AN ARGUS SPECIALIST PUBLICATION

electronics today INTERNATIONAL

May 1983 85p

SPECIAL AUDIO ISSUE

Four Audio Projects:

Power Amplifier Using NDFL

Power Supply Upgrade from Linsley Hood

Balanced Line Amplifier

Compressor Limiter System

PULL-OUT AUDIO BUYERS GUIDE
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DJ90 Stereo Mixer — this is a really versatile new mixer that enables the constructor DJ to produce a professional performance every time. There are two stereo inputs for magnetic cartridges, a stereo auxiliary input and mike input. Other 'plus' features are auto-panning for fast or slow slider controls, multi-mixing, ducking, interrupt, input modulation, in short everything . . . the whole works — AND — under £100 complete! Complete kit **£97.50** + VAT

TRANSCENDENT 2000 — Although only a 3 octave keyboard the '2000' features the same design ingenuity, careful engineering and quality components of its larger brethren. The kit is well within the scope of the first time builder — buy it, build it — play it! You will know you have made the right choice.
Complete kit **£165.00** + VAT

BIG NEWS ABOUT OUR LATEST ADVANCES IN ROBOTICS SEE INSIDE BACK COVER

SALES COUNTER Collect your order from the factory. Open 9-12/1-4.30 Mon-Thurs Easy parking no waiting

Digital Delay Line — With its ability to give delay times from 1.6 mSecs to up to 1.6 secs. Many powerful effects including phasing, flangine, A.D.T., chorus, echo &

vibrato are obtained. The basic kit is extended in 400 mS steps up to 1.6 secs. Simply by adding more parts to the PCB. Compare with units costing over £1,000!
Complete kit (400 mS delay)
£130 + VAT
Parts for extra 400 mS delay
£9.50 + VAT

This versatile modular mixer, featured as a constructional article in Practical Electronics can be built up to a maximum of 24 inputs, 4 outputs and an auxiliary channel. Each input channel has Mic and Line inputs, variable gain, bass and treble controls and a parametric middle frequency equalizer. There are send and return jacks, auxiliary, pan and fader controls and output and group switching. The output channels have PPM displays and record and studio outputs. The auxiliary channel also has a PPM display and there is a headphone monitor jack and a built-in talk-back microphone. The mixer modules plug into base units each of which takes up to 6 channels. To eliminate hum, the power supply is in a separate cabinet.

KIT PRICES

Input channel	£19.90	Base unit and wooden front	£27.50
Output channel	£18.50	Pair of mahogany end cheeks	£12.50
Auxiliary channel	£22.50	Power Supply and cabinet	£19.50
Blank Panel	£3.00		

All prices are VAT exclusive

Free Soldering Practise Kit on request with your first kit — useful tips, well illustrated.

TRANSCENDENT POLYSYNTH — A four octave polyphonic synthesiser with outstanding design characteristics and versatility and performance to match.
Complete kit **£275.00** plus VAT (single voice)
Extra voice (up to three more) **£42.00** plus VAT

MPA 200 — is a low price, high power 100W amplifier, its smart styling, professional appearance and performance, make it one of our most popular designs. With adaptable inputs the mixer accepts a variety of sources yet straightforward construction makes it ideal for the first time builder. Complete kit **£49.90** + VAT

Chromatheque 5000 — a 5 channel lighting system powerful enough for professional discos yet controllable for home-effects. Sound to light, strobe to music level, random or sequential effects — each channel can handle up to 500W yet minimal wiring is needed with our unique single board design. Complete kit **£49.50** + VAT

ETI VOCODER — 14 channels, each with independent level control for maximum versatility and intelligibility; Two input amplifiers — for speech/excitation — each with level control and tone control. The Vocoder is a powerful yet flexible machine that is interesting to build and thanks to our easy to follow construction manual, is within the capability of most enthusiasts. Complete kit **£175.00** + VAT

SP2 200 twice the power with two of the reliable, durable and economic amps from the MPA 200, fed by separate power supplies from a common toroidal transformer. Superb finish and quality components throughout — up to (even over) the standard of high prices factory-built units! Complete kit **£64.90** + VAT

Component packs for most kits are available See our great free catalogue, full details of all our range

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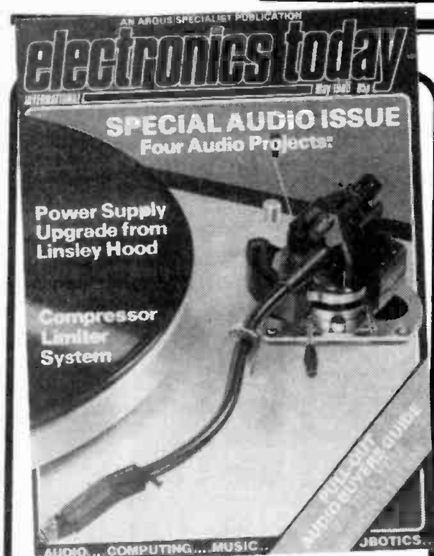

Our thanks to Howland-West International Ltd. for the cover photo.

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PUBLISHED BY:
Argus Specialist Publications Ltd.,
145 Charing Cross Road, London WC2H 0EE.
DISTRIBUTED BY:
Argus Press Sales & Distribution Ltd.,
12-18 Paul Street, London EC2A 4JS
(British Isles)
PRINTED BY:
QB Limited, Colchester.
COVERS PRINTED BY:
Alabaster Passmore.

OVERSEAS EDITIONS and their EDITORS
AUSTRALIA — Roger Harrison
CANADA — Halvor Moorshead
GERMANY — Udo Wittig
HOLLAND — Anton Kriegsman

ABC **Member of the Audit Bureau of Circulation**

Electronics Today is normally published on the first Friday in the month preceding cover date.

☐ Subscription Rates. UK £13.15 including postage. Airmail and other rates upon application to ETI Subscriptions Department, 513 London Road, Thornton Heath, Surrey CR4 6AR.

EDITORIAL AND ADVERTISEMENT OFFICE
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Telex 8811896.

