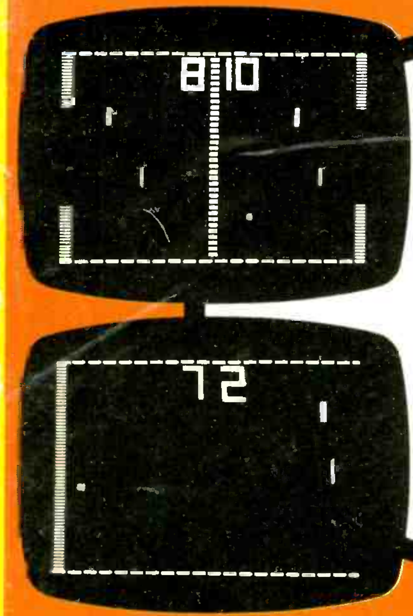
ELECTRONICS TODAY

electronics today international

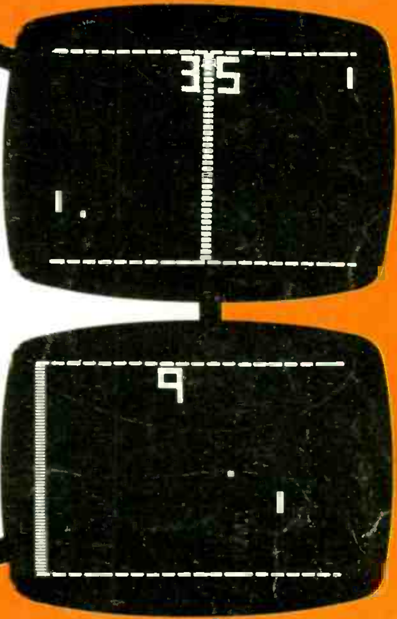
MAY 1977

35p

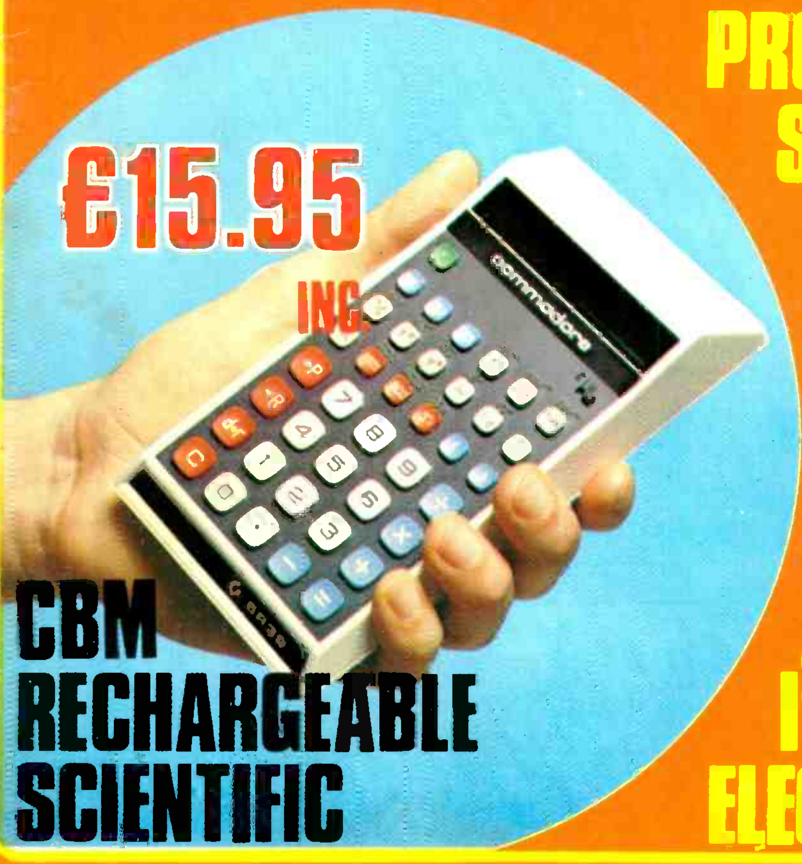


4 IN 1 TV GAMES UNIT

FULL CONSTRUCTIONAL DETAILS OF THIS EASY-TO-BUILD PROJECT FEATURING:
♦ Full sound effects ♦ On screen scoring ♦ Variable angle
♦ Two bat sizes ♦ Ball speed control ♦ 'Rifle' option
★ Special offer on IC.



PROJECTS: HI-FI SPEAKERS
SYSTEM 68 - THE PSU
METRONOME
INJECTOR TRACER



CBM RECHARGEABLE SCIENTIFIC

ALSO: THE VALVES THAT WON THE WAR
I²L EXPLAINED
ELECTRONICS: 2000 A.D.

NEWS . . . CONSTRUCTION . . . DEVELOPMENTS . . . AUDIO

WATFORD ELECTRONICS

33 CARDIFF ROAD, WATFORD, HERTS., ENGLAND
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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.

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 **7p;** 0·0047, 0·0068, 0·01, 0·015, 0·018 **8p;** 0·022, 0·033, **9p;** 0·047, 0·068, 0·1 **11p;** 0·15 0·22 **18p;** 0·33, 0·47 **28p;** 0·68 **38p.**
150V: 0·039, 0·15, 0·22 **11p;** 0·33, 0·47 **19p;** 0·68, 1·0 **22p;** 1·5 **29p;** 2·2 **32p;** 4·7 **36p.**
DUBILIER: 1000V: 0·01, 0·015 **16p;** 0·022 **18p;** 0·047 **16p;** 0·1 **29p;** 0·47 **43p;** 1·0 **68p**

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 **40p; 100V:** 20, **6p; 63V:** 0·47, 1·0, 1·5, 2·2, 2·5, 3·3, 4·7, 6·8 **7p;** 8, 10, 15, 22, **8p;** 47, 32, 50 **10p;** 63, 100, **12p; 50V:** 1·0, **6p;** 50, 100 **10p;** 220 **10p;** 470, **30p;** 1000 **43p;** 2200, **48p; 40V:** 22, 33, **8p;** 100, **10p;** 3300, **52p; 35V:** 33, **7p;** 3·30, 470 **27p;** 1000, **38p; 25V:** 10, 22, 47, **6p;** 80, 100, 160 **8p;** 220, 250, **13p;** 470, 640 **25p;** 1000, **27p;** 1500 **30p;** 2000, **34p;** 3300 **39p;** 4700, **47p; 16V:** 10, 40, 47, 68, **6p;** 100, 125, **7p;** 470, **12p;** 1000, 1500 **18p;** 2200, **25p; 10V:** 4, 100, **6p;** 540, **10p;** 100, **14p.**
TAG-END TYPE: & 70V: 2500, **98p;** 4700, **111p; 64V:** 3300, **94p; 40V:** 10000 **145p;** 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 **25V:** 1·5, 10 **20V:** 1·5 **16V:** 10µF, 22, 47 **10V:** 4·7, 15, 25, 33 **6V:** 47µF, 68 **3V:** 100µF
12p each

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**

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

TETFER Trimmer (Jackson)
10pF **58p**

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, 250, 300, 330, 360, 390, 600, 820 **9p each**
1000, 1800, 2000, 2200 **12p each**

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 **35p**

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 **45p**
5KΩ-2MΩ dual gang stereo **55p**

SLIDER POTENTIOMETERS
0·25W log and linear values 60mm
5KΩ-500KΩ single gang **60p**
10KΩ-500KΩ dual gang **70p**
50KΩ lin 150mm WS 150 **450p**

PRESET POTENTIOMETERS
0·1W 50Ω—5MΩ Miniature Vertical & Horizontal **7p**
0·25W 100Ω—3·3MΩ Horiz larger **8p**
0.25W 200Ω—4·7MΩ Vert. **8p**

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				8p

RHYTHM GENERATOR
(Practical Wireless May-June 1976)
Complete Kit (Inc. VAT) **£42.95**
Ready built (incl. VAT) **£52.95**
Send SAE for complete list

OPTO ELECTRONICS ★
LEDs + clip
TIL209 Red **13p**
TIL211 Grn **28p**
TIL220 Red **20p**
2" Red **16p**
2" Amber Green 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**
DL707 C.C **95p**
DL707 C.A **95p**
DL747 C.A **180p**
2N5777 **54p**

SWITCHES ★
TOGGLE 2A, 250V
SPST **26p**
DPDT **35p**
4 pole on/off **58p**
SUB-MIN TOGGLE
SP changeover **59p**
SPST on/off **54p**
DPDT 6 t **78p**
DPDT Centre off **92p**
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**

JACK PLUGS

	Screened chrome	Plastic body
2.5mm	10p	8p
3.5mm	14p	10p
MONO	19p	15p
STEREO	28p	18p

SOCKETS

open metal	moulded with break contacts	in line couplers
8p		11p
8p		12p
13p	20p	18p
15p	24p	22p

DIN	PLUGS	SOCKETS	In Line
2 PIN Loudspeaker 3, 4, 5 Audio	12p	8p	20p
CO-AXIAL (TV)	14p	10p	8p
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 **28p**
SP changeover centre off **23p**
ROCKER: (black) on/off 10A 250V
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 **37p**
ROTARY: Mains 250V AC, 4 Amp **42p**

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

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

Etch Resist Pen★ **75p**

COPPER BOARDS★
SRBP 7×8" **40p**
Fibre Glass
6×6" **64p**
6×12" **115p**

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**

It's Here!

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 **£37.50** 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)

TTL 74★

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

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
74157	95
74158	80
74159	225
74160	116

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	194
74191	165
74192	120
74193	120
74194	120
74195	95
74196	118
74197	118
74198	248
75150	000
75491	80
75492	90

CMOS★ (RCA)

4000AE	15
4001AE	15
4002AE	16
4006AE	115
4007AE	17
4009AE	55
4010AE	56
4011AE	16
4012AE	18
4013AE	55
4015AE	99
4016AE	55
4017AE	95
4018AE	92
4019AE	48
4020AE	105
4021AE	105
4022AE	95
4023AE	18
4024AE	79
4025AE	17
4026AE	175
4027AE	69
4028AE	85
4029AE	109
4030AE	52
4033AE	130
4034AE	184
4040AE	99
4042AE	85
4043AE	97
4044AE	95
4045AE	140
4046AE	127
4047AE	88
4048AE	58
4049AE	52
4050AE	45
4054AE	120
4055AE	134
4056AE	134
4060AE	112
4067AE	350
4068AE	22
4069AE	18
4070AE	65
4071AE	20
4072AE	20
4076AE	155
4077AE	60
4078AE	22
4081AE	22
4082AE	20
4502AE	135
4507AE	55
4510AE	45
4511AE	165
4512	115
4516AE	140
4518AE	140
4519AE	57
4520AE	130
4528AE	140
4532AE	128
4539AE	120
4585AE	105

LINEAR IC'S

702	75
709C 14 pin	27
710★	41
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
CA3011★	82
CA3014★	137
CA3018	72
CA3020	145
CA3023	145
CA3028A★	96
CA3035	145
CA3036	147
CA3043	165
CA3046	80
CA3048	215
CA3075	150
CA3080	80
CA3081	190
CA3089E	205
CA3090A★	395
CA3123E	180
CA3130★	94
CA3140	95
LM300H	170
LM301A	35
LM308	120
LM318	155
LM380	98
LM381	170
LM379	395
LM382	150
LM3900	62
LM3909N	65
M252AA★	650
M253★	750
MC724★	175
MC845P	150
MC1303L	148
MC1304P	360

MC1310P	165
MC1312PQ	175
MC1458P★	77
MC1496	91
MC1710CG	79
MFC6040★	97
MK50253★	550
MM2112N★	350
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
SL414A	220
SN72733	125
SN76003	240
SN76013	150
SN76023	150
SN76033	235
SN76115	215
SN76227	175
TAA621A	238
TAA661A	155
TAA700	253
TAA960	250
TAD100	150
TAD110	170
TBA120S	90
TBA540Q	195
TBA550Q	355
TBA641B	249
TBA651	160
TBA800	90
TBA810S	110
TBA820	90
TBA920Q	350
TDA2020	300
ZN414	110

TRANSISTORS

	p
AC117	35
AC125★	22
AC126★	18
AC127★	18
AC128★	18
AC141★	22
AC141★K	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★	33
AF178★	70
AF179★	70
AF180★	70
AF181★	48
AF185★	60
AF186★	48
AF239★	39
ASY26★	38
ASY29★	40
BC107★	9
BC107B★	10
BC108★	9
BC108B★	12
BC108C★	12
BC109★	9
BC109B★	12
BC109C★	12
BC113	15
BC114	16
BC115	18
BC116	19
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	99
BC154	20
BC157	10
BC158	12
BC159	13

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BC160★	32
BC167	12
BC168	12
BC169C	14
BC170	11
BC171	11
BC172	11
BC177★	18
BC178★	16
BC179★	18
BC182	10
BC182L	11
BC183	10
BC183L	11
BC184	11
BC184L	11
BC186	22
BC187★	23
BC212	11
BC212L	13
BC213	11
BC213L	13
BC214	14
BC214L	16
BC307B	15
BC328	18
BC338★	21
BC441★	30
BC461★	40
BC462★	30
BC547	15
BC548	15
BC549C	16
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

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BF184★	28
BF185★	30
BF194	12
BF195	11
BF196	14
BF197	15
BF198	15
BF200	37
BF224A	16
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
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

	p
OC25★	65
OC26★	95
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

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ZTX300	14
ZTX301	14
ZTX302	19
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

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2N3702	11
2N3703	12
2N3704	11
2N3705	12
2N3706	10
2N3707	11
2N3708	9
2N3709	9
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★	220
40412★	42
40476	170
40494	89
40495	98
40594	90
40603★	58
40636★	110
40673★	55

Matched Pair 10p extra

NOISE DIODES
Z5J **105p**

DIAC★
ST2 **25**

DIODES

	p
AAZ15	15
AEY11	60
BA100	10
BA102	10
BY100	24
BY126	12
BY127	12
OA9	9
OA10	40
OA47	8
OA70	8
OA90	6
OA91	6

OA95	8
OA200	9
OA202	8
OA79	12
OA81	10
OA85	12
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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Rng 3·3V-33V
400MW **9p**
1·3W **17p**

VARICAPS
MVAM2 **135p**
BB104 **40p**
BB105B **30p**
BB106 **45p**

★BRIDGE RECTIFIERS
(plastic case)

	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★

3A 400V	113
6A 400V	140
8A 400V	1160
10A 500V	195
15A 400V	240
15A 500V	285
30A 400V	398
40430	99
40669	99

THYRISTORS★
SCRs

1A50V	38
1A 100V	42
1A 200V	47
1A 400V	52
3A 100V	43
3A 400V	110
5A 400V	120
7A 400V	125
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SEMICONDUCTORS - COMPONENTS

TRIACS

2 Amp Volts	TO5 Case No	Price
100	TR12A/100	£0.31
200	TR12A/200	£0.51
400	TR12A/400	£0.71

10 Amp. Volts	TO48 Case No	Price
100	TR110A/100	£0.77
200	TR110A/200	£0.92
400	TR110A/400	£1.12

6 Amp Volts	TO66 Case No	Price
100	TR16A/100	£0.51
200	TR16A/200	£0.61
400	TR16A/400	£0.77

10 Amp Volts	TO220 Case No	Price
400	TR110A 400P	£1.12

DIACS

BR100 £0.23 D32 £0.23

SUPER UNTESTED PAKS

PAK	No.	Order No.	Price
U50	100 Germ Gold bonded OA47 diode	16130	£0.60
U51	150 Germ OA70/81 diode	16131	£0.60
U52	100 Silicon Diodes 200mA OA200	16132	£0.60
U53	150 diodes 75mA 1N4148	16133	£0.60
U54	50 Sil Rect Top Hat 750mA	16134	£0.60
U55	20 Sil Rect Stud Type 3 Amp	16135	£0.60
U56	50 400mW Zeners DO7 Case	16136	£0.60
U57	30 NPN Trans BC107/8 Plastic	16137	£0.60
U58	30 PNP Trans BC177/178 Plastic	16138	£0.60
U59	25 NPN TO39 2N697/2N1711 sil	16139	£0.60
U60	25 PNP TO59 2N2905 silicon	16140	£0.60
U61	30 NPN TO18 2N706 silicon	16141	£0.60
U62	25 NPN BFY50/51	16142	£0.60
U63	30 NPN Plastic 2N3906 silicon	16143	£0.60
U64	30 PNP Plastic 2N3905 silicon	16144	£0.60
U65	30 Germ 0071 PNP	16145	£0.60
U66	15 Plastic Power 2N3055 NPN	16146	£1.20
U67	10 TO3 Metal 2N3055 NPN	16147	£1.20
U68	20 Unijunction trans IIS43	16148	£0.60
U69	10 1 amp SCR TO39	16149	£1.20
U70	8 3 amp SCR TO66 case	16150	£1.20

Code No's mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

COMPONENT PACKS

Pack No.	Qty.		Order No.	Price
C1	200	Resistor mixed value approx (Count by weight)	16164	£0.60
C2	150	Capacitors mixed value approx (Count by weight)	16165	£0.60
C3	50	Precision resistors Mixed values	16166	£0.60
C4	80	⅛th W Resistors mixed preferred values	16167	£0.60
C5	5	Pieces assorted ferrite rods	16168	£0.60
C6	2	Tuning gangs MW/1W VHF	16169	£0.60
C7	1	Pack wire 50 metres assorted colours single strand	16170	£0.60
C8	10	Reed switches	16171	£0.60
C9	3	Micro switches	16172	£0.60
C10	15	Assorted pots	16173	£0.60
C11	5	Metal jack sockets 3 x 3.5mm 2 x standard switch types	16174	£0.60
C12	30	Paper condensers preferred types mixed values	16175	£0.60
C13	20	Electrolytics trans types	16176	£0.60
C14	1	Pack assorted hardware — Nuts bolts grommets etc	16177	£0.60
C15	5	Mains slide switches ass	16178	£0.60
C16	20	Assorted tag strips and panels	16179	£0.60
C17	15	Assorted control knobs	16180	£0.60
C18	4	Rotary wave change switches	16181	£0.60
C19	2	Relays 6 — 24V operating	16182	£0.60
C20	1	Pak copper laminate approx 200 sq ins	16183	£0.60
C21	15	Assorted fuses 100mA-5 amp	16184	£0.60
C22	50	Metres PVC sleeving assorted size and colour	16185	£0.60
C23	60	½ watt resistors mixed preferred values	16188	£0.60
C24	25	Presets assorted type and value	16186	£0.60
C25	30	Metres stranded wire assorted colours	16187	£0.60

SLIDER PAKS

Pack No.	Qty.		Order No.	Price
S1	6	Slider potentiometers mixed values	16190	£0.60
S2	6	Slider potentiometers all 470 ohms	16191	£0.60
S3	6	Slider potentiometers all 10k lin	16192	£0.60
S4	6	Slider potentiometers all 22k lin	16193	£0.60
S5	6	Slider potentiometers all 47k lin	16194	£0.60
S6	6	Slider potentiometers all 47k log	16195	£0.60

CERAMIC PAKS

Containing a range of first quality miniature ceramic capacitors Unrepeatable value

		Order No.	Price
MC1	24 miniature ceramic capacitors 3 of each value — 22pf 27pf 33pf 39pf 47pf 68pf 82pf	16160	£0.60
MC2	24 miniature ceramic capacitors 3 of each value — 100pf 120pf 150pf 180pf 220pf 330pf & 390pf 270pf	16161	£0.60
MC3	24 miniature ceramic capacitors 3 of each value — 470pf 560pf 680pf 820pf 1000pf 1500pf 2200pf & 3300pf	16162	£0.60
MC4	24 miniature ceramic capacitors 3 of each value — 470pf 560pf 680pf 820pf 1000pf 1500pf 2200pf & 3300pf	16163	£0.60

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CARBON POTENTIOMETERS

SINGLE GANG with wire end terminations 6mm x 50mm plastic shaft 10mm bushes supplied with shake proof washer and nut Tolerance ±20% of resistance

LINEAR TRACK

Value	No.	Price
1K	1831	£0.22
2K2	1832	£0.22
4K7	1833	£0.22
10K	1834	£0.22
22K	1835	£0.22
47K	1836	£0.22
100K	1837	£0.22
220K	1838	£0.22
470K	1839	£0.22
1M	1840	£0.22
2M2	1841	£0.22

LOG TRACK

Value	No.	Price
4K7	1842	£0.22
10K	1843	£0.22
22K	1844	£0.22
47K	1845	£0.22
100K	1846	£0.22
220K	1847	£0.22
470K	1848	£0.22
1M	1849	£0.22
2M2	1850	£0.22

DUAL GANG. These high quality pots are fitted with wire end terminations 6mm x 50mm plastic shaft 10mm bushes supplied with shakeproof washer and nut Track tolerance ±20% but matched to within 2dB of each other

LINEAR TRACK

Value	No.	Price
4K7	1851	£0.68
10K	1852	£0.68
22K	1853	£0.68
47K	1854	£0.68
100K	1855	£0.68
220K	1856	£0.68
470K	1857	£0.68
1M	1858	£0.68
2M2	1859	£0.68

LOG TRACK

Value	No.	Price
4K7	1860	£0.68
10K	1861	£0.68
22K	1862	£0.68
47K	1863	£0.68
100K	1864	£0.68
220K	1865	£0.68
470K	1866	£0.68
1M	1867	£0.68
2M2	1868	£0.68

SINGLE GANG SWITCHED. Fitted with double pole on-off switches The switch action is incorporated within the rotary action of the pot Switch rating 1.5 amps at 250V AC

LINEAR TRACK

Value	No.	Price
4K7	1870	£0.48
10K	1871	£0.48
22K	1872	£0.48
47K	1873	£0.48
100K	1874	£0.48
220K	1875	£0.48
470K	1876	£0.48
1M	1877	£0.48
2M2	1878	£0.48

LOG TRACK

Value	No.	Price
4K7	1879	£0.48
10K	1880	£0.48
22K	1881	£0.48
47K	1882	£0.48
100K	1883	£0.48
220K	1884	£0.48
470K	1885	£0.48
1M	1886	£0.48
2M2	1887	£0.48

VEROBOARDS

DRILLED COPPER P.C.B.

.1 Pitch

Size	No.	Price
2.5 x 5"	2201	£0.46
2.5" x 3.75"	2202	£0.39
2.5" x 17"	2203	£1.42
3.75" x 5"	2204	£0.52
3.75" x 3.75"	2205	£0.46
3.75" x 17"	2206	£1.82
4.75" x 17.9"	2207	£2.34
2.5" x 1" (pack of five)	2208	£0.57

.15 Pitch

Size	No.	Price
2.5" x 17"	2209	£1.13
2.5" x 5"	2210	£0.42
2.5" x 3.75"	2211	£0.31
3.75" x 17"	2212	£1.51
3.75" x 5"	2213	£0.57
3.75" x 3.75"	2214	£0.42
2.5" x 1" (pack of five)	2216	£0.52

DRILLED PLAIN P.C.B.

.1 Pitch

Size	No.	Price
3.75" x 17"	2217	£1.18
3.75" x 2.5"	2218	£0.26
5" x 3.75"	2219	£0.42

.15 Pitch

Size	No.	Price
2.5" x 17"	2221	£0.78
3.75" x 17"	2222	£1.00
2.5" x 5"	2223	£0.26
2.5" x 3.75"	2224	£0.21
5" x 3.75"	2225	£0.36

VERO SPOT-FACE CUTTER
Order No 2231 Price £0.68

PLUGS AND SOCKETS

PLUGS

		No.	Price
P1	DIN LSP 2 pin speaker	1689	£0.08
P2	DIN 3-pin	1690	£0.12
P3	DIN 4-pin	1691	£0.16
P4	DIN 5-pin 180	1692	£0.14
P5	DIN 5-pin 240	1693	£0.15
P6	DIN 6 pin	1694	£0.20
P7	DIN 7 p.	1695	£0.20
P8	Jack 2.5mm screened	1696	£0.12
P9	Jack Plug 3.5mm plastic	1697	£0.10
P10	Jack Plug 3.5mm screened	1698	£0.15
P11	Jack Plug mono plastic	1699	£0.14
P12	Jack Plug mono screened	16100	£0.28
P13	Jack Plug stereo screened	16101	£0.32
P14	Phono	16102	£0.10
P15	Car aerial	16103	£0.16
P16	Coax free TV	16104	£0.16
P17	Right angle jack	16105	£0.12
P18	Jack 2.5mm plastic	16106	£0.12
P19	Jack stereo plastic	16107	£0.20
P20	Phono free screened	16108	£0.14
P21	DC 2.1 plug	16109	£0.12
P22	DC 2.5mm plug	16110	£0.12
P23	2-pin AC plug U.S. type	16111	£0.18
P24	AM aerial	16112	£0.13
P25	Cassette mains plug	16113	£0.15
P26	FM 300 ohms plug	16114	£0.13

INLINE SOCKETS

		No.	Price
IS1	DIN 2 pin speaker	1672	£0.10
IS2	DIN 3 pin	1673	£0.18
IS3	DIN 5 pin 180	1674	£0.17
IS4	DIN 5 pin 240	1675	£0.18
IS5	Jack 2.5mm	1676	£0.08
IS6	Jack inline 3.5mm	1677	£0.08
IS7	Jack ¼ mono plastic	1678	£0.14
IS8	Jack ¼ mono Chrome	1679	£0.28
IS9	Jack stereo plastic	1680	£0.20
IS10	Jack stereo Chrome	1681	£0.42
IS11	Phono screened	1682	£0.12
IS12	Car aerial	1683	£0.22
IS13	Coax television	1684	£0.1[illegible]
IS14	Coax back-back	1685	£0.40
IS16	2-pin AC connector US	1686	£0.21
IS17	Phono plastic	1687	£0.12
IS18	Back to back phono	1688	£0.24

CHASSIS SOCKETS

		No.	Price
CS1	DIN LS 2-pin loudspeaker	1652	£0.08
CS2	DIN 3	1653	£0.10
CS3	DIN 5-pin 180	1654	£0.10
CS4	DIN 5 pin 240	1655	£0.12
CS5	Jack 2.5mm	1656	£0.06
CS6	Jack 3.5mm	1657	£0.06
CS7	Jack Mono switched	1658	£0.15
CS8	Jack Stereo switched	1659	£0.18
CS9	Phono single	1660	£0.08
CS10	Phono double	1661	£0.10
CS11	Coax surface	1662	£0.21
CS12	Coax flush	1663	£0.25
CS13	Jack switched Mono	1664	£0.20
CS14	Jack socket DPDT switch	1665	£0.32
CS15	Car aerial	1666	£0.10
CS16	AC mains US type	1667	£0.16
CS17	Phono 4-way	1668	£0.16
CS18	D.C. power	1669	£0.18
CS19	AC switched	1670	£0.32
CS20	Phono 8-way	1671	£0.32

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R3 60 mixed ⅛w 10Kohms-82Kohms Order No 16215 £0.60

R4 60 mixed ⅛w 100Kohms-820Kohms Order No 16216 £0.60

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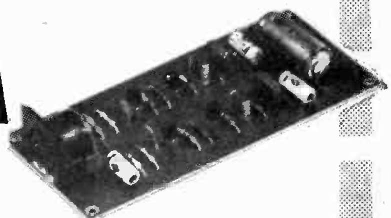
Supply required 20-30v at 90 Ma max.

MPA 30



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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

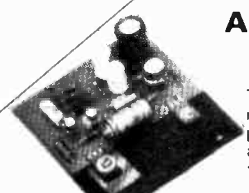
P.U. Input equalises to R1AA curve with 1dB from 20Hz to 20KHz. Supply — 20-35V at 20mA.

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 £10.70** 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

P.O. BOX 6, WARE, HERTS

SHOP AT 18 BALDOCK ST., WARE, HERTS
OPEN 9 to 5.30 Mon./Sat.

news digest

MOVEMENT IN THE STATIC FIELD

Looking rather like a toothbrush for 'Jaws', this device is actually a new method of cleaning L.P.s. The method it adopts is a cross between an anti-

static pistol and a record brush. In fact – it's both!

The piezo-electric cell is mounted in the handle, and ionisation takes place within the head cavity from a needle electrode. The makers say this loosens any dirt present, allowing it to be swept up onto the velvet pad by the brush.

In a field bristling with sweeping claims, this looks ion-clad! It will be shown at the Hi-Fi Exhibition at the Heathrow Hotel for the first time, is called the EARC and costs £11.50. *Sounds Professional, 49 Theobald St., Boreham Wood, Herts.*

A CHIP OFF THE OLE MPU

Fairchild have developed a one-chip version of their F8 MPU called the 'F8 Micromachine', aimed at low-cost and a wide range of consumer and industrial applications.

The Micromachine 1 will be available in sample quantities in April. Designated as the 3859, this circuit provides all the functions of the earlier two chip F8 system consisting of the 3850 CPU and the 3851 PSU (Program Storage Unit). The F8 Micromachine is aimed to provide the most effective solution for applications that can be accomplished with 1-kilobyte of memory. This covers a wide range of equipment such as home appliances, television tuning, video games, industrial and home heating, utility meters and thermostatic controls.

CLIPPING CHEATER WINGS (AND TICKETS)

EMI and GEC Elliot have a contract to develop a ticket inspection system for British Rail. Eventually it will be installed in 600 stations, if successful.

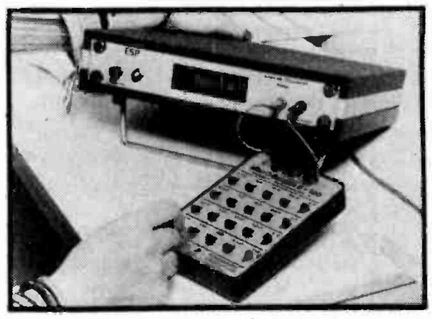
A pilot scheme is about to be run between Waterloo and Staines. Five stations will have the equipment installed as a test run. An automatic gate reads the magnetically encoded ticket checking date, type and destination, and decides whether to let you through or not, and whether to give you back the ticket. A Ferranti 16-bit MPU is around in there somewhere.

Ticket sizes will be standardised and season tickets may well become credit card sized, and even plastic perhaps. With this system BR expect to save the cost of the system eventually out of the £6M now lost to frauds.

USING ESP TO BOOST EXPORTS?

Lurking in the wilds or otherwise of Daventry is a new small company called Electronic Services and Products about whom we had heard some disturbing rumours. In these days of almost total British business pessimism they are apparently daring to *export* (whisper it softly) and export successfully at that.

The firm was started by three electronic enthusiasts who also happen, not coincidentally, to be brothers. Speciality is capacitance measurement, and ESP produce a range of automatic capacitance bridges. The photo below is of their 300 A, which possesses a range of 1 pF to 2000 μF. Autorang-



ing. Accuracy of 0.5%. Time taken to arrive at a measurement is about 1/10th that of the old (well-hated!) ratio bridges.

Exports are by far the largest part of their business, with France and Germany being the main customers.

The firm has plans to expand its field of interest soon, maybe into consumer electronics - although exactly how, they're keeping very much behind a screen at present. Plans on the lab side include an LCR instrument, with the same autoranging and identification facilities as the 300 A, and even a 'smart' component tester.

There is an unshakable air of optimism about the whole operation which must send the poker-faced prophets of impending doom running for their tombs, and provide a welcome fillip for our apparently ailing industry.

741 AND 741 AND 741 AND 741

A new four-in-one op amp is announced by Precision Monolithics Inc. The PM 4136 series provides four 741-type operational amplifiers in a single 14-pin DIP package. Each of the amplifiers has the SSS741 advantages of low noise, low drift and excellent long term stability. *Bourns (Trimpot) Ltd., Hodford House, 17/27 High Street, Hounslow, Middx., TW3 1TE.*

MOTOROLA A2D

The MC 14433B is a new 3½ digit A→D converter from Motorola. Both analogue and digital CMOS circuitry are present on the chip. It is designed to minimise the need for external components.

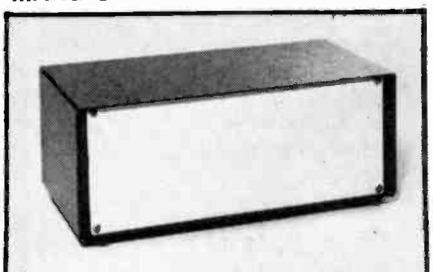
With two Rs and two Cs and a 14433B you have a dual-slope A→D converter with auto zero connection and polarity detection. *Motorola Ltd., York House, Empire Way, Wembley, Middx.*

A CASE FOR SERVICE?

Measuring 15 x 12¾ x 8 ins overall, the case is from the Industrial Division of Link-Hampson Ltd., 5 Bone Lane, Newbury, Berks. It is based on the Link-MK storage system.

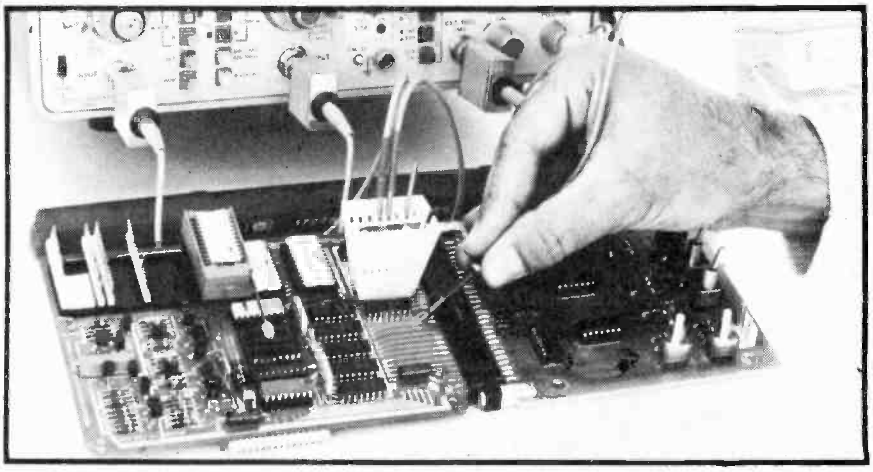
In addition to space for a selection of tools, the case contains 8 small, 3 medium and 1 large full-width drawers. Each is removable and with provision for dividing into two or more compartments. A strong carrying handle and side-straps are fitted. Price is £24.95 plus VAT.

...AND ONE 4 MODS?



West Hyde let loose another range of Contil-Mod cases this month, the 'Mod 4' range, starting at £3.33 inc. p.+p. (and feet!!). Assembly is simple, and follows the well-known Contil style. The cases are black with a white steel front panel. *W.H. Developments, Ryefield Crescent, Northwood, Middx.*

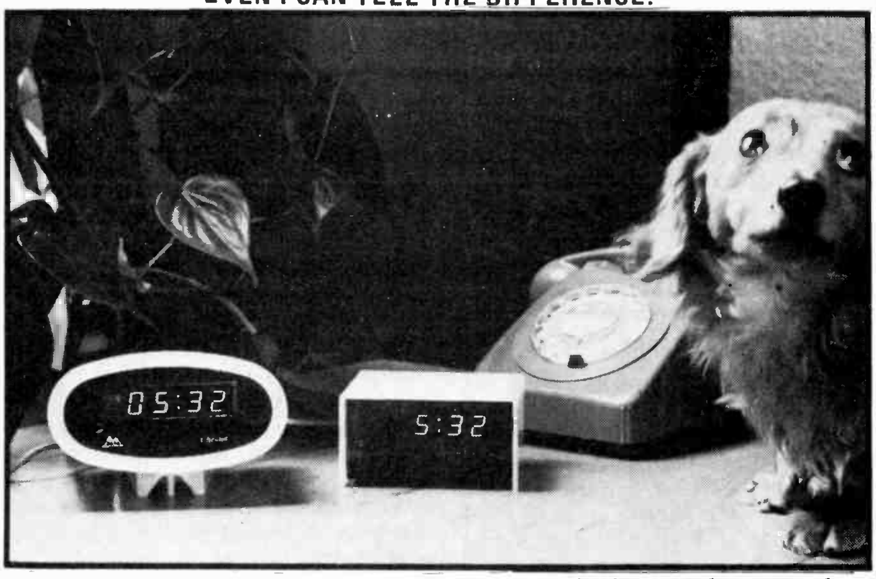
DIP-ING INTO PROBES



HP's solution to the problem consists of a clip that encompasses an entire DIP, and an accompanying set of demountable probes, believed the smallest yet commercially offered. The basic part of each probe can be inserted by itself into the DIP clip at any pin position; indeed, 15 of them can be inserted simultaneously into a DIP clip; one position is used with a grounding pin, so any pin on the DIP can be used as probe ground, holding lead inductance to a minimum.

The series includes high-impedance dividing probes suitably compensated for most oscilloscopes with input capacitances of 9 to 14 pF. 1:1 probes are also available. Each is offered with a choice of 1-metre or 2-metre length cable. The HP miniature divider probes are £70 each. 1:1 probes are £27. The companion 10024A IC Test Clip is £12.*Hewlett-Packard Ltd., King Street Lane, Winnersh, Wokingham, Berkshire RG11 5AR.*

EVEN I CAN TELL THE DIFFERENCE!



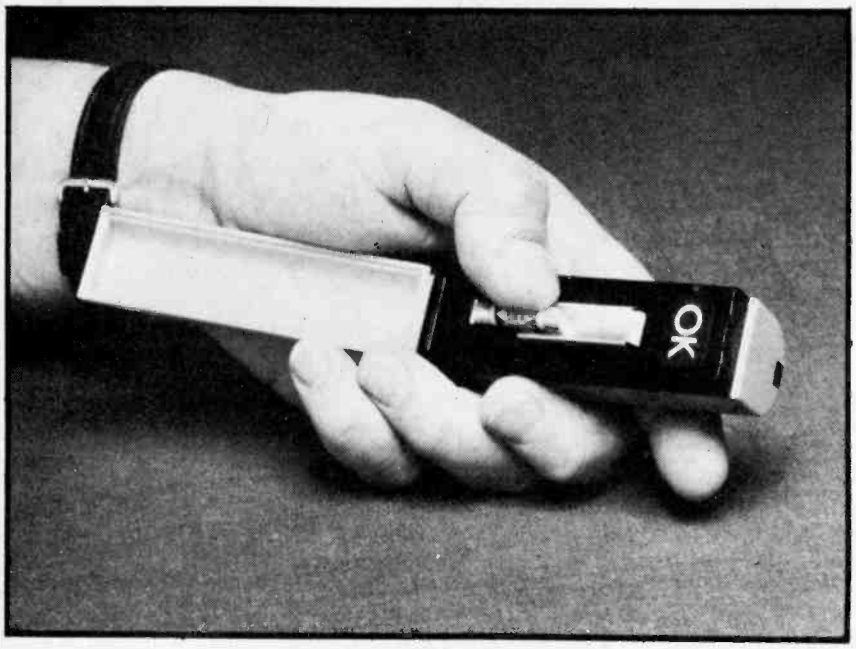
We were rightly collared over this. Last month we lead our readers astray by mixing up the photographs in the Metac advertisements. We had the oval clock where the rectangular kit should have been, and the kit where............. precisely.

We apologise for any misunderstanding and inconvenience this may have caused.

A VACUUM IN CAR LEDS

Chrysler have given the elbow to LED displays in their forthcoming car clocks. Instead Futaba will be supplying them with flourescent 0.3 in. blue-green displays, some 500,000 in fact, next year. The logical bits will be National.

DON'T FORGET DE-FUSE!



The first thing to check when a piece of mains equipment dies in its tracks is the fuse. Many an engineer has gone gibbering into a white coat with straps because he can't find the fault on a stubbornly inert heap of apparently perfect circuitry, while lurking in the plug is a burned out un-linking fuse.

Well, there is a very simple way of avoiding the farm, and it's called an 'MP4 Fuse Checker'. As you can see it's *really* pocket-sized, and gives a good clear indication if the thing is still a fuse as opposed to a piece of ceramic junk. Checks all fuses from 500 mA upward. To get one, write to: Moulds for Plastics Ltd., Watchmead, Welwyn Garden City, Hertfordshire, AL7 1AP. They'll charge you £1.25 all inc. for the privilege

QUARTZ CRYSTAL CRISIS

This time last year U.S. crystal manufacturers were busy ordering yachts and private jets on the strength of the huge shortages prevalent in the field. However, in the past year the worm has spun rather than turned, and sackcloth is now the order of the day. As usual the Japs are the culprits, and stiff imported competition has beached the yachts good and proper.

Prices have hit the bottom so hard, it is threatening to fall out, and watch companies are buying more and more from the land of the rising LCD.

Intriguing eh?

T.V. GAMES DUEL IN THE ROM.

Magnavox, who hold exclusively the Sanders original patent for T.V. games, have made a 'strong suggestion' to Fairchild and RCA that they cough up a license fee for producing their programmable T.V. games. Their claim is that their control extends to these games. So far Magnavox has trampled just about everybody else into the dust – perhaps Fairchild should hire Clint Eastwood to carry out the negotiations ... or play them 'T.V. Tennis' for it.

TAKING THE MAINS TEMPERATURE?

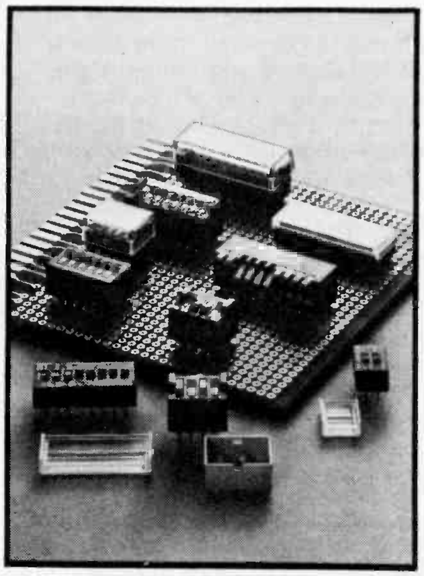
Designed for bench- or rack-mounted temperature measurement applications, the Model 7005 digital thermometer from Jenway has an operational temperature range from –75°C to 999°C with an accuracy of 0.1% of reading.

