ELECTRONICS TODAY

electronics today international

JUNE 1977

35p

PROJECTS FOR ALL!

MASTER-MIND

BASS ENHANCER

10 Hz – 10 MHz DFM

PLUS SYSTEM 68: THE VDU

ALSO: HP67 REVIEWED

LCDs EXPLAINED

WHAT IS VALVE SOUND?

KENNEDY SPACE CENTRE

ETI-MARSHALL'S MULTIPLE OFFER

ETI TOP PROJECTS NO. 5 NOW AVAILABLE

NEWS . . . CONSTRUCTION . . . DEVELOP … AUDIO

WATFORD ELECTRONICS

33 CARDIFF ROAD, WATFORD, HERTS., ENGLAND
MAIL ORDER, CALLERS WELCOME. Tel. Watford 37774

ALL DEVICES BRAND NEW, FULL SPEC. AND FULLY GUARANTEED. ORDERS DESPATCHED BY RETURN OF POST. TERMS OF BUSINESS: CASH/CHEQUE/P.O.s OR BANKERS DRAFT WITH ORDER. GOVERNMENT AND EDUCATIONAL INSTITUTIONS OFFICIAL ORDERS ACCEPTED. TRADE AND EXPORT INQUIRY WELCOME. P&P ADD 25p TO ALL ORDERS UNDER £10.00. OVERSEAS ORDERS POSTAGE AT COST. AIR/SURFACE. SEND S.A.E. FOR OUR FREE LIST.

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VAT Export orders no VAT. Applicable to U.K. Customers only. Unless stated otherwise, all prices are exclusive of VAT. Please add 8% to devices marked ★. To the rest add 12½%.

We stock many more items. Send S.A.E. for our free list. It pays to visit us. We are situated behind Watford Football Ground. Nearest Underground/BR Station: Watford High Street. Open Monday to Saturday. Ample Free Car Parking space available.

POLYESTER CAPACITORS: Axial lead type (Values are in µF)
400V: 0·001 0·0015 0·0022 0·0033 **8p;** 0·0047 0·0068 0·01 0·015 0·018 **9p;** 0·022 0·033 **10p;** 0·047 0·068 **14p;** 0·1 **15p;** 0·15 0·22 **22p;** 0·33 0·47 **39p;** 0·68 **45p.**
160V: 0·039 0·15 0·22 **13p;** 0·33 0·47 **22p;** 0·68 1·0 **29p;** 1·5 **33p;** 2·2 **38p;** 4·7 **47p.**
DUBILIER: 1000V: 0·01 0·015 **16p;** 0·022 **18p;** 0·04 **16p;** 0·1 **34p;** 0·47 **43p;** 1·0 **85p.**

POLYESTER RADIAL LEAD (Values in µF) **250V:**
0·01 0·015 **5p;** 0·022 0·027 **6p;** 0·033 0·047 0·068 0·1 **7p;** 0·15 **10p;** 0·22 0·33 **12p;** 0·47 **14p;** 0·68 **18p;** 1·0 **21p;** 1·5 **24p;** 2·2 **28p**

FEED THROUGH CAPACITORS 1000pF 350V **8p**

ELECTROLYTIC CAPACITORS: Axial lead type (Values are in µF)
250V: 100µF **50p; 100V:** 20µF **63V:** 0·47 1·0 1·5 2·2 2·5 3·3 4·7 6·8 8 10 15 22 **9p;** 47 32 50 **12p;** 63 100 **27p; 50V:** 1·0 **9p;** 50 100 220 **25p;** 470 **50p;** 1000 2200 **68p; 40V:** 22 33 **9p;** 100 **12p;** 3300 **62p; 35V:** 33 **7p;** 330 470 **50p;** 1000 **49p; 25V:** 10 22 47 **6p;** 80 100 160 **8p;** 220 250 **13p;** 470 640 **25p;** 1000 **27p;** 1500 **30p;** 2000 **34p;** 3300 **52p;** 4700 **54p; 16V:** 10 40 47 68 **7p;** 100 125 **8p;** 470 **16p;** 1000 1500 **20p;** 2200 **34p; 10V:** 4 100 **6p;** 540 **10p;** 100 **14p.**
TAG-END TYPE: & **70V:** 2500 **98p;** 4700 **121p; 64V:** 3300 **94p; 40V:** 4000 **70p;** 2500 **65p; 25V:** 4700 **48p; 16V:** 4500 **38p; 40V:** 2000 + 2000 **95p.**

TANTALUM BEAD CAPACITORS
35V: 0·1µF 0·22 0·33 0·47 0·68 1·0 2·2µF 3·3 4·7 6·8 15V. **20V:** 1·5 **16V:** 10µF **13p** each.
10V: 22µF 33 47 **6V:** 47 68 **3V:** 100µF **20p** each

POTENTIOMETERS (AB or EGEN)
Carbon Track ¼W Log & ½W Linear values
1KΩ & 2KΩ (lin only) Single gang **24p**
5KΩ 2MΩ single gang **24p**
5KΩ 2MΩ single gang D/P switch **50p**
5KΩ 2MΩ dual gang stereo **60p**

OPTO ELECTRONICS ★
LEDs + clip
TIL209 Red **13p**
TIL211 Grn **24p**
TIL220 Red **20p**
2" Red **16p**
2" Amber Green **20p**
Yellow **20p**
OCP70 **40p**
ORP12 **68p**
7 Seg Displays
TIL312 & 313 3" C Anode **120p**
C Cath **120p**
TIL321 & 322 5" C Anode **125p**
C Cath **125p**
DL704 C Cth **95p**
DL707 C A **95p**
DL747 C A **180p**
2N5777 **54p**

MYLAR FILM CAPACITORS
100V: 0·001 0·002 0·005 0·01µF **5p**
0·015 0·02 0·04 0·05 0·056µF **6p**
0·1µF 0·15 0·2 **7p. 50V:** 0·47µF **10p**

SLIDER POTENTIOMETERS
0·25W log and linear values 60mm
5KΩ 500KΩ single gang **60p**
10KΩ-500KΩ dual gang **70p**
Self Stick Graduated Bezels **20p**

CERAMIC CAPACITORS 50V
range 0·5pF to 10 000pF **3p**
0·015µF 0·022µF 0·033µF
0·047µF **4p** 0·1µF **6p** **4p**

PRESET POTENTIOMETERS
0·1W 50Ω 5MΩ Miniature Vertical & Horizontal **8p**
0·25W 100Ω 3·3MΩ Horiz larger **10p**
0·25W 200Ω 4·7MΩ Vert **10p**

SILVER MICA (Values in pF) 3·3 4·7 6·8 10 12 22 33 47 50 68 75 82 85 100 120 150 220 **9p** each
250 300 330 360 ~~400~~ 600 820 **16p** each
1000 1800 2000 2200 **20p** each

RESISTORS — Erie make 5% Carbon Miniature High Stability Low noise

	RANGE	VAL	1-99	100+
¼W	2·2Ω-4·7M	E24	1·5p	1p
½W	2·2Ω-4·7M	E12	2p	1·5p
1W	2·2Ω-10M	E12	3p	2p
2% 0·5W Metal Film E12				6p

SWITCHES ★
TOGGLE 2A 250V
SPST **26p**
DPDT **35p**
4 pole on off **58p**
SUB-MIN TOGGLE
SP changeover **59p**
SPST on off **54p**
SPDT c/off **78p**
DPDT 6 tags **78p**
DPDT Centre off **92p**
DPDT Biased **115p**
SLIDE 250V:
1A DP **14p**
1A DP C O **16p**
½A DP **13p**
4 pole 2 way **24p**
PUSH BUTTON
Spring loaded
SPST on off **55p**
SPDT C over **65p**
DPDT 6 Tag **85p**

CERAMIC TRIMMER CAPACITORS
2·7pF 4·15pF 6·25pF 8·30pF **20p**

MINIATURE TYPE TRIMMERS
2·5-6pF 3·10pF 10·40pF **22p**
5·25pF 5·45pF 60pF 88pF **30p**

COMPRESSION TRIMMERS
3·40pF 8·80pF 20·140pF 190pF **25p**
50·200pF 100·500pF 1250pF **39p**

E.T.I. TV GAMES KIT Complete kit including the rifle attachment now available. UHF Modulator only **£3.10**

	JACK PLUGS: Screened chrome	JACK PLUGS: Plastic body	SOCKETS: open metal	SOCKETS: moulded with break contacts	SOCKETS: in line couplers
2·5mm	12p	8p	8p		11p
3·5mm	15p	10p	8p		12p
MONO	23p	15p	13p	20p	18p
STEREO	31p	18p	15p	24p	22p

DIN	PLUGS	SOCKETS	In Line
2 PIN Loudspeaker 3 4 5 Audio	13p	8p	20p
CO-AXIAL (TV)	14p	14p	14p
PHONO assorted colours Metal screened	9p 12p	5p 1-way 8p 2-way 10p 3-way	15p —
BANANA 4mm 2mm 1mm	10p 10p 8p	12p 10p 8p	— — —

SWITCHES ★ PUSH BUTTON:
Miniature Non Locking
Push to Make **15p** Push to Break **25p**
ROCKER (white) 10A 250V SP changeover centre off **28p**
ROCKER: (black) on off 10A 250V **23p**
ROCKER: Illuminated (white) Lights when on 3A 240V **52p**
ROTARY: (ADJUSTABLE STOP) 1 pole 2-12 way 2p 2-6W 3p 2-4W 4p 2-3W **41p**
ROTARY: Mains 250V AC 4 Amp **42p**

DIL SOCKETS★ (Low Profile Texas)
8 pin **10p;** 14 pin **12p;** 16 pin **13p;** 24 pin **30p;** 28 pin **45p;** 40 pin **58p.**

It's Here! **TV GAMES**

The "Olympic" Games Kit

This easy to build no compromise kit using the very latest Integrated Circuits only just available from the United States. Simply plug into the U H F aerial socket of a standard television receiver, sit back into your favourite armchair and spend countless hours with the family playing any six games available.

The central control unit provides Game selection with switching for Bat size, angle and Ball speed adjustment. The Bat position, Score reset and serve controls are remotely connected allowing the players to be many feet apart. The Unit is mains powered (no expensive batteries to buy) and incorporates the unique 'Ventriloquist' audio system which produces realistic Game sounds from your television speaker.

Supplied with each kit are step by step instructions which even the most inexperienced constructor will find easy to follow. Full exploitation of all the facilities offered by the main integrated circuit make this probably the best design of Television Game currently being offered.

Also included are instructions to build the 'Sure Fire' rifle, a simple design which is made foolproof by the 'On Target' detector incorporated in the electronics.

SPECIAL OFFER TO ETI READERS
Complete Kit **£27.85** incl VAT (plus 75p P&P insured)
Ready Built Units (available in limited quantities) price **£34.50** incl VAT plus 75p P&P Insured)

TV Games IC **AY-3-8500 £8.55** (incl VAT)
(Demonstration on at our Shop. Send SAE for leaflet)

FERRIC CHLORIDE ★
Anhydrous 1lb bag **65p** + 30p p&p

DALO ETCH Resist Pen + Spare Tip **75p★**

COPPER BOARDS★
Fibre Glass
Single Sided 6×6" **64p**
6×12" **115p**
Double Sided 6×6" **78p**
6×12" **148p**

VOLTAGE★ REGULATORS
723C **45p**
TBA625B **95p**
TO3 Can
1A 5V **150p**
1A 12V **170p**
1A 15V **190p**
1A 18V **210p**
LM309K **150p**
LM323K **625p**
1A 5V **220p**
1A 12V **220p**
Plastic
1A 5V **130p**
1A 12V **130p**
1A 15V **135p**
1A 18V **140p**
1A 24V **140p**
0·1A 8V **48p**

TTL 74★

Type	p
7400	14
7401	14
7402	16
7403	16
7404	20
7405	22
7406	44
7407	44
7408	22
7409	22
7410	15
7411	25
7412	25
7413	40
7414	74
7416	35
7417	39
7420	16
7421	29
7422	24
7423	30
7425	30
7426	35
7427	36
7428	48
7430	18
7432	28
7433	48
7437	30
7438	33
7440	17
7441	74
7442	74
7443	130
7444	122
7445	94
7446	116
7447	82
7448	80
7450	17
7451	17
7453	17
7454	17
7460	17
7470	32
7472	28
7473	32
7474	36
7475	36
7476	36

Type	p
7480	50
7481	114
7482	82
7483	95
7484	95
7485	125
7488	36
7489	390
7490	43
7491	80
7492	53
7493	40
7494	85
7495	73
7496	82
7497	262
74100	135
74104	48
74105	48
74107	33
74109	84
74110	54
74111	76
74116	193
74118	115
74120	105
74121	34
74122	50
74123	73
74125	89
74126	65
74128	81
74132	75
74136	56
74141	72
74142	315
74143	314
74144	314
74145	90
74147	275
74148	160
74150	128
74151	79
74153	82
74154	150
74155	76
74156	95
74157	95
74158	80
74159	225
74160	116

Type	p
74161	116
74162	116
74163	116
74164	121
74165	120
74166	161
74167	362
74170	186
74172	590
74173	175
74174	173
74175	90
74176	120
74177	116
74180	108
74181	299
74182	85
74184	184
74185	146
74188	650
74190	149
74191	165
74192	120
74193	120
74194	120
74195	95
74196	118
74197	118
74198	248
75150	000
75491	80
75492	90

CMOS★ (RCA)

Type	p
4000AE	15
4001AE	17
4002AE	17
4006AE	115
4007AE	18
4009AE	60
4010AE	60
4011AE	19
4012AE	18
4013AE	55
4015AE	99
4016AE	55
4017AE	104
4018AE	105
4019AE	60
4020AE	125
4021AE	105
4022AE	95
4023AE	20
4024AE	85
4025AE	19
4026AE	185
4027AE	60
4028AE	95
4029AE	109
4030AE	58
4033AE	145
4034AE	195
4040AE	110
4042AE	85
4043AE	100
4044AE	95
4045AE	145
4046AE	135
4047AE	99
4048AE	58
4049AE	60
4050AE	55
4054AE	120
4055AE	134
4056AE	135
4060AE	115
4067AE	380
4068AE	22
4069AE	22
4070AE	55
4071AE	23
4072AE	23
4076AE	155
4077AE	60
4078AE	22
4081AE	22
4082AE	23
4502AE	135
4507AE	55
4510AE	135
4511AE	175
4512	115
4516AE	140
4518AE	130
4519AE	65
4520AE	130
4528AE	140
4532AE	128
4539AE	120
4585AE	105

LINEAR IC'S

Type	p
702	75
709C 14 pin	30
710★	46
741C 8 pin	22
747C	72
748C	36
753	150
8038CC★	345
AY-1-0212	570
AY-1-5051	125
AY-5-1224★	349
AY-1-67216	195
AY-3-8500★	792
AY-5-3500★	810
AY-5-4007	650
CA3011★	82
CA3014★	137
CA3018	72
CA3020	170
CA3023	170
CA3028A★	102
CA3035	170
CA3036	180
CA3043	190
CA3046	80
CA3048	220
CA3075	175
CA3080	80
CA3081	190
CA3089E	210
CA3090AQ	420
CA3123E	200
CA3130★	94
CA3140	95
LM300H	170
LM301A	39
LM308	140
LM318	195
LM380	98
LM381	170
LM379	395
LM382	125
LM3900	65
LM3909N	65
M252AA★	700
M253★	800
MC724★	175
MC845P	150
MC1303L	148
MC1304P	260

Type	p
MC1310P	165
MC1312PQ	195
MC1458P★	90
MC1496	101
MC1710CG	79
MFC6040★	97
MK50253★	550
MM2112N★	350
MM50326★	750
NE350	160
NE518A	210
NE555★	41
NE556DB★	99
NE560★	325
NE561★	395
NE562B★	395
NE565A★	175
NE566★	170
NE567V★	182
RAM2102-2★	247
ROM2513★	750
SG3402★	255
SI414A	220
SN72733	125
SN76003	240
SN76013	150
SN76023	150
SN76033	235
SN76115	215
SN76227	175
TAA621A	238
TAA661A	155
TAA700	353
TAA960	300
TAD100	150
TAD110	170
TBA120S	90
TBA540Q	220
TBA550Q	355
TBA641B	249
TBA651	170
TBA800	90
TBA810S	110
TBA820	90
TBA920Q	350
TDA2020	320
ZN414	110
ZN424	125

TRANSISTORS

Type	p
AC117	35
AC125★	22
AC126★	18
AC127★	18
AC128★	18
AC141★	22
AC141K★	38
AC142★	20
AC142K★	38
AC176★	18
AC187★	18
AC188★	19
ACY17	35
ACY18	28
ACY19	25
ACY20	24
ACY21	29
ACY22	16
ACY28	21
ACY39	78
ACY40	24
ACY44	39
AD149★	54
AD161★	38
AD162★	38
AF114★	20
AF115★	20
AF116★	20
AF117★	23
AF118★	47
AF121★	33
AF124★	30
AF125★	30
AF126★	30
AF127★	30
AF139★	40
AF178★	70
AF179★	70
AF180★	70
AF181★	48
AF185★	60
AF186★	48
AF239★	37
ASY26★	40
ASY29★	40
BC107★	9
BC107B★	10
BC108★	9
BC108B★	12
BC108C★	12
BC109★	9
BC109B★	12
BC109C★	12
BC113	12
BC114	20
BC115	20
BC116	20
BC117	20
BC118	15
BC119	25
BC135	13
BC136	15
BC137	15
BC140★	34
BC142★	24
BC143★	24
BC147	7
BC148	7
BC149	9
BC153	25
BC154	20
BC157	10
BC158	12
BC159	13

Type	p
BC160★	32
BC167	12
BC168	12
BC169C	14
BC170	11
BC171	11
BC172	11
BC177★	18
BC178★	16
BC179★	18
BC182	10
BC182L	12
BC183	10
BC183L	11
BC184	11
BC184L	12
BC186	22
BC187★	23
BC212	12
BC212L	13
BC213	11
BC213L	13
BC214	14
BC214L	16
BC307B	15
BC328	18
BC338★	21
BC441★	37
BC461★	47
BC462★	37
BC547	20
BC548	20
BC549C	20
BC558	28
BCY30★	55
BCY32★	65
BCY34★	80
BCY39★	88
BCY40★	90
BCY55★	204
BCY59★	18
BCY70★	17
BCY71★	20
BCY72★	15
BD115★	52
BD121★	98
BD123★	95
BD124★	105
BD131★	36
BD132★	39
BD133★	60
BD135	45
BD136	40
BD137	42
BD138	47
BD139	54
BD140	57
BD142	53
BD145★	55
BDY17★	195
BDY60★	128
BDY61★	147
BF115★	22
BF154★	22
BF156★	29
BF173★	25
BF177★	26
BF178★	28
BF179★	33
BF180★	33
BF181★	33
BF182★	33
BF183★	33
BF184★	28

Type	p
BF185★	30
BF194	10
BF195	10
BF196	14
BF197	15
BF198	15
BF200	37
BF224A	15
BF244	34
BF256★	34
BF257★	34
BF258★	38
BF259★	48
BF594	30
BF595	28
BFR39	25
BFR40	25
BFR79	25
BFR80	25
BFX18★	54
BFX29★	28
BFX38★	38
BFX53★	40
BFX55★	40
BFX64★	38
BFX81★	141
BFX84★	24
BFX85★	28
BFX86★	28
BFX87★	23
BFX88★	26
BFY50★	17
BFY51★	17
BFY52★	17
BFY65★	25
BSY26★	40
BSY29★	85
BSY78	25
BSX20★	20
BSY95A	18
BU105★	168
BU208★	295
E5567	48
MD8001★	158
MJ400★	90
MJ491★	160
MJ2955★	120
MJE340★	45
MJE370★	68
MJE371★	80
MJE520★	65
MJE521★	74
MJE2955★	98
MJE3055★	82
MPF102	36
MPF103	36
MPF104	36
MPF105	36
MPF106	50
MPF107	50
MPSA05	32
MPSA06	32
MPSA55	30
MPSA56	30
MPSA70	26
MPSU02	60
MPSU05	64
MPSU06	32
MPSU52	70
MPSU55	79
MPSU56	82
MPU131★	39
OC25★	65
OC26★	95

Type	p
OC28★	70
OC29★	70
OC35★	70
OC36★	53
OC41★	17
OC42★	17
OC44★	25
OC45★	17
OC46★	35
OC70★	25
OC71★	23
OC72★	27
OC77★	56
OC79★	53
OC81★	24
OC81D★	28
OC82★	25
OC82D★	35
OC83★	28
OC84★	44
OC84N★	44
OC123★	115
OC139★	140
OC140★	125
OC141★	157
OC170★	40
OC171★	42
OC201★	125
OC202★	135
OC203	150
OC204★	150
TIP29	43
TIP29A	45
TIP29C	68
TIP30	52
TIP30A	56
TIP30B	64
TIP30C	74
TIP31★	52
TIP31A★	54
TIP31B★	58
TIP31C★	68
TIP32★	60
TIP32A★	63
TIP32B★	80
TIP32C★	83
TIP33★	95
TIP33B★	112
TIP33C★	120
TIP34★	110
TIP34A★	115
TIP34B★	140
TIP35★	219
TIP35A	225
TIP35C★	270
TIP36A★	346
TIP41A★	66
TIP41B★	73
TIP42A★	78
TIP42B★	82
TIP2955★	69
TIP3055★	56
TIS43	27
TIS44	27
TIS46	40
TIS50	47
TIS74	47
TIS91	24
ZTX107	12
ZTX108	10
ZTX109	15
ZTX300	14
ZTX301	14
ZTX302	19

Type	p
ZTX303	22
ZTX304	24
ZTX311	15
ZTX314	24
ZTX341	20
ZTX500	17
ZTX501	15
ZTX502	19
ZTX503	19
ZTX504	51
ZTX531	28
ZTX550	18
2N526★	40
2N696★	15
2N697★	21
2N698★	39
2N699★	45
2N706★	17
2N706A★	19
2N707★	50
2N708★	19
2N914★	18
2N916★	27
2N918★	34
2N920★	51
2N930★	18
2N961★	61
2N1131★	21
2N1132★	23
2N1302★	25
2N1303★	27
2N1304★	45
2N1305★	45
2N1306★	45
2N1307★	45
2N1308★	48
2N1613	20
2N1671★	150
2N1671B	190
2N1893★	27
2N2160★	85
2N2217★	40
2N2218A★	25
2N2219A★	24
2N2220A★	26
2N2221A★	21
2N2222★	21
2N2303★	250
2N2369★	14
2N2483★	30
2N2484★	30
2N2614	54
2N2646★	41
2N2904A★	24
2N2905A★	25
2N2906★	18
2N2907★	20
2N2907A★	22
2N2926G	10
2N2926O	8
2N2926R	8
2N2926Y	8
2N2011★	30
2N3053★	17
2N3054★	45
2N3055★	49
2N3525★	96
2N3614★	169
2N3615★	135
2N3663	32
2N3702	11
2N3703	12
2N3704	11
2N3705	12

Type	p
2N3706	10
2N3707	11
2N3708	12
2N3709	12
2N3710	12
2N3711	12
2N3715★	245
2N3771★	164
2N3772★	175
2N3773★	275
2N3819	22
2N3820	44
2N3823★	49
2N3824★	39
2N3866★	90
2N3903	15
2N3904	18
2N3905	18
2N3906	18
2N4037★	39
2N4058	15
2N4061	13
2N4064★	255
2N4191★	66
2N4236	47
2N4289	24
2N4859	35
2N4871	34
2N5135	12
2N5136	12
2N5138	12
2N5179	60
2N5180	60
2N5191	65
2N5305	40
2N5457	35
2N5458	36
2N5459	36
2N5485	42
2N6027	35
40311★	38
40313★	93
40316★	60
40317★	38
40326★	40
40327	48
40347★	65
40348★	73
40360★	43
40361★	43
40362★	43
40411★	295
40412★	42
40476	170
40594	90
40603★	58
40636★	110
40673★	55

Matched Pair 10p extra

NOISE DIODES
Z5J **105p**

DIAC★
ST2 **25**

DIODES

Type	p
AAZ15	15
AEY11	60
BA100	10
BA102	10
BY100	24
BY126	14
BY127	14
OA9	
OA10	40
OA47	8
OA70	8
OA79	12
OA81	15

Type	p
OA85	12
OA90	6
OA91	6
OA95	8
OA200	9
OA202	8
IN914	4
IN916	5
IN4001 2★	5
IN4003★	6
IN4004 5★	6
IN4006 7★	7
IN4148	4
3A 100V★	18
3A 400V★	20
3A 600V★	27
3A 1000V★	30

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Range 3·3V to 33V
400MW **9p**
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MVAM2 **135p**
BB104 **40p**
BB105B **40p**
BB106 **45p**

★BRIDGE RECTIFIERS plastic case

Type	p
1A50V	21
1A100V	24
1A200V	26
1A400V	31
1A600V	34
2A50V	33
2A100V	44
2A200V	46
2A400V	56
4A100V	72
4A400V	79
4A800V	120
6A100V	73
6A400V●	92
BY164	56

TRIACS★

Type	p
3A 400V	113
6A 400V	140
8A 400V	160
10A 500V	195
15A 400V	240
15A 500V	285
30A 400V	398
40430	99
40669	99

THYRISTORS★ SCRs

Type	p
1A50V	38
1A 100V	42
1A 200V	47
1A 400V	52
3A 100V	43
3A 400V	110
5A 400V	120
7A 200V	120
7A 400V	135
8A 400V	150
C106D	55
TIC44	25
TIC45	37
2N4444	191

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BI-PAK

High quality modules for stereo, mono and other audio equipment.

NEW

PUSH-BUTTON

STEREO FM TUNER

OUR PRICE ONLY

£20.45

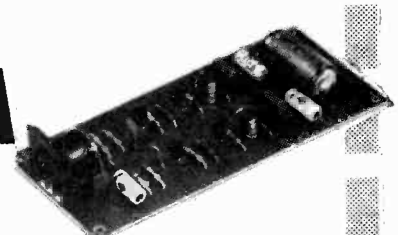
Fitted with Phase Lock-loop Decoder

The 450 Tuner provides instant program selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls.
Used with your existing audio equipment or with the BI-KITS **STEREO 30** or the **MK60** Kit etc. Alternatively the **PS12** can be used if no suitable supply is available, together with the Transformer **T538.**
The S450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

★ FET Input Stage
★ VARI-CAP diode tuning
★ Switched AFC
★ Multi turn pre-sets
★ LED Stereo Indicator

Typical Specification:
Sensitivity 3μ volts
Stereo separation 30db
Supply required 20-30v at 90 Ma max.

MPA 30



Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new M.P.A. 30, a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.
It is provided with a standard DIN input socket for ease of connection.
Full instructions supplied.

£2.85

VAT ADD 12½%

POSTAGE & PACKING
Postage & Packing add 25p unless otherwise shown. Add extra for airmail. Min. £1.00

STEREO PRE-AMPLIFIER

PA 100

OUR PRICE **£13.75**

A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

Frequency Response + 1dB 20Hz - 20KHz. Sensitivity of inputs
1. Tape Input 100mV into 100K ohms
2. Radio Tuner 100mV into 100K ohms
3. Magnetic P.U. 3mV into 50K ohms

P.U. Input equalises to R1AA curve within 1dB from 20Hz to 20KHz.
Supply — 20-35V at 20mA.

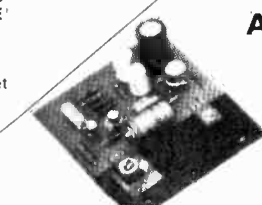
Dimensions 299mm x 89mm x 35mm.

MK. 60 AUDIO KIT: Comprising 2 x AL60's. 1 x SPM80. 1 x BTM80. 1 x PA100. 1 front panel and knobs. 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet. **COMPLETE PRICE £29.55** plus 85p postage.

TEAK 60 AUDIO KIT:
Comprising Teak veneered cabinet size 16¾"x11½"x3¾", other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets etc. **KIT PRICE** [illegible] plus 85p postage.

AL-30

AUDIO AMPLIFIER MODULE



The versatility of the design makes it ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the home.

SPECIFICATION:
- **Harmonic Distortion Po=3 watts f=1KHz 02.5%**
- **Load Impedance 8-16ohm**
- **Size: 75mm x 63mm x 25mm**
- **Frequency response ±3dB Po=2 watts 50Hz-25Hz**
- **Sensitivity for Rated O/P — Vs=25v. RL=8ohm f=1KHz 75mV. RMS**

AL30 10w R.M.S. £3.45

STEREO 30

COMPLETE AUDIO

7+7 WATTS R.M.S.

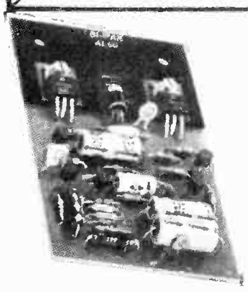
P & P 45p

£16.25

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind will produce a high quality audio unit suitable for use with a wide range of inputs i.e. high quality ceramic pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel knobs, main switch, fuse and fuse holder and universal mounting brackets enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available. Ideal for the beginner or the advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty (can be installed in 30 mins).

TRANSFORMER £2.45 plus 62p p &p
TEAK CASE £5.25 plus 62p p & p.

AL 60



25 Watts (RMS)

★ Max Heat Sink temp 90C. ★ Frequency response 20Hz to 100KHz ★ Distortion better than 0.1 at 1KHz ★ Supply voltage 15-50v ★ Thermal Feedback ★ Latest Design Improvements ★ Load — 3,4,8, or 16 ohms ★ Signal to noise ratio 80db ★ Overall size 63mm. 105mm. 13mm.

Especially designed to a strict specification. Only the finest components have been used and the latest solid-state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

£4.35

NEW

PA12

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL 30 Amplifier Modules. Features include on/off volume. Balance, Bass and Treble controls. Complete with tape output.

Frequency Response 20Hz-20KHz (—3dB). Bass and Treble range 12dB. Input Impedence 1 meg ohm. Input Sensitivity 300mV. Supply requirements 24V .5mA. Size 152mm x 84mm x 33mm.

£6.70

PS12

Power supply for **AL20/30, PA12, SA450** etc.

Input voltage 15-20v A.C. Output voltage 22-30v D.C.
Output current 800 mA Max. Size 60mm x 43mm x 26mm.
Transformer T538 £2.30

OUR PRICE £1.30

Stabilised Power Supply Type SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mains Transformer **BMT80**, the unit will provide outputs of up to 1.5A at 35V. Size 63mm. 105mm. 30mm. Incorporating short circuit protection.
Transformer BMT80
£2.60 + 62p postage

£3.75

BI-PAK

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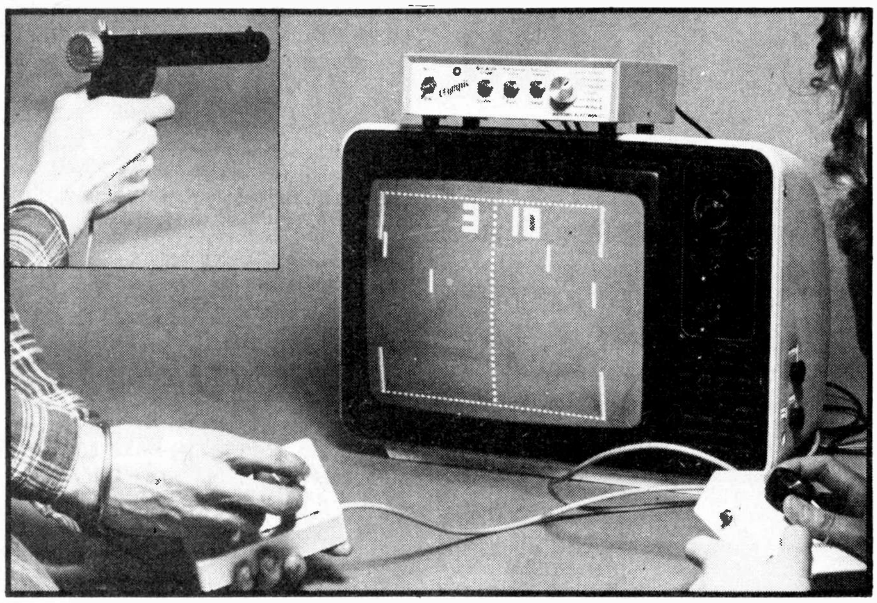
news digest

TV GAMES KIT



The availability G.I. TV games chip has led to kits other than that described in ETI last month. Watford Electronics lent us one of theirs, and this is especially interesting as it includes some special features.

Firstly, the sound is added to the UHF modulated signal and comes out of the TV set, not from a speaker in the unit

The second difference is that the rifle facility is available and is very impressive - circuitry is included which makes the rifle (actually a pistol as shown in the photo insert) sensitive *only* to the spot on the TV screen - it is not sensitive to other light including light bulbs or fluorescents. The pistol circuitry is fairly sophisticated and is an extra, but well worth it. Unlike the regular TV games it is very very difficult to hit the target (one of ETI's staff who used to have marksmen's crossed rifles on his army uniform, scored only 30% hits first time!)

Watford claim that their hand units are designed with children in mind and, although arguably less elegant in appearance than those on the ETI unit, are very practical.

The photo shows two members of ETI's staff battling out a game of football. The inset photo shows the pistol; all the 'business' parts of this are included but the kit builder is left to his own devices as far as the detailed mechanics are concerned.

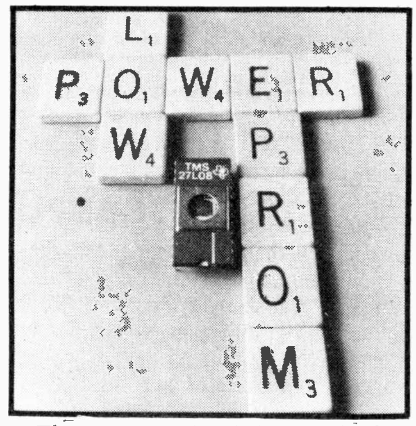
The 'Olympic', as the kit is known, retails for £28.70 with the rifle accessory kit costing another £10.15 (prices inclusive of VAT and postage).
Watford Electronics, 33 Cardiff Road, Watford, Herts.

STOP PRESS: Watford now have UHF modulators in stock suitable for any TV game; price is £3.75 inclusive.

SCRABBLING ALONG THE PROM?

Designated the TMS 27L08, the new EPROM has less than half the power consumption of devices like the TI TMS 2708 and the Intel.

New features are – reduced power consumption - 245 mW is typical : ten per cent power supply voltage tolerances : guaranteed dc noise immunity in both high and low states : increased output drive capability (one Series 74, 74S, or 74LS TTL circuit).



The memory circuit is organised as 1,024 words of 8-bit length. It is designed for high-density, fixed-memory applications. Maximum access and minimum cycle times are 450 nanoseconds. Prices on application.
Texas Instruments Ltd., Microprocessor Dept., MS15 Manton Lane, Bedford, MK41 7PA.

CBM CHEAPEN THEMSELVES

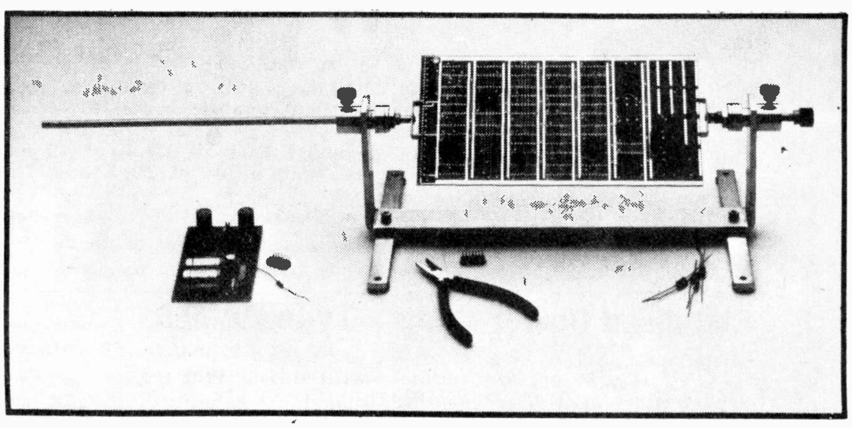
Another price reduction. (Isn't it nice to be able to report things like this?) The CBM 5000 range of LED watches has come down to £11.95 (5001 and 5002) and £14.95 (5003) from £17.50 and £21.00 RRP respectively.

Later in the year CBM will be plunging into the liquidy crystal market.

BEEN FRAMED?

The new Seno PCB Workframe is an inexpensive purpose-designed holder for PCBs. Adjustment is simple and accurate. It will accommodate boards up to 240 mm. x 200 mm. in size, and can be angled to suit the individual.

Designed for inspection, test, soldering or draughting, the Workframe is constructed in plated, heavy-guage mild steel. It costs £13.50 including postage and VAT, from Decon Laboratories Ltd., Ellen Street, Portsdale, Brighton, Sussex BN4 1EQ.



BRITISH? PRECISELY!

From a firm called James Niell comes the Micro 2000 to rise into our News Digest with carefully measured precision. This instrument gets our vote for the best innovation of the year already! A digital *micrometer* no less.

As you can see from the picture, it actually reads out a measurement in seven-segment format. Goodbye verniers. It has so many features and advances, it is perhaps best simply to list them.

Accuracy to ± 0.002 mm., with a 'constant force' spindle and self-calibration facility. As soon as it is switched on, the 2000 self zeros.

The zero reset means that it can be used as a comparator against a known standard, and variations from that can be read directly. Also in awkward situations, the instrument can be zeroed, utilised, and then removed to be read.

The unit is entirely self-contained from rechargeable cells. It can be mains run from a (supplied) recharger.

Operation is very very simple. The slider beneath the display is simply advanced until the jaws grab whatever you're measuring. The display reads the travel.

James Neill will be introducing the Micro 2000 onto the British market almost immediately, and to the world at large in 1978. Patent applications have gone in for 14 countries. We congratulate the makers on a superb achievement, and wish them every success *James Niell Ltd., Napier Street, Sheffield S11 8HB.*

A NIM-ROD FOR OUR OWN BACKS!

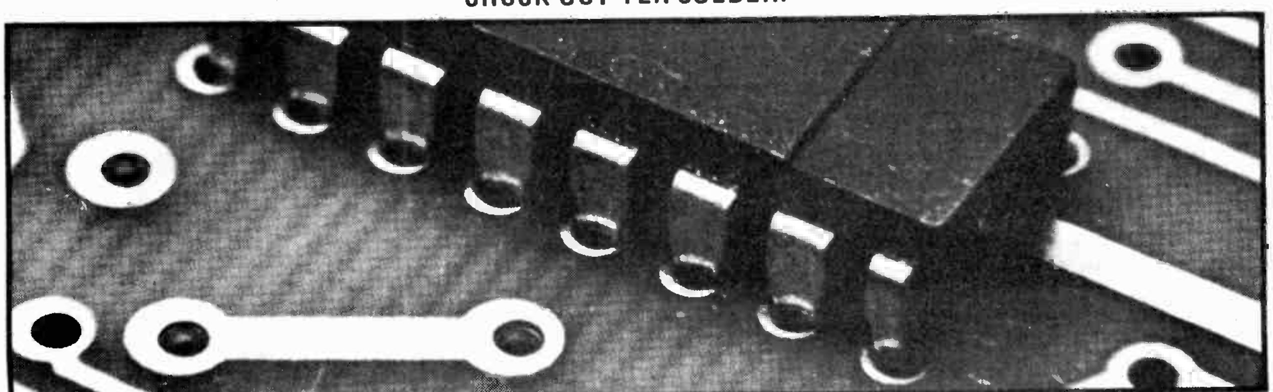
Britain has chosen to buy 11 Nimrod aircraft instead of the 'AWACS' (Air Warning And Control Systems) from Boeing of America. The decision means about 7000 new jobs. Boeing claim their system is superior over land but acknowledge the British edge over sea. American electronics papers have been sarcastic (at the least) about the decision. Well, so would we be, if they'd bought the yankee version!

LOGGING CATS

Bi-Pak Semiconductors are the latest company to submit their catalogue for our editorial perusal (keep 'em coming folks!) and the more we read of these efforts, the more we realise just how great a choice the mail-order constructor (?) has these days.

Bi-Pak are particularly strong on ready-built modules, books and 'hardware' i.e. leads, knobs, plugs etc. A very comprehensive range of semiconductors, ICs and passives is included. Perhaps of special interest are two teak-sleeved cases for audio equipment. Anyone who has built a piece of equipment for his living-room, and tried to find something other than an aluminium bird-cage to house it, will appreciate these. *Bi-Pak Semiconductors, The Maltings, 63a High Street, Ware, Herts.*

CHUCK OUT YER SOLDER!



Fresh as anything can be from the USA, we have a new solderless method of assembling PCBs. The idea is called Augat sockets, and they are designed

for use with plated-through hole boards. They are 'built-in' sockets which fit *inside* the holes to hold leads etc. So they take up no room on the board in height or width. Boards can be spaced closer of need be, and the cost of soldering is lost. Contacts cost less per lead than do normal sockets.

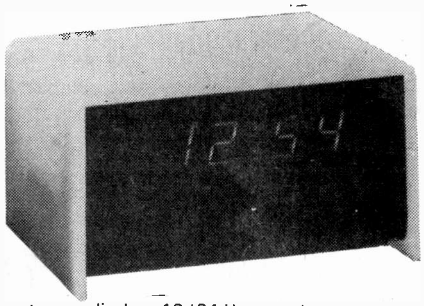
In order to make mass production with this system feasible, a special machine has been developed to fit 30,000 contacts per hour. We suspect however, that this method will gain its initial 'lift-off' from a prototyping market. The contacts are made of berylium-copper, and the producing company has been making switch contacts for well over ten years, which does tend to add a little more reliability to the notion!

Available in U.K. from Semiconductor Specialists, Premier House, Fairfield Road, West Drayton, Middlesex.

Metac SPRING BARGAINS

THE METAC DIGITAL CLOCKS

★ COMPLETE KIT ★



- Pleasant green display · 12/24 Hour readout
- Silent Synchronous Accuracy · Fully electronic
- Pulsating colon · Push-button setting
- Building time 1 Hr. · Attractive acrylic case
- Easy-to-follow instructions · Size 10.5 x 5.7 x 8 cm
- Ready drilled PCB to accept components

A professional product for the home constructor. It has been designed by engineers using the most modern techniques and components. It will appeal both to the confirmed hobbyist and to the man who simply wants to 'have a go'. The kit contains everything except a mains lead. The only tools required are a small soldering iron, solder, screwdriver and wire cutters.

KIT PRICE £9.60
+ 76p VAT P&P inc.