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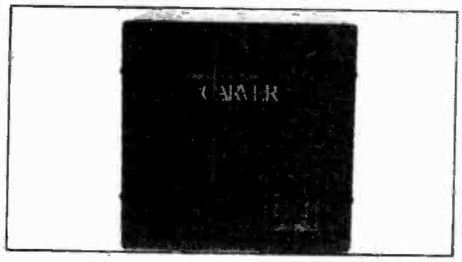

PROJECTS

INFORMATION

WATFORD ELECTRONICS

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ELECTROLYTIC CAPACITORS: (Values in uF) 500v: 10uF 52p; 47 78p; 63V: 0.47, 1.0, 1.5, 2.2, 3.3, 4.7 8p; 10 10p; 15, 22 12p; 33 15p; 47 12p; 68 20p; 100 19p; 220 26p; 1000 70p; 2200 99p; 50V: 68 20p; 100 17p; 220 24p; 40V: 6.8 15p; 22 9p; 33 12p; 330, 470 32p; 2200 90p; 25V: 1.5, 4.7, 10, 22, 47 8p; 100 11p; 150 12p; 220 15p; 330 22p; 470 25p; 680, 1000 34p; 1500 42p; 2200 50p; 2200 50p; 3300 76p; 4700 92p; 16V: 47, 68, 100 9p; 125 12p; 330 16p; 470 20p; 680 34p; 1000 27p; 1500 31p; 2200 36p; 4700 79p.

TAG-END CAPACITORS: 64V: 2200 139p; 3300 198p; 4700 245p; 50V: 2200 110p; 3300 164p; 40V: 4700 180p; 25V: 2200 90p; 3300 98p; 4000, 4700 98p; 10,000 320p; 15,000 345p; 16V: 22,000 350p

POLYESTER CAPACITORS: Axial Lead Type
400V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8 11p; 10n, 15n, 18n, 22n 12p; 33n, 47n, 68n 16p; 150n 20p; 220n 30p; 330n 42p; 470n 52p; 680n 1uF 68p; 2u2 82p.
160V: 10nF, 12n, 39n, 100n 11p; 150n, 220n 17p; 330n, 470n 30p; 680n 38p; 1uF 42p; 1u5 46p; 2u2 48p; 4u7 58p.
1000V: 1nF 17p; 10nF 30p; 15n 40p; 22n 36p; 33n 42p; 47n, 100n 42p.

SIEMENS pcb Type Miniature poly Capacitors 250V
1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 10n, 15n 7p; 18n, 22n, 27n, 33n, 39n, 47n 8p; 39n, 56n 12p; 82n, 100n 11p
100V
100n, 120n 10p; 150n, 180n 12p; 220n, 270n 15p; 330n, 390n 20p; 470n, 560n 26p; 680n 30p; 1uF 34p 2u2 50p

POLYESTER RADIAL LEAD CAPACITORS: 250V
10n, 15n, 22n, 27n 6p; 33n, 47n, 68n, 100n 7p; 150n, 220n 10p; 330n, 470n 13p; 680n 19p; 1u 23p; 1u5 40p; 2u2 46p.

FEED-THROUGH CAPACITORS 1000pF/450V 8p

TANTALUM BEAD CAPACITORS
35V: 0.1uF, 0.22, 0.33 15p; 0.47, 0.68, 1.0, 1.5 18p; 2.2, 3.3 18p; 4.7, 6.8 22p; 10 28p; 16V: 2.2, 3.3 16p; 4.7, 6.8, 10 18p; 15, 36p; 22 30p; 33, 47 40p; 100 75p; 10V: 15, 22, 28p; 33, 47 35p; 100 55p; 6V: 100 42p.

POTENTIOMETERS: Rotary, Carbon, Track 0.25W Log & Lin values.
500Ω, 1KΩ & 2KΩ (Linear only) Single Gang 30p
5KΩ-2MΩ Single Gang Log & Lin 30p
5KΩ-2MΩ Single Gang D/P Switch 78p
5KΩ-2MΩ Double Gang 89p

MYLAR FILM CAPACITORS
100V: 1nF, 2, 4, 4nF, 10 8p; 15nF, 22n, 30n, 40n, 47n 7p; 56n, 100n, 200n 9p; 50V: 470nF 12p.

SLIDER POTENTIOMETERS
0.25W log and linear values 60mm
5KΩ-500KΩ single gang 70p
10KΩ-500KΩ dual gang 110p
Self Stick Graduated Bezel 40p

CERAMIC CAPACITORS 50V: Range: 0.5pF to 10nF 4p. 15nF; 22nF, 33nF; 47nF 5p. 100nF/30V 7p. 200nF/6V 8p.

PRESET POTENTIOMETERS
0.1W 50Ω 5MΩ Miniature Vertical & Horizontal 7p
0.25W 100Ω 3.3MΩ horiz. larger 10p
0.25W 200Ω 4.7MΩ vert. 10p

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POLYSTYRENE CAPACITORS:
10nF to 1nF 8p; 1.5nF to 12nF 10p

SILVER MICA (Values in pF)
2, 3.3, 4.7, 6.8, 8.2, 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 75, 82, 85, 100, 120, 150, 180pF 16p each
200, 220, 250, 270, 300, 330, 360, 390, 470, 800, 800, 820 21p each
1000, 1200, 1800, 2200 30p each
3300, 4700pF 60p each

RAM FOR BBC MICRO 4816AP 100ns 225p

MINIATURE TRIMMERS Capacitors 2-6pF, 2-10pF 22p; 2-25pF, 5-65pF 30p; 10-88pF 36p.

RESISTORS Carbon Film Hi-Stab. 5%.

	RANGE	Val	1-99	100+
¼W	2Ω2 - 10M	E24	2p	1p
½W	2Ω2 - 4M7	E12	2p	1p
1W	2Ω2 - 10M	E12	6p	4p
2% Metal Film		E24	6p	4p
1% Metal Film		E24	8p	6p

100+ price applies to Resistors of each type not mixed.

