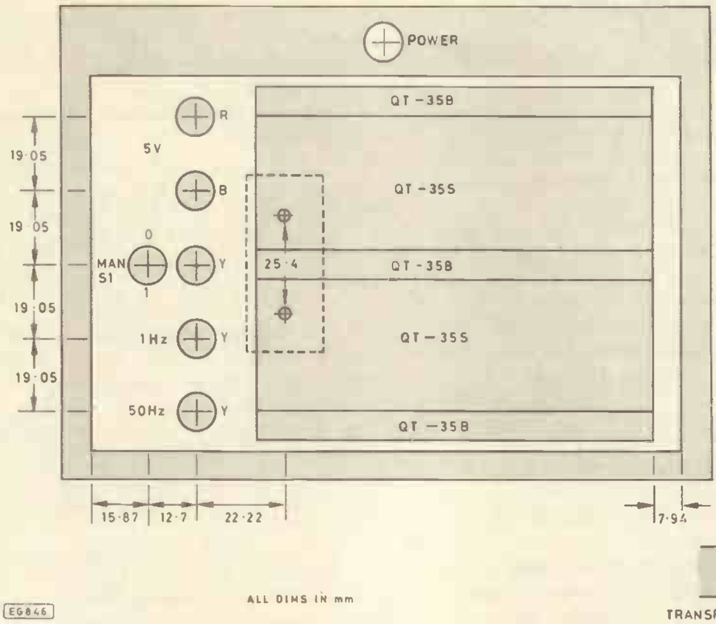


Fig. 4. Suggested circuit for a digital logic probe





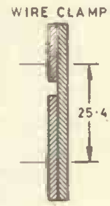


Fig. 5. Front panel cuttings. The "QT" numbers are the breadboard types. See components list under miscellaneous

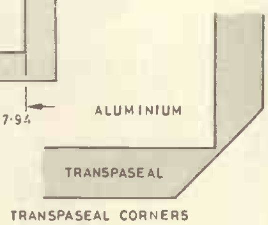
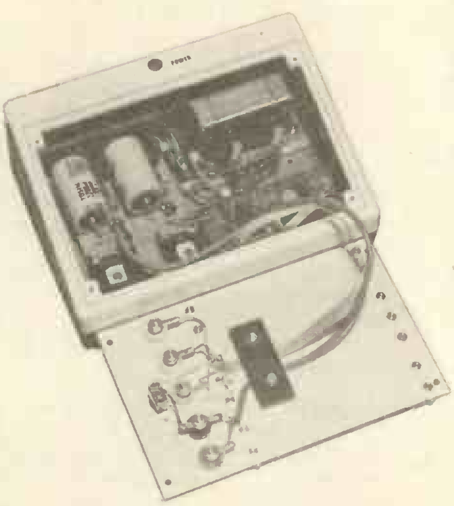
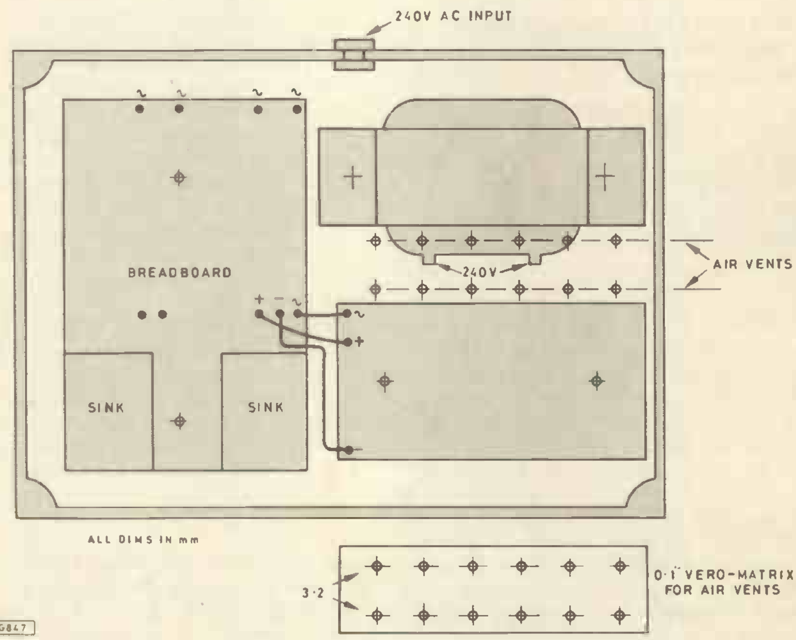


Fig. 6. Internal component layout





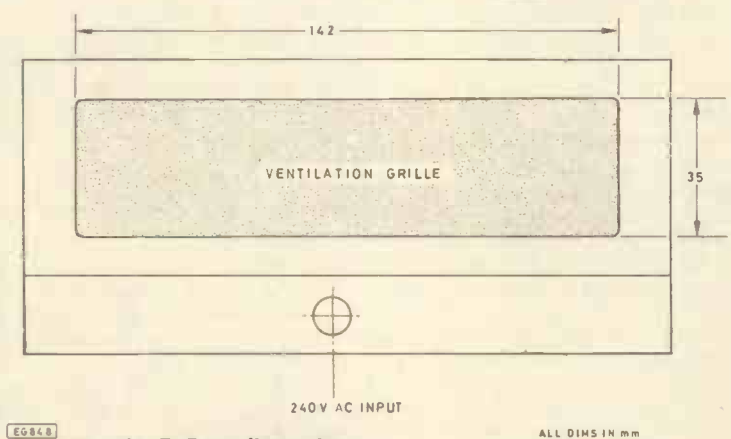
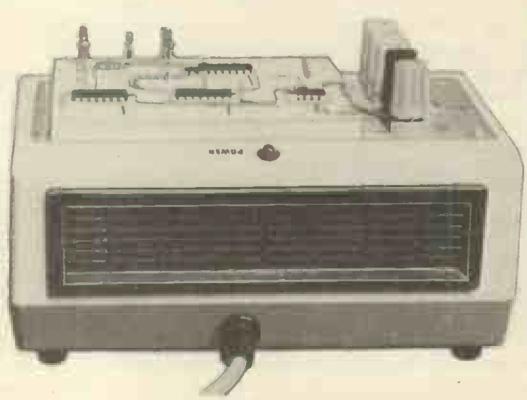


Fig. 7. Rear dimensions, showing the ventilation grille



MICRO PROMPT

GRAPHICS SHORT-CUT

Sir—The medium resolution graphics article in April's copy of Practical Electronics was very interesting and useful. However, the hex dump of the character generator was a bit wasteful considering that it can be generated by the following short program.

```
10 REM ***LOAD GRAPHICS CHARACTER SET***
20 DIMD (8): DIMB (4)
30 INPUT "ENTER START ADDRESS"; ST
100 FOR N=1 to 256
110 C=N-1
120 FOR T=1 TO 8
130 D (I)=c-INT (C/2) * 2: C=INT (C/2)
150 NEXT I
170 FOR J=1 TO 8 STEP 2
180 B (INT((J+2)/2))=D(J)*240+
   D(J+1)*15
200 NEXT J
220 FOR J=1 TO 4: POKEST, B (J): POKEST+1, B (J)
230 ST=ST+2
240 NEXT J
390 NEXT N
400 END
```

S. Grycuk, Handforth, Cheshire.

YOURS . . . DISGRUNTLED

Sir—Mr Dyvik of Norway (Sept 1981) is using a rather complicated adaptation of the "cassette save" routine given in the Compukit manual. Apart from relocation to $0228, two simple substitutions will suffice for use with the new monitor: JMP $FA57 (new screen print) wherever JMP $BF2D (old CRT simulator) is used, and JMP $FE05 to return to address mode in the monitor (or JMP $FE08 to avoid clearing the screen). This information was helpfully supplied by Compshop when I queried the non-functioning of the relocated routine. I have since added instructions to print .00FB/00 so that control returns to the keyboard.

Compshop have been rather less helpful in the matter of how "text scrolls down" as they advertised when the new monitor first became available; I suspect it cannot be done (because of the problems of storing scrolled-up text so that there is something to scroll down), but I would be grateful for readers' advice. I would also appreciate some help with problems relating to MicroPrompt suggestions.

(1) The reverse video modification in the May 1981 issue requires my TV to be set for maximum brightness and minimum contrast, unlike the white-on-black display which uses normal settings. No amount of adjustment of R58 (picture density) obviates this.

(2) D. J. Anderson's error message corrector (Sept 1980) prevents the SAVE command from operating correctly. The flag is set, but nothing is slowed down and sent to tape—new monitor again?

One final grouse about the otherwise useful new monitor; the note about flash rate location is not at all useful, since the monitor constantly puts the value 80 there, so it effectively can't be changed. This means that the flash rate is much too fast in Edit mode when running at 2MHz.

Alfred W. Pauson, Glasgow.

MONITOR CHANGE POINTS

Sir—I refer to the article in Practical Electronics of November 1981 on "UK101 Monitor Change".

Having built the circuit as given in the magazine I would like to draw your attention to two points. On powering up the circuit I found that I could not get it to operate using UK02 monitor although all was well with WEMON. On checking over the circuit I discovered that in my UK101 UK02 was enabled by UK02MCS and not $\overline{\text{UK02MCS}}$ as the circuit was attempting to do. There is a spare gate in IC104 and by disconnecting pin 6 from the MCS line, connecting it to pins 9 and 10 and taking the output to the MCS line from pin 8 all was well. The second point is rather more obscure and concerns the ACIA address. I carried out the modifications to change the address of the ACIA from F000 to E000 to accommodate WEMON and certainly all operates as it should. Now UK02 expects to find the ACIA at F000 and indeed mine does. I am therefore at a loss to understand how the ACIA can live at two addresses: Perhaps you could advise me how this can be.

J. H. Howarth, Bathgate, W. Lothian

The ACIA is not fully decoded; that is to say the least significant address lines have been incompletely utilised. The ACIA, on the standard machine, may consequently be called up anywhere between F000 and F0FF (61440–61695 decimal)—a total of 256 bytes!

SOFT BAUD MOD

Sir—the Soft Baud Rate modification by E. Mawson (Sept. 81) does work very well. When completed however it makes the standard rate after Reset 600. This requires software adjustment if all current tapes are 300. In my case I prefer to be 300 after Reset and then adjust to 600 when required.

To achieve this another inverter is necessary as IC14 should not be used to drive both IC57 and the 1N4148 diode added in the changes. If the RS232 interface is not used when another inverter in IC62 can be utilised. It is only connected with the interface. To use it for our purpose the following changes are required;

connect IC68 (13) to IC62 (9)
and IC62(8) to IC62 (1)

where the numbers in brackets are the pin numbers. This addition will reverse the standard rate otherwise achieved with the modification.

All other connections and comments are as the previous text.

R. L. Curd, Farnborough.

WEMON/TELEPRINTER HANG-UP

Sir—As an owner of a UK101 on a fairly tight budget, I was pleased to see the Teleprinter Interface article in the September '80 issue of Practical Electronics.

Having obtained a printer and constructed the interface circuit, the set-up has been in use for some months now, giving trouble free operation.

However, I recently added to my UK101 Wemon's extended monitor. It was only a short time before I discovered that the interface software for the teleprinter would not run with Wemon.

I would, therefore, appreciate any suggestions you can supply leading to the solution of my problem. Perhaps other readers have encountered similar difficulties and are willing to submit their findings.

Kenneth J. Houghton, Chorley, Lancs.

RELOCATION HANG-UP

Mr. *Keith Wood* of Wakefield has written to tell us of a problem experienced after moving the extended monitor on the UK 101 by the method suggested in Micro-Prompt, July 1981. Has anyone else had this trouble?

"When I use the Return key to drop out of the '@' function on the monitor, the machine locks up, and will not then respond to anything but 'reset'. Using any other odd key to drop out of '@' does not have this effect. The machine uses the latest standard monitor in Eprom, and the cursor returns to the end of the line, stops flashing, but does not line-feed."

GARBAGE STILL BUGGED

Sir—I have just bought Comp Shop's new UK101 BASIC3 ROM with the Garbage Collector fix, and while testing it I discovered that there is still a bug which has not been corrected. The bug occurs when executing an assignment statement with the same string name on both sides of the assignment and where there is not enough memory to perform the assignment.

The following program demonstrates the bug:

```
5 H$ = "+"
10 H$ = "*" + H$ + "*"
15 H$ = "+" + H$ + "+"
20 PRINT H$
25 GOTO 10
```

Before entering the program do a Cold Start, setting Memory Size to 1000 to reduce the available memory below the point where the bug operates.

*The program should print a succession of strings consisting of alternate + and *. However, from the 14th item onwards the string consists of *s with a single + at the right hand end.*

E. W. Ball, London.

E/MONITOR REWORKED

By ROGER DERRY

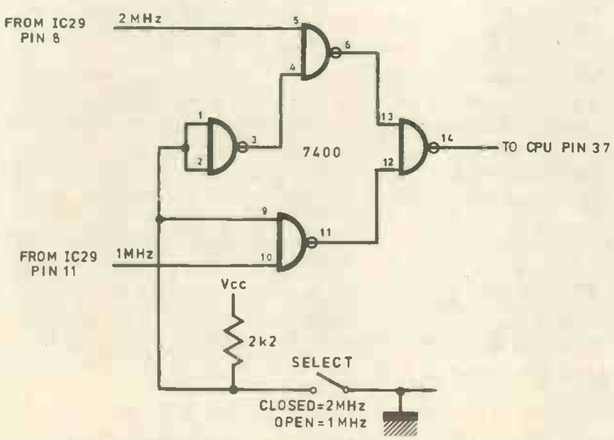
This article suggests some ways of making the extended monitor supplied with the UK 101 easier to use.

Extensive use is made of LINE FEED as an operational control and this is obtained by Control/J. But it is very easy to miskey and drop out of the memory examine mode. This is likely to happen if you are examining a section of memory for ASCII characters, as incrementing to the next memory location is by CONTROL/J and the ASCII character is displayed by SHIFT/2 (")! I decided to replace LINE FEED with the SPACE bar: to avoid using SHIFT I have changed " to . but once the relevant locations are known, virtually any character can be substituted.

NEW MONITOR ROM

When I was modifying the extended monitor I investigated ways of increasing the loading speed of programs in both BASIC and machine code. I had fitted a Cottis Blandford phase-lock-loop tape interface (from Newbear) which not only makes the Compukit dramatically more tolerant of cheap cassette recorders but allows 300, 600, 1200 and 2400 Baud recording and playback. 600 Baud seemed the highest speed Compukit would reliably load BASIC and I had accepted this limitation. I then fitted the new Monitor EPROM by Roger Cuthbert (sold by Comp Shop and now standard on UK101s). However, my Compukit would no longer load reliably at 600 Baud. Most of the time it would be all right but some long lines would fail to enter properly especially if a POKE instruction was split between screen lines.