ALARM CLOCK KIT

As above plus:

- ★ 24-Hour Alarm
- ★ 10 Minute Repeater
- ★ Mercury Tilt Switch

KIT PRICE £11.60
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BRITAIN'S TOP SELLING DIGITAL ALARM CLOCK

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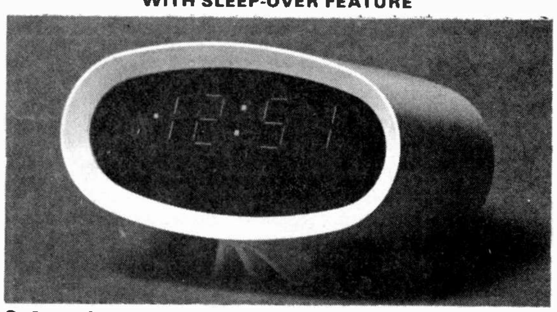
★ Fully Built, Tested and Guaranteed ★
WITH SLEEP-OVER FEATURE



- Bright Orange 12 Hour Display or
- Soft Green 24 Hour Display
- 24 Hour Alarm
- 10 Minute Repetition
- Alarm Set Indicator
- Accurate Silent Timekeeping
- British Designed and Built
- 5 in. across, 3½ ins. deep

Please state choice

COMPLETE CLOCK
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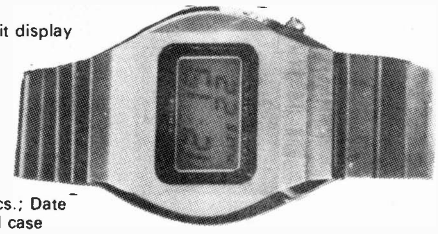
THE 'METAC' DIGITAL WATCHES

THE GRUEN EXECUTIVE AMERICAN MADE LCD

Continuous 6 digit display
with backlight



Hours; Mins.; Secs.; Date
Solid heavy metal case
A superb man's watch

£35
+ £2.8 VAT

THE BLACK WATCH by BULER SWISS PRECISION MADE LCD

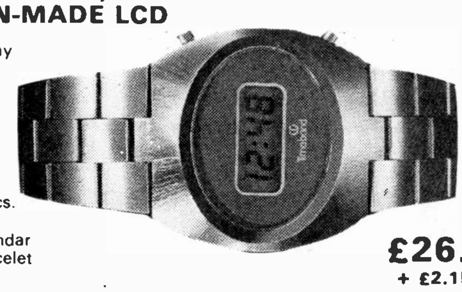
Continuous 6 digit display
with backlight

Hours; Mins.; Secs
Month; Date
Auto 4-year calendar
Glass-filled epoxy black case

£30.55
+ £2.44 VAT

THE TIMEBAND by FAIRCHILD AMERICAN-MADE LCD

Continuous display
with backlight



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Superb metal bracelet

£26.95
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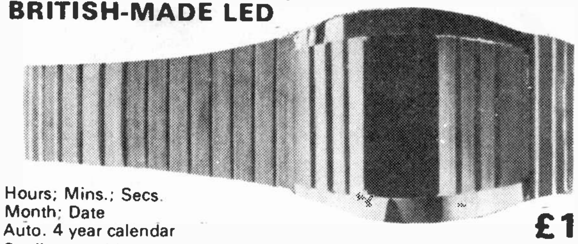
THE SILVER BAND by TIME-MICRO BRITISH-MADE LED



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Month; Date
Auto. 4 year calendar
Quality metal bracelet

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news digest

SINCLAIR STEPS AHEAD (36 TIMES)

Take a good close look at the photo. This is not just another calculator. See the word 'Programmable'? Well, it is! A 36 step programmable machine for £17.22 RRP all inc!!!

Sinclair's new Cambridge Programmable is destined to cause not so much as a stir, as a bloody good whisk! Its price is little more than an average scientific, and after the discounters have done their evil work, heaven only knows what it'll actually *sell* for.

As a straightforward machine, the Sinclair can handle algebraic functions plus $\sqrt{x}$, $1/x$, x^2, sin, cos, tan, arc, rads/degs, ln and antilog, e^x, parenthesis, change sign, scientific notation and constant. So the usual failing of programmable machines, i.e. insufficient key functions, has been comprehensively avoided!

The case is the well-known and (apparently) liked Cambridge case. Power comes from a Mallory (PP3) type cell which gives 30-40 hours running time, or a separate optional (i.e. £3.20 extra) mains adaptor.

But the breakthrough here is the program capability. This has been made possible by the use of a single chip National MPU. This is a four-bit MPU with 12 k of ROM on chip. Sinclair did the algorithms themselves, and according to them they only *just* got it all on - so no one else has a chance they say!

Back-up is provided in the form of a four volume program library containing 294 programs in electronics, finance engineering, mathematics and even games! The market they're going for is honestly all of it! At this price they stand a good chance of interesting everyone from the schoolkid to the technician to the university student. The library includes such stuff as mortgage payments, moon landing game, discount calculations etc., conversions from anything to everything else etc., etc., etc., etc.

Sinclair are expecting 60% of production to end up in the USA, but this leaves plenty for Europe! We're hoping to review this incredible little box very soon, but meanwhile your local retailer will be getting them. But be warned - to play with one is fatal you'll end up taking it home!

Nice one Sinclair.

Sinclair Radionics, London Road, St. Ives, Huntingdon, Cambs PE17 4HJ.

CORRECTIONS AND CORRIGENDA

1. The 9368 Hex display decoder mentioned in Tech-Tips recently is available from Conway Electronics Ltd., John Scott House, Market Street, Bracknell, Berks. The price for the two is £5.48 all inc.

2. DVM, March 77, page 38. The voltage regulator should in fact be isolated from the chassis with a mica washer.

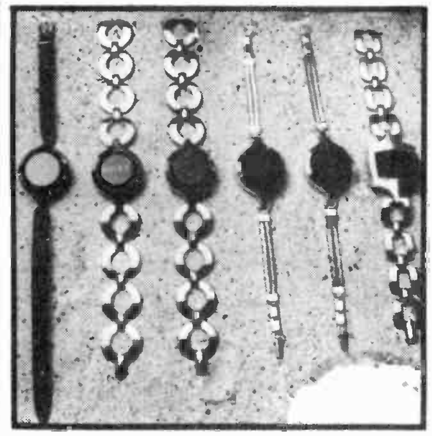
3. System 68 PSU, May 77, page 57. Figure 7: the LEDs are shown the wrong way round - this also applies to figure 11 on page 59.

4. Burglar Alarm, April 77, page 58. Bell test PB2 should be connected to J and K, *not* across SCR1. Page 60, pin 8 of the 4001 should be earthed, *not* pin 10 (which is left unconnected).

5. ERII speakers, May 77, Fig.1. The capacitors C1 and C4 are shown as 5u. This should in fact be 16u. The networks supplied by Badger Sound Services are correct.

TEXAS RANGES EXTENDED

Twenty-seven new low cost LED watches are now unloaded on the public by Texas Instruments. They range in price from £13.95 to £39.95 RRP, no doubt though they will be discounted.



The ladies watches use a new module design, and smaller batteries (life circa six months) to get down to their tiny size. Texas include two free batteries with each watch.

For kiddies there is a plastic watch complete with a set of transfers which can be stuck onto the watch case to customise it! Clever piece of marketing that...

Guarantee an all models one year. (Wonder if that includes the transfers? Don't say it's non-transferable (ouch!)

Texas Instruments, Manton Lane, Bedford.

BIFET OP AMPS CHOPPED

National have reduced prices on their range of bifet op amps, including the 741. Prices of the LF335/6/7 range are down from £1.45 to 52p in 100 off. Let us hope this reflects in the shops as soon as possible.

An interesting comment from National concerning the drop is that they feel they are 'far enough down the learning curve that our production yield has increased significantly.'

Follow that.

SIGNETICS NOW NATIONALISED!

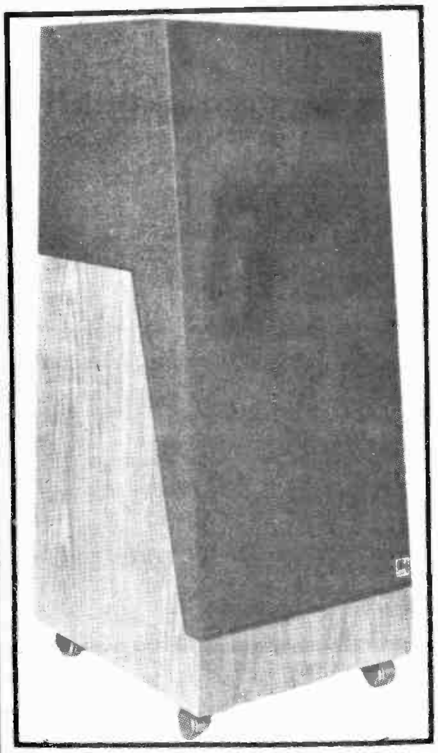
National Semiconductors Corporation of Santa Clara, California, and Signetics Corporation of Sunnyvale, California, have formally signed an alternate source agreement to manufacture and supply each others proprietary 8-bit Microprocessors.

National Semiconductor will second-source Signetic's 2650 Microprocessor, and Signetics will second-source National's SC/MP II Microprocessor.

news digest

HI-FI 77 GETTING HIGHER

The news for this year's superbly organised Heathrow Hi-fi exhibition is mainly about loudspeakers. And within this field, KEF undoubtedly stole the show!



Due for release in October is the KEF 105 linear phase enclosure. Put quite simply, it sounded better than any other domestic enclosure we've heard! The sound was crystal clear, and had a definite 'depth' to it, which lent a pin-point quality to the stereo imagery. You could see the boxes

standing in front of you - it's impossible to miss 'em - but the sound wasn't obviously coming from *there* in particular. Superb.

A new form of bass loading is employed, to improve power handling and efficiency. (It works!)

Linear-phase again, and with some neat ideas. On the front panel (it's impossible to speak of a baffle when there's three!) is an LED, recessed by some amount. When you can see this light from your listening position, the speaker is aligned to you. When you can't, it isn't! This allows optimisation of the vertical dispersion within the room. The LED doubles as a 'clipping indicator'.

Both the smaller top enclosures can be rotated in the vertical and horizontal directions.

The 105 will be expensive (around £700 a pair) but worth every penny!

Completely new this time are a British firm called Mission Electronics, who launched an entire range of enclosures this month. First off the blocks are three speakers, the 710, the 720, and the 730, in order of ascending size. Celestion and Peerless drive units are employed at present, but plans are afoot to make their own. All three of the designs are very good indeed, and should provide some stiff competition to existing wooden boxes. The 720 is particularly impressive,

having a clean and *slightly* forward sound, with good detail and excellent bass. At £232 RRP inc. VAT it has a sound future! (The first five years of which carry a guarantee!)

Mission are working on an amplifier combination to drive their speakers, probably out around Christmas. In the meanwhile add the speakers to any shopping-lists you draw up in the field.

If you missed this year's show, at least make sure you go *next* year - it's still the best exhibition of the year!

NAME PLEASE...

Designed to assist in trouble-shooting in MPU systems, the 5004A 'Signature Analyser' operates by locating faulty bit streams. The instrument recognises a unique hex number (the signature) for each data node, and checks the streams at each, by use of its active

probe. When a mis-match occurs between specified info and what the 5004 is receiving, the signature is displayed for the faulty point. At £744 it is NOT for the home constructor.

007 LINEAR

In the next James Bond film, he will travel on a boat powered by linear motors. In the film, The Spy Who Loved Me, two futuristic boats are situated one on either side of the interior of an ocean-going tanker and are fired through tubes to launch them from the tanker.

In the studio, each boat was supported by air pads above supporting aluminium track, concealed below a plywood floor. This formed a reaction plate for three pairs of linear thrust motors, which were mounted vertically underneath the boat, and travelled along either side of the track.

The boats reached a maximum speed of 12 mph along the 70 yard track.

Each of the three thrust units were wound to give 300 N maximum stalled thrust on 415 volts, 3 phase, 50 Hz supply. The approximate input current was 11.75 amps/line/motor.

The boat and track were designed and supplied by IES Projects Ltd., of Maidenhead, Berks.

LIQUID CRYSTAL DISPLAYS

BY ROBIN C. H. MOORSHEAD B.Sc.

AS DAY FOLLOWS NIGHT, there are certain patterns of change in the physical world which we hold to be always true. Perhaps one of the earliest that we learn is that matter exists in three states, solid (crystalline), liquid or gas. The particular state a substance exists in depends on temperature. At low temperatures substances tend to be solid, at higher temperatures liquid, and yet higher, gaseous. Further more, the transition between the states is clear and precise, for example, ice changes to water at 0°C, there is no gradual transition.

This pattern of change is explained by the "Kinetic theory." This theory is based on several assumptions: 'That matter consists of minute, more or less spherical particles which are held together by "cohesive forces" which are spread evenly over their surface. In the solid (crystalline) state the particles are tightly bound by the cohesive forces and are perfectly ordered like bricks in a wall. As the temperature increases, the particles begin to vibrate and the cohesive forces weaken so the particles can move about but are still attached to one another:

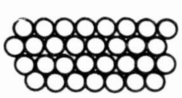


Fig. 1

At higher temperatures (the cohesive forces are vanishingly small and the (gas) particles fly about at random.

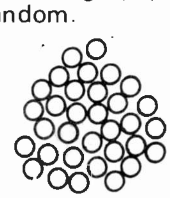


Fig. 2

Simple materials which fit into this description have another property, that their physical characteristics are the same from whichever direction they are approached. This is termed "Isotropic." Examples of isotropic materials are glass, steel or water. Their electrical resistance, refractive index and strength are the same from whichever direction we measure them.

Against the grain

However, by no means all materials are isotropic, wood for example is much stronger across the grain than with the grain, graphite has a higher electrical resistance when measured through it's "plate" structure than when it is measured along the plates. Such materials as these are termed "Anisotropic."

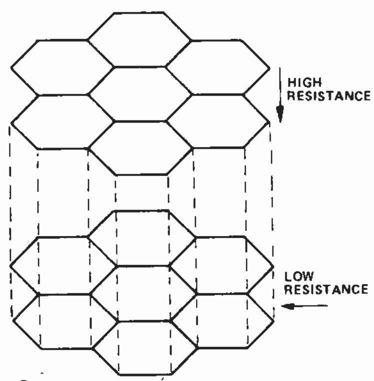


Fig. 3

It would be surprising if wood and graphite were isotropic, since they are constructed of rods (cellulose fibres) and plates (the graphite). In the same way we would not expect roof slates to fall into a box in a random arrangement, they will have a strong tendency to fall flat and so order themselves into an anistropic arrangement.

Rods and plates

In exactly the same way many of the large molecules found in organic chemistry have rod- or plate-like shapes and have anisotropic crystal structures. The tendency towards ordered arrangements in these substances is so great, that when they melt they retain a degree of order until the temperature is considerably increased. As a result the liquid has anisotropic properties, some flowing in a gliding stepwise fashion, or interfering with the passage of light. When this happens the substance is said to possess a liquid crystalline phase (sometimes termed a mesomorphic or paracrystalline state).

So we have:

	Increasing temperature →
For an isotropic material:	solid → liquid → gas
For an anisotropic material:	solid → liquid crystal → isotropic liquid → gas

It is of interest to note that this property has been well known since 1890, and some 0.6% (15,000-20,000) of organic chemicals show this behaviour.

Nematic and smectic

Liquid crystals fall into two main categories: Nematic (from the Greek thread) and Smectic (from the Greek for soap).

Smectic liquid crystals have many interesting properties but have found little practical application, so they will not enter into the article any further.

The nematic liquid crystals have many applications and form the substance of this article. There are several types of nematic materials. The difference in these types is shown in fig. 4.

Some nematic liquid crystals possess properties which cause them to interfere with the passage of light in an applied electric field, or with changing temperature. They are of great interest in modern electronic displays for several reasons:

(1) The power consumption of such displays is extremely small, between 2µA and 0.2µA per segment of a 7-segment display, about 10µW per Cm² of display, where as a similar LED display consumes 500 mW.

(2) They are made of the commonest elements, carbon, hydrogen, oxygen, nitrogen, rather than the more expensive elements

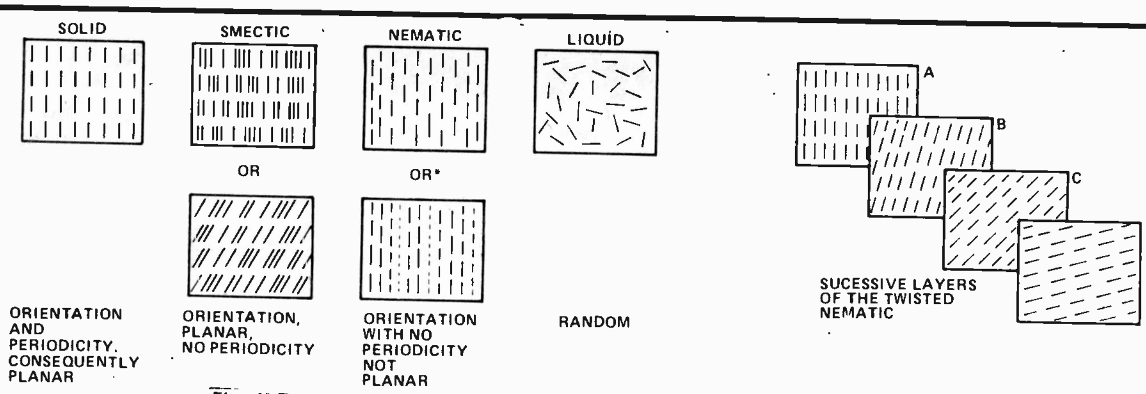


Fig. 4 The second form of nematic structure is 'twisted' each plane being rotated a few degrees with respect to the last; this is known as twisted nematic or more commonly cholesteric (yes, basically the same type of chemicals that cause heart disease!). This type is most important.*

such as gallium, germanium, etc.

(3) Since they do not emit light themselves, but interfere with the passage of incident light, they cannot be "washed out" by strong incident light.

(4) They are compatible with PMOS circuits.

There are, needless to say, disadvantages as well:

(1) Since they are passive, i.e. they do not emit light, they cannot be read in the dark, however, this can be overcome by providing background illumination. This increases power consumption; the power consumed however does not have to pass through the addressing circuit, as it does in LED displays.

(2) Since they are operating in a phase between solid and liquid their temperature range is limited, at a maximum between −20°C and 100°C, but more typically 0°C to 60°C.

Below this temperature the display freezes, above the maximum the liquid is isotropic and no display is visible. Furthermore the response time near the freezing point is rather slow, in the order of 0.2-second rise time and 0.6-second fall time. Freezing or or liquifying the display does no permanent damage, but temperatures in excess of 150°C may cause irreversible damage. There is no doubt that future development will broaden this temperature range considerably.

(3) The lifetime is still limited, but provided conditions are ideal it is now well in excess of 10,000 hours. Future development of materials with higher purity, and chemical stability will improve this a great deal.

Stability may be affected by several factors. Firstly, certain liquid crystalline materials undergo irreversible chemical changes under d.c. conditions, it is critical that such display have no d.c. components whatsoever in the addressing circuit, secondly chemical changes are caused by impurities. Thirdly, certain liquid crystalline materials are effected by ultra violet light.

Chemistry

We have no intention of discussing the detailed chemistry of the materials used — it is quite complex — and most names are longer than those found in the small print on toothpaste tubes. However, an outline of the structure of a typical nematic and a typical cholesteric material are included for comparison:

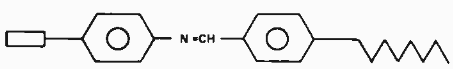
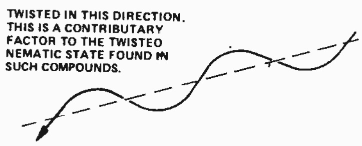


Fig. 5. A 'Shiffs' Base. This has a fairly straight structure about seven times as long as it is broad.



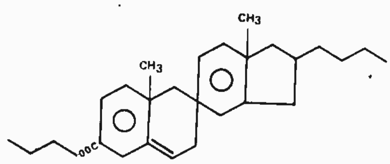


Fig. 6. A cholesterol ester. The molecule is about 8-10 times longer than it is broad.

The actual material used in a display is not usually pure, it is more frequently a mixture of two or more nemetics. This has the advantage of increasing the liquid range by the creation of a "Eutectic" mixture.

The anisotropic properties that materials suitable for display pur-

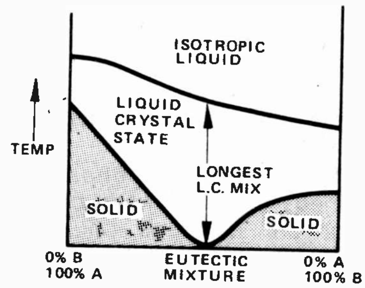


Fig. 7.

poses must include are:

(1) The refractive index is different as the material is viewed from different aspects, i.e. the light is bent more as it passes through the material in one direction then another.

(2) The molecule must possess a dipole. This is an uneven distribution of change on the molecule, which causes it to align in an electric field thus:

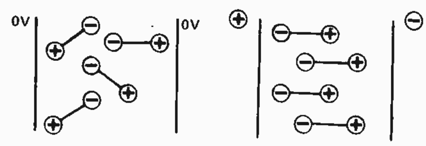


Fig. 8.

A large proportion of organic molecules possess such dipoles. The dipole on the materials used in liquid crystalline displays have two components, one along the long axis (ε∥) and one perpendicular (tε⊥) to it.

If the dipole along the long axis A is greater than dipole perpendicular to it, it is said to possess positive dielectric anisotrophy. If the dipole is greater on the perpendicular axis

LIQUID CRYSTAL DISPLAYS

it is said to possess negative dielectric anisotropy.

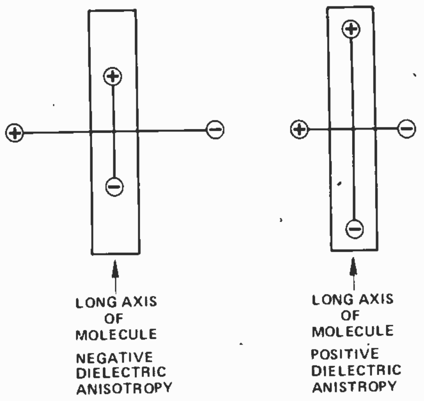


Fig. 9.

(3) The material also must possess anisotropic conductivity (as graphite does). The conductivity in nematic liquid crystals is greater along the long axis than perpendicular to it.

(4) The material should have a resistivity of the order of 10^9 Ω Cm.

Display construction

The displays work in two different ways, but the construction of the cells are similar, the differences are

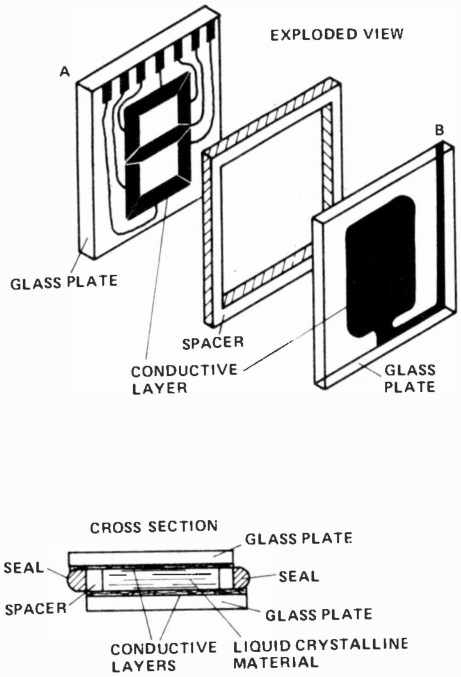


Fig. 10.

mainly in the filters on the back and faces of the display and of the type of background.

The cell consists of a very thin layer (about 12 µm) of the liquid crystalline material between two sheets of glass which have a conductive coating on their inside. One glass plate (a) has the actual seven-segment display etched on it. The other plate (b) has a common electrode etched on it. This conductive coating is either tin oxide, or a mixture of tin and indium oxides This provides an electrode with about 90% transmission of light.

This conductive coat is further treated so that the molecules align themselves with the surface while an electric field is not applied.

This provides a more or less translucent display. When an electric field is applied, the molecules move so as to align their dipoles with the electric field. This causes changes in the optical properties of the liquid crystal material which appears as the display.

There are two principle techniques used here, dynamic scattering and polarization modes.

Dynamic scattering:

In this mode the liquid crystalline material is chosen such that it has negative dielectric anisotropy, with the greater electrical conductivity along its long axis. The molecules are normally perpendicular to the surface when an ac field is applied the molecules, in clusters, move to re-align their dipoles with the field. The re-alignment of the dipole is in opposition to the conductivity and the liquid becomes

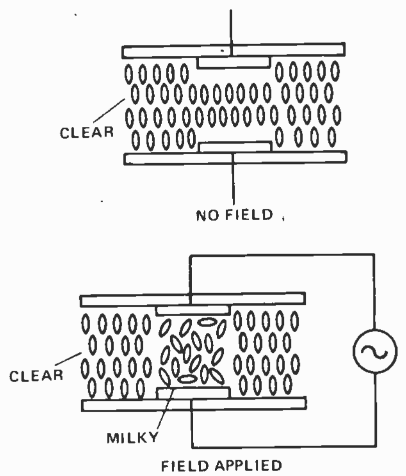


Fig. 11.

turbulent. This turbulence is seen as milkiness in the display.

Since there is no light emitted the display must be used to modify the passage of incident light. This may be done either by passing light through the display, or more usually by reflecting light from a mirror behind the display.

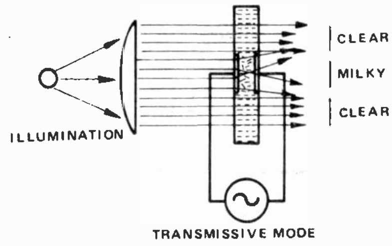


Fig. 12.

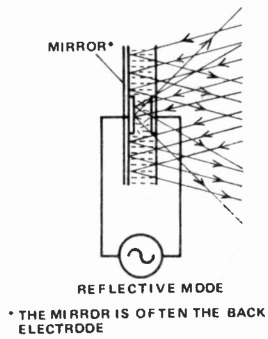


Fig. 13.

The transmissive cell will appear to glow where the segments are switched on. The reflective cell will appear misty where the segments are switched on. These displays have the shortcoming of a rather low "contrast ratio." That is, the apparent difference between the switched on and switched off display is not very great.

Polarization modes

The display is constructed in basically the same way as the dynamic scattering cell. The difference lies in the type of liquid crystalline material. The material used is one which assumed a twisted nematic structure, and has positive dielectric anisotrophy (the major component of its dipole along its long axis).

In this case the inside faces of the cell are coated so that the molecules are parallel to them and aligned in a particular direction when no electric field is applied.

The cell thickness is designed so that there is a complete 90 turn of molecules between the top and bottom faces. The twisted nematic has the property that it twists light that passes through it. Polaroid filters are fitted above and below the cell so that light is polarized as it enters, and is twisted through 90 . exiting through a filter opposed at 90 to the first. The light is then reflected off a mirror and returns via the same pathway.

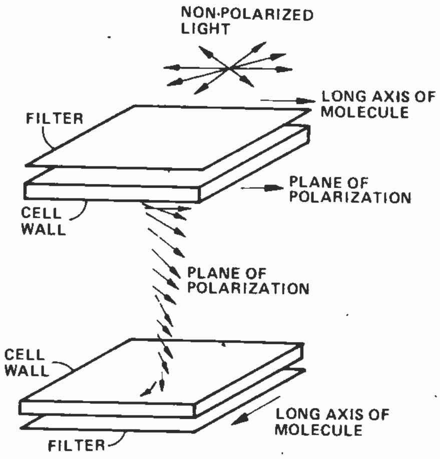


Fig. 14.

In this state the cell is clear. When an electric field is applied the molecules re-orientate to lie perpendicular to the faces of the cell and no longer twist the light. The light is now polarized as it enters the cell, and without being twisted, meets the second filter which is at right angles to the first and so does not pass the light. Hence that portion of the display with the field applied appears black (since no light is re-flected).

If you have not seen this effect before take take two pairs of polaroid sun glasses, look at a source of light with one in front of the other, thus:

Fig. 15.

Held in this way light, although polarized, is free to pass through the second filter since the plane of polarization is the same for both lenses. If one lens is now rotated through 90° thus:

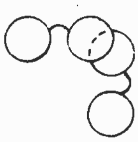


Fig. 16.

No light passes since the light polarized by the first lens will not pass through the second.

The effect of having the "crossed polaroids" in the cell causes almost total extinction of reflected light and consequently a high contrast ratio, an almost completely black and white display. This is many times better than the dynamic scattering cells.

Addressing technique:

The cells are normally operated under ac conditions (although some cholesteric cells may operate under dc.

The technique commonly used is to have dc pulses of identical amplitude, one applied to the back, the other to the display segment via an exclusive — or gate. In the off state the two signals are in phase, in the on state they are out of phase.

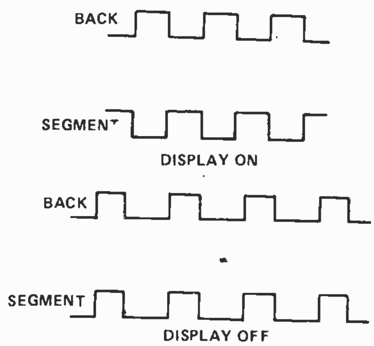


Fig. 17.

This technique has limitations due to the large number of both circuits and connections, however this has been overcome by putting the circuit on the glass of the display using thick film techniques!

Alternatives to this form of drive are to use multiplexed addressing, or m.o.s. shift register memory.

Other uses of liquid crystals:

The use of liquid crystal is not restricted to electrical displays.

Temperature measurement:

Certain nematic liquid crystals (cholesteric) change colour over the whole range of the spectrum (red to violet) as their temperature changes. Furthermore the colour change is over a very narrow temperature range, usually 2 or 3 C. The temperature at which this happens, and the range over which the change takes place can be adjusted by use of mixtures of different cholesterics.

A set of 10 or 12 of such cells in a row, the following one starting to show colour at 2 C higher temperature than the previous one, forms a useful thermometer working over a fairly restricted range. They have

Liquid crystal displays have made big in roads into the watch market but this may only be the beginning of the story.

found application as living room and refrigerator thermometers.

Perhaps a more important application is using liquid crystals which have a very narrow range over which they change colour (0.5 C). They have found application in medicine since they can resolve differences of 0.05 C.

Assuming the liquid crystal is set to show colour at normal skin temperature any local deviation from the correct temperature will show as a different colour. This has applications in detecting cancers, since they tend to be hotter than normal body heat. They can also be used to see areas of poor blood flow, or where allergic reactions are taking place, since they are slightly hotter or colder than the normal body temperature.

Cells with extremely low temperature resolution can even detect field intensity patterns of microwaves and ultrasonic sound fields due to local heating effects.

As might be expected there are also cells which change colour with applied electric field. This would appear to have interesting prospects for the future.

Other interesting possibilities which occur include the "memory effect". Certain cholesterics take hours, or some cases weeks, to return to their clear liquid crystalline state after they have been scattered by an applied electric field. The clear state can be restored by applying a different electric field.

Clearly liquid crystal technology has an enormous amount to offer a wide variety of fields — electronics, medicine and others. We are likely to see further interesting developments in the next few years as this technology takes over, and improves on existing display techniques. How about an alpha numeric display with independently variable colour segments? ●

DIGITAL FREQUENCY METER

five ranges up to 10 MHz

THIS DESIGN USES A HANDFUL OF STANDARD COMPONENTS TO ACHIEVE A SUPERIOR PREFORMANCE TO MANY COMMERCIAL UNITS.

BASED UPON A SIMPLE TTL 'heart', this project grew and grew until it formed a 'Short Circuit' which occupied more development time than most major projects!

The basic range of the DFM extends to 9.9 MHz, and will reliably read down to about 1 Hz. By use of the boards the design will pose no problems to the constructor (we hope!) and should prove straightforward in use.

TAKING READINGS

Let's tell you how to use it first. A reading is taken upon operating the 'Test' button. The display will change - upwards - for a short period, halting once the value of the frequency under test is reached. Before making a second test, clear the display, else the reading will be cumulative.

Calibration is always the biggest hurdle with DFMs, and we must confess we've found no new ladders. One suitable method is to use a high-quality 'scope. The time base is usually very accurate on the better models, and each range can be set up using this signal. Failing this, a signal generator of known 'Q' is needed. Each range is independent of the others, and so will need adjusting separately.

CONSTRUCTION

Assemble the boards as per the overlays. Space within the case is restricted, so it might be a good idea to complete the interwiring before positioning them within the case. Drill all the mounting holes etc, and get an idea of lengths of wire beforehand - it'll look neater if you don't have six mile of cable where two inches would suffice.

Don't forget either to drill the holes into the back panel for calibrating the range pots; it's much easier to carry out this function once the meter is built and working.

FREQUENTLY USED

Just a few points about operation. The input squaring circuit is reasonably sensitive, about 100 mV is all you need to ensure correct operation. If

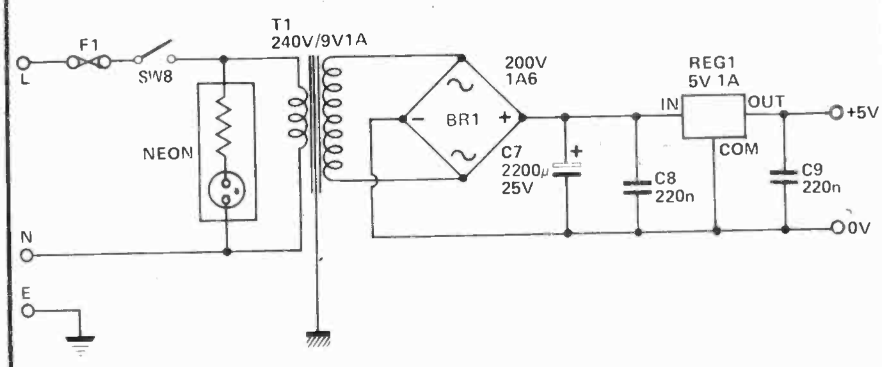


Fig 1. Circuit diagram of the PSU for the frequency meter. An IC regulator is employed to simplify things. This is constructed onto a separate PCB.

DIGITAL FREQUENCY METER

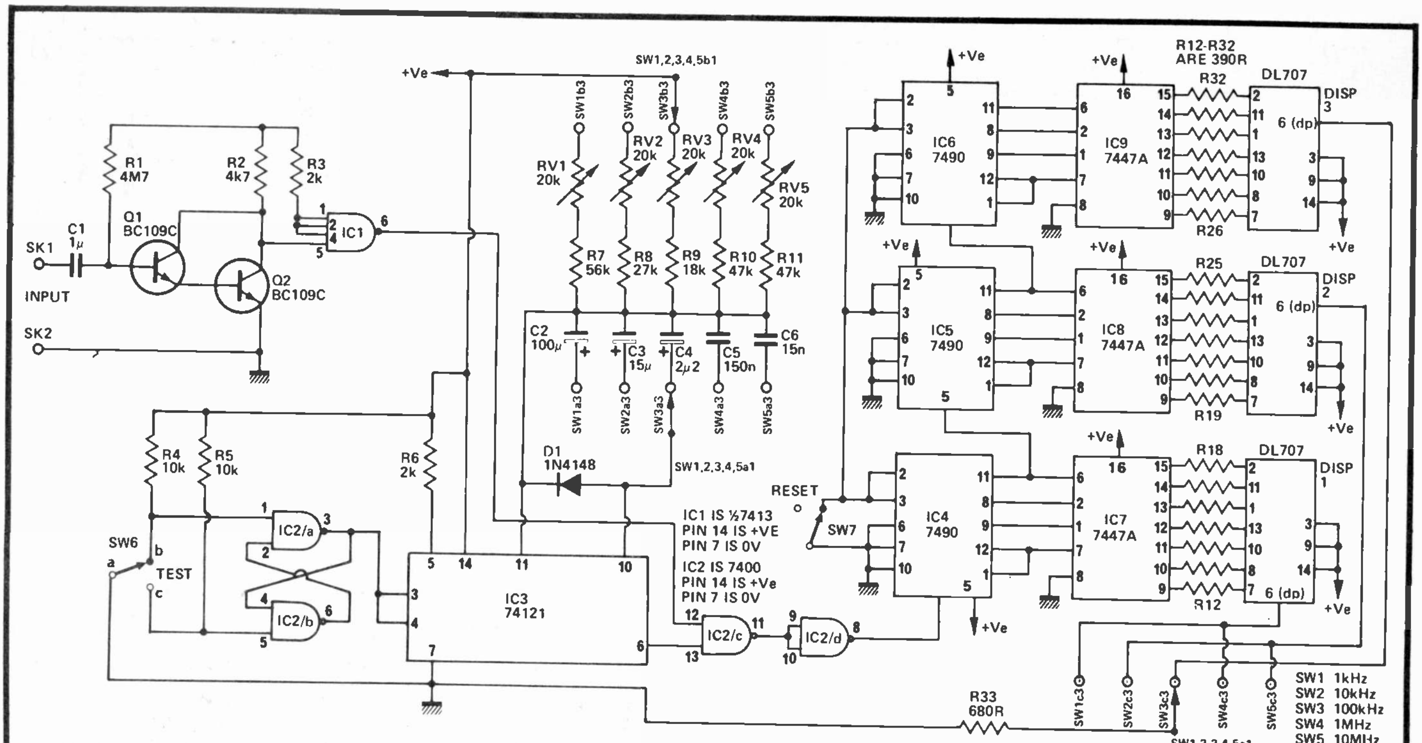


Fig 2. The main circuit diagram for the ETI Digital Frequency Meter. In the centre the ranging components RV1-RV5, R7-R11 and C2-C6 can be seen. The resistor chain R12-R32 is to control the current (here brightness) of the three displays.

you intend to pump appreciably more than this into the terminals, may we suggest an attenuator?

The units may well read with inputs lower than 100 mV, but is not intended to do so. Accuracy will depend on how it is set up, and on the higher ranges may be affected by length of leads from input circuitry etc, so keep these to a minimum.

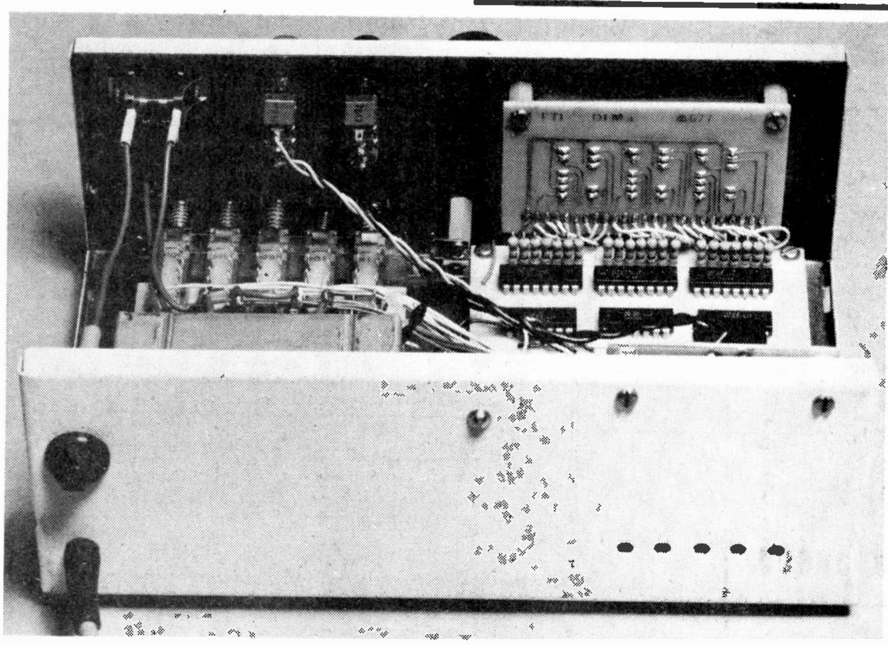
How it works

The input signal is amplified and squared to TTL level by Q1 Q2 and the Schmitt trigger IC1, which means that a train of squarewaves at the input frequency will be presented to the NAND gate IC2c. This will be held open for a preset time depending on the frequency of monostable IC3.

This period is set by the timing (range) components RV1-5, R7-11, C2-6 respectively. The switch bank selects which network is in circuit, and hence for how long IC2c allows the input pulse train to pass. The train is inverted by IC2d and fed to the counter chain IC4-6.

The number of pulses reaching IC4 will represent the input frequency, provided the period of IC3 has been correctly set (calibrated). RV1-5 is adjusted to achieve this.

IC2a and IC2b 'debounce' SW6, the test button, and IC7-IC9 and DISPLAY 1-3 display the input frequency.



An internal view of the meter, showing the mounting of the display board onto the back of the front panel. Note that the display resistors, R12-R32 are mounted vertically onto the PCB.

On the left of this is the range switch bank, mounted onto the panel using standoff pillars. The DFM board DFMd solders onto this directly.

Down at the right hand lower corner the calibrating holes for the range pots can be seen.