RESISTORS NETWORK S.I.L.
7 Commoned: (8 pins) 100Ω, 680Ω, 1K 2k2, 4K7, 10K, 47K 100K 25p
8 Commoned: (9 pins) 150Ω, 180Ω, 270Ω, 330Ω, 1K, 2K2, 4K7, 6K8, 10K, 22K, 47K & 100K 26p
13 Commoned 1K, 4K7, 10K, 47K & 100K 56p

DIODES

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

NOISE Diode
Z5J 196p

VARICAPS

BA102	50
BB105B	40
BB106	40
BB109B	40
MVAM2	165

BRIDGE RECTIFIERS

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	46
2A/600V	65
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	296
25A/200V	240
25A/600V	396
BY164	56
VM18 DIL	50

ZENERS
Range: 2V7 to 39V 400mW 8p each
Range: 3v3 to 33V 1.3W 15p each

TRIACS

3A 200V	54
3A 400V	56
8A 100V	60
8A 400V	69
8A 800V	115
12A 100V	78
12A 400V	82
12A 800V	135
16A 100V	103
16A 400V	105
15A 800V	220
25V 500V	220
25A 800V	296
12800D	120

75 SERIES

75107/8	95
75110	90
75114/5	150
75121/2	130
75150	125
75154	125
75159	125
75182/3	99
75188/9	75
75322	140
75324	360
75J61/3	150
75365	150
75450	86
75451/2	52
75454	70
75491/2	65

SCR THYRISTORS

5A/40V	32
5A 400V	40
5A 600V	48
8A 300V	60
8A 600V	90
12A 100V	78
12A 400V	90
12A 800V	188
BT106	150
BT116	180
C106D	36
TIC44	24
TIC45	29
TIC47	35
2N5062	32
2N5064	38
2N4444	130

DIAC
ST2 25

COMPUTER ICs

1702	300
1802CP	650
2114L-300n	90
2114L-200n	95
2147	425
2532	300
2564	£8
2708	225
2716-5V	225
2732	350
2764	425
3242	590
4027	100
4116-150n	85
4116-200n	80
4118-250	325
4164-200n	425
4334-3 = CMOS	
2114-3	325
4532-3	350
4532-4	350
4816-100ns	225
5101-450	220
6116-150nS	325
6116L 120	500
6117-100n	490
6502CPU	325
6502A	450
6504 250	550
6505	600
6520PIA	100
6522VIA	295
6530	£11
6532RRIOT	570
6545RTC	899
6551ACIA	650
6592PC	650
6800	220
6802	250
6803	860
6804	180
6805	670
6808	620
6809	630
6810	116
6820	110
6821	110
68B54	780
6840	375
6843	£12
6845	650
6847	660
6850	110
6854	599
68B21	220
6875	500
6800	£78
74C922	400
8080A	250
8085A	400
8088	£18
8118-10	225
8123	125
8155	350
8156	350
81LS95	80
81LS96	80
81LS97	80
81LS98	85
8202	£25
8205	225
8212	110
8214	425
8216	100
8224	110
8225	£11
8226	250
8228	220
8243	270
8250	850
8251A	250
8253	400
8255	225
8256AC	£36
8257-5	400
8259	396
8271	£28
8272	£17
8279	385
8282	450
8283	450
8284	350
8285	365
8288	£10
8P8304BN	250
8T26A	99
8T27	150
8T28A	120
8T31	350
8T95	90
8T97N	90
9364AP	550
9602	220
AM26LS31C	125
AM26LS32A	125
AM26LS33A	125
AY-3-1015	300
AY-5-2376	600
COM8017	275
COM8116	700
DM8131	275
DS3691N	290
DS88LS120N	255
DS8820	110
DS8830	110
DS8831	125
DS8832	250
E9365	£38
E9366	£38
FD1771	£15
FD1791	£22
FD1795	£28
FD1799	£28
FD1797	£28
HD26501	76
IM6402	380
INS8060N	1050
INS8154N	£9
MC1488	56
MC1489	66
MC14411	890
MC14412	725
MC3446	250
MC3447P	315
MC3486	175
MC3487	175
MC6845	625
MC6846	625
MK3886-2M	£7
MM5280D	696
MM5303	635
MM5307	1275
MM5387A	475
MM58174	700
MM74C922	420
RO-3-2513L	650
RO-3-2513U	650
SFF96364	800
SPO256AL2	£18
TMS2716-3V	725
TMS4416-2	475
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TMS4532-3	350
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TMS9928	£20
TMS9929	£20
TMS9995	£12
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Z80ACPU 4M	300
Z80 CTC	250
Z80A CTC	280
Z80B	875
Z80 DART	495
Z80A DART	550
Z80 DMA	675
Z80 DART	698
Z80 PIO	260
Z80 PIO	275
Z80 SIO-1	850
Z80A SIO	£9