The problem is solved with a combination of techniques. I can now load BASIC reliably at 2400 Baud with the Cottis Blandford interface. The first modification I tried was to run the CPU at 2MHz. Done simply by disconnecting pin 37 of the 6502 and connecting it to pin 13 of IC 29. You may be unlucky and find that some of your memory or the 6502 will not take the faster speed (a 6502A is rated at 2MHz) but try it—the modification costs nothing. The doubled clock rate halves execution times of programs. It also makes 600 Baud reliable again.



EG576 **Fig. 1. Simple switch for CPU clock. This can be mounted on a small circuit board near the CPU. The switch lead may be lengthy without ill effects**

In fact, I discovered that 2400 is possible. The problem is caused by the new Monitor's two dimensional cursor. When it reaches the bottom of the screen it takes much longer to decide what to do when it meets a Return: not only does it Return to the left, it will scroll the screen up until the top line is not blank which can be anything from 1 line to the full 16. Bypassing the screen print routine would seem to be the answer. A benefit would be greater security in programs like Hangman. Embedded answers would be concealed. The answer is in the advertised but undocumented CONTROL/O facility. This also allows tapes to be recorded in such a way that would disable the screen automatically without extra operations by the user. I have never managed to get CONTROL/O to do anything useful from the keyboard. You are supposed to be able to type CONTROL/O RUN (Return) and have the program running without RUN being echoed onto the screen. What you get is a syntax error. It can be avoided by the sequence COLON CONTROL/O (Return) RUN (Return). The program will then run but will not print anything unless it POKEs the screen directly. All in all, pretty useless until it comes to SAVEing programs. Instead of the normal SAVE/LIST routine add these lines to the end of your program.

```
6000 SAVE:?:?:CHR$(12):?:?:?
60010 ?":NAME OF PROGRAM loading":?:?":";CHR$(15)
60020 LIST -59999
```

and SAVE your program by RUN 60000. CHR$(12) is the screen clear. CHR$(15) is the code for CONTROL/O. Lines 60000 onwards will not be SAVEd. On *playback* the screen will blank and display "*name of program* loading" and nothing else until the OK at the end of the listing provokes a syntax error which will reactivate the screen. Using a 2MHz clock 1200 Baud becomes totally reliable and 2400 Baud will SAVE most programs. Even the most recalcitrant program will LOAD if extra NULLs are put in at the time of SAVEing. NULL 4 covers most programs NULL 8 has yet to fail using a 2MHz clock. Even with a 1MHz clock 12 to 16 NULLs will allow 2400 Baud. The extra NULLs do slow the LISTing but there is still a speed advantage. As an example here are timings for a 7K BASIC program.

1200 Baud	no NULLs	114 seconds
2400 Baud	no NULLs	57 seconds
2400 Baud	12 NULLs	74 seconds
2400 Baud	6 NULLs	65 seconds

This compares with 228 seconds for 600 Baud and 456 seconds for the original 300 Baud facility—a full 7 minutes and 36 seconds! Incidentally the NULL function can only cope with up to 8 NULLs but up to 255 can be put in using POKE 13, *number of nulls*. Apart from the screen clear this should work for the old monitor as well. A further elegance is to use the OK message printer to provide an auto run (see PE November 1980) by printing CR LF RUN : 15 CR LF—where 15 is the CONTROL/O character—instead of "OK".

A similar problem exists with machine code. The normal HEX format will LOAD quite happily at 2400 Baud but the Extended Monitor's checksum format will not; it is limited to 600 Baud at 1MHz because of the carriage return problem. The answer here is to prevent the cursor ever reaching the bottom of the screen!

This is done by removing the Line Feed at the end of each line and shortening each line to fit within a screen line. This is done by changing $ØEEB to $ØEEF to NOPs ($EA) to remove the LF, and changing $OECE to $12. This reduces the number of bytes of data in each block to 18 (dec) and each block now overwrites the previous one, making 2400 Baud loading possible.

Table 1. Changing user controls

LOC	FROM	TO	DESCRIPTION
OB70	OA	20	Increments memory display, changes function from LINE FEED to SPACE bar control
OB67	OD	20	This causes the program to exit the memory display and need only be changed if you want Return to be used for something else.
OB78	22	2E	Key used to display ASCII character at present SHIFT/2(") change to "."
099D	OD	OE	Sets number of lines in block when displaying disassembled listing. Change from 13 to 14
OD2F	OA	20	Key to disassemble next block. Change from LF to SPACE
OD87	3E	??	Key to indicate end of ASCII string using W routine ie W Compukit >0000,FFFF will find the start-up message in the BASIC ROM
OD46	3E	??	Key to indicate end of hex string. Similar to W
OFFD	4C	60	Change Jump to non-existent address to RTS. Makes Z block dump usable
OFDA	08	??	Sets number of addresses displayed in block in Z routine
OFFA	OA	20	Key to display next block in Z routine. Change from LF to SPACE

This allows the ASSEMBLER/EDITOR to be loaded in 75 seconds instead of nine minutes with the original 300 Baud cassette.

PROCEDURE

Load the extended monitor from the cassette supplied with the machine; it will self-execute. The first task is to change the operational controls. Table 1 shows the relevant addresses. Enter the memory examine mode by keying (SHIFT/P or SHIFT/Zero for CEGMON) and then the four HEX digits of the address; thus to change $OB70 type:
@OB70
the computer will display:
@OB70/OA
OA is the Hex value for 10_{dec} (ASCII LINE FEED)
Change this to SPACE by keying in 20. You will now find that pressing the SPACE bar causes the computer to print on the next line:
OB71/FO

It has incremented to the next location. Pressing Up arrow will decrement back to the previous location. If you prefer to use RETURN then OD should be entered; this will give increment and decrement keys next to each other. In addition, a different character will have to be put into $OB67 which is part of the exit routine.

The Table shows other locations where LINE FEED can be changed to SPACE. The number of lines printed at a time by the disassembler can be increased from 13 to 14 without the screen overflowing ($OD to $OE). If at any time you are producing a listing on a printer, this same location ($099D) can be changed to print, say, 55 lines to fit individual sheets of paper (or if you are using a roll to provide a space every 55 lines for subsequent cutting into sheets).

Table 2. Locations that need to be changed by hand to relocate monitor

LOC	FROM	TO		ROUTINE
1961	OB	1B	@	Memory examine and change
1963	OB	1B	A	Print contents of accumulator
1965	OC	1C	B	Install breakpoint
1967	OC	1C	C	Continue from last breakpoint
1969	OC	1C	D	Dump to screen
196B	OC	1C	E	Eliminate breakpoint
196D	OD	1D	F	Fill memory
196F		1B**	G	Execute from here
1971	OE	1E	H	Hex calculator
1973		1C**	I	Address last entered by breakpoint printed plus registers
1975	08	18	J	SPARE (Hex Dump)
1977	OB	1B	K	Print Stack Pointer
1979	OF	1F	L	LOAD in checksum format
197B	OD	1D	M	Move Block
197D	OD	1D	N	Search for Hex string
197F	OE	1E	O	Print Overflow from calculator
1981	OB	1B	P	Print Status
1983	OD	1D	Q	Disassembler
1985		1D**	R	Relocate
1987	OE	1E	S	SAVE in checksum format
1989		1C**	T	Print Table of breakpoint addresses
198B	08	18	U	SPARE (Save Loader in HEX format with Execute command)
198D	OF	1F	V	View cassette without loading
198F	OD	1D	W	Search for ASCII string
1991	OB	1B	X	Print X register
1993	OB	1B	Y	Print Y register
1995	OF	1F	Z	Block Dump
1997	OB	1B		IRQ Vector
1999	08	18		Used at start-up

** You will probably find that these will have been changed already by the Relocator as accidentally they have formed part of a valid code.

If you are using the routines suggested for U and J then the following changes need to be made.

RELOCATED	UNRELOCATED
1974 to $70	0974 to $70
1975 to $16	0975 to $06
198A to $77	098A to $77
198B to $16	098B to $06

SPARE ROUTINES

According to the instruction sheet J,U and Z are spare for use with additional routines. In fact Z can be the basis of a useful sectional dump, ideal for verifying entries visually. To make it work, the JUMP instruction at the end of the program must be changed to an RTS (change $OFFD from $4C to $60). If you now press Z and then key an address, the screen will print out that address and on a new line the contents of that address, and the seven following ones on one line. LINE FEED causes the address of the beginning of the next block to be printed on the next line and the next block of eight contents below it. Change

LINE FEED to SPACE by changing $0FFA. $0FDA controls the length of the block; changing it from $08 to $10 gives a single line of 16. Larger blocks are possible; $40 gives four lines of 16—my own preferred format (these are screen lines, a printer would see the output as one line of 64 contents). With larger blocks the screen starts to look messy as the screen spacing between the start address and the data increases until overflow. This is cured by eliminating two JSRs: change $0FCD-$0FD2 inclusive to $EA (NOP = No operation). For very large blocks also change $0FD4-$0FD6 to $EA. Z now gives a useful extra routine for no extra memory usage.

Routines U and J really are spare and I have used them to call HEX save routines. In the routine shown J is used to call a modified version of the HEX save routine in the manual. The zero page usage has been changed to make it compatible with the extended monitor allowing one of its subroutines to be used for entering the start and finish addresses. The format is Jxxxx,yyyy where xxxx is the Hex start address and yyyy is the end address the comma prompt is produced by the computer. (New monitor users should beware that the cursor must be below the "window" of the 6 digit ROM monitor display or errors will be introduced as the cursor crosses the "window".)

U is used to SAVE the extra routine and the checksum loader in HEX format. Its main use is to record the checksum loader, along with an execute command before a long routine is saved in checksum format. Thus to SAVE the monitor itself start the cassette and key U, when the loader has been recorded key S0800,1000 and the monitor will be SAVEd in checksum format. These routines do not work with, nor are they needed with CEGMON.

It is possible to record an execution instruction at the end. While machine code can be used I usually just use a short BASIC program.

100 SAVE:?:?:?"$0800":?:POKE 11,0:POKE 12,8:X = USR(X)

this is put in after a COLD START and MEMORY SIZE being answered with 1500 to protect the monitor.

RUN and you will be back in the Extended Monitor. The program can be saved as before, but when the checksum has been recorded press RESET W and RUN and the execute command for the monitor is on the tape without any interruption of the CUTS tone. The BASIC program will be destroyed if the Monitor's disassembler is used.

RELOCATION

The monitor can be relocated by using its own relocate facility and then changing the addresses in a look-up table shown in Table 2 for a change to the top of 8K of memory. This is sufficient to make the relocated monitor work. But some parts of other look-up tables are changed where they randomly produce valid code and so some errors may be introduced. So far they have not shown up when I have used the monitor, but beware. To be on the safe side follow the relocate instruction with a move instruction M1861 = 0861, 0960 to restore the main look-up tables.

LOADERS

The checksum loader used to load the Monitor is separate and different from the one within the Monitor. The one in the Monitor will only load and does NOT give an error message. The other ($0700–$07F0) gives an error message asking you to rewind tape past error and press G after starting the tape again. It also uses the $ sign as an execute instruction. As we have already seen $0800 will cause execution from 0800 hex. ★

```
0000        ; **************************
0000        ; **  EXTRA ROUTINE FOR   **
0000        ; **    THE COMPUKIT      **
0000        ; **   EXTENDED MONITOR   **
0000        ; **************************
0000        ;
0000        ;
0000        ;ROGER DERRY
0000        ; 1980
0000        ;
0670        *=$0670
0670        ;
0670        CRT=$FA57
0670        CASS=$FCB1
0670        ;
0670        ;These addresses are for new
0670        ; monitor.The old one for
0670        ; CRT was $BF2D
0670        ; CASS is unchanged
0670        ;
0670        ; USE EXTENDED MONITOR
0670        ; TO ENTER START AND
0670        ; FINISH FOR HEX SAVE.
0670        ; IE MONITOR COMMAND "J"
0670        ;
0670 201C0B JSR $0B1C
0673 209F06 JSR HEXSAV
0676 60     RTS
0677        ;
0677        ; ENTRY POINT FOR
0677        ; SELF SAVE AND PUT
0677        ; START COMMAND AT END
0677        ; IE MONITOR COMMAND "U"
0677        ;
0677 208F06 JSR SELSAV
067A A92E   LDA #$2E
067C 20F006 JSR CC
067F A907   LDA #$07
0681 20DE06 JSR AOUT
0684 A905   LDA #05
0686 20DE06 JSR AOUT
0689 A947   LDA #$47
068B 20F006 JSR CC
068E 60     RTS
068F        ;
068F        ; USES HEX SAVE TO SAVE
068F        ; $0670 TO $07FF
068F        ;
068F        SELSAV
068F A970   LDA #$70
0691 85DC   STA $DC
0693 A906   LDA #$06
0695 85DD   STA $DD
0697 A9FF   LDA #$FF
0699 85DE   STA $DE
069B A907   LDA #$07
069D 85DF   STA $DF
069F        ;
069F        ; MODIFIED HEX DUMP
069F        ; FROM COMPUKIT MANUAL
069F        ;
069F A90D   HEXSAV LDA #$0D
06A1 2057FA JSR CRT
06A4 207AFF JSR $FF7A ;10 NULLS
06A7 A92E   LOOP2 LDA #$2E ; "."
06A9 20F006 JSR CC
06AC A5DD   LDA $DD
06AE 20DE06 JSR AOUT
06B1 A5DC   LDA $DC
06B3 20DE06 JSR AOUT
06B6 A92F   LDA #$2F
06B8 20F006 JSR CC
06BB        ;
06BB A200   LOOP1 LDX #$00
06BD A1DC   LDA ($DC,X)
06BF 20DE06 JSR AOUT
06C2 A90D   LDA #$0D
06C4 20B1FC JSR CASS
06C7 A920   LDA #$20
06C9 2057FA JSR CRT
06CC        ;
06CC E6DC   INC $DC
06CE D002   BNE AA
06D0 E6DD   INC $DD
06D2 38     AA SEC
06D3 A5DE   LDA $DE
06D5 E5DC   SBC $DC
06D7 A5DF   LDA $DF
06D9 E5DD   SBC $DD
06DB 101A   BPL ADD
06DD 60     RTS
06DE        ;
06DE 85FC   AOUT STA $FC
06E0 20ACFE JSR $FEAC
06E3 AD64D1 LDA $D164
06E6 20F006 JSR CC
06E9 AD65D1 LDA $D165
06EC 20F006 JSR CC
06EF 60     RTS
06F0        ;
06F0        CC
06F0 20B1FC JSR CASS
06F3 2057FA JSR CRT
06F6 60     RTS
06F7        ;
06F7        ; EXTRA ROUTINE TO SEND
06F7        ; ADDRESS WHEN ADL=00
06F7 A900   ADD LDA #$00
06F9 E5DC   SBC $DC
06FB D0BE   BNE LOOP1
06FD 4CA706 JMP LOOP2
0700        END
```

D.C. POWER CONTROLLER

Michael Tooley B.A.