The Model 7005 has automatic cold junction compensation, and incorporates either three or four 14 mm gas discharge displays for clarity of temperature indication. The Model 7005 is housed in a rugged metal 96 mm din standard panel mounting case, and operates from an ac mains power supply at 110 V / 240 V 50 Hz. *Jenway Ltd., 26 Broomhills Industrial Estate, Rayne Road, Braintree, Essex.*

BOARD MEETING AT THE POLES?

The new DIP switches are designed for use on printed circuit boards where they should find application in counters, computers, test gear or any situation demanding a simple programming or switching function. Up to 10 single pole switches can be specified in a single module, all with self-cleaning, gold-plated contacts capable of handling 100 mA at 50 V dc.

The pole positions are clearly numbered on the body of the switch to facilitate easy setting. Dust caps and locking mechanisms prevent accidental operation. The switches can be used with sockets or soldered directly to the printed circuit board; the design is such that soldering cannot contaminate the contacts. *Contraves Industrial Products Ltd., Times House, Station Approach, Ruislip, Middx.*



MULL OVER TELETEXT HARD

Mullard will be shoving four dedicated teletext ICs onto the market in June. The chips are N-MOS, and are now being done in sample quantities. Numbered SAA 5020, 30, 40 and 50, and when coupled with 7 k of RAM and 3 standard TTL packs, they produce a fully Viewdata compatible decoder.

Meanwhile back in Texas...

Metac Digital Clock

SEND NO MONEY

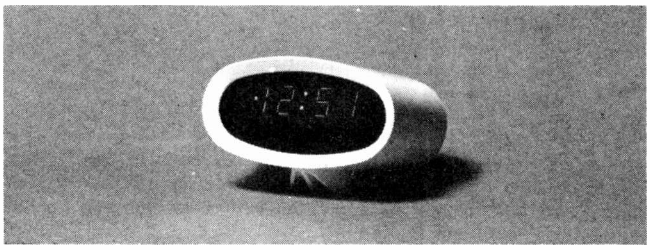
We will invoice you with the clock. Try it out for 7 days then send your payment or return the clock in original condition.

SAME DAY DESPATCH

Clock orders received before 2.00 p.m. are posted on the same day.

2 YEAR GUARANTEE

A commitment by us to repair or replace at our discretion any METAC clock failing to give satisfactory service for two years.



● Precise time-keeping accuracy. ● Solid-state long life reliability.

OUR PRICE COMPLETE **£13.95** **NO MORE TO PAY**

In choice of orange planar gas or soft green fluorescent digit displays. Green model has 24-hour readout. Orange model has 12-hour readout and AM/PM indicator. Both models have flashing second indicator, 24-hour bleeper alarm, 5-minute repeater, main failure indicator, 5" across x 3½" deep. Attractive white case. Thousands sold. Please state choice.

An electronic clock is silent and extremely reliable; because there are no moving parts it is impervious to dust or vibration and will continue to work indefinitely. Timing signals are derived from the 50 or 60Hz domestic electricity supply which in all the developed countries has to be held to very high levels of accuracy.

A bleeper alarm sounds until the clock is tipped forwards. The "snooze" facility can give you 5 minutes sleep before the alarm sounds again, and then another 5 minutes, etc., until you switch the alarm off.

An indicator on the display tells you if the alarm is set, another indicator tells you if it's in the 'snooze' mode.

This remarkable clock even tells you if the electricity supply has momentarily failed.

STOP PRESS our **UXBRIDGE** shop is now open. Visit Metac-Electronics, Time Centre

3 NEW ARCADE, HIGH ST., UXBRIDGE, MIDDX.

and see for yourself the full range of top quality watches, clocks and other consumer electronic products.

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ETI5

ETI PROJECT 804

MAKE YOUR TELEVISION WORK FOR ITS WATTS WITH OUR

TV GAMES UNIT

This low-cost yet sophisticated TV game contains just one main IC plus a handful of other components yet out-performs virtually all other units currently on the market.

SINCE THE ADVENT OF television games in this country, we have met with a steady tide of requests to produce a project for one ourselves. However, even with the higher integration allowed in CMOS chips, and no-one in their right minds would contemplate using TTL, it was still not viable for the home constructor. We were waiting for the single control chip to arrive on the open, as opposed to industrial, market.

At long last it has, in the form of the GI AY-3-8500, and so here is *our* version of a game utilising it. Figure 1 shows the kind of display produced by the chip, with its on-screen scoring facility and all. The games playable are:

1. PRACTISE: The ball reflects off the end and side walls, and the player has to stop it passing him. Every time it does, the machine scores a point.

2. SQUASH: A second bat is added to the display, and you play against each other. When it is your opponents turn, your bat will not affect the ball.

3. TENNIS: Television tennis is widely known and played, but see the specification section for the unusual features of our game.

4. FOOTBALL: The ball reflects off all four sides of the court, except the goal-mouth. This must be defended by the goalie to prevent the opposition scoring. In addition, each player has a forward on the screen, who acts as a normal bat when the ball is heading for his own goal, but allows the ball to pass through him, deflecting it in the process, when it is moving towards the opposite goal.

Rifling the screen

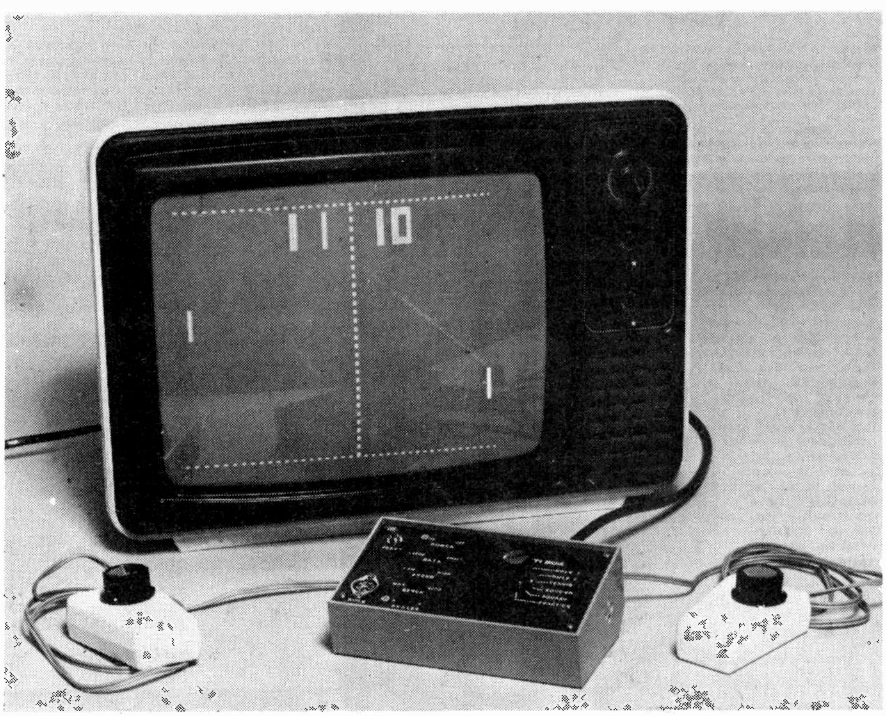
In addition, there are two rifle games included on the chip, but these need a special attachment to operate, which we are not including in this article (but will probably 'do up' later — especially if there is sufficient demand).

Some circuitry, additional to the main IC, in the form of two extra ICs, is required to build the basic game unit, but the complexity is still way way down on any other method of obtaining the same display.

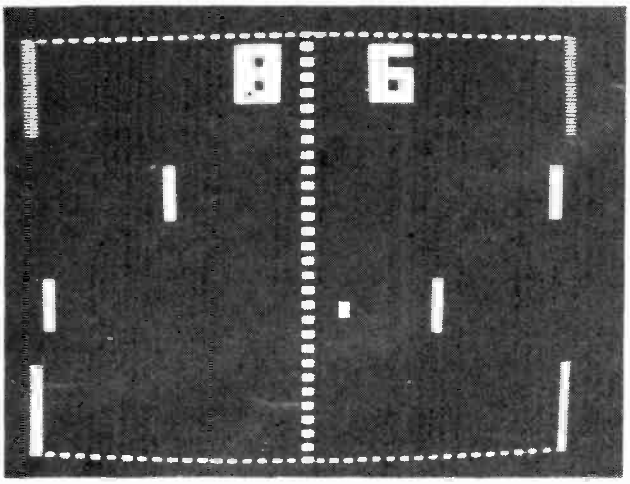
Construction

Assemble the pcb, fitting the passive components and links first, along with the socket to the main chip. Leave this in its packing until you need it. Handle the CMOS chips carefully, and when fitting these, either use sockets or solder the power supply pins (7 and 14) first.

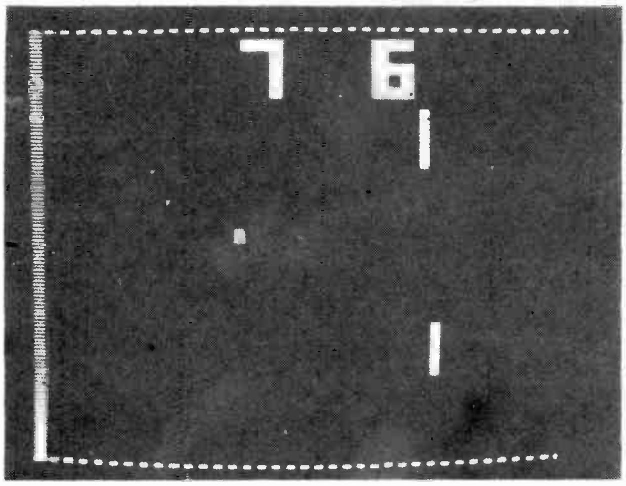
The switches will fit directly onto the board, and the rotary is



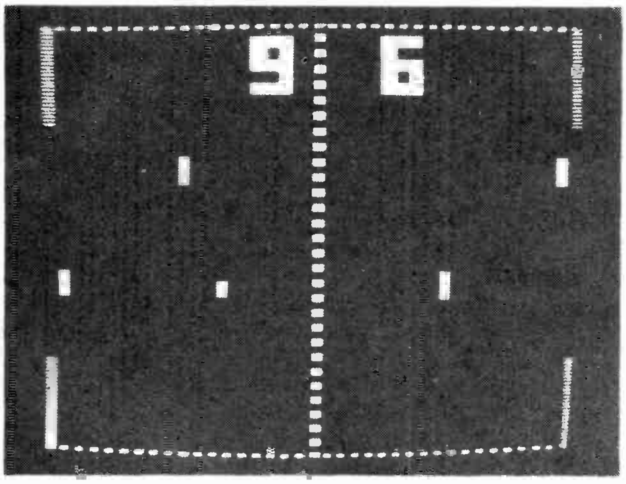
The finished unit positioned ready for use. The kit available from Maplin contains a ready drilled and printed box very similar although neater, in appearance to this.



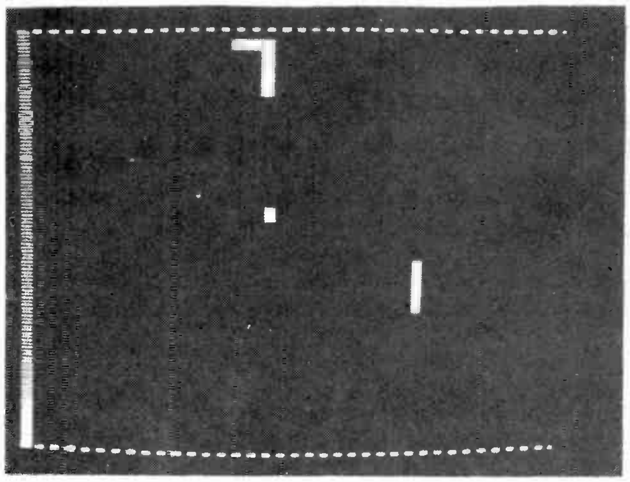
Soccer



Squash



Soccer with small bats



Practice

An illustration of some of the other displays produced by the unit. Note how much smaller the bats are on the soccer display — this facility is available on all the games.

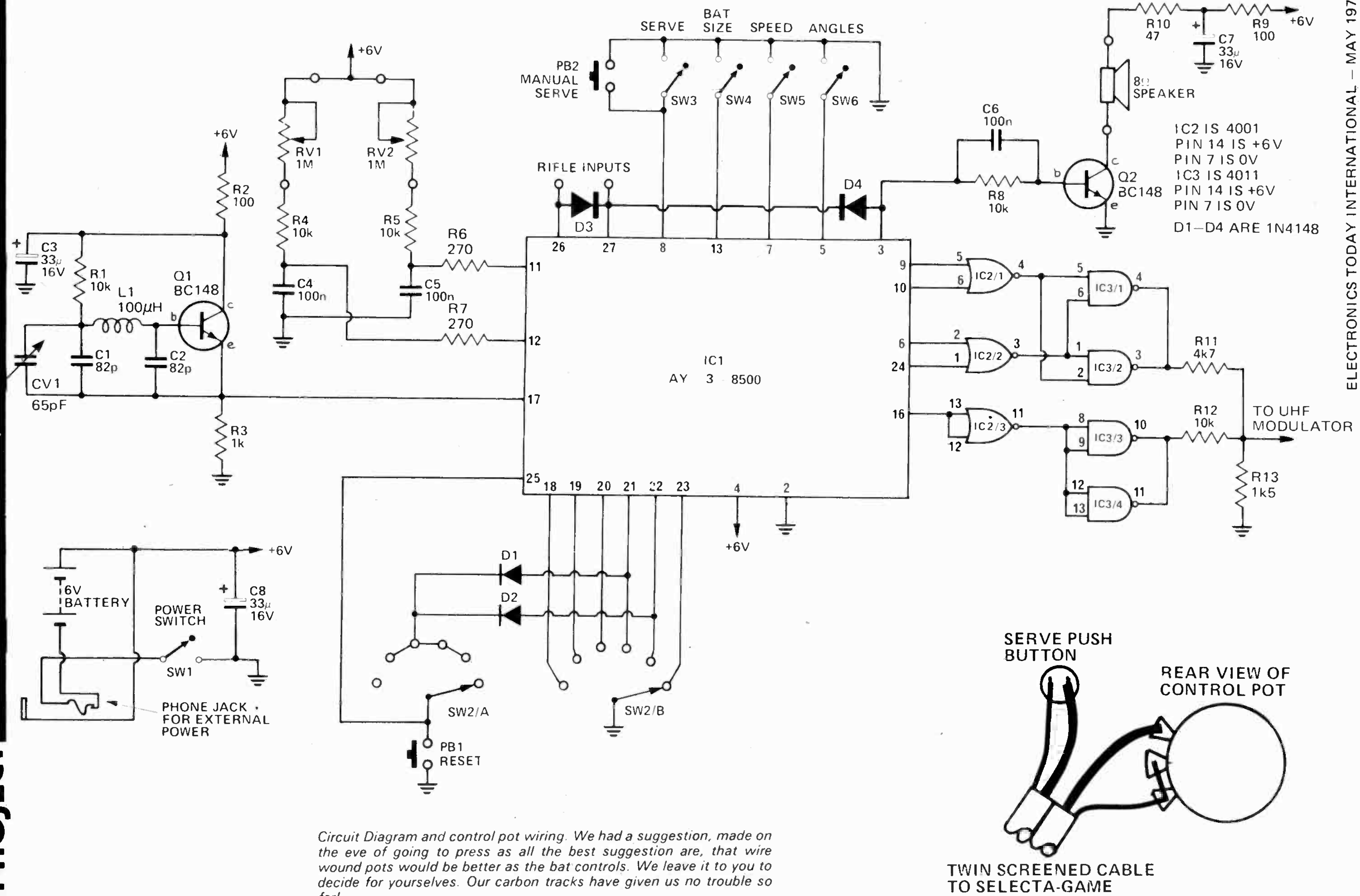
Specification

Output	**Picture: TV signal (can be set up on any channel).** **Sound: Three audio tones indicate hit, bounce and score.**
Players' Controls	**Each player uses a single rotary control to position his bat/men on the screen. In the practice game one control operates; for tennis, soccer and squash two players each have a control. For the rifle games a special rifle is needed (not described in this article).**
Game Selection	**Basic Games:** **1) Practice 2) Squash** **3) Soccer 4) Tennis** **Other Games (these cannot be played without a special rifle):** **5) Rifle–1 6) Rifle–2**
Scoring	**On-screen scoring up to a maximum of 15 points.**
Other Features	**Two ball speeds** **Two bat sizes** **Two angles ± 20°; or four angles ± 20° & ± 40°.** **Manual or automatic service**

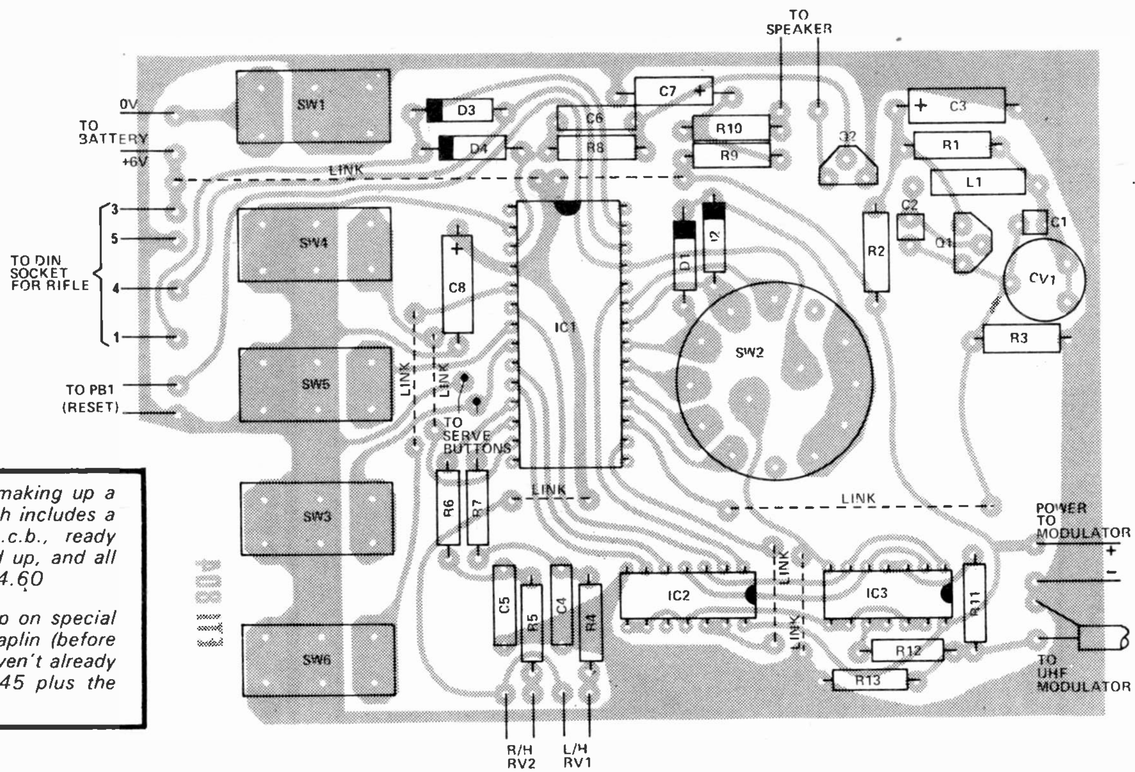
used to hold the board to the front panel, so check your soldering carefully here. Fit the link to the modulator, and the wires out to the hand-held Vero boxes which contain the control and serve button for each player. Push these out through the (hopefully grommeted) holes, tying a knot in each to make sure it doesn't strain the joint if pulled, and connect up the control boxes.

Once all the connections to the board are made, attach it to the front panel using the rotary switch, and two spacers on the switches for power and angle change.

If you use our kit from Maplin, the modulator is ready built, and there is no 'tuning up' to do. Simply bolt it in to the box through the hole provided, connect up power and video, and tune in a



Circuit Diagram and control pot wiring. We had a suggestion, made on the eve of going to press as all the best suggestion are, that wire wound pots would be better as the bat controls. We leave it to you to decide for yourselves. Our carbon tracks have given us no trouble so far!



Component Overlay for the T.V. game. Use UHF cable to connect up the modulator block to the board, and screened cable to wire up the hand-held boxes, connecting the screens and inners of the two "serve" wires to the pins in the center of the board.

Maplin Electronic Supplies are making up a kit of parts for this project which includes a ready assembled modulator, p.c.b., ready drilled box which is also printed up, and all components. All inc. price is £24.60

For those who obtained the chip on special offer at £8.99 all inc. from Maplin (before April 18th so be quick if you haven't already got one!) the kit price is £13.45 plus the voucher sent with the chip.

How it works

Unfortunately the manufacturers don't give much information on how the main IC works – we are only told how to use it. The chip is obviously a digital IC (because there are two ball speeds, the rebound angles are defined and there is no provision for variable speed or bounce).

A 2 MHz oscillator is required for the chip to derive the synchronising pulses required for line and frame synchronisation of the TV set. This oscillator is provided by Q1 and its associated components with CV1 providing calibration.

The bats are simply one megohm potentiometers connected as variable resistors which effectively vary the charging time of capacitors C4 and C5. The capacitors C4 and C5 are discharged by the chip at each frame sync pulse and the time taken to charge again (as set by the bat pot setting) determines the vertical position of the bats on the screen. The bat size, ball speed, deflection angles and serve are simply selected by connecting the appropriate pin of the IC to '0' volts.

Outputs from the chip are left and right bat, sync, ball, score and sound – all on separate pins. The bats, ball and score outputs are combined by IC2/1,2 and IC3/1,2 to produce a composite video signal. The sync pulse is buffered by IC2/3 and IC3/3,4. The sync and information pulses are then added by R11, 12 and 13. The sound output is buffered by Q2 to provide the power necessary to drive the speaker.

So that the game may be fed into the antenna terminals of a TV receiver the video signal must be modulated onto an RF oscillator

Parts List

RESISTORS all ½W 5%

R1	10 k
R2	100
R3	1 k
R4,5	10 k
R6,7	270
R8	10 k
R9	100
R10	47
R11	4 k 7
R12	10 k
R13	1 k 5

POTENTIOMETERS

RV1,2	1 M lin rotary

CAPACITORS

C1,2	82 p ceramic
C3	33 µ 16 V
C4,5,6	1 µ polyester
C7,8	33 µ 16 V

VARIABLE CAPACITOR

CV1	65 pF trimmer

TRANSISTORS

Q1,2	BC148

DIODES

D1 - D4	1N4148

INTEGRATED CIRCUITS

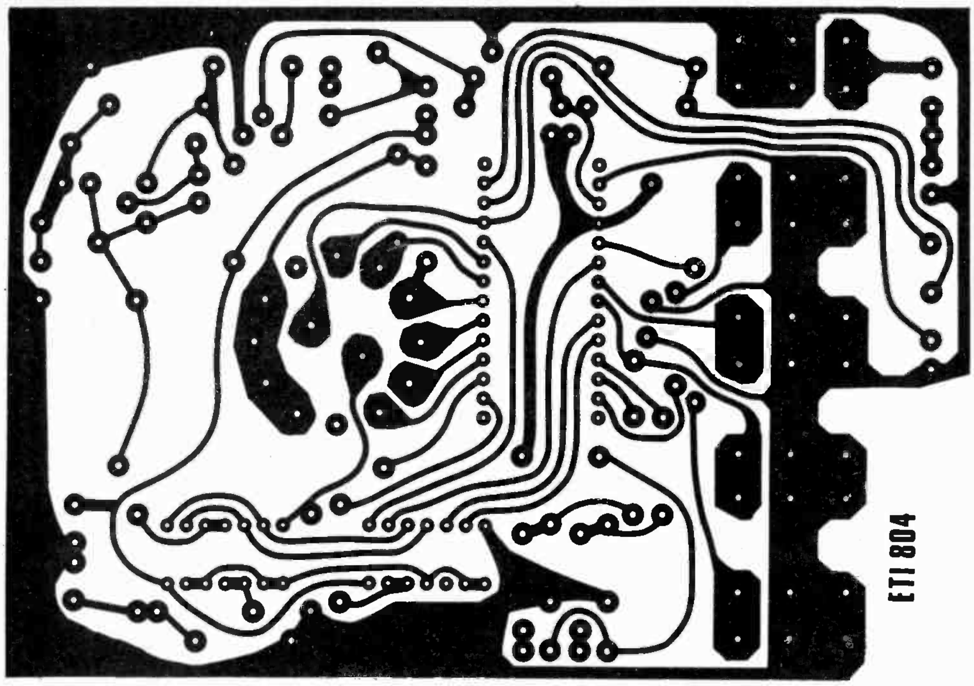
IC1	AY-3-8500
IC2	4001 (CMOS)
IC3	4011 (CMOS)

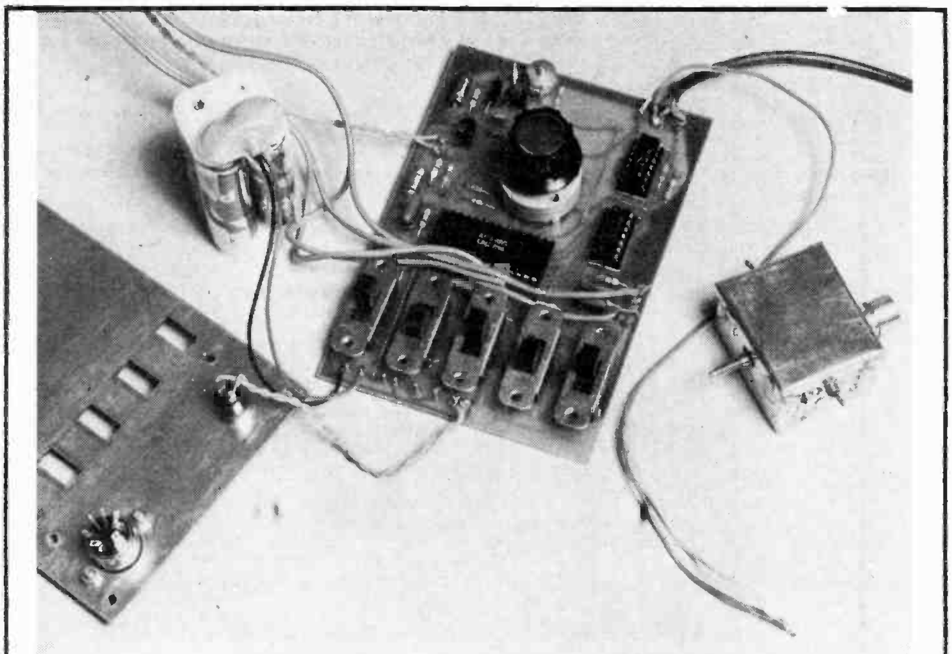
INDUCTORS

L1	100 µH

MISCELLANEOUS

pcb ETI 804
2 pole 6 position switch
5 slide switches
8 ohm speaker
3.5 mm jack socket
5 pin DIN socket type 'A'
3 miniature push buttons
3 knobs
1 box
2 small boxes
Single 6 V battery holder
28 pin IC socket





The "works" — just prior to connecting up the modulator. This is seen as the aluminium box on the right of the board. The 5 blank pins on the left of the board are for wiring to the rifle socket.

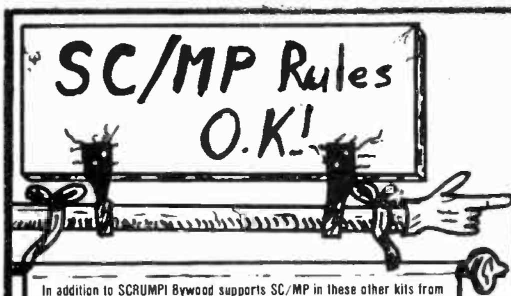
spare button on your TV to give a picture. Adjust C2 until the picture locks.

Use UHF cable to link board and modulator and box and TV Screened cable is all that is required to link control boxes and main unit.

Play the game

With the angles switch at '2', the ball moves at ±20 across the screen. When hitting the side boundaries the laws of reflection are obeyed. When the ball hits the bat this isn't always the case: a ball hitting the top half of the bat will leave with an upward trajectory, and downwards from the bottom half.

With the angles switch at '4' the game becomes much more awkward! The bat is now divided into four sections. Starting from the top, the ball emerges at an angle of +40 , +20 , −20 , −40 . If you think *that* is easy, try playing with small bats and high speed. ●



In addition to SCRUMPI Bywood supports SC/MP in these other kits from National Semiconductors—

INTROKIT: Eurocard PCB with SC/MP chip, 256x8 RAM.512x8 PROM (with KITBUG monitor). Xtal. TTY interface, etc. Requires +5,−12v supply. If you have access to a TTY machine then this kit is a great start in microprocessors. If you do not have access to a TTY then you may consider using NS'S new KBDKIT, replace the KITBUG PROM in an INTROKIT with the PROM supplied, add a few other components (supplied) and you have a portable microprocessor.

INTROKIT £66.33, KBDKIT £66.50

LCDS. National's Low Cost Development Kit for SC/MP. Uses a Hex keyboard and digital display or a TTY to communicate with the 2K monitor programs in PROM. The CPU application card supplied plugs into one of the sockets on the main mother PCB. Additional PROM and RAM application cards are available to allow expansion up to its full 64K capacity. RUN/STEP/HALT run modes allow for simple debugging.

Low Cost Development System £349.30

BITS & PIECES

MM2112-2 256x4 RAM	£4.30
MM2102-2 1Kx1 RAM	£2.95
2513 ASCII char gen ROM	£9.00
DM8678 9x7 char gen + PISO	£15.20
DM8095 6 bit buffer (Uni-Di)	£1.90
DS8833 4 bit buffer (Bi-Di)	£2.10
SC/MP Microprocessor chip	£14.50

74C00 SERIES CMOS

74C00	25p	74C04	25p
74C10	25p	74C42	200p
74C157	200	74C163	130p
74C164	110p	74C165	115p
74C173	100p		

Power Supply P297 (+5,−5, −12) Kit form £11.50

Floppy disks SA400 Minifloppy £495.00

Floppy disks SA800 Standard £625.00

BOOKS AND DATA

SC/MP Technical Description	£1.95
SC/MP Programmers Guide	£6.30
SC/MP Applications Guide	£2.95
SCRUMPI Data Sheets	£0.75
F8 Data (Xerox)	£0.75

All prices exclude VAT at 8%

Don't let the grass grow under *your* feet!

SCRUMPI Bywood's Evaluation Kit for the SC/MP Microprocessor chip

Kit contains—

SC/MP MPU 40 pin DIL IC,
256 x 8 bit RAM chips,
2 four bit I/O latches,
24 LED lamps and drivers,
16 Data and Control switches,
PCB, IC sockets, cable, caps,
Resistors, etc. Requires simple Power Supply.

The switches allow you to enter a program into the RAM and then exec that program, several operating modes allow for ease of testing. SCRUMPI can be extended to address up to 64K bytes and can be inter-faced to ROM, PROM, RAM, EAROM or many types of I/O device. SCRUMPI can also be used to replace a SC/MP in another circuit to give full in-circuit testing facilities.

SCRUMPI KIT £64.81 plus VAT

LATEST ADDITIONS

FLOPPY DATA. Set of manuals for SA 400 Mini-Floppy, includes circuit diagrams, interface circuits, timing data, etc. Set **£8.00** (No VAT).

DM81L597 8 bit Tri-State Buffer **£1.60**

CLOCK CHIPS & KITS

TYPE	SPECIAL FEATURES	£CHIP	£KIT
MM5309	7seg + BCD. RESET ZERO	6.50	8.80
MM5311	7seg + BCD	6.50	8.80
MM5312	7seg + BCD 4 DIGIT ONLY	5.65	
MM5313	7 seg + BCD	6.50	
MM5314	7seg + BASIC CLOCK	4.88	7.00
MM5315	7 seg + BCD REST ZERO	£6.50	
MM5316	Non-mpx ALARM	10.17	
MM5318	7seg + BCD External digit select	4.50	8.00
MM5371	ALARM. 50Hz	10.15	
MM5377	CAR clock. Crystal control. LCD	8.40	
MM5378	CAR clock. Crystal control. LED	7.55	14.00
MM5379	CAR clock. Crystal control. Gas discharge	7.55	
MK5025	ALARM. SNOOZE	5.60	9.00
MK50395	UP/DOWN Counter — 6 Decade	12.10	15.10
MK50396	UP/DOWN Counter—HHMMSS	12.10	15.10
MK50397	UP/DOWN Counter—MMSS.99	12.10	15.10
FCM7001	ALARM. SNZ. CALENDER. 7seg	9.00	12.50
FCM7002	ALARM. SNZ. CALENDER. BCD	9.00	
CT7003	ALARM. SNZ. CALENDER. Gas discharge	9.00	
FCM7004	ALARM. SNZ. CALENDER. 7seg	9.00	12.50
AY5.1202	7seg. 4 digit	4.76	
AY5.1230	7seg. ON and OFF ALARM	5.25	TBA

All above clock kits include clock PC board, clock chip, socket and CA3081 driver IC. MH15378 also includes crystal and trimmers. When ordering kit, please use prefix MHI, e.g. MHI 5309.

OLDE CLOCKS

In kit form or built these clocks are based on designs hundreds of years old. Wood stone and iron are used to reproduce authentic "olde worlde" wall clocks in full detail. The kits contain all you need including glue, screws, etc. and very comprehensive instructions. Stones for weights are excluded.

PRICES		KIT	BUILT
Gothic Clock	Diam 6½"	26.95	42.00
Rotating Dial	Diam 6"	23.50	39.50
Wrought Iron	Diam 5½"	54.25	79.95
Wooden Wheel	Diam 6½"	36.95	52.00
Knight Clock	7½"	48.50	77.50
Oak Foliot	Diam 14"	123.95	145.00

For coloured brochure please send 15p stamps

DISPLAYS

		Litronix class 2 product	
DL707, 704, 701 0.3"	1.48	DL707E	0.70
DL727, 728, 721 0.5" (2 dig.)	3.75	DL727E (2 dig)	1.80
DL747, 750, 746, 0.6"	2.45	DL747E	1.50

MHI DISPLAY KITS

MHI707/4 digit 0.3"	6.60	MHI707E/4	3.50
MHI707/6	9.50	MHI707E/6	4.50
MHI727/4 0.5"	8.50	MHI727E/4	4.50
MHI727/6	12.00	MHI727E/6	6.00
MHI747/4 0.6"	9.80	MHI747E/4	6.00
MHI747/6	14.70	MHI747E/6	8.10

Any one or two of the above MHI display kits will interface directly with any of the MHI clock kits.

CASES (with perspex screen)

VERO 1. 8" x 5½"x3"	3.00
VERO 2. 6"x3¼"x2¼"	3.00

SOCKETS

24, 28 or 40 pin	0.60
Soldercon strip skts, 50 pins	0.30

CLOCK MODULES

MA1002F (12Hr) or MA1002H (24Hr) with Alarm

Module only	7.97
MTX1001 transformer	0.90
Kit including case	13.00

PAYMENT TERMS

Cash with order, Access, Barclaycard (simply quote your number). Credit facilities to accredited account holders. 15% handling charge on goods ordered and paid for then cancelled by customer.

All prices exclude 8% VAT

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The challenge of I²L

I²L is being used for mass production of LSI ICs, but little has been said about the theory behind this new technology.
In this article Brian Dance explains how it works...

A FEW YEARS AGO THERE WAS one principal technique used in the manufacture of logic circuits, namely TTL or Transistor-Transistor Logic. Devices using this technology have the advantage of being able to switch very quickly, but they are not suitable for applications like electronic watches where the logic circuits must consume very little power and occupy the minimum possible area on the silicon chip.

The development of the Complementary Metal Oxide Semiconductor technology known as CMOS (or COS/MOS) by RCA about 1970 provided devices which have an extremely high component packing density on the silicon chip and which operate at a very low quiescent current. The complementary MOS field effect transistors used in CMOS devices take appreciable current only for the time taken to switch logic states. Silicon-on-sapphire is a variation of the basic CMOS technology which offers relatively high speeds of operation, but at the present time such devices are expensive to manufacture.

I²L

Integrated injection logic or I²L now provides serious competition to CMOS circuits where minimum current and high component packing density is required. Devices using I²L circuitry can be produced very economically and the speed of operation rivals that of TTL.

This new technology is being used by some of the major semiconductor manufacturers for products ranging from microprocessors to quartz-controlled electronic watch devices. All I²L devices are large scale integration LSI products — they contain a very large number of components on a single silicon chip.

I²L was developed quite separately (in Europe) by Philips and IBM around 1972. It employs bipolar devices (that is, devices like conventional transistors rather than FETs) in circuits which have been derived from the early DCTL (Direct Coupled Transistor Logic). It is only quite recently that developments in the I²L production processes have made this circuit technique economically attractive.

A DCTL circuit is shown in Fig. 1. Three transistors are shown in each of the three NOR gates with the output of Gate 1 feeding one of the inputs of both gates 2 and 3. Other connections, which are not shown, are made to the other inputs of the gates. Circuits of this type were used in simple SSI (small scale integration) devices, but suffered from the disadvantage that the current was unequally divided among the transistors in any one gate owing to minor differences in their base-emitter voltages. In addition, the load resistor had to be separated from the transistors and this used up a considerable area of the chip.

Note that in the circuit of Fig. 1 there are direct connections between corresponding regions of the transistors: all of the emitters are joined together, whilst the two bases which are driven from the collectors of gate 1 are common. The current to these bases passes through the load resistor of the gate 1 circuit. In an I²L circuit, these common electrodes share the same area on the chip.

A cross section through an I²L gate is shown in Fig. 2 and the circuit is shown in Fig. 3. A single pnp transistor is employed as a current source to supply current to many transistor bases without the use of a load resistor. The whole of the emitter region is a

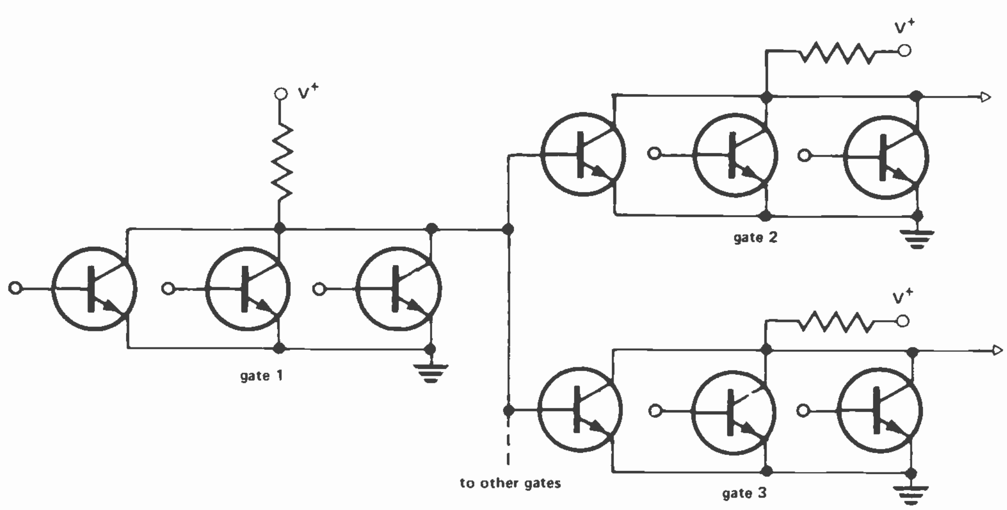


Fig. 1. A Direct Coupled Transistor Logic circuit (DCTL).

The challenge of I²L

common one beneath the surface structure on the chip. This eliminates the need for surface metallisation for each separate ground connection. In addition, the area required per transistor is greatly reduced. IBM initially used the name Merged Transistor Logic (MTL) instead of I^2L.

It should be noted that the pnp transistor is formed laterally along the surface of the silicon chip. The other component is a multi-collector npn transistor characteristic of I^2L devices. However, this npn transistor is formed vertically in the silicon. The n-type epitaxial layer acts as the grounded emitter of the npn transistor and also as the grounded base of the lateral pnp device. The p-type base of the multi-collector transistor also serves as the collector of the pnp device. Thus the two devices do not exist as separate structures.

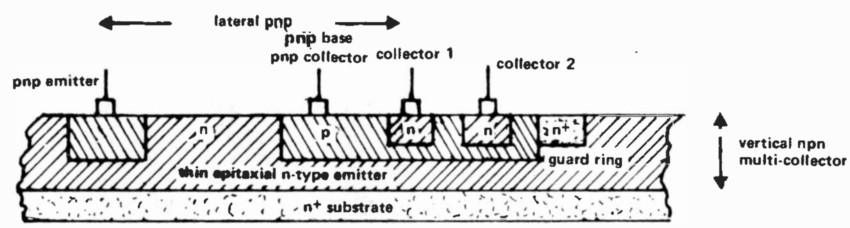


Fig.2. Cross section through an I^2L gate.

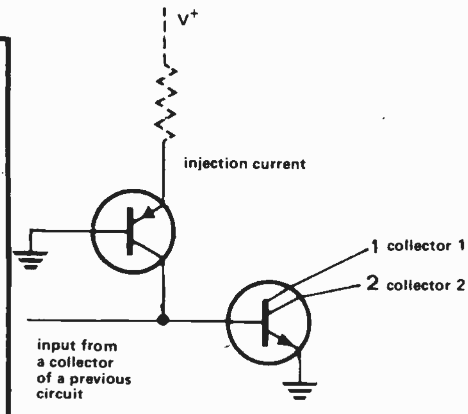


Fig.3. The circuit represented by the I^2L gate shown above in Fig.2.

Injection

The pnp transistor 'injects' current into the base of the multi-collector transistor — hence the name Integrated Injection Logic. Current from a current source (not shown in Fig. 3) passes to the emitter of the pnp transistor and hence to the collector. Switching of the logic state occurs when this current is switched to or from the base of the multi-collector transistor.