LINEAR ICs

555CMOS	80
702	75
709C 8 pin	36
710	48
741 8 pin	14
747C 14 pin	65
748C 8 pin	36
753 8 pin	185
810	150
9400CJ	350
AD7581	£11
AY-1-1320	225
AY-1-5050	99
AY-1-5051	160
AY-1-6720	210
AY-3-1270	730
AY-3-1350	360
AY-3-8910	420
Booklet for AY-3-8910	160
AY-3-8912	625
AY-5-1230	460
AY-5-1317A	630
AY-5-1350	366
CA3011	130
CA3012	175
CA3014	276
CA3018	8
CA3019	80
CA3020	210
CA3023	210
CA3028A	95
CA3035	256
CA3036	270
CA3043	276
CA3045	365
CA3046	70
CA3048	220
CA3059	286
CA3075	213
CA3080E	70
CA3081	190
CA3086	48
CA3089E	215
CA3090AQ	376
CA3123E	186
CA3130	90
CA3140	40
CA3160	96
CA3161	180
CA3162E	450
CA3189	200
HA1336W	240
HA1388	267
ICL7106	690
ICL7107	975
ICL7204	550
ICL7611	99
ICL7660	248
ICL8038CC	300
ICL8211A	150
ICM7205A	1150
ICM7207	475
ICM7215	1050
ICM7216AJ	£22
ICM7216B	£22
ICM7216C	£22
ICM7217A	750
ICM7224	785
ICM7240	300
CM7555	80
CM7556	150
LA3350	250
LA4031P	340
LA4032	295
LA4400	350
LA4422	320
LC7130	340
LC7120	300
LC7137	395
LF347	150
LF351	48
LF353	95
LF355	85
LF356	95
LF357	110
LF398	475
LM10	325
LM301A	24
LM307	45
LM308T	95
LM311	55
LM318N	160
LM319	195
LM324A	65
LM334Z	90
LM335Z	128
LM339	47
LM348	64
LM349	115
LM358	60
LM377	175
LM379	480
LM380	75
LM381N	145
LM382	116
LM384	160
LM386	90
LM387	120
LM389	95
LM393	45
LM558	75
LM725CN	325
LM733	70
LM1458	46
LM1871	325
LM2917	196
TAB1042	110
LM307	45
LM3302	75
LM3900	60
LM3909N	85
LM3911	125
LM3914	250
LM3915	250
LM3916	250
LM13600	110
LS7220	280
M253AA	1150
M51513L	230
M51515L	320
M51516L	475
MB3712	220
MB3756	440
MC1204	250
MC1301	79
MC1303	98
MC1304P	260
MC1310P	150
MC1445	250
MC145106	695
MC1465	50
MC1469	300
MC1494	694
MC1495	350
MC1496L	70
MC1596	225
MC1648	290
MC1709G	90
MC3302	80
MC3340P	120
MC3360P	120
MC3401	65
MC3403	75
MC3405	150
MC3423	80
MC4016	00
MF10	350
MFC6040	75
MK50398	635
ML924	275
MSM5526	820
NE515	276
NE529	225
NE531	140
NE534	150
NE543K	225
NE544	210
NE555	18
NE556	45
NE560	325
NE561	398
NE562B	410
NE564	420
NE565A	120
NE566	155
NE567V	140
NE570	410
NE571	400
NE5532	145
NE5534A	150
OM335	750
RC4136D	60
RC4558	45
S566B	225
SAB3209	425
SAB3210	325
SAB3271	486
SAB4209S	686
SG3402	296
SL490	350
SL6270CD	150
SN76013	350
SN76023ND	240
SN76131	125
SN76227N	95
SN76477	420
SN76488	480
SP8629	299
TA7130	150
TA7204	175
TA7205	90
TA7222	150
TA7120	160
TA7310	125
TAA621AX1	296
TAA661A	190
TAA700	275
TAA900	395
TAD100	159
TBA120S	70
TBA540Q	275
TBA550Q	330
TBA641BX or BX11	290
TBA651	190
TBA800	80
TBA810	95
TBA820	80
TBA920Q	200
TBA950	300
TBA990Q	350
TBA540	275
TC9109	775
TCA220	350
TCA270Q	350
TCA280A	220
TCA940	175
TCA965	145
TDA1004	290
TDA1008	310
TDA1022	499
TDA1024	115
TDA1034	360
TDA1490	350
TDA2002	325
TDA2004	496
TDA2020	320
TDA2030	296
TDB0701	420
TL170	50
TL061CP	40
TL062CP	80
TL064CN	96
TL071CP	24
TL072CP	46
TL074CN	100
TL081CP	24
TL082CP	46
TL083CP	76
TL084CN	90
TL091CP	56
TL507	110
UA2240	120
UA78540	230
UGN3020T	160
ULN2001	80
ULN2003	75
ULN2004	75
ULN2283	100
UPC575	275
UPC1025H	375
UPC1182	320
UPC1156H	275
UPC1366	195
XR2206	300
XR2207	375
XR2211	575
XR2216	675
XR2266	360
ZN414	80
ZN419E	180
ZN423E	130
ZN424E	130
ZN425E	345
ZN426E	300
ZN427E	600
ZN428E	410
ZN429E	210
ZN459	325
ZN1034E	200
ZN1040E	666
ZNA234E	850