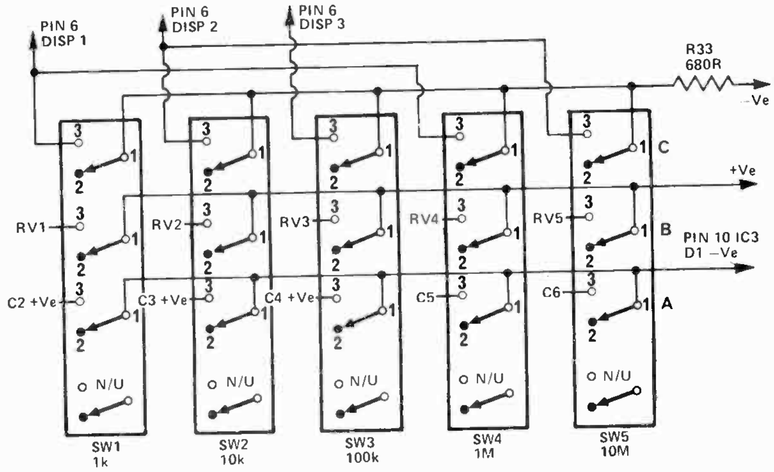
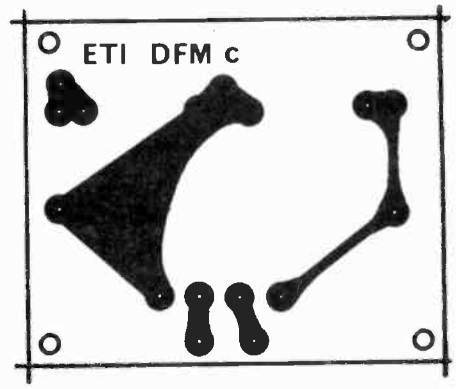
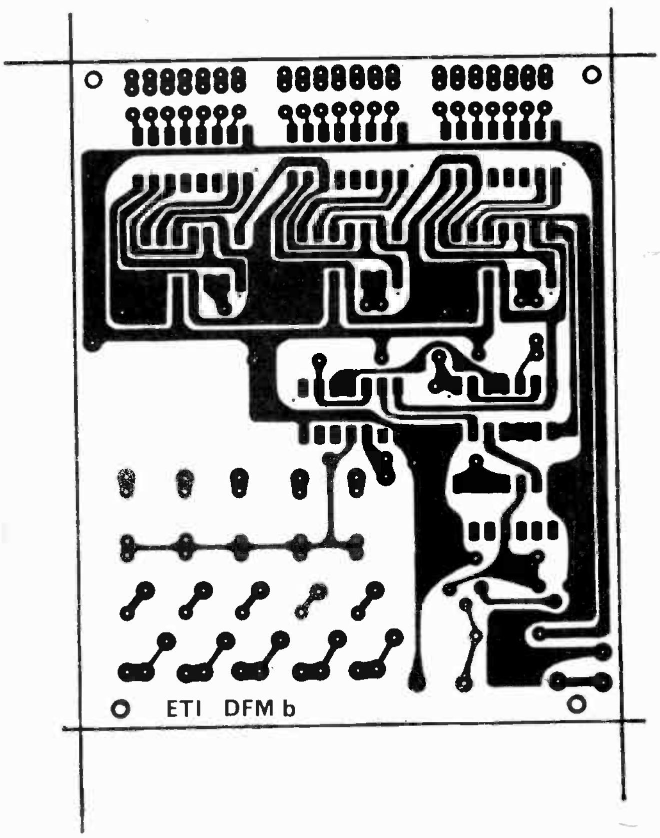
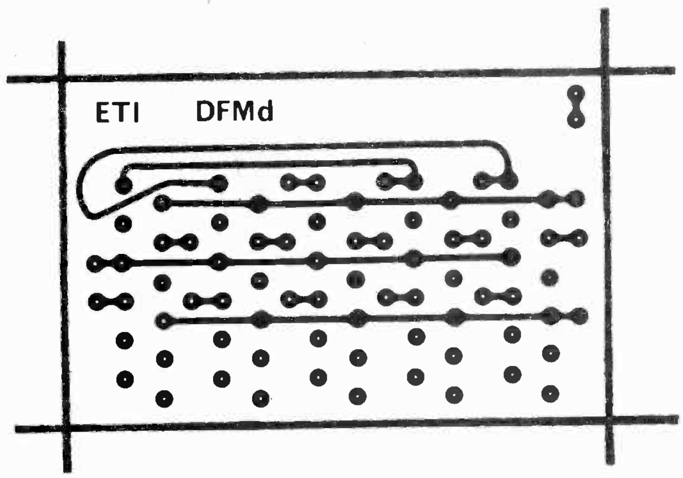


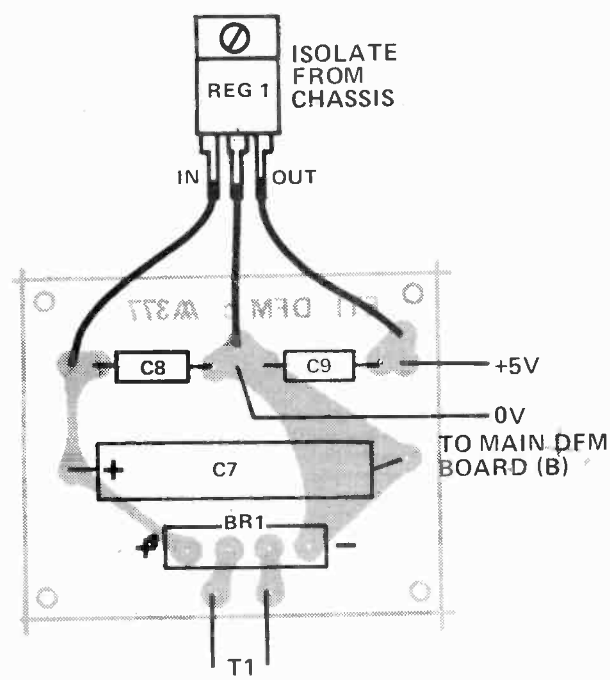
Fig 3. The switching circuit for the DFM. Connections are achieved via the PCB which solders beneath the actual bank

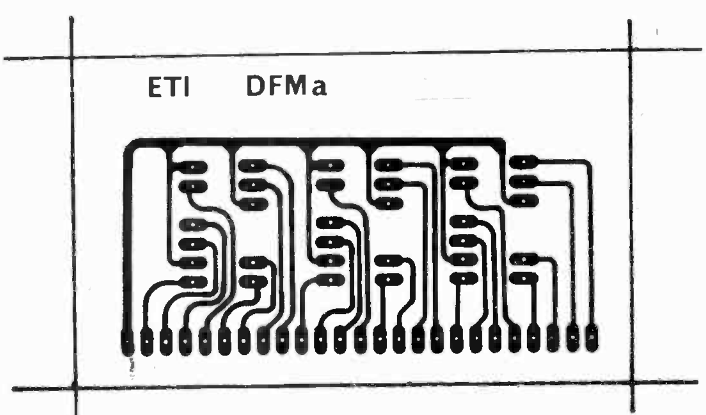


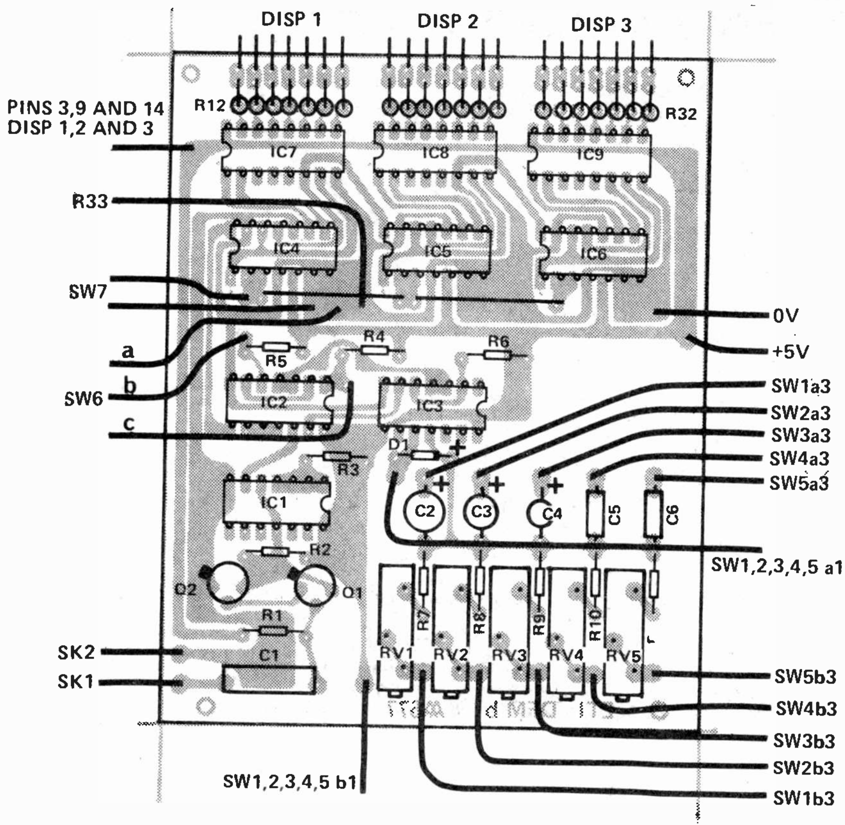


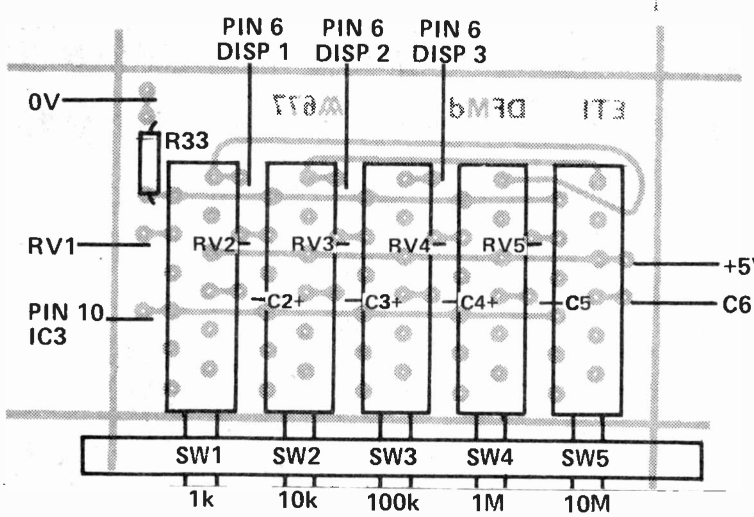


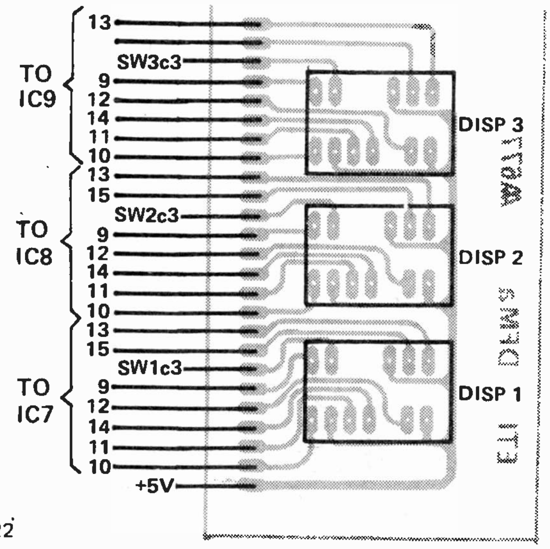
Above and below left: The foil side PCB patterns for the four DFM boards. These are all shown full size and from the 'foil side upwards' direction.
Below right: Component Overlay for the PSU board, DFMs. Reg. 1 is mounted off board.











Above: Component Overlays for the main three printed circuit boards. Assembling these is the major part of the electronics work involved in constructing the DFM. Refer to the parts list (right) for values of the components.

Parts List

RESISTORS All ½ W 5%

R1	4M7
R2	4k7
R3,6	2 k
R4,5	10 k
R7	56 k
R8	27 k
R9	18 k
R10,11	47 k
R12-32	390
R33	680

CAPACITORS

C1	1 u Polyester
C2	100 u 10 V tantalum electrolytic
C3	15 u 16 V tantalum electrolytic
C4	2.2 u 25 V tantalum electrolytic
C5	150 n polyester
C6	15 n polyester
C7	2,200 u 25 V electrolytic
C8,9	220 n polyester

SEMICONDUCTORS

Q1,2	BC109C
IC1	7413
IC2	7400
IC3	74121
IC4-6	7490
IC7-9	7447A
D1	IN4148
DIS.1-3	DL707
REG.1	5 V 1 A voltage regulator
BR1	200 V 1.6 A bridge rectifier

POTENTIOMETERS

RV1-5	20 k Multiturn (.75" type or sim.)

SWITCHES

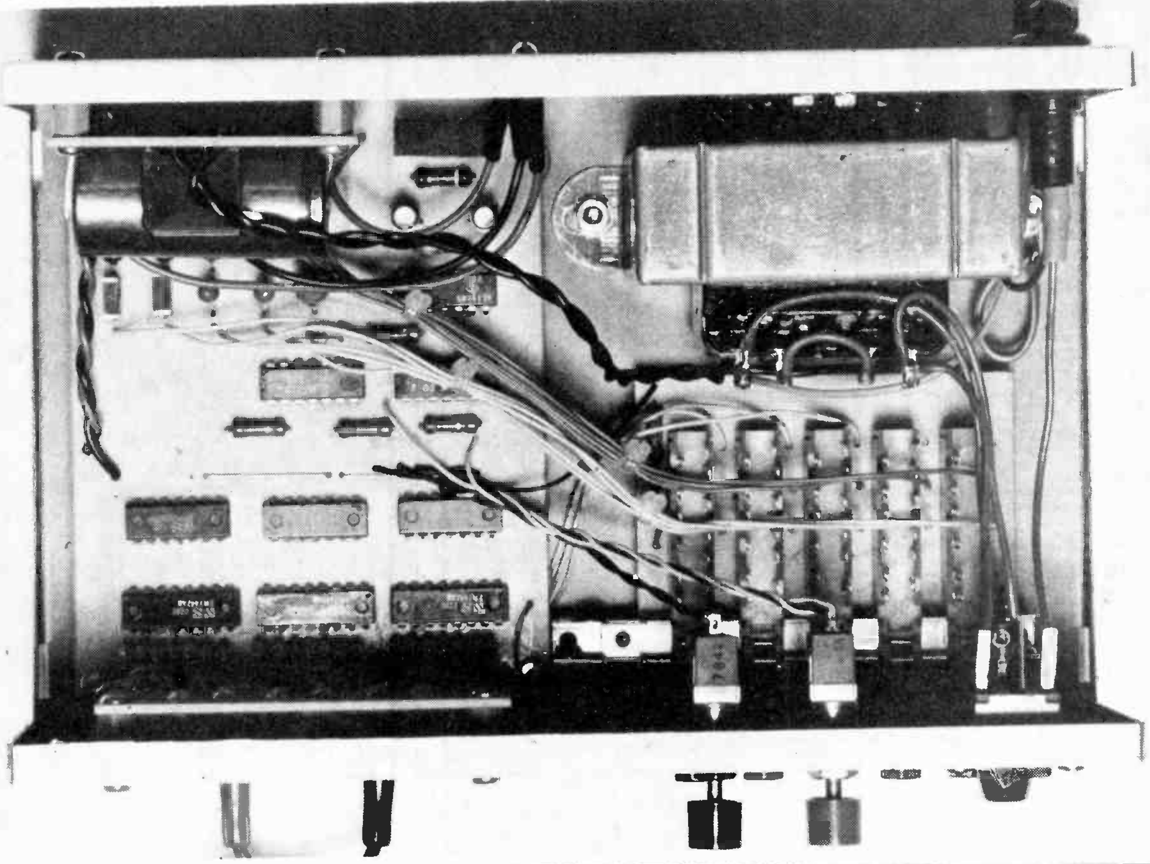
SW1-5	5 bank assembly, 4 pole 2 way push button with cancelling action (Doram: 5 x 338-636, 5 x 338-563 1 x 338-254)
SW6	S.P.D.T. momentary action
SW7	S.P.S.T momentary action
SW8	Off/on 1 A 250 V type

TRANSFORMER

T1	240 V - 9 V 1 A type

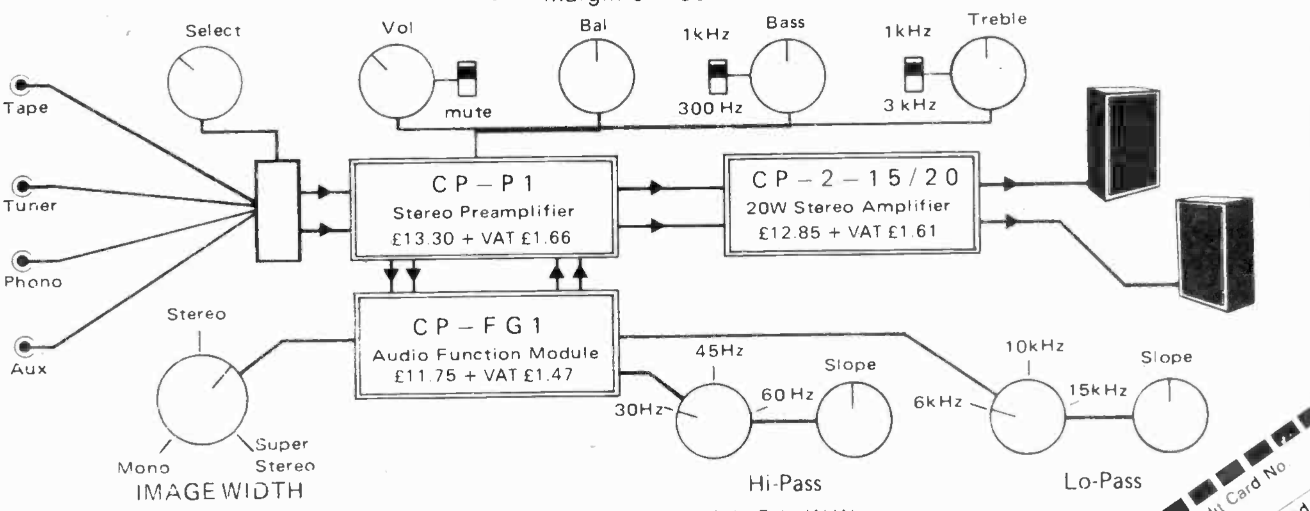
CASE
Samos S7 (Doram: 984-497)

MISCELLANEOUS
Fuse holder, fuse, mains neon, 2 mm red and black sockets, PCB pillars, wire, 3-core mains flex, nuts, bolts, etc. PC boards as pattern.

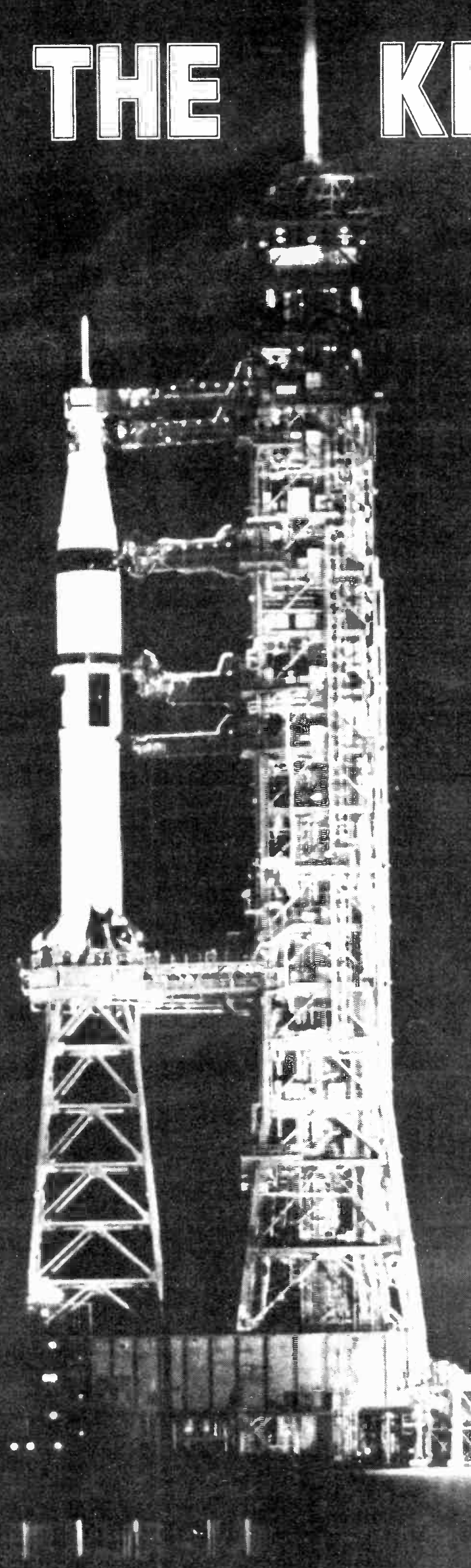


An aerial view of the meter! Taken by a friendly passing sparrow, this shot clearly shows the layout of the boards within our recommended case. To the top left is the PSU board mounted vertically over the main board. Space is very tight — but it does all go in — honest!

The transformer we used came from Radiospares (i.e. Doram!) and fitted nicely. Most other versions should go in easily as well however.



THE KENNEDY SPACE CENTRE



By Mike Howard

PERHAPS THE BEST known of the NASA installations lies on the east coast of Florida midway between Jacksonville and Miami in the area known as Cape Canaveral. Here stands the major U.S. spaceport and launch facility now named the John F. Kennedy Space Center. Within the Center are two separate federal facilities, one operated by NASA, the other by the U.S. Department of Defense.

The NASA Kennedy Space Center (KSC) occupies some 88,000 acres of land and water on and around Merritt Island extending 35 miles north-south with the Atlantic on its eastward side and the Indian River to the west. Adjacent to NASA KSC is the Cape Kennedy Air Force Station managed for the Department of Defense by the U.S. Air Force. This is the prime station of the Eastern Test Range which stretches southeast 10,000 miles to the Indian Ocean.

KSC's History

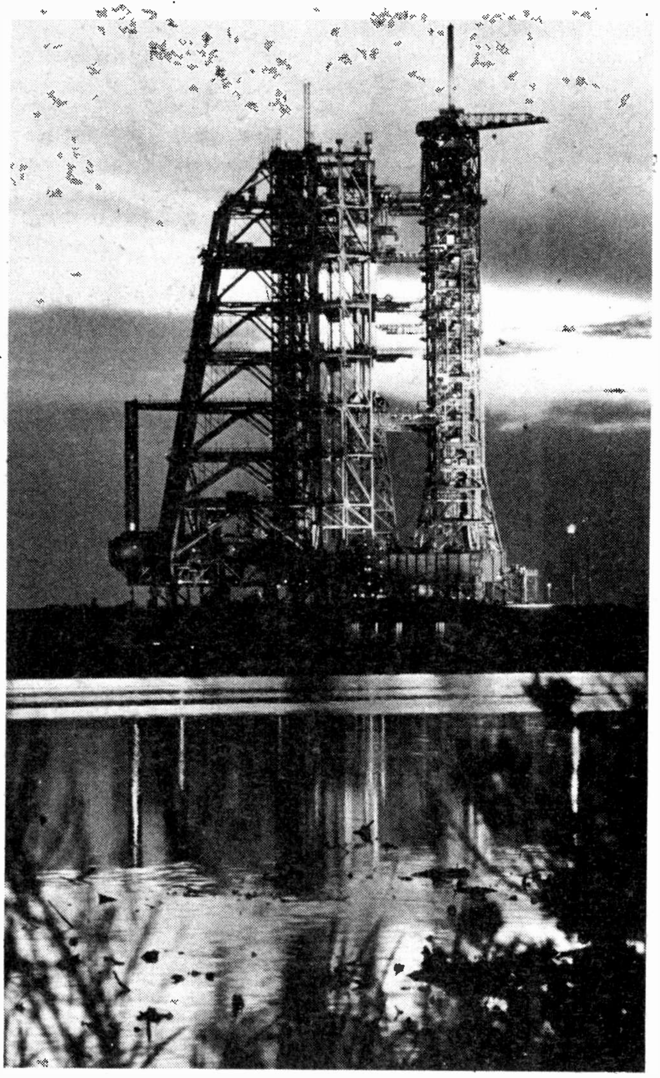
On 8 July 1947 Cape Canaveral was formally approved as a test area for long-range guided missiles under the management of the USAF. This site was chosen largely because of the chain of islands, spread out in a south-easterly chain as far as Ascension Island, which were suitable for the tracking stations required to monitor the flight of research missiles. Shortly after the Cape was established, Congress authorised the acquisition and construction of the Atlantic Missile Range, later renamed the Eastern Test Range and extended into the Indian Ocean.

The Cape became operational as a missile test centre in May 1949 with the first launch on 24 July 1950. That first vehicle was a 56ft missile called WAC-Bumper. Its first stage was a modified V-2 with a WAC Corporal as the upper stage. The launch pad was a concrete slab, the service structure a painter's scaffold, and the launch team utilised a tar-paper shack (formerly used as a bath house) as the launch control centre. From these meagre beginnings would develop the most advanced launch facility in the world.

In October 1958 the National Aeronautics and Space Administration was established. Just 3 days short of a year earlier the Soviet Union had orbited Sputnik 1, the Earth's first artificial satellite, followed a month later by Sputnik 2 with a canine passenger. It was small consolation that a U.S. Army team headed by Dr Kurt H. Debus, who later became Director of the Kennedy Space Center, had succeeded in placing Explorer 1 into orbit on 31 January 1958 since it was only a fraction of the weight of the Sputniks.

THE KENNEDY SPACE CENTRE

With this state of affairs NASA came into being with the peaceful exploration of outer space as its goal. To this end the Launch Operations Center was established at the Cape. On 5 October 1958 Project Mercury got underway and on 5 May 1961 Alan Shepard made a brief sub-orbital flight to become America's first astronaut; however, once again, the Russians had beaten the U.S. because on 12 April of the same year Yuri Gagarin had become the first man to orbit the Earth. In 1960 John F. Kennedy had been inaugurated as President of the United States and on 25 May 1961, just 20 days after Shepard's flight, he committed the U.S. "to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth . . ."



The results of that commitment are now well known in the steady progression up through Mercury, Gemini, and finally to Apollo: Kennedy was not to see his dream fulfilled. On 22 November 1963 the President who pushed America to the Moon was assassinated while riding in a motorcade through Dallas, Texas. Seven days later the new President, Lyndon B. Johnson, officially directed that the NASA Launch Operations Center and Station No. 1 of the Atlantic Missile Range be renamed the John F. Kennedy Space Center.

KSC Facilities

Few people realise that the Kennedy Space Center is also a wildlife refuge. On 2 June 1972 the entire spaceport was incorporated into the Merritt Island National Wildlife Refuge which comprises some 145,000 acres of land and water. In spite of the occasional rocket blastoffs, racoons, bobcats, alligators and wild pigs roam the scrubland; rare species of birds, such as the Bald Eagle and Peregrine Falcon can also be found within the bounds of the space centre. When the KSC site was acquired NASA took over some 3306 acres of citrus trees which it now leases to their former owners. Also on site are 2 fishing camps and three private burial grounds.

Functions of the Space Center's life that are not required at the launch complexes are mostly grouped together in the Industrial Area. Here in the Headquarters building are located the Director of the Kennedy Space Center, procurement, programme management, legal, and other support functions.

The largest structure within the Industrial Area is the Manned Spacecraft Operations Building (MSOB) in which Apollo-type spacecraft underwent modification, assembly, and preliminary checkout. Within the MSOB are two 50ft altitude chambers capable of simulating altitudes up to 250,000 ft for the testing of spacecraft and systems. Here, also, are the astronaut quarters and medical facilities. Instrumentation to receive, monitor, process, display and record information from the space vehicle during pre-launch, launch and immediate post-launch activities, is located in the Central Instrumentation Facility. The Flight Crew Training Building is the KSC equivalent of the Mission Simulation and Training Facility at the Johnson Space Center, Houston. Here astronauts and flight controllers practise for manned flights utilising the computerised mission simulators.

Other facilities within the Industrial Area include a cafeteria, fire station, occupational health building, security offices, warehouses, and specialised laboratories for spacecraft pyrotechnics checkout.

The Kennedy Space Center is also responsible for the launch of unmanned space vehicles from the Western Test Range at Vandenberg Air Force Base in California.

Launch Complexes

Within the Kennedy Space Center are fourteen main launch complexes plus launch and test facilities for Polaris, Poseidon, and Minuteman missiles. Some sites are no longer operational but all have played their part in the history of U.S. space exploration.

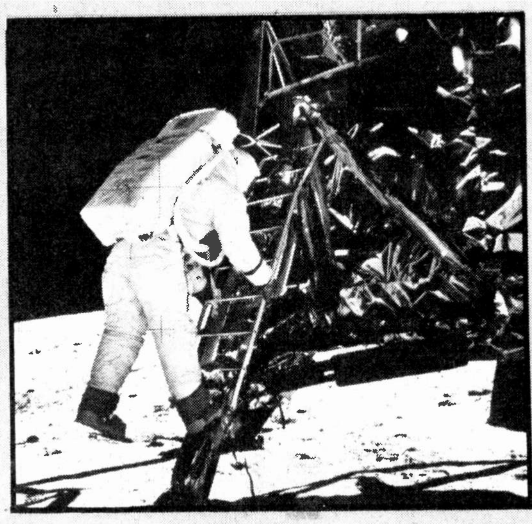
Heading northward from Port Canaveral the first call is at the pads of Complexes 5 and 6. It was from here that the early Mercury-Redstone flights began. Today the pads are part of the Air Force Space Museum and are marked by a plaque commemorating Shepard's 1961 flight and a full-scale Mercury-Redstone space vehicle on the site of that historic launch. The Museum also incorporates Complex 26 from which Explorer 1 became the first U.S. satellite. Moving on, the next stop is the Delta launch complex 17. From this area the versatile Delta vehicle has launched many well known unmanned spacecraft including Echo, TIROS, Relay, Telstar, Early Bird and Intelsat. Further north are the twin pads of complex 36 from which the Atlas-Centaur launches lunar and planetary spacecraft including Surveyor, Mariner, and Pioneer. Launch Complexes 12 and 13 were once the launch sites from which Atlas-Agena vehicles boosted Ranger and Lunar Orbiter spacecraft on their moonbound journeys. More Atlas-Agenas ascended from Complex 14 during the Gemini programme to place target docking vehicles into Earth orbit. This site was also used to launch the later Mercury missions using the Atlas booster. Moving on again we encounter Complex 16 which was utilised for Apollo Service Module static tests. Complex 19 was the launch site for the Titan II vehicles that placed 10 Gemini crews into Earth orbit during a 20-month period commencing in March 1965. Complex 34 and the adjacent Complex 37 were used for Saturn I and IB flights preceding and during the Apollo programme. The first manned Apollo launch took place from Complex 34 on 11 October 1968 when a Saturn IB lifted the Apollo 7 crew to orbit. Both complexes have since been deactivated and dismantled.

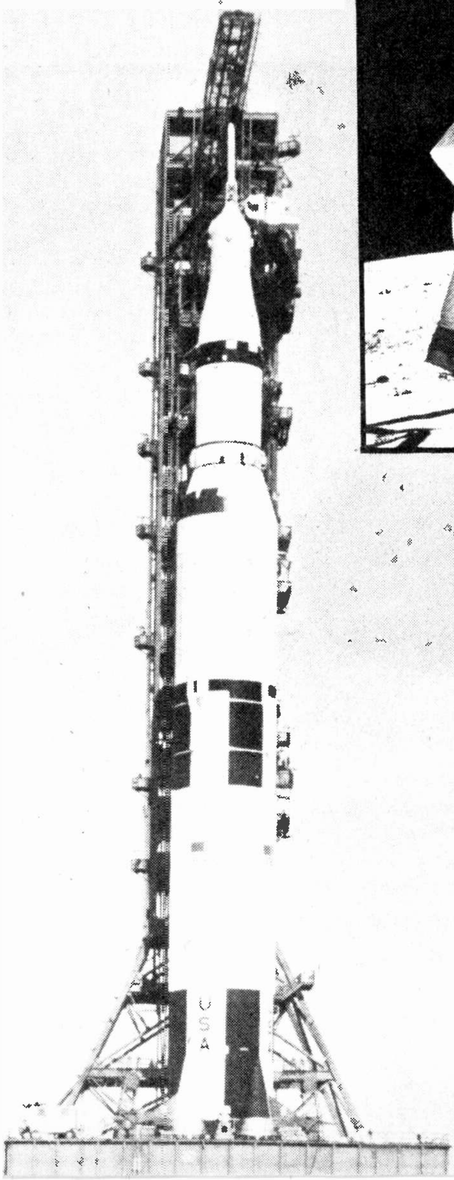
The next area reached is the Air Force's Integrate-Transfer-Launch (ITL) Facility. This site includes Launch Complexes 40 and 41. From here the Air Force conducts its own launch programme using Titan III-C vehicles. Tital III-E/Centaur vehicles which NASA uses to launch Helios solar probes and Viking Mars landers are also launched from LC-41 when the facility is under the operational control of NASA. The last stop in the tour of launch complexes is at the twin pads of Kennedy Space Center's Launch Complex 39.

Launch Complex 39

Inspecting Complex 39 is like moving to another world where everything is larger than life. The main components are the Vehicle Assembly Building (VAB), the Launch Control Center, three Mobile Launchers, two Crawler-Transporters, the Crawlerway, a Mobile Service Structure, and two launch pads. Standing 526 ft high, 716 ft in length and 518 ft wide the Vehicle Assembly Building covers 8 acres of ground. Due to its immense size the VAB can sway up to 12 inches in strong winds and is equipped with a gravity ventilation system which forces a complete change of 130 million cubic feet of air every hour to prevent condensation and fogging within the structure.

Once the space vehicle has been assembled and checked out in the VAB aboard its Mobile Launcher (ML) it is ready for transfer to the pad. To accomplish this one of the Crawler-transporters moves under the ML and raises it ready for transfer. This vehicle itself weighs some 6 million pounds, is 131 ft long, and 114 ft wide. At a maximum speed of 1 mph the transporter moves out of the VAB carrying its precious cargo along the specially constructed crawlerway, the overall width





of which is equal to an 8-lane highway. On arrival at one of the 3000 ft wide pads the transporter gently lowers its load and backs off. Pad A is some 3.5 miles from the VAB while Pad B is about a mile further on. In the centre of each of the octagonal pads is a 390-by-325 ft reinforced concrete hardsite, the top elevation of which is some 50 ft above sea level to allow the rocket's thrust chambers to rest above a 650-ton mobile flame deflector.

The Mobile Service Structure weighs over 10 million pounds and contains 5 service platforms from which the space vehicle can be serviced at the launch pad. This 410 ft high structure is also moved by the crawler-transporter.

Alongside the VAB, and connected to it by an enclosed bridge, is located the Launch Control Center (LCC) — a far cry from the blockhouses at other launch pads. The ground floor of the LCC contains offices, a dispensary, and a cafeteria. The first floor houses telemetry, measuring, and check-out systems used during assembly in the VAB and later at the launch pad. On the second floor are the four firing rooms (only 3 are fully equipped) and their respective computer support rooms. Viewing of the firing rooms and the launch area is possible through specially laminated and tinted glass windows on the LCC's mezzanine level.

To date Launch Complex 39 has been used to launch Saturn V's for the Apollo and Skylab programmes and Saturn IB's for Skylab and the Apollo-Soyuz Test Project. In the future the Space Shuttle is planned to use complex 39's facilities. To accommodate the different vehicle, modifications to the Launch Pads, Mobile Launchers, and VAB will be necessary and these are already the subject of design contracts. In addition, since the Shuttle will return to a runway landing, a 15,000 ft long by 300 ft wide landing strip with associated overruns, apron, taxiway and access roads has been constructed to the north-west of the VAB on a northwest-southeast alignment.

Epilogue

The John F. Kennedy Space Center is also a site of great historical significance. During construction of the Center archeologists unearthed traces of pre-Christian human activity, Indian burial mounds and refuse piles, and signs of French and Spanish occupation. The petrified bones of prehistoric mammals were dredged up from the Banana River at the same time. It was with these discoveries in mind that Professor Charles Fairbanks of the University of Florida remarked that "this was one of the areas where Western civilisation came to the New World, and now it is the area from which our civilisation will go forth to other worlds".

Acknowledgements

We thank Spaceflight for their kind permission to reproduce this article.

HP 67 reviewed

Fig. 1 The HP67 keyboard is rather complex, but logically arranged. You can have the pleasure of tickling its keys for £350.00 (inc. VAT). We wonder why dealers don't like demonstrating it?

IT IS NOW three years since Hewlett Packard released the HP65 fully programmable pocket calculator, and that is a long lifetime for any calculator by today's standards. Although the HP65 represented a considerable advance in personal computing, technology has progressed somewhat since then; specifically, the level of integration which can be achieved in LSI logic has gone up, along with improvements in IC packaging and tricks like pin multiplexing, etc. In addition, users quickly came to appreciate the new approch to problem-solving afforded by the programmable calculator and now want more powerful machines.

The HP67 is the latest in the HP line of programmable calculators, and is by far the most powerful. It has 224 steps of program memory and 26 data registers, with indirect addressing. An important feature is the "smart" card reader, which permits the loading or recording of data, as well as angular mode, display and flag settings, so that initialization routines are not needed.

PREPROGRAMMED FUNCTIONS

The HP67 seems to have been designed, keyboard-wise, at least, with existing HP65 users in mind. Most of the HP65's pre-programmed functions are duplicated with the same keyboard layout. Gone is the NOP (no-operation) function: the PAUSE facility is more useful for program debugging as you can see intermediate results without single-stepping. The HP67's program memory is line-numbered, not a rotating shift register as in the 65. Each line of memory contains a complete keyphrase, so that all prefixes are merged, e.g. LBL f a (three keystrokes) is one memory step. By contrast, the LBL A instruction on the 65 is two keystrokes, two memory steps. The same applies to TI's SR 52; a label occupies two steps.

Several new functions have been implemented on the HP67 — many of them prompted by the desire for software compatibility with the printing HP97. The -x- or "flash x" command halts the calculator for five seconds, allowing output of data (analogous to PRINT x). The REG and STK instructions are similar functions for reviewing the contents of the registers or operational stack. An HP97, encountering this instruction in a program, would print them.

The HP67 also includes functions which have been found useful in recent HP calculators — the PAUSE instruction, % functions, ENGineering display format, mean and standard deviation with automatic accumulation. The only major new keyboard function is RND, which rounds off the display to the number of digits displayed. This is important in financial calculations.

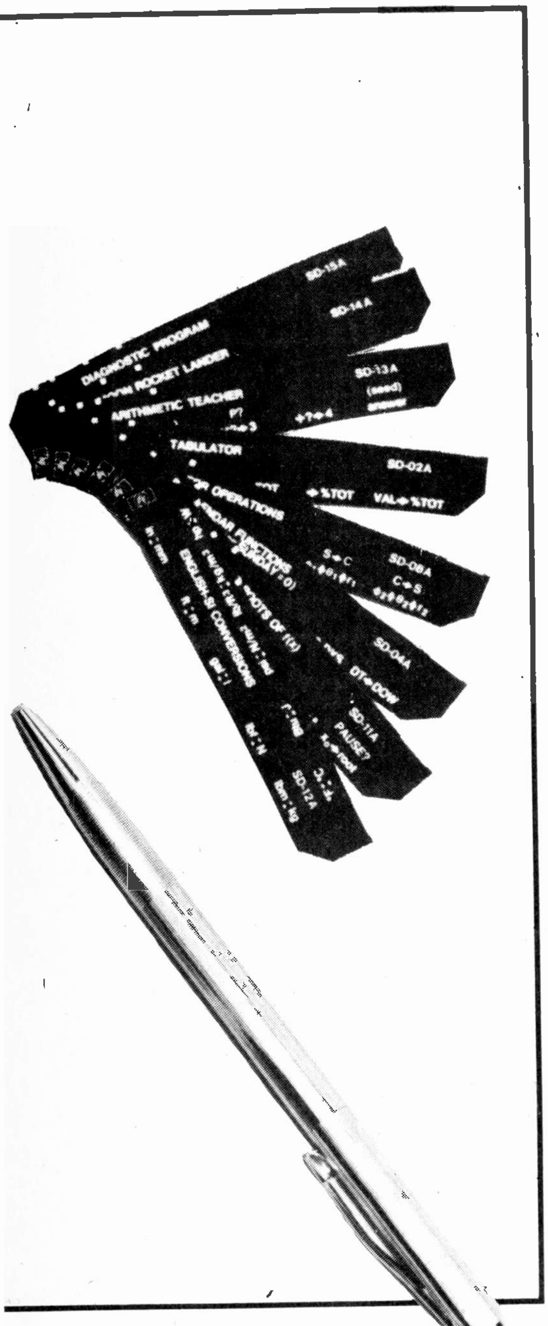
PROGRAMMING FACILITIES

With the W/PRGM-RUN switch in the RUN position, programs may be loaded from magnetic cards, or the machine may be used as a conventional calculator.

In the W/PRGM mode, when a key is pressed, that function is not immediately executed, but is instead stored in the program memory, and a keycode is displayed. For example, the code 31 would represent the first key in the third row (f). Similarly, the complete code 001 31 52 11 would represent f LBL A and would be the first step of the program.

A major advance on the HP65 is the ability to nest subroutines three deep. This is achieved through use of the "GSB" instruction, and the program will then jump to the designated label to continue execution until it encounters a RTN command, when it will return to the instruction following the GSB. This function can be used with the I-register for indirect addressing.

The I-register is the key to the



BY LES BELL

indirect addressing facility. When the number in the I-register is between 0 and 19, GTO (i) or GSB (i) unconditionally jump to the label specified (0-9, A-E, or a-e). If the I-register contains a negative number, GTO (i) or GSB (i) will branch backwards the number of steps specified.

The I-register can also be used to control STO and RCL operations on the data register, i.e. STO (i) and RCL (i), where the I-register contains a value between 0 and 26. 0-9 refers to the primary register, 10 to 19 refers to the secondary storage registers, which are not directly accessible by STO and RCL, and 20-25 represents registers A through E. An (i) value of 26 accesses the I-register itself.

As we have said, the 10 secondary storage registers, R_S0-R_S9, are not accessible through the STO and RCL commands, except indirectly, and also the $\Sigma+$ key, which accumulates statistical information. In order to get at the secondary registers, you have to swap them with the primary registers using the P ⇆ S function. At first we were slightly bemused by this method of addressing storage in comparison with the SR52's 00 to 19 (and 60 to 99, if they're unused by program), but in practice it turned out to be no problem at all.

CARD READER'S IQ

As the program memory is 224 steps, this has to be recorded on two sides of a magnetic card, using the same basic method as the HP65. When one zips a card through with the machine in the W/PRGM mode, the first 112 steps of the program are recorded in the form of a header, program and checksum. The calculator, before writing the card, checks whether the program is over 112 steps long, and if it is, it writes the appropriate 28-bit header. This identifies whether the card is *(a)* a one-sided program, *(b)* first side of a two-sided program, *(c)* second side of a two-sided program, *(d)* a one-sided data file, *(e)* first side of a two-sided data file, or *(f)* second side of a two-sided data file. If the program is over 112 steps, the card will have to be passed through again to record the second side, and the calculator will prompt the user to do this by displaying CRD. A similar process is used to read the card — the calculator will identify from the header whether the second side is required and prompt the user.

The ability to write data onto a card is very useful also. When the W/DATA key is pressed, the calculator displays CRD, and checks the contents of the secondary registers to see

Continued overleaf

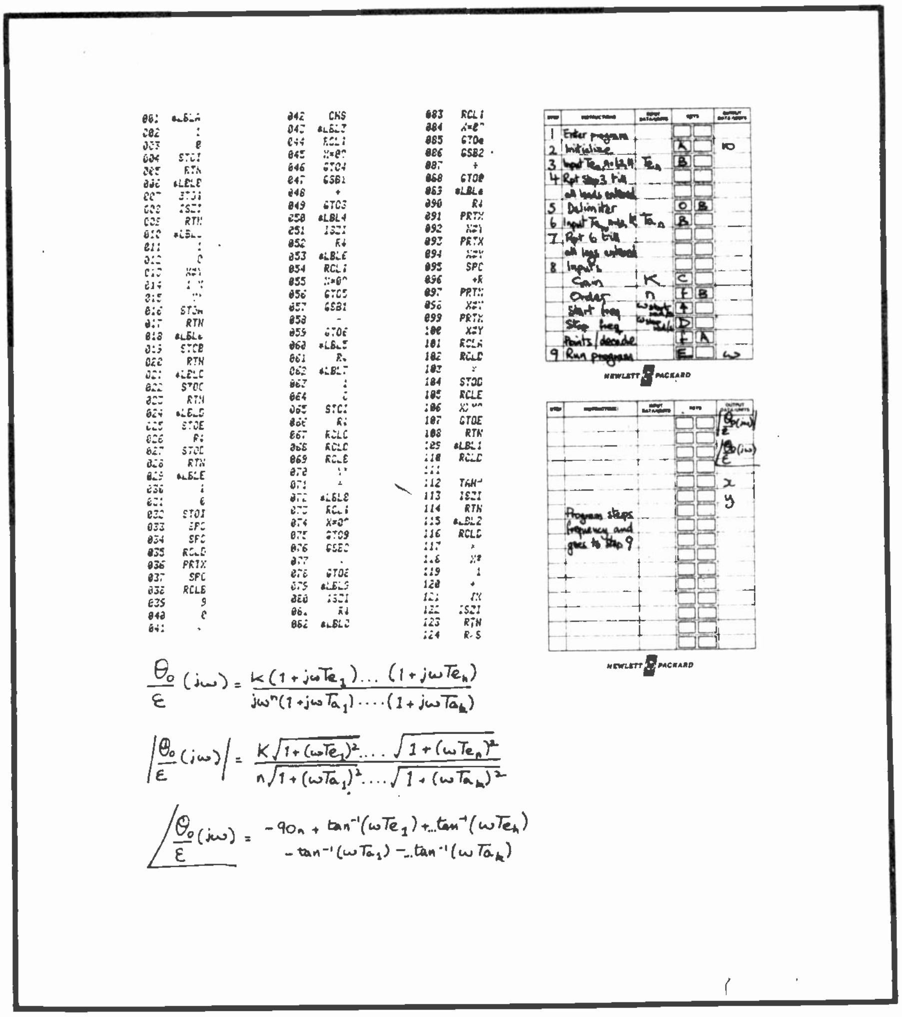


Fig. 2. This program listing was produced on an HP97, but the program will produce a print-out of the open loop amplitude and phase response (Nyquist plot) of a control system. The various time constants are entered serially, leads first, then a zero to separate them from the lags, then the lags. The program pulls data from the secondary registers and processes it as leads, until it finds the zero, and the continues to process the remaining data as lags.