ALTERNATING current power controllers using silicon controlled rectifiers and triacs are now commonplace in both home and workshop. Such devices provide power control by allowing current to flow through the load for only a part of each cycle of the mains current. These arrangements are highly efficient and very little power is dissipated in the controller itself. There are a number of occasions when a similar high efficiency power control facility is desirable for use with equipment operating from a low voltage d.c. supply (eg: 12V car battery). One possible solution is the use of duty cycle control where current is allowed to flow through the load in a series of rectangular pulses. The duty cycle of these pulses (ie: the ratio of 'on' to 'off' time) can be made variable whilst the periodic time of the pulses (ie: 'on' plus 'off' time) remains constant. The *average* value of current flowing over one or more periods of the pulse waveform is directly dependant on the duty cycle and thus the load power can be controlled.

The circuit described provides for the efficient control of power from d.c. supplies in the range 5V to 15V. The output is rated at 5A maximum (maximum load power 55W from a nominal 12V supply) and can be varied over any desired range from zero to full output. Typical applications include the speed control of d.c. motors and dimmers for emergency and vehicle lighting systems.

DUTY CYCLE POWER CONTROL

The block diagram of a duty cycle power controller is shown in Fig. 1. This consists of an astable oscillator which has an adjustable duty cycle. The output of the oscillator which consists of a series of rectangular pulses is fed to the control input of a switching device connected in series with d.c. supply. The supply is thus interrupted in accordance with the pulses produced by the astable. The series switching device must be capable of handling the full rated output current and of switching at a fast enough rate to faithfully follow the control pulses. Any power dissipated in the series switching device is wasted and must obviously be kept to an absolute minimum. Fortunately the saturated switching action (ie: *fully* 'off' or *fully* 'on') ensures that the efficiency is very high since, in the 'on' state the voltage dropped across the device is very low whilst the current is high whereas, in the 'off' state the current is negligible whilst the voltage is high. Neither of these conditions results in any appreciable power wastage. The actual efficiency obtained depends upon a number of factors including the rise and fall times of the control pulses and the 'on' and 'off' resistances of the switching device.

CMOS ASTABLE CIRCUIT

A basic CMOS astable circuit is shown in Fig. 3. This simple arrangement consists of two inverters together with a resistor and capacitor. Assuming that initially the output of gate B is 'high' and the input of gate A will also be 'high'. Due to the inverting action of the gates, the output of gate A will then be 'low' and the capacitor will start to charge through the resistor. Eventually the input voltage to gate B will exceed its threshold value and its output voltage will then rapidly fall to zero as the gate changes state. This, in turn, causes the output of gate A to become 'high' and a positive going pulse is transferred through the capacitor to the input of gate B. This further re-inforces the change of state with the output of gate B in the 'low' condition. The capacitor now discharges through the resistor until it again reaches the threshold value at which point the circuit reverts to its original state. Since there is only one time constant in the circuit (C × R) the 'on' to 'off' ratio is approximately 1:1. In order to alter the duty cycle it is necessary to provide different charging and discharging time constants and this may be readily accomplished with the aid of two silicon switching diodes as shown in Fig. 4. The charging time constant of this arrangement is (C × R1) whereas the discharging time constant is (C × R2). The diodes merely provide a current steering function, selecting the appropriate resistor depending upon the state of the circuit. In practice the duty cycle may be adjusted over a very wide range (typically 100:1 or more) and time related waveforms for a near-unity duty cycle are shown in Fig. 5.

THE 4502

The i.c. used in the d.c. power controller is a CMOS tristate hex inverter. Whilst all six of the gates may be used independantly, separate Inhibit and Enable inputs are provided which are common to all of the gates. In normal operation the Enable and Inhibit inputs (pins 4 and 12 respectively) are connected to 0V. Alternatively, if the Enable input is taken to +V all of the inverter outputs float and effectively become open circuit or, if the Inhibit input is taken to +V all of the outputs become 0V. This latter facility is used in the d.c. power controller to override normal gate operation and set the final output (after a transistor inverter) 'high'.

CIRCUIT DESCRIPTION

The complete circuit of the d.c. power controller is shown in Fig. 6. The astable formed by IC1 and associated components has a duty cycle which can be varied by means of VR1.

SPECIFICATIONS

Input voltage range:	5V to 15V
Output voltage range:	5A maximum
Load power:	55W maximum
Control range:	Zero to full-output or pre-set
Switching frequency:	1·8kHz
Efficiency:	90% at 12V input and 2·5A load current

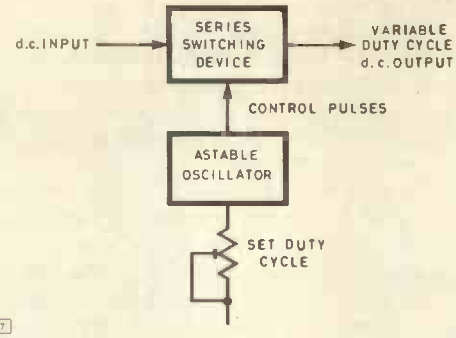


Fig. 1. Block diagram of duty cycle power controller

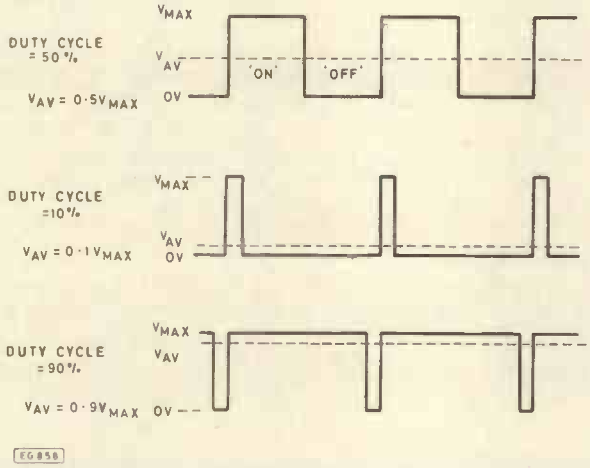


Fig. 2. The effect of various values of duty cycle on the average value of voltage present

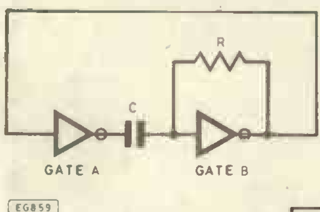


Fig. 3. Basic CMOS astable circuit

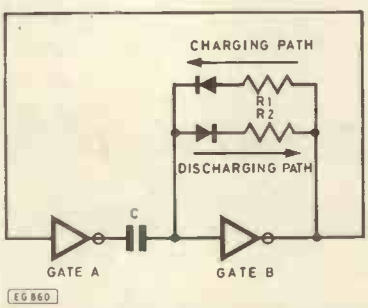


Fig. 4. CMOS astable with unequal duty cycle

Two pre-set resistors, VR2 and VR3, are used to determine the minimum and maximum output duty cycle respectively and hence the range of adjustment which can be obtained by means of VR1 can be modified accordingly. To obtain the full range of control both pre-sets should be in the minimum resistance position and, in applications where the widest possible range of adjustment is desirable, they may be replaced by short circuit links. Alternatively where only a single reduced power setting is required VR1 may be replaced by short circuit links and the output is then pre-set by means of VR2 and VR3. The series switching device is a Darlington power transistor operated in common emitter mode with the load connected in its collector. A fuse is included for protection and an l.e.d. is incorporated in order to provide a rough indication of the state of the output.

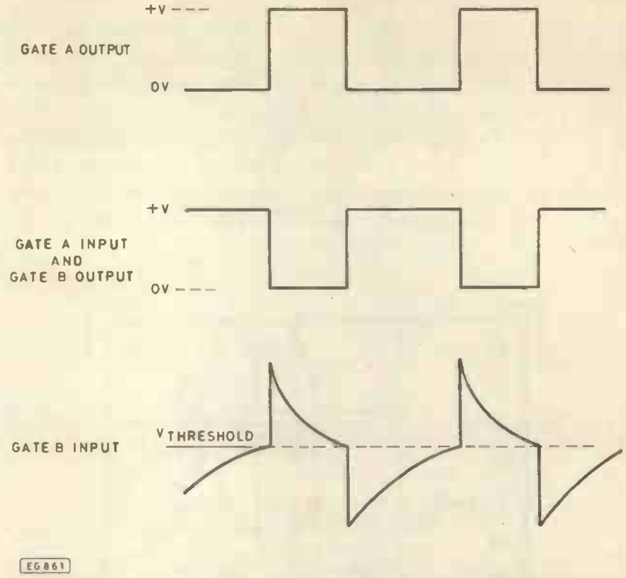
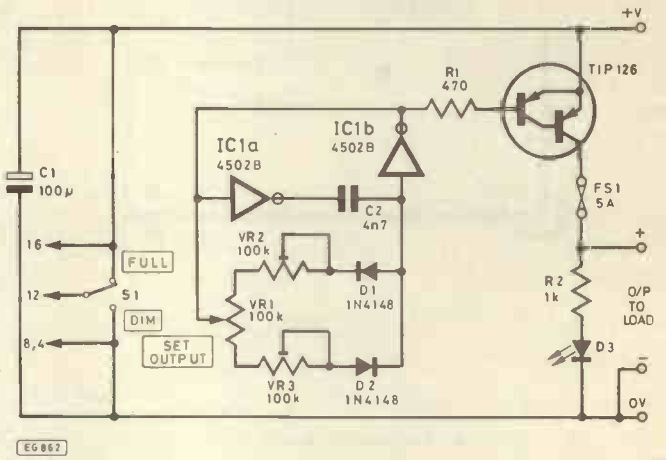


Fig. 5. Waveforms for a CMOS astable oscillator

Fig. 6. Full circuit diagram



CONSTRUCTION

The power controller is built on a small single sided p.c.b., the foil layout of which is shown in Fig. 7. The corresponding component layout (on the top side of the p.c.b.) is shown in Fig. 8. The use of a 16-pin d.i.l. socket is recommended for IC1 as this readily facilitates removal of the device in the event of failure. The power Darlington, TR1, requires a heat sink at least 10·5°C/W for output currents of up to 2·5A. Above this value a heat sink of 4°C/W is recommended. In the former case the heatsink may be secured to the p.c.b. using the same nut and bolt (M3) which retains TR1. Insulating washers and bushes are thus not required. In the latter case the heatsink may be external to the p.c.b. with the transistor connections consisting of three short flying leads. The metal tab of the TIP126 is connected to the collector and hence it may be necessary to insulate the tab from the heatsink in applications where the heatsink is to mounted directly upon a metal chassis. Good thermal contact between the transistor and heatsink is essential in either case. Care should be taken to ensure the correct connection of the polarised components and it is recommended that assembly be made in the following sequence; i.e. socket, fuseholder, resistors, diodes, capacitors, pre-sets, transistor and heatsink. Connections to the p.c.b. are made using terminal pins which are a push-fit and then soldered to the copper foil.

When the p.c.b. assembly is complete it should be carefully checked for dry joints and solder bridges between tracks. The p.c.b. is then mounted in the base of the case to which the controls and l.e.d. have been fitted. The wiring diagram for the p.c.b. and controls is shown in Fig. 9. When the wiring is complete the 5A fuse should be inserted in the fuseholder and the entire assembly should be carefully checked before connecting to the supply. Note that the supply input and output wiring should be capable of carrying the full load current of at least 5A.

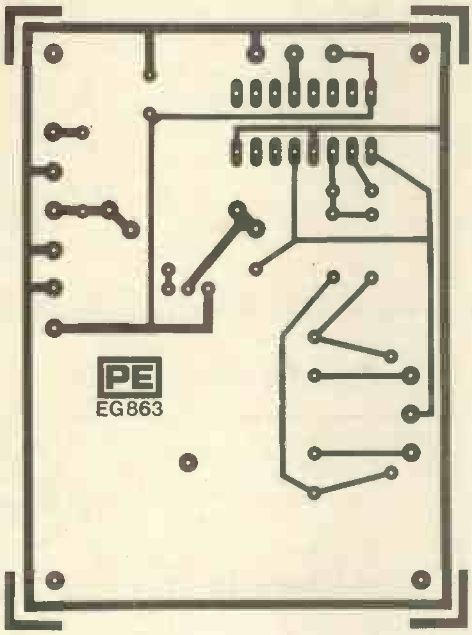
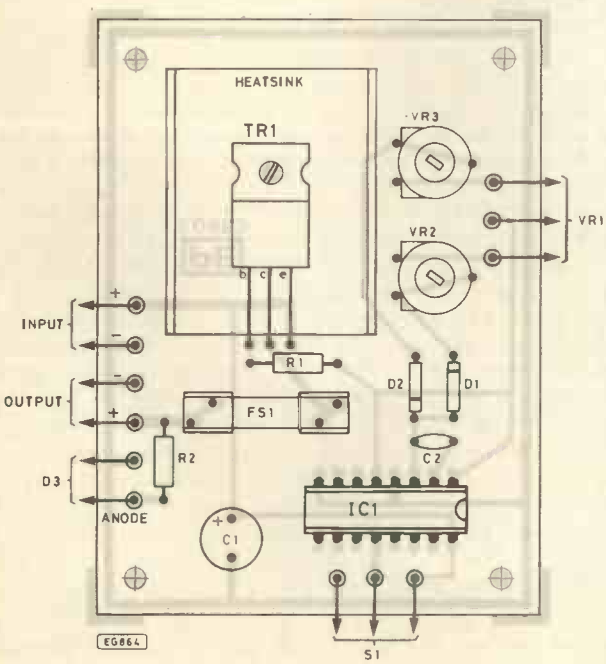


Fig. 7. Printed circuit layout (actual size)

Fig. 8. Component layout



TESTING

Connect a 12V d.c. supply to the input of the power controller. The supply should preferably be current limited at around 1A but, if this facility is not available, a 1A fuse can temporarily be fitted in the positive supply lead during the initial testing. With S1 in the 'full' position the output l.e.d. indicator should be brightly illuminated and the brightness should not vary with the setting of the output control, VR1. Set VR2 fully anti-clockwise and VR3 fully clockwise then select the DIM position of S1. The l.e.d. brightness should now vary from zero to full over the entire range of adjustment of VR1. Now set VR2 fully clockwise and VR3 fully anti-clockwise. The l.e.d. brightness should now be somewhat reduced and should vary over only a small range as VR1 is adjusted.

Connect a 12V lamp of 6W rating to the output of the controller. The previous checks should be repeated and the brightness of the lamp load should be seen to vary accordingly. Note that switching from the 'dim' to the 'full' position of S1 should always restore full brightness regardless of the setting of VR2, VR3 or VR1. This completes the testing and the power controller is now ready for use.