TRANSISTORS

AC126/7	35
AC141/2	30
AC176	28
AC187	30
AC188	32
ACY19/21	75
ACY22/41	75
AD142	120
AD149	79
AD161	42
AD162	42
AF115/6	80
AF118	80
AF124/26	70
AF139	40
AF178	75
AF186	70
AF239	65
BC107	10
BC107B	12
BC108	10
BC108B	12
BC109	10
BC109B	12
BC109C	12
BC114/5	22
BC117/8	20
BC137/9	40
BC142/3	30
BC147B	9
BC148B	9
BC149C	9
BC153/4	27
BC157/8	10
BC159	11
BC160	45
BC167A	10
BC168C	10
BC169C	10
BC170	15
BC171/2	11
BC173	11
BC177/8	16
BC179	20
BC181	20
BC182/3	10
BC184	10
BC182L	10
BC183L	10
BC184L	10
BC188 6/7	25
BC212	10
BC212L	10
BC213	10
BC213L	10
BC214	10
BC214L	10
BC237/8	14
BC256B	30
BC307B	14
BC308	16
BC318	80
BC327/8	15
BC337/8	15
BC441/61	34
BC477	40
BC516/7	40
BC547/8	12
BC549C	14
BC556/7	15
BC558/9	15
BCY39/40	85
BCY45	50
BCY58/59	15
BCY70/71	18
BCY72	20
BCY78	24
BD114	190
BD121	95
BD124	115
BD131/32	48
BD133	70
BD135	46
BD136/37	40
BD138/39	40
BD140	40
BD144/45	198
BD158	65
BD205/6	110
BD246	46
BD378	70
BD517	75
BD645	80
BD695A	125
BD696A	125
BF115	35
BF154/8	25
BF184/5	38
BF194/5	12
BF198/9	18
BF200	80
BF224A	25
BF224B	29
BF245	30
BF256A	35
BF256B	46
BF257/8	32
BF259	36
BF336/7	40
BF594/5	30
BFR39/40	23
BFR41/79	23
BF494/5	30
BFR41/79	23
BFR80/81	25
BFR98	105
BFX29	28
BFX81	45
BFX84	28
BFX85/6	28
BFY50/51	23
BFY52	23
BFY53	28
BFY55/6	32
BFY64	35
BFY81	120
BFY90	80
BRY39	40
BSX20	20
BSX26/29	34
BU105	170
BU205	180
BU206	200
BU208	200
BUY69C	225
E421	250
MD8001	250
MJ2955	70
MJE170	150
MJE180	150
MJE340	64
MJE370	100
MJE371	100
MJE520	95
MJE521	95
MJE2955	98
MJE3055	70
MPF102	40
MPF103	30
MPF104	30
MPF105	30
MPF106	40
MPSA05	25
MPSA08	25
MPSA12	32
MPSA55	30
MPSA56	30
MPSA70	30
MPSU02	58
MPSU05	55
MPSU06	55
MPSU52	65
MPSU55	50
MPSU56	60
MPSU56	80
OC26	170
OC28	220
OC35	50
OC36/41	75
OC71/72	40
OC81/82	50
OC83/84	40
OC170/71	50
OC42	50
OC70	40
OC75/76	40
TIP29A	32
TIP29C	38
TIP30A	35
TIP30C	37
TIP31A	38
TIP31B	39
TIP31C	39
TIP32A	39
TIP32C	42
TIP33A	65
TIP33C	78
TIP34A	74
TIP34C	88
TIP35A	110
TIP35C	128
TIP36A	130
TIP36C	140
TIP41A	50
TIP41B	52
TIP42A	56
TIP42B	58
TIP120	70
TIP121/2	73
TIP141/2	105
TIP147	120
TIP2955	60
TIP3055	60
TIS43	32
TIS44/5	45
TIS88A	50
TIS90/91	30
UC734	65
VK101	80
VN10KM	55
VN46AF	78
VN66AF	80
VN88AF	94
VN89AF	96
ZTX107/8	11
ZTX109	12
ZTX212	28
ZTX300	13
ZTX302	16
ZTX303	25
ZTX304	17
ZTX326	30
ZTX451	23
ZTX500	14
ZTX501/2	15
ZTX503	18
ZTX504	25
ZTX531	25
ZTX550	25
2N697	23
2N698	40
2N699	48
2N706A	19
2N708	19
2N918	35
2N1131/2	24
2N1302	46
2N1671B	180
2N2160	295
2N2219A	28
2N2220A	28
2N2221A	28
2N2222A	28
2N2368	25
2N2369A	18
2N2483/4	27
2N2646	45
2N2904/5	28
2N2906/7	25
2N2907A	28
2N2926G	10
2N3053	28
2N3054	68
2N3055	48
2N3252	46
2N3441/2	140
2N3614/5	198
2N3702/3	10
2N3704/5	10
2N3706/7	10
2N3708/9	10
2N3713	140
2N3771	170
2N3772	186
2N3773	210
2N3819	22
2N3820	38
2N3822/3	45
2N3866	90
2N3903/4	15
2N3905/6	15
2N3906	17
2N4284	24
2N4286	15
2N4314	78
2N4400	18
2N4427	80
2N4871	55
2N5135/6	20
2N5138	11
2N5172	18
2N5179	45
2N5180	46
2N5190/1	75
2N5194	80
2N5305/8	30
2N5457/8	30
2N5459	30
2N5485	36
2N5777	46
2N5879	190
2N6027	32
2SA671	250
2SA715	60
2SC495	70
2SC496	70
2SC1061	260
2SC1096	85
2SC1162	30
2SC1173	125
2SC1306	100
2SC1307	160
2SC1449	85
2SC1678	140
2SC1679	190
2SC1923	60
2SC1945	225
2SC1963	90
2SC1957	90
2SC1969	140
2SC2028	85
2SC2029	210
2SC2078	170
2SC2091	85
2SC2314	85
2SC2166	165
2SC2335	225
2SC2547	30
2SC2612	225
2SD234	74
2SK45	90
2SK288	225
2SJ83	225
2SJ85	225
3N128	112
3N140	112
40315	90
40316	95
40324	100
40326/7	70
40347	90
40348	120
40360	80
40361/2	70
40407/8	75
40411	285
40412	90
40467A	130
40468	85
40594	105
40603	110
40673	75
40871/2	90

RF CHOKES Miniature PCB type
1uH, 2u2, 4u7, 10u, 22u, 33u, 47u, 100u, 220u, 330u, 470u 30p
1mH, 1m5, 2m2, 4m7, 10mH 35p
22m, 33m, 43m 80p
100m 75p

TTL74

7400	11
7401	11
7402	11
7403	12
7404	13
7405	15
7406	20
7407	20
7408	14
7409	14
7410	14
7411	16
7412	18
7413	18
7414	24
7416	20
7417	20
7420	15
7421	20
7422	20
7423	20
7425	18
7426	18
7427	15
7428	26
7430	14
7432	22
7433	22
7437	25
7438	22
7440	15
7441	55
7442	32
7443	90
7444	90
7445	55
7446	60
7447	40
7448	45
7450	16
7451	16
7453	18
7454	16
7460	16
7470	35
7472	24
7473	28
7474	20
7475	25
7476	25
7480	48
7481	120
7482	65
7483	38
7484	70
7485	80
7486	20
7489	170
7490	20
7491	36
7492	25
7493	25
7494	36
7495	36
7496	36
7497	90
74100	80
74104	50
74105	55
74107	20
74109	25
74110	35
74111	56
74112	170
74116	60
74118	55
74119	80
74120	60
74121	25
74122	35
74123	35
74125	35
74126	35
74128	35
74132	30
74136	28
74141	56
74142	175
74143	210
74144	210
74145	50
74147	76
74148	60
74150	50
74151	40
74153	40
74154	55
74155	40
74156	40
74157	30
74159	80
74160	60
74161	48
74162	40
74163	40
74164	40
74165	48
74166	48
74167	150
74170	125
74172	250
74173	80
74174	54
74175	55
74176	40
74177	46
74178	80
74179	80
74180	40
74181	116
74182	80
74184	90
74185	95
74188	250
74190	48
74191	48
74192	46
74193	45
74194	40
74195	40
74196	48
74197	40
74198	80
74199	64
74221	54
74246	120
74247	120
74248	120
74249	120
74251	66
74259	150
74263	56
74273	150
74276	120
74278	100
74279	50
74283	50
74284	155
74285	165
74290	105
74293	80
74297	238
74298	100
74351	195
74365	30
74366	30
74367	30
74368	30
74390	75
74393	90
74490	95

74C

74C244	195
74C245	195
74C373	240
74C374	245
74C922	420
74C923	500

74S

74S00	30
S02	30
S03	30
S04	30
S05	60
S08	60
S20	40
S32	70
S74	75
S86	65
S112	80
S114	80
S132	110
S133	60
S138	100
S139	115
S157	225
S158	210
S188	140
S189	140
S194	195
S195	195
S201	250
S225	240
S241	250
S244	290
S251	170
S257	170
S262	850
S287	225
S288	210
S289	200
S301	350
S412	380
S470	325
S471	620
S472	1150
S475	800
S571	620