If the input at the base of the multi-collector transistor is low (less than about +0.7 V), this potential will be inadequate to overcome the natural forward junction potential of the npn base-emitter junction and the npn device will be non-conducting. The injected current will flow out of the input connection to the collector of the previous circuit (not shown in Fig. 3). The multi-collector transistor outputs will therefore rise to the 'high' logic level, this voltage being determined by the collector circuitry.

If the input voltage now becomes 'high' (that is, over +0.75 V), the npn transistor will be biased to saturation and the output of the collector will be 'low'. This low value can be about 0.02 V. Thus the change of the logic level is represented by a voltage swing of around 0.7 V.

Power Supply

The positive power supply line of I^2L circuits is connected only to the emitters of the pnp injection transistors. The base of these transistors is earthed, so the I^2L circuit as viewed from the power supply line is effectively just a forward-biased silicon diode. The total power supply current is therefore the sum of the currents fed to the injection transistor emitters.

The voltage levels in I^2L circuits can be very low; indeed, such circuits can operate from a supply of 0.85 V upwards. The supply current per gate can be very low (about 1 nA), but the injected current can be increased in value up to about 1 mA to permit switching of the circuit at a much higher speed.

Although the I^2L circuits can operate at such low voltages, the input and output circuits normally included in the same package require a higher supply voltage and their requirements normally determine the operating voltage of the whole device. A series voltage-dropping resistor is used in the power supply line of some I^2L devices, whilst other devices incorporate a voltage regulator on the chip to eliminate the need for an external resistor.

The use of an internal regulator circuit also enables various injector current levels to be obtained at different points in the circuit so that each part can operate at the minimum power level for the switching speed required by that particular part. For example, the fast frequency dividing circuits of a quartz controlled watch can operate at a high injection current for a satisfactory performance at 32 kHz, whereas the following frequency dividing circuits operating at a low frequency can use lower injection current levels. The increased cost of fabricating such circuits may be well worth while when current consumption must be minimised.

In many applications a single dry cell can be an ideal power source for I^2L circuitry.

A guard ring of n+ material (shown in Fig. 2) is required in I^2L devices to reduce cross-talk between adjacent gates. However, this ring can touch the base of the npn device and it occupies little surface area.

Gates

I^2L gates can be made by "wire-ORing" the isolated collector outputs as shown in Fig. 4. Similarly NAND gates can be made by using the multiple collector outputs of the npn transistor connected as shown in Fig. 5.

Input/Output Circuits

I^2L is almost always used in conjunction with other circuitry. The voltage change when an I^2L circuit switches is only about 0.7 V at current levels which may be very low. If the inputs and outputs of the I^2L circuits were brought out directly to external connecting pins, any small stray noise pulses or interference picked up by the circuit would be likely to trigger the I^2L circuitry, owing to its great sensitivity to low amplitude pulses.

Buffer interfacing circuits are therefore used between the input and output connections of a device and the I^2L circuitry itself. A typical input buffer which can accept TTL input pulses and convert them into pulses suitable for the operation of an I^2L circuit is shown in Fig. 6. The input buffer circuit used with some of the older logic systems can be even simpler.

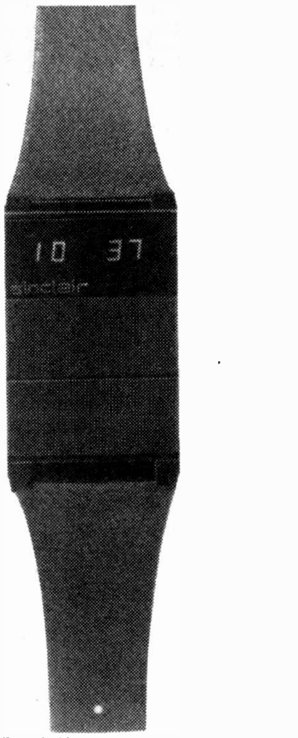
Discovery of I^2L

The discovery of I^2L is quite a story in itself. Horst H. Berger and Siegfried K. Wiedmann of the IBM Boeblingen Laboratory in Germany reported on their MTL (or I^2L) circuitry at the International Solid State Conference in Philadelphia in February 1972. However, the next paper at the Conference was by Cornelius M. Hart and Arie Slob of Philips Research Laboratories of Eindhoven, in which they disclosed details of their I^2L circuits.

The IBM workers produced their circuit designs after a long, but rational, effort. On the other hand, the Philips workers evolved their basic ideas within a few days in what was essentially a flash of inspiration. Within three months the Philips Laboratories were producing large scale I^2L chips.

Hart and Slob saw I^2L from the physicist's point of view in which minority carriers from a p region were injected into an npn device in order to solve the problem of the high current and large limiting resistors required with conventional bipolar logic. On the other hand, Berger and Wiedmann saw their circuits from the point of view of a circuit designer in which the individual devices on a chip were merged together.

The Philips organisation produced a pocket calculator using I^2L technology as early as 1971. It contained over 1000 gates in an area of 4x4mm. Even in the first I^2L chips, the elimination of the physically large resistors and the thermal dissipation in these resistors showed the main advantages of I^2L technology. Each logical operation required about one picojoule of energy; this may be compared with the estimated value of 0.2 picojoule required to operate the logic cells (the "neurons") of a human brain.



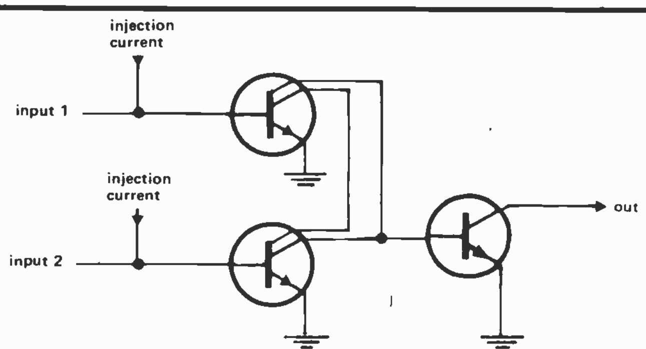
The Sinclair Black Watch was one of the first commercial applications using I^2L.

I^3L

The symbol I^3L is a trade mark used by the Fairchild Company for their Isoplanar Integrated Injection Logic technology. It is employed in such products as the Fairchild 9408 microprogram sequencer which controls the order in which micro-instructions are fetched from a control memory having up to 1024 words; it is fully compatible with TTL devices.

Applications

I^2L devices are used in such applications as electronic games, frequency synthesisers, microprocessors, high speed calculators, computer interfaces, counters, timers, telephone switching, tone generators, electronic organs, remote control systems for TV sets, analogue to digital converters, digital voltmeters, vehicle anti-skidding, fuel injection control, etc. In Europe it can be used in the "Teletext" and "Viewdata" decoders.



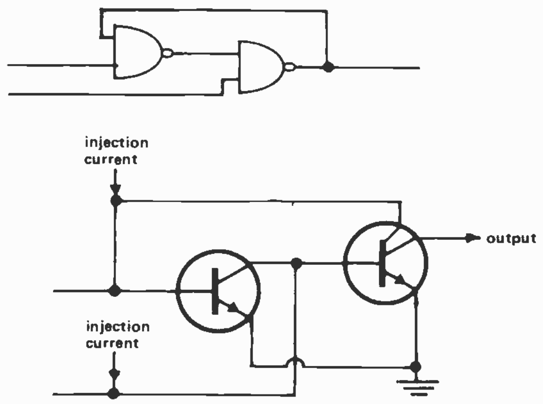


Fig.4. (above). I^2L gates can be made by 'wire-ORing' the isolated collector outputs.
Fig.5. (right). NAND gates can be made by using the multiple collector outputs of the npn transistor.

An output buffer circuit which can amplify the low voltage pulses from the output of an I^2L circuit and provide enough current and voltage to drive a TTL input is shown in Fig. 7.

Technology Comparison

An I^2L gate can be made with what is effectively a single component on a chip area about one tenth of that required for a normal three-component CMOS gate. In addition, I^2L is one of the most economical technologies used in device fabrication, since the number of masking and diffusion operations on the silicon slices are less than in most comparable techniques.

One of the advantages of I^2L technology is that it is so very similar to that of other standard linear and Schottky TTL manufacturing processes that it is easy to fabricate other types of component on the same chip. For example, light emitting diode driver circuits can be built on the same chip as I^2L circuitry; this enables a single chip to be used to drive the display of a watch or a calculator as well as to carry out the required logic operations. Operational amplifiers, oscillators, voltage regulators, etc. can be fabricated on chips containing I^2L circuitry.

The CMOS process is essentially

The challenge of I²L

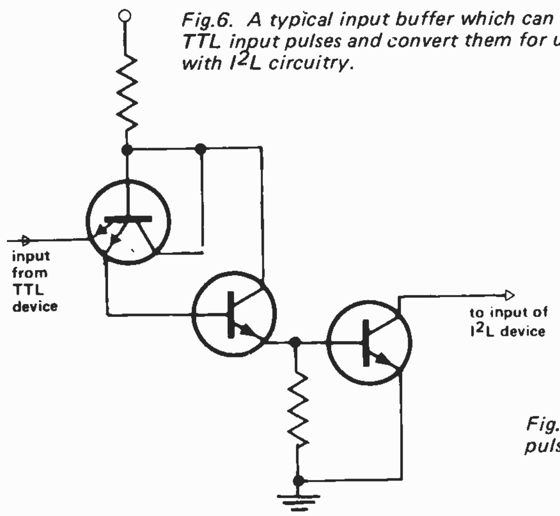


Fig.6. A typical input buffer which can accept TTL input pulses and convert them for use with I2L circuitry.

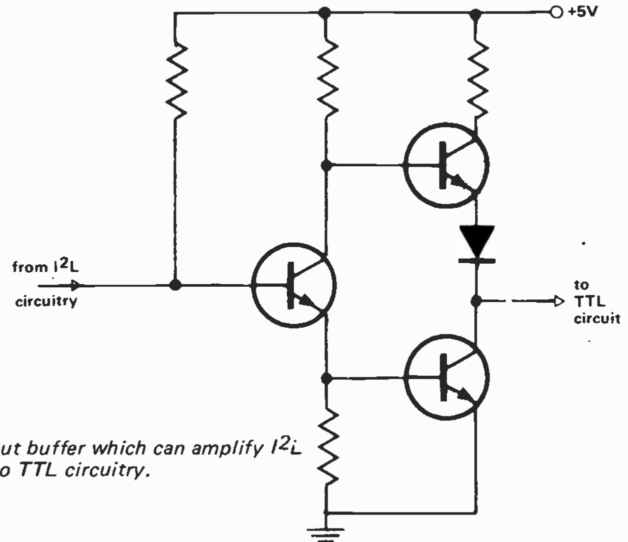


Fig.7. An output buffer which can amplify I2L pulses to feed to TTL circuitry.

suitable only for the production of purely digital devices, although simple devices such as transistors and diodes can be fabricated on the chip. In contrast, Schottky TTL devices can be combined with I2L circuits on a single chip to produce products which are faster and which have higher component densities than can be achieved in other ways. The Texas Instruments SN74S201 and SN74S301 256 bit random access memories are examples of such products.

The power consumption of I2L circuits increases linearly with the speed of operation required and in practice you can use the minimum injection current required for maximum speed at which the circuits will ever operate. CMOS circuits consume very little power in the quiescent state, but the power required increases with the switching speed. Thus no circuit adjustments or settings need be made if minimum power consumption is important and the maximum operating speed is always available. In other words, CMOS circuits always consume minimum power at low operating speeds, but have a high speed capability "on demand" whereas I2L circuits must be adjusted for low power or high speed or some intermediate value of power consumption and speed.

I2L is faster than CMOS, whilst Schottky-clamped I2L is even faster still. The silicon-on-sapphire version of CMOS is another way of obtaining faster logic devices, but emitter coupled logic (ECL) offers the highest speed at the expense of ease of use.

The susceptibility of I2L devices to noise pulses has already been mentioned. CMOS devices require input pulses with an amplitude of about half the supply voltage used and are therefore very resistant to spurious operation by stray noise pulses. It is difficult to see how future I2L can be fabricated without input and output buffer circuitry because of the noise problem.

A comparison between the various logic systems is given in Table 1.

Table 1. A Comparison of TTL, CMOS and I2L

Type of logic	Packing density (Gates/mm^2)	Typical Quiescent dissipation per gate	Typical Dissipation per gate at 1 MHz	Logic voltage swing
I2L	140 to 220	5 nW	100 µW	0.7 V
CMOS	70 – 80	5 nW	150 µW	Varies with supply voltage
TTL	20	10 mW	10 mW	3.5 V

Applications

I2L is employed in a wide range of applications which require large scale integration. It is unsuitable for making devices with only a few gates, so it seems most unlikely that simple I2L logic devices will become available (like those one meets using CMOS and TTL technologies).

I2L devices are expected to have a wide range of applications in the computer field. Although most of the larger semiconductor manufacturers are considering whether to become involved in I2L device manufacture, a few (such as Texas Instruments) are already producing devices in quantity. The SBPO400, for example, is Texas' 4-bit parallel binary processor element in I2L. I2L computer and microprocessor devices satisfy fairly high speed requirements, but they meet competition from fast versions of CMOS and silicon-on-sapphire devices.

I2L technology is likely to be used in many consumer applications where its relatively low price is a vital factor. ITT are already producing their ITT 7170 device in England for the Sinclair "Black Watch" which is a very economical product. The 7170 chip incorporates over 2000 transistors on a piece of silicon only 3mm by 3mm in area. It is used in the first watch to incorporate all of the circuitry on a single chip, since I^{2}L can offer the high drive current for the LED display (whereas CMOS devices must be used with separate display-driver devices). The frequency of the quartz-controlled oscillator used in this watch is 32.678 kHz. Current consumption without the display is 159 μA. The display operates on demand and naturally requires a greatly increased current from the batteries to produce the emitted light.

The Exar Company of California also produce a watch using I^{2}L logic.

Cameras

Another consumer field in which I^{2}L seems destined to play an important part is in the electronic control of camera shutter speeds. Conventional electronic shutter devices consume a current from the battery in the camera whenever they are switched on, but I^{2}L devices can be operated on the current from a photocell. Unfortunately a battery is required in such cameras to actually operate the shutter magnets, but the time for which the battery current is required is very small and hence new cameras employing I^{2}L devices will have a much longer battery life than other types.

One camera circuit is made by Micro Components Corporation in Cranston, Rhode Island, USA. The I^{2}L circuit operates as a light to frequency converter to produce an output of 100 Hz to 1 MHz, linearly related to the intensity of the incident light. This signal drives a ring oscillator made from I^{2}L transistors which determines the shutter speed. The whole device is mounted in a clear plastic package consuming some tens of nA. The Matsushita Company of Japan are also working in this field using I^{2}L.

Another consumer example of the use of I^{2}L, is the Motorola three-chip logic synthesiser for digital tuning of car radios. The devices can scan the band and make the tuning lock the required frequency.

Conclusion

In the end the challenge any new technology must meet if it is to be successful is either (i) it must perform tasks which competitive techniques cannot accomplish or (ii) it must perform a task more economically than other technologies. I^{2}L can't do much that can't be done in other ways. However, in certain applications, it can be very cost effective. This criterion will determine in which applications it will be employed in the future. ●

PART 3

ELECTRONICS IN THE YEAR 2000

EVOLUTION OR REVOLUTION

By Peter Sydenham

In this third part, we take a look at the communications systems of the future. These may well include systems which are totally new, not simply extensions of our present methods. These include gravity waves and even ESP.

MAJOR CHANGES THAT COME about in our lifestyle and attitudes are usually the result of basic needs being recognised by some agency that has the resources to bring such changes about. We begin to use new products of technology when both the need emerges and the technological availability to fulfil it is available. Progress can come from either direction: either as technology developed to meet a big enough need or a need being exploited because a new technology has become available. In both instances our society has generally, in the past, helped this process where economic or political gains are to be had. Not all developments are as good as they are promoted to be and many excellent concepts fail to catch on because the cost expended cannot be regained. In too many instances the quality of the promotion given to a new device or technique is the key to its acceptance. In numerous instances the inherent quality of the product is not a factor in people's minds when selection — the act of helping the idea gain a hold — is made. Communication and its off-shoot, entertainment, are aspects of life which are very susceptible to over-promotional effort (what Dorothy Parker once described as worship of the fecund rate).

In order to extrapolate and, perhaps, predict some breakthroughs in communication method in the future century we can and should look at ideas from the two progress motivations above — what we need and what we could be given.

The Role of Communication

Communication is needed to enable information to be imparted from one person to another person (Fig. 1). It is the act of passing information from point to point. An energy medium is always needed for information to pass. Some messages mean more than others, even though they may have the same number of words — a phenomenon not definable in scientific terms. We do have a good idea, however, of the carrying capacity, of a given communication channel. To do this we ignore the *meaning* of messages and concentrate on their *'bit'* content. On this basis — the Shannon concept — it is easy to see that facts containing many 'bits' of information will need a communication method having the required 'bit'-carrying capacity — this turns out to be the available frequency bandwidth in electronic communication techniques. Increasing the bandwidth usually means an increase in cost, so many potential communication needs are limited by economic reasons, not technological ability to provide bandwidth. As an example, for cost reasons, we make do with telex and telegram messages written in stilted format doing without the facial and tonal expression of face-to-face communication. A better alternative would be to use a video-link (such as may one day be in widespread use) instead of the teleprinter, though such a thing requires around 10 000 times more bandwidth. Figure 2 shows a unit that has been on trial since 1971.

The pattern of current civilisation requires people to interact as a living system of coordination, cooperation and coexistence. This means people need to communicate with each other. Usually the closer that a man-made

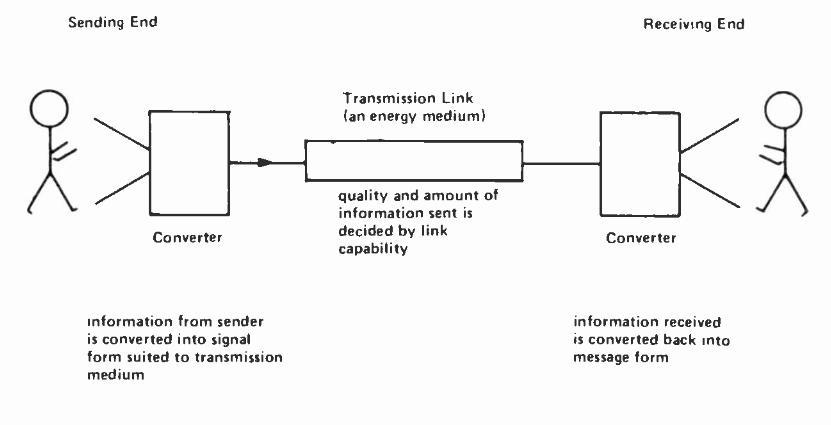


Fig. 1. A communication link conveys preset kinds of information from one point to another using an energy medium as the carrier.

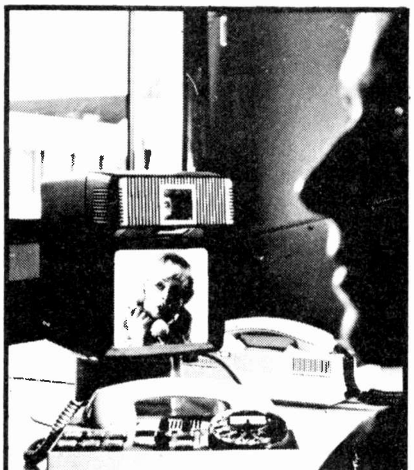


Fig. 2. Video links provide a greater communication capability but require more bandwidth than a telephone. (This Siemens experimental system uses 1 MHz).

Electronics 2000

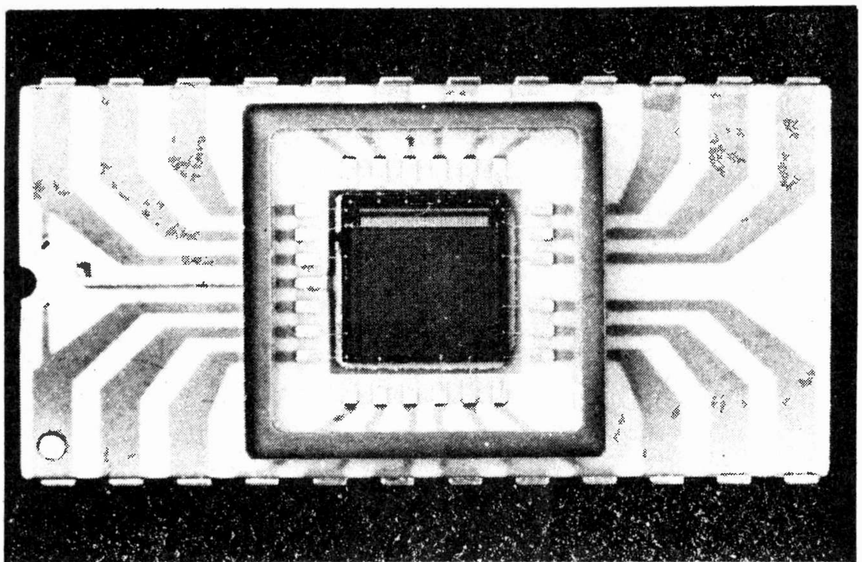


Fig. 3. Solid-state sensing array research is paving the way to tricolour LED panel televisions of the future. This unit has 64 x 64 photo diodes integrated into 6 mm square.

communication link can approach the real face-to-face case the better. Our awareness is enhanced as the simulation provided by the communication link is made more and more a true image of real contact.

Distances, cost and time often make direct communication unrealistic, so technology is brought to bear to reduce the inconveniences. Communication is needed to make commercial and political decisions, to fulfil social needs, to provide education and to entertain. In each of these the hardware forms are similar — it is the use to which they are put that may influence improvement.

The telephone grew from commercial needs for faster and more informative communication than was offered by telegraphy (which, in itself, was a vast improvement over hand-carried letters) but by contrast television grew because of its consumer market in the entertainment and news media fields. A few video-links have been established but the great operating cost limits them at present more to mass-audience needs, such as inter-city television interviews, than to telephone replacement.

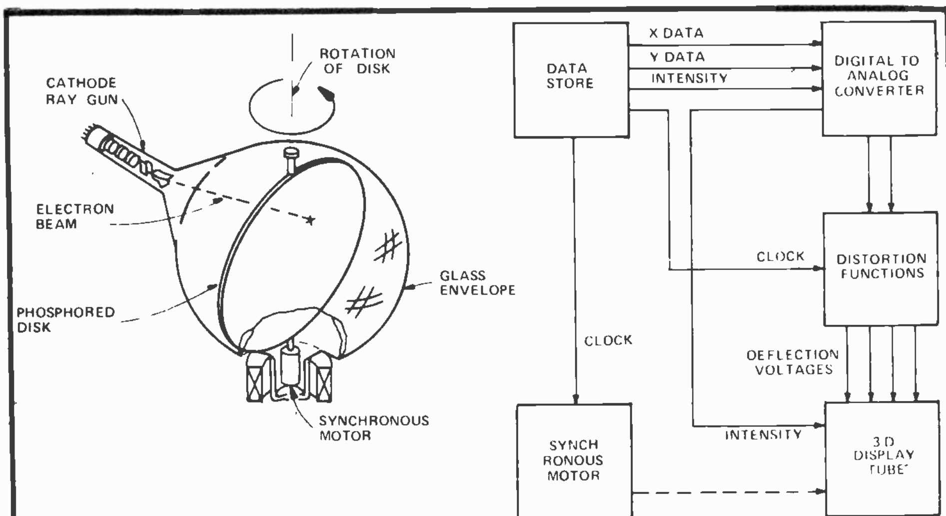


Fig. 4. 3-D display from a special CRT — a 1960's invention helping progress into 3-D television (Courtesy Electronics).

Expected Hardware of the Future

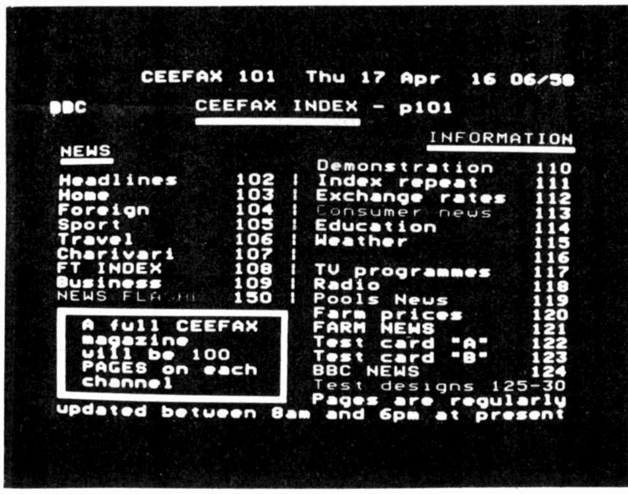
The area where greatest development in communications will be seen must be in the forms and use of the domestic television receiver. The receiver itself is sufficiently inexpensive for the majority of people in the developed countries to expect to own a set. We would, therefore, expect little more development on the receiver itself from the point of view of need-induced research.

Styling and operation changes will be prevalent in keeping with promotionally-induced change brought about by manufacturers who must keep seeking markets. Future receivers will most surely incorporate solid-state screens comprising millions of light emitting diodes giving the three primary colours. These screens will be flat and of insignificant thickness — they will be suitable for wall mounting like a picture. The receiving and processing circuits will be integrated onto the same panel. The concept of a television set as a piece of furniture will vanish. This development is currently at the very small monochrome (black and white system) stage — see Fig. 3 — with cameras, rather than displays, being the point of emphasis. The size will gradually increase to acceptable proportions after or during which colour solid-state systems will emerge. The cost of the technology, not its capability, limits this approach at present. IBM have made a 1 m x 1 m area of light sensitive diodes that has close to the current television resolution.

At present, however, the cathode-ray tube method is the only economic technique for generating the picture in a television set.

Because visual experience is in three dimensions, not two, development will not rest with the current 2-D systems. A 3-D cathode ray oscilloscope trace representation was demonstrated back in the 60's using a rotating phosphored disc as shown in Fig.4. Holography using coherent light enables 3-D images to be generated in colour as well as in the usual red experienced when using the helium-neon laser source.

Barriers to the introduction of 3-D television are both cost and the lack of a suitable technique. We have no obviously acceptable systems in existence at present. We can expect the usual period of multiple source development which will generate many alternatives



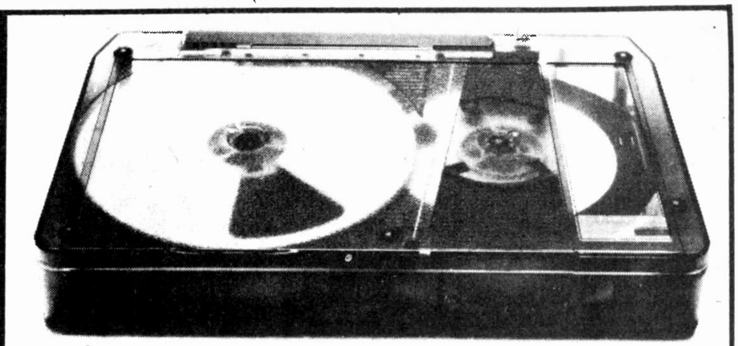


Fig. 6. This Sony cassette gives one hour of colour television with soundtracks using a domestic television receiver to display the output of a special replay tape deck.

Fig. 5. Index page of earlier CEEFAX page system now available on domestic television in the U.K.

in the outset before one or two methods settle-out to become the norm.

Returning to more obvious extras for use with the domestic television set we will very soon see widespread use of the currently developed systems which transmit information over a spare part of the television channel. In the CEEFAX and ORACLE systems the data is stored until a complete single frame of written or pictorial information is ready to show. These are now combined as TELETEXT. Television networks in Britain have systems now well past the prototype test-state. Any television set owner (who can build or purchase a decoder unit) in Britain can today obtain up to several hundred full 'page' items on the screen. Items such as the weather forecast, share prices, programmes, time and programme reviews are listed. Figure 5 gives just one of the selection. It is not hard to see that this offering logically extends to giving access to an enormous amount of information.

The TV monitor of the future will also become the domestic equivalent of the micro-film/micro-fiche reader now rapidly replacing the book in libraries and storehouses. Recorded video-tapes can be quite cheap to replay on special purpose replay-only units. Such units have been available for about five years now and it will not be long before the cost will be such that we will be buying video as well as audio cassettes in the music shop. Video discs are also close to being marketed in large volume. Figure 7 shows one market contender for the consumer market — prototype development having been reported three years ago.

One day in the future we will be visited by salesmen selling encyclopaedias in video cassette form instead of as bulky books. The publishers will also be able to offer an exchange service — old cassettes can have their facts updated at minimal expense.

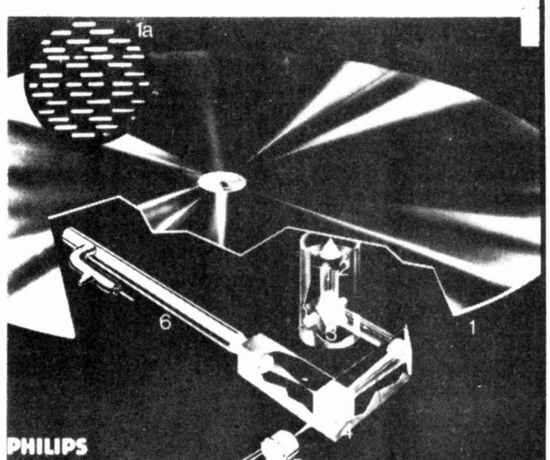
Perhaps, too, the monitor will become the terminal for optimal video-links added to the telephone. For this to occur we would need low-cost very-wide bandwidth telephone channels. Current open wire and cable telephone systems have inadequate bandwidth handling capabilities on a single line so the change to video phones would need an entirely new concept of transmission or a complete replacement of the telephone cable network including the switching and processing plant installed within the telephone system. The bigger the capital invested the longer it can take to change to new technology.

The bi-motional mechanical selector switches (see Fig. 8) used in telephone exchanges were first patented by Strowger in 1891. Many are still in use today.

A spread of the currently introduced cable TV systems — small networks wherein other than broadcast television programmes are 'sold' to clients connected to a specific suburban network of coaxial cables might duplicate all local telephone cables with adequate video-bandwidth networks. This would set the scene for a gradual change to video-phones. There will still, however, remain the immense task of providing national and international bandwidth capability that is 10 000 times its current provision for not much more in cost to the user.

Laser beams sent along fibre-optic paths are often reported to be the answer to bandwidth needs: considerable research and development is being performed today on these technologies. If and

Fig. 7. Video record playing equipment is already developed. Records provide 10-45 minutes of colour television.



Electronics 2000

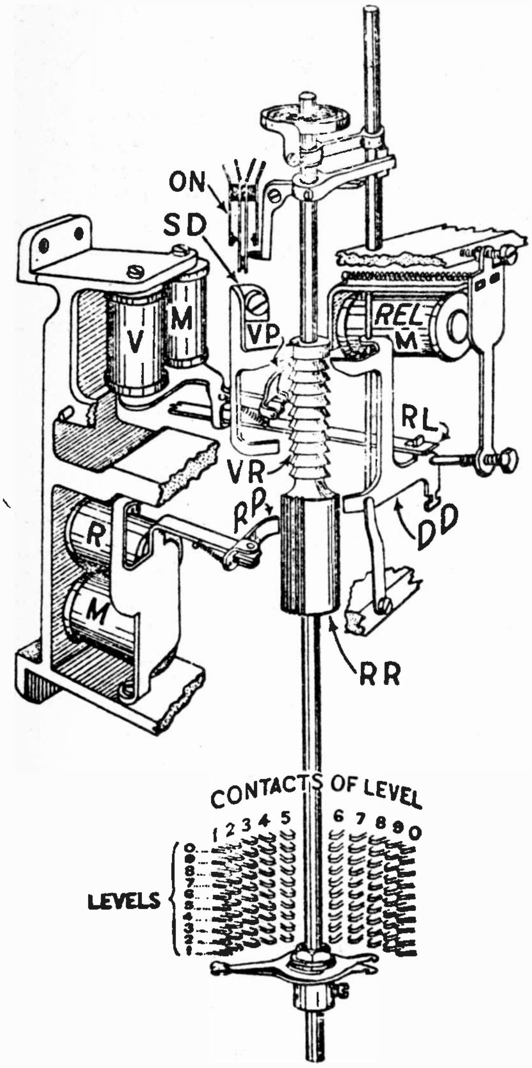


Fig. 8. Strowger bi-motional selector switches were first patented in 1891. Today many telephone exchanges still use them because it is uneconomic to change to new technology.

when their price falls enough to be competitive with other wide-band systems the first places of application will most likely be in heavy-traffic telephone and video links between cities. Domestic application, on the other hand, (in the form of cable TV) is an area where developers will be able to influence change more rapidly due to the smaller clientele to satisfy and persuade.

New Forms of Transmission Medium may Emerge

It is instructive to go back in history and try to imagine the attitudes of 18th century people to the likelihood of a communication form other than by message or word of mouth. To people of that era, sending messages over electro-magnetic (EM) waves would have been fantasy indeed. They knew and had some understanding of acoustic waves but knew nothing of radio waves. In the 19th century Maxwell predicted from his mathematical understanding of magnetic fields and their observed local-field behaviour, that it was possible to radiate a field away from a source — the energy literally escapes from the generator. It took about thirty years for this idea to be verified (by Hertz) by a crude experiment (see Fig. 9) and out of this was born radio. Once the concept of the electromagnetic spectrum was realised, EM frequencies other than in the radio region were exploited for communication purposes. Even today we have not completely filled in our use of all EM radiation wavelengths.

Field theory is a generalised theory that handles any kind of effect that can be experienced in space — magnetic, electric, gravity and force fields are examples. The operative word is 'experienced'. Until Hertz demonstrated radio waves no one had experienced them and, therefore, they did not exist as a tool of technology. Perhaps, today there are similarly other methods of radiation, so small in magnitude and so alien to any detectors we possess at present that we do not know of their existence. There is much evidence to suggest this is the case. Theory predicts the existence of gravity waves which are force fields propagated from exploding galaxies. On a closer basis we know that a mass exerts a force on another mass by gravitational attraction (but why is an unknown of science). The force falls off as the square of the distance between the masses. In theory a small mass (the transmitter) vibrating rapidly causes a minute varying attractive force on another mass (the receiver). These forces can be calculated and the sums show that they are exceedingly small if the masses are of reasonably small size. To date many scientific research projects have tried to detect macro gravity — wave effects from the galaxies but now it appears that the current mechanical detectors being used are clouded by their own internal Brownian motion, which appears as a noise source. A new detection principle is needed — a second Hertz type historical event will occur one day when, and if, the generation and detection of gravity waves is demonstrated providing practical experience of the effect.

Moving on to less theoretically based fields there are the photographs made of energy fields of objects. These are unexplained but it is fact that photographs taken in a special way reveal an 'aura' surrounding the object. Lack of understanding of such phenomena is not an adequate basis for saying they are necessarily fakes.

Extra sensory perception (ESP) also may be part of potential future communication. Perhaps it, too, makes use of an energy field we do not yet recognise. It is sobering to remember we only understand experiences that our physiological senses and brain allow us to observe.

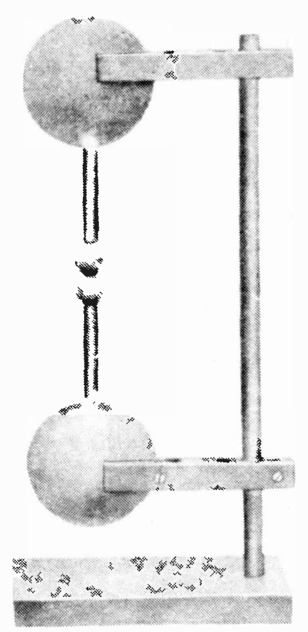


Fig. 9. Hertz oscillator (upper) and resonator (lower) of 1894. Until Hertz proved radio waves could be generated, transmitted and detected, communication by EM waves was fantasy even though they existed.

ESP, mental-telepathy, clairvoyance, precognition and parapsychology contribute physical experiences such as levitation, materialization, automatic writing, spirit photographs, psychokinesis, apparitions, poltergeists, miracles and voice recording. These are observed (perhaps apparently observed?) facts. It is quite in order to expect them to have a rational basis, one which we cannot understand as yet. It must be remembered that fantasy is only fact unexplained. There is no reason to think all knowledge is known at this point in time.

The brain produces electrical signals — one kind is known as alpha rhythms. These can be recorded and a little is known that enables the signals to be associated with certain physiological actions of the body. Progress of understanding these rhythms is positive but slow. No doubt at some time in the future brain rhythms will be used to produce extensive communication as a direct thought process between people and machines — see Fig. 10. If we could hook up to another person by a wirelink it would be clearly feasible to do so without wires using wireless techniques of today. Typewriters that write directly from thought waves will emerge to speed up the tedious task of transducing thought into clearly printed text. Here the hold-up is a scientific knowledge barrier for we cannot adequately decode the rhythms to obtain any more than the most simplistic data about the person's functions. Perhaps allied research will reveal the existence of radiated energy waves which are allied to the brain rhythms.

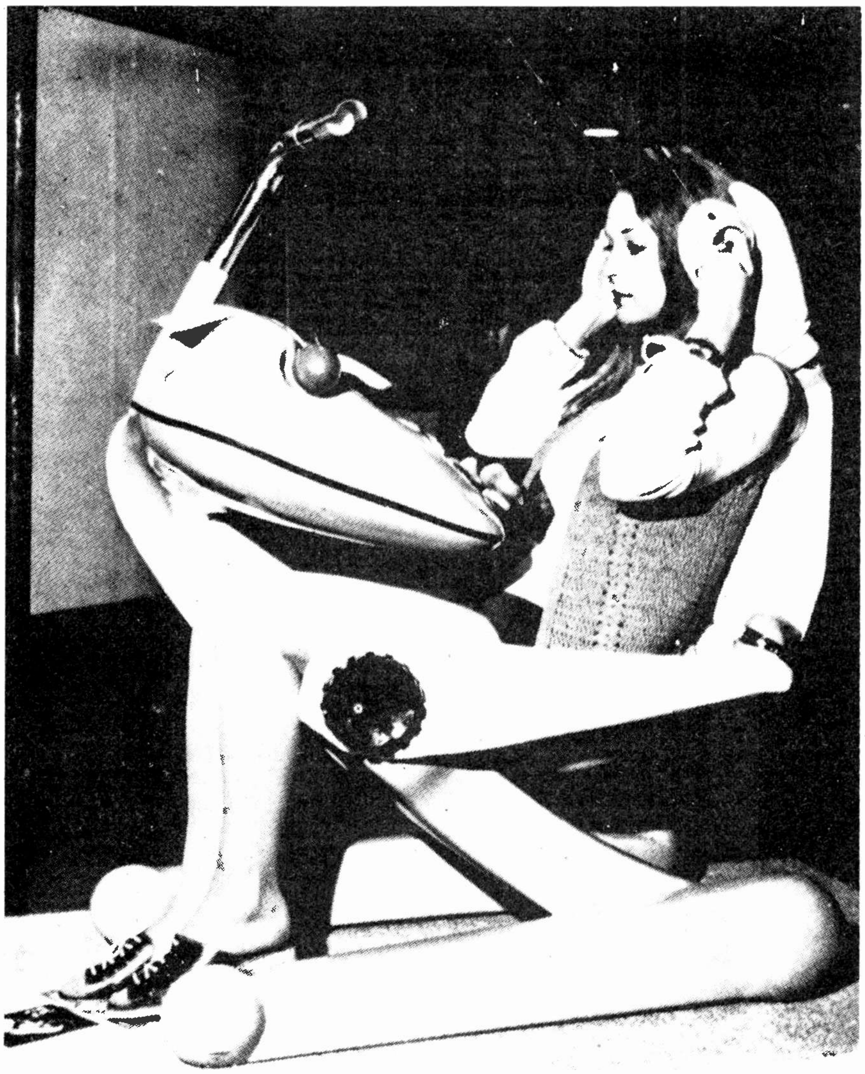


Fig. 10. This Luigi Colani integrated office could be the basis of a Year 2000 automatic writer operated by brain-waves.

Assuming another form of energy field were discovered we could surmise that it might have direct person-to-person communication ability over global ranges rather than over the several metres experienced by our acoustic talking and hearing communication system. If this were so then the bandwidth problem of current systems might not be the limitation of the future. We would then have a breakthrough discovery that would completely change our attitude to what is feasible. Attitudes to community participational behaviour would be completely upset by such a finding.

For example, consider the experiences arranged in a theatrical show. Instead of having to relay the performance over cable or EM systems we might be able to 'attend' from remote distances. The whole concept of theatre would change. For this to be an adequate experience the "distance attendance" form of participation must fully simulate actual participation in the audience. Such a capability would obviate a vast amount of travel necessity and vastly reduce the need for transport mechanisms.

The live theatre is one form of entertainment that has changed little since its inception — at least until recent times. Lighting has improved beyond the lime-light of the last century to computer-controlled electric lighting of today. Electronic amplification of players' voices is still often avoided but electronic effects are used extensively in musical productions.

Current moves in the industry are to automate set changing. At the command of a mini-computer the several tonne sets will soon trundle out from the wings to their correct positions on stage without the aid of any stagehands. Will the players one day become automatons controlled by computer also?

We have seen in this and the previous part that electronic facility is a major influence on change. The mass-production of integrated circuits by photo replication methods enables many identical parts to be made most cheaply. Cheap data processing will continuously influence the kinds of ideas that are exploited and promoted in the future. One interesting question to ask, however, is whether electronics is the only discipline for powerful information handling. In the 1940s mechanical elements were thought to be the answer; today it is electronics. Could tomorrow see a change to electro-chemical or some other system of signalling not yet known?