APPLICATIONS

One obvious application for the d.c. power controller is that of dimming the lights fitted to a vehicle. These should be rated at no more than 55W but, where several lamps are to be controlled simultaneously, the Darlington output stage can be duplicated in order to permit a maximum power of 55W in each load as shown in Fig. 10. The dimmer may be

COMPONENTS . . .

Resistors

R1	470 ohm $\frac{1}{4}$W
R2	1k $\frac{1}{2}$W
VR1	100k lin. carbon pot.
VR2	100k hor. min. skel. preset
VR3	100k hor. min. skel. preset

Capacitors

C1	100µ 16V p.c. mounting
C2	4n7 ceramic plate or disc

Semiconductors

D1, D2	1N4148 (2 off)
D3	Red l.e.d.
TR1	TIP126
IC1	4502B

Miscellaneous

S1 SPDT toggle or slide switch
P.c.b.
P.c.b. fuseholder or fuse clips
5A 20mm fuse
Heatsink (see text)
ABS case
16 pin d.i.l. socket

Constructors Note

Components and p.c.b. available from **Howard Associates,** 59 Oatlands Avenue, Weybridge, Surrey, KT13 9SU.

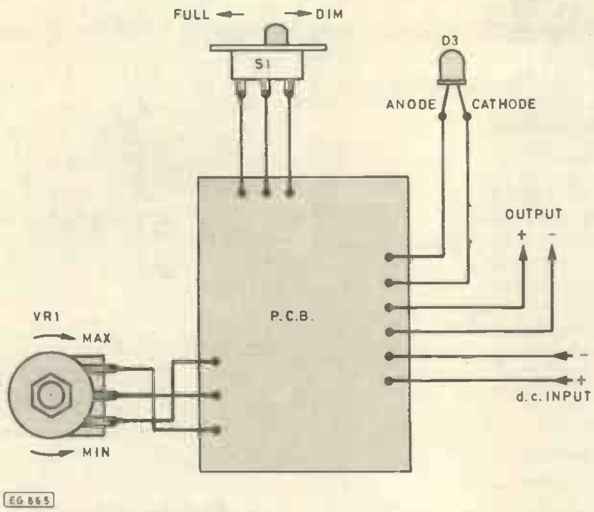


Fig. 9. Wiring diagram for the power controller

fitted to interior lights, spot-lamps or fog-lamps and also to dipped (or 'half-beam') headlamps in order that they may be operated in a reduced brightness condition during conditions of marginally impaired visibility (eg: light mist, twilight, or drizzle). Such a facility ensures that the vehicle is readily visible whilst eliminating the unpleasant dazzling of oncoming drivers which may otherwise occur. Many motorists will agree that, under certain conditions, dipped headlights are too bright whilst sidelights can be inadequate. The power controller helps bridge the gap between the two and furthermore the change to full brilliance can be made at the flick of

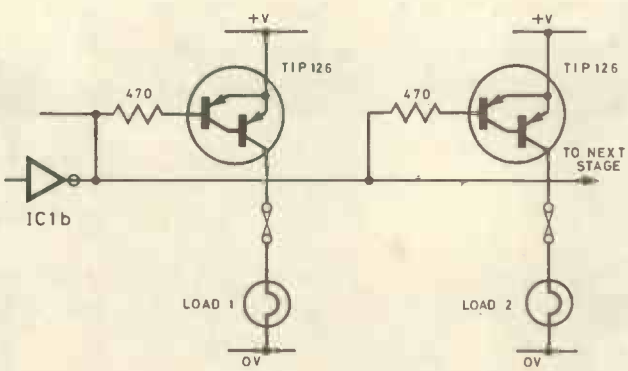


Fig. 10. Method of driving two (or more) loads

a switch without reverting to the variable control. If a single dimmed position is all that is required the three connections to the variable control, VR1, are simply linked together and the desired brightness adjusted by means of VR2 and VR3. Another use for the controller is when a high intensity light is to be used for background illumination or as an inspection lamp. In this case the power controller not only reduces the lighting to a suitable level but also helps reduce the load on the battery. Small d.c. power tools (including 12V p.c.b. drills) can be controlled provided they require no more than 5A from a nominal 12V supply. Similarly 12V soldering irons can be kept running at low heat and will quickly return to full temperature when the power controller is switched to full. The model maker can use the unit to provide variable motor speed control with the added bonus of prolonging battery life when an a.c. power supply is not available. ★

FRANK W. HYDE

THE SHUTTLE

Readers will have had a continuous briefing on the recent Shuttle mission named Pathfinder which had the task of evaluating the extent of the Shuttle's capability to deal with fundamental Scientific tasks. All the nine experiments of the special package were United States derived with the exception of one. This was the one designed and built by the University of Kent at Canterbury, it is known as the Microabrasion Foil Experiment (MFE). It will test a new method of analysing micrometeorites and cosmic dust, including material from comets, with the aim of improving understanding of the solar system. The experiment was funded by the Science and Engineering Research Council.

THE IMPORTANCE OF A COMET

A new move in an attempt to cover adequately the return of the Halley comet has now come from America. A group of officials from The National Aeronautics and Space Administration have met to discuss the possibility of diverting a satellite already in orbit to intercept a short period comet, Giaconbini-Zinner, in order to gather data that could be of use when the Halley encounter is made. This mission could provide data at least six months earlier before the Halley encounter.

It is proposed that the International Sun-Earth Explorer craft should undergo a trajectory change that will enable a Lunar swing by to put the ISEE within 186 miles of the comet nucleus on September the 11th or thereabouts, in 1985. The spacecraft could gather data about particles and the field conditions of the comet and also measure the extent of the solar wind which could possibly be disturbed by Halley.

It would seem that there has been a wealth of data, which has passed un-noticed, thrown up from the imaging of Giaconbini-Zinner by Elizabeth Roemer of the University of Arizona. She noted that this comet 'was unusually dusty for a short period comet and would appear to be more active than others'. The comet has a period of 6·5 years. Another point about it is that it is associated with the Draconid meteor shower. Roemer's findings wholly justify a visit in its own right. These circumstances have combined to make it possible for a proposal to be made for which the cost will be considerably below the amount that NASA were originally expecting with the full scale Halley Mission.

The reason for the capability of the ISEE 3 to perform this special change of activity is the manoeuvring propellant from Earth and circling above and below the ecliptic plane at something of the order of 93,000 miles every six months. This vehicle is the first that has ever been parked in the 'Halo Orbit' at a libration point where the gravitational equilibrium exists between the Sun, the Earth and the Moon. Data about the solar wind has been returned and this is being combined with other data from satellites nearer to Earth to provide a warning of changes that might affect other Air Force activities.

The amount of cometry data that can be usefully gained is of course limited since it has no imaging capability. About half the payload of instruments could be useful. The others can be shut down thus conserving some energy. However studies of the plasma densities and speeds of flow could be recorded. Indentification of some of the heavy ions could be made and the magnetic field level direction in vicinity could be recorded. Useful data is to be gathered about the Earth's Tail which may contain unusual particles and field orientation. This is expected to be in the region of 80–250 radii. The early swing by for the Lunar manoeuvrer in March 1983 would improve the data acquisition from the Earth's tail and then the next lunar swing by on January 1st 1984 would fling the vehicle away from Earth toward the intercept point. During these activities the spacecraft would pass within 12,500 miles of the Moon's surface. The actual intercept date is likely to be September 11th 1985.

The greatest cost of the modification is likely to be in the tracking facilities. The deep space tracking station in Australia would lose contact with the spacecraft since the tilt of the Earth would be wrong at that time of the year. However, the Arecibo 1,000 feet diameter telescope at Arecibo which is expected to be doing radar scans of the comet anyway would be ideally placed. Following this point of intercept the spacecraft would then come back in a trajectory within one degree of the Sun line to Halley's comet. There is little that the spacecraft could do in regard to Halley's comet yet no doubt the mission would be worthwhile.

THE SECOND LANDING ON VENUS

On March 5th the USSR Venera 14 landed on Venus. The type of terrain was quite different from that of the area where the other Venera spacecraft landed. Venera 13 showed no signs of the harsh and jagged rocks on its area of landing. It was clear that this lander which arrived four days earlier than Venera 14 was in an area which suggested weathered foothill surface. Some small craters could be seen. These were no larger than potholes covered with hillside debris.

The pictures from the Venera 14 site showed large thick boulders of dark grey rock and apparently of cellular texture suggesting chemical erosion.

The areas between the rocks appear to be of a brownish black fine grained material. Data received from the landers seems to indicate that the sky is orange brown or reddish and the result of a reflection of the colour of the Venusian surface. The process that may be taking place is similar to that on Mars. There is some photochemical disassociation of water and carbon dioxide with the oxygen getting bound up in the rocks. Analysis of the rock shows that 60 to 70% of the planet's surface is covered with an ancient basalt melt. There is evidence of highly alkaline potassium basalts that are the prevalent components of Venus. These do not appear on the Earth's surface according to Soviet belief. There seems to be a measure of disagreement here. However the full revelation of the data will not be made till later. There are claims that the Soviet statement is not quite true and that although rare these basalts have been found on the Earth's surface. Generally the hopes for these two landers were not as special as was expected. Venera 14 did transmit data for 57 mins after landing and this included chemical data derived from drilling surface material and depositing it in the X-ray fluorescence analysis chamber.

There is now a revival of interest for the original radar imaging plan for Venus. This was removed from the 1983 budget. It is now suggested that a modified mission might be attempted. Called the Venus Mapper Spacecraft it would be placed in a 3·3hr. elliptical orbit round the planet. At its lowest altitude the height would be of the order of 250km. At its highest it would be about 8,000km. It would have a pole to pole sweep about 26km wide. This would give a varying height of pass between 250km and 2,000km. The change in height would not affect the resolution, so it is said. To arrive at the essential requirements such items as 75 metre resolution requirements would be dropped and in a number of cases ordinary airflight instruments might be used.

NASA DROPS BACKUP CREW SYSTEM

Nasa has now put into operation a new system for crews. It now intends to nominate prime crews well in advance of the missions to be undertaken. This change of attitude has grown out of the fact that so many astronauts have flown the shuttle or are so highly trained that they could take over immediately in the event of a prime crew member not being fit.

Another reason for this move is that the shuttle flights have to become much more frequent as the turn round time is reduced to accommodate the time already sold.

It has become increasingly clear that the shuttle must reduce to the original concept and that is that it will have to follow the pattern of normal flight processes, albeit at a higher technological level. It is also a requirement if the fiscal success is to be achieved and the way made free for the vast commercial expansion of the use of space for the benefit of all mankind.

PROGRAMMABLE TIMER/CONTROLLER

T. J. JOHNSON PART TWO

AS mentioned in the introduction last month, the system has a capacity of 18 "timer sets". A timer set is simply a string of instructions which tells the micro-computer the number of the switch, which day of the week and at what time the switch should be turned on or off.

All 18 timer sets can apply to just one switch on one day in a 7-day cycle or to four switches on just one day or two switches on three days etc etc. The number of variations is very large and it can be seen that the applications for such a system are endless.

However the first function to be programmed is actually setting the clock.

CLOCK SETTING

A typical keyboard sequence for setting the clock would be:

WED WEEK* AM 3 0 0 CLK

which would start the clock at 3:00 AM on a Wednesday. For other times and day of the week the key sequence is always the same. The day of the week is registered by operating the WEEK key. Either the AM or PM key is pressed for the time of the day, and then the actual time is entered. The clock will not actually start until the CLK key is pressed, this makes it very easy to synchronise the display with another clock or time signal.

Note that all times must be entered in the 12 hour system to avoid errors. The timer will convert times in the 24 hour system but the AM/PM selection will not operate. For example if a time of 18:45 is entered, the timer will convert this to 6:45 but it will not change the AM or PM indication to match.

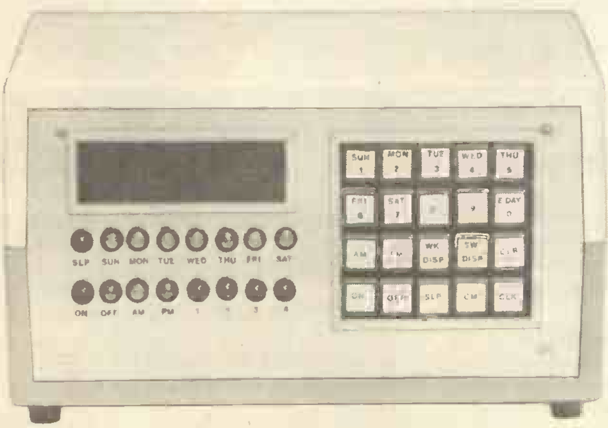
** The "WK DISP" key should of course be used here, and in subsequent programs.*

FIXED TIME PROGRAMS

A fixed time program will change the state of a switch when the clock reaches the time programmed. For example:

1 SW TUE WEEK AM 7 1 5 ON

would turn switch 1 on at 7:15 AM on Tuesday and every subsequent Tuesday.



Keys 1 2 3 4 select the required switch number and are entered by the SW key. The day and time are in the same order as for setting the clock. The last key pressed assigns a particular function to that switch. Either: ON, OFF or SLP (Sleep).

OVERLAPPING PROGRAMS

Several programs may be overlapped in time. However, if a number of different functions are programmed to occur at the same time, all except the last program entered is ignored. For example:

2	SW	WED	WEEK	PM	2	0	0	ON
2	SW	WED	WEEK	PM	2	0	0	OFF
2	SW	WED	WEEK	PM	2	0	0	ON

the overall result would be that switch two would be turned on at 2:00 PM on Wednesdays.

A variation on the above would be where the programmed time is the same, but the day of the week is different. For example:

3	SW	E DAY	WEEK	AM	5	0	0	ON
3	SW	SAT	WEEK	AM	5	0	0	OFF

would turn switch three on at 5:00 AM on every day of the week except Saturday, when the switch would be turned off.

Programs may also be entered where the day of the week is the same but the time is different. For example:

4	SW	MON	WEEK	PM	5	0	0	SLP
4	SW	MON	WEEK	PM	4	4	5	OFF

this set of programs would turn switch four off at 4:45 PM on Monday instead of 5:00 PM.

DIRECT SWITCH CONTROL

Any of the four switches may be operated directly via the keyboard. The standard key sequence would be:

3 SW ON

which would turn switch three on as soon as the ON key was pressed. The switch would therefore remain on until it was turned off by the sequence:

3 SW OFF

The SLP key may also be used in direct switch control programs, in these cases the switch would be turned on and then turned off one hour later. None off these direct programs are stored in the memory, and all are independent off any pre-programmed sequence assigned to that switch.

As they key sequence is entered, the display and l.e.d. indicators display the program setting. All indications can remain on display without halting the operation of the timer or clock. Any switch already programmed will switch on or off as required without altering the display status.

To return to real time, the CLK key is pressed and the current time and day is displayed.