HP 67 reviewed

if any are non-zero. If they are all zero, this data is compressed and recorded, along with the registers 0-9 and A-E, on the first side; otherwise the calculator again prompts the user to insert the second side where it records the secondary register contents. When a program is running, insertion of a card will not trigger the card drive, until a W/DATA instruction is encountered; hence you can set a long program running, insert a card and forget it, knowing that your results will be recorded.

the instruction/address line.

A new chip developed for the HP67 combines 1024 10-bit words of ROM with 16 56-bit registers in a single 8-pin package — this is why multiplexing techniques are so important. Programs are stored in these 56-bit registers in the form of 224 8-bit instructions. This allows 256 possible instructions, of which 250 are used. Another 18-pin ROM also carries the anode drivers for the DMA for card reading, with the micro-processor not involved at all, in

packs. Now available are Stat Pac 1 (21 programs), Math Pac 1 (19 programs), Electrical Engineering 1 (18), Business Decisions (22), Mechanical Engineering (23), Clinical Lab and Nuclear Medicine (19) and Surveying (19 programs). Soon to be announced is a Games Pac.

The overall impression we gain from using the HP67 is that it is a more powerful machine than the SR52 if you have really tough problems to solve. It is more efficient in using program memory, particularly STO and RCL instructions.. The smart card reader is a very useful feature and gives the machine a real "data-base" of use in business applications.

We weren't terribly happy with the

Fig. 3. If you want a print-out, the £580.00 (inc VAT) HP97 is software compatible with the HP67.

Finally, the card reader can merge programs or data automatically. For instance a numerical integration routine may call as a subroutine the function f(x) to be integrated. Several standard functions can be pre-recorded and loaded from cards, avoiding the necessity to key them in through the keyboard.

WHAT'S INSIDE?

The microprocessor around which the HP67 is very solidly built, is the Arithmetic, Control and Timing (ACT) chip used in the HP21, 22, 25 series of calculators. This chip carries eight general-purpose registers, four of which form the stack, In addition, the instruction decoding ROM, clock, control and timing, keyboard control, addressing and pointer logic are on this chip. It can access up to 4096 instructions by sending out a 12 bit address, least significant bits first, on the HP67, the card reader chip (CRC) and ACT interact. The CRC contains two 28-bit buffers which are alternately loaded while the ACT chip deals with the contents of the other buffer. Each card side carries 32 28-bit records, either 112 program steps (3½ steps per record) or 16 data registers (½ register per record), plus header and checksum. As each record is stored it is also added to a running total, which is finally compared with the checksum. If they differ, memory is cleared and "Error" is displayed.

SOFTWARE SUPPORT

An important application area for programmable calculation is the specialist user who requires a wide range of preprogrammed functions rather than a truly user-programmable machine. HP cater to this area by supplying a wide range of application

67's approach to indirect addressing, particularly when trying to write a version of the computer game "REVERSE", for the calculator. No matter how we tried, we always needed a second I-register so we never did get the program to run. We suspect that it should be considerably easier on the SR52. Please, HP, give us two I-registers next time, or a similar implementation to the SR52's!

SUMMING UP

In conclusion, then, the HP67 is an extremely efficient and powerful calculator. The HP97 printing version, because of its data handling capabilities should be popular in commerce. But we can't help feeling that the efficiency has been achieved at the expense of ease and flexibility of programming, so that it's just not as much fun. ●

VIDEO DISPLAY UNIT — PART 1

Described by John Miller-Kirkpatrick

The System 68 VDU board A is really a complete VDU with more characters and more variety than the 560. If the address outputs were connected to switches and comparators as in the 560 VDU then the end result would be very similar. In part two next month we will demonstrate the interface to the MPU. (although primarily designed for System 68 with a 6800 chip in mind,) the VDU boards A and B could be used with any other 8 bit MPU system.

Before you start

The VDU described here uses a commercial 625 line 50Hz television set as an output device. In order to be able to display at least 64 characters per line we need a master dot frequency (to be described later) of 10Mhz or more. As most TV modulators and demodulators only accept frequencies up to about 6MHz it was decided to use a, modified, "dedicated" television.

The modification needed is similar to that described in other similar articles where a point inside the TV at which a 2V p-p composite video circuit can be inserted. As this usually means physically breaking the connections between the TV tuner and the rest of the circuitry it is possible to install a 'video switch' to allow the modified set to work normally if required.

In our experience people tend towards linear or digital circuitry but not both, and so if you are not willing to sacrifice the family TV set to the VDU, then consider buying a secondhand portable and modifying that. Or ask your local dealer to modify it for you. As the TV is used to set up the VDU you will need to do this before starting the VDU, i.e **now!**

Basic VDU concepts

In order to display anything on a TV set we must first set up the timing signals to represent the mixed sync television signals. These signals instruct the TV where to start a new line and a new frame. As all of our character display signals are referenced to the line and frame syncs these are very important. Each TV frame contains 312 or 313 TV lines which are "interlaced" in normal program display to give a total of 625 displayed lines. In our VDU we have not used interlacing as this leads to over-complexity in the circuitry and concept, thus our system uses only 312 (or 313) lines per frame.

In practice we have only used 300 lines per frame as this gives enough accuracy to obtain frame lock on most TVs, the resultant timing means that a complete frame is displayed 50 times per second.

The frame sync signal is derived from counting the line sync signals and dividing these into groups of 300. Each line sync signal has a total duration of 64μS which is broken up as shown in Fig 1. As the actual negative going strobe is decoded by the TV as being off the screen, we need a gap between this strobe and the start of our display, for similar reasons and for neatness we need a similar gap after the last part of the display, and before the next line sync signal. The display time we have left in the middle is the time used to display our 64 character slots.

Characterisation

Each character slot is capable of displaying 5 dots of a 5×7 matrix plus a "null" dot to define a space between characters, thus each character time slot is further sub-divided into six "dot times." If each line sync is 64μS in length it can be calculated that each dot time is only about 100nS long thus requiring an oscillation of about 10MHz which is our "master dot frequency."

In order to cut down on the number of ICs required it was decided to design a system where each line sync is broken up into 100 time slots and to use two divide by ten counters for the purpose. This idea requires no gates for "reset to zero" signals, as the counters automatically zero after 99. If we use 64 of these times slots for characters, and decode others to give the margins before and after the display then we have a requirement for a master dot clock frequency calculated as follows —

1. Line sync period required = 64μS or 64000nS
2. Character time = LS/100 = 640nS
3. Dot time = CHAR/6 = 640/6 nS
4. Dot Freq = 1000x6)/64=75/8 = 9.375MHz.

Figure 2 shows a diagram of the timing generation system derived from our master clock. The dot frequency is divided by six to give a character frequency and both signals are also used in the display side of the VDU. The character rate clock is divided by 100 and decoded to give signals for line sync, start and stop character count, start and stop display (border generation). The line sync signal is passed to the vertical counters which divide the LS by 300 and decode to give a frame sync pulse and vertical count and display enables. These timing signals plus others derived from them are passed over to the RAM addressing and character generation circuitry of the VDU.

Display of character

The character clock signal is divided, in binary, by 64 to give 6 lines. This is used to partly address the RAM storing the character data; the other 4 lines needed to uniquely address any of the 1024 characters stored in the RAM come from a character row counter. Each character row is made up from 16 TV lines and we need 16 rows per frame, the 256 TV lines required are decoded by the divide by 300 counters so that they are positioned in the centre of the screen by the vertical display enable signal.

In order to address and display a character we have to use the divide by 64 counter and the divide by 16 row counter to uniquely access one character in the RAM. As the row counter is only updated every 16 TV lines this means that each character slot in the RAM is accessed 16 times (ie once per TV line for the particular character row).

Each time that the RAM is accessed 8 bits of data is retrieved from the RAM and passed to the character generator ICs.

The basic generator is (a new one!) from National Semiconductors and it includes latches, counters, ROM and shift registers on one chip. Using this chip cuts the package count considerably when compared to using 2513 ROMs and associated components.

The DM8678-CAB generates 64 upper-case ASCII characters in a 5x7 matrix, other chips in the range give lower-case characters, 9x7 matrices and other character sets. All of these chips are pin compatible and can be used solo or in tandem to give full upper and lower or other mixes of character sets. The design philosophy of the System 68 VDU has allowed for future expansion of this type if required. (If expansion is not required then there are three display options included in the VDU which are normally only to be found on expensive commercial equipment.) Only six of the eight RAM data bits are required by the DM8678 and we have used the other two bits to enable the normal white character on a black background to be changed to black on white, black on grey, white on grey or to flash once per second. These options can be used on any of the 1024 characters to be displayed and can be used to denote special areas or important messages on the VDU screen.

Call a Cab

Each of the 8 data bits from the RAM is latched for the whole character display period to prevent spurious changes from affecting the display. The six data bits sent to the DM8678 are used to partially address the ROM inside the DM8678, the rest of the ROM address being supplied by the divide by 16 TV line counter (also inside the DM8678).

In the CAB version of the chip only the first 7 TV lines of each group of 16 are used to address the ROM.

This responds with a set of 5 dots for each ASCII data plus TV line number address. These 5 dots are loaded into an internal shift register which then shifts out the dot data at the master dot rate. Thus for each of the dots which we have defined on the VDU screen the RAM plus the DM8678 can tell us whether the dot is on (white) or off (black). This data is routed through more gates which add the options selected by the other 2 of the 8 RAM data bits and then gate this video signal with the mixed syncs signal to produce the composite video signal to be passed to the TV monitor.

Assembly and testing board A

We would strongly advise that the VDU is assembled using the available PBCs; though building on Veroboard would be possible it might be difficult to trace faults without a good oscilloscope. As some of the tracks on the PCB are very fine we would also recommend that you invest in a new bit for your soldering iron and use sockets for *all* ICs.

Assembly of the System 68 PCBs starts with the boring job of inserting all of the through-hole links and soldering both sides of the link, (it will save trouble later if each of these links is tested with a continuity tester after soldering to ensure an electrical link.

Before inserting any ICs all sockets and passive components can be soldered into place. With most of the soldering done the chances of damaging an IC with the iron are now eliminated. Set the preset VR1 to its mid-point and apply the 5V supply and check for short circuits. It is a good idea at this point to check that each IC socket has 5v and ground at the required pinouts. Before inserting each IC to ensure that the IC is in the correct way round. Note that there is a mix of TTL, 74C Cmos and 4000 series CMOS — *do not use 7400 series in place of 74C00 series or vice-versa*

Master Dot Clock

The master dot clock is based on a 7400 NAND gate pair set up as an oscillator. It was found in the prototypes that this gave a reasonably stable oscillation although the value of R1 changed from 390 ohm in one prototype to 220 ohms in another. Use of a 9.375MHz crystal was thought of but decided to be an optional luxury as the non-crystal VDU showed only a very very slight but acceptable "wobble" in the overall display (less than ±5mm

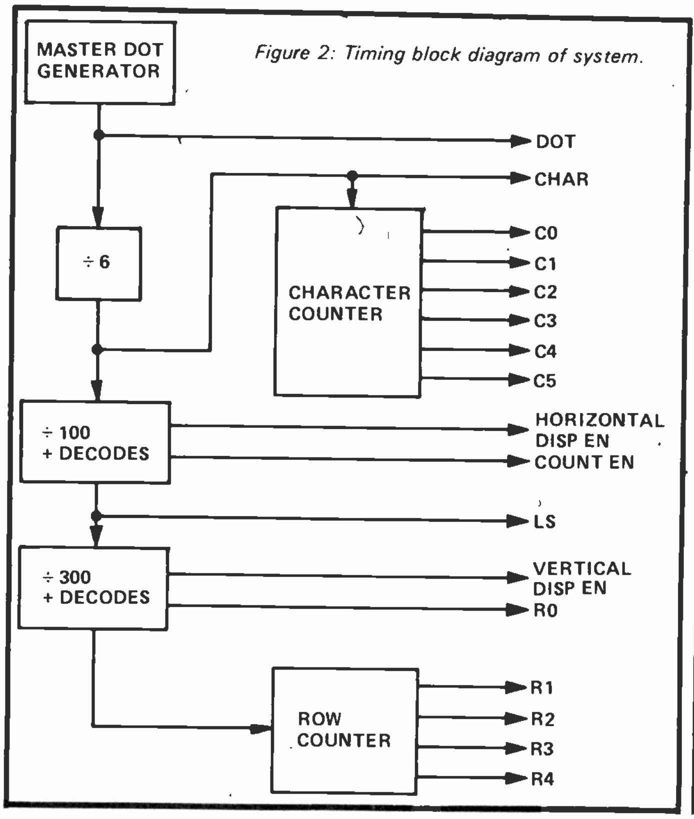


Figure 2: Timing block diagram of system.

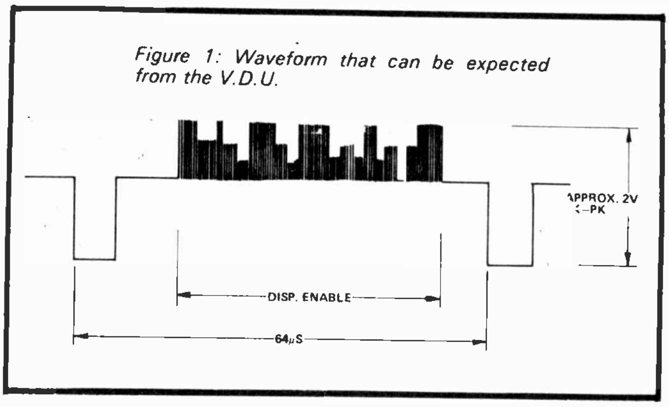


Figure 1: Waveform that can be expected from the V.D.U.

on the edges). With the 5V supply off at each IC insertion, ICs 1-13 and 15 can be inserted and the video output connected to a monitor or converted TV set. The resultant display on the screen should be a white box with grey borders, on a 12in TV and borders will be about ½in wide with a centre box about 9in wide.

If you have a display of a lot of sloped lines then adjust VR1 until the sync locks and the box display is obtained. In case of no display the following IC pins can be checked with a scope or frequency meter —

ICI pin8 9.375MHz
IC2 pin1 9.375MHz,
IC2 pin11 approx 1.5MHz
IC3 pin 12 approx 150KHz
IC4 pin 12 approx 15KHz
IC5 pin 5, 64uS line sync (negative)
IC6 pin 13 64uS horizontal count enable
IC7 pin 6 64uS horizontal display enable
IC12a AND of horizontal and vertical display enables.
IC12b AND of frame and line syncs.
C4 output should be similar to fig 1.

Take a wire link about 9in long and strip both ends. Push one end into IC socket 14 pin 11 and use the other end to check the following effects on the Central portion of the VDU. With the link connected to IC13 pin 2 the screen is split in two halves with the left side black and the right side white. Similarly, check that connection to IC13 pins 3, 5, 6, 7, 9 produce respectively vertical divisions into 4, 8 16, 32 and 64 divisions. Connection to IC8 pin 13 will divide screen horizontally by two, pin 4 by 4, pin 2 by 8 and pin 3 by 16. These lines represent the character slot counters and the character row counter outputs. With these checks successfully completed the wire link can be removed from IC14 socket and IC14 inserted.

With IC14 in position the VDU should display a question mark in all 1024 character locations, if the question mark tends to change into other characters in horizontal bars this is only because of stray 50Hz getting into the open data inputs of the DM8678.

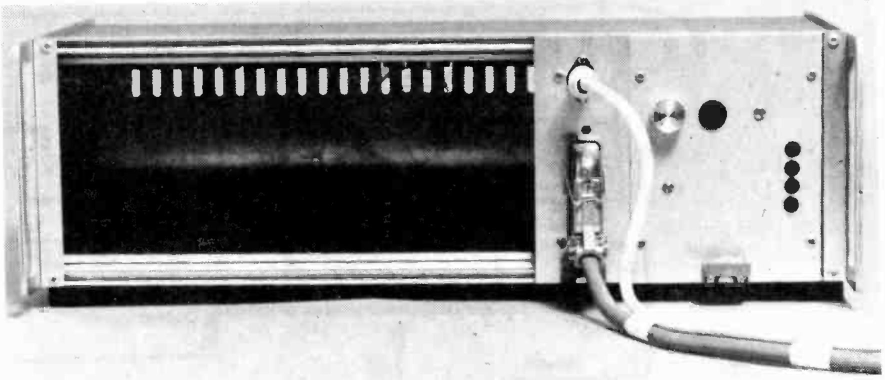
Board A is now virtually finished and requires only the insertion of two ICs to complete it. In order to fully demonstrate the facilities of the VDU and to fully test all of the ICs temporary links can be made from the address counter outputs to the data inputs. These should be done in the following sequence and the effects checked with those predicted until all links have been installed. It will be necessary to remove all of these temporary links before connection to board B.

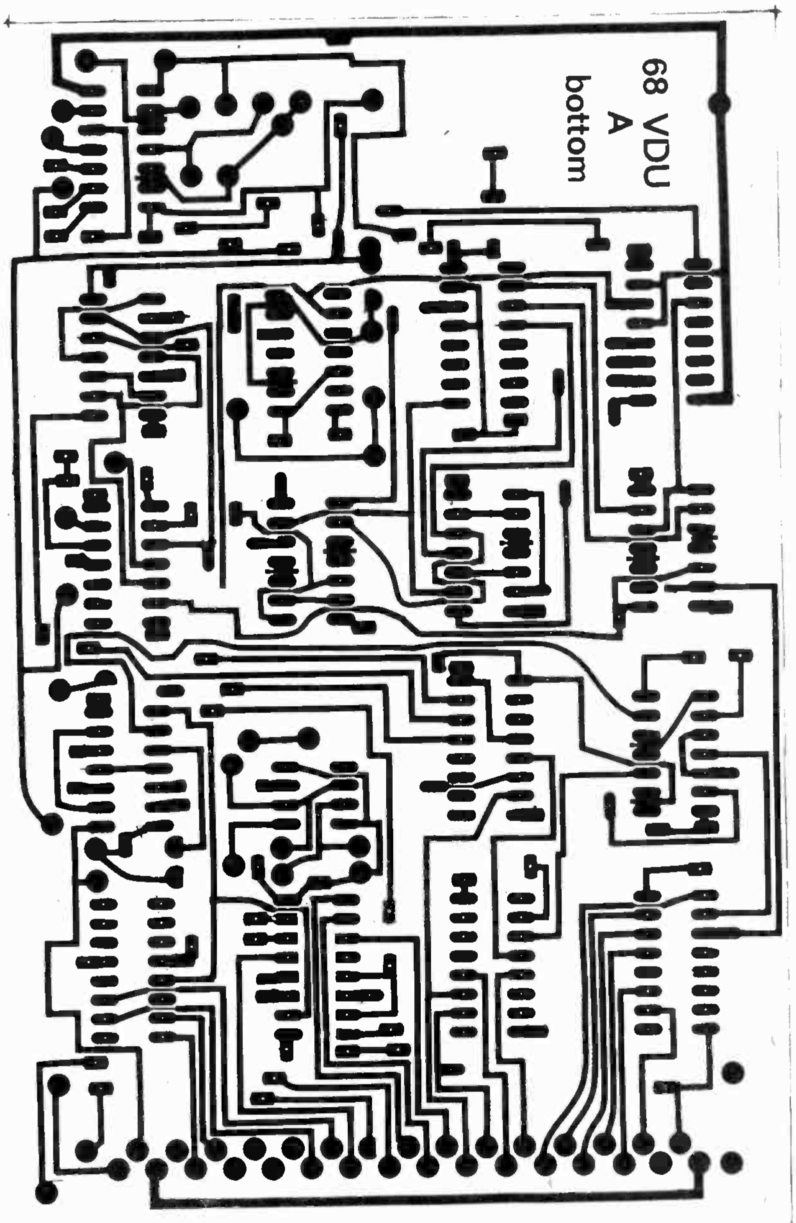
Link D0-C0 All '?' changes to all '?'
Link D1-C1 All '?' changes to '=?'
Link D2-C2 '89:;' added before ' = ?'.
Link D3-C3 '01234567' added.
Link D4-C4 Special characters added (brackets, quotes, asterisk, etc)
Link D5-C5 Alphabet and rest of chracter set added.

Each row of the VDU should now display 64 different characters, white on black background. Now insert IC16 and make 'permanent' links A-D and B-E, and continue with temporary links.

Link D6-R0 Alternate character rows will show inverted video signal as black characters on white background.
Link D7-R1 Alternate pairs of character rows will take on a grey background (two shades of grey are possible)

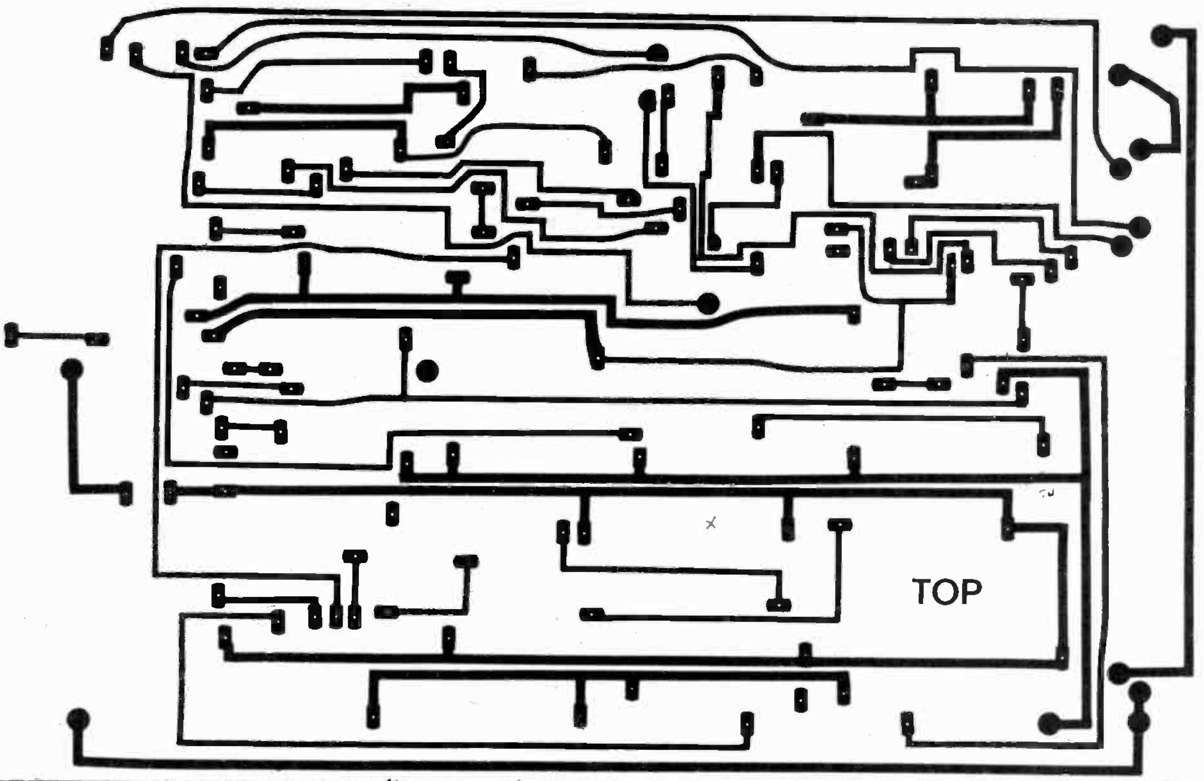
Insert IC17 and check that the whole display flashes at about 1Hz, during the flash which takes about 1/5 second the video signal is inverted ie a B/W character becomes W/B and vice-versa. To stop the flashing connect point C to ground.





Full size 100mm by 160mm

VIDEO DISPLAY UNIT



Full size 100mm by 160mm

PARTS LIST –

Resistors

R1 220R
R2, 3, 4, 390R
R5, 6, 7, 1K
R8 68K
R9 10K
RV1 1K vert preset
All resistors ¼W 5%

Capacitors

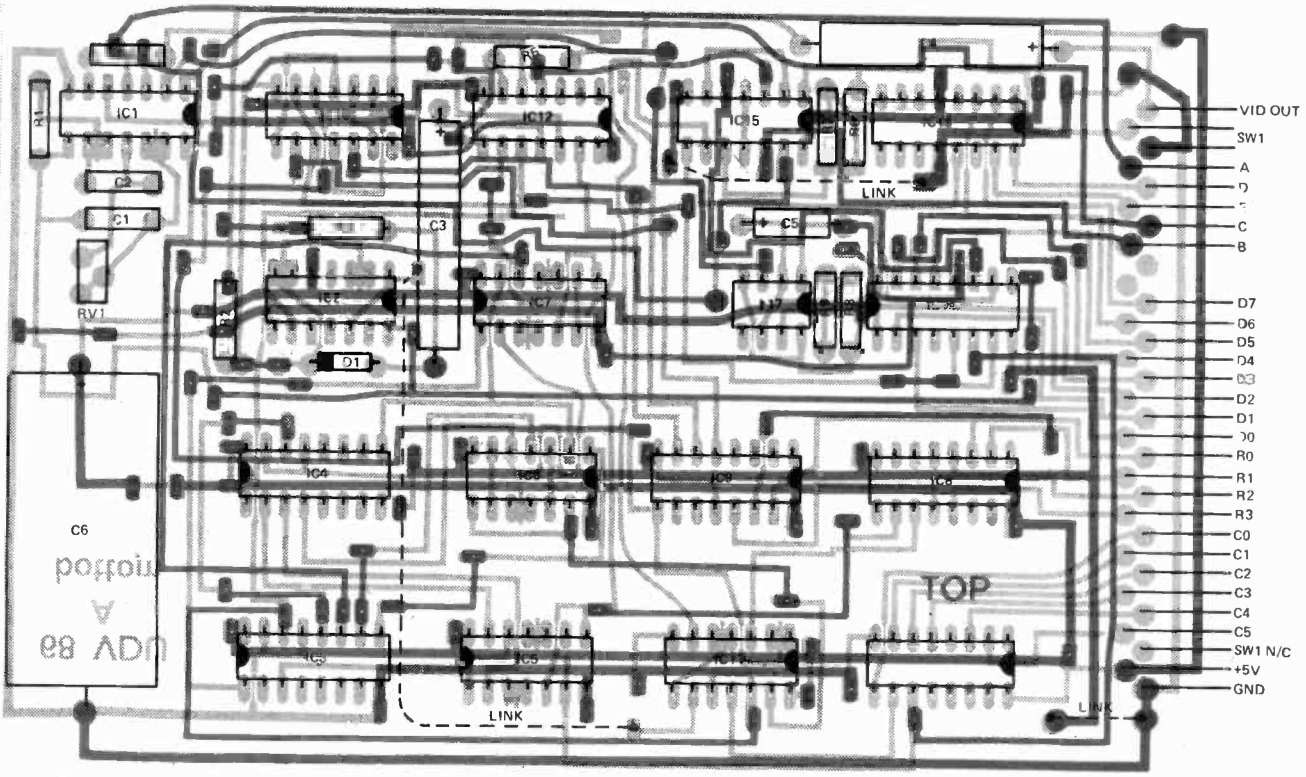
C1, 2 150pF
C3, 4 100uF 16V
C5 10uF 16V
C6 500uF 16V

Integrated Circuits

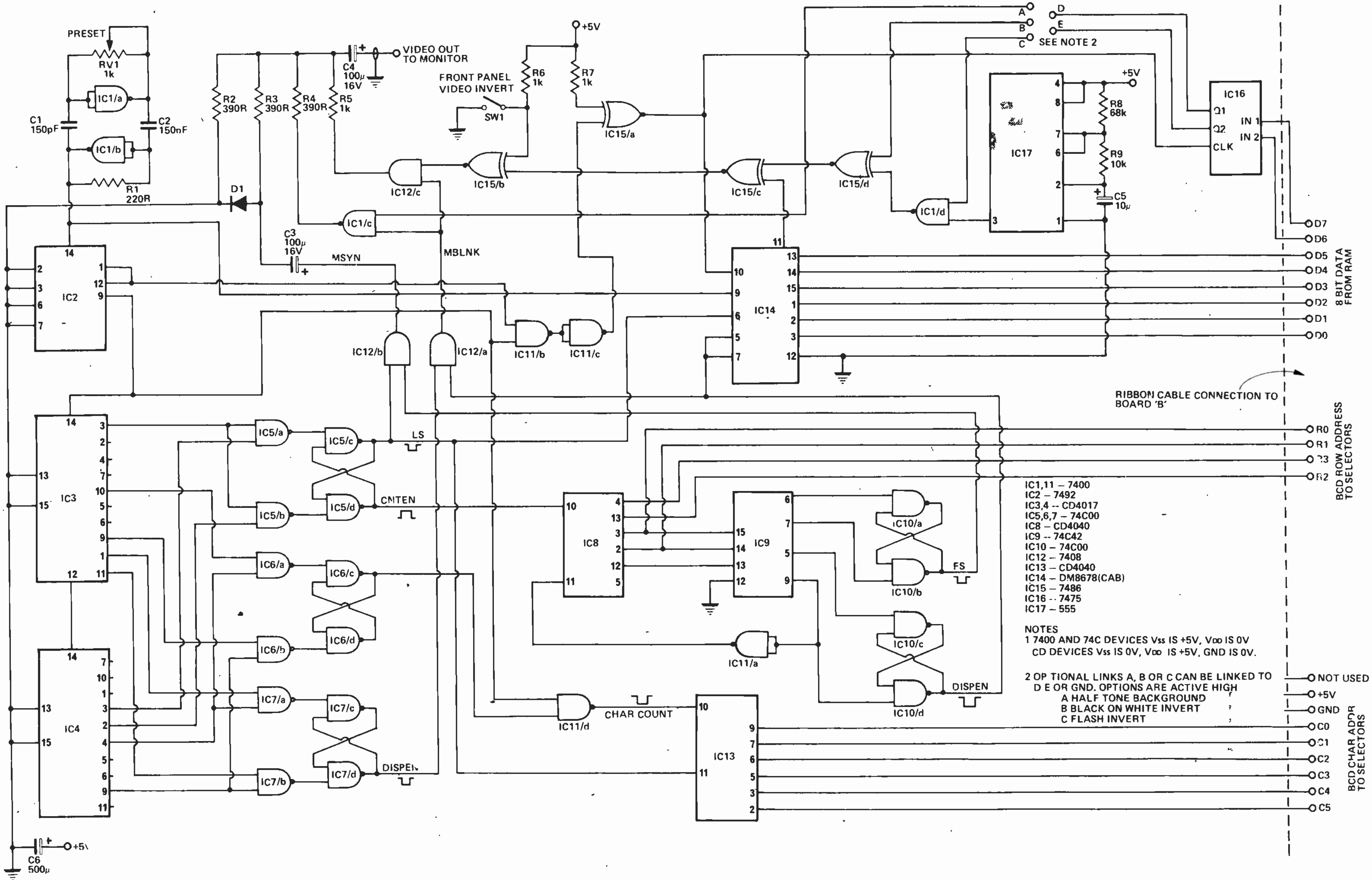
IC1	7400	IC10	74C00
IC2	7492	IC11	7400
IC3	CD4017	IC12	7408
IC4	CD4017	IC13	CD4040
IC5	74C00	IC14	DM8678
IC6	74C00	IC15	7486
IC7	74C00	IC16	7475
IC8	CD4040	IC17	555
IC9	74C42		

Hardware

71-3845B 2in Front panel (Vero)
25 Way socket (466-220)
25 Way plug (466-191)
25 Way cover (466 258)
Co-axial socket, surface (455-545)
Ribbon cable
ETI 68VDU board A
Doram (RS) numbers in brackets.



IMPORTANT NOTE: The outputs from this half of the VDU module will be connected via ribbon cable to the B board next month. The PCB has however been laid out with connections for a Vero 31 way connector, if the memory board is not used a connector can be used on this board — so if you intend to build the complete module **DO NOT** solder a 31 way connector to this board.



IC1,11 – 7400
IC2 – 7492
IC3,4 – CD4017
IC5,6,7 – 74C00
IC8 – CD4040
IC9 – 74C42
IC10 – 74C00
IC12 – 7408
IC13 – CD4040
IC14 – DM8678(CAB)
IC15 – 7486
IC16 – 7475
IC17 – 555

NOTES
1 7400 AND 74C DEVICES Vss IS +5V, VDD IS 0V
CD DEVICES Vss IS 0V, VDD IS +5V, GND IS 0V.

2 OPTIONAL LINKS A, B OR C CAN BE LINKED TO D E OR GND. OPTIONS ARE ACTIVE HIGH
A HALF TONE BACKGROUND
B BLACK ON WHITE INVERT
C FLASH INVERT

Options

With the assembly of board A completed it is only necessary to decide on the optional links of points A, B, C, D and E. At the end of the tests these are connected as A-D and B-E and give the results shown, (in this example the flash option is ignored.) Points D and E are the latched outputs from RAM data bits 6 and 7. Points A, B and C are the option inputs, any unused option inputs should be connected to logic 1 or 0 and not left floating.

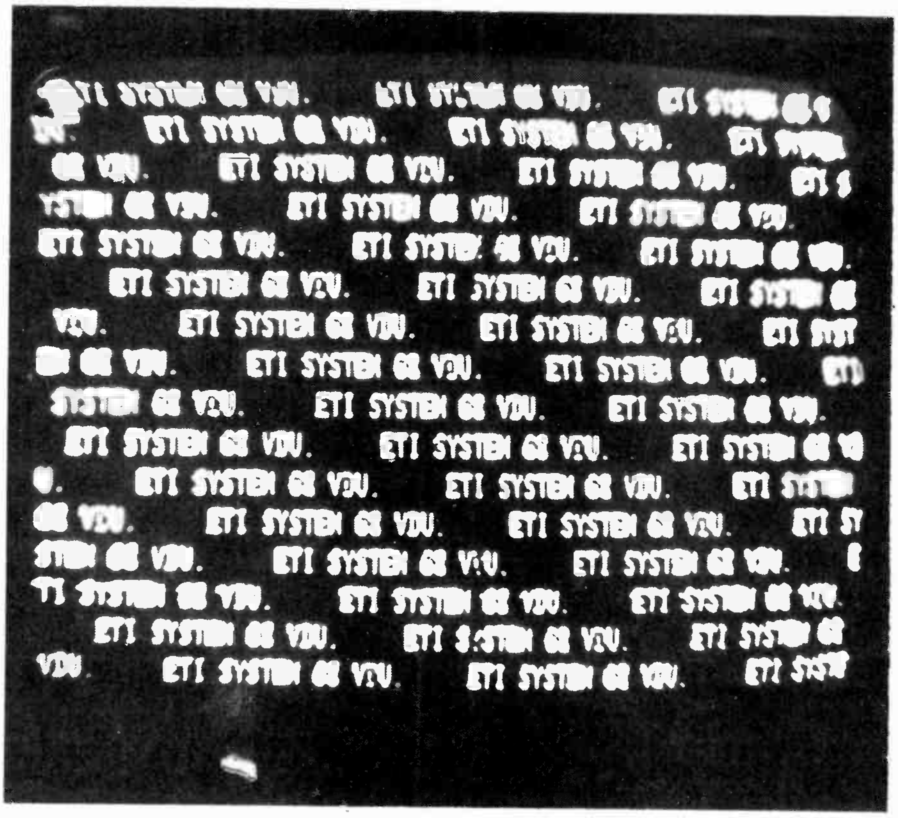
The option inputs are as follows —

Point A gives a half-tone (grey) background when selected as logic 0.

Point B gives B/W character when 0, W/B character when 1.

Point C gives 1Hz video invert "flash" when 1, steady state when 0.

Because these options are controlled by RAM bits 6 and 7 each character can have a different option from its neighbour, thus with the 64 different characters from the DM8678 each with four options we have a VDU with 256 different possible characters.



NEXT MONTH

In next month's issue we will continue with board B which contains the RAM and the MPU interface. The basic interface could also be used to connect the ETI 560 VDU, PW Videowriter (if you must!) or other similar units to System 68.

Detecknow-ledgey

Detecknowledgey ? No, we haven't forgotten how to spell - a number of you thought we had during our 'Tecknowledgey' ad series last year - it is simply an expression of Ambit's specialist topic for Summer 1977: Metal Detectors. In other words, we want you to know that we know about them, not just selling them, but how they work, and why. It is surprising how few people can explain the theory and application of first principles to metal locators. Things like why a bunch of keys can sometimes fail to register, whilst a 2p piece indicates at 8 -10" or why a lump of iron reacts as if it were non-ferrous. See our new publication on the subject, a consise reference work that sets out to explain from first principles the various phenomena you will encounter. £1.00 inc PP.

PW SEEKIT COMPLETE KIT

Speaking of technology - that is, the application of scientific discoveries to practical situations and every day equipment - the PW Seekit can claim to have used a few innovative features only achievable with devices that we have been largely instrumental in promoting, so it is not surprising we are able to offer complete kits, and all parts for this exciting project. The complete Seekit-kit costs £36.00 including PP AND VAT. This kit contains all electronic and plastic components (undrilled), bar things like glue, foil etc., which you are more than likely to have around the house. An SAE will bring you our new leaflet (A5 size please) with a more detailed list. Please note we can only consider service/testing on complete kits purchased from US.

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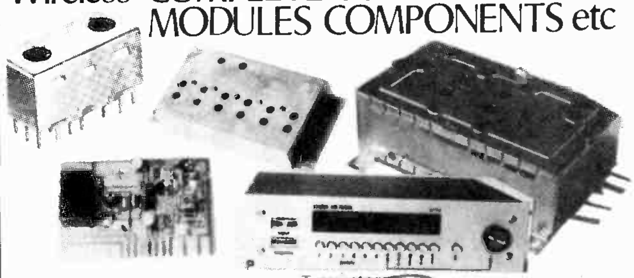

Linear ICs:

CA3089E	1.94
MC1310P	2.20
TBA120	0.75
uA753	1.80
HA1137W	2.20
CA3090AQ	3.75
HA1196	4.20
uA720	1.40
CA3123E	1.40
HA1197	1.40
TBA651	1.81
LM380N	1.00
LM381N	1.81
LM3900*	0.75
TDA2020	2.99
TBA810	1.09
TCA940	1.80
7805UC*	1.55
78M12*	1.20
tda1412*	1.20
7815*	1.55
78 M20*	1.20
78M24*	1.20
uA723CN*	0.80
TAA550*	0.50
8038CC*	4.50
NE555V*	0.70
NE566/7*	2.50
NE565*	2.50
NE560*	3.50
MC1312	1.50

Digital ICs

11C90DC	14.00

Transistors:

40673 *	0.57
~~MEM680*~~	~~0.75~~
MEM614*	0.38

Varicaps

BA102	0.30
BA121	0.30
BB104	0.45
BB105	0.32
MVAM2	1.35
MVAM115	0.95
MVAM125	0.90

TUNER BITS

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EF5600	12.50
EC3302	7.50
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7253	26.50
7252	26.50
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an electronic game to develop clear thinking

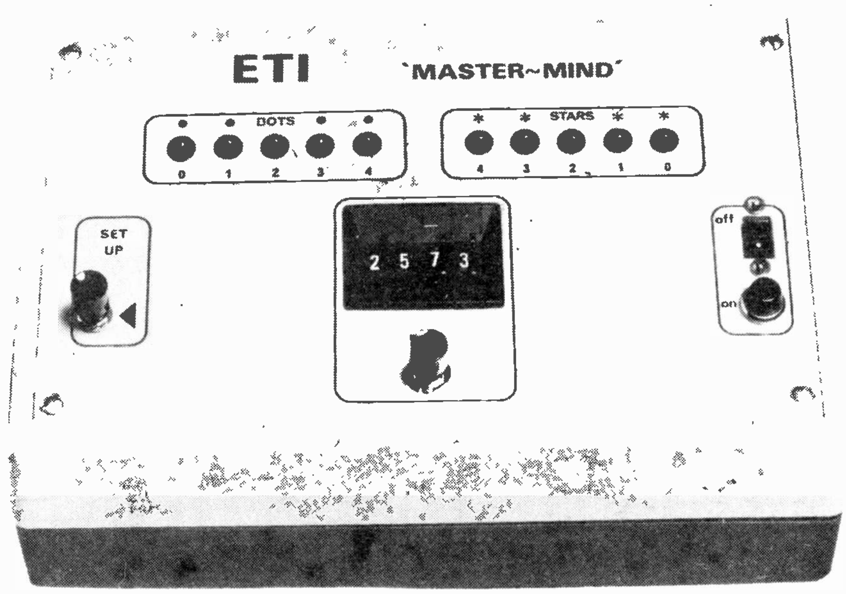
ETI MASTERMIND

FROM A CIRCUIT DESIGN BY GILES GUMMER

DIGITAL ELECTRONICS is a natural for game circuits. Things that go 'high' in the night and will keep scores accurately (when told to), conjure up visions of nice neat Veroboxes lined with LEDs and seven-segment displays all flashing away in time to a maniac beat.

In practice such pyrotechnic exuberance is rarely achieved, and the vaulted scheme reaches completion as yet another digital dice, or in the event of a unprecedented brainstorm, a clock.

Well, although we must admit to a minimum of pyrotechnics, we can *truthfully* claim to have gone beserk with the T.T.L! This project should, however, provide a nice 'middle-class' undertaking for those wishing to move from Reaction Testers to MPU's.



Getting stars for dots

The game is based on the old 'star and dot' game where one player sets up a number code consisting of three to six digits (depending on how clever his opponent is — or thinks he is!) and another attempts to 'break' the code. Stars are awarded for correct digit, correct position, and dots for correct digit, wrong position.