In the next part we shall investigate likely medical developments and the impact of the computer on our life style.

RON HARRIS INTRODUCES

THE ETI ER II LOUDSPEAKER

a high-quality design for the home constructor

LOUDSPEAKER ENCLOSURES are perhaps the least understood, and understandable, of hi-fi components for the home constructor. Crossover networks for example look deceptively simple on paper, but can be more complex to design properly than a digital system comprising 100 IC's Enclosures too commonly called "the bloody box," are all too often taken too lightly with the result that a great deal of effort expended in the design of the crossover unit and quality inherent in the units is thrown to the wind.

Our design is a two-unit home system, designed to give a very high quality sound output, allied with the advantages of easy construction and reasonable cost (about £70 a pair in cash, and whatever blood sweat and tears prove appropriate).

Specification

FREQUENCY RESPONSE: 50Hz-25kHz ± 4dB
EFFICIENCY: approx 16W required to generate 96dB (test room conditions)
POWER HANDLING: Min. 15W per channel recommended, max 40W programme.
DIMENSIONS: 21¼"h x 13¼"w x 12"d.
APPROX COST: £70 a pair.

Getting Cross Over Components?

Frequency division networks for loudspeaker use are generally required to overcome six main problems. These are:

(1) Voice coil impedances are very much lower than is usually met in communications theory (for which most standard filter designs were evolved) and this makes termination difficult.

(2) Power requirements are high, although this is relatively easily overcome by use of high rated components, correct gauge wire etc.

(3) Drive unit impedance varies greatly with frequency, and the reactive component changes very rapidly near resonance. The filter load thus changes appreciably with frequency.

(4) The network will introduce phase shift ie. delay, and if poorly designed this may be significant on transient waveforms, ringing occurring at some frequencies.

(5) It is convenient to have the network 'level out' the efficiencies of the different drive units, and this involves controlled dissipation in the network. Also any variation in the amplitude response should be, if at all possible, minimised.

(6) Reactive elements within the network may well resonate with loudspeaker motor reactive elements at some frequencies. This could present a much reduced impedance to the power amplifier, which in turn might show its displeasure in some, unpleasant, tangible form or other.

Pointing Things Out

Number four of the preceding is one aspect of the now abating furore that the so-called linear phase loudspeakers caused upon their release.

In every case with these designs, the reason for their audible quality can be more easily ascribed to the fact that they (B&W DM6, B&D M70, Leak 3000 range etc) are simply damned good speakers in their own right, rather than to the dubious benefits of a linear time delay with frequency.

Ours is not a linear-phase design.

Point five is very important indeed, and is one of the main reasons we are recommending, as strongly as the nibs of our pens will stand, that you do not attempt to fabricate the crossovers for this project yourselves. Badger Sound Services can supply the complete unit off the shelf, and you are advised to look thence! (Deliveries are superb.)

Several of the components in the network are chosen to compensate for 'meanderings' in the units. For example the two 5µF capacitors are selected tolerance components, and the 2mH coil across the B200 has a very critical impedance to present. Also important is the grade of ferrite employed in the cores, as this will determine saturation level, a nasty parameter to fall foul of!

I hope that has convinced most of you. For those adamant souls still set on the winding path — good luck 'cos yer gonna need it!

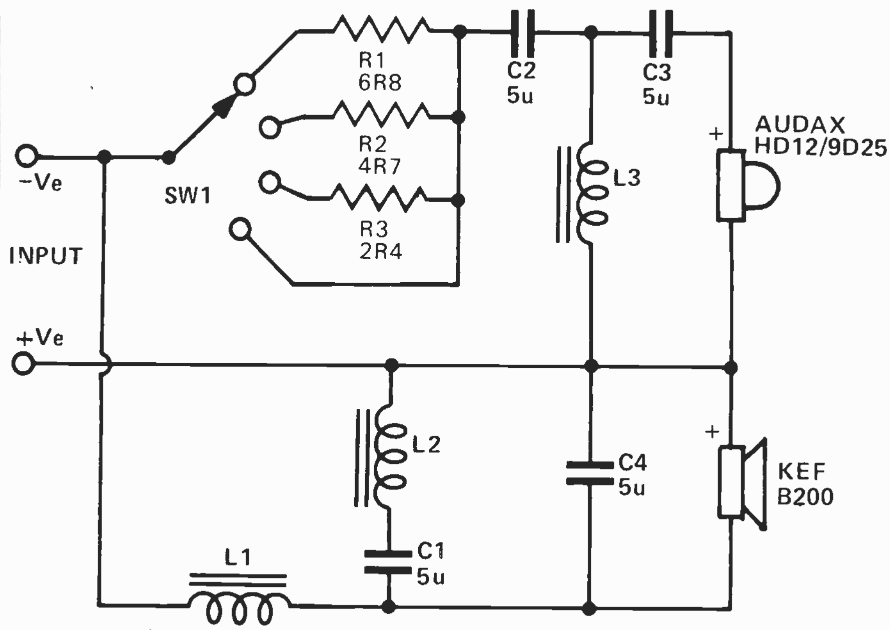


Fig 1. Circuit diagram of the crossover network. Component values are nominal. Note that R1-3 are mounted off board on to SW1 which is the h.f. level control. The units are wired in 'antiphase.'

Closed Shop

And so to the boxes they come in. Ideally a speaker enclosure should do precisely that and no more — it should enclose without reacting. It should do — but naturally doesn't. The volume of air within the enclosure acts as a mechanical resistance to cone movement, especially at bass frequencies. When using the "Infinite Baffle" design, as we are here, the cabinet volume must be set to match the bass unit.

If the mid-range is not a 'sealed-back' or dome unit (a la Celestion which is both!) then this too will be affected by the air load An acceptable solution is to provide a tube within the main cabinet for the mid-range driver to work in. (Both Kef and Wharfedale adopt this solution in their speakers.)

The type of wood, or more honestly chipboard, that constitutes the cabinet is also an important factor. What you want to hear is the sound from the flapping cones — not from flapping cabinet sides. The denser the better is the rule here. This 'flexing' of panels can be a major source of colouration in a design, and it is surprising commercial firms do not pay more attention to bracing or stressing their enclosures. As you can see from the drawings and 'Construction' text, our enclosure is heavily braced, and if you want the best results from your work don't be tempted to leave any out. The volume of the batten used has been allowed for in the calculation of cabinet air load on the bass units, so don't worry about it!

Specifics

The actual construction design presented here is intended for use in rooms up to about 2000 cu. ft., with amplifiers of up to 50W r.m.s output — but be careful with the volume control when using amplifiers of more than 35W or so. Efficiency is slightly higher than average — see table. The main design criteria throughout was how it *sounded*, not how it measured or looked, but how musical was the noise eminating from the grille cloth!

Construction

Woodwork is the main problem facing the constructor. When cutting the baffle keep the units themselves in exactly the same place as the drawing shows them. If you change the positioning you'll change the sound, and we cannot guarantee the result!

Perhaps the best way to give constructional details is a list of DO's and DON'T's!
Here goes:

DON'T omit any of the enclosure bracing shown.
DON'T attempt to 'bodge up' your own crossover network.
DON'T mount the drive units on the back of the baffle because its easier — it will show up as soon as you switch on!
DON'T leave any gaps in the joints of the enclosure.
DON'T commit the cardinal sin of using hardboard for the back panel.

DO fit the bracing *across* the grain of the veneer. It is best to have the grain running vertically on the sides and back panel, and parallel to the baffle on the top and bottom.
DO leave a small hole in the back panel no larger than 1/16in diameter, to allow any changes in air pressure within the enclosure due to temperature etc to equalise. This will not affect the sound at all.

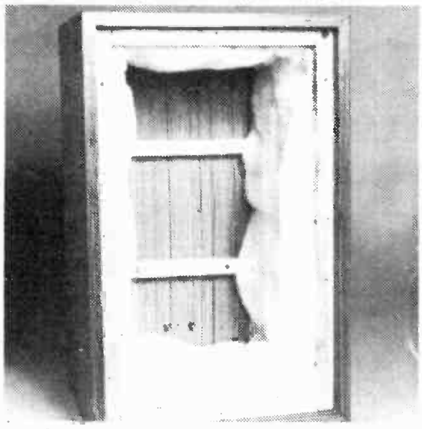


Fig 2. Internal shot with the wadding fitted to the sides. The back panel has not yet been lined. The bracing across the panel can be seen, and this continues around the sides.

Fig 3. Here the cabinet is complete, and the final wadding has been folded into place. This loosely fills the enclosure. You'll have to attach the wires to the input sockets first though!

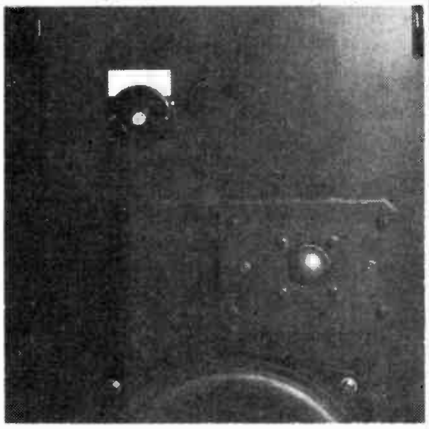


Fig 4. Front panel detail. The h.f. level control at the top is set to +2dB. From this the relative position of the drive units can be seen. When attaching these to the front panel, seal them off airtight.

DO use chipboard veneered on both sides.

DO 'glue and screw' all joints to ensure that other than the above hole the enclosure is totally air-tight. Evo-stick Woodworking Adhesive is particularly suitable for the job.

DO mount the baffle as close to front edge of the enclosure sides as possible. This minimises diffraction effects and greatly aids dispersion of high frequencies. Take care however with the dome of the Sonaudax. Put *that* too close to the front and it'll get 'grilled'!

DO use best quality chipboard — ⅝'' min 'flooring quality' etc or even hard wood if your bank balance can stand the shock and your floorboards the weight!

We mounted the crossover unit on the rear of the baffle next to the level control, so that wiring is kept to a minimum. The back panel is sealed when passing wires through the enclosure, make sure they can't 'rattle' on the sides of the box, or on the units.

Once the woodwork is complete line the enclosure using BAF wadding or the like (1in thick). Stick one layer on all the sides and *two* layers on the back panel. Taking care with the wiring, fold in sufficient wadding to just fill the remaining space, making sure it doesn't foul the B200 cone.

When screwing up the baffle put some draught excluder around the frame if you can, it helps the sealing.

We haven't shown a grille design on our prototypes, as we thought all you lot out there would do it your own way anyway! This is not critical, provided you use proper grille cloth or even better acoustic foam. Grannys old net curtains may have a nice pattern and match the 3-piece, but it'll sound awful. Gag the missus if need be, but don't give in!

Use and Abuse

The speakers should really be used on stands if free standing, of no less than 10in in height. Stand them at least a foot from a wall, and not in a corner, as this will introduce 'boom' at the low end that these enclosures don't need to help the bass response.

They can be used on a shelf against the wall, and in this mode set the tweeter at 'ear level' (when you're seated of course). Keep the enclosures about 6ft-8ft apart — never further if you want stereo in preference to two sound puddles around the boxes.

As with all speakers, damping from the amplifier is best preserved by using as thick a connecting lead as possible, say a minimum of 5A cable. And no, screened lead is neither suitable nor necessary.

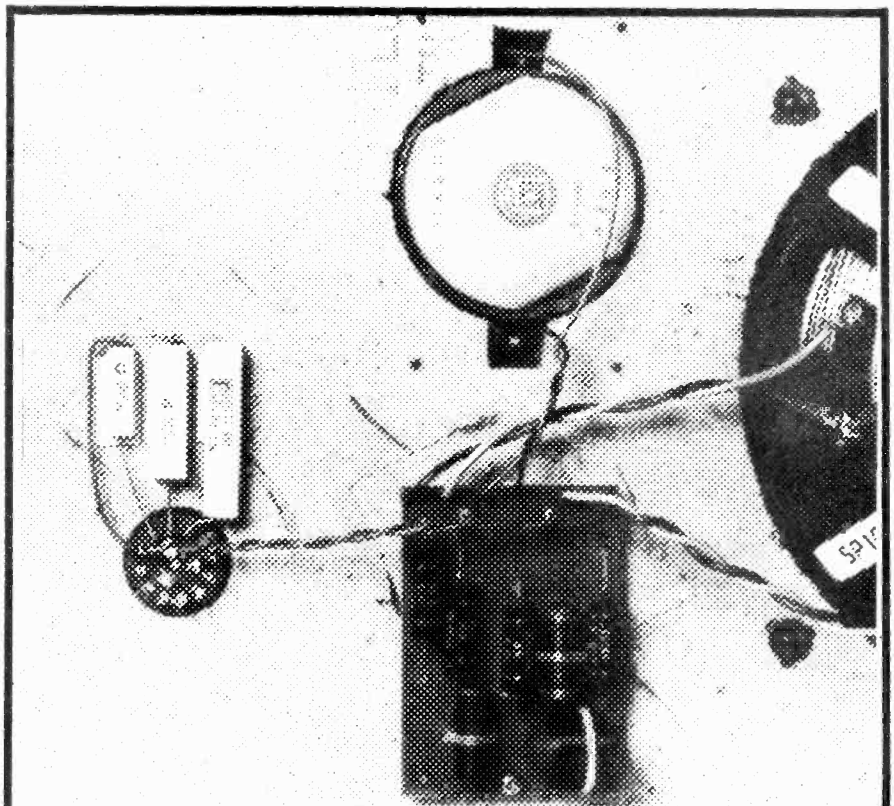


Fig 5. The rear of the front panel. Here the crossover board is shown attached to the left of the Sonaudax. The attenuation resistors are arranged next to the switch, held on in our case by double-sided sticky pads. It is important that none of the wiring or components is attached in such a way that it can 'rattle' in time with the bass!

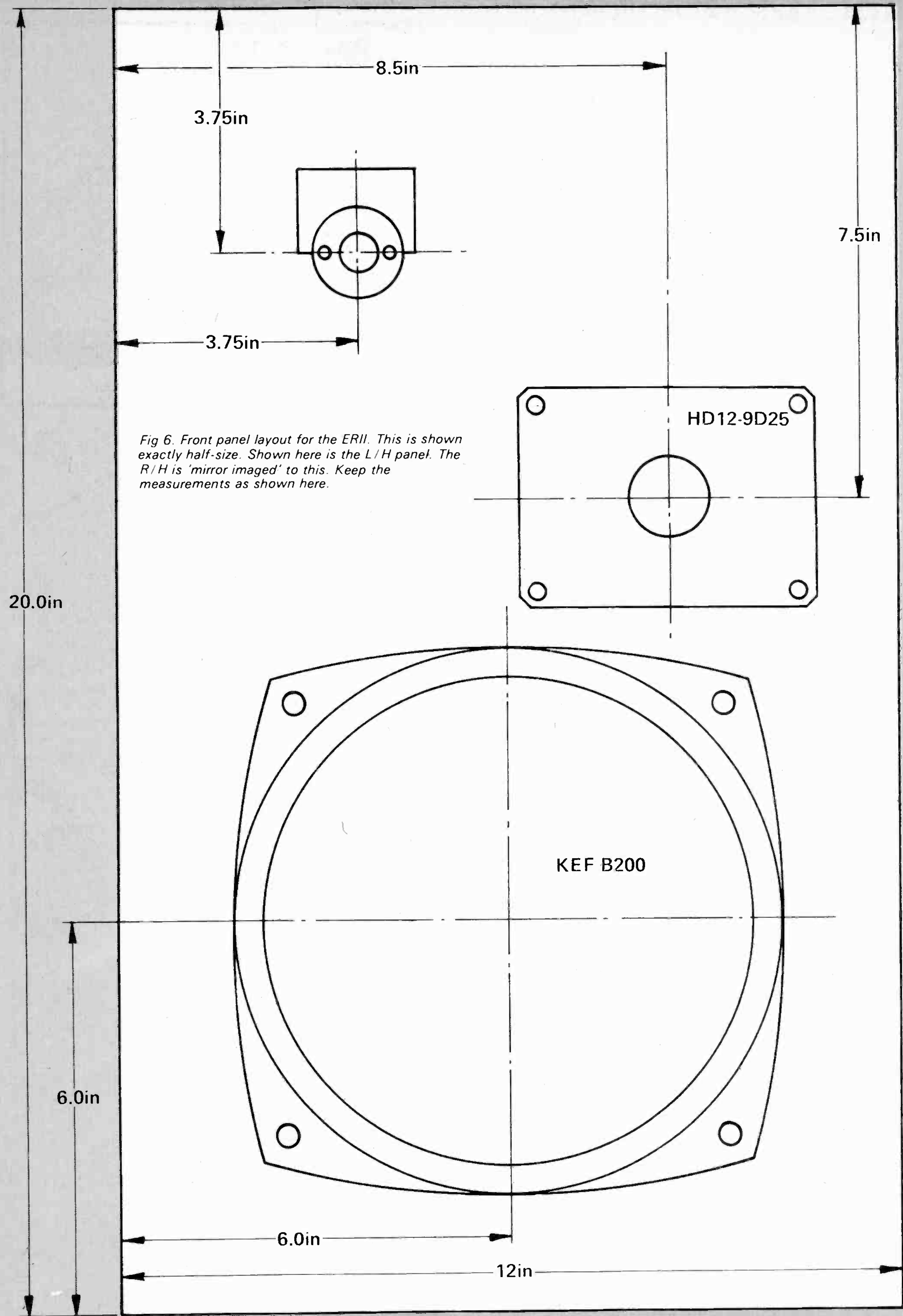


Fig 6. Front panel layout for the ERII. This is shown exactly half-size. Shown here is the L/H panel. The R/H is 'mirror imaged' to this. Keep the measurements as shown here.

Last But Not Least!

As we said before the main criteria for the design was how the things sounded. It is hard if not impossible to convey a subjective impression on paper, and a long string of well-nigh standard, albeit strange, adjectives have been developed for the task, such things as 'boxy', 'chesty', 'wooden' etc etc ad nauseam. And now of course we have 'musical' and 'un-musical'. Forgive us if we use any of these insults to English herein!

For the purpose of final evaluation, the ERII's were wired up next to a known reference speaker, in this case Celestion Ditton 66's, in order to better assess their subjective performance. It is all very well to listen to an unknown design on its own and gain some general impression of its fidelity, but to come to a definite decision, there must be something there to compare it with, and something of known vices at that.

The rest of the reference system comprised a Technics SL120 and SME3009 V15III and G900SE record deck, Pioneer SA 9100 and Quad 22/II .just to keep valve enthusiasts happy!) amplifiers, a Revox A77 Mk IV tape deck and of course the Celestions. A calibrated power output meter (based on our level meter ETI March 1976) was also used to gain some impression of subjective efficiency. Several pairs of hi-fi and concert going ears were assembled at various times to comment on the ERII's, in order to see if we were pleasing all of the people all of the time, or none of the people none of the time.

Parts List

Per pair:

2x	HD12 - 9D25
2x	B200
2x	CN104/ETI crossover networks
2x	3 pole 4 way switch
2x	recessed flange and matching knob for switches.
2x	2R4
2x	4R7 10 W or greater
2x	6R8
2x	4 mm banana skt. red
2x	4 mm banana skt. black

Chipboard & battening to suit method of construction: see text
BAF wadding to fill cabinets, approx. 12 yds. at 24"x 1".
Badger Sound Services, of 38A St. Andrews Road South, St. Annes, Lytham St. Annes, Lancs FY8 1PS can supply the crossovers at £4.99 + 35p p+p each, and just about everything else for this project too. Ring them on St.Annes 729247 to check prices and availability before ordering.

Our thanks go out to our friend David Pickler of Barnet, who produced the woodwork for the prototype ER II's. We changed the cabinets quite a few times before settling on the final design. We can only say he showed patience! Nice one David.

Verdict

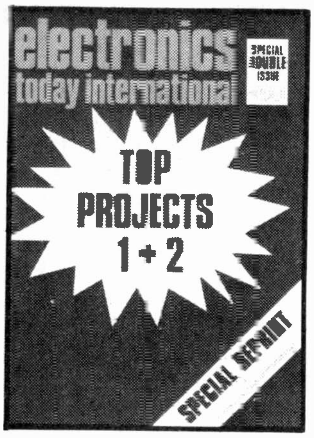
Direct comparison with the reference showed the ERII's to be very musical indeed in their output. Naturally, due to the much smaller size of the enclosure, deep bass level was down on that from the reference, but not seriously so, and it was quite possible to advance the bass control on the amplifier without boxes squawking out in protest. Bass quality is good, with notes being well defined and boom conspicous by its absence.

The Sonaudax tweeter showed itself to be a very smooth unit indeed, and gave the speaker a slightly bright sound, which was present on both amplifiers (lest the valve brigade began to nod their heads sagely), although in no way objectionable. Setting the control to −2dB position tended to remove this anyway. The room in which the tests were carried out was in any case 'hard' in character, with little absorbtion, and doubtless the ERII's are a great deal less guilty than the room'.

Considering their price of around £70 the ERII's produced a remarkable performance, and one that some listeners commented bettered their commercial units, all of which cost in excess of £150 a pair.

All in all then a good little speaker, and one well worth considering if you're in the market to upgrade, or even about to set foot on the slippery incline of hi-fi for the first time. ●

SPECIALS FROM ETI

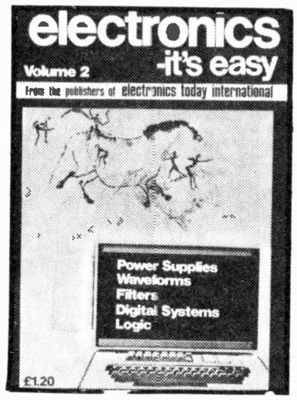


TOP PROJECTS No. 1 + No. 2

Tens of thousands of our first two projects books have been sold — finally we ran out but all is well. we've reprinted No. 1 and No. 2 in a massive 180-page book. At present this is only available direct from us. It is a limited print run but we have adequate stocks at the moment.

See our ad elsewhere in this issue listing the projects included.

£2.50 + 20p P&P

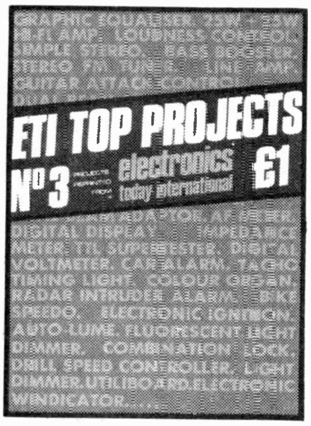


ELECTRONICS — IT'S EASY

Our unbelievably successful series, now drawing to a close, is available complete in three parts — not surprisingly known as Volumes 1, 2 and 3

At the time this issue goes to press, we only have Volume 2, but Volume 3 will be available in early April and a reprint of Volume 1 (which we sold out of completely) will be available late April Orders can be accepted now for immediate despatch upon delivery to us.

Each **£1.20 + 20p P&P**
Complete set **£2.50 + 35p P&P**



TOP PROJECTS No. 3

Originally published in March 1976, Top Projects No 3 contains 27 constructional projects including Graphic Equaliser, International 25W Stereo Amp, Simple Stereo, New Sound for your Guitar, Bass Booster, Line Amplifier, Loudness Control, Electronic Ignition, Tacho Timing Light, Car Alarm, Dual-Beam Adaptor, AF Meter, Impedance Meter, Digital Display, Digital Voltmeter, TTL Supertester, Fluorescent Light Dimmer, Radar Intruder Alarm, Light Dimmer, FM Tuner, Colour Organ, Drill Speed Controller plus many more

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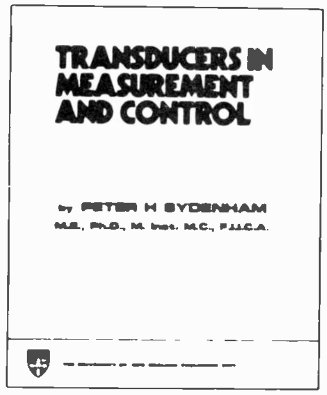
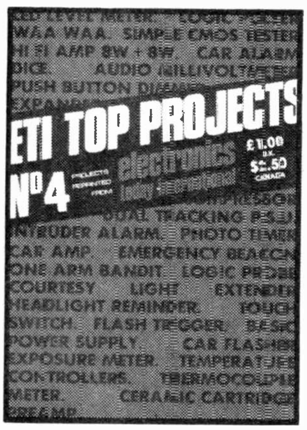


TRANSDUCERS IN MEASUREMENT AND CONTROL

This book is rather an unusual reprint from the pages of ETI The series appeared a couple of years ago in the magazine and was so highly thought of by the University of New England that they have re-published the series splendidly for use as a standard textbook Written by Peter Sydenham M E Ph D M Inst M C F I I C A, this publication covers practically every type of transducer and deals with equipment and techniques not covered in any other book Enquiries from educational authorities, universities and colleges for bulk supply of this publication are welcomed These should be addressed to H W Moorshead Editor

£2.55 + 20p P&P



TOP PROJECTS No. 4

Available at your newsagents or from ETI direct. Published October 1976 This includes Sweet-Sixteen Stereo Amp, Waa-Waa, Audio Level Meter, Expander-Compressor, Car Anti-Theft Alarm, Headlight Reminder, Dual-Tracking Power Supply, Audio Millivoltmeter, Thermocouple Meter, Intruder Alarm, Touch Switch, Push-Button Dimmer, Exposure Meter, Photo Timer, Electronic Dice, High Power Beacon, Temperature Controller, Electronic One-Armed Bandit plus many more.

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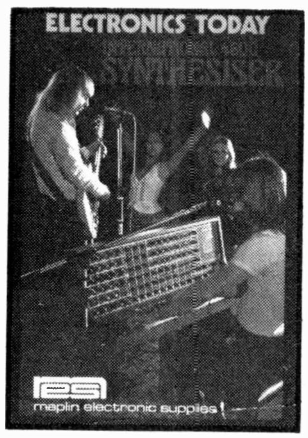

ETI 4600 SYNTHESISER

A complete reprint of our superb synthesiser design, published with Maplin Electronics (who also supply the parts) This reprint will also be of interest to those not specifically wanting to build the unit as the circuitry is highly original and is in fact patented by ETI!

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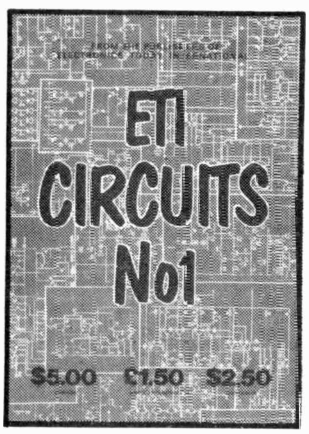
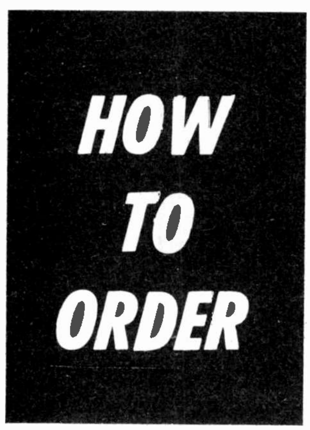


ETI CIRCUITS No. 1

Just published and available from your newsagent as well as from us direct is this new concept in Specials. ETI Circuits No. 1 contains over 200 circuits, largely based on the Tech-Tips section and Data Sheet but great care has been taken to index each circuit carefully to enable rapid selection. This publication is likely to be regarded as a bible by the experimenter for not only does it contain complete circuits but also ideas and circuit sub-assemblies.

£1.50 + 20p P&P



HOW TO ORDER

ETI Circuits No. 1 and Top Projects No 4 are available at newsagents or direct from ETI Others are available only direct from ETI

Postage and packing is 20p for the first, 15p for each subsequent issue (Overseas 25p and 20p respectively). Send remittance (in Sterling only) to:

ETI Specials,
ETI Magazine,
25-27 Oxford Street,
London W1R 1RF.

Please mark the back of your cheque or PO with your name and address.

SHORT CIRCUITS

INJECTOR/TRACER

WE SPENT A LONG TIME trying to think of an excuse to present a signal injector/tracer before realising that since ours is so good (and simple!) we didn't need one!

The unit is built into a Vero hand-held box, and has a separate amp and oscillator sections, allowing them to be used separately if need be. The injector turfs out a 1 kHz square wave at 1 V.

WHAT A TURN ON

The output is to a crystal earpiece, and the 3.5 mm jack socket is modified to switch on the amp upon insertion. To inject a signal shove the button on the top down. Everything is mounted onto a single pcb within the box which also contains a PP3 battery.

Access to the amplifier section is provided via the phono socket which is also bolted to the board. The quality of this stage might just surprise you, incidentally.

MOUNTING TROUBLES

The board is held within the box by the pillars (designed for the job!), and to get the PP3 in, you'll have to file these down a bit - have a look at the photograph to see what we mean. Apart from this the project is ridiculously easy to build, and should pose no real problems.

How it works

Eyes down for the shortest How It Works ever.

The injector is a multivibrator running at 1 kHz, with R5 and R6 dividing down the output to a suitable level (≈ 1 V).

The tracer is a single-stage BC108 amp, current biased, and feeding into SK4 to drive the high impedance earpiece. C4 decouples the input.

Enough said?

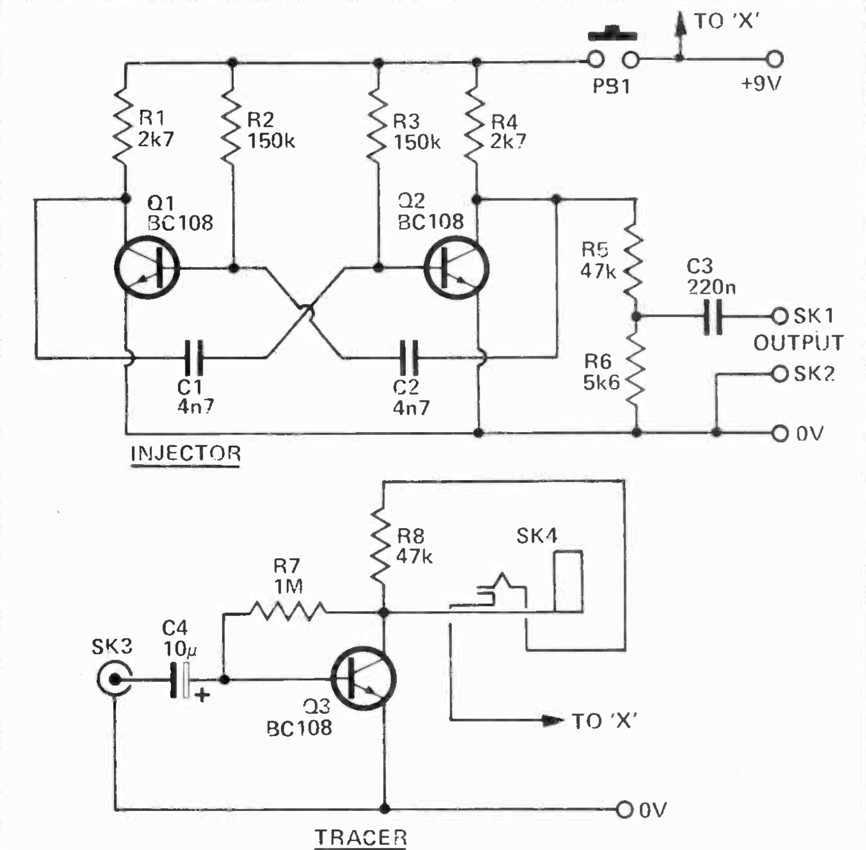


Fig 1. The circuit diagrams for both parts of the injector/tracer. Note that SK4 is used to apply power to the amplifier section.

Short Circuits

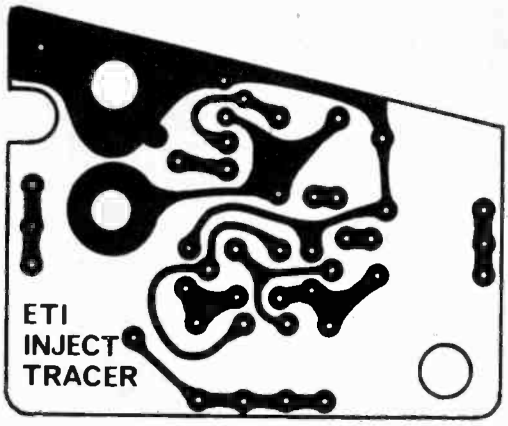


Fig 2. Pcb foil pattern for the circuit. Shown full size. The large areas of copper are where the sockets fix directly to the board.

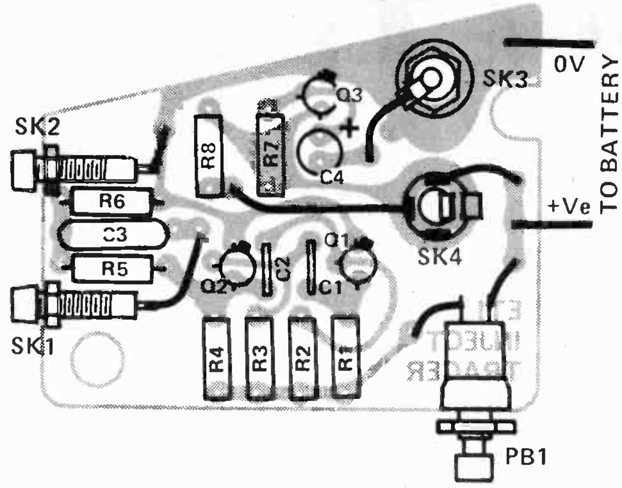


Fig 3. Component overlay. Note that SK2 and SK1 are held in place by the Verobox closing around them. SK3 and SK4 are attached directly onto the pcb, and face out of the box on the copper side of the board.

In order to get the PP3 to fit into the hand-held box, it will be necessary to file down the pillar within the box. Drop the pcb over the retaining stubs as shown, so that when the other half of the box is clipped onto it, the fins on it will hold the board in place. It is these fins which will need to be filed almost flat.

SK2 and SK1 can be seen in place on the front of the box. Here also a little filing will help, in as much as the sockets will then be flat and the probe be perpendicular to the verobox body.

Parts List

RESISTORS — all ¼ W 5%

R1,4	2k7
R2,3	150 k
R5,8	47 k
R6	5k6
R9	1 M

CAPACITORS

C1,2	4n7 polyester or ceramic
C3	220 n polyester
C4	10 μ 10 V electrolytic

SEMICONDUCTORS

Q1,2,3	BC108 or similar

SWITCH

PB1	Push to test type

SOCKETS

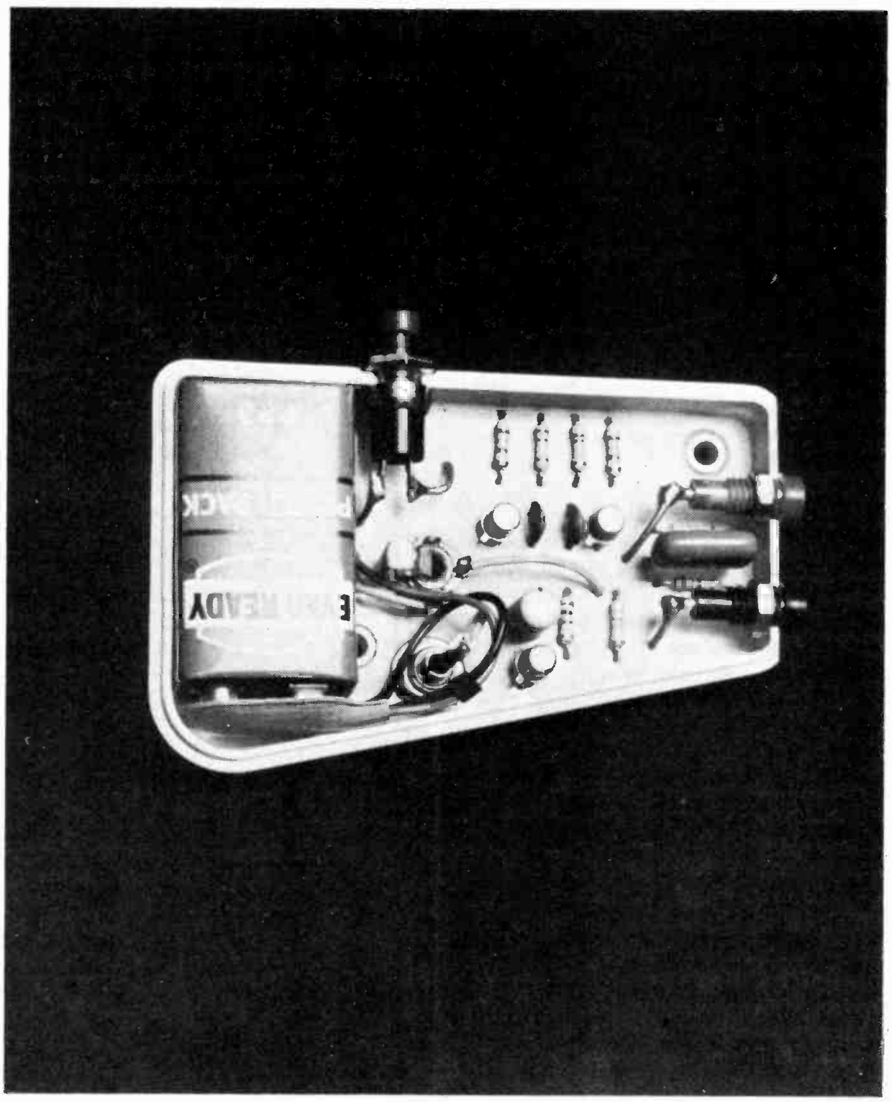
SK1,2	2 mm panel type
SK3	Phono socket (Doram 477-848)
SK4	3.5 mm chassis jack socket (see text)

CASE

Vero	'Hand Held' type (75/1799E)

MISCELLANEOUS

PP3 battery, battery clip, 2 mm plugs, probe, phono plug, screened wire, flex, crystal ear-piece fitted with 3.5 mm jack plug.
Cost ≏ £3.50.



METRONOME

THE TRADITIONAL metronome is well-known to those who have learnt the piano for beating out the time - these mostly operate by clockwork.

A variable beat with a far greater range than the mechanical types is very easily produced electronically, especially if a unijunction transistor is used as a relaxation oscillator.

In our circuit we have opted for a tantalum capacitor for C1; an electrolytic can be used but due to the enormous tolerance spreads (usually +100% to −50%) the range can be very different from that of our prototype.

A volume control is hardly necessary but we have included a preset control which can be adjusted from outside the box which can be used to attenuate the level considerably: a low volume is almost essential when using an earphone.

RV1 sets the 'beat' and can be log or lin but a log type wired as reverse log gives a smooth calibration over the range which varies from 30 beats per minute to 400 beats per minute. Calibration can easily be done using a watch.

The normal nominal impedance of small speakers is 8 ohms and that is what we have used but higher impedance types will work.

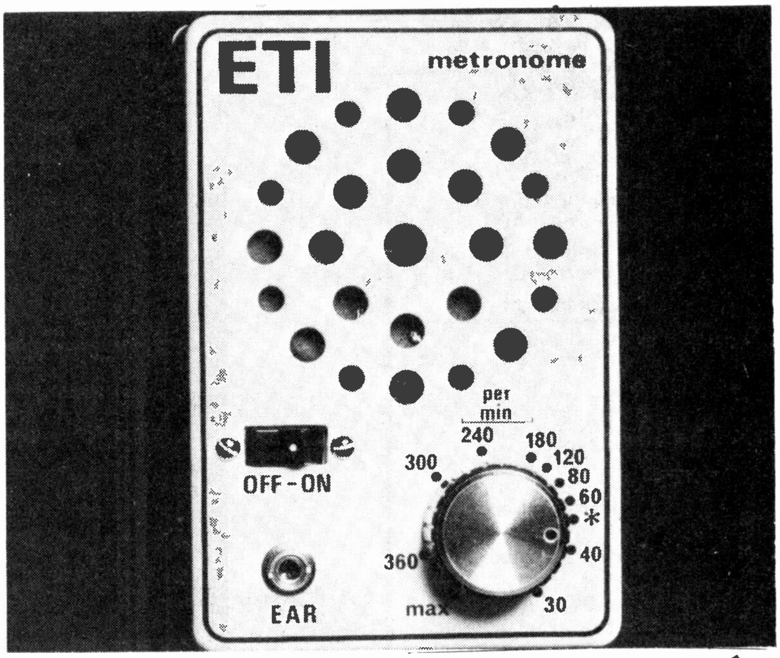
Construction is very straightforward. We have used a small pcb but there's nothing to prevent other constructional methods from being used.

USES

The use of a metronome for a musician is well-known but there are other applications. People learning to touch-type now sometimes use a regular beat to improve performance.

There are other areas where a metronome may be of use — in curing stammering. We know of someone who was helped enormously by the use of a metronome set at the fairly critical frequency of 50 beats per minute. We have marked this as an asterisk on our calibration.

However we have checked with a qualified speech therapist and it seems that this use of a metronome is not so widely recognised as an aid as it once was. What they would say was that 'In some cases, it could help, but not always.'