74LS

LS00	11
LS01	11
LS02	11
LS03	12
LS04	12
LS05	12
LS08	12
LS09	12
LS10	12
LS11	12
LS12	13
LS13	15
LS14	26
LS15	12
LS20	12
LS21	12
LS22	12
LS	75
LS254	80
LS26	12
LS27	13
LS28	14
LS30	13
LS32	13
LS33	16
LS37	16
LS38	16
LS40	13
LS42	28
LS47	36
LS48	46
LS49	50
LS51	14
LS54	14
LS55	14
LS63	120
LS73	18
LS74	18
LS75	20
LS76	16
LS78	18
LS83	38
LS85	42
LS86	16
LS90	24
LS91	60
LS92	32
LS93	23
LS95	40
LS96	96
LS107	40
LS109	23
LS112	22
LS113	20
LS114	22
LS122	36
LS123	36
LS124	90
LS125	24
LS126	25
LS132	30
LS133	30
LS136	24
LS138	25
LS139	28
LS145	70
LS147	100
LS148	75
LS151	40
LS153	40
LS155	30
LS156	36
LS157	25
LS158	30
LS160	32
LS161	37
LS162	35
LS163	35
LS164	43
LS165	50
LS166	52
LS168	84
LS169	00
LS170	70
LS173	50
LS174	36
LS175	36
LS181	90
LS183	105
LS190	36
LS191	36
LS192	36
LS193	37
LS194	36
LS195	35
LS196	45
LS197	46
LS221	55
LS240	56
LS241	56
LS242	56
LS243	56
LS244	50
LS245	70
LS247	50
LS248	55
LS249	56
LS251	30
LS253	32
LS257	30
LS258	36
LS259	56
LS260	22
LS261	100
LS266	20
LS273	54
LS275	125
LS279	30
LS280	90
LS283	40
LS290	40
LS293	40
LS295	75
LS298	80
LS299	150
LS320	200
LS323	160
LS324	168
LS325	295
LS326	240
LS327	240
LS347	95
LS348	90
LS352	62
LS353	62
LS356	240
LS363	140
LS365	28
LS366	32
LS367	28
LS368	35
LS367	60
LS374	55
LS375	50
LS377	85
LS378	80
LS379	110
LS384	395
LS385	250
LS386	54
LS390	46
LS393	42
LS394	00
LS396	150
LS398	140
LS399	150
LS445	100
LS447	100
LS465	75
LS490	200
LS540	75
LS541	80
LS624	80
LS640	180
LS641	180
LS645	180
LS668	125
LS669	120
LS70	100
LS73	550
LS74	550
LS87	350
LS99	99

SWITCHES

TOGGLE: 2A, 250V

SPST	33p
DPDT	44p

SUB-MIN TOGGLE

SPST on/off	54p
SPDT c/over	60p
SPDT centre off	85p
SPDT biased both ways	105p
OPDT 6 tags	75p
DPDT centre off	88p
OPDT biased both ways	145p
DPDT 3 positions on/on/on	185p
3-pole 2 way	205p

SLIDE 250V:

DPDT 1A	14p
DPDT 1A c/off	15p
DPDT ½A	13p

PUSHBUTTON 6A with 10mm Button

SPDT latching	99p
DPDT latching	145p
SPDT moment	99p
DPDT moment	145p

Mini Non Locking

Push to Make	15p
Push to Break	25p

DIL SWITCHES
(SPST) 4 way **70p**; 6 way **85p**; 8 way **90p**; 10 way **145p**.
(SPDT) 4 way **190p**.

ROTARY SWITCHES:
(Adjustable Stop type)
1 pole/2 to 12 way; 2p/2 to 6 way; 3 pole/2 to 4 way; 4p/2 to 3 way **45p**

ROTARY: Mains DP 250V 4 Amp on/off **68p**

ROTARY: (Mak'a-switch)
Make a multiway switch. Shafting assembly has adjustable stop. Accommodates up to 6 wafers (max. 6 pole/12 way + DP switch).
Mechanism only **90p**

WAFERS: (make before break) to fit the above switch mechanism.
1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6-/2 way **65p**
Mains DP 4A Switch to fit **45p**
Spacers 4p. Screen 6p

ROCKER: 5A/250V SPST	28p
ROCKER: 10A/250V SPDT	38p
ROCKER: 10A/250V DPDT c/off	95p
ROCKER: 10A/250V DPST with neon	85p

THUMBWHEEL Mini front mounting

Decade Switch Module	220p
B.C.D. Switch Module	275p
Mounting Cheeks (per pair)	75p

ETI PROJECTS
We stock most of the parts

JUMPER LEADS (Ribbon Cable Assembly)

Length	14 pin	16 pin	24 pin	40 pin
Single ended DIP (Header Plug) Jumper				
24 inches	145p	165p	240p	380p
Double ended DIP (Header Plug) Jumper				
6 inches	185p	205p	300p	465p
12 inches	198p	215p	315p	490p
24 inches	210p	235p	345p	540p
36 inches	230p	250p	375p	595p

IDC Female Header Socket Jumper Leads 24"

	20 pin	26 pin	34 pin	40 pin
Single ended	160p	200p	260p	300p
Double ended	290p	370p	480p	525p

VEROBOARD 0.1in

	clad	plain
2½ × 3¼	85p	
2½ × 5	100p	–
3¾ × 3¾	100p	–
3¾ × 5	115p	
3¾ × 17	390p	98p
4¾ × 17	495p	275p
Pkt. of 100 pins	55p	
Spot face cutter	150p	
Pin insertion tool	185p	

VQ Board	195p
DIP Board	395p
Vero Strip	95p

PROTO DECs

Veroblock	405p
S-Dec	350p
Eurobreadboard	520p
Bimboard 1	575p
Superstrip SS2	1350p

VERO WIRING

PEN + spoool	340p
Spare spool	75p
Combs	6p

DALO ETCH RESIST PEN
Plus spare tip **90p**

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

ULTRASONIC TRANSDUCER
40KHz 325 pr

COPPER CLAD BOARDS

Fibre glass	Single-sided	Double-sided	S.R.B.P. 9.5" × 8.5"
6" × 6"	90p	110p	95p
6" × 12	150p	195p	