For example if the code was 1234, and the guess 0247, one star is awarded for the '2' and one dot for the '4'. The game has recently been marketed under the name 'Mastermind', using colours for numbers.

Our version uses logic to replace one of the protagonists, such that the game becomes playable in solo fashion. When the 'set up' button is operated, the circuit generates its own random 4-digit number and stores this. The player then has to 'guess' using the four BCD switches and use the 'play' button.

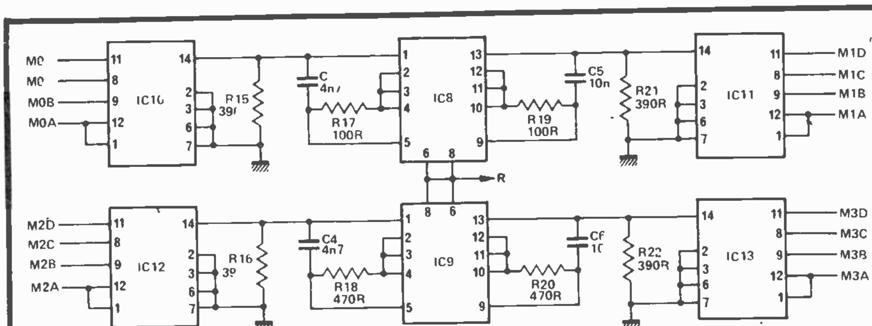
Once this is pressed, a comparison is run, and the machine will award the appropriate stars and dots on the bars of LED's. These *do not* correspond in position to the BCD switches, so that all you know is how many you got right, and not where the correct numbers lie.

Conditional discharge

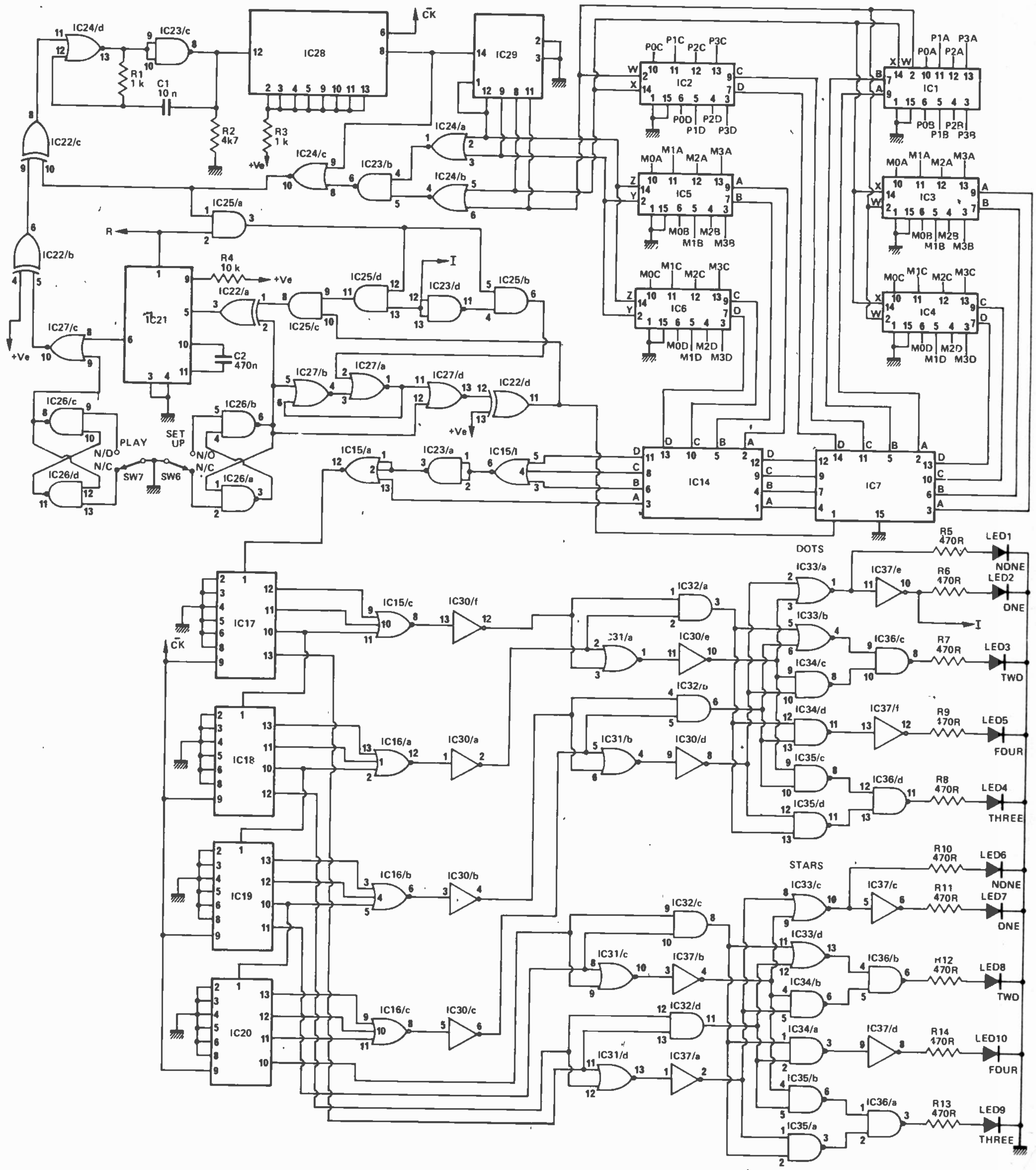
One proviso — repeated digits are not allowed in either your guesses or the machines code. The circuit won't cheat you — it checks its own number on generation, and will re-run the counters if a repeat occurs. This means there will be 10 x 9 x 8 x 7 (5040) possibilities for the answer. We consider this sufficient for all except the bionic brained!

Keep a note of past attempts and what score you obtained for it if you like, but its more fun just playing without notes — time yourself and see how the time you take goes down the more you play. As a competition between two people, it is the fastest time which will be an obvious decider rather than number of attempts.

Having said that, it would require very little extra circuitry to add a counter and LED display to the play button, so that every time it was pushed, the display advanced by one. A limit could be set, and the game played much the same way as the commercial version.



This is the machine counter circuit which generates the four numbers for the player to guess at. IC8 and IC9 'run' the other four as counters, and the four numbers appear in BCD as M0, M1, M2, and M3.



This is the main circuit diagram of the MasterMind unit. The only sections not shown here are the counters (page 41) and the BCD switch wiring (page 46).

How it works

The control logic has to provide a single cycle of WXYZCk whenever a play push-button is pressed, must run the machine's counters, stop them, run a self-comparing play sequence, and repeat the process if the number generated is illegal.

The two control pushbuttons — play and set-up — are each bounce-protected by a pair of cross-coupled NAND gates — IC26. A test sequence is run, either by pushing play or by triggering the monostable IC21, through the OR gate formed by IC27c and IC22b. The five bit counter that cycles WXYZCk (IC28 and IC29) is run by a gated astable built around IC24d and IC23c. The gating input comes from IC22c and the astable runs when the gate line goes low.

Exclusive OR (XOR) gates are used to drive both the astable (IC22c) and the monostable (IC22a). These gates provide four distinct phases of operation per cycle, and allow for slow fingerwork from the player.

The five bit counter has a five input NOR gate, formed from IC23b and IC24a, b and c, attached to its output lines, which goes high when the counter is in its rest state (00000).

Normally the test input of IC22 is low and the other input high. Thus its output will be high and the astable disabled. When play is pressed, its output falls and the astable runs. The counter counts once, the five input NOR gate goes low, the inputs of IC22c differ again, and the counter stops. Releasing play lowers the second input, and the astable runs the counter once more until the NOR gate detects the end of the cycle, and stops it.

Since the shift register is clocked by a falling pulse, the $\overline{Q}$ output of IC28 ($\overline{Ck}$) is used, though the NOR gate is fed with Q.

Pressing set-up does two things. Firstly, it sets the anti-race latch formed by IC22d and IC27a, b and d, which raises P/M to order the 'self-comparison' test from the multiplexers. Secondly, it triggers the monostable IC21. This causes its $\overline{Q}$ output to go low, which enables the four astables running the machine's number counters (via line R). Simultaneously its Q output rises and, as described above, the five bit counter counts to 00001, and stops. (This means that the first test comparison is run on the machine's old number, but this information is not in fact used.) When the monostable falls, the machine's counters stop and the rest of the test sequence is run on the number they have settled into.

The display logic includes circuits to detect illegal numbers which are signalled on Line I. At the end of the test cycle, IC25a turns on IC25d if the number is declared illegal, and IC25b if not — IC23d is an inverter. IC25b resets the latch and ends the set-up sequence. IC25d re-triggers the monostable if the latch is set (IC25c) and if the set-up button has been released (IC22a — which operates similarly to IC22c).

The four machine counters (ICs 10, 11, 12 and 13) are each run by one of the four gated astables formed by NOR gates in ICs 8 and 9. These astables run at different speeds and provide an unguessable, if not truly random, four digit number after a run pulse on Line R. The data from these counters, as well as that from the player's BCD switches, is passed to the multiplexers, ICs 1 to 6. These are dual four-to-one multiplexers, type 74153, wired so that each multiplexer (two to a package) chooses the same bit from one of our digits, e.g. for the four player digits, bit B is multiplexed in the lower half of ICI. ICs 1 and 2 form multiplexer 2 (Mpx 2) and present at their four outputs the bits of the digit selected by W and X, their control inputs. Mpx 3 (ICs 3 and 4) does the same for the machine's number, and Mpx 4 (IC7, a 74157 quad two-to-one multiplexer) presents either the selected machine digit or the selected player digit to one side of the comparator circuit. P/M is the control line; raising it selects the machine digit, required for a 'self-comparison' test.

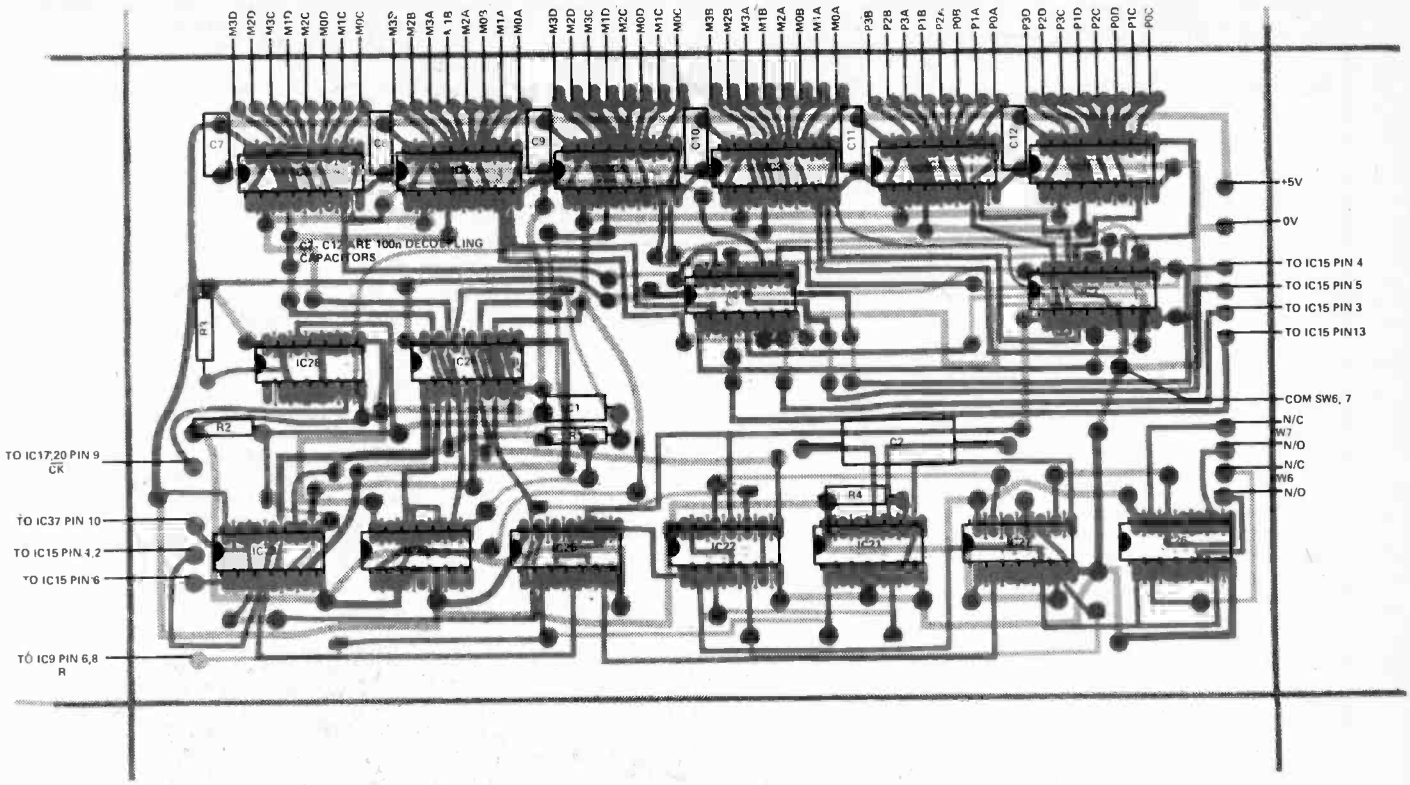
The other side of the comparator circuit is permanently connected to Mpx 1 (ICs 5 and 6) which selects a machine digit according to the state of the control lines Y and Z.

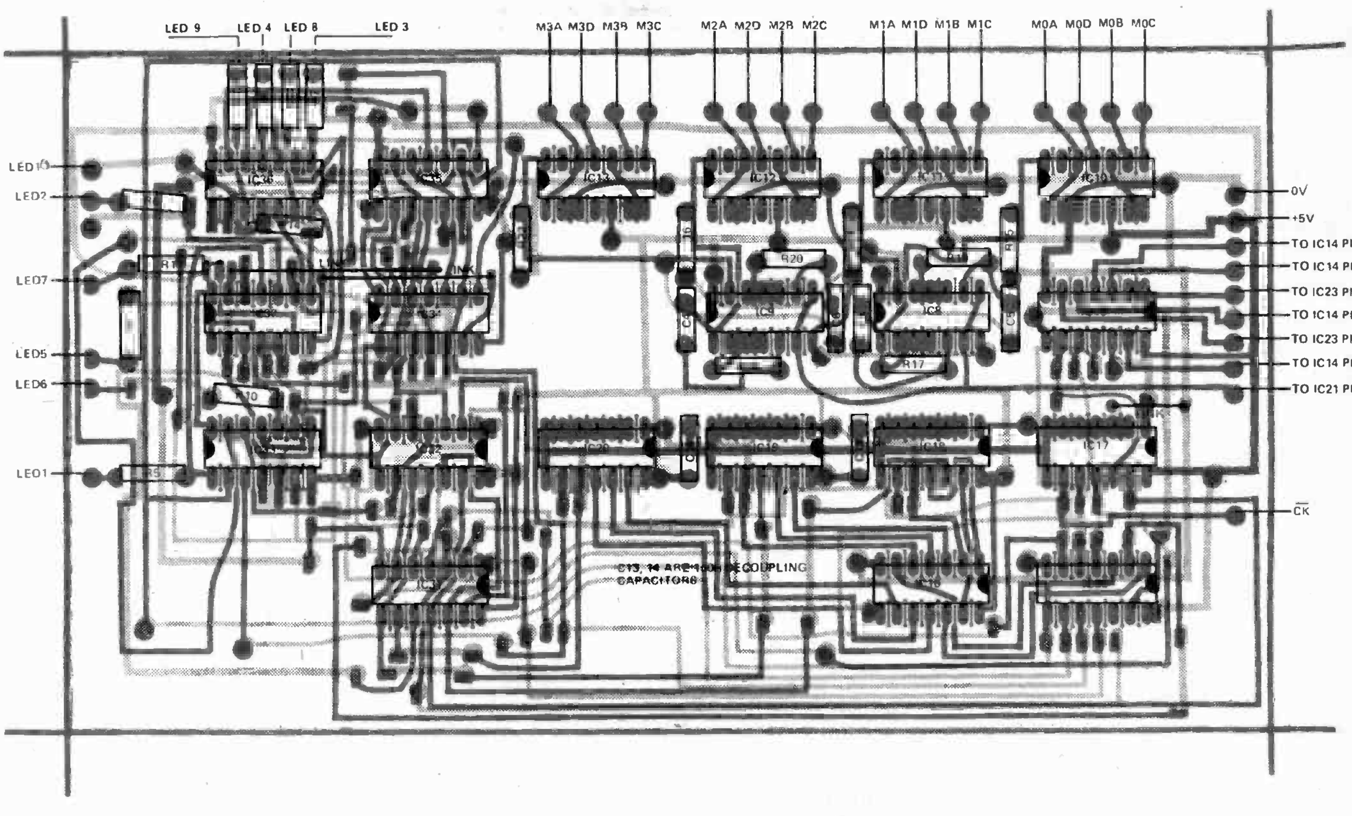
In the comparator circuit equivalent bits are compared in an XOR gate (all four in IC14). All four bits must be identical if the digits are equal, so all four XOR gates must be low. IC15a and b, and IC23a, form a four input NOR gate that sums the outputs and goes high for identical digits.

Information from this gate is passed to the serial input of the shift register (ICs17 to 20). These four ICs, type 7495, are cascaded to form a 16 bit, serial in/parallel out register. Data is clocked in once the state of the multiplexer outputs has had time to settle — on the rising edge of $\overline{Ck}$, i.e. the falling edge of Ck.

The sixteen parallel outputs of the register provide Star information directly the cycle has ended, but as each digit has a choice of three from which it can 'earn' a Dot, four three input OR gates are required to sum this redundant information. These are formed from IC15a, b and c, IC16c and IC30a, b, c, and f.

An illegal number generates at least one Dot when compared with itself. Thus the I Line is driven from the same source as the 'ONE' Dot LED.





Component overlays of the main circuit boards. Any holes without component leads are through -board links. Solder these both sides, and check for continuity. Because of the size of these double-sided boards, we have not given the foil patterns, as usually we do. Home etchers can obtain these by sending an S.A.E. to 'MasterMind Boards' ETI Magazine. Firms should note however that Crofton Electronics hold the copyright on these designs.

Parts List

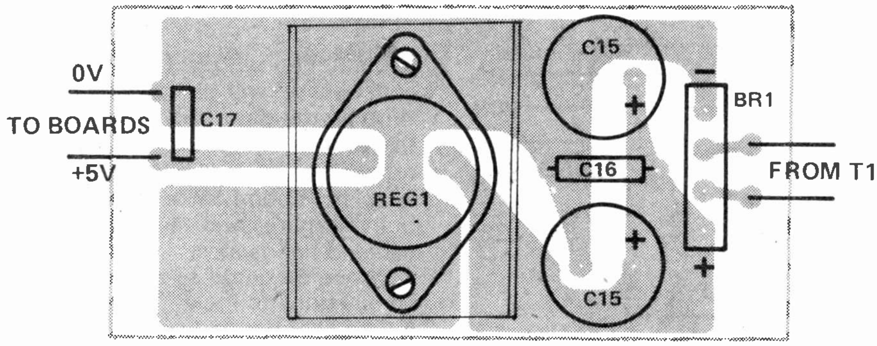
RESISTORS — all ¼W 5%	
R1,3,23-38	1k
R2	4k7
R4	10k
R5-14,18,20	470R
R15,16,21,22	390R
R17,19	100R
CAPACITORS	
C1,5,6	10n polyester
C2	470n polyester
C3,4	4n7 polyester
C7-14,17	100n polyester
C15	2,200u 16V (or 2 x 1000u 16V)
C16	220n polyester
SEMICONDUCTORS	
IC1-6	74153
IC7	74157
IC8,9,24,27,31,33	7402
IC10-13	7490
IC14,22	7486
IC15,16	7427
IC17-20	7495
IC21	74121
IC23,26,34-36	7400
IC25,32	7408
IC28	7472
IC29	7493
IC30,37	7404
LED1,6	.2" type green
LED2-5,7-10	.2" type red
REG1	5V 1.2A (min.) TO3 cased regular i.e. 7805 k.c.
BR1	200V 1.6A bridge rectifier
SWITCHES	
SW1-SW4	min.B.C.D. switches Doram: 4 x 338-339 mounted in end cheeks (Doram: 1 x 338-406)
SW5	On-off rocker 240V 1A type
SW6,7	S.P.D.T. momentary action
TRANSFORMER	
T1	240V - 9V 1A type

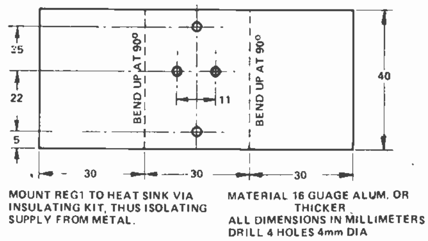
(Maplin have a suitable type to fit within the restricted case space, with two 9V ½A windings which are paralleled to give 9V 1A. From Maplin Electronic Supplies, Rayleigh, Essex. Cost: £2.35 inc. VAT, p&p. Order as: Min tr. type 9V.)

BOARDS
Board A and B are available from Crofton electronics, 35 Grosvenor Road, Twickenham.

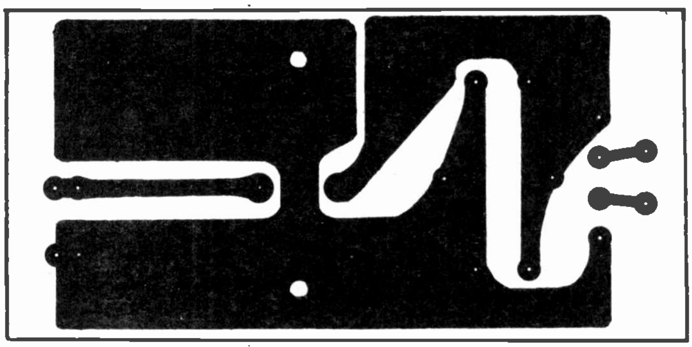
CASE
Vero type 65 - 2523E sloping front.

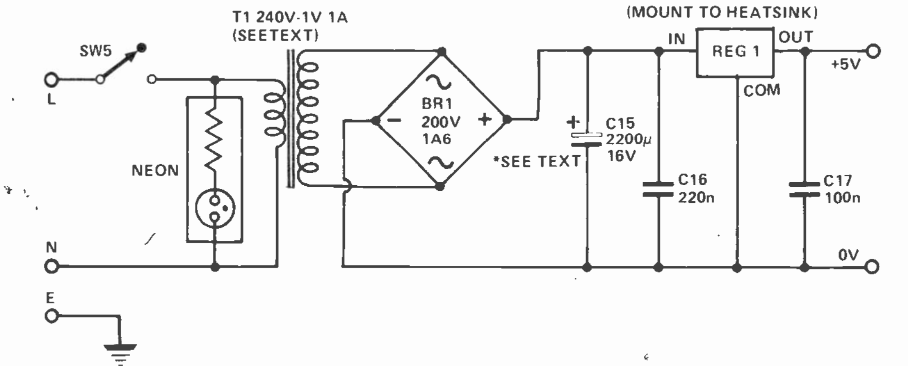
MISCELLANEOUS
Mains neon, multiway cable, pcb mounting pillars, nuts, bolts, etc., 3-core mains flex, aluminium for heatsink, TO3 insulating kit, mounting feet for case, power supply board as pattern.





Power supply details. below the foil pattern for the PCB is the circuit diagram of the supply. Reg.1 will get very warm in operation, and if it is a problem, or you run the thing continually for hours and hours, some ventilation holes will be needed in the case:- say beneath the heatsink and in the rear of the box will do. Heatsinking is necessary in this case, so PLEASE don't leave it off!





Building up to it

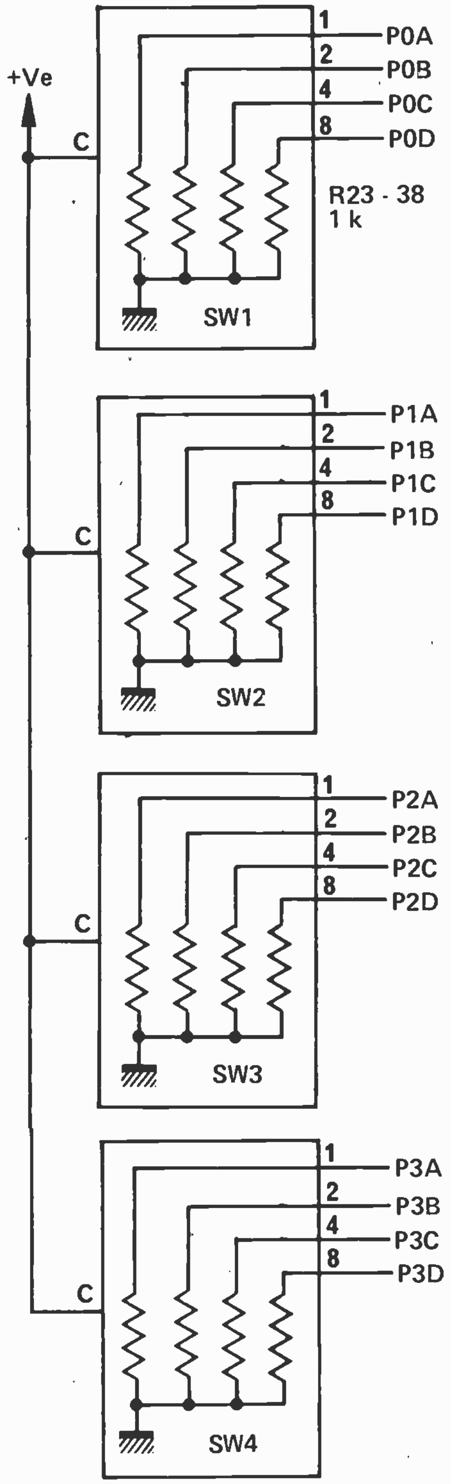
Although this is a very complex project, actual construction is not *that* bad. Having paused a second there to allow those who fainted at the audacity of that remark to recover, let us continue unabashed, to point out that most of the potential problems are side-stepped by use of the PCB's.

If you are the proud owner of a wiring pen however, this is the perfect chance to put those pretty little reels to work. Make up a list of point-to-point connections from the circuit diagram before you start (and CHECK it) and work your way down the list. Use IC holders.

This method produces excellent, neat results, but requires amounts of patience guaranteed to enhance the soul — or so they tell me.

Meanwhile back at the PCB there are a large number of through hole connections to make. With a logic circuit of this complexity it is unfortunately unavoidable. Through-plating the holes pushes the price too high to reach. So the first step is to wire up all the through board links, solder top and bottom, and check each one with an ohm-meter. IC sockets (or soldercon pins) *must* be used for all ICs; we spent hours unsoldering, when troubleshooting a faulty chip on the first prototype!

ETI MASTERMIND



Wiring for the BCD switches. The lettering refers to the contacts on the switches. These are best wired before mounting the switches on the front panel.

Another important point is that ¼ W 5% resistors *must* be used, especially on the back of the BCD switches, otherwise the front panel will not fit properly, fouling the PCBs inside.

Decoupling capacitors should be mounted on the boards where indicated, and if soldered both sides will act as through-links quite happily. The biggest hurdle to construction will be the interwiring. With all the data passing around the various circuit blocks, there is no way we could make this any simpler. Ribbon cable is expensive, but will more than save its cost in avoided headaches.

Since there are so many connections to make, keep a record (written, preferably emblazoned on marble with holy fire), of which colour goes where, *and* which is what in each ribbon cable. Don't try and build the project in an evening. The small hours are no time to be checking a 20-way ribbon cable connection, and 'midnight-oil' light will confuse the colours anyway. Take your time!

Boxing clever

There is not much room inside the case to fit all the various bits into — you would never swing a diode in there, let alone a cat. Have a look at our photographs and keep to our layout — we've had the nightmares already trying to get everything in so why suffer yourself?

There are two types of BCD switch on the market at least, our choice, and those ingenious, but difficult to read, '7 segment' type. If you intend to use the latter, your front panel will need altering, and so will the internal wiring.

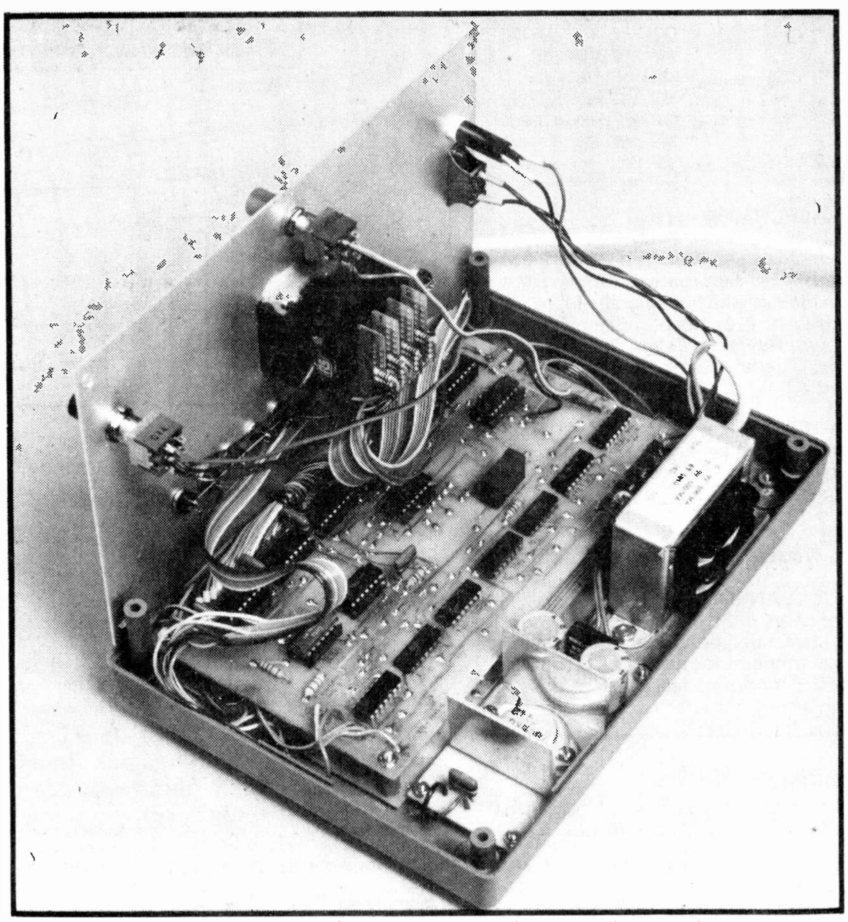
Don't ring us; we'll . . . .

As regards a PSU, batteries will most definitely *not* do this time — current consumption is not far short of an amp most of the time, and a PP3 won't last long enough to switch off again!

Conclusions?

Well it could have been simpler, but it could have been worse! If we'd used static logic, there would have been approx 70 chips, and about 2.5A (yes Amps) drawn from the supply. As it is the project is a good exercise in logic design, and following through the circuit in conjunction with the 'How It Works' should pay dividends in return for time expended.

Once built of course it is a compulsive game to play (if there is no ETI next month you'll know why!) and should prove a nice alternative to 'Crossroads' now and then!



Internal shot of the MasterMind. If you use the same box as us, keep to this layout, as there is very little room.

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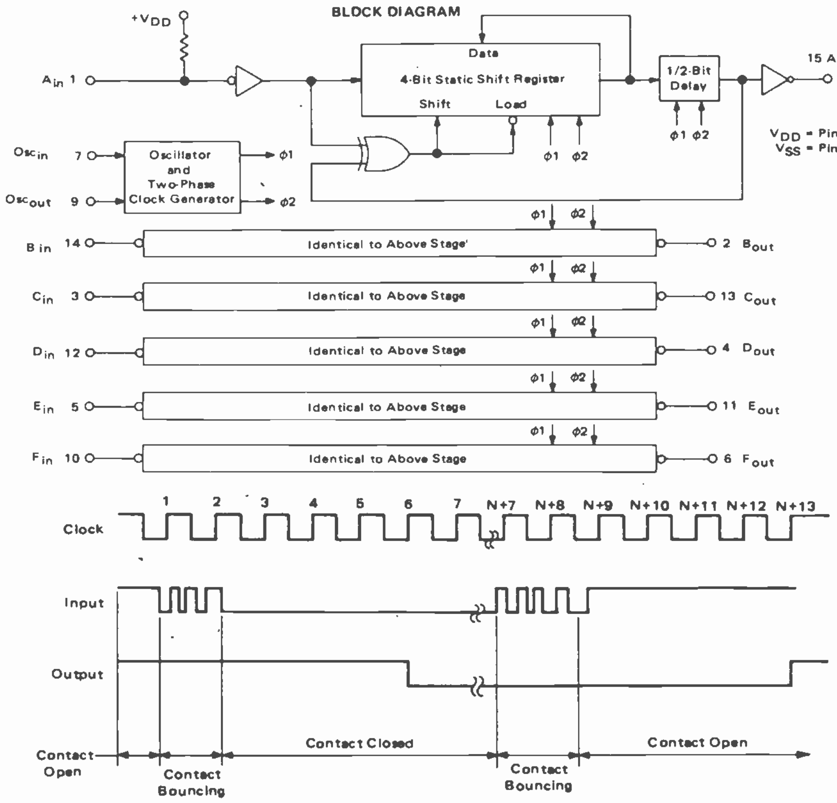
ETI DATA SHEET

MC14490 HEX BOUNCE ELIMINATOR — MOTOROLA

The MC14490 is constructed with complementary MOS enhancement mode devices, and is used for the elimination of extraneous level changes that result when interfacing with mechanical contacts. The digital contact bounce eliminator circuit takes an input signal from a bouncing contact and generates a clean digital signal four clock periods after the input has stabilized. The bounce eliminator circuit will remove bounce on both the "make" and the "break" of a contact closure. The clock for operation of the MC14490 is derived from an internal R-C oscillator which requires only an external capacitor to adjust for the desired operating frequency (bounce delay). The clock may also be driven from an external clock source or the oscillator of another MC14490.



The MC14490 is available ex-stock from **Celdis Ltd., 37-39 Loverock Road, Battlefarm Estate, Reading, Berks.** Two versions are stocked in plastic 16-pin packages. The VP suffix indicates 3.0 Vdc to 6.0 Vdc operation, the other version is suffixed FP which has 3.0 Vdc to 18 Vdc operation range.

MC14490 VP is **£6.61** inclusive MC14490 FP is **£8.36** inclusive. Both prices are for 1 off, for further prices contact Celdis direct.

CHARACTERISTICS

The single most important characteristic of the MC14490 is that it works with a single signal lead as an input, making it directly compatible with mechanical contacts.

The circuit has a built in pullup resistor on each input. The worst case value of the pullup resistor is used to calculate the contact wetting current. If more contact current is required, an external resistor may be connected between V_{DD} and the input.

Because of the built in pullup resistors, the inputs cannot be driven with a single standard CMOS gate when V_{DD} is below 5V. At this voltage, the input should be driven with paralleled standard gates or by the MC14049 or MC14050 buffers.

The clock input circuit (pin 7) has Schmitt trigger shaping such that proper clocking will occur even with very slow clock edges, eliminating any need for clock preshaping. In addition, other MC14490 oscillator inputs can be driven from a single oscillator output buffered by an MC14050.

The MC14490 is TTL compatible on both the inputs and the outputs. When V_{DD} is at 4.5V, the buffered outputs can sink 1.6 mA at 0.4V. The inputs can be driven with TTL as a result of the internal input pullup resistors.

OPERATION

To understand the operation, we assume all bits of the shift register are loaded with 1's and the output is at a 1 or high level.

At clock edge 1 the input has gone low and a 0 (low level) has been loaded into the first bit or storage location of the shift register. Just after the positive edge of clock 1 in input signal has bounced back to a logic 1. This causes the shift register to be reset to all 1's in all four bits — thus starting the timing sequence over again.

During clock edges 3 to 6 the input signal has stayed low. Thus a logic 0 has been shifted into all four shift register bits and, as shown, the output goes to a 0 during the positive edge of clock pulse 6.

It should be noted that there is a 3½ to 4½ clock period delay between the clean input signal and output signal. In this example there is a delay of 3.8 clock periods from the beginning of the clean input signal.

After some time period of N clock periods, the contact is opened and at N+7, a 1 is loaded into the first bit. Just after N+7, when the input bounces low, all bits are reset to 0. At N+8 nothing happens because the input and output are low and all bits of the shift register are 0. At time N+9 and thereafter the input signal is a high (1) clean signal. At N+13 the output goes high (1) as a result of four 1's being shifted into the sift register.

Assuming the input signal is long enough to be clocked through the Bounce Eliminator, the output signal will be no longer or shorter than the clean input signal plus or minus one clock period.

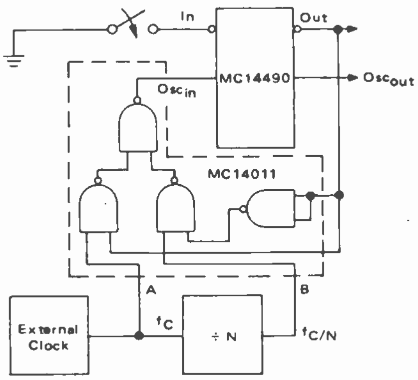
CLOCKING

The only requirement on the clock frequency in order to obtain a bounce free output signal is that four clock periods do not occur while the input signal is in a false state.

If the user has an available clock signal of the proper frequency, it may be used by connecting it to the oscillator input (pin 7). However, if an external clock is not available the user can place a small capacitor across the oscillator input and output pins in order to start up an internal clock source. The clock signal at the oscillator output pin may then be used to clock other MC14490 Bounce Eliminator packages. With the use of the MC14490, a large number of signals can be cleaned up, with the requirement of only one small capacitor external to the Hex Bounce Eliminator packages.

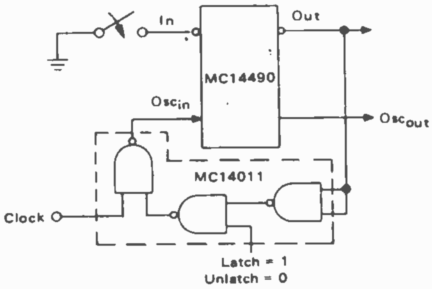
ASYMMETRICAL TIMING

In applications where different leading and trailing edge delays are required (such as a fast attack/slow release timer.) Clocks of different frequencies can be gated into the MC14490. In order to produce a slow attack/fast release circuit leads A and B should be interchanged. The clock out lead can then be used to feed clock signals to the other MC14490 packages where the asymmetridal input/output timing is required.



LATCHED OUTPUT

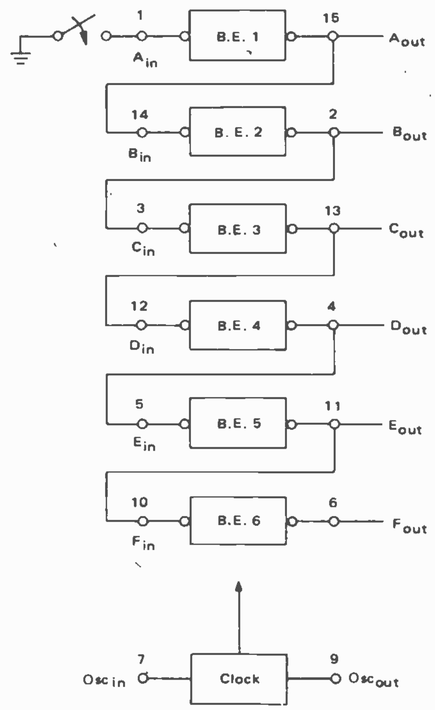
The contents of the Bounce Eliminator can be latched by using several extra gates. If the latch lead is high the clock will be stopped when the output goes low. This will hold the output low even though the input has returned to the high state. Any time the clock is stopped the outputs will be representative of the input signal four clock periods earlier.

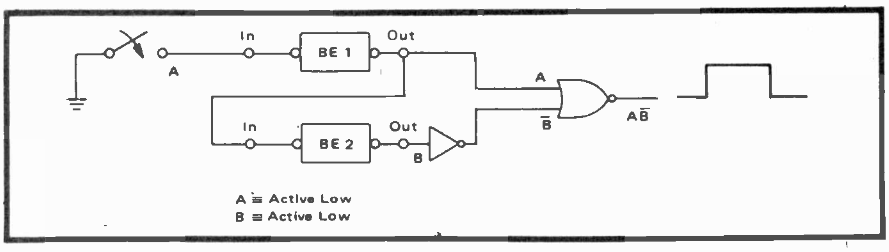


MULTIPLE TIMING SIGNALS

Bounce Eliminator circuits can be connected in series. In this configuration each output is delayed by four clock periods relative to its respective input. This configuration may be used to generate multiple timing signals such as a delay line, for programming other timing operations.

One application of the above is where it is required to have a single pulse output for a single operation (make) of the push button or relay contact. This only requires the series connection of two Bounce Eliminator circuits, one inverter, and one NOR gate in order to generate the signal AB. The signal AB is four clock periods in length. If the inputs to the NOR gate are interchanged the pulse AB will be generated upon release or break of the contact. With the use of a few additional parts many different pulses and waveshapes may be generated.





Voltage regulator use can be expanded beyond that of the simple three-terminal fixed voltage regulator. Some of the circuits which are practical and useful are described in this section. Pertinent equations are included rather than providing fixed component values as the circuits are equally applicable to all regulators within a family.

POSITIVE REGULATORS

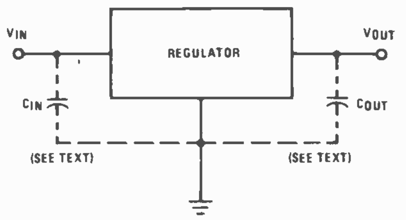


FIGURE 1 Basic Regulator Connection

If the regulator is located more than two inches from the supply filter capacitor, a supply bypass capacitor is required to maintain stability (much as is the case with op-amps). This should be a 0.22 µF or larger disc ceramic, 2 µF or larger solid tantalum, or 25 µF or larger aluminium electrolytic capacitor. Transient response of all the regulators is improved when output capacitors are added. To minimize high frequency noise, an 0.1 µF output capacitor is recommended on the LM78LXX and LM3910 series.

HIGH CURRENT REGULATOR

This current circuit takes advantage of the internal current limiting characteristics of the regulator to provide short-circuit current protection for the booster as well. The regulator and Q_1 share load current in the ratio set between R_2 and R_1 if $V_D = V_{BE(Q1)}$.

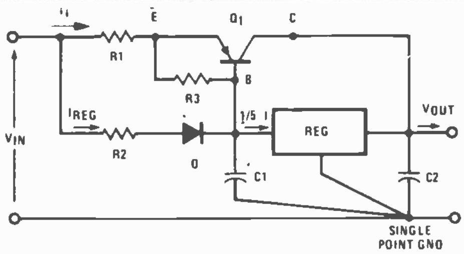


FIGURE 2 High Current Regulator with Short Circuit Limit During Output Shorts.

$$I_1 = \frac{R_2}{R_1} I_{REG}$$

During output shorts

$$I_{1(SC)} = \frac{R_2}{R_1} I_{REG(SC)}$$

If the regulator and Q_1 have the same thermal resistance θ_{JC} and the pass transistor heat sink has R_2/R_1 times the capacity of the regulator heat sink, the thermal protection (shutdown) of the regulator will also be extended to Q_1. Some suggested transistors are listed below.