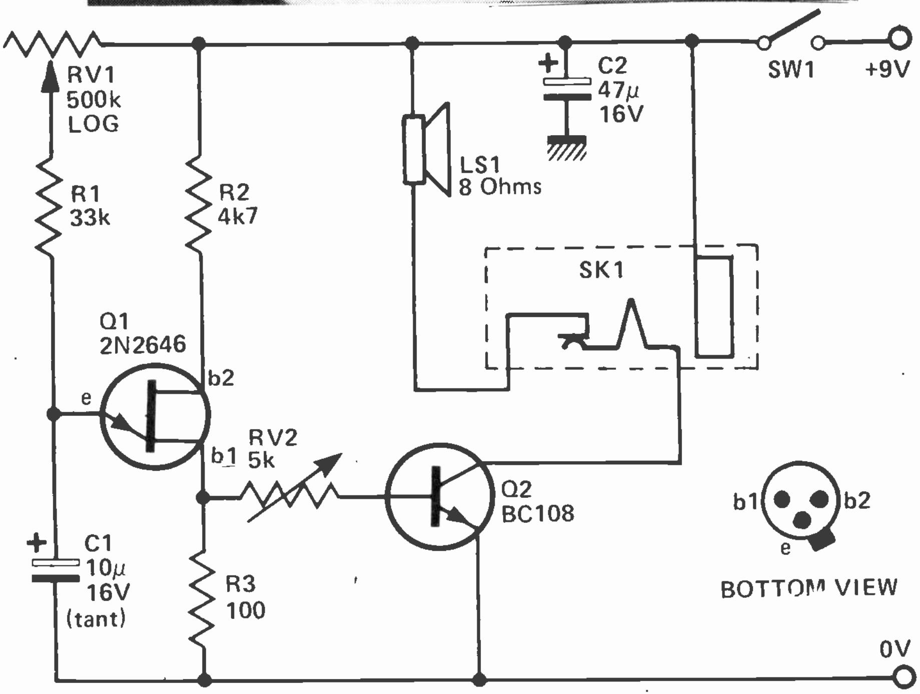


Fig 1. Circuit diagram for the metronome. SK1 switches off the L.S. upon insertion of the earpiece. The connection diagram is for the 2N2646.

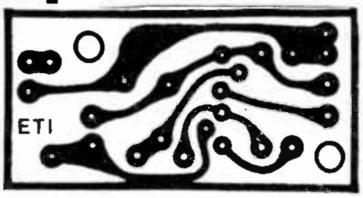
How it works

The circuit makes use of the special properties of a unijunction transistor, Q1. When voltage is applied to the circuit, C1 charges up through RV1 and R1, the rate at which it charges depending on the setting of RV1.

When the voltage is at the emitter of Q1 reaches a certain level, this effectively shorts out the two bases. This raises the voltage at the junction of R3/RV2 briefly and C1 is discharged through R3 enabling the cycle to start again. The waveform across R3 appears as a series of short spikes.

RV2 acts as a crude volume control as it passes these spikes to Q2 which is switched on and off in sympathy in turn passing the burst of voltage to the speaker or the earphone.

Short Circuits



Parts List

RESISTORS all ½ W, 5%
R1 33 k
R2 4k7
R3 100

CAPACITORS
C1 10μ 16 V tantalum electrolytic
C2 47μ 16 V electrolytic

SEMICONDUCTORS
Q1 2N2646 unijunction
Q2 BC108 or similar

POTENTIOMETERS
RV1 500 k log rotary
RV2 5 k lin trim type

SWITCH
SW1 On-off rocker switch

SOCKET
SK1 3.5mm panel jacket socket

SPEAKER
LS1 8 Ω (2½" - 2¾") type

CASE
Norman P.B.1 or similar
(4½"x 3"x 1½"/115mm x 75mm x 35mm)

MISCELLANEOUS
PP3 battery, battery clip, knob, nuts, bolts, etc, pcb as pattern, wire, 8Ω earpiece with 3.5mm plug.

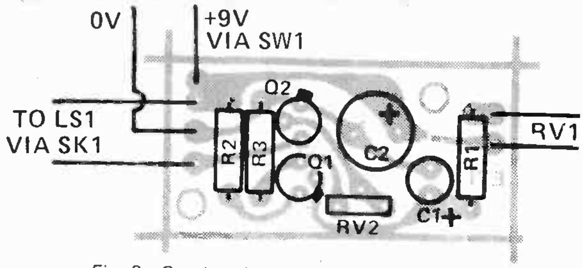
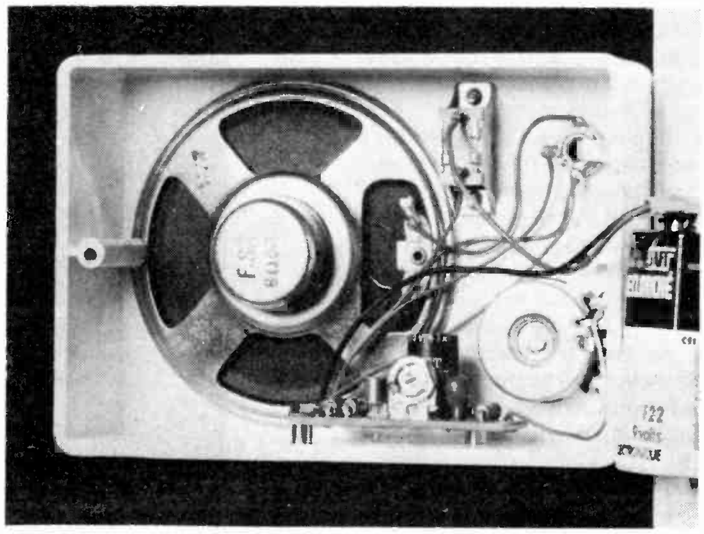
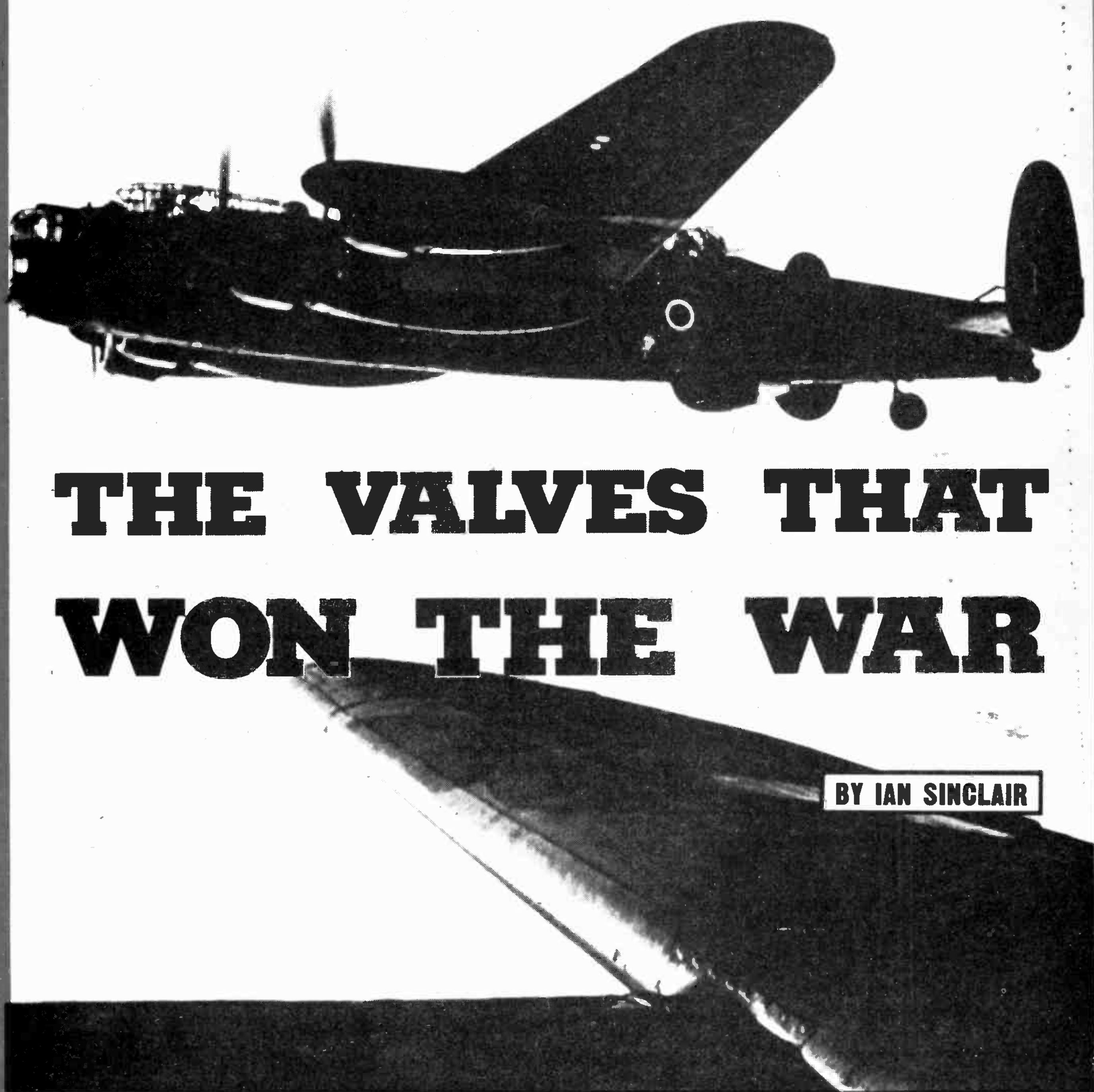


Fig 2. Overlay for the metronome. RV2 is mounted vertically to allow adjustment. Take care with the semiconductor connections.



RV2, the preset volume control can be clearly seen on the pcb. A hole is drilled in the back panel to allow this to be adjusted by screwdriver when need be, which is surely infrequently. The rate control down on the right works most effectively if a log control wired in 'reverse log' is employed.

AS A RECENT TELEVISION SERIES DEMONSTRATED, THE USE OF RADAR BY BOTH SIDES IN WORLD WAR II WAS OF CONSIDERABLE STRATEGIC IMPORTANCE, WITH THE ADVANTAGE SHIFTING FROM ONE SIDE TO THE OTHER WITH EACH NEW DEVELOPMENT. THIS IS THE STORY OF ONE KEY INVENTION WHICH SWUNG THE BALANCE CONSIDERABLY AND WHICH CONTRIBUTED MUCH TO OUR UNDERSTANDING OF ELECTRONICS.



THE VALVES THAT WON THE WAR

BY IAN SINCLAIR

THE VALVES THAT WON THE WAR

THE ESSENCE OF RADAR is that radio signals sent out from a transmitter will reflect from a target which is large compared to the wavelength of the signals, and the reflected signals can be picked up on a receiver.

The time delay between transmission and reception is then a measure of the range of the object which is reflecting the waves. The wavelength which can be used is of considerable importance, since short wavelengths can detect smaller targets and also need smaller aerials. If we want to use reasonably small aerials and to detect objects about the size of an aircraft, then we must use wavelengths of about one metre or less. The methods which we use to generate these wavelengths are therefore of great importance, and the amount of power which can be delivered to the aerial will decide what range is usable, since the received signal can be detected only if it has an amplitude greater than the noise level of the input stage of the receiver.

Thanks to the use of low-noise input stages, pulse gating, and correlation techniques, we can now recover signals which have apparently been lost in noise, but these techniques were not available in the years of the war.

REFLECTIONS AND SHORTENING

Early radar experiments used standard or slightly modified short-wave radio transmitters, with power output stages which were usually large air-cooled triodes with conventional inductor-capacitor tank circuits. In the early experiments, detection was considered more important than range-finding, and the received signal was allowed to beat with a fraction of the transmitted signal to form a slowly changing beat note from a moving target. These arrangements were sufficient to show that the reflected waves could be detected, but the wavelength was too long (frequency too low) and the power too small for radar as we now know it.

What was needed was a generator of waves of much higher frequency and much greater power. In addition, if such a generator could be made small enough to be carried in an aircraft, a substantial advantage in night bombing would be obtained.

Using conventional triodes, this was impossible. The stray capacitances of a large triode are so large that even the inductance of a short piece of straight wire gives a tuned circuit whose frequency is too low (assuming that oscillation takes place). The power output of such a valve at extremes of frequency is too low in my case.

Fortunately, as so often happens, the foundations for a new type of construction were already laid. These foundations were the magnetron effect on electron beams, and the resonant cavity tuning system.

MAGNETIC SPACES

When electron beams travel from a hot cathode to a positively charged anode, the speed of the electrons is decided by the voltage applied between anode and cathode. Equating the potential energy, eV, with the kinetic energy $\frac{1}{2}mv^2$, for each electron we get:

$eV = \frac{1}{2}mv^2$, where e = electron charge
V = accelerating voltage
m = electron mass
v = electron speed.

From this equation, the electron speed, $v = \sqrt{\frac{2eV}{m}}$

Using modern units, the ratio e/m, the specific charge of the electron, is 1.76×10^{11} C kg^{-1}, so that for 5kV accelerating voltage, the speed of the electron is about 4.2×10^7 ms^{-1}, some 42 million metres per second. At this speed, an electron will cover a distance of 1 cm in 0.24 ns, so that we should have no trouble in generating oscillations of a comparable wavetime if we can use such a beam in an oscillating system.

Now if we apply a magnetic field to such a beam, and direct the magnetic field so that it is at right angles to the direction of motion of the electrons as they enter the field, the path of the electrons will be an arc of a circle whose axis is the magnetic field direction. Equating the magnetic force, Bev, on a moving electron with the force needed to move an electron in a circular path, $\frac{mv^2}{r}$ we have: $Bev = \frac{mv^2}{r}$, so that $r = \frac{mv}{Be}$

BEAM BENDING

Using the value of speed given above, to bend the electron beam into a circle of radius 1 cm needs a magnetic field strength of about 2.4×10^{-2} Wb m^{-2}, about one thousand times the magnetic field strength of the Earth. This is not a particularly large field strength, and it was attainable by either permanent or

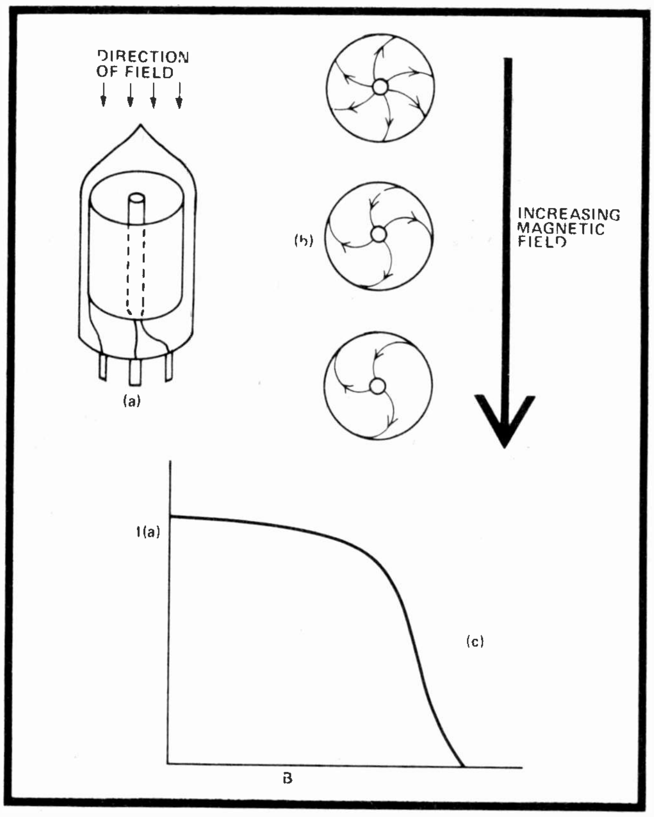


Fig 1. The magnetron effect. (a) Simple magnetron valve, magnet not shown. (b) Paths of electrons as the strength of the magnetic field is progressively increased. (c) Graph of anode current against magnetic field.

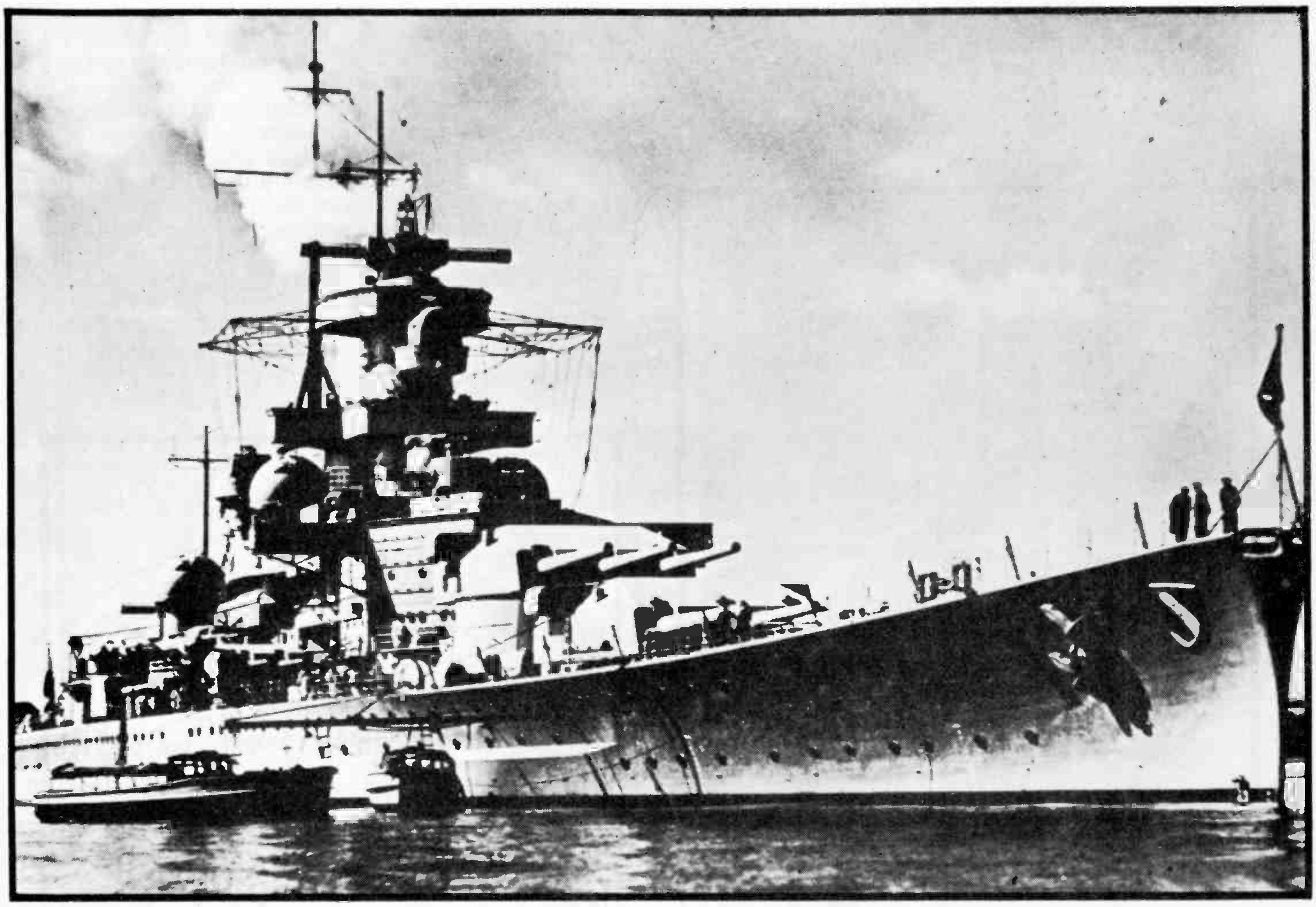
electro magnets. All of this basic theory has been known since early in the century due to the work of J. J. Thomson on the specific charge of the electron.

Later work had made use of the magnetron effect to measure the specific charge of the electron in a different way, as shown in Fig. 1. A tubular cathode emits electrons which are accelerated to a circular anode coaxial with the cathode. When a magnetic field is directed along the axis of the tube, the path of the electrons curves, and becomes more curved as the strength of the magnetic field is increased. If we plot a graph of anode current against magnetic field strength, the graph shows current dropping as fewer electrons reach the anode, and then reaching zero when the magnetic field is strong enough to prevent the fastest electrons from reaching the anode. Using such a "magnetron" valve made to accurately known dimensions, the value of e/m for the electron could be found to very close limits. The great breakthrough in radar was to realise that this valve structure could be combined with resonant cavities to enable us to generate oscillations in the GHz region.

RESONANCE

In the study of sound waves, any space may have resonances, meaning that sound waves of certain wavelengths, related to the dimensions of the space, will be emphasised; these are resonant frequencies, and designers of loudspeakers go to great lengths to get rid of them. A tube is one type of resonant space, and organ pipes and other wind instruments are examples of resonant tubes used to generate sound waves of various frequencies.

A tube which is resonant to one particular frequency will generate this frequency if the air in the tube is set into oscillation by any disturbance. An example of particular interest in this case is the flute. In this instrument, the player blows air across a small hole in a resonant tube. Air striking the edge of the hole (controlled by the players mouth-shape) builds up a pressure wave which sets the air in the tube into oscillation at its resonant frequency, and the resonant waves in the tube then make the air passing across the hole flutter, keeping up the oscillation. What we have here, translating into familiar electronic terms, is a d.c.



The mighty Scharnhorst. One of Germanys new generation of capital ships. As modern as anything then afloat, fast enough to outrun anything which could outgun her, and armed sufficiently to sink anything fast enough to catch her. Yet the Scharnhorst fell victim to the Magnetron!

The battle of North Cape was the battle which proved the importance of radar in surface engagements. Leaving Norway to attack convoy JW 55B the Scharnhorst was dogged by a series of disasters and unfortunate decisions by High Command which led her, on December 26th 1943 in appalling weather to face the British cruisers Belfast, Norfolk and Sheffield — all radar equipped and using it! Scharnhorst herself had radar equipment, but standing orders prevented its use (as a measure against breaking radio silence!) In the engagement which followed the British ship directed their fire with radar, and by chance destroyed the Scharnhorst radar!

They followed her on radar until the battleship Duke of York came up to engage, also using radar, with her superior armament. Scharnhorst was sunk. Her superior speed and firepower were of no avail.

On New Years Day 1944 Admiral Dönitz reported to Hitler "Without serviceable radar equipment it is no longer possible for surface forces to fight the enemy."

supply (the player's breath), a resonant tuned circuit (the tube of the instrument), and postive feedback (the effect of the resonant waves on the breath stream.

A similar effect can be expected using a beam of electrons. A circular cavity cut into a block of metal will act as a tuned circuit, using the inductance of the conducting material and the stray capacitance between sections at (momentarily) different potentials. This is a resonant cavity, and the wavelength of resonance is related to the size of the cavity. When such a cavity oscillates, both electric and magnetic fields will exist, and these will be rapidly alternating fields, going through a cycle of building up in one direction, dying away, reversing, building up in the reverse direction, dying away and so repeating millions of times per second.

Can we carry the similarity a little further, and imagine a small slot in the cavity? At such a slot, alternating electric and magnetic fields will exist, and these will alternately repel and attract an electron beam which is just skimming past the slot like the breath of the flautist. Would such an arrangement give enough positive feedback to keep a resonant cavity oscillating? At the beginning of the war, only experiment could decide, and it fell to Randall and Boot, working at Birmingham, to perform the crucial experiment, so creating the first cavity magnetron oscillator. This valve was capable of supplying U.H.F. oscillations at power levels greatly in excess of any previously obtained at such frequencies, the perfect answer to the demands of the radar system.

Fig 3. A coastal defence tower. Standing some 360 ft high, the apparatus was used to detect low flying intruding aircraft which were flying too low for normal stations to detect them. Lone raiders often adopted this tactic to reach specified targets, or to make photographic records.

CAVITY MAGNETRON

The cavity magnetron combines the principles of the resonant cavity with the earlier magnetron valve. The cathode is a tube coated with electron emitting material, and with a heater winding inside for starting the electron emission. The anode is metal block, finely machined to a circular profile with a set of resonant cavities breaking into the inner surface of the block. The whole valve is evacuated and sealed, and then mounted between the poles of a strong permanent magnet. Since it would be inconvenient to run the cathode at earth potential and have the metal anode and its cooling fins positive, the anode is earthed (and connected to waveguide through a thin "window") and the cathode run at a negative voltage.

When an accelerating voltage exists between the anode and the cathode, the electrons are accelerated from the cathode, and the magnet shapes the beam so that its shape is circular, brushing past the ends of the cavities as it tries to reach the anode. For a given strength of magnet, the voltage between anode and cathode would have to be the correct value for the beam to take the correct path, but this value is fortunately not too critical. The movement of the beam excites the cavities into oscillation, and the oscillating cavities in turn will alternately repel and attract the beam.

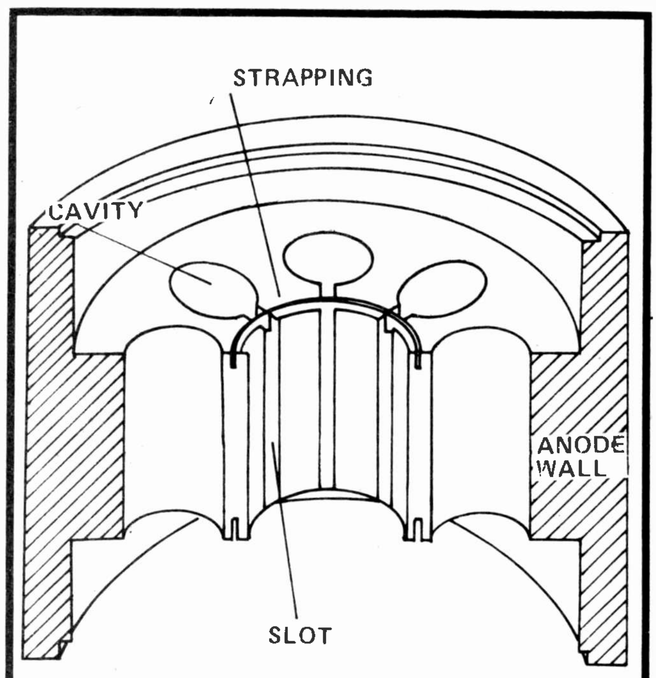
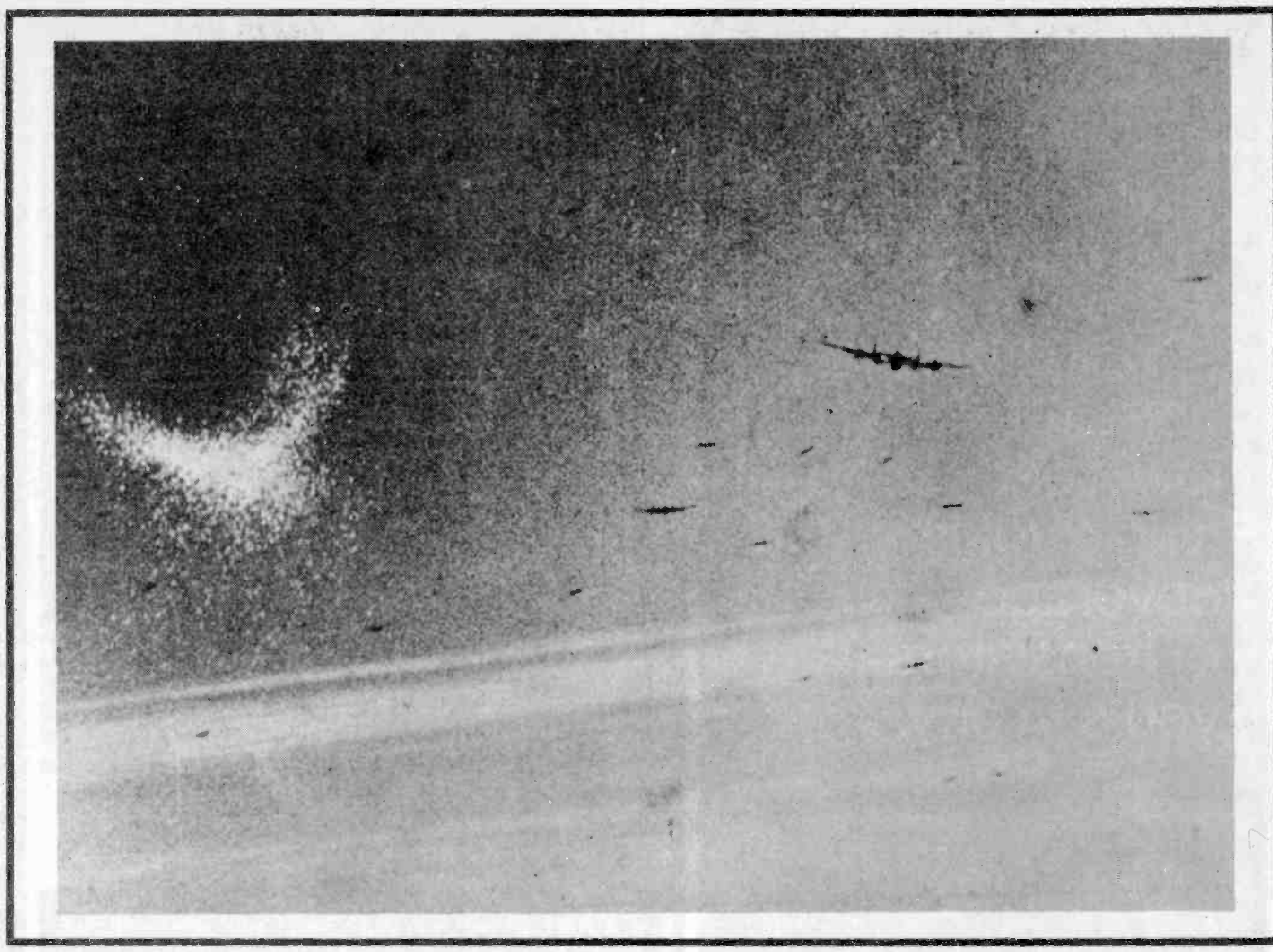


Fig 4. Cross-section of a cavity magnetron, which in this case uses cavities of cylindrical shape, linked to the anode by slots. The strapping links can also be seen. Other cavity shapes are also used.



PHOTOGRAPHS BY COURTESY OF IMPERIAL WAR MUSEUM.

The photograph shows a Lancaster bomber dropping 'window.' This was shredded aluminium foil, dropped to confuse German ground radar. The beams were scattered by the foil, giving totally erroneous readings upon re-receipt. In the background can be seen some of the other aircraft in the raid, in this case a 1,000 bomber attack on Essen.

The foil is the silvery shimmer to the left of the photograph, scattering as it falls.

COMBINATION LOCK

The combination of these effects causes the beam alternatively to strike and then be repelled from the anode, so that the oscillations in the cavities can have very large voltage amplitude, of the order of the applied voltage. Similarly, by using a large cathode, high beam currents are possible so that the peak power developed in one cycle of oscillation can be very large. At the same time, the size of the magnetron is modest, since the radius of curvature of the electron beam is small, and the power dissipated would melt the anode if the beam were applied continuously. The answer here was to pulse the beam by applying a short (1 µs or less) negative pulse of several kV amplitude to the cathode at a repetition rate of1 000 pulses per second or so. By using this technique, the power developed during a pulse, which could be of thousands of cycles of the microwave frequency, could be many kilowatts, giving excellent range, yet the average power, and hence the heat dissipation, would be only a thousandth of this value, since the valve would be on (in this example) for only one microsecond in each millisecond.

DEVELOPMENTS

Inevitably some development was needed. The early cavity magnetrons were unstable, changing frequency for no apparent reason. This is a problem which also afflicts those learning to play wind instruments, because all resonant cavities will resonate to harmonics (multiples of frequency) of the lowest note which is possible (the fundamental). The resonant cavities of the magnetron have the further complication that two sets of oscillations are taking place in them, oscillations of magnetic field and oscillations of electric field. The cure was to shape each cavity to make one mode of oscillation dominant, and to use cavities which were interconnected, with alternate cavities "strapped" so as to reinforce the desired frequency of oscillation.

In addition, the tendency of magnetrons to burn out their cathodes too quickly was found to be due to the extra heating caused by the beam current. This could be counteracted by using the heater only for starting the tube, switching it off whenever the magnetron started to oscillate so that the beam current could then provide the heating.

FROM THE NORTH CAPE TO OVENS

Nowadays, the magnetron is still the high power, high frequency microwave signal source, used in radar, in microwave ovens, and in materials research. The advantage which the cavity magnetron gave us during the war was of major importance, and the advantage, unlike so many others before and since, was never quite lost.

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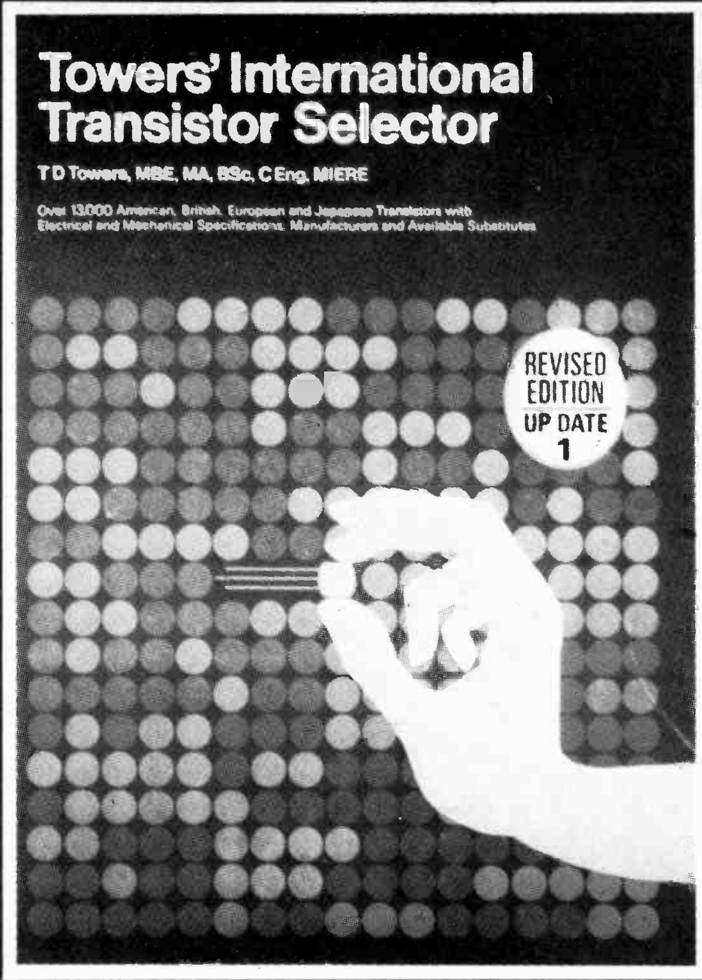

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ETI DATA SHEET

LM1812 ULTRASONIC TRANSCEIVER — NATIONAL

The LM1812 is a special monolithic IC which consists of a 12W ultrasonic transmitter circuit, which uses novel circuitry to eliminate costly alignment adjustments, a selective receiver which uses only one external LC network, impulse noise rejection circuitry, a 10W display driver, and a keyed modulator. The system operates from a 12V battery, drives power into a transducer, receives an echo and drives a display lamp.

A single LC network is time shared between the receiver and the transmitter to reduce external parts, to eliminate alignment labour and to guarantee that the received signal is always of the proper frequency.

TRANSDUCERS

Transducers are available for use either in water or air. The appropriate transducer is important for proper functioning in the intended application; for example, the high frequency attenuation in air usually requires a lower operating frequency. The modifications for a 40 kHz system are shown.

LAYOUT

As the LM1812 contains both a transmitter and a receiver in proximity, PC layouts or breadboarding has to be done with special attention to ground loops and common coupling paths. The use of three ground pins on the IC package helps reduce grounding problems, but at the time of transmission, with the display driver also ON, there can be 1-2A of peak current passed into the ground trace.

INTERFERENCE

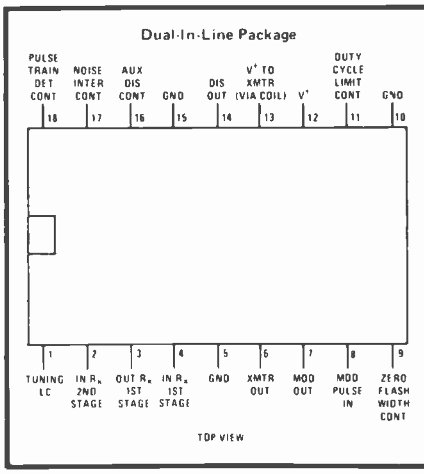
Local sources of High energy impulse noise, if not locally shielded, can cause an unwanted display "blip."

A small valued capacitor (approximately 30 pF) can be connected across the first receive stage (between pins 3 and 4) to reduce the bandwidth and filter out these noise pulses.

Impulse noise is rejected by the combined action of the "Pulse Train Detector" and the "Integrator" circuits.The integrator requires a number of cycles of valid returns to be received before turning ON the display driver. The pulse train detector will dump the integrator if a continuous train of pulses is not received (if 2 or 3 are missing, the integration capacitor is discharged to ground).

POWER LEVELS

For ranging applications, large transmit power levels are necessary due to the two-way path and the resulting received echo power falling as the fourth power of range (additional external receiver gain can be used to extend the range). One way communication links can use reduced power. Transmit power can be checked by measuring the voltage swing across the transducer (of known impedance) during the transmit mode. The magnitude of the transmitter power depends on the transducer impedance as presented to the transmitter power amplifier (usually a transformer is used to couple the transducer to the power amplifier). A minimum value of 10Ω causes



FEATURES

- Has special access pins (7 and 16) which allow adding an audible alarm feature to indicate an echo within a presettable maximum depth (or range).
- Does not require any heat sinking of the IC package
- Uses a built-in monostable multivibrator, with the capacitor on the chip, to pulse drive the transmitter for high efficiency and to minimize transducer interaction
- Has special circuitry to limit the maximum ON time of the display driver
- Can operate with a neon, a LED display device, a digital readout or a CRT

approximately 1A peak current pulses out of this power amplifier. The inductance of the secondary should be designed to resonate with the sum of the capacitance associated with the cable feeding the transducer and that of the transducer. The low Q resonance allows transducer replacement without tuning.

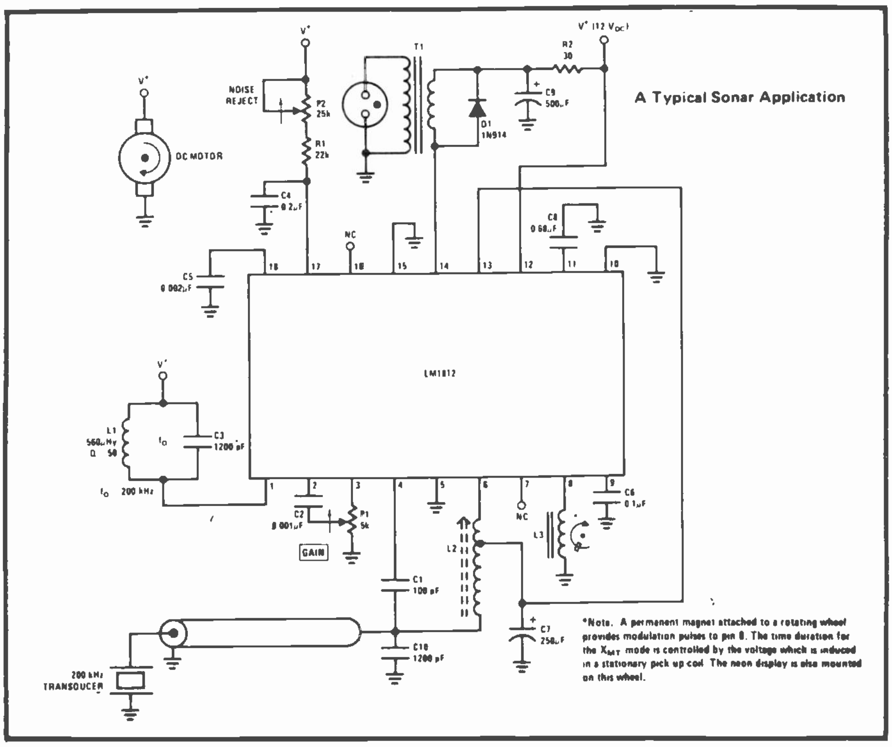
An internal one-shot multivibrator with a fixed time of 1 µs is used to drive the transmitter power amplifier into saturation for this time period once for each cycle of the transmit frequency. At a frequency of 200 kHz, this results in a high efficiency class-C type of operation for the power amplifier. The transmit frequency is equal to the natural resonance of the external LC network which is tied to pin 1. This network is also used to establish the centre frequency and the selectivity of the receiver.

DISPLAY CONTROL

The collector of a grounded-emitter NPN transistor can be tied to pin 16 to allow an auxiliary control of the display driver. This transistor should normally be held OFF and should go ON for a time interval no longer than 1 ms if a neon display is used, due to the rapid current build-up in the primary of the step-up transformer. If a LED is used as a display device with a series limiting resistor, this ON time can be made longer as it is now limited only by the increased dissipation of the IC which results from the saturation voltage at pin 14 and the ON current of the LED.

AUDIO

An IC audio amplifier can be used to amplitude modulate the carrier for an AM commu-

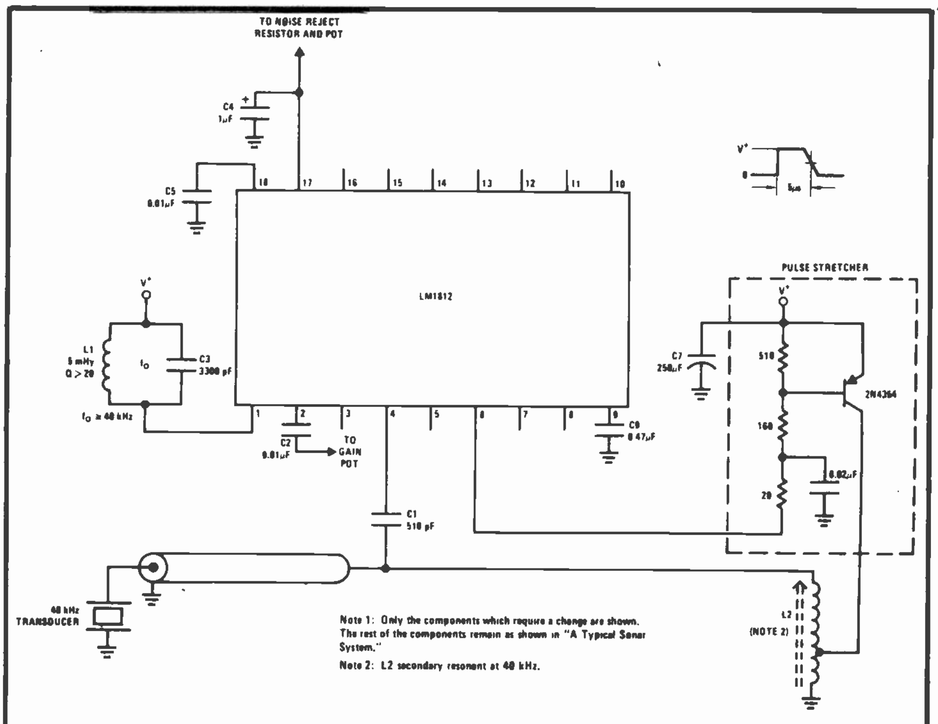


nication link. A high-input impedance detector and audio amplifier attach to pin 1 for the receiver. One audio amplifier can be switched between the modulator and the receiver section. FM or pulse modulation techniques can also be used to reduce the modulator power requirements.