If the next program is completely different, for example a different switch is to be used, then a similar set of key operations as before is required to enter that program in the memory. If however, the switch and day of the week are the same, then a shortened key sequence can be used. For example:

1 SW TUE WEEK AM 7 3 0 ON—Normal key sequence
AM 8 0 0 OFF—Shortened key sequence
would turn switch one on at 7:30 AM and then off at 8:00 AM on each Tuesday. A number of these shortened key sequences can be used to program several functions of the same switch on the same day.

It is important to note that each sequence counts as one timer set. To program the same action of switch one to occur on each day of the week the E DAY key is used in place of the day of the week key in the above examples. Example:

1 SW E DAY WEEK AM 7 1 5 ON

would turn switch one on every day at 7:15 AM.

From the above it can be seen that the ON and OFF keys switch the programmed switch on or off at the pre-programmed time, a third function key is available and is designated SLP (Sleep). This key differs from the other two in that it will switch on a switch at a certain time and then turn that switch off exactly one hour later. For example:

2 SW WED WEEK AM 7 0 0 SLP

would turn switch two on for one hour beginning at 7:00 AM on Wednesday.

INTERVAL PROGRAMS

In an interval program, only the switch number and the time interval is entered. The function, either ON, OFF, or SLP is performed after the time interval has passed. For example:

4 SW 3 4 0 ON

would turn switch four on, after three hours and forty minutes has elapsed. As with fixed time programs, a shortened key sequence may be used.

PROGRAM DISPLAY

Programs which are stored in the memory can be re-called and displayed using the SW/DISP or WK/DISP keys. For example the key sequence:

2 SW/DISP SW/DISP

displays the programs for switch number two. Note that the SW/DISP key must be pressed twice before the program is displayed. Successive programs for the same switch are displayed every time the SW/DISP key is pressed twice. A similar key sequence is used to display the programs for the remaining three switches. Programs for a specific day of the week are displayed in a similar manner except this time the WK/DISP key is used. For example a typical key sequence would be:

WED WK/DISP WK/DISP

the display would then show, with every second successive depressing of the WK/DISP key, all the programs entered for that day. The display would thus indicate the switch number, and whether the switch would be on or off at the time shown. The day of the week l.e.d. would of course be already illuminated. Programs which have been entered to occur each day are re-called in a similar manner but using the E DAY key. For example:

E DAY WK/DISP WK/DISP

would show all the programs which were entered with the E DAY key. Once again two depressions of the WK/DISP key are required to show each program.

When programs which use the SLP function are displayed, the display changes with the progress of the program. For example the program;

2 SW FRI WEEK AM 6 0 0 SLP

would turn switch two on for one hour beginning at 6:00 AM on Friday.

Before the program is executed, the indication would show it as a SLP program. The l.e.d.s would indicate switch two, Friday, SLP, AM, and the display 6:00. However between 6:00 and 7:00 AM when the switch is on, the display would indicate switch two, Friday, AM, OFF and 7:00. After this time the display would return to the original SLP settings.

Thus each time the switch state of a SLP program changes the display is updated to show the next change in state of the switch.

PROGRAM ERASING

Programs entered in the memory can be cleared entirely or selectively by using the CM key. When this key is pressed twice, all programs stored in the memory are erased. Programs for individual switches or days of the week can be cleared without affecting any other programs in the memory. For example the key sequence:

2 SW CM

will erase all programs relating to switch number two. The following key sequence would clear all programs entered for Wednesday:

WED WEEK CM

Programs which have been stored using the E DAY key are erased using that key in place of the day of the week.

PROGRAMMING ERRORS

The four digit display will show the error indication of 99:99. This error indication occurs if the key sequence is incorrect, or if a program is entered with an invalid time. The clock and timer operate both in the 12 hour system, so it is therefore important to convert any time settings from the 24 hour system to the 12 hour system.

The timer will accept times entered in the 24 hour system, and will convert the time to the 12 hour system. Note however, the AM/PM display will not be affected, thus resulting in programs which seem to be correct but are of course invalid. The indication of 88:88 on the display occurs if an attempt is made to store more than 18 programs (timer sets).

During programming, errors may be corrected by several methods. Depressing the CLK key will display the current real time and at the same time will erase any attempted program which have not yet been completed or stored in the memory. The CLR key is used during the course of programming, and is pressed when a known error has just been made. An example here, is when the time 6:46 has just been entered when it should have been 6:45. The CLR key is pressed and erases all which preceded it.

APPLICATION AND EXAMPLES

Before giving one or two examples it is important to realise the maximum power which is available. When the unit is connected to a standard 13A mains socket, the maximum power available is 3120W (13A). As we are using four outlet sockets this means that the maximum power available at each socket is 780W (3·25A). Obviously, not all the sockets are going to be in operation at the same time, thus it is feasible to connect appliances which require more than the 780W available at each socket, providing the maximum power is not exceeded. Note also for safety reasons the maximum power which can be taken from each socket is 1440W (6A— the rating of the sockets/plugs). The relays used in the design can handle this sort of power quite easily, as their maximum rating is 10A.

EXAMPLES

A simple example to start with. It is required that a radio be switched on at 7:00 PM and switched off half an hour later. At the same time a tape recorder is required to switch on and record the half hour program. The recording needs only be done on Saturdays. A program for the above would be:

1	SW	SAT	WEEK	PM	7	0	0	ON
(Recorder)				PM	7	3	0	OFF
2	SW	SAT	WEEK	PM	6	5	9	ON*
(Radio)				PM	7	3	0	OFF

*(To allow the radio to warm up!)

Thus, on every Saturday the Radio would switch on one minute early to warm up, then at 7:00 PM for half an hour the recorder would record the program and then at 7:30 PM both would turn off. Simple isn't it!

One of the most useful applications of a programmable timer is in home security. A typical example for controlling say two appliances, thus enabling a wide range of on/off times to be achieved so the pattern cannot be recognised could be as follows: (One switch for a downstairs light, and one for the TV or hi fi).

1	SW	MON	WEEK	PM		6	1	7	ON
(Lights)				PM	1	1	0	8	OFF
1	SW	TUE	WEEK	PM		6	5	6	ON
				PM	1	1	3	5	OFF
1	SW	WED	WEEK	PM		5	5	9	ON
				PM		9	3	8	OFF
1	SW	THU	WEEK	PM		6	5	1	ON
				PM	1	1	4	5	OFF
1	SW	FRI	WEEK	PM		7	0	8	ON
				PM	1	1	2	6	OFF
1	SW	SAT	WEEK	PM		8	5	2	ON
1	SW	SUN	WEEK	AM		2	2	8	OFF
1	SW	SUN	WEEK	PM		7	5	3	ON
				PM		9	4	5	OFF
2	SW	E DAY	WEEK	PM		7	1	9	ON
(TV/HI FI)				PM	1	1	5	0	OFF
2	SW	SAT	WEEK	PM		9	3	7	OFF
2	SW	WED	WEEK	PM	1	0	5	2	OFF

A total, and in fact the maximum number available, of 18 timer sets. Note, that for a home security system, we must give preference and the widest variation to the lights. After all it is the house that is well lit that is usually avoided by potential burglars. Sound of course plays a great part and the remaining timer sets available give a reasonable appearance that the house is in fact occupied. Of course, if you had two Programmable Timer/Controllers, the number of appliances (lights for example) can be increased as well as the variation between them. For example, one timer controller can be used to control the lights for say Monday to Thursday, while the other can control the lights from Friday to Sunday.

Finally, some constructors might be interested in a more practical example. As with all program listings we must first write down exactly what we require.

First is the central heating, this must be turned on say, an hour before you come home on most days except Saturday and Sunday when we can turn the heating on earlier. Next is the radio/tape recorder which is a half hour program beginning at 2:00 PM Monday to Friday. The television is required to turn on at home-coming time, 5:30 PM and then turn off at, say 11:50 PM, except on Sunday. The kettle must of course be boiling by the time you arrive home, so say we turn it on at 5:27 and allow it to boil for 3 minutes. The program listing is:

Switch allocation: Switch 1—Central heating
2—Radio/tape recorder
3—Television
4—Kettle

1	SW	E DAY	WEEK	PM		4	3	0	ON
				PM	1	1	0	0	OFF
1	SW	SAT	WEEK	AM		8	0	0	ON
1	SW	SUN	WEEK	AM		8	0	0	ON
2	SW	E DAY	WEEK	PM		2	0	0	ON
				PM		2	3	0	OFF
2	SW	SAT	WEEK	PM		2	0	0	OFF
2	SW	SUN	WEEK	PM		2	0	0	OFF
3	SW	E DAY	WEEK	PM		5	3	0	ON
				PM	1	1	5	0	OFF
3	SW	SUN	WEEK	PM		5	3	0	OFF
				PM		7	0	0	ON
4	SW	E DAY	WEEK	PM		5	2	7	ON
				PM		5	3	0	OFF
4	SW	SAT	WEEK	PM		5	2	7	OFF
4	SW	SUN	WEEK	PM		5	2	7	OFF

In all, a total of 16 timer sets are used. Note in one or two of the switch programs, we must cancel the ON times when the switch is not required to switch on (say Saturday and Sunday). The clearest example is in the case of the kettle. Obviously it is not required to turn on at 5:27 PM on both Saturday and Sunday. Thus we cancel that instruction by providing the micro-computer with two instructions to be performed at the same time.

BATTERY BACK-UP UNIT

Some constructors may feel that a battery back-up system would be useful in the event of a mains supply failure. The following circuit can be conveniently built as an add-on unit with very little modification to the original Programmable Timer/Controller.

CIRCUIT DESCRIPTION

The complete circuit diagram for the back-up unit is shown in Fig. 1.

IC1 acts as a comparator, which compares the relatively stable reference voltage of the Zener diode with that of the input voltage, V_{in}. This voltage can be between 12 and 16V depending on the components used in the power supply.

In its stable state, where V_{in} is present and is higher than the voltage of the Zener diode, the output of IC1 is normally high. Thus TR1 is turned on and the relay is energised. This allows the input voltage V_{in} to be passed to the remainder of the power supply. Reference to Fig. 4 will make this clear and show the connections required.

If for any reason the mains supply should fail, V_{in} will no longer be present, thus the voltage at pin 3 falls, the output of the i.c. goes low, TR1 turns off and the relay de-energises (contacts as shown in Fig. 1). In this position, the relay contacts connect the ni-cads into circuit and a d.c. voltage to the power supply is maintained.

Reference to Fig. 4 will illustrate an important function of the back-up circuit which is to effectively "blank" the display and l.e.d.s. As can be seen from the diagram, when the back-up is connected into circuit only the 9V regulator receives the battery voltage. No voltage appears on the 12V line, thus the displays are effectively turned off.

This arrangement is not perfect however, in practice the display and l.e.d.s are illuminated but only faintly. However, as we shall see later the displays and l.e.d.s can be turned off completely thus saving battery power.

The remainder of the circuit is the battery charger, this is a fairly simple arrangement which keeps the batteries "topped up" rather than charging them at their full rate.

TR1 and associated components form the charging circuit, together they provide a constant current of between 1 and 3mA to keep the ni-cads trickle charged during normal mains operation.

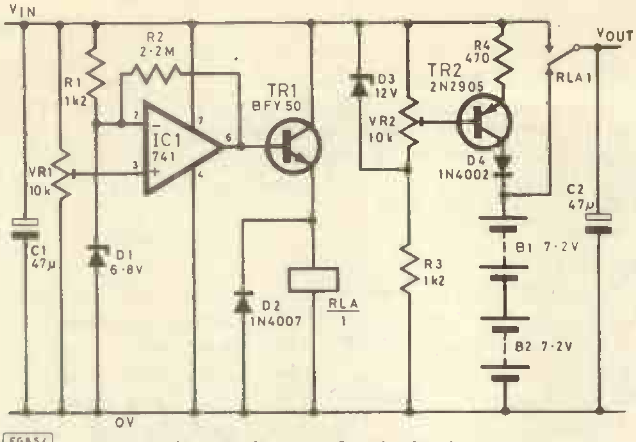


Fig. 1. Circuit diagram for the back-up unit

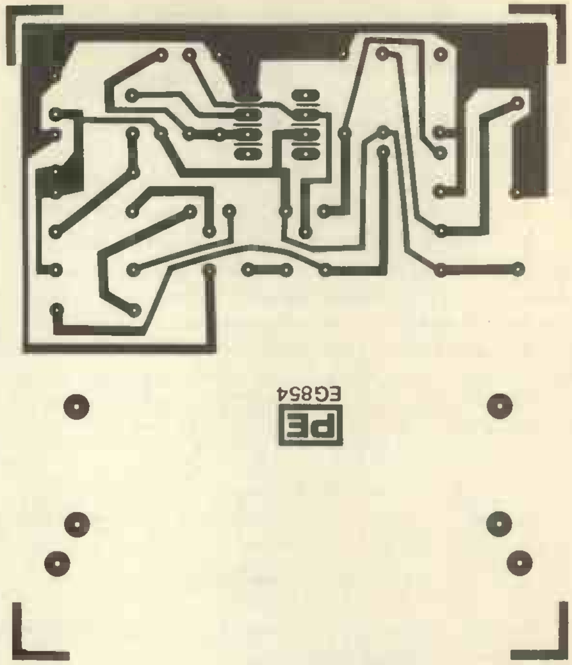


Fig. 2. P.c.b. design

CONSTRUCTION

Construction is quite straight-forward, the entire circuit being constructed on a small p.c.b., the track layout is shown in Fig. 2 and the component layout is shown in Fig. 3.

The p.c.b. has been designed such, the ni-cads can be mounted on the board thus making the back-up unit completely self-contained. All components are standard and should present no problems when buying. Once construction is completed and before continuing, adjust the wipers of VR1 and VR2 to about $\frac{3}{4}$ rotation clockwise.

CONNECTION TO THE TIMER

Connect the V_{in} and OV wires from the back-up unit to convenient points on the power supply board, say across C1 (see Fig. 4). Next, unsolder the input lead of the regulator and position the lead well away from the heatsink. Connect the V_{out} lead from the back-up to this lead, preferably sleeving the connection. No other connections are required and the unit can be tested.

TESTING AND ADJUSTMENT

At this stage the ni-cads should not be connected. Connect the Timer/Controller to the mains and switch on, the relay should not operate. Assuming it does not, rotate VR1 wiper anti-clockwise until the relay does operate. It may be found that the relay "chatters", if this is the case continue rotating the wiper until the relay operates cleanly.

Check that the relay operates cleanly by repeatedly turning off and on the mains supply. If the relay still chatters, then rotate the wiper slightly further anti-clockwise. It is important to get this adjustment correct to ensure trouble free operation later on.

If an ammeter is available connect the leads between B1 positive and B2 negative. Adjust VR2 to give a reading of between 1 and 3mA. If no meter is available then leave the

COMPONENTS . . .