DIL SOCKETS

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

EDGE CONNECTORS

	.1	.156
2 × 15 way	–	140p
2 × 18 way	180p	145p
2 × 22 way	199p	200p
2 × 23 way	175p	–
2 × 25 way	225p	220p
2 × 28 way	190p	–
2 × 30 way	245p	–
2 × 36 way	295p	–
2 × 40 way	315p	–
2 × 43 way	395p	–
2 × 75 way	550p	–

ANTEX SOLDERING IRON

C-15W	455p	CX17W	475p
CCN-15W	495p	CX25W	510p
Spare tips, assorted sizes			65p
Spare elements			210p
Iron Stand with sponge			165p

SIL SOCKET
0.1" pitch 20 way **65p**

IDC CONNECTORS

	PCB Plugs with latch Pins Strt	PCB Plugs pins Angle	Female Header Plug	Female Card Edge Connect
10 way	90p	99p	85p	120p
16 way	130p	150p	110p	–
20 way	145p	166p	125p	195p
26 way	175p	200p	150p	240p
34 way	205p	238p	189p	320p
40 way	220p	250p	190p	340p
50 way	235p	270p	200p	395p
60 way	–	–	230p	495p

EURO CONNECTORS

	Female Socket Strt. Pins	Female Socket Angle Pins	Male Strt. Pins	Plug Angle Pins
DIN41617 31 way	170p	–	–	175p
DIN41612 2 × 32 A + B	275p	320p	220p	285p
DIN41612 2 × 32 A + C	295p	340p	240p	300p
DIN41612 3 × 32 A + B + C	380p	385p	280p	395p

DIL PLUG (Header)

	Solder	IDC
14pin	40p	99p
16pin	48p	105p
24pin	88p	170p
40pin	250p	265p

ZIF DIL SOCKETS

24 pin	575p
28 pin	820p
40 pin	975p

RIBBON CABLE price per foot

	Grey	Color
10 way	15p	28p
16 way	25p	40p
20 way	30p	50p
24 way	40p	65p
34 way	60p	85p
40 way	70p	90p
50 way	100p	135p
64 way	120p	160p

'D' CONNECTORS miniature

	9 way	15 way	25 way	37 way
Male				
Solder lugs	80p	105p	160p	250
Angle pins	150p	210p	250p	385p
PCB pins	120p	130p	195p	285p
Female				
Solder lugs	105p	160p	209p	335p
Angle pins	165p	215p	290p	440p
PCB pins	150p	180p	240p	420p
Covers	90p	85p	90p	100p

IDC 25 way 'D' Plug 385p; Socket 450p

25 way 'D' CONNECTOR (RS232)
Jumpe Lead Cable Assembly

18" long, Single end, Male	495p
18" long, Single end, Female	525p
36" long, Double Ended, M/M	1025p
36" long, Double Ended, F/F	1050p
36" long, Doubel Ended, M/F	995p

● SPECIAL OFFER ●

	1+	50+
2764	450p	395p

PANEL METERS
FSD
60 × 46 × 35mm
0-50μA
0-100μA
0-500μA
0-1mA
0-5mA
0-10mA
0-50mA
0-100mA
0-500mA
0-1A
0-2A
0-25V
0-50V AC
0-300V AC
"S"
"VU" 425p each

CRYSTALS

32.768KHz	100
100KHz	235
200KHz	288
455KH	370
1MHz	275
1.008M	275
1.28MHz	382
1.6MHz	395
1.8NHz	395
1.8432M	200
2.0MHz	225
2.4576M	200
3.278M	150
3.5794M	98
3.6864M	300
4.0MHz	150
4.032MHz	290
4.80MHz	200
4.194304M	200
4.433619M	100
5.0MHz	160
5.185MHz	300
5.24288M	390
6.0MHz	140
6.144MHz	150
6.5536MHz	225
7.0MHz	150
7.168MHz	250
7.7328MHZ	250
7.68MHz	200
8.0MHz	160
8.08333M	385
8.86723M	175
9.00MHz	160
10.0MHz	175
10.24MHz	200
10.7MHZ	150
12.0MHZ	175
12.528M	300
14.31814M	170
16.0MHz	200
18.0MHz	180
18.432M	150
20.0MHz	200
19.968MHz	150
24.0MHz	170
24.930MHz	325
26.69M	150
27.648M	170
27.145M	190
38.66667M	175
48.0MHz	170
100.0MHz	295
116.0MHz	250

RELAYS

Miniature, enclosed, PCB mount.
SINGLE POLE Changeover
RL-91 205Ω Coil; 12V DC, 10V5 to 19.5V). 10A at 30V DC or 250V AC **185p**
DOUBLE POLE Changeover. 6A 30V DC or 250V AC
RL6-100 53Ω Coil, 6V DC (5V4 to 9V9 **190p**
RL6-111 205Ω Coil, 12V DC (10V7 to 19V5) **195p**
RL6-114 740Ω Coil, 24V DC (22V to 37V) **200p**

AMPHENOL PLUGS

IEEE 24 Way	550
Centronics Parallel 36 Way solder	530
Centronics Parallel 36 Way IDC	495
Centronics 36 Way IDC Female	520p

BUZZERS, miniature, solid-state 6V: 9V & 12V **70p**

PIEZOI TRANSDUCERS
PB2720 **65p**

LOUDSPEAKERS
Miniature, 0.3W: 8Ω
2in, 3¼in, 2¼in, 3in **60p**
2¼in 40Ω, 64Ω or 80Ω **80p**

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Standard 6MHz	325p
Wideband 8MHz	480p

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A 4K Monitor chip specially designed to produce the best from your: Superboard Series I & II, Enhanced Superboard & UK101. As reviewed by Dr A. A. Berk in Practical Electronics, June 1981.
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BBC Micro

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Model B	£399 (incl VAT)

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We supply complete range of BBC Plugs, Sockets, Leads, Peripherals, Software etc. Send SAE for list

TRANSFORMERS:

3-0-3V; 6-0-6V; 9-0-9V; 12-0-12V; 15-0-15V @ 100mA **98p**
pcb mounting. Miniature, Split Bobbin
3VA: 2x6V-0.25A; 2x9V-0.15A; 2x12V-0.12A; 2x15V-0.1A **200p**
6VA: 2x6V-0.5A; 2x9V-0.3A; 2x12V-0.25A; 2x15V-0.2A **270p**
Standard Split Bobbin type:
6VA: 2x6V-0.5A; 2x9V-0.4A; 2x12V-0.3A; 2x15V-0.25A **220p**
12VA: 2x4.5V-1.3A; 2x5V-1A; 2x9V-0.6A; 2x12V-0.5A; 2x15V-0.4A; 2x20V-0.3A **295p** (35p p&p)
24VA: 2x6V-1.5A; 2x9V-1.2A; 2x12V-1A; 2x15V-0.8A; 2x20V-0.6A **330p** (60p p&p)
50VA: 2x6V-4A; 2x9V-2.5A; 2x12V-2A; 2x15V-1.5A; 2x20V-1.2A; 2x25V-1A; 2x30V-0.8A **465p** (60p p&p)
Specially wound for Multirail Computer PSUs
50VA: Outputs +5V/5A; +12V, +25V, −5V, −12V at 1A 575p (60p p&p)
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2.5A; 2x25V-2A; 2x30V-1.5A; 2x50V-1A **920p** (75p p&p charge to be added over and above our normal postal charge).