ADJUSTABLE OUTPUT VOLTAGE

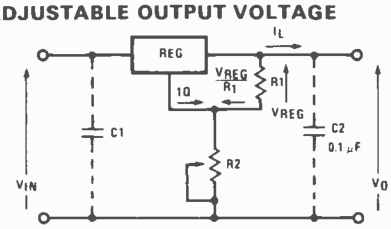


FIGURE 3 Adjustable V_{OUT}

A fraction of the regulator current V_{REG}/R_1 is used to raise the ground pin of the regulator and provide through voltage drop across R_2, an adjustable output voltage.

$$V_O = V_{REG} + R_2\left(I_Q + \frac{V_{REG}}{R_1}\right)$$

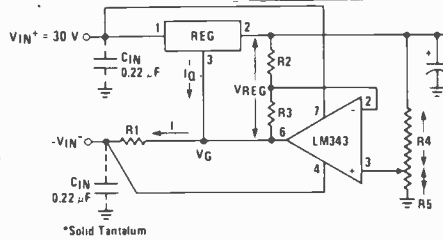


FIGURE 4 Variable Output Voltage of 0.5 - 28V

A wide range of output voltages can be obtained with the circuit of Figure 4. A 0.5- to 20-volt supply can be built using a 30-volt supply and a conventional op-amp, such as the LM143. If

$$R_2 + R_3 = R_4 + R_5 = R, \quad \text{and} \quad R_2/R_3 = 1/10,$$

$$\text{then } V_O = V_{REG}\left(\frac{R_2}{R_4}\right) = V_{REG}\left(\frac{1}{11}\right)\left(\frac{R_4 + R_5}{R_4}\right)$$

Since V_O is inversely proportional to R_4, low output voltages can be very accurately set. The required R_1 is

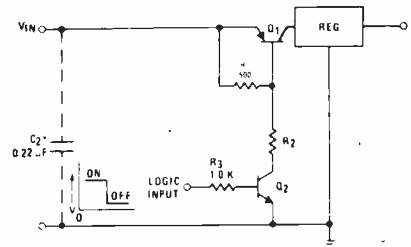
$$R_1 = \frac{V_{IN}^-}{I_Q}$$

The $V_{O(MAX)}$ is dependent on V_{IN} and $V_{dropout}$ provided that the amplifier can source the current required to raise V_G to $V_O - V_{REG}$.

Example:

$V^-_{IN} = -15$ V	$R_1 = 2K2$
$V^+_{IN} = +30$ V	$R_2 = 910R$
$V_O = 0.5\text{-}28$ V	$R_3 = 9K1$
LM340K-05	$R_4 + R_5 = 10K$

ELECTRONIC SHUTDOWN



• Required if regulator far from power supply filter

FIGURE 5 Electronic Shutdown Circuit

Electronic shutdown in three-terminal regulators is done by simply opening the input circuit using a transistor switch. Q_1 operates as the switch which is driven by Q_2. The control voltage V_C can be TTL compatible with the use of R_3 = 1K. R_1 is a biasing resistor, and R_2 can be calculated as

$$R_2 = \frac{V_{IN} - 1\ V}{I_O} \beta_{SAT(Q1)}$$

Figure 6 illustrates a short-circuit-dependent power shutdown circuit with reduced heat sink requirements under short-circuit conditions.

When the power is first applied, Q_2 turns ON and saturates Q_1. The regulator output ramps up to turn Q_3 ON, which turns Q_2 OFF (V_C should be > V_A), thus maintaining Q_1 in the ON state.

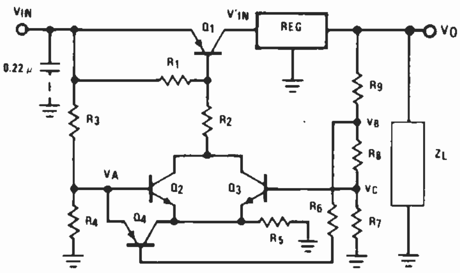


FIGURE 6 Output Electronic Shutdown on High Voltage Regulator

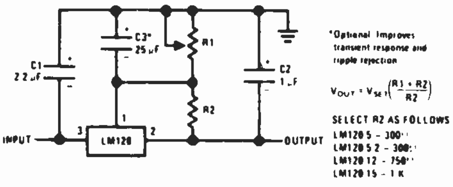
When the output is shorted, Q_3 turns OFF, Q_4 turns ON to clamp Q_2 OFF. Q_1 loses base drive and so opens to isolate the regulator from V_{IN}. When the short circuit is removed, Q_4 loses some base drive and enables Q_2 to re-start the regulator. Q_1 always operates as a switch and needs no heat sinking. Q_2 and Q_3 need not be matched. Q_4 may be any small signal PNP transistor. The entire circuit (less regulator) fits easily on a one-inch squre PC board.

Example: LM340K-24

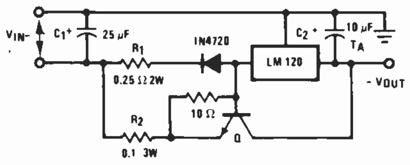
V_{IN}=36V	R_1=500R
V_O=24V	R_2=250R, 2W
I_O=1A	R_3=3K3
V_A=2.5V	R_4=240R
V_B=8V	R_5=62R
V_C=4.8V	R_6=2K
Q_1=NSD32	R_7=1K
Q_2=2N4141	R_8=680R
Q_3=2N4141	R_9=3K3
Q_4=2N2906	

NEGATIVE REGULATORS

All the applications circuits for positive regulators can be used with the polarities inversed for the negative regulator LM320/345 series (e.g., reverse the sense of the diodes, replace PNP's with NPN's etc., etc.),



Variable Output

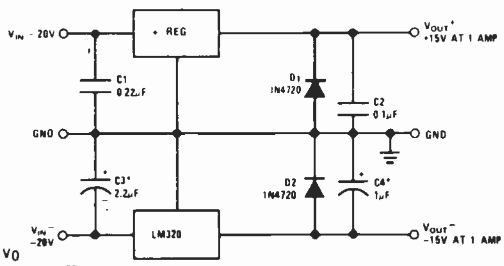


(d) High Current Regulator

Q = 2N3055 (for 5 A)
or NSD31 (for less than 2-3 A)

FIGURE 7 Negative Regulator Circuits

BASIC DUAL POWER SUPPLY



*Solid tantalum
Note: C1 and C2 required if regulators are located far from power supply filter

FIGURE 8 Dual Power Supply

A positive regulator can be connected with an LM320 to form a non-tracking dual power supply. Each regulator exhibits line and load regulation consistent with their specifications as individual devices. Protective diodes D_1, D_2 allow the regulators to start under common load. They should be rated at the regulator short circuit current.

TRIMMED DUAL SUPPLY

Figure 8 may be modified to obtain a dual supply trimmed to a closer output tolerance. The trimming potentiometers are connected across the outputs so positive or negative trimming currents are available to set the voltage across the R_1 (R_2) resistors. R_3, R_5 are included to linearize the adjustment and to prevent shorting the regulator ground pin to opposite polarity output voltages.

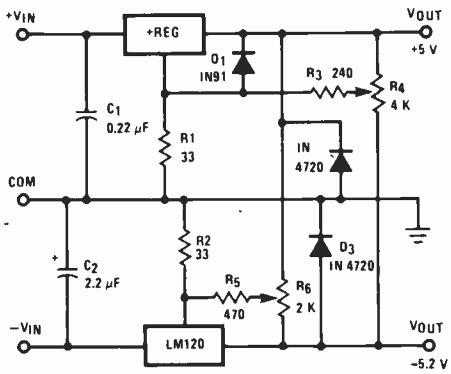
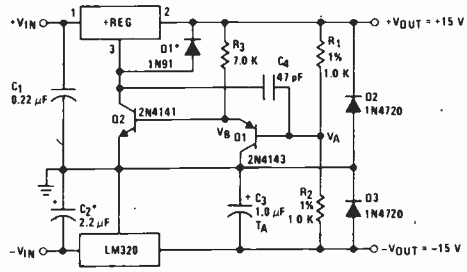


FIGURE 9 Trimmed Dual Supply

Tracking Dual Supply



• Solid Tantalum

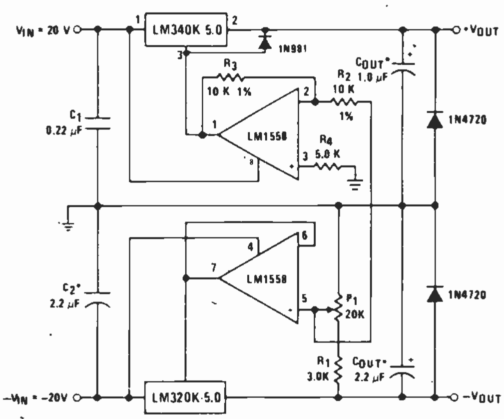
FIGURE 10 Tracking Dual Supply

A tracking supply can be built as in Figure 10 where the positive regulator tracks the negative regulator. V_A is a virtual ground under steady state conditions. Q_2 conducts the quiescent current of the positive regulator.

If $-V_{OUT}$ falls, V_A follows forward biasing collectorbase junction of Q_1. V_A falls, thus raising the collector voltage of Q_2 and $+V_{OUT}$ to restore V_A to desired voltage. Germanium diode D_1 may be needed to start the positive regulator with a high differential load.

Example: +15V, 1A tracking dual supply: LM340T-05, LM320T-15.
The 340 will track the LM320 within 100 mV. D_2, D_3: IN4720.

VARIABLE TRACKING DUAL SUPPLY



• Solid Tantalum

FIGURE 11 Variable Tracking Dual Supply ±5.0 V— ± @ 18V

The ground pins of the negative regulator and the positive regulators are controlled by means of a voltage follower and an inverter, respectively. The positive regulator tracks the negative to within 50mV over the entire output range if R_2 is matched to R_3 within one per cent.

What to look for in the July issue: On sale June 3rd.

DATA SUPPLEMENT

Next month's ETI carries an 8-page pull-out supplement that is a must for the home constructor. EIGHT pages of the kind of information you've always had to hunt for hours to find. Such things as abbreviations, codes and pin-out data collected and assembled into one easy-reference supplement to speed up your projects.

ACTIVE FILTERS

An article explaining how to design active filters doesn't sound very exciting, does it? Well, it should do! Next month we have a DIY guide to active filter design written by an expert in the field which will enable you to make use of circuits you always thought too complex to design!

T.V. RIFLE

The ETI TV game (May '77) has proved very popular. Next month we describe the extra circuitry to enable the two rifle games described in May to be played.

GSR MONITOR

As a follow-up to our biofeedback article recently, we present full constructional details of a galvanic skin response monitor — simply because you asked us to!

SOFTWARE-HARDWARE

Experience gained with digital hardware can be extremely valuable in MPU designs.

We describe the interaction between the development of software and the hardware design of a system.

SHORT CIRCUITS

ALARM ALARM:—

An alarm to alarm you if your car alarm is active! Provides a good deterrent to the would-be thief.

MICROAMP:—

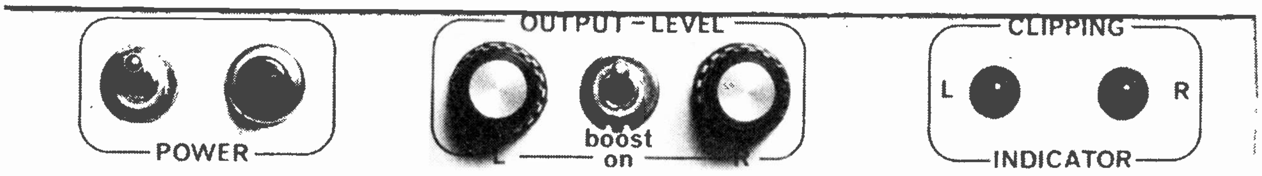
A very ingenious self-contained STEREO test-amp — it's of surprising quality!

TACHOMETER:—

A design to convert a 1 m/A meter into a RPM indicator for your car.

SHORT CIRCUITS

BASS ENHANCER



ONE UNAVOIDABLE DRAWBACK of small speakers, as compared to their larger brethren, is a lack of extreme bass frequencies. They may not 'boom' and they may sound less 'coloured', but they will NEVER play the lowest of the low as well!

There are many high quality 'mini-monitors' around these days - Rogers, Chartwell and Videotone are the first names to come to mind, which possess an excellent sound overall, but are victims of their size with regard to bass response. Let it not go unsaid, however, that all the aforementioned designs produce a bass signal which is incredible for that size!

As you may have gathered (or hoped!) from this little lecture, this circuit has something very much to do with small speakers. It is designed to compensate in some degree for this lack in the last octaves. Turning up the bass control on the amp doesn't help, indeed it will generally make things worse by introducing too much lift too high in the spectrum. Most tone controls have a turnover at about 100-200 Hz, and will thus still have some appreciable effect at 500 Hz or more.

What is needed is a boost below about 70 Hz, but above 15 Hz or so (to avoid amplifying warp signals) and this is impossible to apply with conventional tone controls.

ETI TO THE RESCUE!

Having now told you what's wrong with your 'Mighty Mouth XXV Mini Super Monitors' we'd better explain how we can help put it right. Our Bass Enhancer is designed to insert a 'hump' at precisely the aforementioned frequency, into that part of the overall frequency response where the small speakers are rolling off.

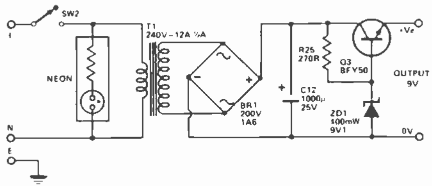
The circuit is of no use to you unless your speakers, and your amp, are capable of taking the extra punishment at these frequencies. Most hi-fi components are. Most of the hardboard boxes which are sold with music centres masquerading as loudspeakers are most definitely not. If in doubt, either check with your supplier, or give us a ring. (Not all the same day PLEASE, and not before 4 p.m.)

As a precaution against smoking ruins replacing your amplifier, we have included the ETI 'Overled' project to keep watch for clipping in the amplifier. With this unit in circuit, more power is drawn at the lowest frequencies, and amplifiers driven to distraction by these demands will exact revenge in horribly audible form.

How it works

IC1 and associated components form a buffer amplifier stage which isolates the lowpass filter R8, C3, R9, C4, R10, C5 from the source. C6 forms a single-pole roll-off filter to get rid of warp signals etc below the band with which we are concerned.

IC2 amplifies the low frequency signal fed to it from the filter, and so provides the 'enhancement' signal. This is mixed back with the amplified and buffered version of the input signal coming from IC3 in the mixer amplifier IC4. RV2 provides output level control, and SW1 allows the unit to be bypassed completely.



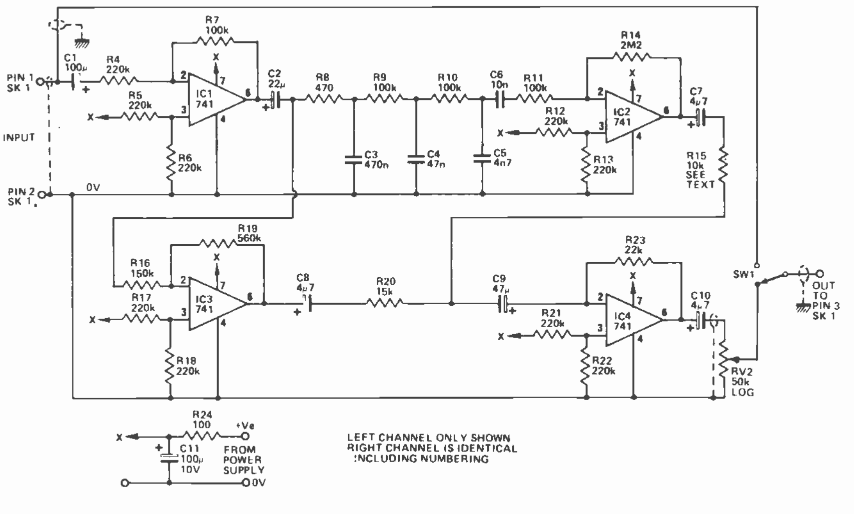


Fig. 1. Circuit diagram of the Bass Enhancer and power supply (left).

BASS ENHANCER

CONSTRUCTION

A single board layout has been chosen, to keep down the cost, and to simplify things as much as possible. The clipping indicator section is in fact the 'Overled' circuit previously published, so if you've already built this, you don't really need to build up this section of the unit. A mains supply was added simply because it is cheaper in the long run.

Standard - good quality - 741s are employed in the prototype, and very well they work too. However, there is a low noise 741, the 741N, which does have much less inherent noise and if you find the noise is too high for your liking, Doram Electronics can supply a pack of eight 741s for £10.20 all inc.

When building up the Over-Led, refer to the table given to set the values for your amp and speakers.

All that is entailed is to fit all the components to the board as shown in the overlay drawing, and wire up to the LEDs and controls.

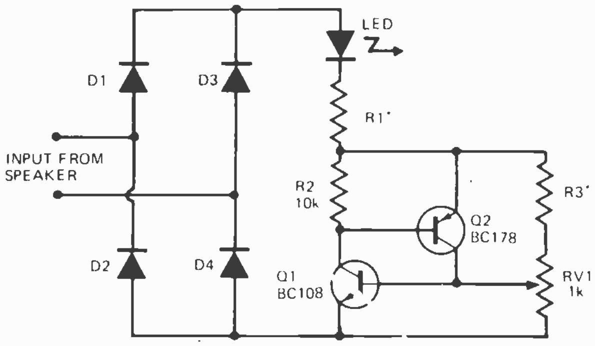
GET SET...

Setting up the clipping indicator is best done with the enhancer out of circuit. Advance the volume until the sound from the speakers becomes distorted - it doesn't matter whether it's the amp or the speakers cracking up, something is! - and then advance the pre-set until the LED just lights. This is the point of 'no-fidelity'!

The enhancer goes into the chain between pre- and main-amps, or into the tape monitor circuits, and can be switched out of circuit by SW1. Set the output levels so that there is no 'jump' in level when you switch it in from another source path - it's much kinder on both your ears and your hi-fi.

Varying the value of R15 varies the amount of enhancement produced by the circuit, so if you think we've over (or under) done it - let's see you do it better! Our value gave consistent results on quite a few different speakers, from Wharfedale to Celestion.

If the clipping indicators come on you're driving things too hard - turn *something* down! (If your neighbours bang on the walls floor or cieling - move house!)



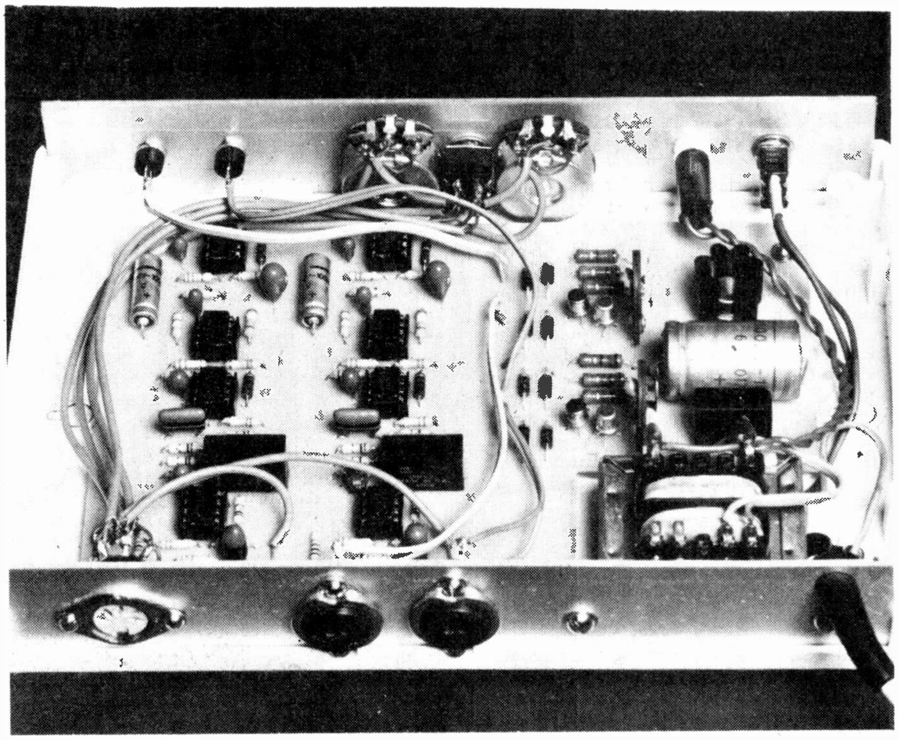
*SEE TABLE 1 FOR VALUES

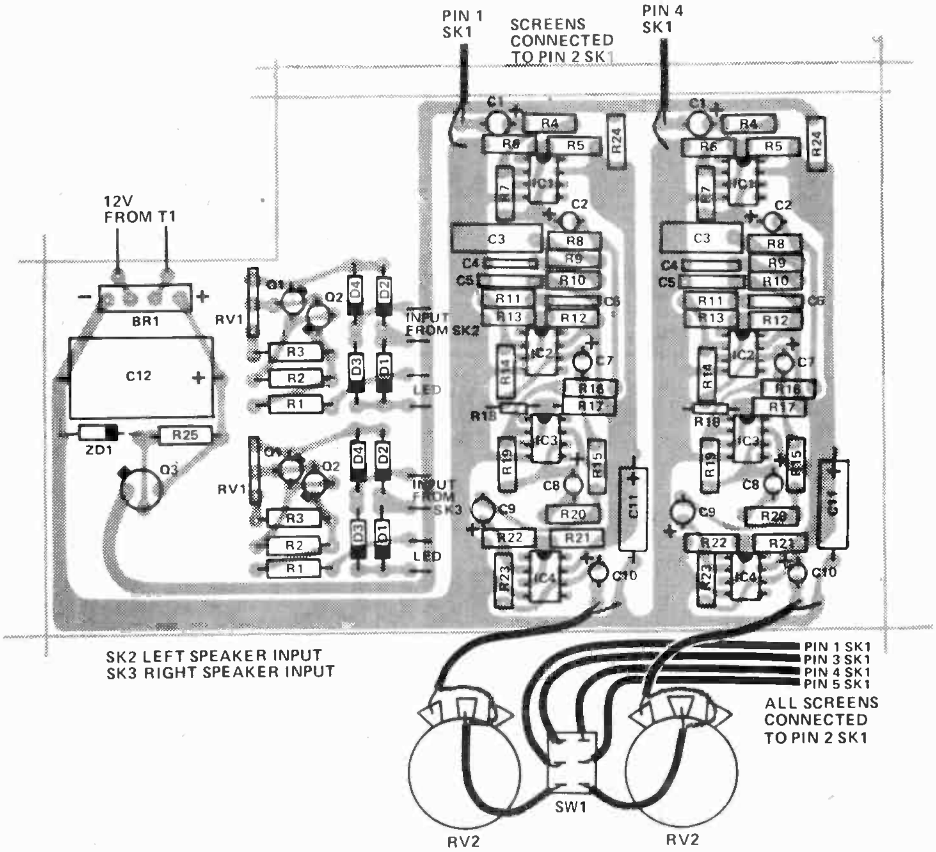
ONE CHANNEL ONLY SHOWN

Fig. 2. The circuit of the Overload Indicator. This is the 'Over-Led' project taken from ETI Top Projects No. 2. Further details can be found in Top Projects 1 and 2 reprints.

TABLE 1

RMS watts per channel	SPEAKER IMPEDANCE 4Ω R1	4Ω R3	8Ω R1	8Ω R3	16Ω R1	16Ω R3
5	68	5.6k	82	8.2k	120	12k
10	82	8.2k	120	10k	180	18k
15	100	10k	150	15k	220	22k
20	120	12k	180	18k	240	24k
25	150	15k	220	22k	270	27k
35	180	18k	240	24k	330	33k
50	220	22k	270	27k	390	39k
75	240	24k	330	33k	470	47k
100	270	27k	390	39k	560	56k



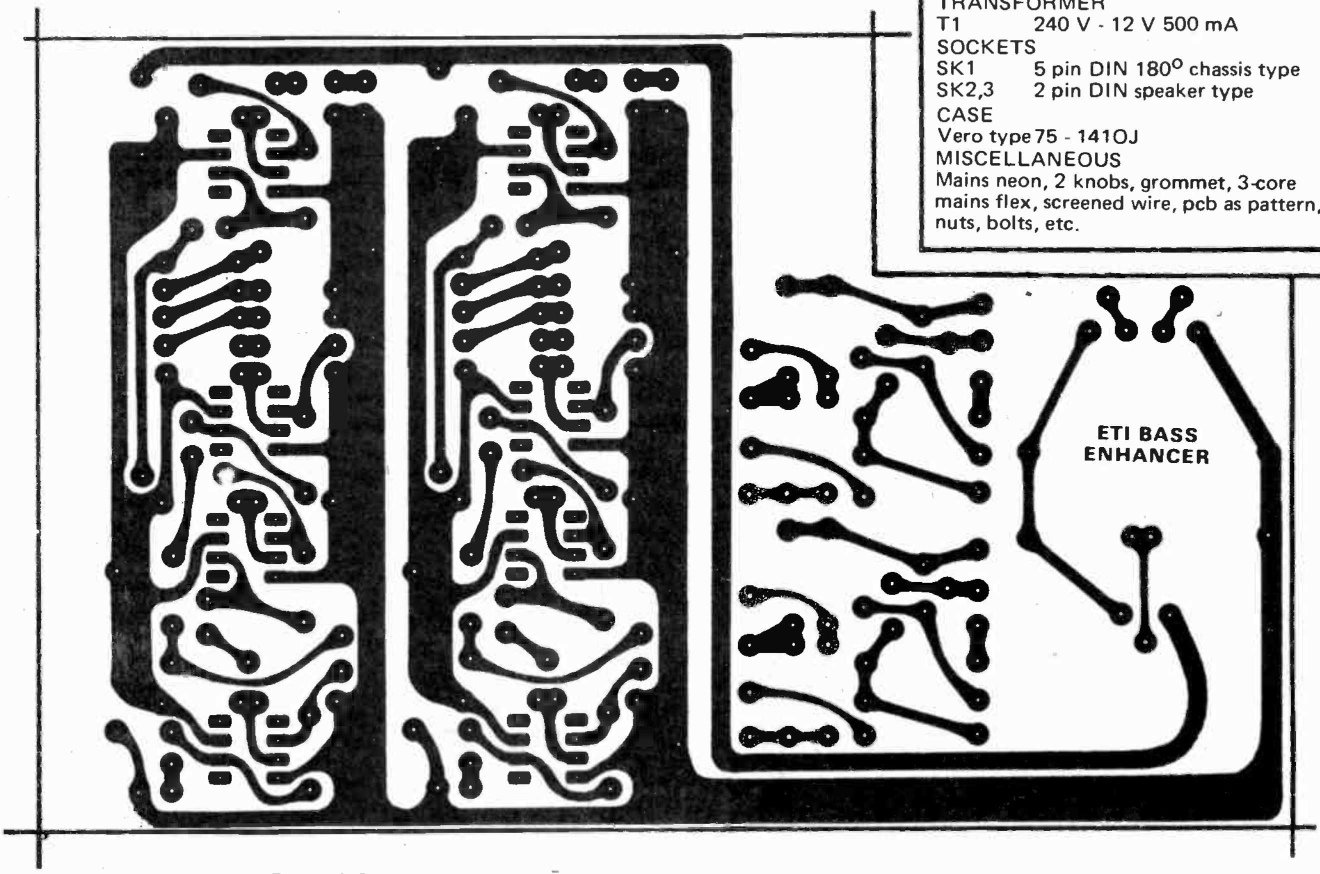


Overlay and Foil Pattern for the Enhancer. Note that a single board construction is used, so that whilst the overlay may look complex it is in fact only half as bad as that! (Two identical channels!)

Parts List

ONE SET REQUIRED PER CHANNEL

RESISTORS	
(All ¼ W except where stated)	
R1	as table 1
R2	10 k ½ W 5%
R3	as table 1
R4-6, 12, 13, 17, 18, 21, 22	220 k
R7, 9-11	100 k
R8	470 R
R14	2M2
R15	10 k (see text)
R16	150 k
R19	560 k
R20	15 k
R23	22 k
R24	100 R
R25	270 R ½ W 5% (only 1 req.)
CAPACITORS	
C1	100 u 16 V tantalum
C2	22 u 16 V tantalum
C3	470 n polyester
C4	47 n polyester
C5	4n7 polyester
C6	10 n polyester
C7,8,10	4u7 16 V tantalum
C9	47 u 16 V tantalum
C11	100 u 10 V
C12	1000 u 25 V (only 1 req.)
SEMICONDUCTORS	
Q1	BC108
Q2	BC178
Q3	BFY50 (only 1 req.)
D1-4	IN4001
ZD1	9 V 400 mW zener (only 1 req.)
BR1	200 V 1.6 A bridge rectifier (only one req.)
LED	.2" type red
IC1-4	741
POTENTIOMETERS	
RV1	1 k vertical preset
RV2	50 k log rotary
SWITCHES	
SW1	D.P.D.T. mini toggle
SW2	On-off toggle 240 V 1 A
TRANSFORMER	
T1	240 V - 12 V 500 mA
SOCKETS	
SK1	5 pin DIN 180° chassis type
SK2,3	2 pin DIN speaker type
CASE	
Vero type 75 - 1410J	
MISCELLANEOUS	
Mains neon, 2 knobs, grommet, 3-core mains flex, screened wire, pcb as pattern, nuts, bolts, etc.	



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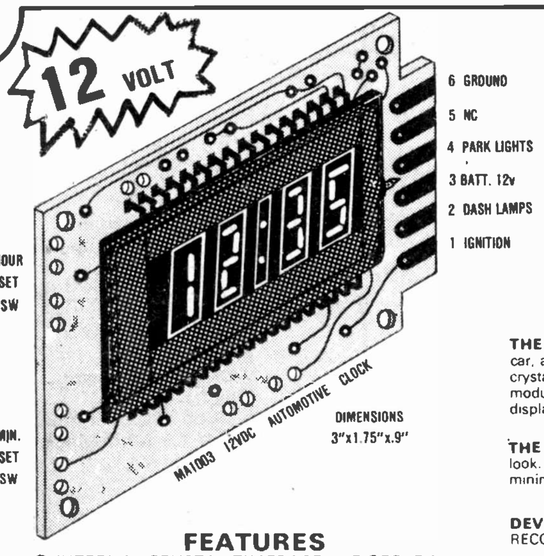

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SN7404	26p	14	SN7453	21p	12	SN7496	1 03	60	SN74LS04	27p.	21
SN7408	29p	16	SN7454	21p	12	SN74107	43p	25	SN74LS08	24p	19
SN7410	21p	12	SN7460	21p	12	SN74121	49p	27	SN74LS10	24p	21
SN7417	61p	32	SN7474	43p	25	SN74123	58p	35	SN74LS13	65p	50
SN7420	21p	12	SN7475	58p	30	SN74141	1.03	60	SN74LS32	25p	20
SN7440	21p	12	SN7481	1 10	80	SN74150	1 66	1.25	SN74LS42	1 01	91
SN7441AN	1 03	70	SN7486	41p	25	SN74154	1 88	1.50	SN74LS74	40p	30
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VALVE SOUND — WHAT IS IT?

Can Valve Sound be achieved from Solid State?

An investigation by Mark A Sawacki, M.Sc.

"Almost every musician has a favourite amplifier which may be so old it's held together with chewing gum and solder, but it produces exactly the sound he wants, so he has to carry it around with him, practically packed up in cotton wool to keep it from falling apart."
(Melody Maker, April 10 1976, Karl Dallas)

A reasonable man might be expected to ask the following: "If you want it to sound like valves, why not use Valves? and the two answers to this would be — reliability and weight — "When he plugged into a transistor amp, it didn't distort, it reproduced a more accurate sound, but he didn't like it, neither did the rest of the band . . ."
(International Musician and Recording World, July 1976, Ray Hammond)

IN ORDER TO UNDERSTAND the above quotes more fully an early history and problem presentation will clarify the situation. Recently there was a great hulabaloo about "valve sound" in the U.K. instrument market and way back in March/April 1976 Tony Reeves (Curved Air basist) told Melody Maker's Karl Dallas that — Dick Parmee, a Cambridge University graduate, currently with PA:CE as an Electronics Research Engineer, had analysed this dilemma and solved the problem of making a transistor amp sound like a valve amp.

Around the same time I visited another Cambridge factory — H.H. Electronics, where boss Mike Harrison showed me (with great pride) his new baby — V.S. Musician — a 100W RMS power combination amplifier, as well as his V.S. Musician Solo model, both *valve sound* constructions.

During that same year, the Japanese musical giant YAMAHA came onto the market with their G100 series of solid state amplifiers, claiming to capture the warmth of vacuum tubes without sacrificing the reliability, economy or portability of transistor amps.

This phenomenal "vacuum tube" market explosion has been in answer to a deep seated and widespread conviction amongst guitar sounds and certain other instruments, a valve amplifier will produce a far better *sound* than a transistor amplifier.

Filling a vacuum

Some elementary considerations should be taken into account before delving into this issue any further. Solid state with simulation of "vacuum tube sound" of the 60's is now a fact, although for people not *au courant* with the problem, it will appear as a regression, which is of course completely untrue. Since I intend to concentrate on the technical side of the "valve phenomena", I will leave all associated aspects, ie psycho-social, for others to deal with (only recently I heard it said that it was a mass hypnosis phenomena — upon which I prefer not to comment!)

In my analysis of the problem, I set up a small experiment. I tested eight internationally known instrument amplifiers, all from highly reputable manufacturers, and chosen as representative of both solid-state and valve technologies. The choice itself was made by a person who is not associated with the investigation, but who did have 15 years musical stage experience!

The first "valve" group:

1. Marshall MK2 — Master Model 100W Lead Amp (GB)
2. Fender 160 PS Vocal Amp (USA)
3. Fender Guitar/Bass 300 PS Amp (USA)
4. Roost Session Master SM 100R Combination Amp (GB)

and these are presented in Table 1 with a comparison of the T.H.D. (Total Harmonic Distortion) in % plotted against specific amplifier power output in W.RMS as shown in Fig. 1.

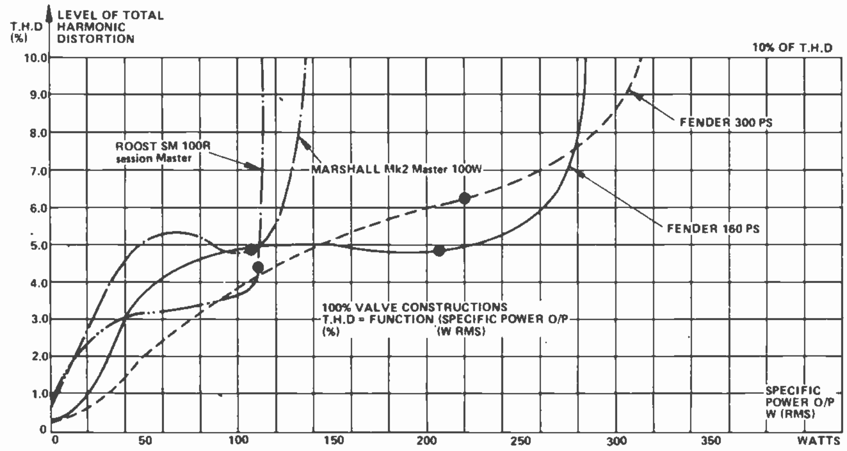

Figure 1.

● POWER AT ONSET OF CLIPPING
REF. STATED O/P IMPEDENCE
MEASURED WITH 1 kHz I/P SIGNAL

VALVE SOUND – WHAT IS IT?

TYPE	COUNTRY of origin	POWER OUTPUT in Watts R.M.S., ref. 1 kHz	TOTAL HARMONIC DISTORTION measured at specified power level	COMMENTS
MARSHALL Mk.2 Master Model 100 W Lead Amp.	G.B.	136.1 W R.M.S. at 10% THD into 8 R 107.2 W R.M.S. at clipping into 8 R	4.75% at 100 W 5.25% at 80 W 5.05% at 50 W 3.81% at 30 W 1.45% at 10 W 0.57% at 1 W Measured into 8 R dummy load ref 1 kHz	Classical European design. Only slight changes since introduction 10 years ago. Still very successful. 'Marshall sound' - predominance of 2nd. harmonic in overload.
FENDER 160 P.S. Vocal Amp.	U.S.A.	285.0 W R.M.S. at 10% THD into 2.6 R 206.0 W at clipping into 2.65 R	4.95% at 160 W 4.82% at 100 W 0.42% at 10 W 0.23% at 1 W Measured into 2.6 R dummy load ref 1 kHz	Very special piece of equipment - original design for musician P.A. system. Incl. built in graphic equaliser & four channel mixer.
ROOST Session Master Combination Amp.	G.B.	110.5 W R.M.S. at clipping into 8 R	3.80% at 110 W 3.85% at 80 W 3.22% at 10 W 1.85% at 10 W 0.55% at 5 W Measured into 8 R dummy load ref 1 kHz	Relatively 'new' when compared to other three. Very orthodox in design. Predominance of 2nd. harmonic in overload.
FENDER 300 P.S. Bass Amp.	U.S.A.	312.5 W at 10% THD into 8 R 220 W R.M.S. at clipping into 8 R	5.94% at 200 W 5.14% at 150 W 3.74% at 100 W 2.14% at 50 W 0.38% at 10 W 0.26% at 5 W Measured into 8 R dummy load ref 1 kHz	Popular on both sides of Atlantic. Very high power delivery, quite high THD levels, but still respectable for valve amps. Predominance of 2nd. harmonic in overload.

Table 1.

Omission

Someone is bound to ask at this point why I did not include makes such as VOX, Orange, Carlsboro, or Leslie, and the reason is that this selection was purely a matter of individual preference (as well as limited space!)

The second "solid-state" group consists of:–

1. H.H. V.S. Musician Reverb 100W Amplifier (GB)
2. Pearl Vorg 102 Guitar Combination Amp (Japan)
3. Dynacord Emminent 200 vocal Amp (West Germany)
4. "MM" Electronics — AP 360 Dual Power Slave (GB)

and the results of experiments on this group are presented in Table 2 and Fig. 2.

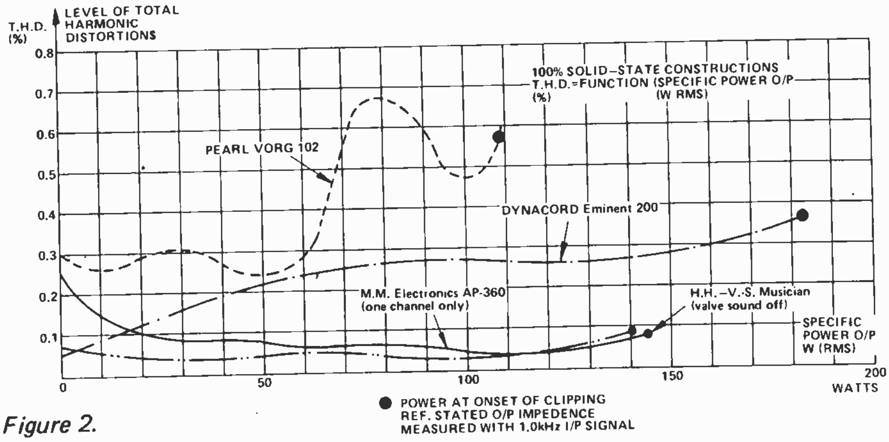

Figure 2.

TYPE	COUNTRY of origin	POWER OUTPUT in Watts R.M.S., ref. 1 kHz	TOTAL HARMONIC DISTORTION measured at specified power level	COMMENTS
H.H.V. S. Musician Reverb 100 W Amp.	G.B.	144.03 W R.M.S. at clipping into 4 Ohms	0.04% (20.5%) at 100 W 0.06% (13.9%) at 80 W 0.06% (13.8%) at 60 W 0.08% (14.5%) at 40 W 0.1% (13.2%) at 20 W 0.14% (9.8%) at 10 W 0.24% (3.2%) at 1 W Measured into 4 Ohms dummy load, ref 1 kHz	T.H.D. values in brackets correspond to 'valve sound' in 'ON' position. AS000 - 15/A - is the tone correction module. (Anatomical heart of 'valve sound').
PEARL VORG 102 Guitar Combination Amp.	JAPAN	108.16 W R.M.S. at clipping into 4 Ohms	0.47% at 100 W 0.67% at 80 W 0.28% at 60 W 0.27% at 40 W 0.28% at 20 W 0.26% at 10 W 0.30% at 1 W Measured into 4 Dhm dummy load ref 1 kHz	Quite a high level of THD as far as solid-state technology is concerned. Recently extremely popular due to proven reliability and good sound produced.
DYNACORD Eminent 200 System Amp.	WEST GERMANY	162.5 W R.M.S. at clipping into 2 Ohms	0.27% at 140 W 0.27% at 100 W 0.085% at 10 W 0.05% at 1 W Measured into 2 Ohms dummy load ref 1 kHz	Very popular on continent because of good quality sound & reasonable price. Built-in EQ-graphic, reverb, as well as 6 channel mixing system and 100 W R.M.S. approx. monitoring amp.
'MM' Electronics AP - 360 Dual Power Slave Amp.	G.B.	140.28 W R.M.S. at clipping into 8 Ohms	0.080% at 140 W 0.04% at 100 W 0.04% at 70 W 0.035% at 40 W 0.04% at 20 W 0.075% at 5 W Measured into 8 Ohms dummy load ref 1 kHz	Very low level of THD by any standard. AP-36 is a Dual Power Slave Amp. of very universal character. Input sensitivity approx. 0.5 V R.M.S. Both channels driven simultaneously produce quite a high power level suitable for P.A. systems, stereo systems, discos, etc, etc.

Table 2.

Drawing in the threads

From Fig. 1 and 2 it is possible to draw the following conclusions; the transistor amp output is relatively distortion free and a typical THD figure across the whole power range would be about 0.15%. The figure of 0.05% is also realistic, even just prior to clipping.

Similar figures were also confirmed sometime ago by D. T. N. Williamson in a series of articles proposing standards of THD for audio amplifiers at full rated power output and they have been generally accepted as the target figures for high quality audio.

We found the average level of THD for our four valve amplifiers was somewhere in the region between 4.5% and 6.5% (for power levels measured at onset of clipping). When the power output was slightly increased, then the THD shot up rapidly reaching 10% with no problem!