DIGITAL DISPLAY

A digital depth (or range) readout can be used with the OLM1812. This eliminates the requirement for the constant speed dc motor. The modulator, pin 8, is electronically pulled ON for approximately a 1 ms transmit time at a repetition rate which controls the updating of the displayed information. The "neon driver," pin 14, will provide a negative output pulse (from V+ to approximately +1Vdc) if a load resistor (5.1 kΩ is used from pin 14 to V+. This pulse is used to latch the output of a counter. This output is decoded and then drives a 7-segment LED display. The repetition rate of the clock input to the counter provides a direct conversion from elapsed time (total count) to depth (or range).

The LM1812 is available from **A. Marshall (London) Ltd., 42 Cricklewood Broadway, London NW2 3ET.** Price is £6.50 inclusive, delivery time about 3 weeks. Further details of Ultrasonic transducers available from **Vernitron Limited, Thornhill, Southampton SO9 5QF.**



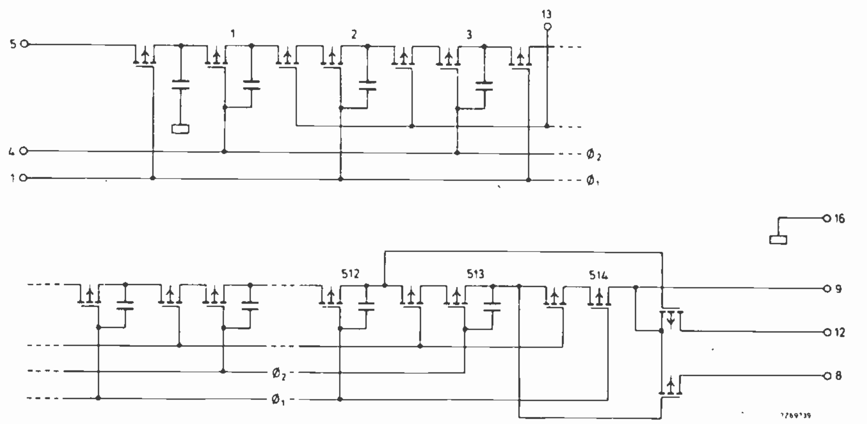
Component Changes for Operation in Air (40 kHz)

TDA 1022 BUCKET BRIGADE-DELAY LINE — MULLARD

The TDA 1022 is a charge-coupled delay line with 512 stages. The principle of operation is transfer of charge from stage to stage under the control of a two phase clock pulse. The descriptive title of 'Bucket Brigade' sums this up neatly. Just think of it as a line of buckets in fire fighting — the water gets passed along the line by pouring it into the next line, eventually it reaches the end. In the TDA 1022 the input signal is sampled at the rate of the clock pulse and passed along the line at this rate also.

AUDIO

For audio use the sampling clock) frequency should be at least twice the highest frequency you want to process. This means that for good quality audio with a high of 20 KHz the clock rate is 40 KHz, however, 100 KHz gives far better quality. The delay produced at this rate is 5.12mS. This may not seem very much but devices can be cascaded to produce longer delays. Also if a reduced bandwidth is acceptable longer delays can be produced, for example with a clock rate of 5 KHz usable bandwidth of 2 KHz) the delay is a healthy 51.2 mS. This can be useful for speech processing.



PINNING

1. Clock input 1 (V_{CL1})	5. Signal input	9. Negative supply (V_{DD})	13. Tetrode gate (V_{13-16})
2. Not connected	6. Not connected	10. Not connected	14. Not connected
3. Not connected	7. Not connected	11. Not connected	15. Not connected
4. Clock input 2 (V_{CL2})	8. Output 513	12. Output 512	16. Ground (substrate)

QUICK REFERENCE DATA				
Supply voltage (pin 9)	V_{DD}	nom.	−15	V
Clock frequency	f_ϕ		5 to 500	kHz
Number of buckets			512	
Signal delay range	t_d		51,2 to 0,512	ms
Signal frequency range	f_s		0 (d.c.) to 45	kHz
Input voltage at pin 5 (peak-to-peak value)	$V_{5-16(p-p)}$	typ.	7	V
Line attenuation		typ.	4	dB [1]

OTHER APPLICATIONS

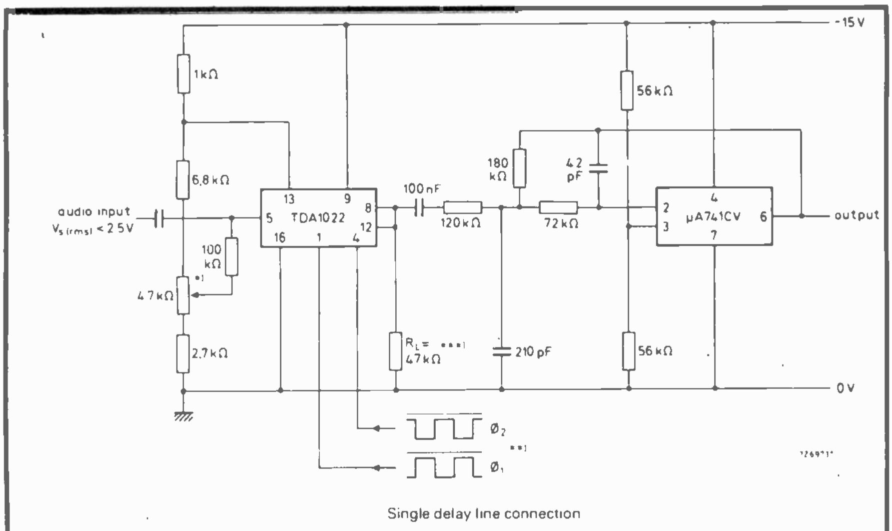
Other applications for this neat device include variable compression and expansion of speech in tape recorders, speech scrambling in communication systems, vibrato and chorus effects in organs, reverberation units and to equalise delay in public address systems.

PROTECTION AND USE

A couple of things to watch when using the device are that it uses a positive earth arrangement — unusual in modern circuits, and is MOS — handle with care. In respect of this it is advisable to use a 741 buffer before the device as well as the 741 output buffer, this makes sure signals can't blow it up if the power is off.

The clock pulses are out of phase and a suggested circuit is shown. In the main circuit the 741 output buffer, also acts as a lowpass filter, to get rid of residual high frequency noise from the clock.

The TDA 1022 is available from **A. Marshall (London) Ltd, 42 Cricklewood Broadway, London NW3 3ET.** Price £7.50 inclusive, delivery time about 2 weeks.



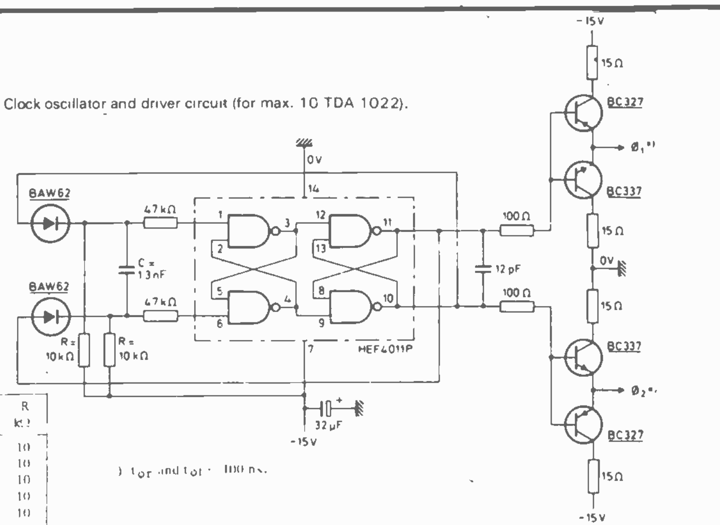
Single delay line connection

*) Adjust d.c. voltage for class-A operation (≈ 5 V).

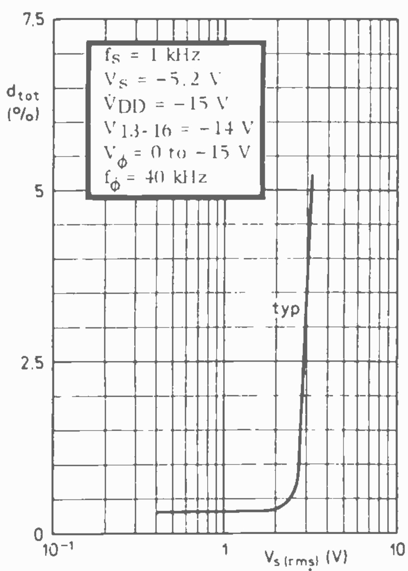
Conditions: low pass filter μA741CV (12 dB per octave); gain +3.5 dB (compensation for line attenuation). $f_Ø$ 50 kHz (min.); cut-off frequency 15 kHz

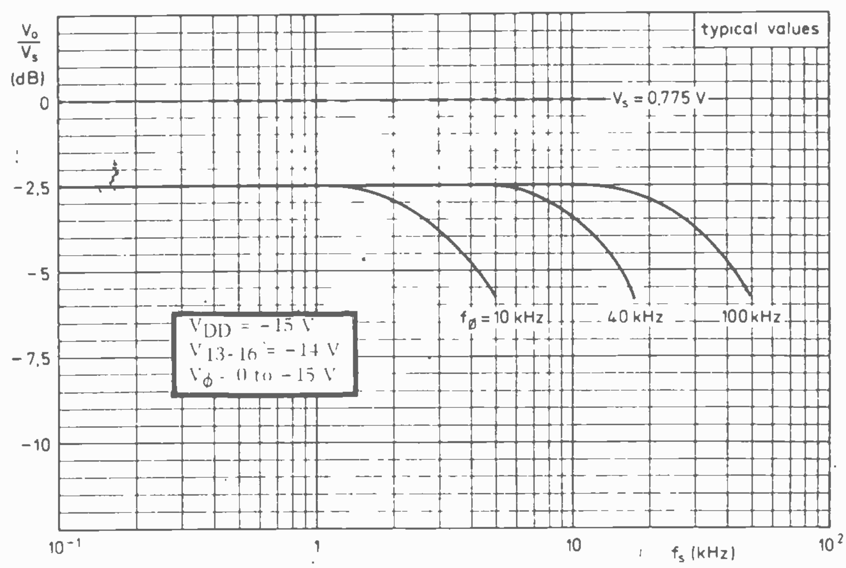
**) Clock input voltage amplitude, V_{CL} −15 V

***) Can be replaced by a current source of 100 to 400 μA (see also note 1 on page 4).



$f_Ø$ kHz	C	R kΩ
5	8.4 nF	10
10	3.9 nF	10
30	1.3 nF	10
100	330 pF	10
300	68 pF	10
500	30 pF	10





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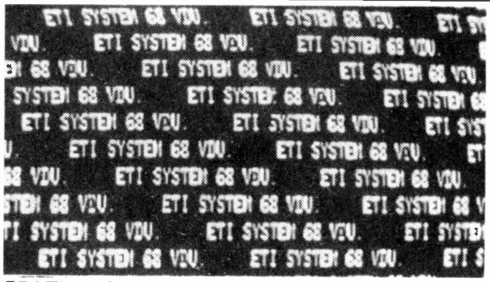
What to look for in the June issue: On sale May 6th

Master-Mind

THE GAME 'MASTERMIND' — not that on TV but the 'peg' game — has caught on like wildfire. If you don't know it, one player sets up a code for the other to break: it's a game which really tests your ability to think logically. Next month we describe an electronic version. Press a button and the circuit sets the problem — it will also reveal to you the necessary clues. It uses umpteen IC's but construction has been enormously simplified by the use of pcb's.

System 68 VDU

THE FIRST PART of our System 68 VDU project, covering the Video and Character generation board. Part 2 will cover the Interface and RAM board.



FEATURES include 64 character by 16 line display, parallel I/O with less than ¼ second for full screen from memory, White on Black or Grey or any combination plus character flash. e.g. Black letters on grey flashing background. All built into a 2in module on two Eurocards!

Valve Sound

AUDIO TECHNOLOGY marches on — distortion figures grow ever more negligible with the passing days. Transistor and IC amplifiers are rapidly approaching the frontiers of design possibility (on paper). Every now and then problems appear to become significant as their (smaller) contribution to final sound quality becomes the largest remaining.

Yet in the wake of this sweep to perfection, professional musician's are hanging on with tooth and nail to their aged and totally outdated VALVE amplifiers. Why? Simple; they say it sounds better.

Why? Has modern technology missed something? What is the vital factor that valve designs possess and solid-state designs don't? Next month we'll tell you — and the answer is ***very*** controversial!

ETI–MARSHALL'S–NATIONAL

DFM

AN ETI short circuit. A 3-Digit LED display is used to give coverage from 1Hz to 9.99MHz in five ranges. Input sensitivity is 100mV. A short circuit? Yes; although complex in its theory we've reduced the problem to a minimum by using carefully designed pcb's.

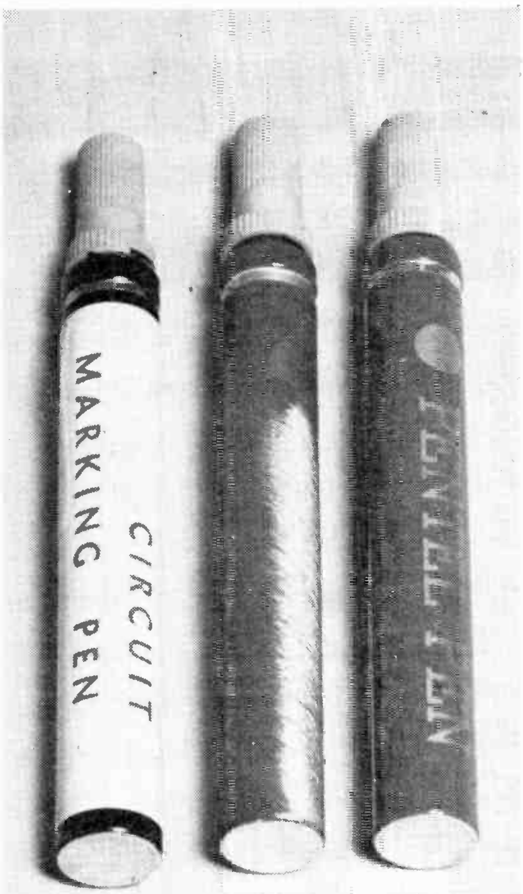
Bass Enhancer

IF YOU'RE just starting in Hi-Fi, or would like to improve the sound of your present bookshelf enclosures — this project is for you. This is *not* simply a bass boost circuit: it is an active filter design which compensates for the falling response of most small speakers below 100Hz. Part of the design eliminates rumble and warp signals below 15Hz so that fidelity is preserved.

P.S. Also a must if you hate your neighbours!!)

LCD

LIQUID CRYSTAL DISPLAYS were practically unknown a few years ago



A B C

tip of the month!

For some time now a printed circuit resist pen, A in the photograph, has been on sale. The price varies a bit, but 65 - 75p is typical.

They're good. We've used them; it dries fast, is certainly acid resistant, and is easy to clean off afterwards.

A paper label is wrapped around the barrel and being of a curious disposition, we decided to remove it — shown as B. Rather odd, we thought, that someone should go to all the trouble to sand off part of the barrel. Apart from this area, the rest of the barrel carries Japanese wording which happens to be identical to the Pentel Pen (C) sold in stationers, not for 65 - 75p but for 30 - 35p — and they're available in many colours. Wishing to take nothing for granted, we tried the Pentels as resists. They're good too!

So far we have been unable to discover the advantages of the paint-free area on the barrel — and 35 - 40p extra does seem rather a lot, doesn't it? We couldn't resist telling ETI readers about this!

DON'T BLAME YOUR NEWSAGENT

British newsagents are among the best in the world. No, we're not trying to butter them up but we are an international magazine and are in a position to make comparisons. But they've got a tough job — they don't know how many of you want ETI, so they've got to guess, and since they're bound to order conservatively, this leads to shortage. The February, March and April editions of ETI were total sell-outs within a few days in most areas. We don't like it, you don't like it, and your newsagent doesn't like it.

Please help us all, place a regular order; your newsagent will normally be delighted to help.

SINTEL for KITS - CMOS - BOOKS

Components from Leading Manufacturers only

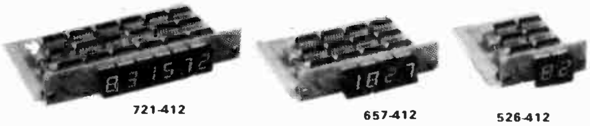
SINTEL

A NEW RANGE OF SINTEL INDUSTRIAL MODULE KITS

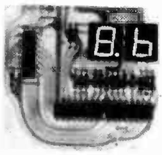
Using only the highest quality components — Fibreglass roller-tinned PCBs — ICs and Displays direct from "Blue chip" Manufacturers.

KITS FOR TTL LATCHED COUNTER MODULES
Each kit includes a set of displays (0.5" Red LED type TIL321/FND507) and two PCBs, one each per digit of 7447, 7475 and 7490, plus brackets, resistors, capacitors, a single in-line plug and socket, nuts, screws, washes, instructions, etc. Sockets are NOT included and we recommend that you order Soldercon Pins separately (112 for a 2 digit module, 224 for a 4 digit module and 336 for a 6 digit module).
Each module consists of one vertical PCB holding the displays, fixed by two brackets to a horizontal PCB, which holds the remaining components.

Full Kit for 2 digit TTL Counter with Latch	Order as **526-412**	**£12.50**
Full Kit for 4 digit TTL Counter with Latch	Order as **657-412**	**£22.50**
Full Kit for 6 digit TTL Counter with Latch	Order as **721-412**	**£32.50**



721-412 **657-412** **526-412**



KIT FOR SINGLE PCB CMOS COUNTER MODULE WITH LATCH
A complete kit for building a 2 digit, single PCB, CMOS Counter Module with Latch. Includes PCB, 2 x TIL322 or FND500, 2 x 4511, 1 x 4518, Rs, socket pins, etc. Size h 67mm w 71mm d 18mm.
Order as **142-269** **£8.60**

SETS OF JUMBO DISPLAYS WITH DISPLAY HOLDING PCB
Each kit consists of the appropriate number of 0.5" red LED displays (either common anode TIL321/FND507s or common cathode TIL322/FND500s) and a display holding PCB. OPTIONS: PCBs wired for multiplexing or non-multiplexing, clock format or counter format.

TYPE Non-Multiplexed	COMMON ANODE Part No	Price	COMMON CATHODE Part No.	Price
2 digit Counter	574-822	£3.37	446-822	£2.97
4 digit Counter	777-822	£6.63	128-822	£5.83
6 digit Counter	684-822	£9.89	271-822	£8.69
Multiplexed				
4 digit Clock	801-822	£6.66	262-822	£5.86
6 digit Clock	417-822	£10.15	452-822	£8.95
8 digit Counter	119-822	£13.09	515-822	£11.49

DISPLAYS

These Jumbo LED displays take no more current than 0.3" types. All our common cathode (C.C.) digits can be used in place of any other C.C. display (DL704, D1750, MAN3640, etc.) since they are all electrically identical (but may have different pin-outs). Similarly our common anode digits may be used in place of any other C.A. types (DL707, DL747, RS/Doram 586/699, etc.).

FND500 C.C. **£1.30**
Red 0.5" by Fairchild

TIL321 C.C. **£1.50**
TIL322 C.C. **£1.49**
Red 0.5" by T.I.

5LT01 £5.80
A very attractive four digit display with large 0.5" green digits. AM/PM and colon. Phosphor diode (vacuum fluorescent).

DATABOOKS

RCA CMOS and Linear IC Combined Databook	£6.70
National Semiconductor 7400 series TTL Databook, c. 200 pages	£3.45
TTL Pin-Out Card Index	£2.95
Intel Memory Design Handbook, c. 280 pages	£5.20
Intel 8080 Microcomputer Systems Users Manual, c. 220 pages	£5.25
Motorola McMOS Databook (Vol 5 Series B), c. 500 pages	£3.50
Motorola M6800 Micro Applications Manual, c. 650 pages	£12.95
Motorola M6800 Programming Manual c. 200 pages	£5.35
Motorola Booklet introducing Microprocessors	£1.80
National SC/MP Introkit Users Manual	£0.75
Zilog Z80-CPU Technical Manual	£5.60
Zilog Z80-CTC Product Specification	£0.80
Zilog Z80-P10 Technical Manual	£3.30

DATASHEETS on Microprocessors, etc. (usually Xerox Copies)

Intersil IM6100 12 bit	£0.75	RCA CDP 1802 8 bit CMOS	£0.75
National SC/IMP 8 bit	£0.75	Zilog Z80 (enhanced 8080)	£0.75
Signetics 2650 8 bit. Low cost	£0.75	Motorola MC 6800	£0.75
TMS 8080	£0.75	TMS 5501 for 8080	£0.75
9131 Memory	£0.75		

Our offices are at Link Property, 209 Cowley Road, Oxford, but please do not use this as a postal address.

FAST SERVICE. We guarantee that Telephone Orders for goods in stock, received by 4.15 p.m. (Mon-Fri.) will be despatched on the same day by 1st Class Post (some heavy items by parcel post) and our stocking is good. Private customers should telephone and pay by giving their Access or Barclaycard number, with a minimum order value of £5. Official orders, no minimum.

ORDERS: C.W.O. add VAT @ 8% + 25p p&p. TELEPHONE and CREDIT (invoice) Orders add VAT @ 8% + 50p p&p and please see FAST SERVICE. EXPORT Orders welcome, no VAT but add 10% (Europe), 15% (Overseas) for Air Mail p&p. For Export postage rates on heavy items — contact us first.

A FREE CATALOGUE requested by post or phone, will be sent by return giving full details of our range of CASES ● KITS ● DISPLAYS ● MPUs ● MPU KITS ● and other components not listed here, with same day despatch for goods in stock. All prices valid until 31st August, 1977.

COMPONENTS

CMOS
Mainly RCA

		CD4026	1.78	CD4052	0.94	CD4093	0.92
CD4000	0.17	CD4027	0.58	CD4053	0.94	CD4094	1.94
CD4001	0.18	CD4028	0.92	CD4054	1.20	CD4095	1.08
CD4002	0.17	CD4029	1.18	CD4055	1.36	CD4096	1.08
CD4006	1.20	CD4030	0.58	CD4056	1.36	CD4097	3.85
CD4007	0.18	CD4031	2.30	CD4059	4.93	CD4098	1.13
CD4008	1.00	CD4032	1.02	CD4060	1.15	CD4099	1.90
CD4009	0.58	CD4033	1.44	CD4063	1.13	CD4502	1.24
CD4010	0.58	CD4034	1.97	CD4066	0.63	CD451D	1.41
CD4011	0.20	CD4035	1.22	CD4067	3.85	CD4511	1.72
CD4012	0.23	CD4036	3.29	CD4068	0.23	CD4514	2.84
CD4013	0.58	CD4037	0.98	CD4069	0.23	CD4515	3.24
CD4014	1.04	CD4038	1.10	CD4070	0.51	CD4516	1.40
CD4015	1.04	CD4039	3.20	CD4071	0.23	CD4518	1.25
CD4016	0.58	CD4040	1.11	CD4072	0.23	CD4520	1.19
CD4017	1.04	CD4041	0.86	CD4073	0.23	CD4527	1.64
CD4018	1.03	CD4042	0.86	CD4075	0.23	CD4532	1.39
CD4019	0.58	CD4043	1.01	CD4076	1.34	CD4555	0.90
CD4020	1.28	CD4044	0.96	CD4077	0.45	CD4556	0.90
CD4021	1.04	CD4045	1.45	CD4078	0.23	MC14528	1.22
CD4022	0.94	CD4046	1.37	CD4081	0.23	MC14553	4.68
CD4023	0.23	CD4048	0.58	CD4082	0.23	IM6508	8.05
CD4024	0.80	CD4049	0.58	CD4085	0.74		
CD4025	0.23	CD4050	0.58	CD4086	0.74		
		CD4051	0.94	CD4089	1.60		

VEROCASES
751410J 3.36
751411D 4.10
751237J 2.50
751238D 3.00
751239K 3.58

CLOCK CHIPS
AY51202 3.10
AY51224 3.50
MK50253 5.60

CRYSTALS
32.768kHz 3.50
5.12MHz 3.60

VEROBOARDS
3.75" x 5" (2 per pack)
103/P16xPK 1.12
4.7" x 17.9"
126/P16 2.55

TRANSFORMERS
LEDTRF 1.95
5LTRF 1.95

FLAT CABLE
20w 1m 1.00
10m for 8.00

SOLDERCON IC PINS
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1000 4.00
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MEMORIES
9131 (new) 19.50
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2112A-4 4.10
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MPU KITS
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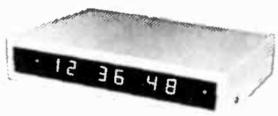
HIGH QUALITY KITS



ACK £27.80

ATTRACTIVE SIX DIGIT ALARM CLOCK KIT
A complete kit including slim white case h 40mm w 205mm d 140mm with deep red panel. Features bleep alarm, snooze, automatic intensity control and high brightness display driving. Twelve or twenty-four hour format (easy to add a switch to switch between them). Touch switch snooze.

This alarm clock is also available with CRYSTAL CONTROL and BATTERY BACKUP. If mains power is disconnected (deliberately or accidentally) the clock will keep perfect time. Accuracy to within a few seconds a month. While on backup, the displays are off to conserve battery but the alarm remains fully operational.
Order as **ACK+BBK+XTK** **£34.33**

DIGITAL CAR CLOCKS

CCK

AUT-CK

CRYSTAL CONTROLLED 6 DIGIT CAR CLOCK WITH INDEPENDENT JOURNEY-TIMER
Shows time or elapsed time in hrs. mins. secs ● Runs off car 12v supply ● Nine push buttons for Start-Stop-Reset, selecting display to show time or elapsed time ● All controls functional irrespective of display mode ● Kit complete with case h 40mm w 205mm d 140mm.
Order as **CCK** **£42.00**

THE SINTEL CAR CLOCK KIT
Four 0.5" red digits ● Neat white case ● Crystal control ● Battery backup ● Suitable for all 12v negative earth cars ● Size h 40mm w 154mm d 85mm. Complete less battery.
Order as **AUT-CK** **£17.85**

GCK CLOCK KIT
Four bright green 0.5" digit mantlepiece or office clock ● Crystal control ● Battery backup ● White case ● Size h 40mm w 154mm d 85mm. Complete less mains cable, plug and battery.
Order as **GCK+BBK+XTK** **£19.65**
Also available less crystal control and battery back-up.
Order as **GCK** **£14.40**

50Hz CRYSTAL TIMEBASE KIT
Use to improve accuracy of your digital clock ● As a 50Hz source in a clock with battery backup ● Accurate to within a few seconds a month ● Size h 14mm w 64mm d 49mm.
Order as **XTK** **£6.28**

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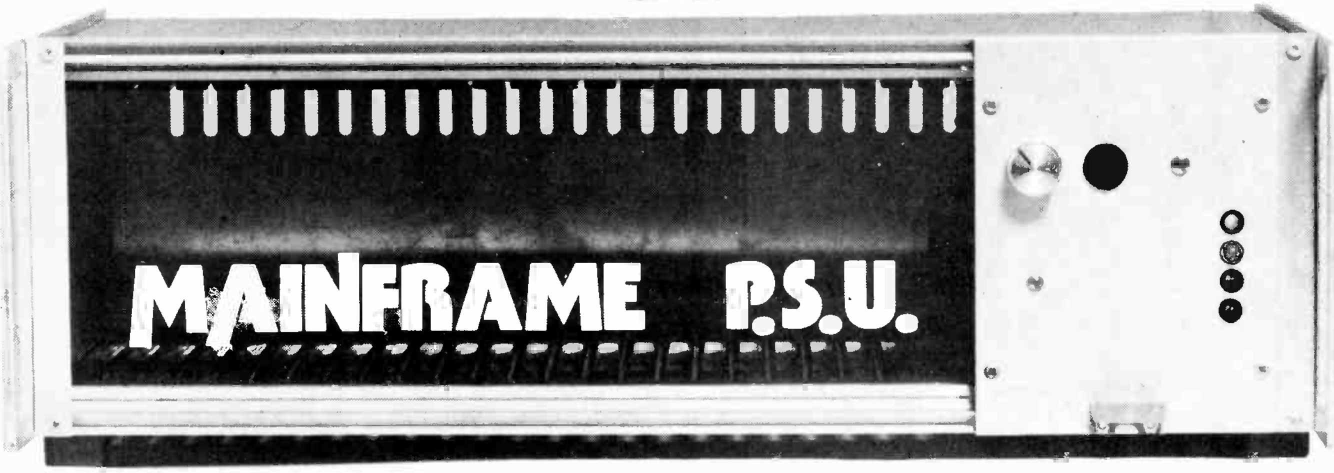


MAINFRAME P.S.U.

Modular supply for the System 68 Computer system. Described by Jim Perry

THE ETI MAINFRAME PSU has four output voltages, +5 for the CPU and TTL, CMOS circuits; this is capable of supplying about 2½ amps. The other voltages are −7, −12 and −20 volts for various bias requirements in RAM's etc. All the negative voltage rails can supply up to 100 mA less the monitor LED current, which is about 10mA. The main considerations in the design were size and reliability. The final version is indeed very small, fitting into a 4in. module! All outputs are overload proof, if a supply rail is short circuited the front panel LED will extinguish.

Connections are provided via a standard 31 way plug and socket, which will be used for the rest of the system. The advantage of this is cost, the disadvantage is that with 31 ways all 'bus' wiring will be 'hardwired', meaning that for example the VDU module has to be plugged into a particular position in the rack.

Fig. 1 and 2. Two views of the assembled module, note the use of insulated sleeving and 'p' clips in figure 1. The transformer mounting can be seen in both figures, figure 2 also shows the ribbon cable to the front panel LED's.

Construction

Construction is reasonably straightforward if the sequence outlined is followed. The PCB can be assembled at virtually any time, we did it first, make sure all components are as low in profile as possible. If you leave 1in. leads on the capacitors, the module won't fit!

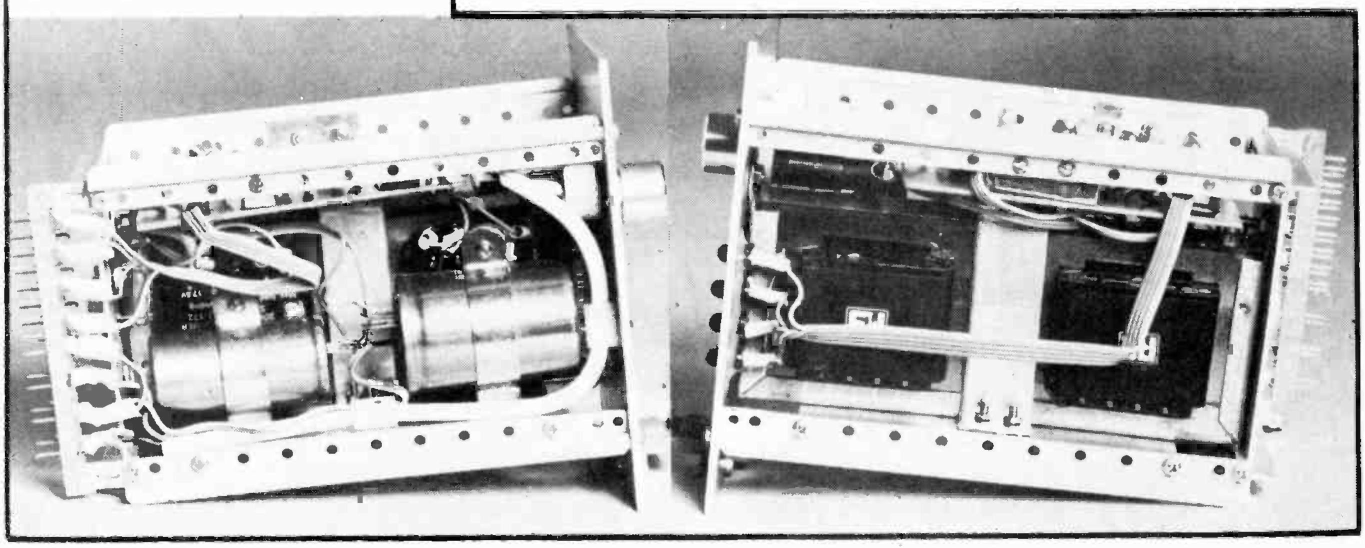
Front panel drilling is not shown, but positioning can be seen from the heading photograph.

The drilling of metal work and fabrication of brackets should be done next. The dimensions are all quite precise, so if a dimension is 13mm — we mean it! The case can also be assembled at this point, don't forget the end plates — which take ½in. off the front panel.

Mains Input

Mains input should be fitted to the frame, this uses bracket A and plastic guard B. Also a 'U' shaped notch should be made in the case back panel. Figures 3, 4, 5 show the mains input in closeup, note that the spare pins in between low voltage and mains, and LNE are snipped off the 31-way socket and plug.

The base plate, back plate and front panel of the 4in. module, when drilled, can have various compon-



MAINFRAME P.S.U.

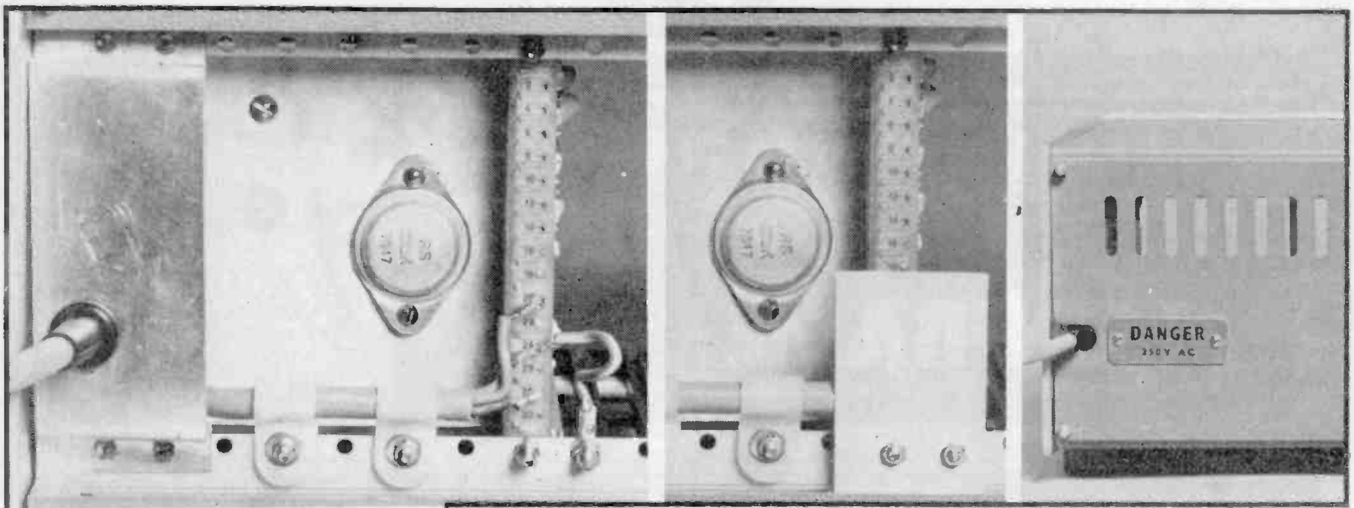


Fig. 3, 4, 5, the mains input on the back panel, note the positioning of 'p' clips and plastic guard. The sign came from a piece of surplus P.O. equipment.

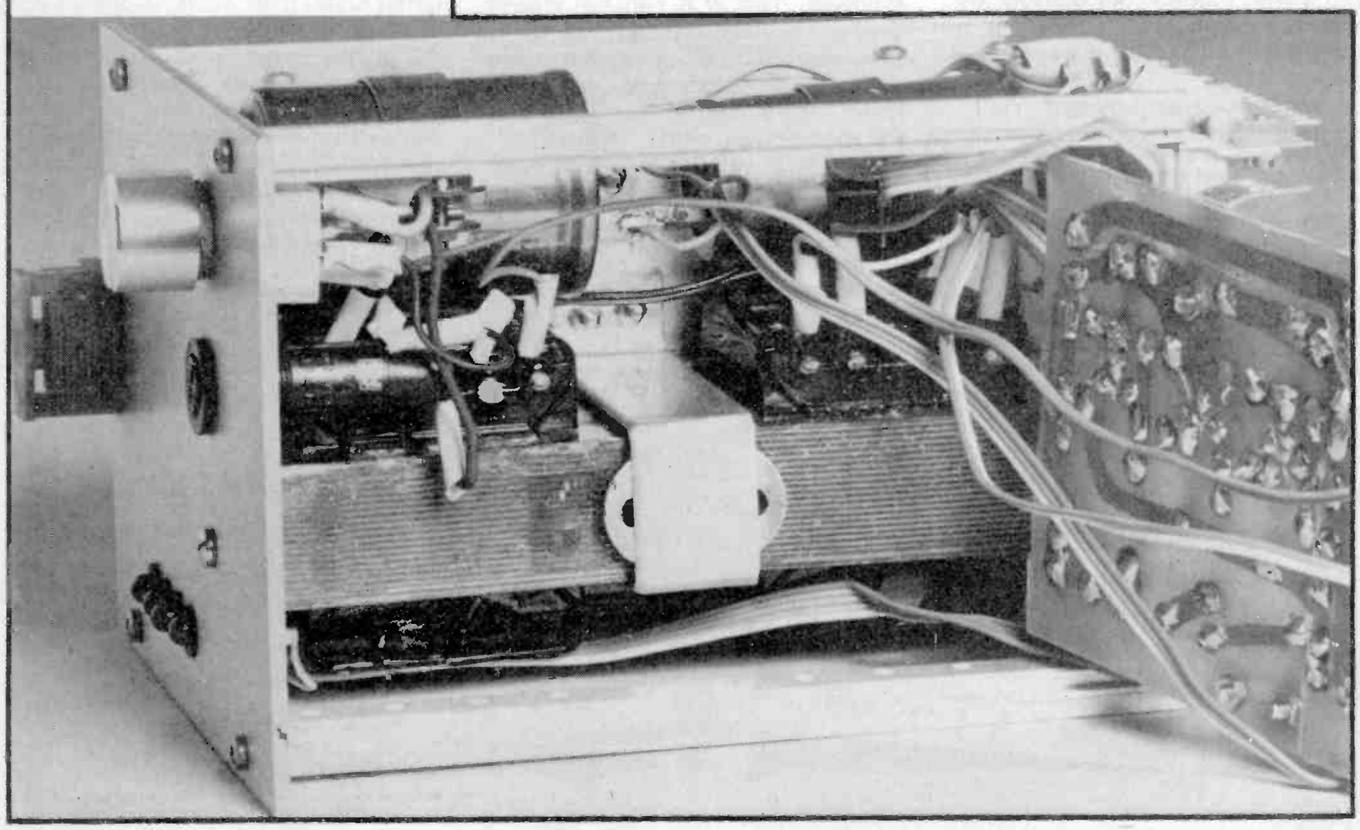
ents attached — before being bolted together. The back plate is fitted with Reg 1, complete with mica insulating kit, and C3, C7 are soldered in place on the regulator.

FS1, SW1 and LED 1-4 can be mounted on the front panel of the module. Ribbon cable and sleeving should be soldered to the LEDs (see figure on page 59). The two mains transformers can be strapped to the base plate, but first their mounting lugs must be bent. One lug is bent down through 90° and the other through 170°, see photographs to see how they mount. The two lugs bent through 170° are strapped under the mounting bracket. Both transformers should be wired up before C1 and C2 are mounted.

Module Assembly

The module can now be assembled by bolting and screwing the base plate, front and back together. Fit the snipped 31-way plug at the same time as the back plate. The mains wiring from connector to FS1 and SW1 can now be soldered, use insulating sleeving on all exposed connections. The mains lead from T1, T2 can also be wired into SW1. The remainder of the wiring can now be installed, including the PCB — which is mounted with two brackets as shown.

Fig. 6, general view of opened out module, again note extensive use of insulating sleeves and transformer mounting.