Resistors

R1, R3	1k2 (2 off)
R2	2M2
All $\frac{1}{4}$W 5% carbon	
VR1, VR2	10k hor (2 off)

Capacitors

C1, C2	47µ 25V electrolytic (2 off)

Semiconductors

D1	BZY88C6V8 6·8V Zener
D2	1N4007
D3	BZY88C12 12V Zener
D4	1N4002
TR1	BFY50
TR2	2N2905
IC1	741

Miscellaneous

RLA 12V 320 ohm coil 1 pole change over (Electrovalue SMR12)
B1,B2 PP3 size ni-cads.
Battery connectors, printed circuit board.

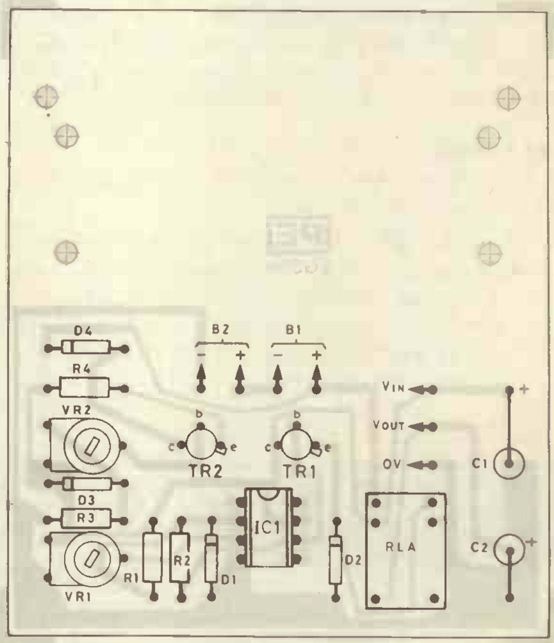


Fig. 3. Component layout

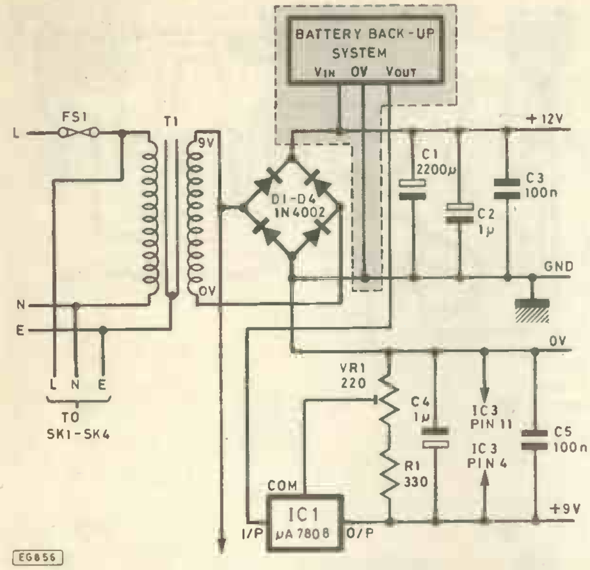


Fig. 4. Connection diagram

wiper about $\frac{3}{4}$ clockwise, this should give approximately the correct charging current.

Finally connect the ni-cads using the two PP3 connectors. It is important that the batteries are connected whilst the mains supply is on, otherwise it will be found that the Timer/Clock cannot be reset when the mains supply is eventually connected. If this situation does occur, and this can be recognised by the switch l.e.d.s not pulsing, then disconnect the batteries, turn on the mains supply, insuring that the circuit has been reset, and reconnect the batteries.

FINAL CHECK

As a last final check, enter the correct clock time and a simple program. For example:

1 SW SAT WK PM 2 0 0 ON

Press the CLK key followed by 1 SW SW to display the program. Allow the Timer/Controller to run for a few minutes then switch off the mains supply. The display and l.e.d.s should dim considerably but should still show the program as entered. Do this check several times allowing a few minutes between each switch on and switch off. If all is well the Timer/Controller is then ready for use.

Remember that, if the location of the unit is changed for any reason thus disconnecting the mains supply, the batteries should also be disconnected before re-applying the mains. This will then allow the unit to be reset correctly. Some constructors may like to mount an on/off switch connected in series with the batteries to provide an easier method of disconnection rather than opening the case each time.

LIMITATIONS

The main limitation imposed upon the circuit is that of battery current capacity. The types used can provide up to 75mA, and in the present circuit this means that the unit can continue on battery power for up to 10 hours, or slightly more. Obviously larger capacity batteries can be used, for example 10 'AA' size batteries can be used giving about 12V which gives a reasonable margin before the voltage drops below the necessary 9–10V required. Using batteries such as these will extend the operation of the unit by a factor of about 7. It is perfectly feasible to use batteries of the type just mentioned, providing space can be found inside the case.

As mentioned earlier, blanking of the display and l.e.d.s is not complete. This is due to various leakage paths within the circuit, applying the 9V supply to the displays. However, there is a method which can be used to turn off the display and l.e.d.s completely.

Assuming that real time is being displayed and a power cut occurs. The battery back-up circuit will come into operation, preserving the programs but NOT the time. With the mains removed there is no source of 50Hz to operate the clock. The display should show the time at which the power cut occured but at a very much reduced brilliance.

To turn off the display, thus reducing the current drain the following key sequence should be entered:

1 SW SW ....

This key sequence should in fact display the first program entered for switch number 1. With further presses of the SW key, subsequent programs should be displayed. There should however, be a point reached such that no further programs will be displayed, i.e. neither the display or any of the l.e.d.s should be illuminated. It is at this point where no further keys should be pressed, in this situation the absolute minimum current drain is achieved. In the prototype, this was about 3·5mA. ★

BAZAAR

Step-by-step fully illustrated assembly and fitting instructions are included together with circuit descriptions. Highest quality components are used throughout.

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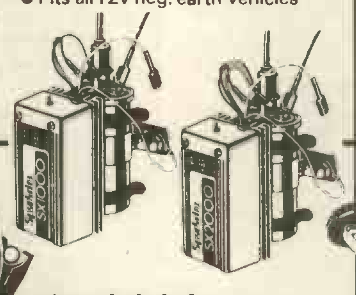

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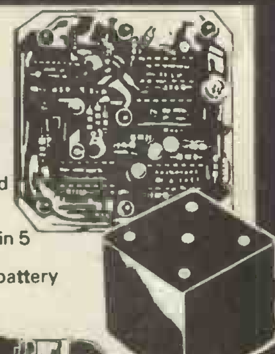

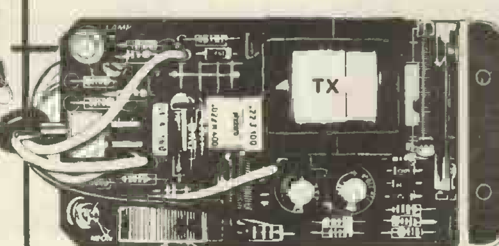

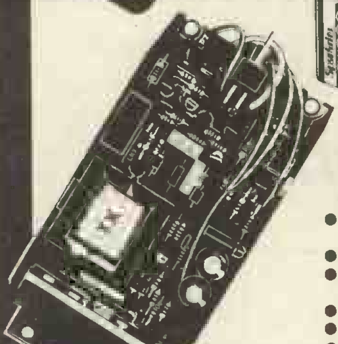

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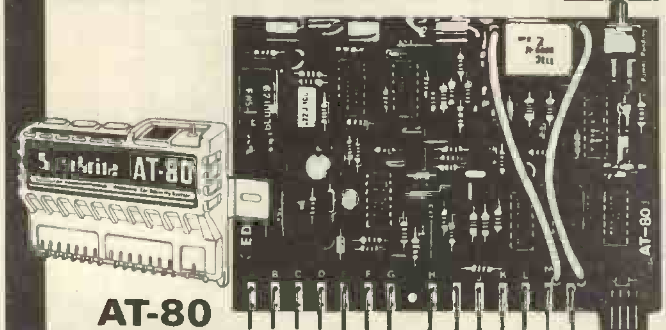

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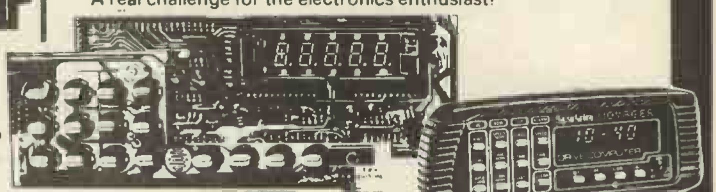

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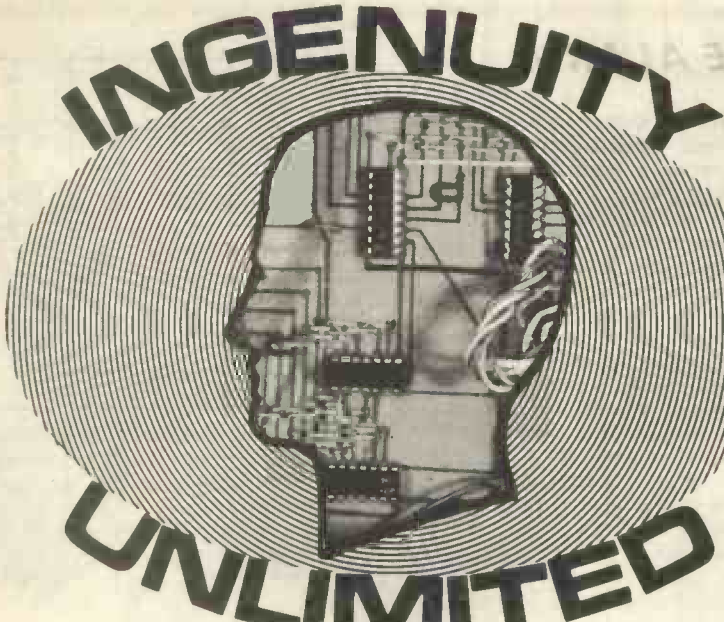


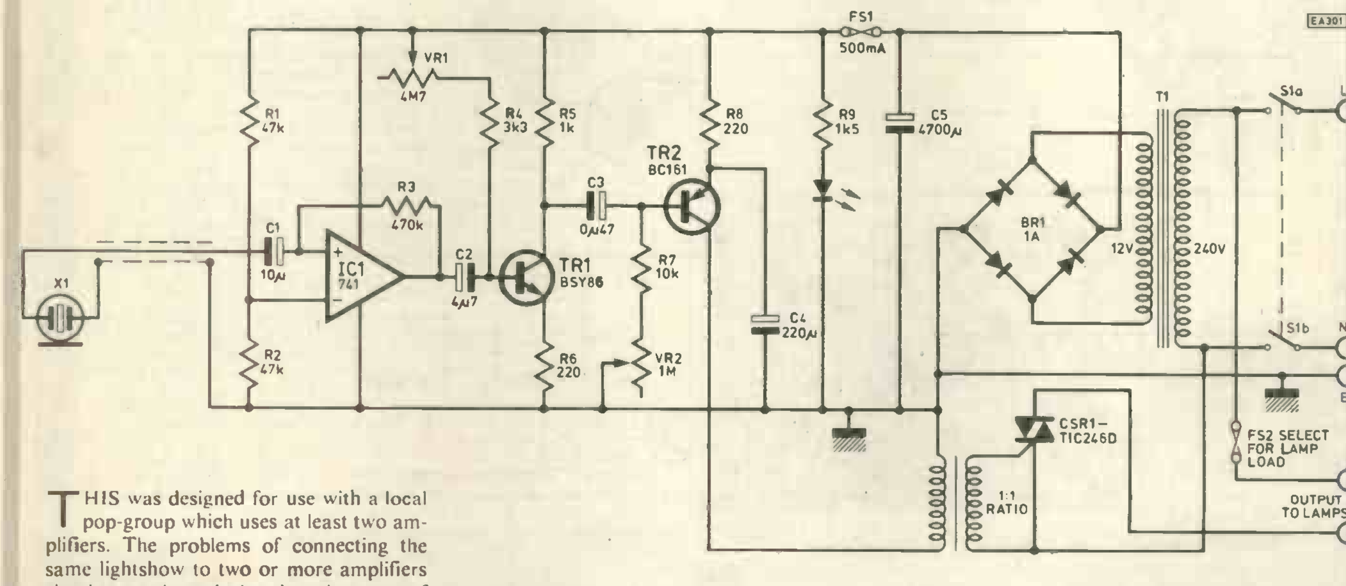
A selection of readers' original circuit ideas.

Why not submit *your* idea? Any idea published will be awarded payment according to its merits.

Each idea submitted must be accompanied by a declaration to the effect that it has been tried and tested, is the original work of the undersigned, and that it has not been offered or accepted for publication elsewhere. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.

Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not inserted in the text.

MIC OPERATED SOUND-TO-LIGHT



THIS was designed for use with a local pop-group which uses at least two amplifiers. The problems of connecting the same lightshow to two or more amplifiers simultaneously and also the reluctance of the musicians to let me connect anything to them (the amplifiers, that is!) made it necessary to use a microphone.

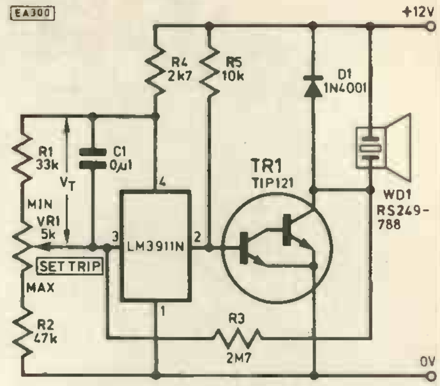
The crystal earphone used was the usual high-impedance type, and the earplug had been removed for this application. The minute signal given out by this device is greatly amplified by the 741 operational amplifier, the gain of which can be increased or decreased by altering the 470k feedback resistor. It is important that the input lead is screened, and the screen must be connected to 0V.

The output of the 741 is a.c. coupled by a capacitor to a transistor amplifier and inverter. The variable resistor used was dug out of an old valve chassis, and it was logarithmic. The output transistor amplifies the signal and passes it to a pulse transformer. When this transistor is turned on by an input signal, the capacitor connected to its emitter discharges through the pulse transformer. It had a noticable effect on the brightness of the lights when this capacitor was added. The signal when it reaches the pulse transformer must still be of a reasonable quality, for the pulse transformer will only transmit a change of potential difference across its primary. If the signal is excessively distorted, the result is not impressive.

There is nothing special about the power supply, and the l.e.d. can be omitted if an indicator is not required. FS2 in the output lead should be selected according to the power of the lighting to be connected. If you want to be able to switch all the lights on manually, connect a metal plate to the input. Touching this should result in all the lights coming on when the two variable resistors are correctly adjusted. The isolating transformer makes this safe, but it would be suicide to use touch control on any unit without isolation!

P. Gatehouse,
Stowe,
Bucks.

LOW TEMPERATURE ALARM



In greenhouses it is often preferred to use oil rather than electric heating, in which case accurate temperature control is difficult to achieve. However, expensive plants can easily be ruined if the ambient temperature falls below a critical value. This, for example, could happen in cases where the heater extinguishes because of lack of oil or wick.