This fairly high THD level however, is nothing new as far as valve technology is concerned, and even well-known European standards and specifications often rate power output at 10% THD for valve amps. To conclude then, the most important difference noticed in the performance between valve and transistor amps was the overload distortion characteristics of the output stages. Comparing the value (0.04 — 0.4% THD for solid state systems to 2.0 — 10% in valve constructions), it is quite easy to see the differences and consequently understand the changes in the specific character of both types of sound. All these THD tests were carried out with a single 1KHz sine input which is acceptable as a very useful standard. A practical set-up arrangement for this test is shown in Fig. 3.

Further into tubes

Before discussing the problem any further, a little mathematics will help in clarifying it. In order to examine the construction of sound (even single frequencies), it is necessary to use analysis of the tonal spectrum characteristics. The oldest historical model known was developed by a German physicist and physiologist, Herman Helmholtz in 1863, at present the most popular method used is the "Fourrier Array".

According to Fourrier's hypothesis, every periodical wave can be divided into a family of sinusiodal harmonic components (Fourrier

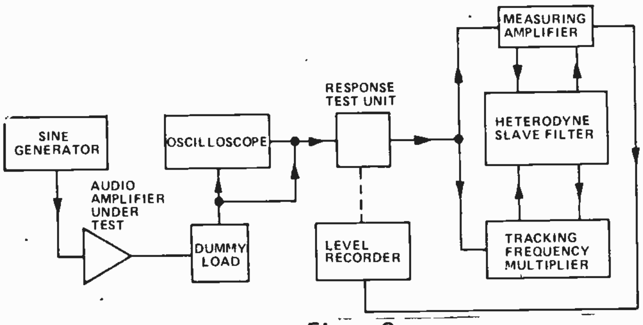

Figure 3.

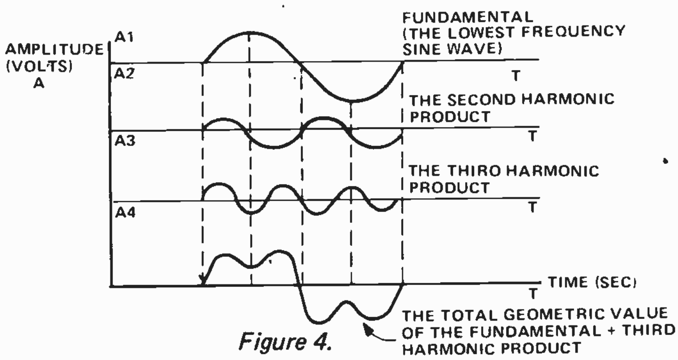

Figure 4.

components) where the lowest Fourrier component is equal to the fundamental frequency and the others are: 2f, 3f, 4f, and so on.

A 1Khz frequency sinusiodal signal will produce the subsignals, 2Khz, 3Khz, 4Khz etc. The THD waveform of an amplifier's output is quite a complicated construction, and its final shape depends not only on the operating frequency but also on its amplitude and phasing. See. Fig. 4.

The above analysis is quite complicated and requires a lot of calculation to obtain the results of the number of harmonic amplitudes. In the simplest one dimensional case there may be expressed as:

$f(x) = \frac{1}{2} A_0 + \Sigma A_h \cos 2\pi (h\,x/a) + B_h \sin 2\pi (h\,x/a) \ldots$

where h=0, 1 . . . . .

where f(x) is known as the repetition interval (o, a) and it is required to determine the values of Fourrier components Ah and Bh. Naturally, we also have from the orthogonality of the sine as well as the cosine, the functions:

$Ah = 2/9 \int_0^a f(x).\cos 2\pi (h\,x/a)\, dx$

where: h = 0, 1 . . . . . .

and respectively

$Bh = 2/9 \int_0^a f(x).\sin 2\pi (h\,x/a)\, dx$

where: h = 1, 2 . . . . . .

To solve this problem computing numerical methods were developed and for more technical areas, the most common method is — Heterodyne/Resonance Analysers and Spectroscope filters.

In the circumstances it seemed worth while to obtain more detailed information, with special emphasis on the systems analysis. This is available by measuring the amplitude of each of the harmonic separately. For this experiment a band stop filter rejects the fundamental for measurements of THD, but the band pass filter can measure distortion components individually. The next two tests carried out on valve as well as solid state construction show the harmonic spectrograms in Fig. 5.

The amps tested had a similar power output of approximately 100W. RMS and again the difference is easy to see.

Valve:—

Apart from the fundamental frequency the dominant line is at 2f, with 'train' of amplitudes at 3f, 5f, 7f where 4f, 6f and 8f attain quite a low level.

The relatively distortion free solid-state amps have harmonics which are much lower but still with a 3f predominance. 4f, 6f, and 8f are difficult to measure because of very small magnitudes and their influence in our analysis can be easily ignored.

We can now say that valve amps have a tendency to clip on the *second* harmonic which gives that characteristic 'punch', whilst a transistor amp tends to clip on the third harmonic, which *may* create a quite unpleasant sound. Of course 'unpleasant' or 'pleasant' is really a question of personal taste.

Solutions

Bearing in mind the practical non-linear amplifier (and any real amp is non-linear to some degree) only a very small portion of the Input/output characteristic (LAPLACE transform) may be considered substantially linear. The curvature of the Input/output characteristic (nonlinearities) generally give rise to distortion known as "non-linear" distortion, which consists of the previously presented harmonic distortion tests, in addition to the intermodulation group, where the intermodulation groups consists of:

Difference frequency Intermodulation and Transient Intermodulation

Even a brief look at other methods of testing shows the effects of nonlinear distortion in both types of amplifiers, but the

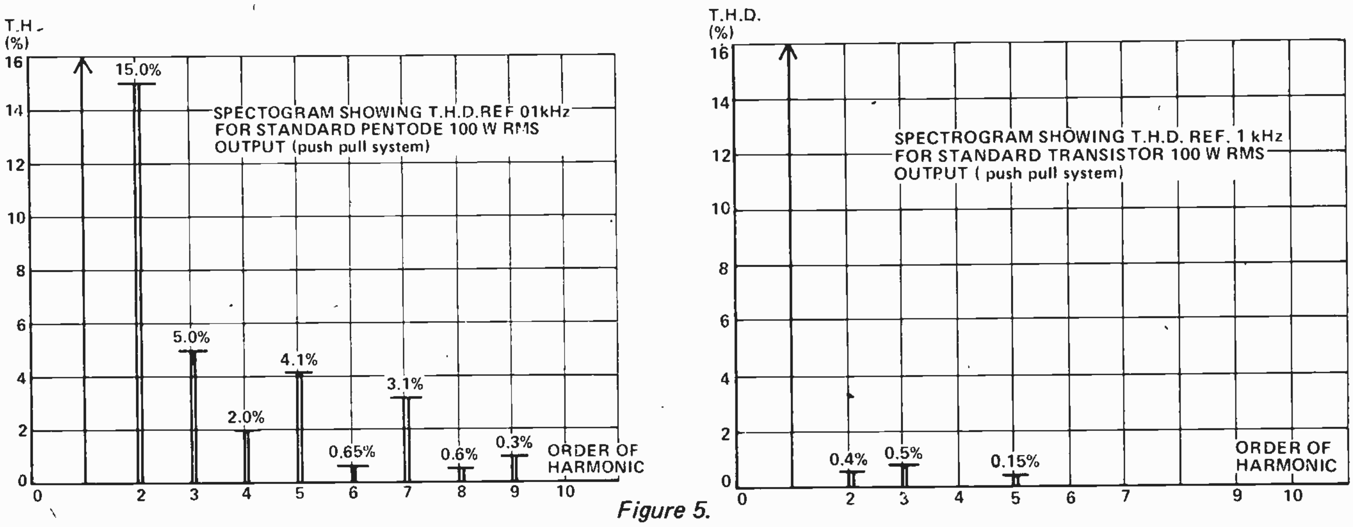

Figure 5.

VALVE SOUND – WHAT IS IT?

The Yamaha G-100-B-212:

The H.H. V.-S. Musician.

complexity of the work should I imagine be undertaken by scientists as part of a (really fascinating) research program.

Buttons for tubes

Let's look at what the Japanese YAMAHA engineers call the 'vacuum tube' sound, and what Cambridge H.H. Electronics claim as the 'valve sound' — As can be expected both are 'combotype' designs in principle but designed as a real effort to simulate the valve 'character'. The Yamaha G 100B 212 amplifier 's THD figures plotted against specific power output, ref. 1Kz is shown in fig. 6.

And now the H.H. V.S. Musician Reverb Model 100W — Fig. 7.

Both the Yamaha G100B 212 and the H.H. V.S. Musician were tested in conjunction with a good quality electric guitar and the test was carried out purely from the subjective sound quality point of view.

Subjected subjectively

Both amps performed satisfactorily, however, the sound which was obtained was entirely different in both cases. H.H.'s amp and gave a more dynamic sound, very harsh but with good sustain when the 'valve sound' footswitch was on. At the same time, the sound produced was very similar to an overworked valve amp, but the overall volume was controlled by the 'Master Volume Control'. This was found to be a useful feature when very loud volume is a problem, but when the wound-up 'valve amp' sound is still necessary. This particular feature has a wide range of applications as far as studio recording work is concerned.

After testing the Yamaha G 100B 212 amplifier, one important difference emerged, namely the total absence of an ON/OFF pedal footswitch. However, the manufacturer provided a special rotary 'Distortion Control' specially for this function. By experimenting with the different distortions and volume settings, an unusually wide variety of effects was obtained, but to get really clean chord playing, rhythm guitar work or certain keyboard instruments, this control was set on the 'minimum' of its rotation.

The Yamaha G100B 212 compares with the H.H. V.S. Musician producing a much more mellow tonal character, whether it was played softly or at a crashing volume, but on the other hand the H.H. amp would be much more effective in pure rock practice or whenever a lot of high frequency was desired.

To summarise, one can say that as long as the manufacturers analyse those designs on the market with the best valve performance, and then try to obtain this by duplicating it will be possible for him to construct a solid state amp with realistic valve sound. But, of course, whether musicians will go for one or the other, remains a question of personal preference. ●

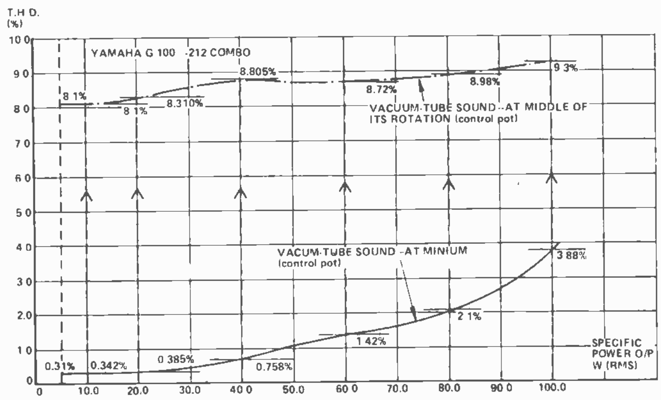

Figure 6.

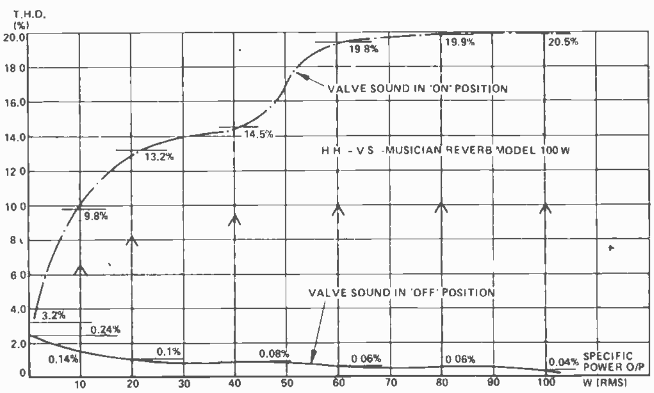

Figure 7.

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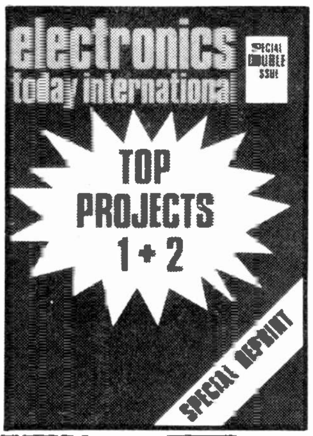

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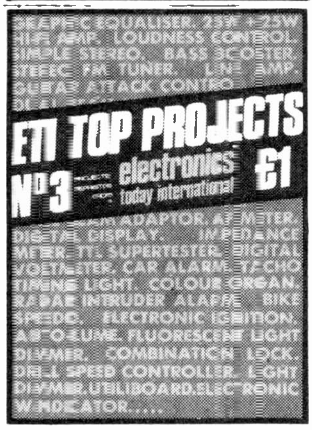

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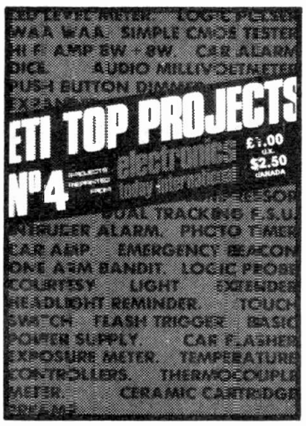

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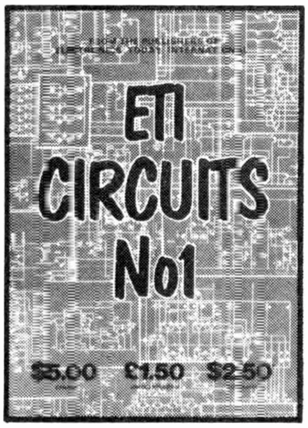

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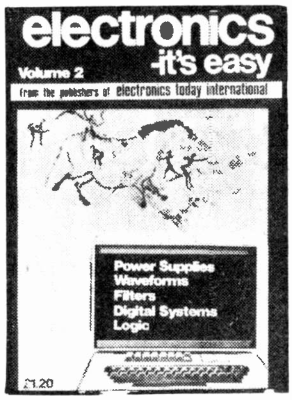

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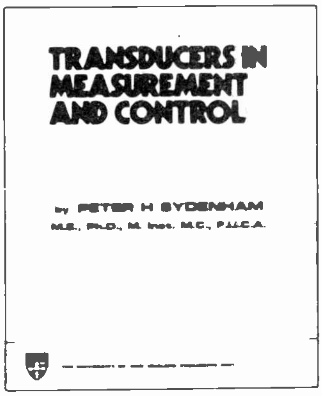

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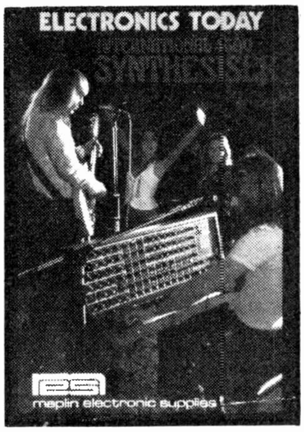

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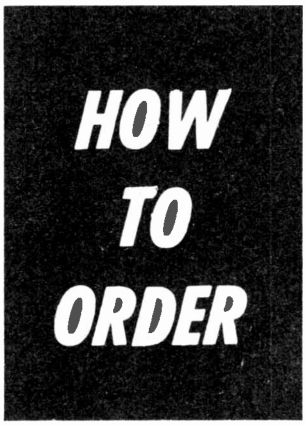

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Oscilloscopes PART 40

OF THE MANY INSTRUMENTS required to service, test and maintain electronic systems, the cathode-ray oscilloscope must be the most versatile and useful. Other names are derivatives from the full name – the C.R.O., CRO (pronounced crow), oscilloscope and scope. Early works also refer to it as an oscillograph.

THE CATHODE RAY TUBE

The first cathode-ray tubes were experimental, designed to investigate the nature of beams of particles produced in thermionic-diode arrangements operating at extremely-high voltages.

Figure 1 shows the three stages in developing the basic cathode ray tube. Fig. 1(a) is a thermionic diode – a valve diode. The cathode, heated by the current passing through it, emits electrons into the space around it. These, being negatively charged, are attracted to the positive anode.

The greater the voltage between the cathode and anode the greater the velocity of the electrons. If a hole is made in the anode, as in Fig. 1b, many of the electrons will pass through, forming a diverging beam on the other side of the hole. When a phosphor powder is placed on the inside of the tube the electrons reaching it cause it to glow as they give up their kinetic energy. The powder re-emits this energy as photons of visible light. Early researchers' tubes did little more than this. The nature of cathode rays was studied in the early 1900s by such famous names as Goldstein, Braun, Crookes, J. J. Thompson, Rontgen, Coolidge and Dumont. Experiments showed that the beam could be deflected by a permanent magnet and by electro-magnetic and electrostatic fields. Prior to 1897 interest had been in physical-science investigation – not in the measurement of electronic signals. Then in 1897 K.F. Braun produced the first basic measuring device from the CR tube.

FURTHER DEVELOPMENTS

However the CRO to become a useful, practical instrument more development was needed. From Fig. 1b it can be seen that the beam of an elementary device is badly defined and floods over the entire area of the phosphor. A tube or grid arrangement placed between the cathode and anode causes the beam to pass through the anode more cleanly, because of the negative repulsive effect of this tube assembly. The whole assembly – cathode, anode, grids and tube – is called the electron gun. Its full design is quite complex: Other elements are used to make electron-lenses (akin to optical lenses and light) to focus control and an intensity control, the former adjusts the spot shape and size on the screen, the latter the current flowing in the electron beam.

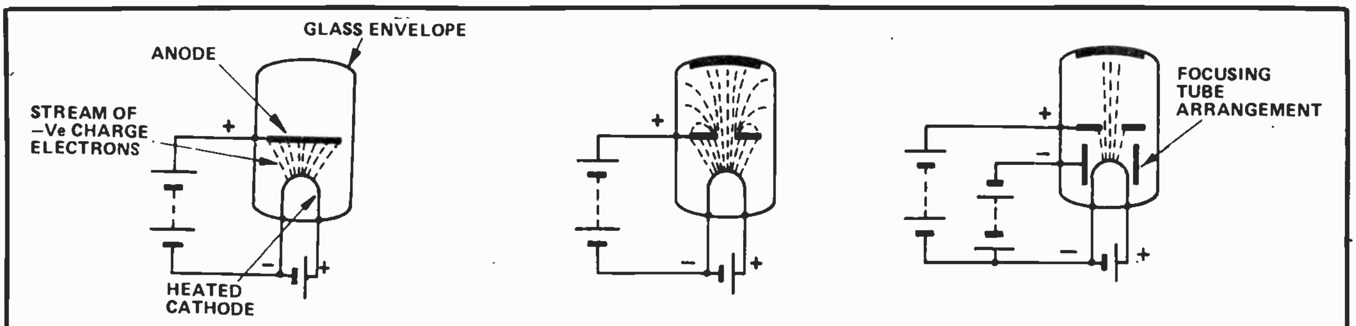

Fig. 1. The basic cathode ray tube developed through stages to provide a gun aimed at a screen.
(a) Thermionic diode in which the cathode is self-heated to cause liberation of electrons which move to the positive anode.

(b) A hole in the anode allows some electrons to pass through to the phosphorescent screen.

(c) A tube arrangement or grid is added to form a more concentrated and smaller size beam.

Phosphor European/ U.S. code	Fluorescence	Phosphorescence	Persistence	Burn resistance	Relative luminance	Comments
GP/P2	Bluish-green	Green	10 µs–1 ms	Medium high	55%	Medium speed oscillography
GM/P7	Purplish-blue	Yellowish-green	100 ms–1 s	Medium	35%	Low speed oscillography.
BE/P11	Blue	Blue	10 µs–1 ms	Medium	15%	Best photographic writing speed.
GH/P31	Green	Green	10 µs–1 ms	High	100%	General purpose oscillography. Brightest available phosphor.
GR/P39	Green	Green	5–100 ms	High	50%	Sampling oscillography.

Fig. 2. Chart showing characteristics of oscilloscope screen phosphors.

The choice of phosphor on the screen determines the persistence (the length of time the spot glows after removal of the beam) of the display. The storage effect of various phosphors enables CROs to be made so that beam energy can be dispersed as light over time durations varying from microseconds to milliseconds. Fig. 2 is a guide to the selection of a phosphor. Manufacturers often offer a choice of screen persistence values to suit various applications. Fast moving spots, where the spot is likely to reappear on the same point in a short time, require short persistence. Long-persistence screens are suitable for slowly changing signals. (See the discussion of storage methods in the next part.)

ELECTROSTATIC DEFLECTION

The next refinement provides a method by which the beam can be made to deflect under the control of electrical signals. Fig. 3 shows how this is done for one axis, using the electrostatic method. A voltage difference of zero between the deflection plates allows the beam to pass along the tube axis undeflected. Any voltage differential will cause the beam to be deflected towards the more positive plate. Thus we have a way to cause the beam to move in the vertical direction (called Y-axis or Y plates). A further two plates set ar right angles to these (the X plates) will cause the beam to deflect in the horizontal plane when a voltage is similarly applied to them. Beam-intensity control by electrical means is defined as the Z control.

Electrostatic deflection is the easiest to deploy for voltage measurements because deflection is proportional to applied voltage. Small cathode ray tubes usually use electrostatic deflection. Large tubes, such as those used in television systems or large-screen teaching oscilloscopes, usually use magnetic deflection because electrostatic deflection would require very high deflection voltages. These do not have deflection plates set inside the tube, but make use of magnetic fields created by electromagnet coils placed around the neck of the tube. The deflection in this case is approximately proportional to the current in the coils.

Cathode ray tube design (for CROs and TV) has remained reasonably static since the late 1930s, the only obvious differences being in the linearity of beam sweeps and the shortness of tubes for a given screen size in television applications. Figure 4 is a modern oscilloscope with the cover removed to show the tube. From the instrument viewpoint the differences have been improvements in frequency response, spot control, linearity of sweep and a wider choice of phosphors. In addition the development of tubes with more than one gun and deflection system (some dual-beam oscilloscopes, but not all, use separate beams for each channel) and storage tubes which enable the effective persistence to be varied at will have greatly improved the versatility of today's instruments.

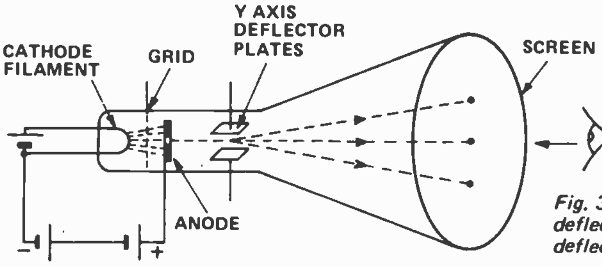

Fig. 3. The electron beam can be deflected by voltages applied to deflection plates.

TURNING THE TUBE INTO A MEASURING INSTRUMENT

In the majority of cases the CR tube is used to produce a graphical display with the amplitude of a signal being expressed in the vertical (Y) direction and its variation with time being along the horizontal (X) direction.

Time-base: If the X plates are driven by a signal voltage that increases proportionally with time the electron beam will be deflected across the tube at a steady speed. When the signal returns to its original value the spot returns to begin the next sweep. The waveform required to produce such linear deflections is a sawtooth. (During return the beam is normally blanked out.) This provides a sweep function. The period of the sawtooth determines the time taken to cross the screen; this is expressed in the units of time per division (screens are divided into a grid of centimetre squares by means of plastic graticule or by engraving the inner face of the tube). A selector switch in the time-base section of the panel enables the sweep rate to be chosen to suit the period of the signal being examined. Basic units will have time bases which range from 0.5 μs to 0.1 seconds per centimetre; sophisticated units can go as slow as

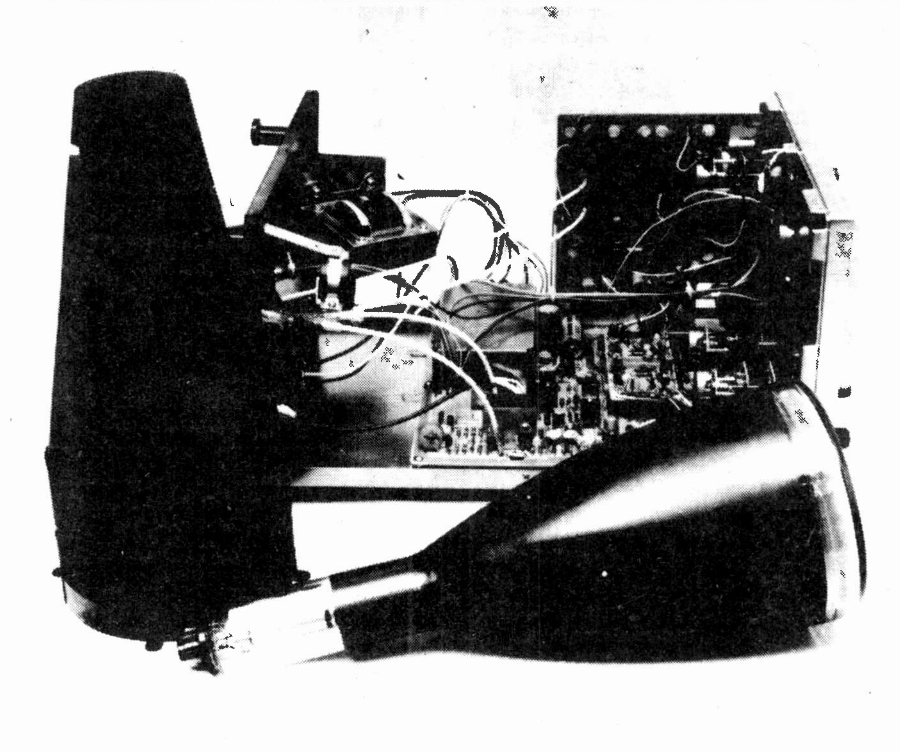

Figure 4. The insides of a modern oscilloscope – the Trio CS-1562. The cathode ray tube and its cover have been removed. Note the tube is much longer than the tubes used in TV sets (when you consider the small screen area). The cover screens the electron beam from the influences of stray magnetic and electric fields.

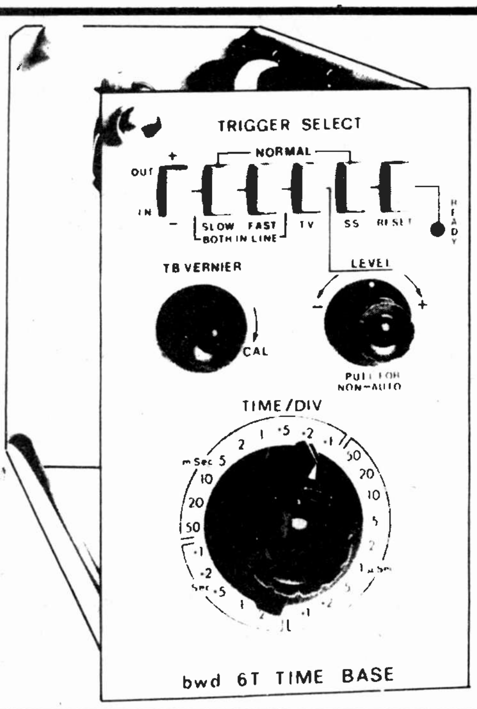

Fig.5. Controls of a basic time-base unit include those shown on this plug-in. Terminology is generally the same for all makers but layout and controls will vary.

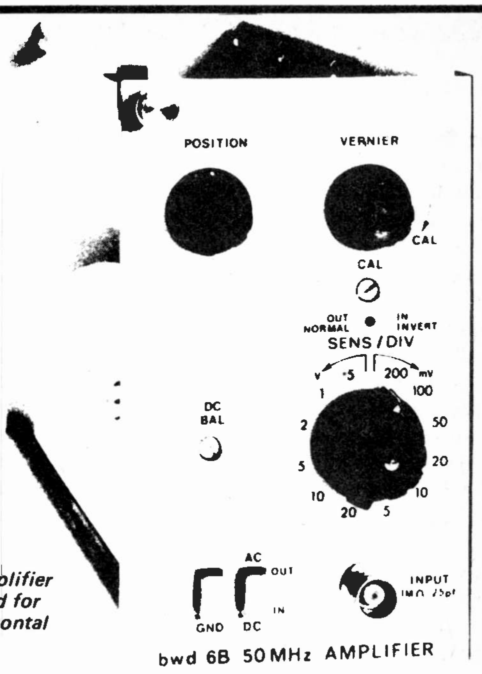

Fig.6. Single-trace amplifier unit. These can be used for both vertical and horizontal amplification.

10 seconds per division to as fast as 1ns per division. (Special "sampling" plug-ins can provide 10 ps/division.)

The time-base sawtooth generator is an integral part of all CRO measuring instruments. The accuracy of the rates are determined by circuit components — more expensive units can provide more-accurate information. A further control in the time-base section (See Fig.5) allows the switch-selected sweep rate to be varied continuously. This is usually referred to as a vernier control. When making time measurements, such as waveform period, it is important to set the vernier control to the calibrated position.

To obtain a static display (where each cycle of a periodic signal overlays the previous one) the time-base must be synchronized with some point of the input signal. That is, the time-base is caused to begin its sweep across at the same point on the waveform being viewed. The circuit which does this is called the triggering circuit. Triggering can be taken from either an internal or an external source. When switched to 'internal' it is possible to vary the voltage level of the signal operating the trigger. Thus the sweep may be adjusted to commence at a chosen point on the waveshape. An 'auto' control position provides automatic selection of the voltage level for most reliable triggering.

Time Base Amplifier: The voltage required to deflect the beam over the full X (or Y) traverse is of the order of hundreds of volts. The time-base generator therefore requires an 'X' voltage amplifier between it and the plates.

In certain applications the X plates are used with signals in the same way as Y plates — that is without a time-base signal. In such cases considerable amplification may be needed. More versatile CROs offer plug-in facilities for the X input to give the user a wide choice of functions from the one unit. Simple units however, have the 'X' amplifier wired in permanently.

Vertical Inputs: At the same time as the time-base circuits sweep the line across the screen the 'Y'-plates are driven with a voltage proportional to the amplitude of the signal of interest. This causes the beam to be deflected in the vertical direction whilst it is swept across the screen. The result is the graphical display of signal amplitude versus time.

Again an amplifier is needed to increase the signal level so that a useful vertical deflection results. Such an amplifier must be able to amplify the incoming signal without distortion to provide vertical sensitivities up to 10 mV/centimetre (typically the most sensitive range of educational units), or maybe as high as 10 μV per division (in sensitive oscilloscopes). The insensitive end of the range will usually be around 50 V/cm but special units (for electrical supply authority use) provide for much higher levels. (Attenuator probes also enable high voltage signals to be investigated.)

The application needed from Y-amplifiers can, therefore, rise to 100 000 on the most sensitive range. In addition it is important that the gain be constant over the bandwidth of the signals being monitored.

Basic units provide amplifier response flat from dc to a megahertz or more. (Bandwidths are defined between points 3 dB down from maximum.) Magnetic-deflection display monitors will only reach 20 kHz whereas sophisticated high-quality instruments have bandwidths rising to 350 MHz. Sampling plug-ins provide bandwidths equivalent to dc to 1 GHz.

Vertical amplifier controls are usually grouped together on the front panel, as are time-base controls. Figure 6 shows the panel layout of a 50 MHz bandwidth amplifier. From this it may be seen that the vertical sensitivity is selected by a switch and that the y amplifier has a 'vernier' sensitivity control which must be at the 'calibrate' position when measurements of signal amplitude are being made.

The position of the trace on the screen depends upon the standing voltage applied to the plates. On both Y and X axes extra controls enable vertical and horizontal shift of the trace position by adjustment of the bias applied. When using the CRO to probe circuits involving ac signals combined with standing dc levels — as is the case in ac amplifiers for example — the dc level on the Y signal causes the trace of the ac signal to be displaced vertically and, perhaps, to go right off the viewing area. This difficulty is overcome if you couple the circuit signal to the Y-amplifier via a capacitor. The ac signal then centres itself on the screen at the position chosen by setting the vertical shift control. This method is acceptable provided frequencies below

ELECTRONICS–it's easy!

the cut-off of the RC filter produced are not wanted. Measurement of very-low frequency to dc signals must be dc coupled on the ac/dc selector switch provided. A further switch position enables the input to the plates to be brought to its dc zero position. This helps the operator to establish where this level is on the screen

Signal Input Connections: Oscilloscopes for use with frequencies below about 1 MHz can make use of separate plug-in/screw-down banana-plug terminals. More usually, however, the input to the Y amplifier, and perhaps to the external trigger, will use standard BNC connections. These are designed for use with coaxial cable and coax should be used for all except the shortest end connections to the circuit. The input impedance characteristics are usually quoted – 1 megohm with 20-100 pF shunting capacitance being typical values. In some applications the CRO must be matched to reduce reflections – in such cases the input might be 50 Ω or 600 Ω. For fast rise-time studies it is necessary to ensure that the capacitive value presented does not reduce the overall bandwidth by shunting the device to which the CRO is connected. In exacting cases, needing high input impedance and small capacitance, special probes are used. These are described later.

Calibration of the Time Base and Y-Amplifier: The value of electronic components may drift with time, altering the sweep rate and vertical amplifier values from those indicated by the selector switch. To enable the operator to check these, more advanced oscilloscopes incorporate a special circuit that provides a fixed-frequency, fixed-amplitude square wave signal for calibration purposes. A typical signal would be 1 volt peak-to-peak. As it is derived from the mains frequency (50 Hz or 20 ms period) its time duration is also quite accurate.

MULTIPLE TRACE OSCILLOSCOPES

Measurement situations involving oscilloscopes more often than not require display of comparative information between two points in a system – the relative input and output signals in an amplifier response test, or the phase shift between two signals across a filter stage. Single-beam oscilloscopes are very limited because they cannot provide as much information to the user as a unit that can compare the waveforms at two points simultaneously. Three distinct alternatives are available to provide dual beam operation:

Separate gun: These use two, physically-separate, electron beams and deflection systems that are mounted inside the tube envelope. The beams may be generated by splitting the beam from a single gun. These are generally referred to as dual-beam units (dual-trace is a term reserved for the next method described).

Each beam has its own Y-input panel with a complete set of controls as described earlier. Dual-beam units drive both X-scans with a common set set of deflection plates (as in Fig.7) but some (rather rare) oscilloscopes enable each time-base to scan at a different rate.

In general, dual-beam units are less common because of the higher expense compared with the next method.

Electronic switching – chopped mode: The deflection response of an electron beam is rapid enough to allow it to be directed from one position to another at a speed exceeding the scan rates used with the signal being viewed. Fast electronic switches are used to switch the common single beam between two (or three or four) Y-inputs. Figure 8 illustrates this. Appropriate blanking (that is reduced Z intensity) is applied when needed, when the beam is chopping from one trace to the other. If the chopping rate is chosen to be at least 100 times faster than the highest frequency to be viewed the two traces appear as separate traces. Hence the name "dual-trace" for this method. In reality the traces are not continuous but are made up of dash-spaces. A hundred dashes across a screen produces a virtually continuous trace to the eye. The limit of usefulness is reached when the inbuilt chopping rate comes close to the upper frequency being viewed thus producing a dashed-line trace in which the dashes are of length equal to wanted signal features. At this point information is lost.

As far as the user is concerned there are still two groups of Y controls – just the same as for a dual-beam arrangement. The difference arises as the position chosen on the selector switch where a 'chop' mode must be selected.

Chopped operation ensures that the time relationship between the two signals is faithfully presented: phase measurements are also accurate (that is, providing the input amplifiers to each are identical).

Chopped operation will also display two simultaneous, non-recurrent signals, such as transients induced at various points when a complex resonant system is excited by an impulse. It is quite suitable for low-frequency signals but less convenient as the frequency rises.

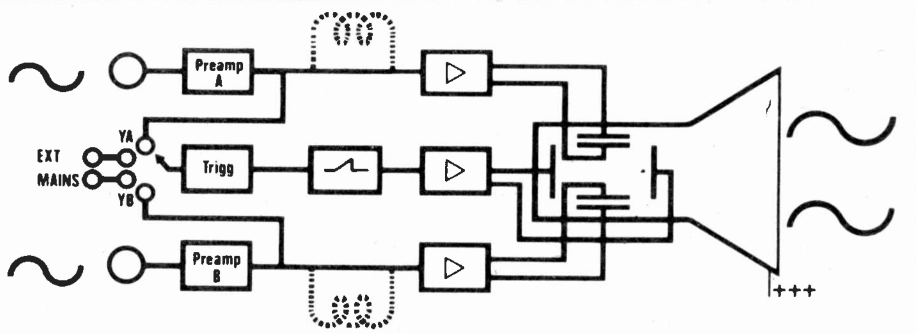

Fig.7. Schematic of Philips 3232 dual beam oscilloscope. Common x plates provide scan for both beams, separate y plates deflect the two distinctly separate electron beams that are derived from a common gun.

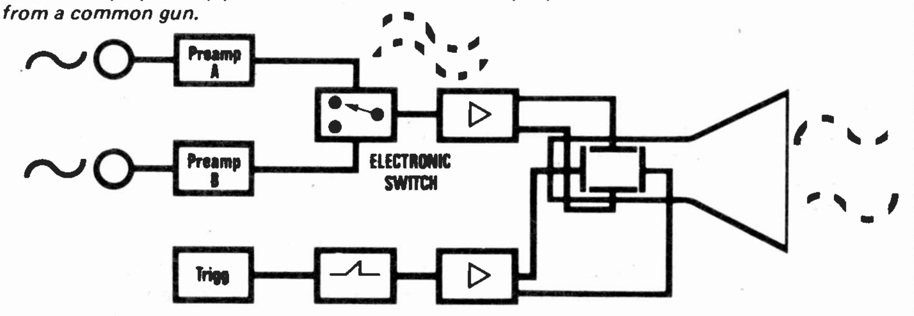

Fig.8. Electronic-switching enables a single-beam and deflection system to provide dual-trace operation.

ELECTRONIC SWITCHING-ALTERNATE MODE

Switching can also be employed on a full alternate trace-by-trace basis. The first trace is a scan of channel 1, the next of channel 2 and so on. This does not suffer from the dotted defect with high-frequency viewing but it suffers from another deficiency in that the phase relationship between the two signals may not necessarily be as indicated on the screen.

The method is unusable for observation of "once-only" dual events because the second transient signal may have gone to zero by the end of the trace of the first simultaneous transient signal. The panel shown in Fig. 11 is typical of dual trace units. The selector switch enables choice of alternate, chop, channel 1, channel 2, and channel 1 plus channel 2 modes.

With two channel operation it is necessary to decide which input will synchronize the time-base scan. A switch provides the choice of appropriate internal triggering. Although only channel 2, for example, may be being viewed there are circumstances where it is desirable to trigger from the channel 1 signal.

The electronic-switching method enables more than two traces to be displayed– three and four-trace units are available.

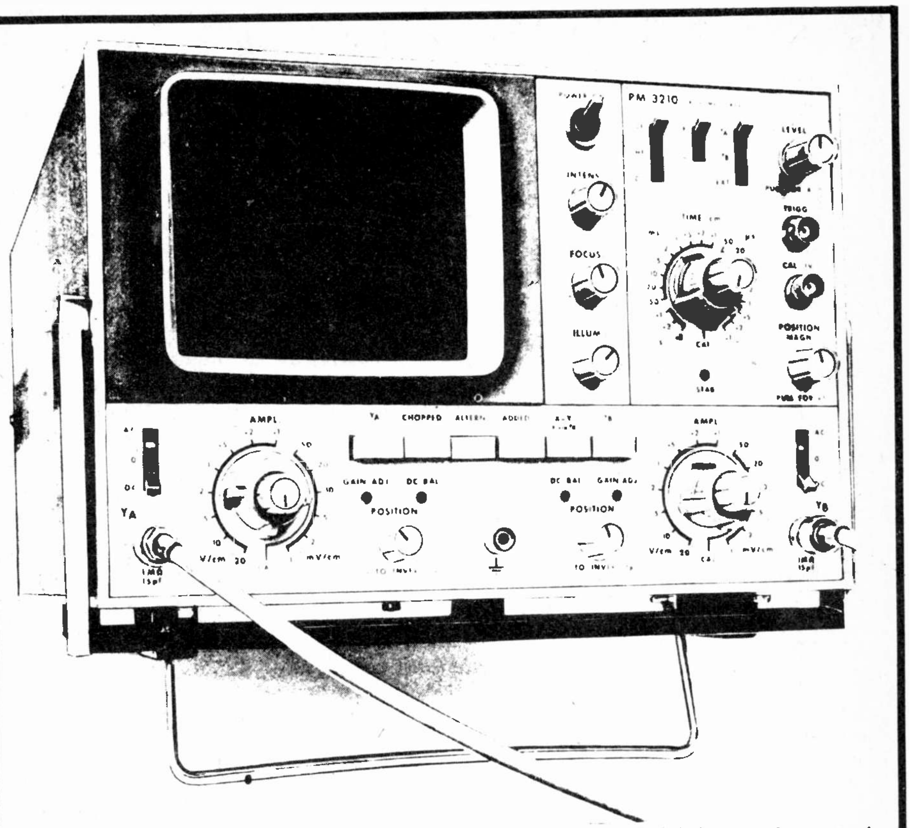

Fig.9 is the front view of a modern unit. It is given as an exercise. 1. Locate the controls that are associated with the quality of the dot produced by the beam. 2. Does it provide two trace display, and if so by what method? 3. Which is the time-base control area? 4. Where is a Y-amplifier vernier control to be found? 5. What are the input terminating conditions?

DIFFERENTIAL AMPLIFIERS

Generally the dual-trace oscilloscope is recognised by two sets of input terminals. There is, however, another two-input unit that is for single trace operation. This is the differential input amplifier unit; it is normally provided as an optional plug-in.

Two two inputs are amplified by the high-gain differential arrangement of a dc amplifier. These are used when common-mode noise rejection is needed and when the difference between two fully floating inputs must be studied.

FINDING THE TRACE

Even experts can experience temporary difficulty when confronted with an unfamiliar oscilloscope – especially when it is complicated. Naturally it takes training to get the best from a unit. A basic difficulty is often finding the trace! These steps provide an efficient procedure that should be learned. Begin with the input to the Y-amplifier unconnected.

1. Ensure that the power is on. The on-off switch control is usually built in with the intensity knob, but not always.

2. Turn the intensity to 75% clockwise.

3. Switch the time-base (horizontal) to a medium speed – say 1ms/cm. This ensures that the screen displays a full line across the screen rather than a point which occurs when the scan speed is on the slow ranges.

4. Switch to auto triggering. This may be a marked position of the trigger control or a separate switch. This ensures that the trace is being triggered.

5. Switch to internal triggering. This is necessary for (4) above. Relying on an external signal to trigger the scan is unreliable – it may not be of adequate magnitude.

6. With this done slowly vary the vertical position control about its mid range point widening out to get the trace on screen.

7. The above may still not produce the trace. If not put the vertical position in its middle point and the gain at an insensitive value and begin a scan of the x-position control. This should be somewhere mid range. Too much x-shift can cause the trace to slide off screen.

Complicated oscilloscopes will invariably incorporate a variety of controls that may also need adjustment to find the trace. Space prevents a full guide to spot finding. Fortunately the more expensive units often provide a spot-finder button. Press it and the spot appears on screen enabling the controls to be adjusted accordingly to bring it back from the direction it flies too when the button is released.