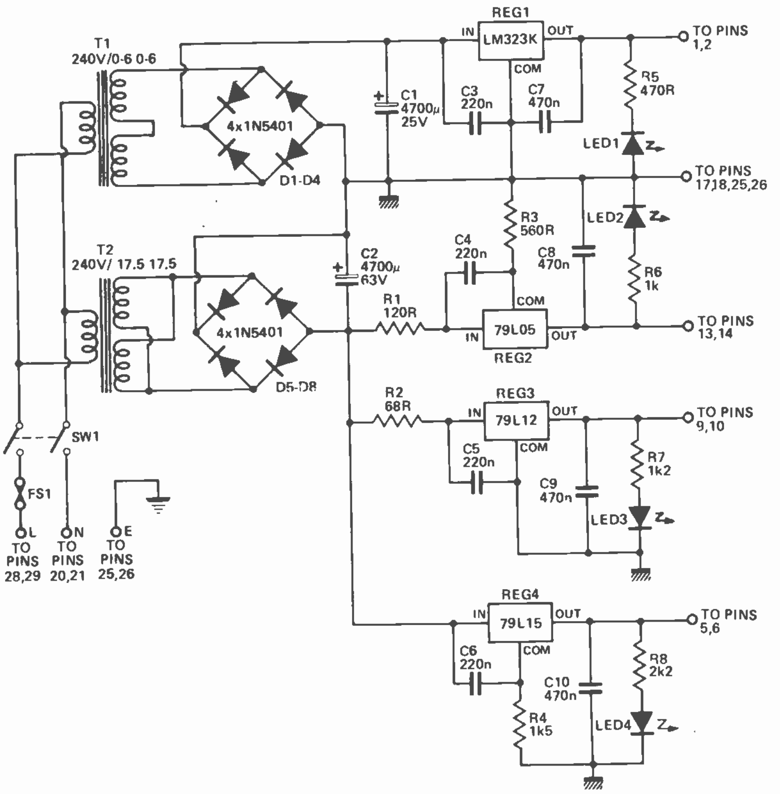
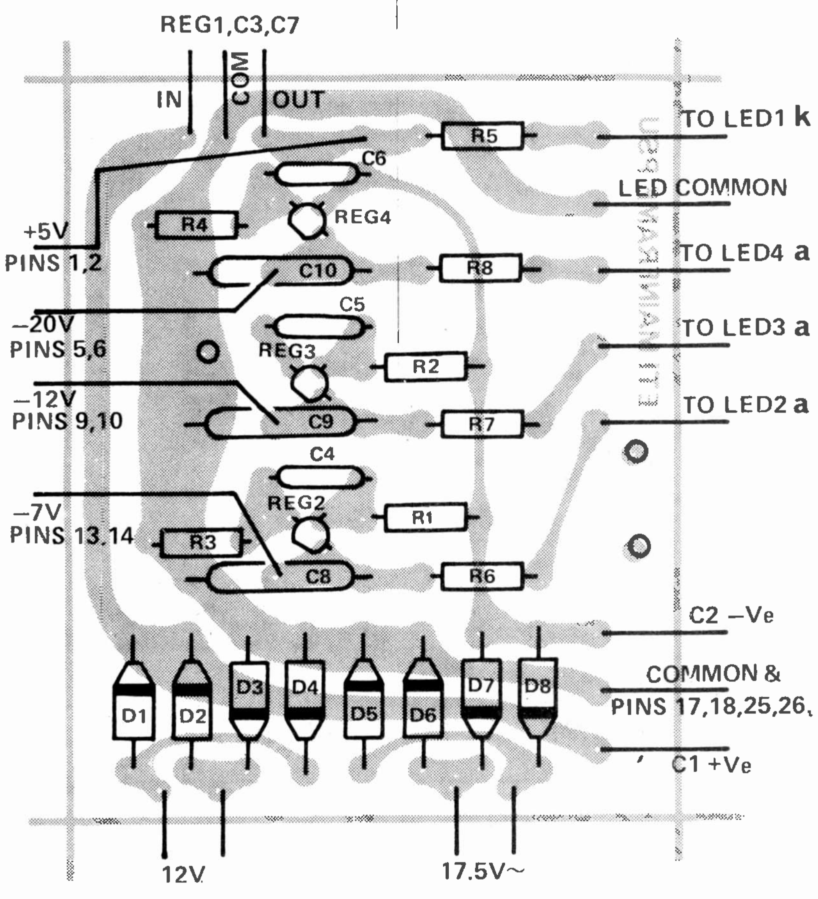


Fig. 7. Circuit diagram of the P.S.U.

Fig. 8 Component overlay and off board connections.



How it works

The circuit is based around four monolithic regulator IC's. Two types are used, the + 5 volt supply is provided by a TO3 cased 3A device, all the negative supplies are provided by TO92 100mA regulators. Separate transformers and bridge rectifiers are used for positive and negative supplies.

All the regulators work in the same manner, all are fixed voltage with overload and short circuit protection, in addition the TO92 regulators have thermal overload shutdown.

To produce a non-standard output voltage Reg 2 and Reg 4 have resistors in their common leads, Reg 2 is raised from —5 to —7 and Reg 4 from —15 to —20. In addition Reg 2 and Reg 3 have resistors in series with their inputs to reduce to voltage across them, and hence reduce power dissipation in them.

The 220n capacitors are to help stability by preventing RF oscillation. The 470n capacitors are to improve transient response.

Parts List

Resistors

R1	120	2.5WW/W
R2	68	2.5WW/W
R3	560	
R4	1K5	
R5	470	
R6	1K	
R7	1K2	
R8	2K2	

All ½W 5% except R1, 2

Capacitors

C1	4700u 25V	(102-774)
C2	4700u 63V	(103-064)
C3, 4, 5, 6	220n min polyester	
C7, 8, 9, 10	470n	

Semiconductors

D1-8	1N5401 (3A 100V)
REG1	LM323K
REG2	79L05
REG3	79L12
REG4	79L15
LED1	Green (586-481)
LED2, 3, 4	Red (586-475)

Card Frame/Module

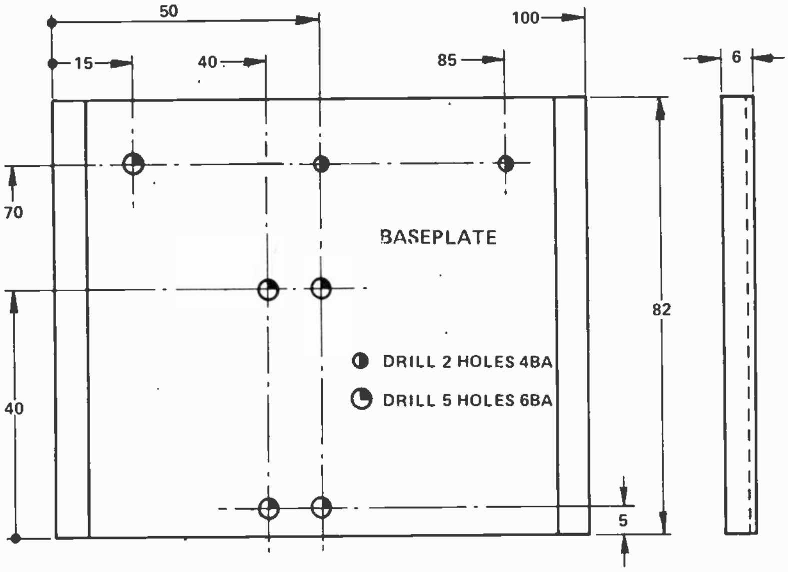
71-3841L	Card frame/case including guides
71-3842F	1 pair end plate angles
71-3844G	4 inch module
17-0267H	Connector plug 31 way
17-0268C	Connector socket 31 way.

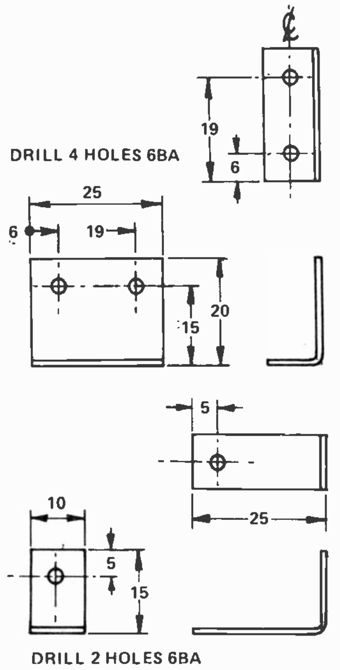
Miscellaneous

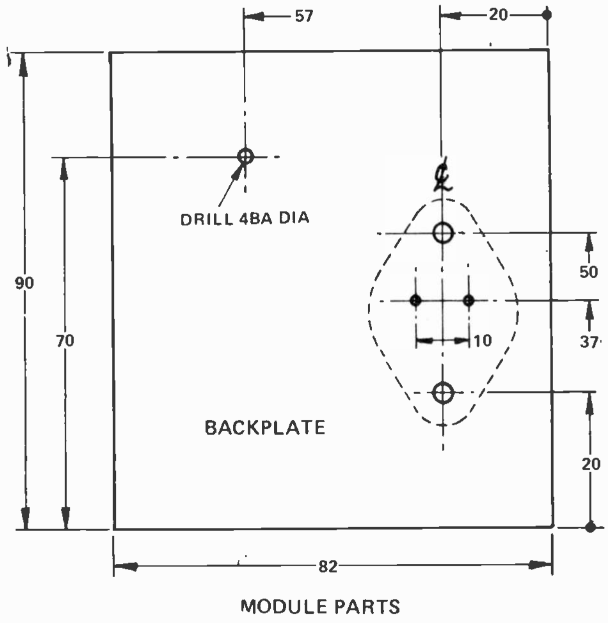
T1 0-6, 0-6 @ 1.6A (207-138)
T2 0-17.5, 0-17.5 @ 0.5A (207-172)
SW1 DPST 250v4A (316-800)
FS1 20mm fuseholder (412-879)
Mounting clips for C1 + C2 (543-052, 543-383) 20mm 500mA fuse, 18mm knob, mounting kit for Reg 1, Heatshrink sleeving (1.6m + 3.2mm), 4 'p' clips (543-355), sleeved grommet, ribbon cable, 6BA + 4BA nuts + bolts, anti-shake washers. Aluminium for brackets, mains cable, etc.

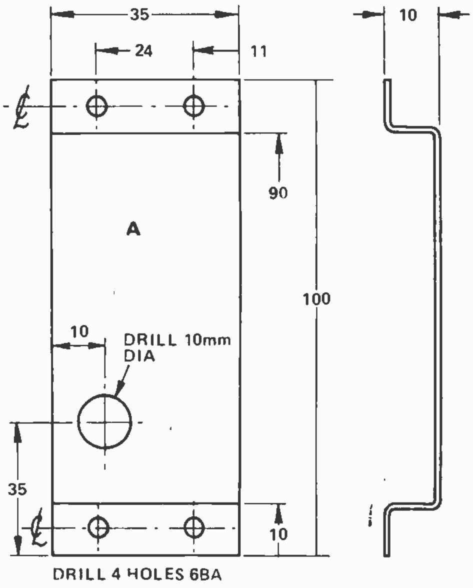
All numbers in brackets eg. (207-138) are Doram type numbers.
Card frame/Module numbers are Vero Electronics reference codes.

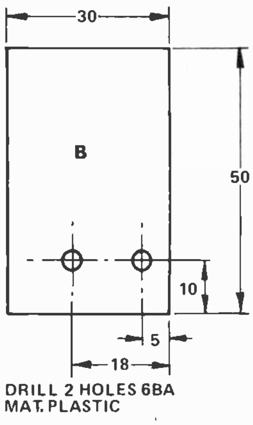
MAINFRAME P.S.U.











MATERIAL 18 SWG ALUM.
UNLESS OTHERWISE SPECEIFIED

ALL DIMENSIONS IN MILLIMETRES
UNLESS OTHERWISE SPECEFIED

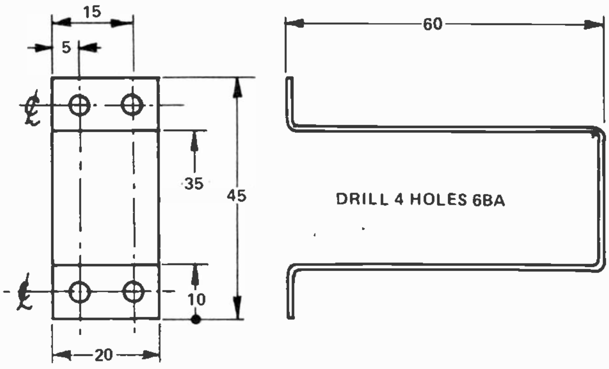


Fig. 9 Metal work details, front panel is not shown as exact positioning can be varied to allow for different components. See text.

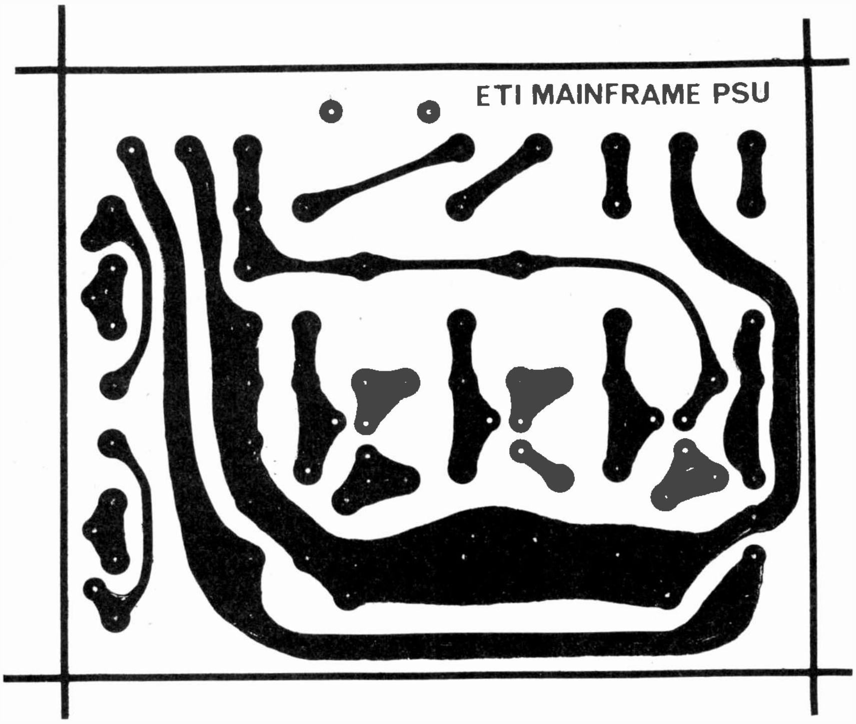


Fig. 10 PCB shown full size.

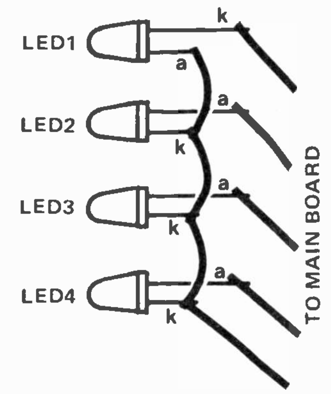


Fig. 11. Method of wiring the front panel LED's, note that LED1 is reversed to all the others.

METAL GLAZE RESISTORS

PART 10

THIS ARTICLE TAKES A LOOK AT CERMET RESISTORS, AND MOVES ON TO CONSIDER THERMISTORS AND VDR's.

THESE RESISTORS ARE MADE BY fusing a suspension of metal and glass particles to a ceramic rod at temperatures between 750°C and 930°C. This forms a thick resistive film, fused with the surface of the ceramic former, resulting in a resistance element that is virtually impervious to environmental extremes of moisture, temperature, shock and vibration.

The fusion of the metal resistive material and the ceramic rod gives rise to the common name 'CERMET' resistor.

The construction of cermet resistors is generally the same as for film resistors: the desired resistance is obtained by spiralling the resistive element. Owing to the high firing temperatures, these resistors may be rated for higher temperatures and loads than similar sized film resistors. Conduction of heat away from the resistance element is superior, owing to the better thermal contact possible between the resistance element on the rod and the metal end-caps. Body temperature rise is lower than for comparably-sized resistors of other types having similar ratings. As a result of these characteristics, cermet resistors are generally smaller than other resistors of the same rating.

The temperature coefficient of cermet resistors is generally comparable with most metal-film and metal-oxide resistors, common types having a TC of ± 100 ppm/°C. Some types exhibit a TC of +50 ppm/°C and may be as low as ±25 ppm/°C. This characteristic shows little variation with the value of the resistor.

Noise level for these resistors is generally higher than for other types, typically ranging from 0.4 μV/V to 1.0 μV/V, which is worse than other types but far below the level of carbon composition resistors. This level of noise is rarely a problem.

The voltage coefficient is generally better than 100 ppm/V, similar to most other film resistors and is not a consideration in the majority of applications. Generally, the voltage coefficient is only a consideration with carbon composition resistors.

As the construction of cermet resistors is similar to the other types of film resistors they have similar frequency characteristics. Values below 10k show little variation in value well into the UHF region.

Cermet resistors have excellent stability owing to body temperature being low for the amount of power dissipated. Figures of 0.5 – 1.0% are common. Generally, cermet resistors are manufactured in standard tolerances of ± 2% and ± 5%. Tolerances of ±1% are available on special order.

Like the common types of metal film resistors, metal glaze or cermet resistors have a hotspot or zero load temperature rating between 150°C and 160°C. They are derated linearly from 70°C as is standard with other film resistors. The derating curve for common types of cermet resistors is given in Figure 1. The miniature 0.5 W type (GLP), and some similar types by other manufacturers, have a hotspot temperature of 155°C, in common with various styles of metal film resistors and are derated according to the curve in Figure 2. Some styles have a dual rating. These are derated linearly from full power at 70°C to half power at 125°C, and then from there to 160°C, the hotspot temperature. The curve for these types is given in Figure 3.

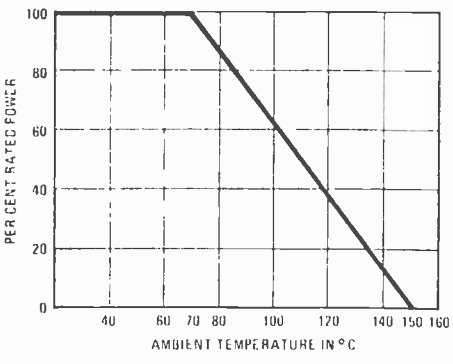


Fig. 1. Derating curve for most common metal blaze resistors - common to the majority of film resistors.

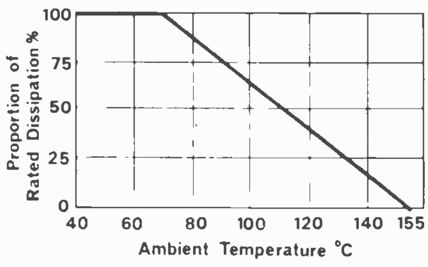


Fig. 2. Derating curve for miniature 0.5 W cermet resistor, type GLP; also applicable to some other manufacturers.

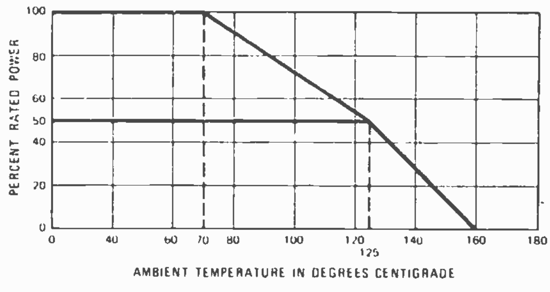


Fig. 3. Derating curve for dual-rated styles of cermet resistors.

Metal glaze (cermet) resistors

Cermet resistors are generally available in ratings from 0.1 W to 0.5 W, and some less common types up to 5 W. Cost is comparable to most types of film resistors which makes them very attractive where their small size and high power rating is required or in applications where they are likely to experience moisture and temperature extremes, etc. Trimpots are manufactured having cermet resistance elements to take advantage of the ruggedness and resistance to environmental extremes that this type of element offers. The general characteristics of metal glaze or cermet resistors are illustrated in Table 1.

TABLE 1. General Characteristics of Metal Glaze (Cermet) Resistors

Rated Wattage @ 70°C	Max. Working Voltage	Max. Operating Temp.	Critical Resistance	Typical Sizes Length	Diameter	Typical Resistance Ranges
0.125 W (@125°C)	250 V	160°C	0.36 M	6.4 mm	2.3 mm	10Ω – 301 k
0.25 W	250 V	160°C	0.36 M	6.4 mm	2.3 mm	10Ω – 301k
0.33 W	350 V	150°C	0.12 M	10 mm	3 mm	10Ω – 270k
0.5 W*	250 V	155°C	0.36 M	5.5 mm	2 mm	2.2Ω – 470k
0.5 W	250 V	150°C	0.36 M	6.4 mm	2.3 mm	6.2Ω – 1 M
0.5 W	500 V	150°	82 k	14.3 mm	5.7 mm	10Ω– 270 k

*IRC type GLP – see text, miniature 0.5 W resistor.
(1) Wattage rating assumes voltage limit not exceeded.
(2) Max. Working Voltage assumes wattage rating not exceeded.
(3) Max. Operating Temperature is equal to hot-spot temperature.
(4) Sizes given are body sizes for axial-lead types.

Miscellaneous Special Types

Special applications call for resistors having particular characteristics. Special resistors are manufactured, taking advantage of certain properties of different materials or construction techniques, to meet the requirements of applications outside those normally found with ordinary resistors.

High voltage circuitry requires resistors having very high maximum working voltages (up to 50 kV in some cases). RF applications require resistors that substantially maintain their dc value up to quite high frequencies as well as being able to dissipate considerable power. Various special resistors having controlled non-linear temperature or voltage characteristics are also useful in a variety of circuit applications.

High Voltage Resistors

High voltage resistors generally have higher values than the normal range of resistor types. Values up to 10^{13} ohms are available.

They are constructed of a carbon-composition film applied in helical form to a ceramic tube, resulting in a long conducting path. The element may be mounted in an evacuated glass envelope or coated in a special varnish. The helical element provides a uniform pitch allowing a uniform voltage gradient between turns throughout the length of the resistor.

They find application in voltage-multiplier probes, high voltage bleeders, CRT circuits, photocell cicuits, ionization equipment etc. They can be obtained in voltage ratings up to 50 kV and wattage ratings from 2 W to 100 W.

Ferrule, terminal lugs and wire lead terminations are available depending on style and application.

Typical temperature coefficients range between 50 ppm/°C and 700 ppm/°C for low resistance values and high resistance values respectively.

High voltage resistors generally have a hotspot temperature of 100°C although this is much greater for forced-air cooled and oil-cooled types occasionally encountered. Those operated in free air are derated from 25°C as indicated in Figure 4. Note that it is non-linear.

These resistors are available in values ranging from 2k5 to 10^{5}M generally, higher values by special order.

Dimensions depend on wattage rating and intended application.

High Frequency Resistors

These resistors have a specially designed resistance film which provides optimum performance on all desired characteristics while operating up to quite high frequencies. The cross-sectional are of the resistive element is kept small (less than 0.3 mm!) to assure low inherent capacitance and freedom from skin effect. The resistance element is generally not spiralled in order to reduce inductance effects.

Terminal bands of colloidal silver are deposited over the ends of the resistive element, forming a permanent, low-resistance contact. Axial-lead, terminal lug or ferrule terminations are attached to the silver bands, as required. A protective coating encapsulates the entire resistive film.

These resistors maintain their value well into the UHF region, mounting usually limiting its performance. Values up to 300 ohms vary less than 20% from their nominal dc value up to 400 MHz. Values up to 3k3 vary less than 20% up to 200 MHz. The nominal value decreases with frequency.

These resistors find extensive application as RF dummy loads, antenna terminating resistors etc, and in radar pulse equipment. They are available in wattage ratings up to 100 W and as low as 1 W; values from 20 ohms to 130 M (useful at low frequencies to 100 kHz) and voltage ratings to about 10 kV. They are derated from 25°C in free air, as per Figure 4, and have a hotspot temperature of 100°C – more if forced-air cooled or oil cooled.

Thermistors

Thermistors belong to a group of resistors made from semiconductor materials and are thermally sensitive, having a controlled temperature co-

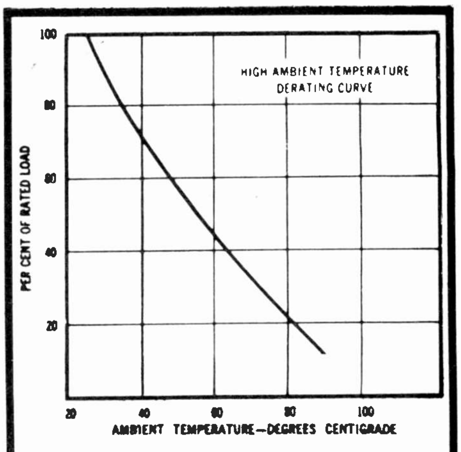


Fig. 4. Power derating curve for high voltage and high frequency resistors.

efficient that may be positive (PTC thermistors) or negative (NTC thermistors).

Thermistors are widely used for temperature measurement and control, temperature stabilisation, current surge suppression, and a wide variety of other applications. They are non-reactive and non-polarised and are therefore suitable for use in either ac or dc circuits.

The resistive element consists of barium titanate in PTC thermistors and various metal oxides in NTC thermistors. The compounds are sintered into special shapes, depending on the required application. They are formed into small elements in a variety of shapes -- generally discs, rods, blocks or tubes. They may be encapsulated simply with a varnish or epoxy or inside a glass or metal tube. Some types are not encapsulated at all.

PTC thermistors are available in two basic characteristics. The 'A' characteristic type exhibits linear change of logarithmic resistance values against temperature. The 'B' characteristic exhibits abrupt increase of resistance when the temperature increases above a specified value, showing only small change in resistance below this temperature.

Some typical PTC thermistors are illustrated in Figure 6. Individual characteristics are best obtained from manufacturers' literature.

NTC thermistors are available covering a wide range of values and temperature ranges. They are available as two basic types — directly heated and indirectly heated. The directly heated types consist simply of the NTC element with two leads (see Figure 7). Some types have a metal or glass header surrounding the element. A typical type, made as a water temperature sensor, is also illustrated in Figure 9. Indirectly-heated types consist of an NTC element integrally mounted with a heater.

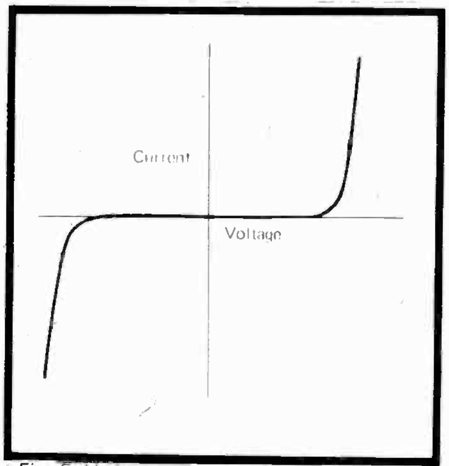


Fig. 5. Varistor voltage-current characteristics.

Voltage Dependent Resistors

These resistors are generally known as 'Varistors' and are another type of semiconductor resistor. They are principally used as voltage surge suppressors, some types being used in voltage stabiliser applications.

The element generally consists of a sintered ceramic material, the most common types zinc oxide as the main ingredient. Other types employ elements containing titanate ceramic (sometimes known as 'variatite') or silicon carbide (SiC varistors). The common types are often referred to as ZNR varistors from Zinc Oxide Nonlinear Resistor.

The general characteristics of varistors is illustrated in Figure 5. They are available in a wide variety of encapsulations, some are illustrated in Figure 8. They are often found as 'spike' suppressors in solid state TV sets, as back-emf suppressors across relays, and in rectifier circuits protecting rectifiers from voltage surges. ●

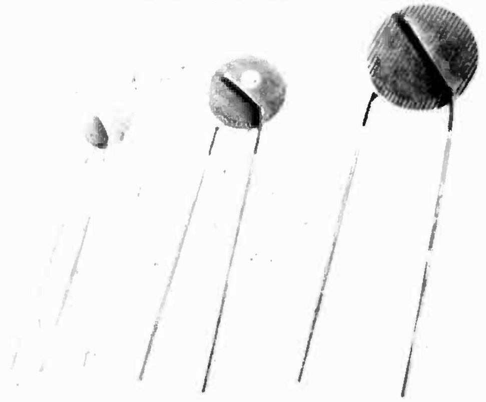
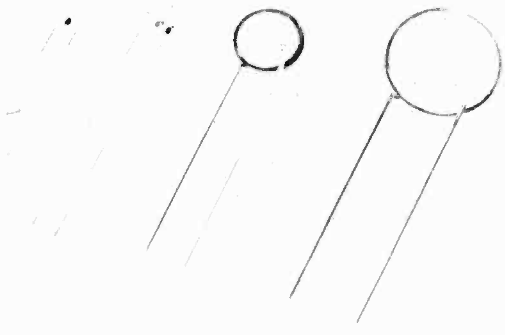


Fig. 6. Typical PTC thermistors (actual size).



(varnished)

Fig. 7. Typical NTC thermistors.

(bare)

Fig. 9. NTC element as automative water temperature sensor.

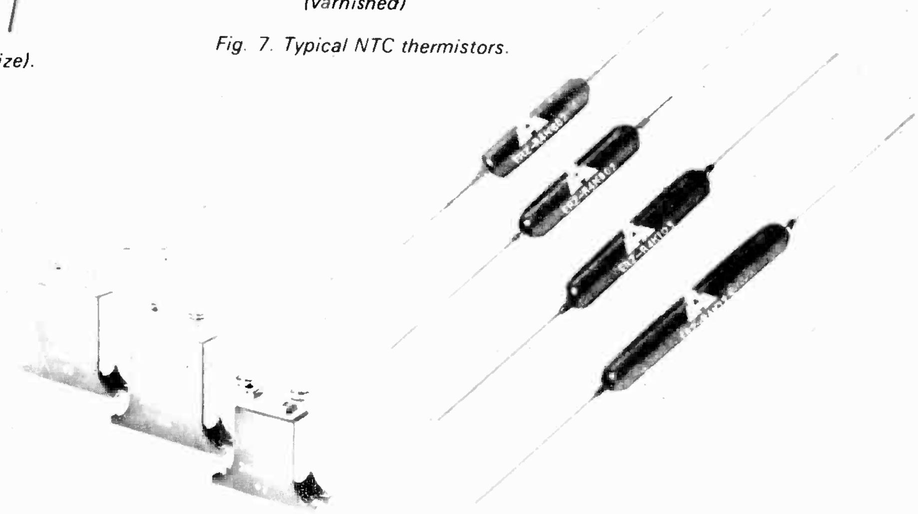


Fig. 8. Various types of varistor encapsulations for different applications.

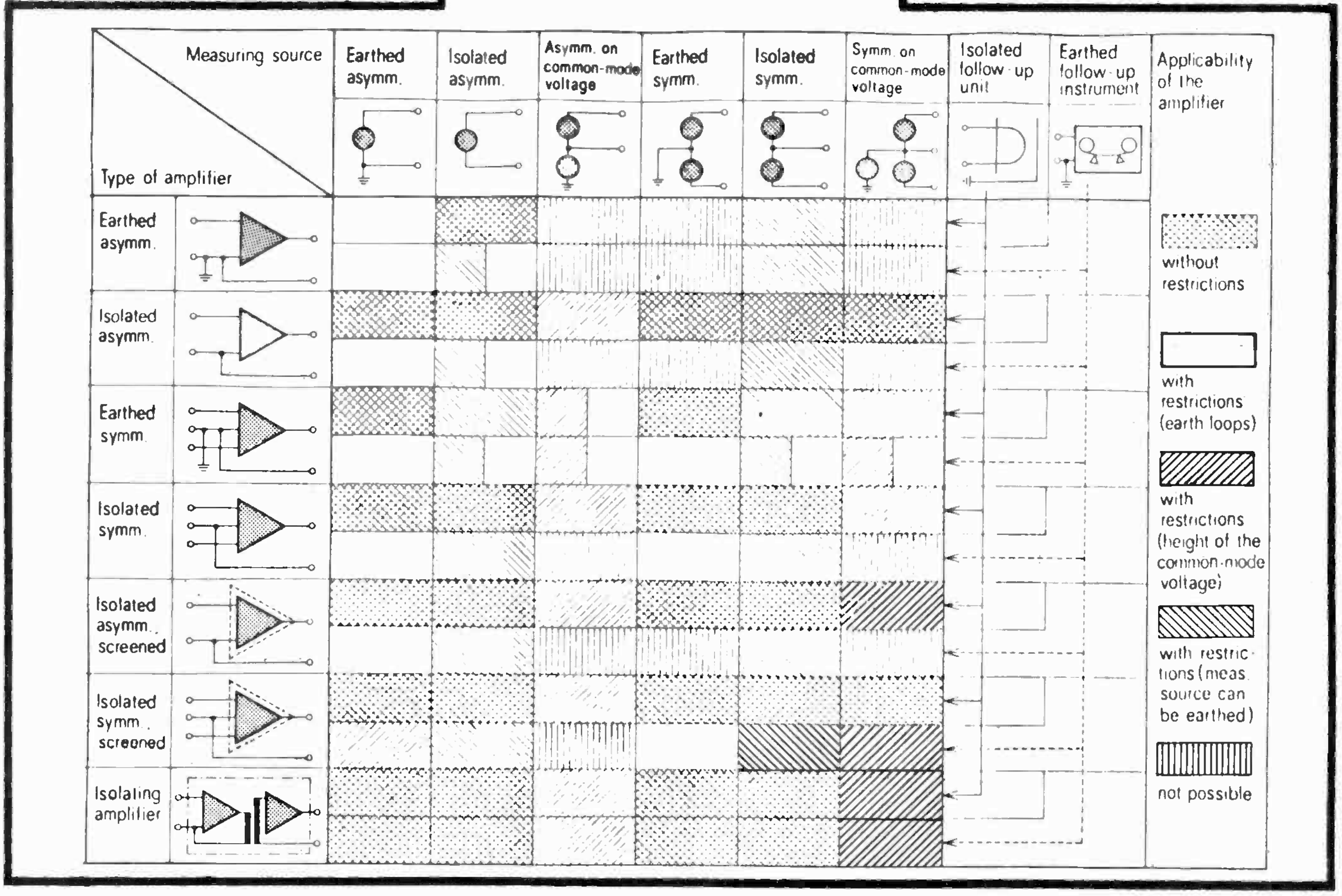
ELECTRONICS —it's easy! PART 39

Coupling electronic stages

Connection arrangements

As was pointed out in the discussion of meters, electronic subsystems must be cascaded intelligently or loading of the output of a stage by the input impedance of that following may degrade the signal. Output configuration of the various stages involved in instrumentation can take many forms depending on how the earth is connected and if the signal is symmetrical or assymmetrically connected. The six commonly encountered source output schemes are shown at the top of Figure 1. On the left-hand side are seven common kinds of amplifier connection (any other form of black box could be regarded similarly). On the right-hand side are leader lines that show a link between the output of the chosen amplifier and one of the two most commonly used instrument connections — fully isolated ciruit with case only grounded, or one pole grounded to earth. Using the legend, the chart shows the applicability of connections between chosen combinations of source arrangement, amplifier and output device. Not-possible situations usually arise because the earth connection shorts out one of the source arms.

Fig. 1a. Chart showing common combination possibilities of various output to input cascaded schemes incorporating amplifier stages of various kinds between the first stage and the two commonly used output recording/monitoring connections. (Courtesy Siemens Industries).



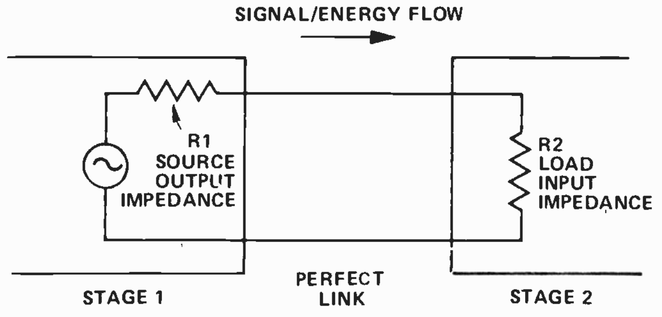
Matching

Three basic matching criteria exist when connecting two stages together. Figure 2 summarizes these.

If the need is for maximum power transfer, as when driving a loudspeaker from an output stage of an amplifier, the output impedance (usually thought of as an average value of resistance) of the driving stage must equal the input of the stage being driven. When maximum voltage transfer is required, as occurs when a pick-up cartridge or other voltage generating transducer is used or when measuring a voltage in a circuit, the rule is to ensure the connecting stage has a much higher input resistance than the output resistance of the stage producing the voltage signal. A factor of ten to one hundred times is usually sufficient.

The opposite situation, that is, loading a high output impedance stage with a low input impedance, arises when the maximum current transfer is required.

In many cases the appropriate buffer amplifier is required to provide the desired matching condition. In certain ac coupled systems — those which do not require a dc patch between stages — a transformer can provide an adequate impedance match in an economic way. Transformers, however, have limited frequency response and must be chosen carefully to suit the signal requirements.



Matching requirement	relative R1, R2 values
Maximum energy transfer	R1 = R2
Maximum voltage signal transfer (least voltage loss across R1)	R2 >> R1
Maximum current signal transfer (least current change due to R2)	R1 >> R2

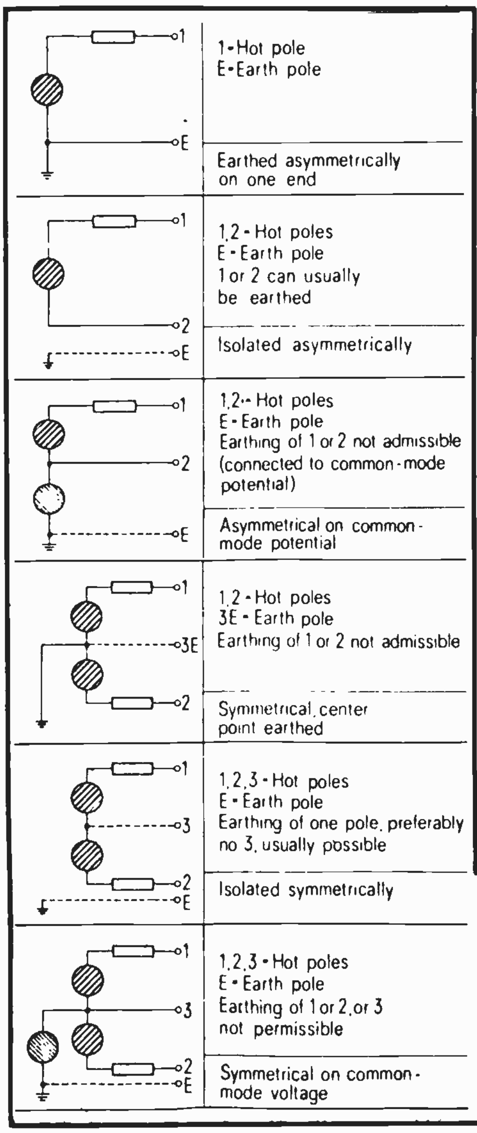
Fig. 2. Summary of impedance values for various matching requirements.

Eliminating noise

In the ideal situation any circuit added after another should add no more noise energy to the signal than is fed to it. We specify the ratio of the two as the signal / noise or S / N ratio. In practice all circuits, including connections, will add a finite amount of noise — degrading the S/N ratio. An amplifier or other cascaded stage should ideally increase or modify the signal amplitude without reducing the S/.N ratio (input noise will be amplified equally with the signal).

A common unit used to describe the degree of degradation is the noise-figure NF which is calculated as NF = 10 lg (Signal in/Noise in, divided by Signal out/Noise out); the ratio being expressed in decibels (dB). The perfect additional stage has NF = 0 dB, so-called low-noise amplifier stages will have noise figures better than 3 dB (S/N ratio reduced to half). NF is a function of device characteristics, frequency of operation, source resistance and temperature — the correct choice of components to yield a low NF is a skilled task.

Connections between stages are most common source of noise addition. Observing several basic rules will usually greatly reduce the noise pick-up in wiring between and within stages.



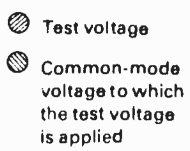


Fig. 1b. Extra detail of source arrangements.

Grounding and Shielding

When wiring circuits and interconnections the circuit diagram shows a signal ground. (Terms ground and earth are used somewhat synonymously). This line is assumed to be at exactly the same potential at all points where a ground symbol is indicated. From the electricity supply authority's viewpoint any good low resistance connection to mother earth is a good ground or earth point. But this is not so for instrument stages operating at millivolt and microvolt signal levels. Signals as large as volts can be induced, or dropped, between two points of a metal chassis! The rule for avoiding this ground loop problem is to attach all circuit points required to be grounded to a substantial size copper bus bar — the circuit ground — that is grounded to earth at one place. Better still, use a single common connection point.

Shields of cables are too often assumed to have the same potential at each end, both ends being presumably at ground potential. This is often incorrect for the shield becomes an earth-loop having a

ELECTRONICS–it's easy!

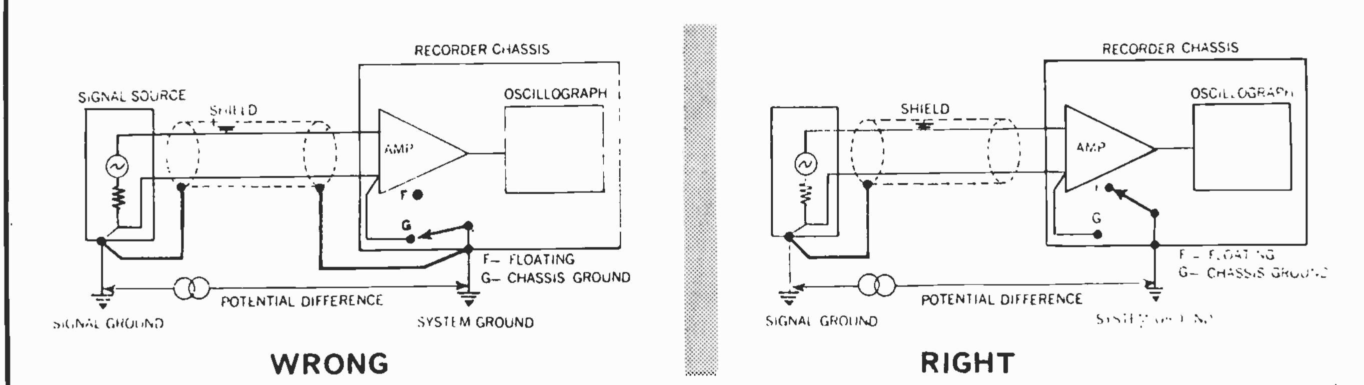


Fig. 3. Correct and incorrect methods of joining a sensor to a recorder. Most output instruments offer the user the choice of leaving the instrument floating above ground or grounding it.

finite resistance when both ends are grounded. Only one end, the input end, should be earthed and the shield should be insulated against earth at all other points. Figure 3 shows the right and wrong ways to connect two stages together with a shielded two-core lead. Special quality low-level signal cables are available. These incorporate an inner twisted-pair that is wrapped inside a multi-layer metal foil along with a bare copper drain wire, the whole being well insulated.