The circuit shown was constructed to signal the failure of such a heating system. Once the temperature falls below a preset valve, an alarm gives an audible indication of the condition.

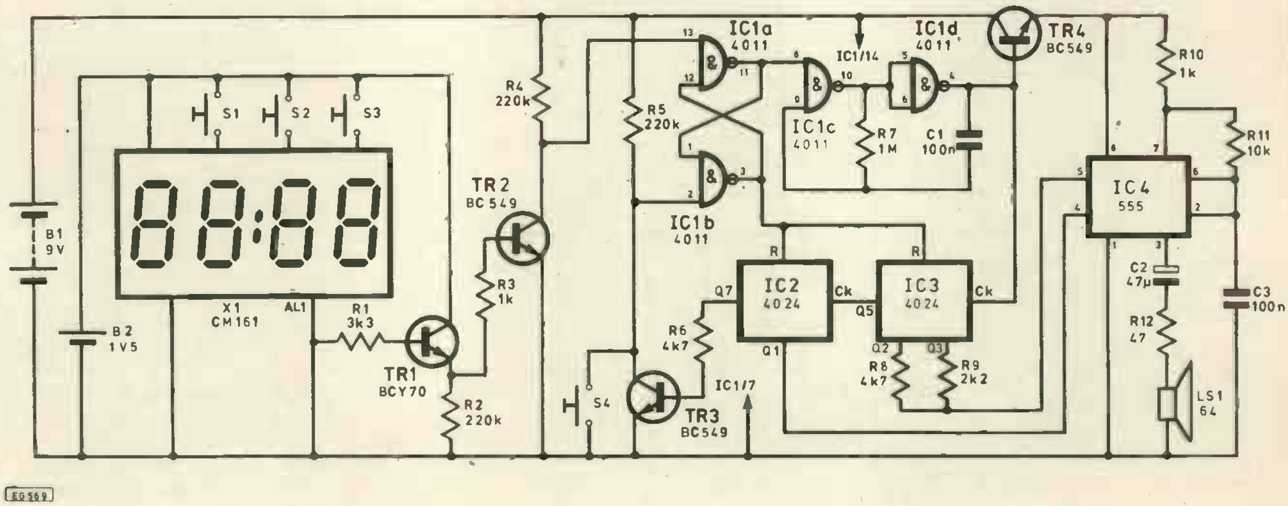
The sensor is an LM3911N temperature transducer which has a sensitivity of 10mV/°K. It has also a voltage reference and operational amplifier fabricated on the same chip. In the circuit the op-amp is connected as a comparator, the output being made to switch as the temperature traverses a set trip point determined by VR1. The trip voltage V_T is derived from the internal voltage reference which comprises the power leads of the LM3911N and, with the values shown, gives a typical variation equivalent to 0 – 30°C. (Note: trip temperature in °C = $100V_T - 273.2$). If necessary, the lower and upper limits can be extended by altering R1 and R2 respectively. However, one should bear in mind that the maximum operating range of the temperature transducer is 0 to 70°C. For good stability, R1 and R2 should be metal oxide or thick film.

The output from the sensor is applied to the Darlington power transistor which is made to operate a 12V audio alarm. A small amount of positive feedback is applied via R3 to give a little hysteresis at the point of switching.

The circuit requires a 12V (9V min) power supply and the standing current is 3mA. The sensor can be made into the form of a probe by insulating with sleeving and encapsulating with silicon rubber compound or epoxy resin, making connections with 4 core cable. Encapsulation is essential, otherwise surface moisture would affect the performance.

D. Wedlake,
Newport Road,
Cardiff.

ALARM CLOCK



THIS alarm was designed to wake a heavy sleeper by quality of the noise produced rather than by mere volume, and so far seems to be fairly successful. Clock functions are performed by a CM161 l.c.d. module from Ambit, which is connected to a 1½V cell and setting switches S1–3 as described in the supplied data sheet.

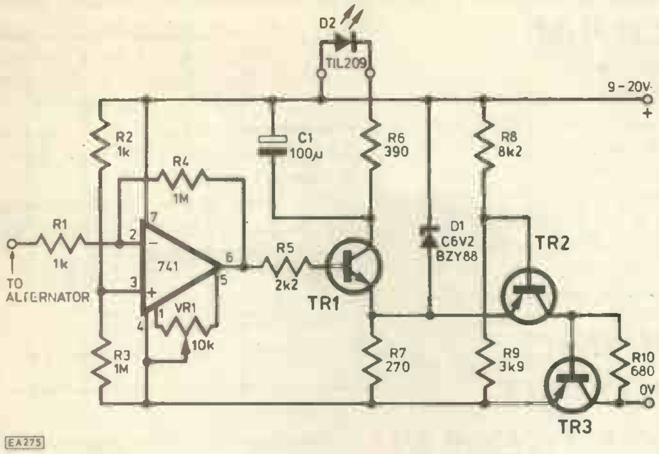
The AL1 output from their module is normally high, giving a pulsed output when the alarm time is reached. This resets itself after fifteen seconds. Here it is used to set the latch formed by IC1a,b; TR1/TR2 translate the level of the alarm output to the 9V supply of the circuit.

When the latch is set, IC1a output goes high, IC1b low, thus the reset is removed from counters IC2/IC3 and the astable around IC1c, d is enabled and oscillates at several Hz. The oscillator output now clocks the counters and drives TR4 to provide an interrupted supply for the 555 AF oscillator (which is effectively disconnected when the alarm is off).

Outputs from IC3, via R8,R9, change the pitch of the bleeps from IC4 using the FM input pin 5. The Q1 output of IC2 is taken to the reset input of the 555, thus the alarm sounds a sequence of notes then a series of quiet clicks at the supply is switched, a cycle which repeats until the Q7 output of IC2 goes high (after about four minutes), resetting the latch via TR3, or the manual reset, S4, is pressed – this has no effect in the first fifteen seconds as the pulses from the AL1 output continually set the latch again.

K. Penton,
Caversham,
Reading

CAR BATTERY DISCHARGE INDICATOR



THIS circuit lights a l.e.d. when the car battery supplies a current of more than about 1 amp.

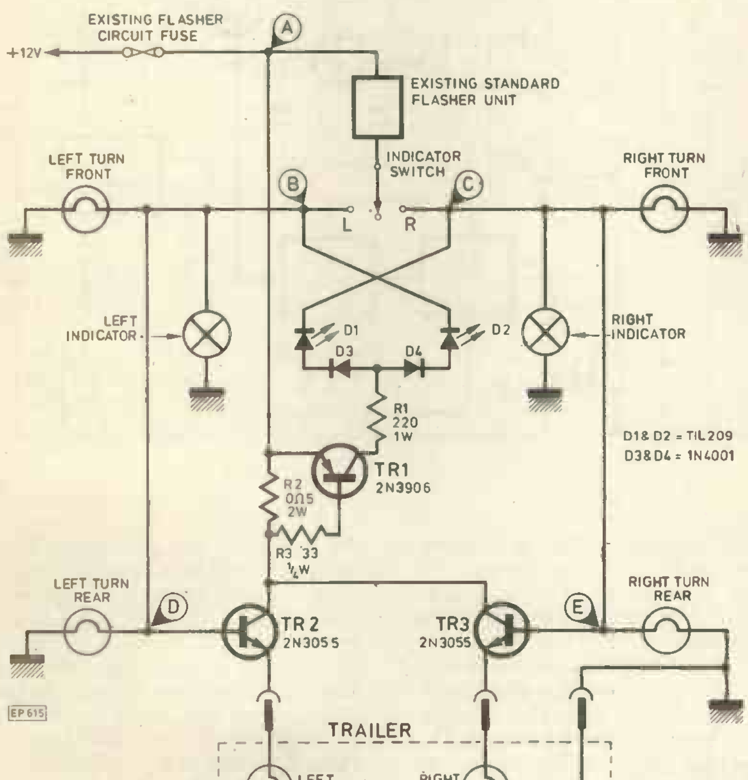
The positive supply to the circuit is taken direct from the battery pole and the input to the 741 is taken from the alternator (or dynamo) output. The 741 thus compares the voltages between the ends of the thick cable which connects the alternator to the battery. A 1 amp discharge produces a voltage drop along this cable of the order of a few millivolts, causing a rising voltage at the output, and switching on TR1. VR1 allows the current threshold to be varied. Apart from providing the reference voltage for the voltage regulator formed by TR2, TR3, R8, R9 and R10, the Zener diode D1 clamps TR1 emitter. The current through R7 is therefore practically constant, current to drive the l.e.d. being diverted from the Zener, which helps to improve voltage regulation.

Transistor types have not been specified, since low gain, low power types work successfully in the circuit.

Although the circuit should be protected from extremes of humidity and temperature, the prototpye has worked reliably for three years mounted in a ventilated box in the engine compartment.

A. Ljungfeldt,
Götoborg,
Sweden.

TRAILER LAMP MONITOR



THE circuit shown gives automatic indication of correct trailer direction indicator lamp operation by sensing the current drawn by the trailer lamps.

The circuit works as follows: when the trailer or caravan lighting plug is connected, and the car direction indicators are operated (for example to "left") TR2 operates as an emitter follower with the trailer left-turn lamp as its emitter load.

The current drawn by the trailer lamp produces a voltage across R2 sufficient to turn on TR1 via R3 and therefore the l.e.d. D1 left-turn warning indicator flashes, its cathode being grounded by the non-flashing car right-turn warning lamps.

The l.e.d. D2 right-turn warning indicator does not flash because its cathode is connected to the flashing car left-turn warning lamps, and therefore has both its anode and cathode at 12 volts at the same time.

D3 and D4 prevent reverse polarity breakdown of the l.e.d.s when the trailer is not connected.

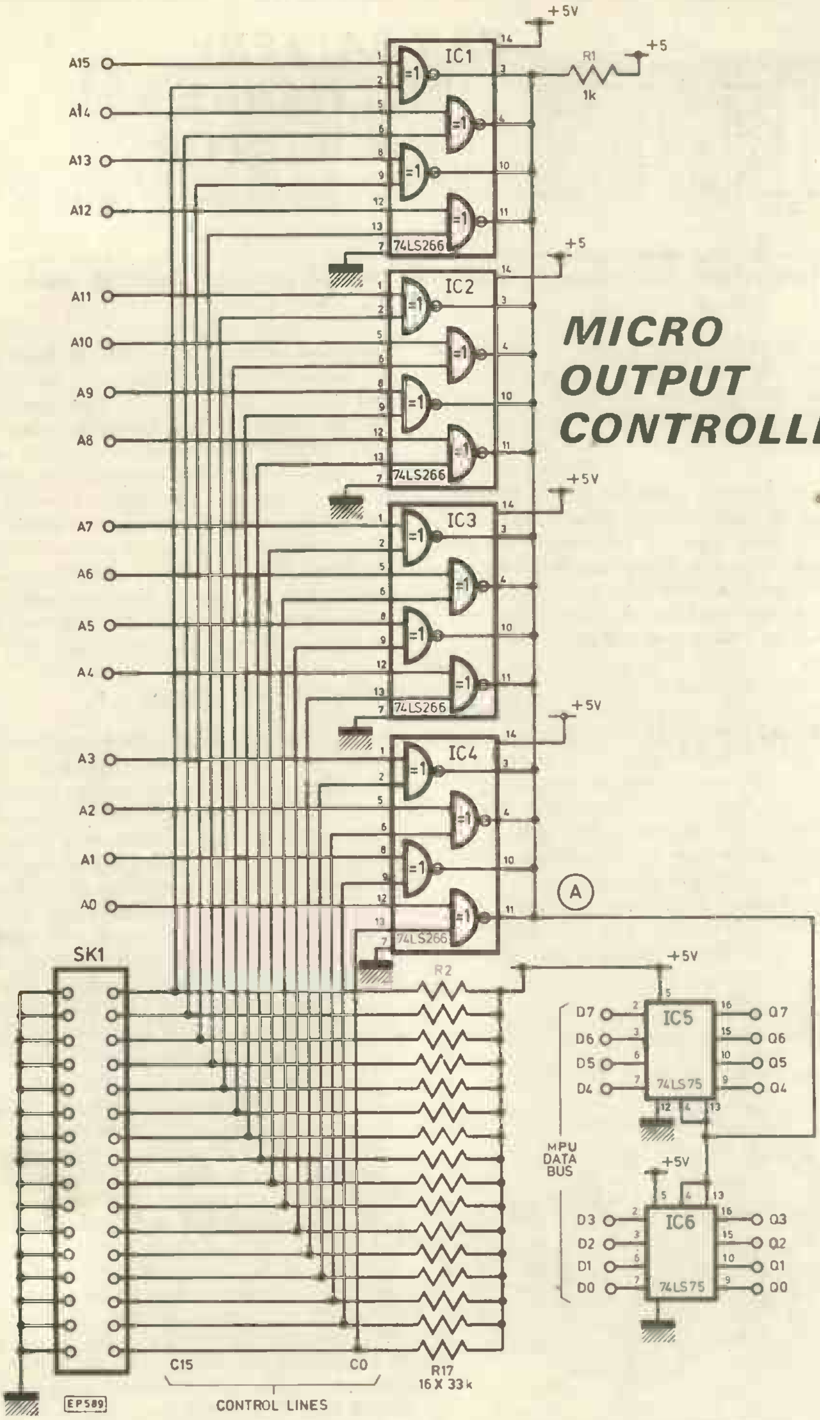
One big advantage of the use of this circuit is that the car flasher unit has virtually no extra load when towing (base current of TR2 or TR3 only) and therefore operates at the same flash rate as normal.

Note that R2 should be reduced to 0·25 ohm if there are two flasher lamps for each turning direction on the trailer or caravan.

The circuit as shown is for negative earth cars, but by using *p.n.p.* transistors for TR2 and TR3, and *n.p.n.* for TR1, and turning the diodes and l.e.d.s around, it should work for positive earth cars.

Connection of the circuit to the existing car wiring is at points A, B, C, D and E.

R. O'Rourke,
Eastleigh,
Hants.



MICRO OUTPUT CONTROLLER

WHEN an external device is required to be controlled by a microcomputer the usual method is to employ a Peripheral Interface Adapter or PIA. However, in a dedicated system where the input function is not required the following circuit may be used.

The circuit can be placed anywhere in the computer's memory by selecting the required address on the control inputs of the exclusive OR gates IC1, IC2, IC3 and IC4.

For example, if the address

1111000011110000	BINARY
61680	DECIMAL
F0F0	HEX

is placed on the control lines then, when the same address appears on the MPU address bus, the wired OR output, point A, goes high and the information which was present on the data bus is strobed through to the Q outputs. When the address bus alters due to the next programme instruction, point A goes low and latches this information. The data bus can now change without altering the Q outputs.