When the trace is located in mid screen the intensity and focus are then adjusted by switching the scan to the slowest rate to produce a spot. These should be adjusted to produce a small round spot without halo: stationary spots on screens should be avoided as this shortens the life of the phosphor at that point.

The next part will continue the discussion on oscilloscopes providing understanding of storage kinds, the delay sweep mode, probes and special plug-ins.

TTLs by TEXAS

7400	16p	7485	130p	74191	160p
7401	18p	7486	36p	74192	130p
7402	18p	7489	340p	74193	160p
7403	18p	7490	43p	74194	130p
7404	25p	7491	81p	74195	96p
7405	25p	7492	55p	74196	120p
7406	45p	7493	43p	74197	120p
7407	45p	7494	96p	74198	220p
7408	25p	7495	75p	74199	220p
7409	27p	7496	90p	**C-MOS ICs**	
7410	18p	7497	340p	4000	21p
7411	26p	74100	116p	4001	21p
7412	27p	74104	60p	4002	21p
7413	38p	74105	60p	4006	120p
7414	96p	74107	36p	4007	21p
7416	34p	74109	96p	4009	87p
7417	40p	74110	55p	4011	21p
7420	18p	74116	216p	4012	19p
7421	43p	74118	90p	4013	55p
7422	24p	74120	130p	4015	90p
7423	40p	74121	32p	4016	54p
7425	33p	74122	52p	4017	110p
7427	45p	74123	73p	4018	247p
7428	39p	74126	75p	4020	140p
7430	18p	74132	75p	4022	180p
7432	37p	74136	81p	4023	19p
7437	37p	74141	80p	4024	100p
7438	37p	74142	300p	4025	19p
7440	18p	74145	90p	4026	200p
7441	85p	74148	173p	4027	81p
7442	75p	74150	155p	4028	152p
7443	116p	74151	77p	4029	130p
7444	116p	74153	92p	4030	59p
7445	108p	74154	164p	4042	150p
7446	108p	74155	96p	4043	218p
7447	90p	74156	96p	4046	150p
7448	85p	74157	97p	4047	110p
7451	20p	74160	120p	4049	68p
7453	20p	74161	120p	4050	50p
7454	20p	74162	120p	4054	130p
7460	20p	74163	120p	4055	140p
7470	32p	74164	130p	4056	145p
7472	32p	74166	136p	4060	130p
7473	36p	74167	370p	4069	30p
7474	36p	74174	131p	4071	29p
7475	48p	74175	92p	4072	29p
7476	37p	74176	131p	4081	21p
7480	54p	74177	120p	4082	29p
7481	108p	74180	120p	4510	142p
7482	85p	74181	322p	4511	200p
7483	99p	74182	89p	4516	140p
7484	103p	74185	146p	4518	140p
		74190	155p	4528	130p

OP. AMPS

301A	Ext. Comp.	8 pin DIL	40p
536T	FET Op. Amp	TO 99	300p
709	Ext. Comp.	8/14 pin DIL	36p
741	Int. Comp.	8/14 pin DIL	25p
747	Dual 741	14 pin DIL	70p
748	Ext. Comp.	8/14 pin DIL	40p
776	Prog. Op. Amp.	TO 99	200p
1458	Dual Op. Amp.	8 pin DIL	70p
3130	CMOS Op. Amp.	8 pin DIL	108p
3140	BIMOS/FET input	8 pin DIL	108p
3900	Quad Op. Amp.	14 pin DIL	70p

LINEAR I.C.s

AY-1-0212	Tone Generator	16 pin DIL	650p
CA3028A	Diff. Cascade Amp	TO99	112p
CA3046	5 Transistor Array	14 pin DIL	85p
CA3048	4 Lo Noise Amp	16 pin DIL	250p
CA3053	~~Diff. Cascade Amp~~	~~TO5/DIL~~	70p
CA3080	Op. Transcond. Amp.	8 DIL	97p
CA3089E	FM IF System	16 pin DIL	250p
CA3090AQ	FM Stereo Decoder	QIL	500p
ICL8038CC	VCO Fun. Gen.	16 pin DIL	370p
LM380N	2W Audio Amp.	14 pin DIL	115p
LM381N	Stereo Pre Amp.	14 pin DIL	190p
LM389N	Aud. Amp.+3 Trs. Array	18 pin DIL	175p
M252	Rhythm Generator	16 pin DIL	850p
MC1310P	~~FM Stereo Decoder~~	~~14 pin DIL~~	190p
MC1351P	Lim/Det. Aud. Pre amp	14 pin DIL	104p
MC3340P	Electronic Attenuator	8 pin DIL	180p
MFC4000B	¼W Audio Amp.	PCB	90p
NE540L	Aud. Pwr. Driver	TO5	175p
NE555V	Timer	8 pin DIL	40p
NE556	Dual 555	14 pin DIL	96p
NE561B	PLL with AM Demod	16 pin DIL	425p
NE562B	PLL with VCO	16 pin DIL	425p
NE565	PLL	14 pin DIL	200p
NE566V	PLL Fun. Gen.	8 pin DIL	200p
NE567V	PLL Tone Decoder	8 pin DIL	200p
2567	Dual 567	16 pin DIL	400p
SG3402N	Ring Modulator	14 pin DIL	275p
SN72710N	Diff. Comparator	14 pin DIL	54p
SN72733	Video Amp.	14 pin DIL	150p
SN76003N	Aud. Pwr. Amp. with HS	16 pin DIL	275p
SN76008	10W Amp. in 4 ohms	5 pin Plastic	280p
SN76013N	Aud. Pwr. Amp. with HS	16 pin DIL	175p
SN76023N	Aud. Pwr. Amp. with HS	16 pin DIL	175p
SN76033N	Aud. Pwr. Amp. with HS	16 pin DIL	275p
TAA621A	Aud. Amp. for TV	QIL	270p
TAA661B	~~FM/IF Amp. Lim/De.~~	~~QIL~~	150p
TBA641B	Audio Amp.	QIL	300p
TBA800	5W Audio Amp.	QIL	100p
TBA810	7W Audio Amp.	QIL	125p
TBA820	2W Audio Amp.	QIL	100p
TDA2020	20W Audio Amp.	QIL	375p
XR2240	Prog. Timer/Counter	16 pin DIL	400p
ZN414	TRF Radio Receiver	TO18	140p

TRANSISTORS

AC125	20p	BF194	13p	TIP41C	81p	2N4427	97p
AC126	20p	BF195	11p	TIP42A	76p	2N5089	34p
AC127	20p	BF196	17p	TIP42C	88p	2N5296	65p
AC128	18p	BF197	19p	TIP2955	85p	2N5401	62p
AC176	20p	BF200	40p	TIP3055	70p	2N6107	70p
AC187	20p	BF257	34p	TIS93	30p	2N6247	175p
AC187K	25p	BF258	39p	ZTX108	11p	(Comp. to 2N3055)	
AC188	20p	BFR39	34p	ZX300	16p	2N6254	140p
AC188K	25p	BFR40	34p	ZTX500	19p	2N6292	70p
AD149	70p	BFR41	34p	ZTX504	60p	40360	43p
AD161	45p	BFR79	34p	2N697	25p	40361	43p
AD162	45p	BFR80	34p	2N698	45p	40362	45p
AF115	22p	BFR88	37p	2N706	22p	40410	75p
AF116	22p	BFX30	36p	2N708	22p	40409	75p
AF117	22p	BFX84	30p	2N918	43p	40411	325p
AF139	43p	BFX85	30p	2N930	19p	40594	90p
AF239	48p	BFX86	30p	2N1131	20p	40595	97p
BC107/B	10p	BFX87	30p	2N1132	20p	**FETs**	
BC108/B	10p	BFX88	30p	2N1304	70p	BF244	36p
BC109/C	11p	BFY50	18p	2N1305	70p	MPF102	40p
BC147	9p	BFY51	16p	2N1306	70p	MPF103	40p
BC148	9p	BFY52	18p	2N1613	27p	MPF104	40p
BC149	10p	BRY39	45p	2N1711	27p	MPF105	40p
BC157	11p	BSX19	20p	2N1893	32p	2N3819	27p
BC158	13p	BSX20	20p	2N2219	25p	2N3820	50p
BC159	13p	BU105	175p	2N2222	25p	2N3823	54p
BC169C	15p	BU108	312p	2N2369	15p	2N5457	40p
BC171	12p	MJE340	70p	2N2484	32p	2N5458	40p
BC172	12p	MJ2955	130p	2N2904/A	25p	2N5459	40p
BC173	13p	MJE2955	130p	2N2905/A	25p	3N128	95p
BC177	20p	MJE3055	80p	2N2906	25p	3N140	95p
BC178	17p	MPSA06	40p	2N2026RB	9p	3N141	95p
BC179	20p	MPSA12	62p	2N2926OG	11p	40603	63p
BC182	12p	MPSA56	40p	2N3053	20p	40673	70p
BC183	12p	MPSU05	72p	2N3054	65p		
BC184	14p	MPSU06	78p	2N3055	65p	**UJTS**	
BC187	32p	MPSU55	90p	2N3442	151p	TIS43	40p
BC212	14p	MPSU56	98p	2N3702	14p	2N2160	95p
BC213	12p	OC28	90p	2N3703	14p	2N2646	48p
BC214	17p	OC35	90p	2N3704	14p	2N4871	65p
BC478	32p	OC71	25p	2N3705	14p	**PUJT**	
BC547	12p	TIP29A	50p	2N3706	14p	2N6027	60p
BC557	12p	TIP29C	62p	2N3708	14p		
BCY70	22p	TIP30A	60p	2N3709	14p	**DIODES SIGNAL**	
BCY71	24p	TIP30C	72p	2N3707	14p	OA47	10p
BD124	140p	TIP31A	56p	2N3773	270p	OA81	15p
BD131	60p	TIP31C	68p	2N3866	97p	OA85	15p
BD132	63p	TIP32A	63p	2N3904	22p	OA90	9p
BD135	54p	TIP32C	85p	2N3905	25p	OA91	9p
BD136	55p	TIP33A	97p	2N3906	22p	OA95	9p
BD139	54p	TIP33C	120p	2N4058	19p	OA200	8p
BD140	60p	TIP34A	124p	2N4060	19p	OA202	10p
BDY56	225p	TIP34C	160p	2N4123	22p	1N914	4p
BF115	24p	TIP35A	243p	2N4124	22p	1N916	11p
BF167	25p	TIP35C	290p	2N4125	22p	1N4148	4p
BF173	27p	TIP36A	297p	2N4126	22p		
BF178	30p	TIP36C	360p	2N4401	34p		
		TIP41A	70p	2N4403	34p		

RECTIFIER

BY100	31p
BY126	12p
BY127	12p
1N4001	6p
1N4002	6p
1N4004	7p
1N4005	7p
1N4007	8p
1N5401	15p
1N5404	20p
1N5407	25p

ZENER
2.7 to 33V
400mW 11p
1W 22p

NOISE
Z5J 140p

DIAC
BR100 30p

BRIDGE RECTIFIERS

1A	50V	25p
1A	100V	27p
1A	400V	31p
1A	600V	37p
2A	50V	37p
2A	100V	44p
2A	400V	56p
3A	200V	70p
3A	600V	75p
4A	100V	84p
4A	400V	90p
6A	50V	90p
6A	100V	96p
6A	200V	108p
6A	400V	120p

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Amp	Volts	
3	400	85p
6	400	107p
6	500	120p
10	400	140p
10	500	160p
15	400	200p
15	500	225p
40430		130p
40669		130p

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2104-4 RAM	£11.00
2107 RAM	£8.80
2112-2 RAM	£4.70
2513 ROM	£8.50
74S262 ROM	£18.00

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1A 100V TO5	45p
1A 400V TO5	50p
3A 400V STUD	81p
12A 400V Plastic	190p
16A 400V Plastic	220p
16A 600V Plastic	270p
BT106 1A 700V STUD	130p
C106D 4A 400V Plastic	63p
MCR101 ½A 15V TO92	27p
2N3525 5A 400V TO66	120p
2N4444 8A 600V Plastic	200p
2N5060 0.8A 30V TO92	36p
2N5062 0.8A 100V TO92	40p
2N5064 0.8A 200V TO92	43p

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15V	7812	150p	7915	215p
18V	7818	150p	7918	215p
24V	7824	150p	7924	215p

LM309K	5V	1 Amp	TO3	150p
LM309H	5V	100mA	TO5	97p
TBA625B	12V	0.5A	TO5	106p
LM323K	5V	3A	TO3	650p
Variable: 723		14pin DIL		45p

TO-92 V.R.

78L05	60p
78L08	60p
78L12	60p
78L15	60p
79L05	80p
79L08	80p
79L12	80p
79L15	80p

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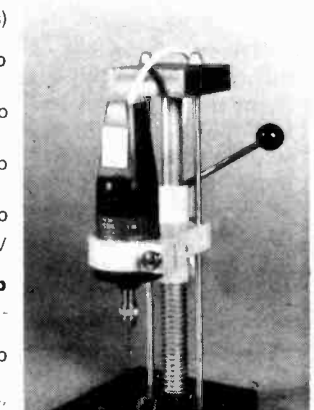

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ELECTRONICS TOMORROW

by John Miller-Kirkpatrick

SOME YEARS AGO, in the early days of TTL, the first character generators were creeping onto the market. By a character generator I mean 7447 or 7448 type of device deigned to output to filamentary (pre-LED) seven segment displays. Before this displays used the 'I and n' selection system where a different lamp or anode was energised for each numeral or character to be displayed, typical of this type was the 'Nixie' tube display and the 7441 decoder.

The seven segment market was a bit slow in starting due to the vast differential in price between the 'Nixie' display and the seven segment LED (which started life at over £10 per digit). Eventually, the LED grip tightened and the prices started to tumble, helped enormously by the calculator chip.

As the price of the seven segment LED and of lamps' dropped, so did the prices of other forms of displays.

These came in a variety of disguises with 8,14 and 16 segment displays and 5x7 matrixes as LED manufacturers tried to come up with a display which could show most letters and special characters as well as numerals. None of the devices 'took off' very well due to the high cost per digit of decoding and driving 16 segment units. The 5x7 system was helped by the introduction of reasonably low cost ROM decoders which input as ASCII or other code and output one of seven sets of 5 logic signals. The choice of which of the seven sets of data per character was the job of an external counter which also addressed a 'row driver' on the LED.

This rather cumbersome system at least had the advantage of having multi-character multiplexing virtually inherent in its design so that the multichip character generator could drive several LEDs thus cutting the cost per character. However, the cost of each 5x7 LED matrix was high and apparently difficult to make due to problems of getting all 35 LED dots to work to the same intensity.

TV or not TV

Designers looked elsewhere for the low-cost alphanumeric output device and came up with the CRT or TV tube. These break down immediately into two groups, the CRT where the spot is controlled by the logic and the TV where the spot must follow a fixed pattern of movements and the logic must interpret these movements. CRT display systems can usually be seen associated with computer graphics displays where the computer uses the CRT like an oscilloscope with a storage facility or a regular refresh or repeat of the drawing.

With this type of unit the computer draws or writes each character or line as a complete unit and then starts another and so on until the whole pattern is complete and then repeats the whole operation perhaps up to 20 times per second.

The TV type of VDU relies on the regular line scanning circuitry already installed in a normal TV set. Most applications use the TV the normal way up and scan horizontally, some systems use the TV on its side and scan vertically; the basic logic is similar for both systems but we will continue with the more usual horizontal scan.

Scanning for lines

A normal 625 line TV set whether it be a complete set or simply a monitor expects to receive about 300 odd lines of picture information 50 times per second with the beginning of each set marked by a frame syncronisation signal, and the beginning of each line marked by a line sync signal.

These signals must meet certain specifications for the TV to lock into them properly and thus to display the required picture information without loss of line or frame hold. The picture information for each line is basically a modulated signal peaking at about 5-6MHZ and denoting the intensity of the spot in a B/W set or the intensity of each gun in a colour set. This signal is derived from a light sensor which produces different voltage levels according to the light falling on the sensor. The signal could also come from a logic source which indicated that a logic 1 was to indicate a low intensity spot (black) and a logic 0 was to indicate a high intensity spot (white).

In this way a TV could be persuaded to show a black and white picture (no greys) if the dots were arranged by the logic to occur at certain points on the screen. The most usual example of this type of logic/TV combination can be seen in the 'Ball & Paddle' TV games.

Imagine the TV dots arranged as 5x7 matrixes repeated all over the screen, each character space would have to be at least 6x8 dots to give a gap between characters. With the picture line data being about 50uS in each 64uS line a time 5MHz dot rate would yield about 250 dot positions per line, at 6 horizontal dots per character this would give a maximum of about 40 characters (eg TELETEXT output).

Similarly, there are about 250 usable TV lines per 20mS frame, at 8 lines per character row so we could display about 30 rows of characters. In practice, at least 10 and more usually 16 lines are used per character row to give a reasonable vertical spacing. This results in two standard row counts of 16 and 24 (TELETEXT) rows per frame.

The payoff

With more manufacturers (and amateurs) turning towards TV as a display system it was obviously not going to be long before someone put it all into a 16 pin IC — it's called the DM8678/0 (from National).

The DM8678 is a 64 character ROM, latches, PISO, counters and ancilliary logic packaged into a 16 pin DIL. The data input is a six bit binary code to select 1 of 64 characters from the ROM, and to output that data as a serial signal dependent on a line counter and a dot frequency input. The input data can be internally latched if required to enable external devices to set up the input for the next character. The DM8678 can be supplied with various character sets in 5x7 or 7x9 matrixes in upper or lower case format. The DM8679 is a similar chip but has the additional feature of ignoring the first 4 TV lines thus resulting in a 'below the line' facility for lower case, g, j, p, q, z display if required.

Making an example

To illustrate the operation of the DM8678 an example is given tracing the sequence of events in generating the letter 'N' on a 7x9 matrix. The required input data is latched from the input pins and directed to a 1 of 64 decoder which in turn addresses the ROM. The ROM is organised as 64 words each 63 bits long, each word can be further sub-divided as 9 set of seven bits. The choice of 1 of 9 is controlled by a TV line counter which in our example is currently accessing the first set of 7 bits. The 7 bits are loaded into the shift register and the next low-to-high transition of the input dot clock would load the first of the seven bits into the sèrial output stage; in our example' this would be a logic 1. The next low-to-high transition of the dot clock would load the next bit into the output stage and so on until all 7 bits had been output for row 1, in our example row 1 data is 1000001.

On the next transition of the TV line count input the counter would be advanced to the second set of 7 bits and these would be output in the same way as the first, the other rows would also be output in the same way until all 9 rows had been output. The 9 sets of data in our example are —

1000001
1000001
1100001
1010001
1001001
1000101
1000011
1000001
1000001

(if you hold this page at a distance the letter 'N' will be seen.

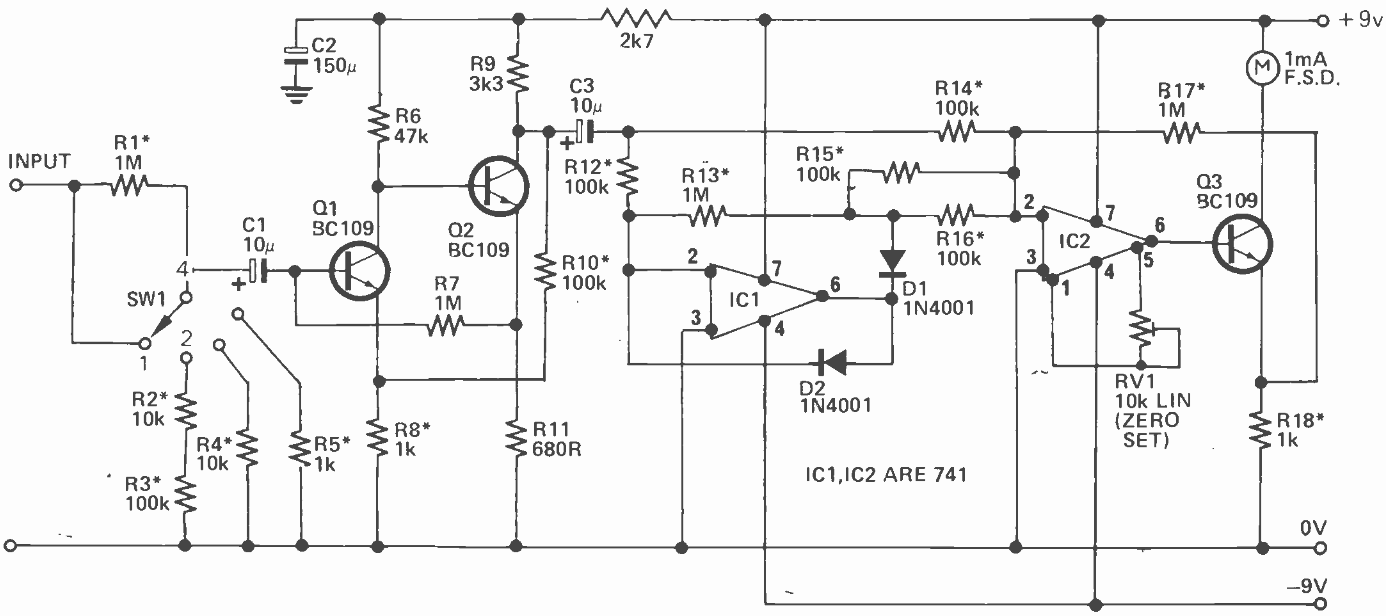
Rows of characters

In a typical application more than one character per row is displayed. This simply means that a character per row counter will access a RAM and retrieve a different set of input data for each character per TV line. Each TV line might access 32 RAM locations for character data, all other TV lines in that character row would access exactly the same RAM locations and each time a different set of serial outputs could come from the DM8678.

The DM8678 can be used in 16 or 24 rows per frame systems, and with a maximum 20MHz dot rate could generate over 100 characters per row, in practice 80 is a reasonable maximum to look for. At about £16 it compares favourably with the multichip design on grounds of package size and count. ●

tech-tips

Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.
ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS, Electronics Today International, 25-27 Oxford St., London W1R 1RF.



SW	F.S.D.
1	1mV
2	10mV
3	100mV
4	1V

AUDIO MILLIVOLTMETER

This circuit was conceived as an easily built instrument offering a ±2% accuracy.

Q1 and Q2 are connected as a high gain feedback pair with a fixed gain of 100.

IC 1 and IC 2 form a precision-full wave rectifier with a gain of 10 over a bandwidth extending from below 20 Hz to above 50 kHz.

The gain of the whole circuit therefore is 1000 and input signals above 1 mV must be attenuated.

No setting up is required except for the zero adjustment of RV1. Input impedance is 1 MΩ on all ranges.

Resistors marked with an asterisk are 1% types.

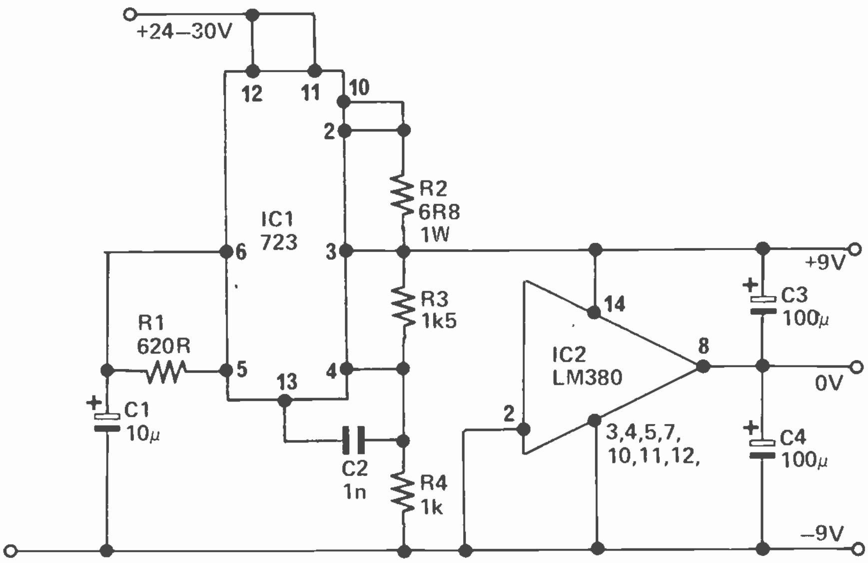
DUAL P.S.U.

Anyone who experiments with op-amps will need a dual stabilised power supply. The circuit shown was designed to power up to twenty 741s simultaneously.

IC 1 is used to provide an output voltage of 18 V at pin 10. R2 sets the short circuit current at 100 mA and should be rated at 1 W.

IC 2 is used as a precision short circuit proof voltage divider.

A 9-0-9 V supply has been found in practise to cater for most op-amps with the notable exception of the CA3130 which has a maximum supply rating of 16 V.



tech-tips

TELEPHONE RINGING AND SPEECH CIRCUIT

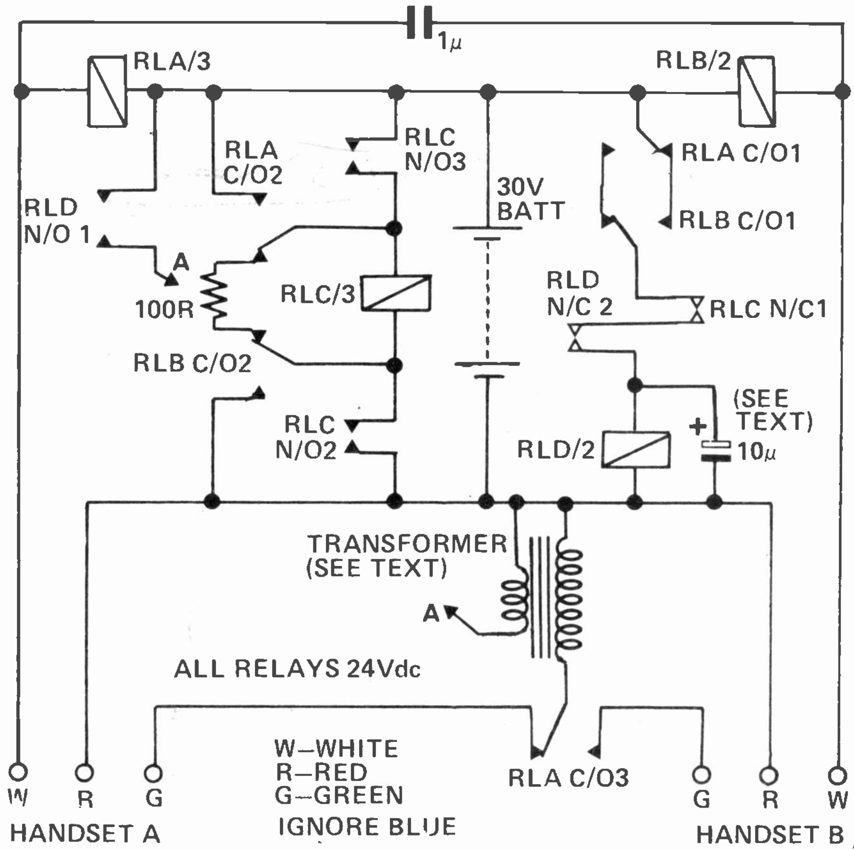
This circuit was designed to be used by children as a language teaching aid in primary school. For safety reasons, power is taken from a dc battery source, necessitating the incorporation of an ac generator in the circuit.

If handset A is lifted, RLA is activated changing over contacts RLA energising RLD. RLD has a pair of N/C contacts wired in series with its coil and this causes the relay to vibrate. The contacts would not however, change over fully, and a capacitor is wired in parallel and stores enough charge to allow the relay to change fully. The value of the capacitor will depend on the type of relay being used but the value selected should be chosen to cause the relay to vibrate at about 25 Hz.

A second set of contacts is wired in series with the transformer, which in the prototype was an old 250 to 125 V transformer with the 125 V winding being used as the primary. The output of the transformer is fed to the third set of contacts of RLA which selects which telephone is to be rung.

On lifting the other handset relay RLB will energise and the exclusive OR arrangement of contacts RLA and RLB will inhibit the bellringing circuit.

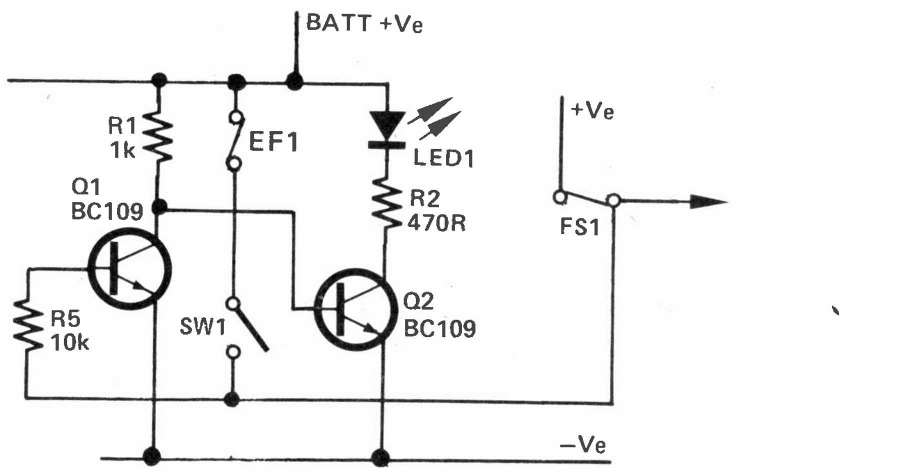
To prevent either bell ringing again if one of the handsets is replaced RLC is included. When both handsets are raised RLC energises and is self-latching, one set of its contacts being in series with RLD. When both handsets are replaced, RLC is shorted through the 100 Ohm resistor and turns off, resetting the bellringing circuit. The 1 uF capacitor provides the required coupling for speech between the two handsets.

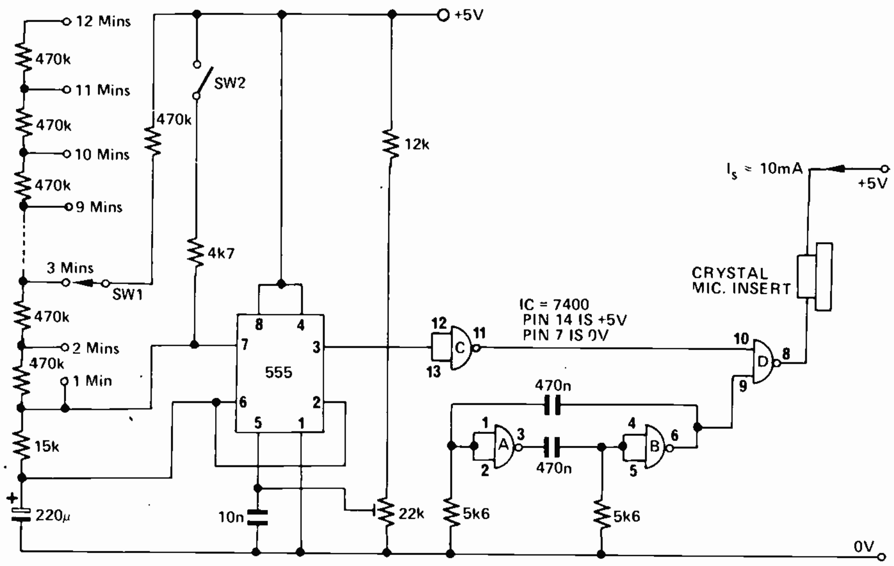


BLOWN FUSE INDICATOR

Base current for Q1 is taken from the 'earthy' side of FS1. Q1 will conduct its collector voltage falling to zero. Q2 base will also be zero, switching LED 1 off.

If FS1 were to 'blow' or cease to exist, depart for its maker, have a rest, go to sleep, peg out, become inoperative, deceased, out of order, or duff, kick the bucket, bite the dust, pass away, self destruct, become no longer intact, or cease to conduct in any way, due to war, flood, corrosion or act of God etc., Q1 would switch off, causing its collector to rise to 12 V, switching Q2 and LED 1 on. R2 is the current limit resistor for LED 1. SW1 will bypass FS1 via emergency fuse 1, until FS1 can be replaced.

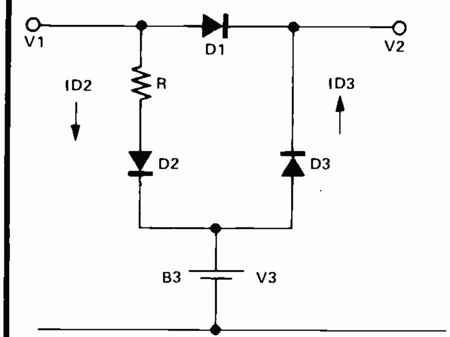




1 - 12 MINUTE TIMER

The circuit is centred around the NE555V timer which provides a logic 0 level at pin 3 every 1 - 12 minutes, depending upon the position of the 12 way switch (SW1). SW2 is a push-button switch which synchronises the first pulse (originally a switch circuit was fitted to the reset pin, 4, but the first timing period was never the same as the subsequent periods). The variable 22k resistor allows a degree of fine adjustment for the timing period.

Gates A and B form a tone generator. Gate C inverts the output of the NE555V so that a logic '1' is fed to gate D at the end of each timing period. Thus a tone burst of a few seconds is produced by the transducer (any surplus crystal microphone insert should be suitable).

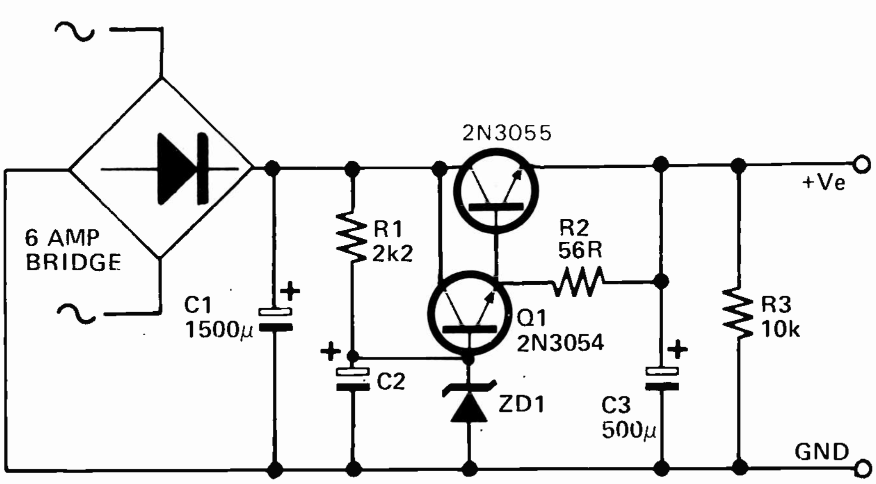


DIODE VOLTAGE MONITOR

R is chosen such that as ID2 is the 'trickle charge' rate of B3.

If V2 > V3; ID3 = 0 and ID2 is the charging current.

If V3 > V1, ID3 flows, but ID2 is now zero.

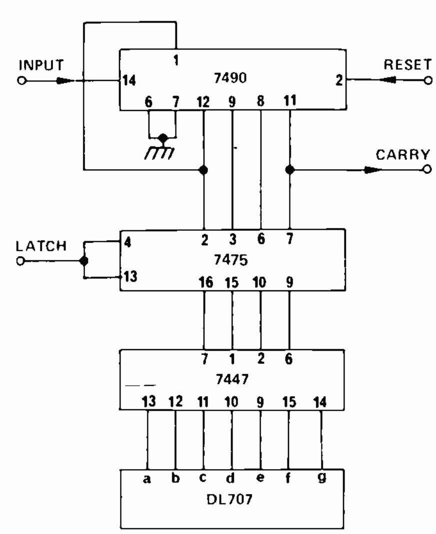


LOW RIPPLE P.S.U.

The power supply circuit shown may be used where a high current is required with a low ripple voltage (such as in a high powered class AB amplifier when high quality reproduction is necessary).

Q1, Q2 and R2 may be regarded as a power darlington transistor. ZD1 and R1 provide a reference voltage at the base of Q1. ZD1 should be chosen thus: ZD1 = $V_{out} - 1.2$.

C2 can be chosen for the degree of 'smoothness' as its value is effectively multiplied by the combined gains of Q1/Q2, if 100uF is chosen for C2, assuming minimum h_{fe} for Q1 and Q2, C= 100 x 15(Q1) x 25(Q2)= 37,000 uF.



SIMPLE COUNTER/DISPLAY MODULE

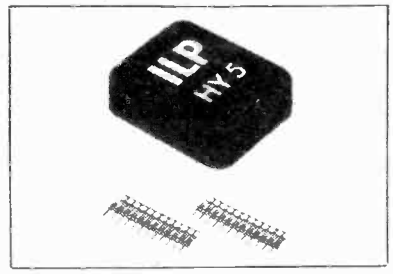
The signal is connected to the input line of the 7490 decade counter. When the 'latch' is high, the display will follow the count. When the 'latch' goes low, the display holds.

The module may be constructed on two pieces of veroboard, the boards being held together by wire soldered at each corner.

In order to cascade, common up all the latch hold and reset lines, and connect the carry line to the input line of the next module.

15—240 Watts!

HY5
Preamplifier



The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (mag Cartridge, tuner, etc.) are catered for internally, the desired function is achieved either by a multi-way switch or direct connection to the appropriate pins. The internal volume and tone circuits merely require connecting to external potentiometers (not included). The HY5 is compatible with all I.L.P. power amplifiers and power supplies. To ease construction and mounting a P.C. connector is supplied with each pre-amplifier.

FEATURES: Complete pre-amplifier in single pack — Multi-function equalization — Low noise — Low distortion — High overload — two simply combined for stereo.

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SPECIFICATIONS:
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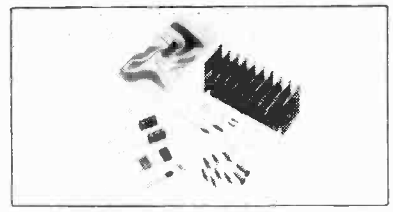
HY30
15 Watts into 8Ω



The HY30 is an exciting New kit from I.L.P.; it features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up-to-date technology available.

FEATURES: Complete kit — Low Distortion — Short, Open and Thermal Protection — Easy to Build

APPLICATIONS: Updating audio equipment — Guitar practice amplifier — Test amplifier — Audio oscillator

SPECIFICATIONS:
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INPUT SENSITIVITY 500mV; FREQUENCY RESPONSE 10Hz-16kHz — 3dB
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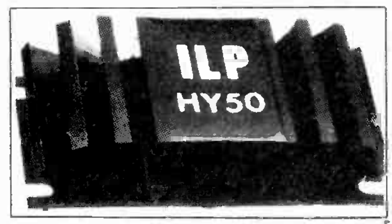
HY50
25 Watts into 8Ω



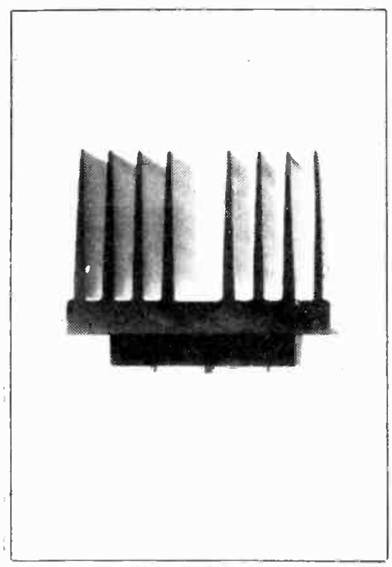
The HY50 leads I.L.P.'s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust High Fidelity modules in the World.

FEATURES: Low Distortion — Integral Heatsink — Only five connections — 7 Amp output transistors — No external components.

APPLICATIONS: Medium Power Hi-Fi systems — Low power disco — Guitar amplifier

SPECIFICATIONS: INPUT SENSITIVITY 500mV
OUTPUT POWER 25W RMS in 8Ω; LOAD IMPEDANCE 4-16Ω; DISTORTION 0.04% at 25W at 1kHz
SIGNAL/NOISE RATIO 75dB; FREQUENCY RESPONSE 10Hz-45kHz — 3dB
SUPPLY VOLTAGE ± 25V; SIZE 105.50.25mm
Price £6.82 + 85p VAT P&P free

HY120
60 Watts into 8Ω



The HY120 is the baby of I.L.P.'s new high power range, designed to meet the most exacting requirements including load line and thermal protection, this amplifier sets a new standard in modular design.

FEATURES: Very low distortion — Integral Heatsink — Load line protection — Thermal protection — Five connections — No external components

APPLICATIONS: Hi-Fi — High quality disco — Public address — Monitor amplifier — Guitar and organ

SPECIFICATIONS:
INPUT SENSITIVITY 500mV
OUTPUT POWER 60W RMS into 8Ω; LOAD IMPEDANCE 4-16Ω; DISTORTION 0.04% at 60W at 1kHz
SIGNAL/NOISE RATIO 90dB; FREQUENCY RESPONSE 10Hz-45kHz —3dB; SUPPLY VOLTAGE ± 35V
Size: 114 x 50 x 85mm
Price £15.84 + £1.27 VAT P&P free.

HY200
120 Watts into 8Ω

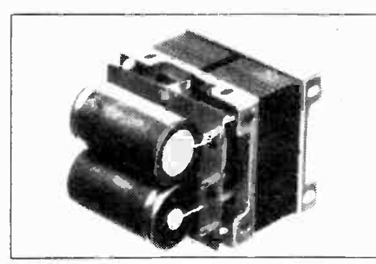
The HY200 now improved to give an output of 120 Watts has been designed to stand the most rugged conditions, such as disco or group while still retaining true Hi-Fi performance.

FEATURES: Thermal shutdown — Very low distortion — Load line protection — Integral Heatsink — No external components

APPLICATIONS: Hi-Fi — Disco — Monitor — Power Slave — Industrial — Public address

SPECIFICATIONS:
INPUT SENSITIVITY 500mV
OUTPUT POWER 120W RMS into 8Ω; LOAD IMPEDANCE 4-16Ω; DISTORTION 0.05% at 100W at 1kHz
SIGNAL/NOISE RATIO 96dB; FREQUENCY RESPONSE 10Hz-45kHz — 3dB; SUPPLY VOLTAGE ± 45V
SIZE 114 x 100 x 85mm
Price £23.32 + £1.87 VAT P&P free.

HY400
240 Watts into 4Ω



The HY400 is I.L.P.'s "Big Daddy" of the range producing 240W into 4Ω! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.

FEATURES: Thermal shutdown — Very low distortion — Load line protection — No external components

APPLICATIONS: Public address — Disco — Power slave — Industrial

SPECIFICATIONS:
OUTPUT POWER 240W RMS into 4Ω; LOAD IMPEDANCE 4-16Ω; DISTORTION 0.1% at 240W at 1 kHz
SIGNAL/NOISE RATIO 94dB; FREQUENCY RESPONSE 10Hz-45kHz — 3dB; SUPPLY VOLTAGE ± 45V
INPUT SENSITIVITY 500mV; SIZE 114 x 100 x 85mm
Price £32.17 + £2.57 VAT P&P free.

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