Common-mode rejection

Before other aspects of connections with cables can be appreciated we need to study the principle of common-mode signal rejection.

We begin by looking at the noise pickup from supply mains radiation by two open wires used to complete a link, as shown in Fig. 4. If both wires are at the same potential above earth, that is, neither is earthed, the noise pickup in each wire will be closely similar. One wire, however, passes signal currents in the opposite direction to the other so noise induced in each wire will add to the signal in one wire and subtract in the other — the result is that the noise just about balances out. This is known as a common-mode rejection arrangement.

It is a balanced system as far as unwanted signals are concerned because of the use of a differential arrangement.

The same concept is used in low-noise, high gain, dc amplifiers — to eliminate transistor defects. A slight disadvantage of differential configurations is that many testing instruments operate with one grounded input. Connecting an oscilloscope to probe a differential-mode circuit may short out a line to ground in certain connections. For such work a differential input amplifier is essential in the oscilloscope.

Once the signal level has been amplified well above the ambient noise levels the symmetrical dual output can be converted to a single pole with earth output, using a suitably connected operational amplifier.

For the best low-level signal transfer, wiring between stages should observe the common-mode principle, the aim being to make each wire of the pair appear as identical as is possible to the interfering noise sources present. Figure 5 demonstrates why the twisted pair is better than two separate lines to connect a symmetrically-connected source to a following differential input stage. The distributed capacitances of the two wires are different (with resultant different pickup noise) in the open-wire case than they are in the twisted line.

Shielded two-core cables used with a symmetrical outputs source should have the shield grounded at the source, not at the following stage. The latter option degrades the common-mode rejection capability.

Common-mode principles must be carried through completely in exacting low-level signal applications, even to providing identical terminating conditions at the wire ends — similar length open wire ends, similar, dissimilar-metal, conditions at terminal posts with identical temperature for each to ensure identical thermo-electric currents are generated in each lead.

Active devices, such as amplifiers, have a limit to the common-mode signal levels that they can handle. If the induced signals are too great in amplitude, they may saturate the amplifier, removing its ability to operate correctly. It is, therefore, always best to reduce interference at source rather than attempt to eliminate it by common-mode rejection alone.

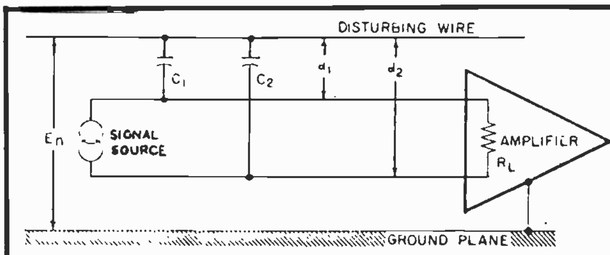


Fig. 4. Common-mode pick-up of noise is balanced out by the differential system.

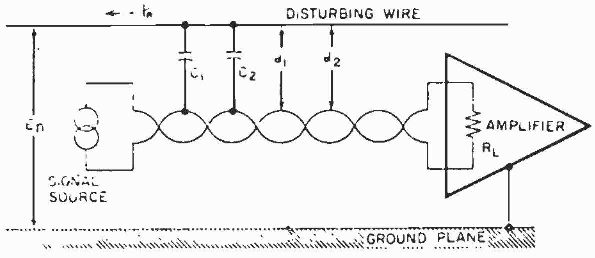


Fig. 5. Twisted wires provide best common-mode rejection when making connections between stages in which a symmetrical signal source is joined to a differential input amplifier.

RF Shielding

Mains frequency interference (50 Hz) is comparatively easy to eliminate from or retain within equipment by using low conductivity enclosures. RF interference, however, tends to penetrate the best designed enclosure — remember waveguides transmit RF — through apertures of size similar to wavelength. Cracks, where covers join, may act as waveguides for UHF signals. As modern circuits operate with transition times of nanoseconds they too generate considerable quantities of RF energy. By way of example of what can be achieved by careful mechanical construction Figure 6 compares different instrument enclosure designs of a manufacturer. Slots introduced into frame elements form wave-traps (as opposed to wave guides) when the metal covers are bolted in. Modern instrument enclosure design is as much a case of containing RF radiation *inside* the unit as it is to prevent it entering. ●

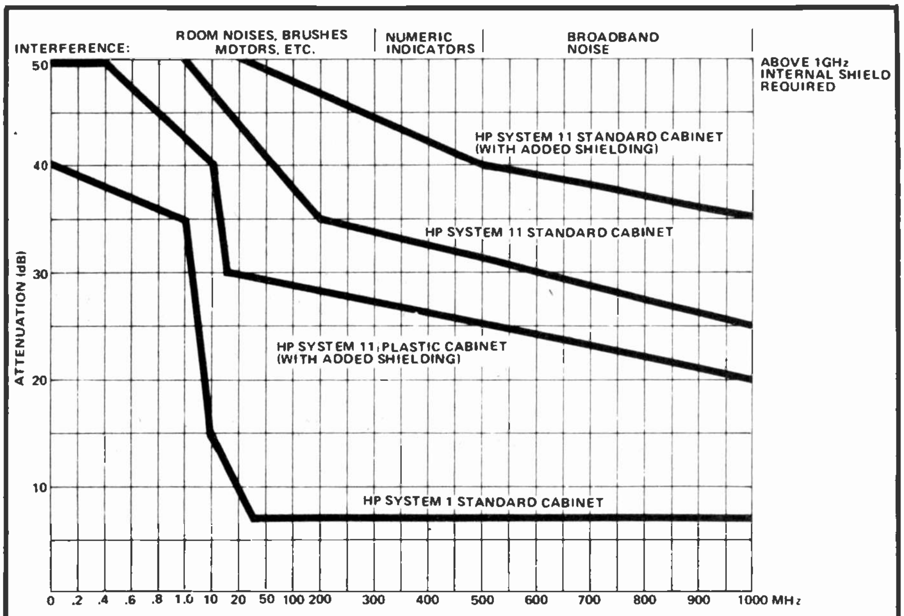
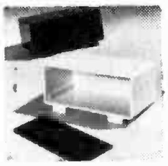


Fig. 6. Shielding of RF energy by various designs of enclosure used for H.P. instruments. The actual value of a particular unit depends upon the need for holes and shafts through the panels.

Greenbank



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74C08	**0.25**	74C90	**0.90**	74C175	**1.21**	74C910	**7.18**
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74C14	**1.51**	74C95	**1.31**	74C193	**1.48**	74C918	**2.89**
74C20	**02.5**	74C107	**1.29**	74C195	**1.31**	74C925	**8.28**
74C30	**0.25**	74C151	**2.63**	74C200	**7.19**	74C926	**8.28**
74C32	**0.25**	74C154	**3.92**	74C221	**1.49**	74C927	**8.28**
74C42	**1.93**	74C157	**2.35**	74C901	**0.72**	74C928	**8.28**
74C48	**2.37**	74C160	**1.48**	74C902	**0.72**	80C95	**0.72**
74C73	**0.70**	74C161	**1.48**	74C903	**0.72**	80C97	**0.72**
74C74	**0.63**	74C162	**1.48**	74C904	**0.72**	88C29	**4.13**
74C76	**0.70**	74C163	**1.48**	74C905	**7.70**	88C30	**4.13**
74C83	**1.96**	74C164	**1.31**	74C906	**0.72**		

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4000	**0.20**	4027	**0.60**	4051	**1.04**	4081	**0.24**
4001	**0.20**	4028	**1.00**	4052	**1.04**	4082	**0.24**
4002	**0.20**	4029	**1.27**	4053	**1.04**	4085	**0.80**
4006	**1.31**	4030	**0.60**	4054	**1.29**	4086	**0.80**
4007	**0.20**	4031	**2.46**	4055	**1.46**	4089	**1.74**
4008	**1.07**	4032	**1.19**	4056	**1.46**	4093	**0.89**
4009	**0.60**	4033	**1.55**	4057	**29.81**	4094	**2.08**
4010	**0.60**	4034	**2.11**	4059	**6.20**	4095	**1.16**
4011	**0.20**	4035	**1.31**	4060	**1.24**	4096	**1.16**
4012	**02.0**	4036	**3.09**	4061	**25.60**	4097	**4.13**
4013	**0.60**	4037	**1.06**	4062	**10.10**	4098	**1.22**
4014	**1.12**	4038	**1.20**	4063	**1.22**	4099	**2.03**
4015	**1.12**	4039	**3.09**	4066	**0.69**	40101	**1.76**
4016	**0.60**	4040	**1.19**	4067	**4.13**	40102	**2.16**
4017	**1.12**	4041	**0.93**	4068	**0.24**	40103	**2.16**
4018	**1.12**	4042	**0.93**	4069	**0.24**	40104	**2.26**
4019	**0.60**	4043	**1.12**	4070	**0.65**	40107	**0.66**
4020	**1.24**	4044	**1.04**	4071	**0.24**	40108	**6.18**
4021	**1.12**	4045	**1.56**	4072	**0.24**	40109	**2.21**
4022	**1.07**	4046	**1.48**	4073	**0.24**	40181	**4.30**
4023	**0.20**	4047	**1.01**	4075	**0.24**	40182	**1.73**
4024	**0.87**	4048	**0.60**	4076	**1.71**	40194	**2.26**
4025	**0.20**	4049	**0.60**	4077	**0.65**	40257	**2.26**
4026	**1.92**	4050	**0.60**	4078	**0.24**		

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14174	**1.08**	14412	**17.07**	14440	**11.58**		

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ELECTRONICS TOMORROW

by John Miller-Kirkpatrick

A COUPLE OF YEARS ago I mentioned the time code being transmitted from MSF Rugby on 60KHz. This gave BCD time of day information each minute in GMT 24 hour format, there is also a very accurate one pulse per second transmission which can be used for seconds counting. The time is based on the official GMT standard and is corrected for changes of millionths of a second per year.

The problem with this system is that the data is recognised by a cut in the 60KHz carrier and this absolute cut rather than a modulation of the carrier can cause problems in phase locked loop decoders. Changes to allow for BST rather than GMT must be made by the user and this adds further complexity to the circuit. At the time someone sent me a copy of a German magazine with an article on the German DCF77 system which is a similar system being transmitted from near Frankfurt. This is even more complex as it gives time of day (Central European Time), day of the week, day of the month, day of the year and month number. As the 77.5KHz carrier is modulated it would seem that a PLL system could be used to decode the data which is transmitted at one bit per second (this also gives you the option of a seconds counter). The circuit obviously contained a plethora of counters, latches and LEDs and was virtually too complex to consider building. Last year at the Watch and Clock fair in Basle I saw a clock working from DCF77 and it was to say the least very effective to see a clock which had just been plugged in come up with time and date and day, etc.

Rugby On Line

It was only recently that someone mentioned that they were going to try to feed MSF Rugby into a SC/MP that it occurred to me that feeding DCF77 in as serial data might be a much better idea. The SC/MP could do all of the decoding and displaying whilst checking each bit of data, and comparing it to the previous minute data, as a double check against rubbish.

Wake me on Thursday

If we now have an MPU with regularly updated, correct time and date (corrected by the MPU for GMT or BST) we can easily add a few alarm features such as:

1 Wake me every morning at 7.30 except Saturdays, Sundays and Bank or personal holidays.
2 Remind me of my wife's birthday, anniversaries and more important remind my wife of my birthday.
3 Don't wake me on April 1st until after 12.00.
4 Correct yourself for GMT/BST changes on the appropriate days.

Add on a few addition features such as one alarm for you, and one half an hour earlier for your wife, snooze alarms which become louder or faster or operate buckets of water, remote displays to other parts of the house and suddenly you have quite a clock.

I should keep your Mickey Mouse Alarm for old times sake — it might be an antique one day!

Now comes the crunch — I have lost (mis-filed) the original data on DCF77. I have the MPU, the displays, etc but I cannot build the receiver (aerial, PLL, etc) nor can I decode the data as I do not know what sequence it is transmitted in. If anybody has this info I would be very glad of a copy and I will publish said info in a future column. On the other hand, if any one has circuits to make up into an article please let us know at ETI.

Coding distances

One last point on these transmitted time codes, as they are VLF (Very Low Frequency) the reception distance are phenominal. If MSF can be received and decoded in Athens (quote National Physical Laboratory) then there should be no trouble in picking up DCF77 over most of the UK, does anyone have any figures on this?

Same device, but —

One of the most annoying things that can happen is when you remove an IC from a circuit and replace it with a brand new identical component and it just sits there and laughs quietly to itself (or even better, decides to start smoking.)

The MM5311 series of clock chips are not known for smoking but they do have a habit of not liking a circuit in which an identical device from another batch works perfectly. Take the MM5314 for example, out of several thousand devices I have known one *literally* blow up! and two others to be faulty — one gold star for National. National are also the sort of company that will redesign a product if they think that they can make it better, another gold star for NS.

Unfortunately in designing some of the later chips in this family National decided to change the design of all of the family to make them all as compatible as possible. This means that a three or four-year-old circuit for the early MM5311, 12, 13 or 14 will not necessarily operate with one of the later batches of chips.

The usual problem is that the new chip will only display one digit at a time or will multiplex very slowly giving an unsettling flashing effect. The cure for this is to change the values of the components connected to the multiplexing input from the typical 100K and 0.01uF to something more like 470K and 0.01uF or even 0.005uF. To my knowledge NS have never published this change and their latest data on these devices still refers to the old component values:

It seems a shame that one of the first clock chips on the market which is still probably one of the most popular with amateur constructors should be treated this way. I suspect that NS have had some disappointed customers with these devices for the sake of a resistor change, black mark and lose two gold stars NS. ●

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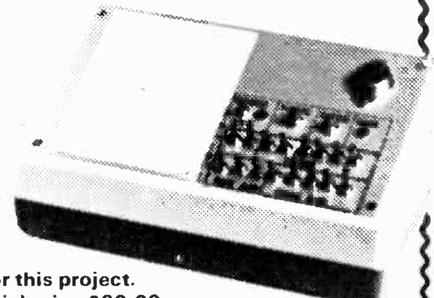

as described AUG.-SEPT.-OCT. issues

All items available for this project.
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Components also available separately — PCB set, £6.65; 2112-2, £4.50; 2513, £9.25; 555, 47p; 7400 series — see below.
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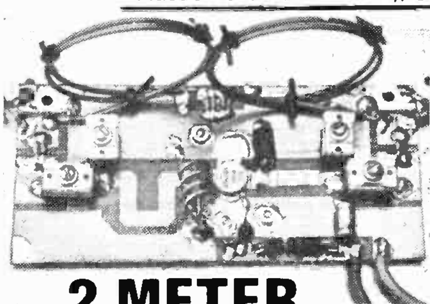

2 METER POWER AMP as described SEPTEMBER ISSUE (page 19)

2 METER POWER AMPLIFIER

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tech-tips

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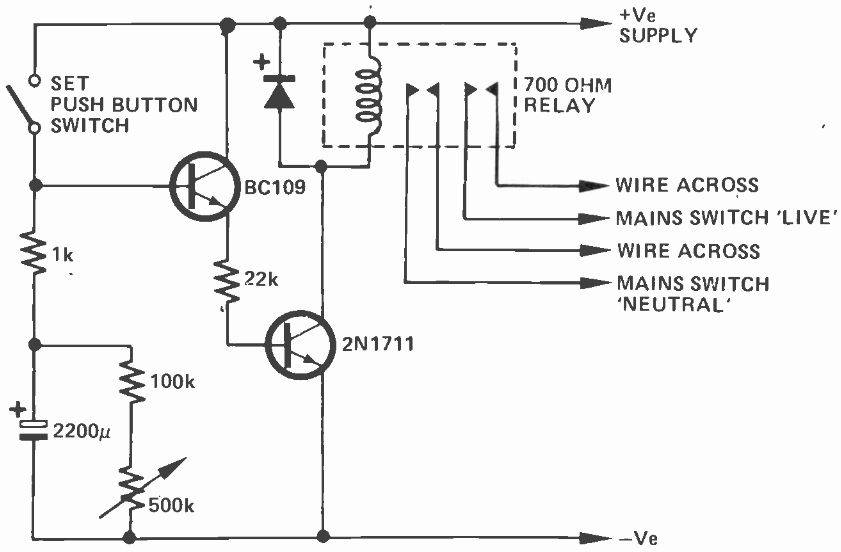
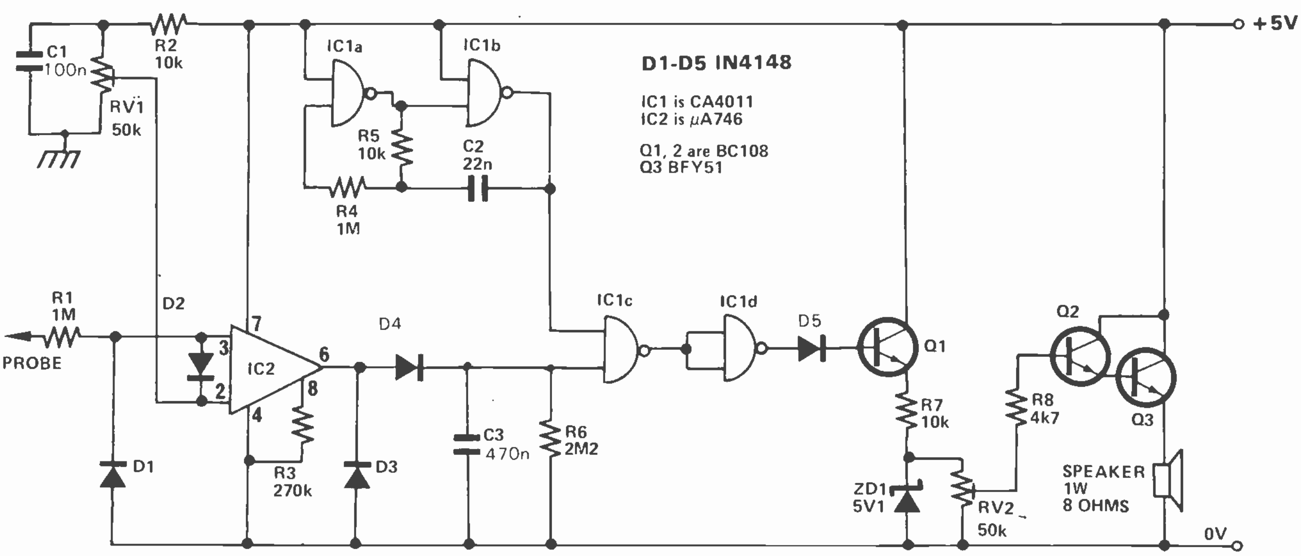


'SNOOZE' DELAY UNIT

When the Set switch is depressed the large electrolytic capacitor is charged via the limiting resistor (1k). This charge causes the BC109 to conduct which supplies enough base current to switch on the 2N1711 space and operate the relay. The relay contacts are wired in parallel with the mains switch so that if the mains switch is now turned off, the equipment will continue.

The supply voltage is taken from the equipment in which the unit is fitted and will determine the choice of relay. The maximum delay being 1.75 hours.

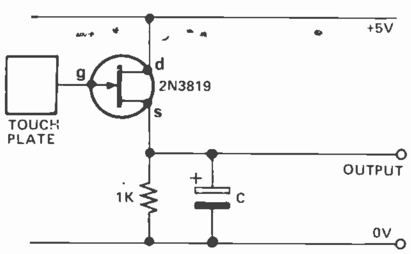


AUDIBLE LOGIC STATE INDICATOR

The indicator will work with either TTL or CMOS circuits. A useful feature is that the unit can be powered by the same supply as the one supplying the circuit under test. Logic state 1 at the probe will produce an audible tone on the loudspeaker. A switching signal at the probe also activates the loudspeaker.

RV1 sets the threshold level at which IC2 will switch on. This is normally set at maximum (wiper at the R2 end). RV2 sets the volume of the audible tone, and can be adjusted as required.

IC2 can be substituted by the equivalent LM748, but R3 must be removed first.

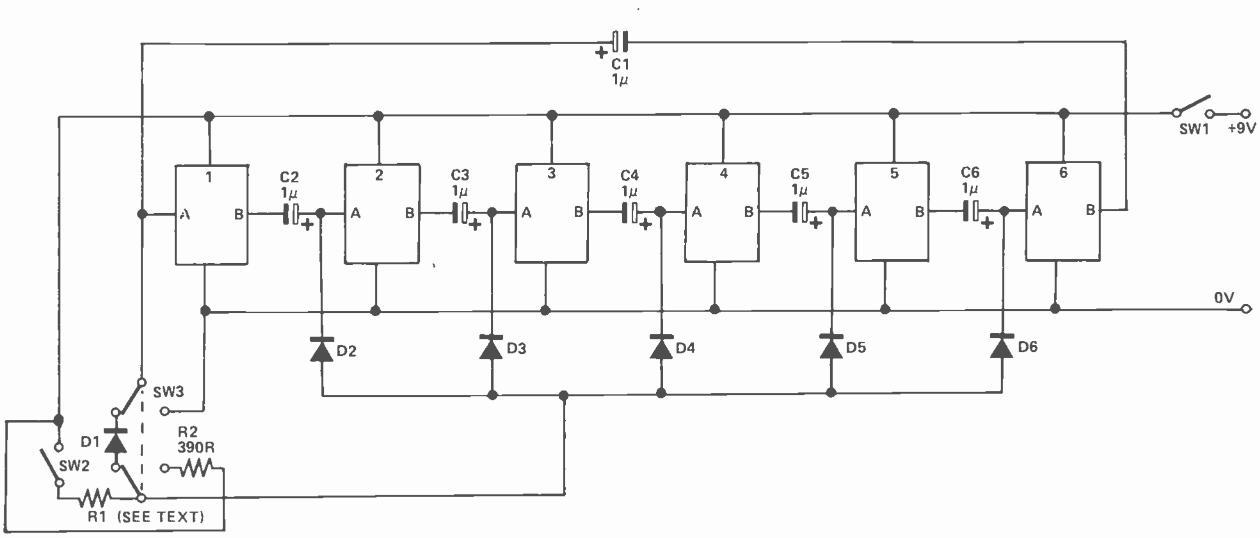


TOUCH-SWITCH FOR LOGIC

An n-channel field-effect transistor is the basis of this simple trigger. In its quiescent state the voltage at the output is about 3V. When the plate is briefly touched with a finger, the minute currents between the body and the plate alter the electric field at the gate of the transistor. The effect is to cause a drop in output voltage. It falls almost to zero and can be used to trigger a TTL flip-flop. This can be constructed in the usual way, using two NAND gates from a 7400 IC. If several triggering circuits are required, it is more convenient to use the 74118 sextuple bistable latch.

The value of the capacitor is not critical, but 10uF is convenient. The touch-plate can be an area of copper etched an a circuit-board, a square of aluminium foil, or simply a drawing-pin pressed into an insulating support.

tech-tips



'FREEZING' SEQUENTIAL OSCILLATOR

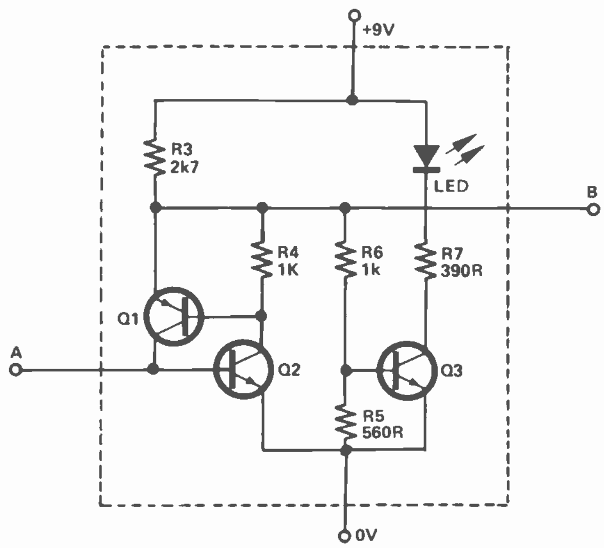
After switch on SW3 (a dpco) is operated and then returned to its normal position. This switches off the first module, and switches on all the others via the diodes. A biased switch may be used.

On the closure of SW2, a number of LEDs will flash in sequence. On the opening of SW2, the circuit will 'freeze' in whatever state it was in, the LED remaining on.

The basic circuit consists of a number of transistor pairs, one for each LED. They are connected in a 'ring' by capacitors from the emitter of one pair to the base of the next. The LED associated with each pair is driven by the inverter-driver transistor Q3.

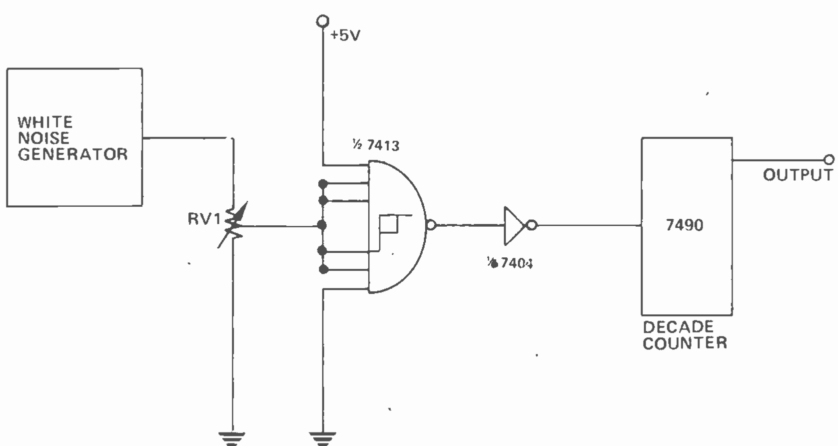
The rate of oscillation is dependent on R1, a value of 10 k gives a rate just faster than the eye can perceive.

Q1 is a BC212. Q2, Q3 are BC108s. All diodes are 1N4148s.



RANDOM PULSE GENERATOR

The 7413 provides a means of 'squaring up' waveforms before applying them to logic circuits. A reverse biased germanium diode is used to provide random 'sine-wave' type pulses, i.e. white noise. The output from the white noise generator is fed into the input of the 7413. When the output from the generator attains the value of 1.8V, the output goes low and the output from the hex inverter goes high. This output is then fed to the counter. By making the output from the white noise generator variable, via a potentiometer, some degree of control over the 'randomness' may be obtained.



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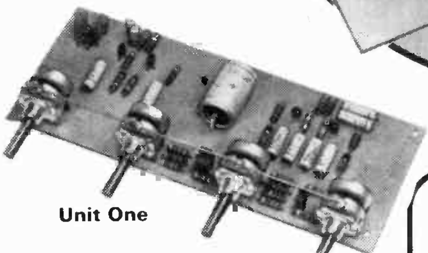

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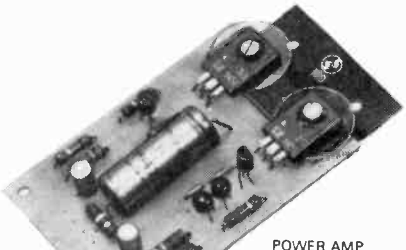
Combined pre-amp with active tone-control circuits. 200mV output for 50mV in. Runs on 10 to 16V supply, treble ±15dB at 10KHz, bass ±15dB at 30Hz. Stereo bal., vol., treble & bass controls. **£7.80**

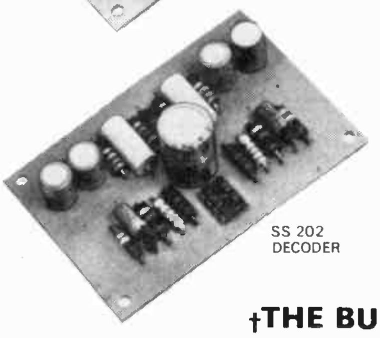
SS.100
Active tone control, bass & treble. **£1.60**

SS.101
Pre-amp for ceramic cartridges, etc., passive tone control circuit shown in data supplied. **£1.60**

SS.102 STEREO PRE-AMP
R.I.A.A. corrected for mag. p/ups, tape, radio, etc. **£2.65**



POWER AMP SS.110



SS 202 DECODER

POWER AMPLIFIERS

SS.103
A 3 watt amplifier using single I.C. type SL 60745 with built-in short circuit protection **£1.75**
SS.103-3. Stereo version (2 I.C.s) of above **£3.25**

SS.105
5 watts R.M.S. into 4 ohms using 12V supply. Ideal for use in in-car entertainment. Size: 89 x 51 x 19mm **£2.25**

SS.110
Similar in size and design to SS 105, this QV module delivers 10 watts R.M.S. into 4 ohms using a 24V supply, e.g. SS.324. Of great use in domestic applications **£2.75**

SS.120
Using a 34 volt supply, such as SS.334, this amplifier will deliver 20 watts into a 4 ohm load. Same dimensions as above **£3.25**

There are suitable Stirling Sound power supplies for all the above. When ordered with above amplifier VAT becomes 12½%.

FM TUNING

SS.201
FM Front End with geared slow motion tuning and A.F.C. facility 88-108MHZ **£5.00**

SS.202
I F amp A meter and/or A.F.C. can be connected (size 3" x 2"). For use with SS.201 .... **£2.65**

SS.203
Stereo decoder (illustrated). For use with Stirling Sound modules or with any other good mono FM tuning section. A LED beacon can be added (Price 18p) to indicate when a stereo signal is tuned in (3" x 2") **£3.85**

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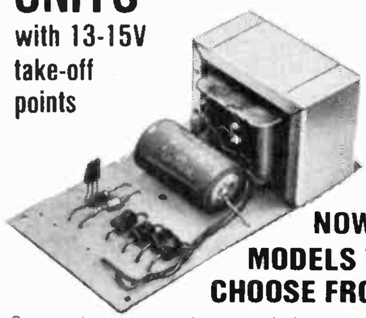

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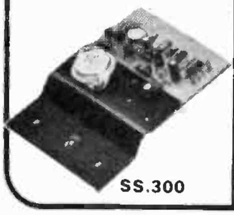
SS.312	12V/1A	**£3.75***
SS.318	18V/1A	**£4.15***
SS.324	24V/1A	**£4.60***
SS.334	34V/2A	**£5.20***
SS.345	45V/2A	**£6.25***
SS.350	50V/2A	**£6.75***

SS.300. Add-on power supply stabilising unit. Short-circuit protected. Ensures stabilised output variable from 12V/2A to 50V max. at 8A. Ideal for workbench and experimenting. **£3.25*** (P&P 35p).



SS.300

SS.310/350 VARIABLE OUTPUT STABILISED SUPPLY

With continuous variable output at 2A from 10 to 50 V.D.C. With built-in protection against shorting and fully adequate heat sink. Guaranteed. Superb value at **£11.95***.

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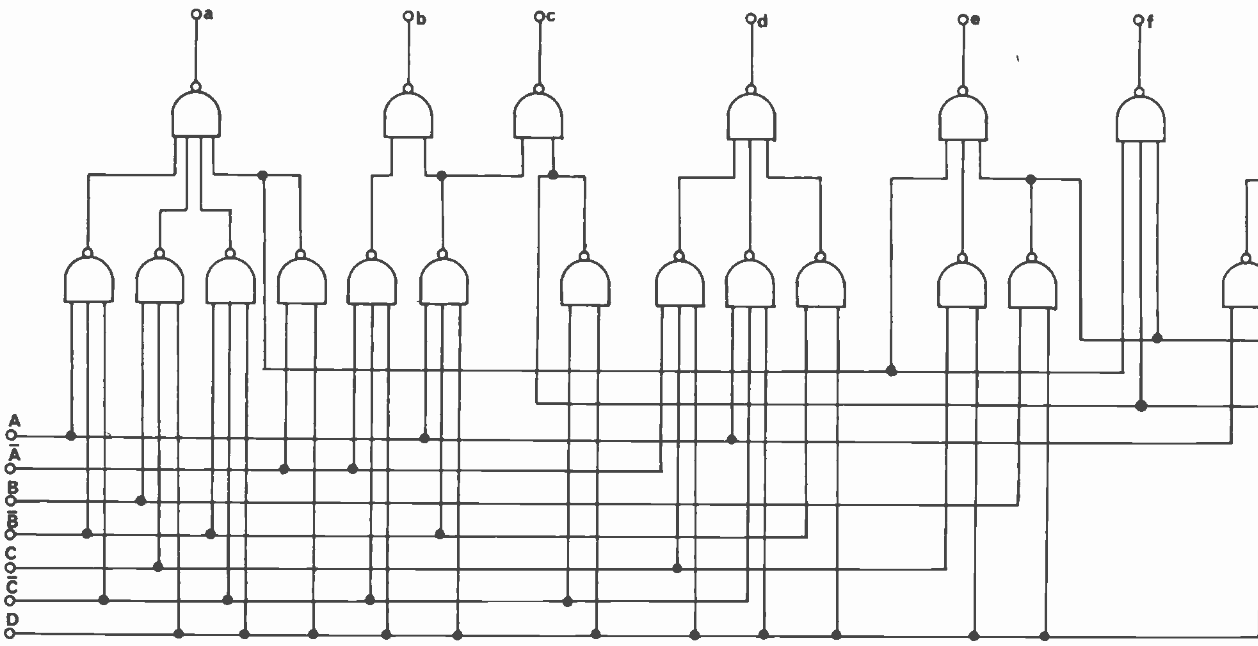


HEXADECIMAL TO 7-SEGMENT DECODER.

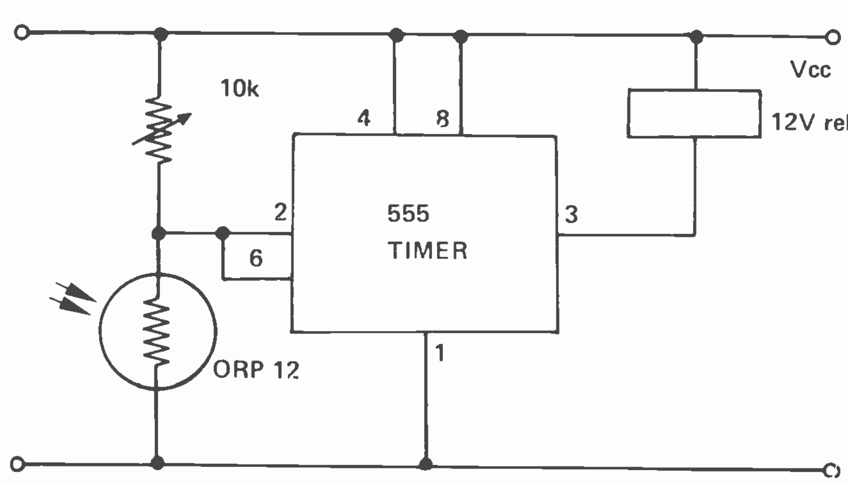
The circuit described below provides an extension to the 7448 BCD to seven-segment decoder, converting it into a hexadecimal to seven-segment decoder which will give the numerals 0-9 and the characters A,B,C,D,E, and F as output for a four bit binary input.

(Inputs of A,$\overline{A}$,B,$\overline{B}$,C,$\overline{C}$,$\overline{D}$ are needed with an inverting buffer - fan out 30 - on the $\overline{D}$ input.)

The 7448 is disabled by bringing the blanking input low when the input is greater than 0111_2 (i.e. $\overline{D}$ is connected to B1/RBØ on the 7448.) Outputs from the 7448 and the add-on decoder are OR-ed together creating a single seven-segment output.

D	C	B	A	a	b	c	d	e	f	g
Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Ø	Ø	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Ø	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Ø	Ø	1	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Ø	1	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Ø	1	1	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø
Ø	1	1	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø
1	Ø	Ø	Ø	1	1	1	1	1	1	1
1	Ø	Ø	1	1	1	1	1	Ø	1	1
1	Ø	1	Ø	1	1	1	Ø	1	1	1
1	Ø	1	1	Ø	Ø	1	1	1	1	1
1	1	Ø	Ø	1	Ø	Ø	1	1	1	Ø
1	1	Ø	1	Ø	1	1	1	1	Ø	1
1	1	1	Ø	1	Ø	Ø	1	1	1	1
1	1	1	1	1	Ø	Ø	Ø	1	1	1

TRUTH TABLE for the 'add-on' decoder. Note that when the input is $Ø11Ø_2$ ($6_{1Ø}$) a logical one is inserted in the 'a' column to provide the resulting seven-segment '6' with a cap, thus differentiating it from a 'B'.



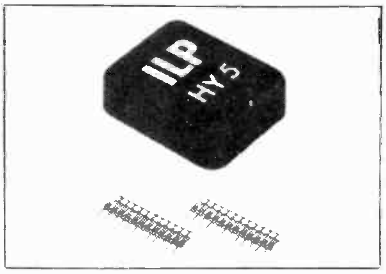
SCHMITT TRIGGER

A very useful schmitt trigger can be made by utilising a single 555 timer with its trigger and threshold inputs connected together. The schmitt has a very low input current (1.5uA) and can directly drive a relay taking up to 200mA of current.

The circuit shows a 555 schmitt being used to energise a relay when the light level on a photoconductive cell falls below a preset value; the relay energises when the voltage on pins 2 and 6 is greater than 2/3Vcc and de-energises when the voltage falls below 1/3Vcc. This gives a hysteresis of 1/3Vcc. The circuit can be used in many other similar applications where a high input impedance and low output impedance are required with the minimum component count.

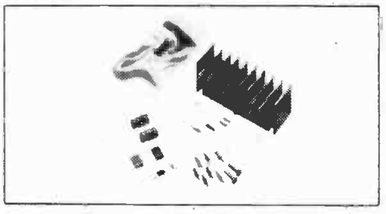
15—240 Watts!

HY5
Preamplifier



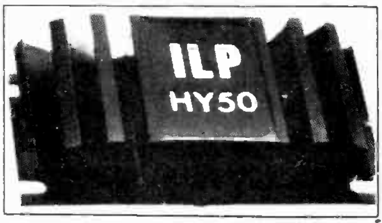
The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (mag Cartridge, tuner, etc.) are catered for internally, the desired function is achieved either by a multi-way switch or direct connection to the appropriate pins. The internal volume and tone circuits 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.
APPLICATIONS: Hi-Fi — Mixers — Disco — Guitar and Organ — Public address
SPECIFICATIONS:
INPUTS: Magnetic Pick-up 3mV; Ceramic Pick-up 30mV; Tuner: 100mV; Microphone 10mV; Auxiliary 3-100mV; input impedance 47kΩ at 1kHz.
OUTPUTS: Tape 100mV; Main output 500mV R.M.S.
ACTIVE TONE CONTROLS: Treble ± 12dB at 10kHz; Bass ± at 100Hz
DISTORTION: 0.1% at 1kHz; Signal/Noise Ratio 68dB.
OVERLOAD: 38dB on Magnetic Pick-up; SUPPLY VOLTAGE ± 16-50V
Price £5.22 + 65p VAT P&P free
HY5 mounting board B1 48p + 6p VAT P&P free

HY30
15 Watts into 8Ω



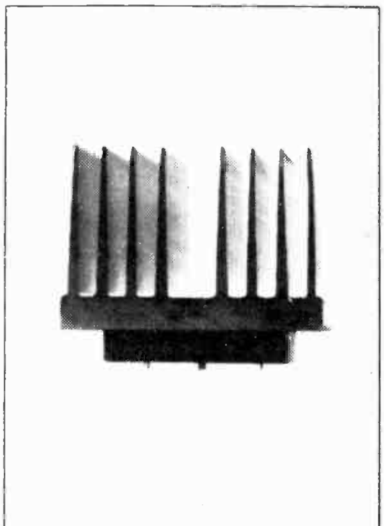
The HY30 is an exciting New kit from I.L.P., it features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. This amplifier 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:
OUTPUT POWER 15W R.M.S. into 8Ω; DISTORTION 0.1% at 15W.
INPUT SENSITIVITY 500mV; FREQUENCY RESPONSE 10Hz-16kHz — 3dB.
SUPPLY VOLTAGE ± 18V.
Price £5.22 + 65p VAT P&P free.

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

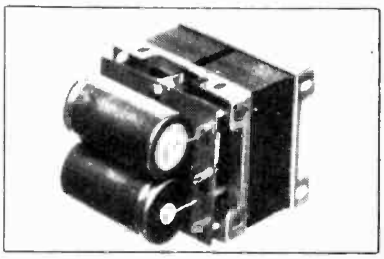


The HY120 is the baby of I.L.P.'s new high power range, designed to meet the most exacting requirements including load line and thermal protection, this amplifier sets a new standard in modular design.
FEATURES: Very low distortion — Integral Heatsink — Load line protection — Thermal protection — Five 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 1 kHz.
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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BC114	12p	BF173	24p	2N3055	50p
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·BC153	16p	BF184	22p	TIP30A	32p
·BC157/8/9	12p	·BF194/195·	12p	TIP31A	55p
BC177	18p	·BF196/197·	13p	TIP32A	64p
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BC182/3/4L	11p	2N5459	40p	2A 50V	36p
BC186/7	30p	IN914	3p	2A 100V	41p
BC212/3/4L	12p	IN916	6p	2A 200V	46p
BCY70/71/72	13p	IN4001	5p	2A 400V	54p
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