If used in conjunction with the UK101, the data could be poked to the above address example using the instruction,

POKE 61680, 38

This would set the Q outputs to,

00100110

and switch on lines six, three, and two. A later instruction,

POKE 61680, 1

would switch off lines six, three and two and switch on line 1. The circuit can be used in this manner to switch eight devices. However, by further decoding of the eight Q output lines a maximum of 256 devices could be controlled.

As a debugging aid, the contents of any preselected memory location could be examined. If the particular memory location is addressed during a program run then the memory contents will appear on the Q outputs until the location is re-addressed and the new contents will then be displayed.

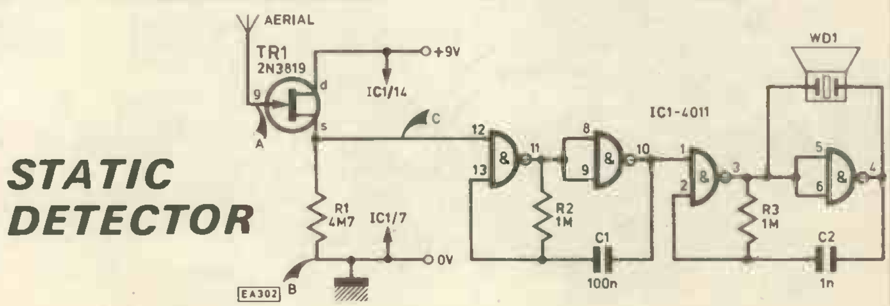
R. Macfarlane,
Aberdeen,
Scotland.

STATIC DETECTOR

WHEN dealing with MOS integrated circuits, it is often necessary to be able to detect static charges. The device to be described will do this.

When something with a static charge is brought into the vicinity of the circuit a voltage is induced between points A and B, this forces the f.e.t. (TR1) to conduct causing the voltage at point C to rise from 0 to 9 volts. This will enable the oscillator, and bleeping will come from the crystal earpiece (WD1).

B. Harvey,
Oxford.



PATENTS REVIEW...

Copies of Patents can be obtained from:
the Patent Office Sales, St. Mary Cray, Orpington, Kent. Price £1·45 each.

SPEAK AND MATHS

The flurry of patenting activity by Texas Instruments of Texas, USA, continues. European patent applications 0 042 488 covers the Speak and Maths toy which is now in the shops. Speak and Maths is a modification of Speak and Spell, which is covered by patents previously reported. For Speak and Maths a non volatile memory stores digital data representative of random arithmetical problems. The same memory also stores digital data representative of the correct solutions and data to control a speech synthesis IC when triggered into action the toy throws up stored problems at random, announces them in a synthesised voice, checks answers keyed in by the user against the store of correct solutions and responds accordingly with synthesised speech.

Adjacent European application 0 042 487, also from Texas, covers a toy which is not yet on the market. The aim is to improves a student's hand writing but it could be of value in teaching dyslexic children who confuse *b* with *d* and so on. Figure 2 shows the basic unit and figure 1 shows the block circuit. Drawing surface 10 is a "magic slate" of the well-known type where a translucent plastic sheet overlays a dark waxy backing. Pressure on the top sheet, with a blunt scribe, causes local adhesion and a visible mark. This can be erased by separating the sheet from the backing. Imager II is either a tv camera or, more simply an array of 32 x 32 light sensitive elements arranged in a matrix. RAM 12 stores a digital representation of the image on the slate 10 as viewed by imager II. Microprocessor 13 examines the contents of RAM 12 and compares it with stored digital data which is representative of letters of the alphabet and numbers.

The student turns on the system through keyboard 21. Speech synthesis circuits 14, 16, 17, 18 and for digital display 23 they create an audible and/or visual instruction to draw a letter or number on the slate 10. This is viewed by imager II and analysed by microprocessor 13 to produce a verbal or digital display comment. If for instance the user is asked to draw the letter "N", the response may be "you have printed to N backwards. Try again" or "Correct, That is a well drawn N".

Figures 3 and 4 show a more compact design, with the imager housed inside the unit and arranged to view the underside of the slate via lens 35 and mirror 36.

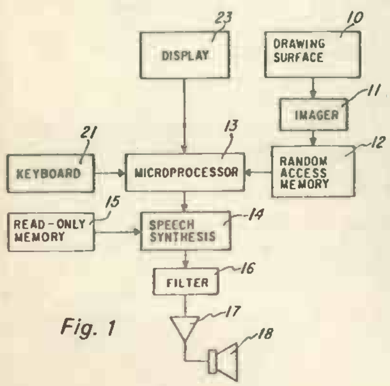


Fig. 1

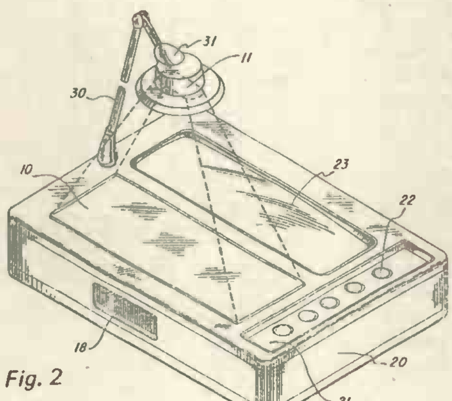


Fig. 2

SPEECH SYNTHESIS

Text books can't carry up to date information on speech synthesis, because the technology is moving so fast. So patents remain the best and most current source reference. They are also a very cheap source of information, even at the recently increased cost of £1·60 per published British patent or patent application, post free and regardless of length. We have already reported on the publication of British patent application 2 058 522 from Texas Instruments of Dallas which describes speech synthesis circuitry used by Texas for the "Speak and Spell" toy now in the shops. Now two more Texas patent applications have been published and these are also concerned with Speak and Spell. British patent numbers 2 076 205 and 2 077 018, are lengthy and detailed documents, and thus good value for money. No. 2 076 205 for instance runs to 32 pages of text and 50 sheets of drawings and circuit diagrams, all for £1·60. Again it contains useful source references to background information, including published IEEE lectures and prior patents on synthesis chips and digital filters. Some of the ground covered in previously reported application 2 058 522 is repeated (e.g. the compression of a 6000 Hz bit rate to 1000 bits per second), but the logic used for Speak and Spell is detailed.

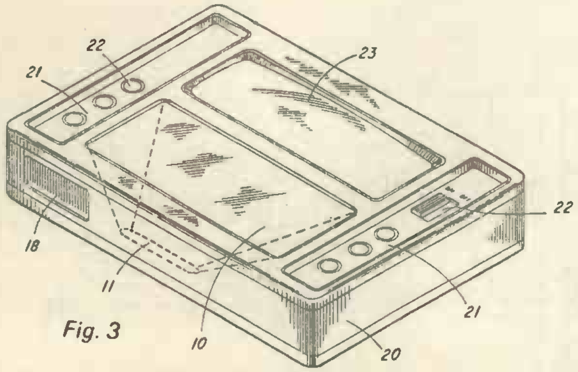


Fig. 3

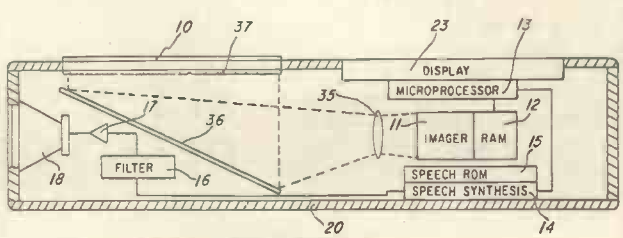


Fig. 4

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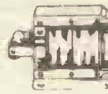

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Type **LS6/L11**. Coil 240V 50 Rs. Contacts – 3 make: 600V: 20amp. 1 break: 600V: 20amp. Price: **£5.75** P. & P. 75p. (£7.47 incl. VAT). N.M.S.

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Type FFB. 1706. Small, quiet, smooth running. 240V. A.C. operation. Output aperture 45×40mm. Overall size 135×165mm. Flange mounting. Price: **£4.75**. P. & P. £1.00 (£6.61 incl. VAT). Other types available. S.A.E. for details. N.M.S.

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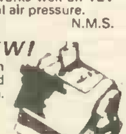

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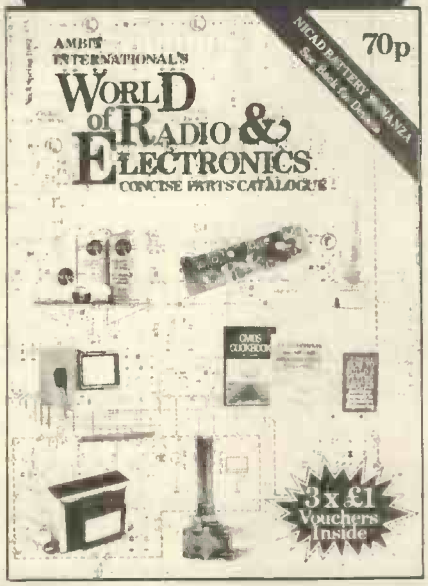

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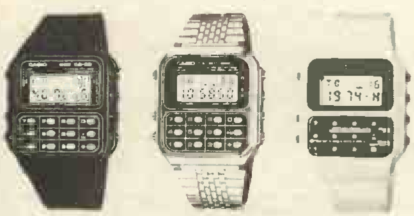

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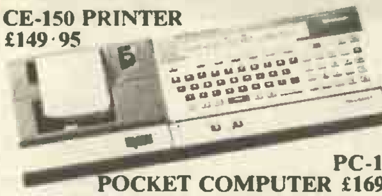

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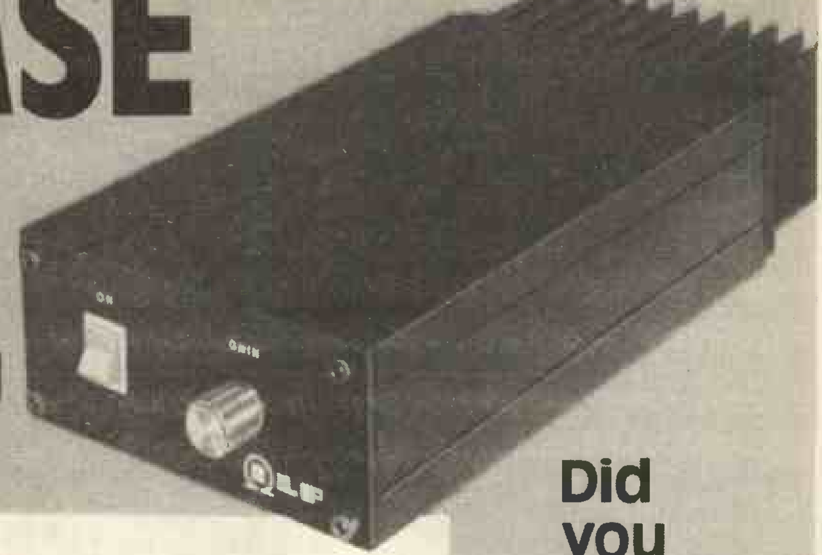

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113*	15	£2.39	£1.20
64	80	£4.85	£1.40
4	150	£6.48	£1.60
67	500	£13.30	£2.24
84	1000	£22.70	£2.80
93	1500	£28.17	O.A.
95	2000	£42.14	O.A.
73	3000	£71.64	O.A.
80	4000	£93.01	O.A.
57	5000	£108.30	O.A.

*0, 115, 220, 240.

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Clean mains to computers/peripherals
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1kVA £203.12
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96/48/36V RANGE
Pri 0-120/240V
Sec 2 windings 0-36-48V to give 36-0-36V or 48-0-48V or 96V.

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1	2	431	£8.93	£1.64
2	4	432	£14.69	£1.60
3	6	433	£17.79	£2.40
4	8	434	£22.24	£2.40
5	10	435	£32.23	£2.40
6	12	436	£40.36	O.A.
8	16	437	£44.03	O.A.

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AVO DA211 L.C.D. Digital (Hand £58.50
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2000	£74.79	O.A.
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Barrie Electronics Ltd.
3, THE MINORIES, LONDON EC3N 1BJ
TELEPHONE: 01-488 3316/7/8
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7403	.16	7438	.35	74105	.70	74174	.81	7403	.16	7442	.42
7404	.15	7440	.21	74107	.35	74175	.81	7404	.17	7447	.17
7405	.21	7442	.44	74109	.40	74176	.63	7405	.18	7448	.92
7406	.29	7445	.73	74118	.92	74177	.86	7406	.18	7452	.18
7407	.29	7446	.68	74120	.85	74180	.75	7408	.17	7454	.18
7408	.17	7447	.55	74121	.34	74190	.80	7409	.18	7473	.29
7409	.20	7448	.55	74122	.52	74192	.80	7410	.18	7474	.25
7410	.17	7451	.20	74123	.57	74193	.75	7411	.18	7475	.32
7411	.24	7453	.20	74125	.47	74194	.81	7412	.23	7476	.24
7412	.20	7454	.20	74126	.46	74196	.73	7413	.31	7483	.58
7413	.28	7460	.20	74128	.47	74197	.73	7414	.55	7485	.78
7414	.22	7470	.41	74132	.52			7415	.24	7486	.38
7416	.28	7472	.32	74136	.39			7420	.17	7490	.40
7417	.29	7473	.34	74141	.78			7421	.19	7492	.44
7420	.18	7474	.27	74154	.84	DIODES		7422	.18	7493	.40
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7425	.29	7482	.86	74160	.69	1N4003	.07	7428	.30	74112	.36
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7427	.32	7486	.27	74162	.70	1N4005	.07	7432	.18	74122	.51
7428	.33	7491	.60	74163	.71	1N4006	.08	7433	.23	74123	.63
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6116	500p	450p

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(Speedblock Type)

No. of ways	Header Plug	Receptacle	Edge Conn
10	90p	90p	200p
20	165p	165p	240p
26	200p	200p	300p
34	240p	240p	380p
40	270p	270p	650p
50	310p	310p	600p

D-CONNECTORS

	9 way	15 way	25 way	37 way
MALE				
Solder	95p	135p	200p	280p
Angled	160p	230p	265p	425p
FEMALE				
Solder	125p	190p	245p	375p
Angled	175p	240p	310p	500p
Hood	100p	100p	100p	150p

DIL HEADER PLUGS

	Solder type	IDC type
14 pin	50p	100p
16 pin	60p	110p
24 pin	100p	150p
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RIBBON CABLE (Grey)

10 way	50p
14 way	70p
16 way	80p
20 way	100p
26 way	125p
34 way	170p
40 way	200p
50 way	250p
64 way	300p

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24" Ribbon Cable with headers

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24" Ribbon Cable with D Conn.
25 way Male 500p Female 650p.

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2×22 way	310p	170p
2×23 way	335p	—
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1×43 way	260p	—
2×43 way	450p	—
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(for 2×32 way specify a+b or a+c)

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