VOLTAGE REGULATORS

1A	TO220 + ve		Plastic − ve	Casing
5V	7805	40p	7905	45p
12V	7812	40p	7908	60p
15V	7815	40p	7912	45p
18V	7818	40p	7915	45p
24V	7824	40p	7918	45p
			7924	45p

100mA TO92 Plastic package

5V	78LO5	30p	79LO5	60p
6V	78LO6	30p	–	
8V	78LO8	30p	–	
12V	7BL12	30p	79L12	60p
15V	78L15	30p	79L15	60p

ICL7660	248p	TAA550	50p
RC4194	375p	TDA1412	150p
RC4195	160p	78H05 +5V/5A	550p
LM309K	135p	78H12 +12V/5A	580p
LM317K	320p		
LM317KP	99p	78HG +5V to +25V 5A	599p
LM323K	450p		
LM337	175p	79HG +2.25V to 24V 5A	685p
LM723 Var	36p		

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100 pins	75p
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3 × 2 × 1"	65p
4 × 2½ × 2"	85p
4 × 2½ × 2½"	103p
4 × 4 × 2"	105p
4 × 4 × 2½"	120p
5 × 4 × 1½"	99p
5 × 4 × 2½"	120p
5 × 2½ × 1½"	90p
5 × 2½ × 2½"	130p
6 × 4 × 2"	120p
6 × 4 × 3"	150p
7 × 5 × 3"	160p
8 × 6 × 3"	210p
10 × 4 × 3"	240p
10 × 7 × 3"	275p
12 × 5 × 3"	280p
12 × 8 × 3"	295p

CMOS

4000	10	4075	13	4541	140
4001	10	4076	50	4543	70
4002	12	4077	13	4544	150
4006	60	4078	16	4548	40
4007	14	4081	13	4549	375
4008	32	4082	13	4553	245
4009	24	4085	50	4554	190
4010	24	4086	60	4555	35
4011	10	4089	125	4556	35
4012	18	4093	20	4557	320
4013	20	4094	70	4558	120
4014	46	4095	95	4559	395
4015	40	4096	70	4560	180
4016	20	4097	290	4561	104
4017	32	4098	75	4562	495
4018	45	4099	110	4566	165
4019	25	4160	95	4568	250
4020	42	4161	99	4569	175
4021	40	4162	99	4572	36
4022	40	4163	99	4580	460
4023	13	4174	99	4581	250
4024	32	4175	105	4582	99
4025	13	4194	105	4583	90
4026	80	4408	790	4584	40
4027	20	4409	790	4585	60
4028	39	4410	725	4597	330
4029	45	4411	675	4599	280
4030	15	4412	775	40085	90
4031	125	4415	480	40097	45
4032	80	4419	280	40098	42
4033	125	4422	770	40100	215
4034	140	4435	850	40101	130
4035	45	4440	998	40102	140
4036	275	4450	350	40103	175
4037	115	4451	350	40104	95
4038	110	4490	350	40105	105
4039	250	4500	675	40106	35
4040	40	4501	28	40107	60
4041	40	4502	80	40108	198
4042	40	4503	40	40109	80
4043	40	4504	75	40110	198
4044	40	4505	185	40114	240
4045	106	4506	35	40161	194
4046	46	4507	35	40163	50
4047	40	4508	130	40174	45
4048	40	4510	46	40175	50
4049	25	4511	45	40181	220
4050	25	4512	50	40182	90
4051	45	4513	199	40192	75
4052	60	4514	115	40193	70
4053	50	4515	115	40194	70
4054	86	4516	55	40195	75
4055	86	4517	275	40244	195
4056	86	4518	40	40245	195
4057	1915	4519	30	40257	195
4059	436	4520	50	40373	180
4060	45	4521	90	40374	160
4061	1195	4522	125	45106	595
4062	995	4526	70		
4063	85	4527	65		
4066	24	4528	70		
4067	245	4529	150		
4068	14	4530	90		
4069	16	4531	130		
4070	13	4532	70		
4071	13	4534	400		
4072	13	4536	275		
4073	15	4538	80		
		4539	90		

OPTO

LS400C	295
OCP71	120
ORP12	85
ORP61	86
2N5777	45
BPX25	195
BPW21	295
BPX65	270

OPTO ELECTRONICS

LEDs with Clips	
TIL209 Red	10
TIL211 Grn	14
TIL212 Yel.	14
TIL220 .2" Red	12
.2" Green, Yellow or Amber	14
0.2" Bi colour Red/Green	65
Green/Yellow	78
0.2" Tri colour Red/Green/Yellow	85
Hi-Brightness Red	59
Flashing red 0.2" red	55
Square LEDs, Red, Green, Yellow	30
Rectangle Stackable LEDs Red, Green or Yell	18
Triangular LEDs Red	18
Green or yellow	22
LD271 Infra Red	46
SFH205 Detector	118
TIL32 Infra Red	58
TIL78 Detector	60
TIL38	45
TIL100	60
BARGRAPH. Red 10 segments	225
ISOLATORS	
IL74	55
ILD74	99
ILQ74	185
TIL111/2/4	90
TIL117	125
4N33 Photo Darlington	135
7 Segment Displays	
TIL312 .3" CA	105
TIL313 .3" CC	105
TIL321 .5" CA	115
TIL322 .5" CC	115
DL704 .3" CC	99
DL707 .3" CA	99
FND357 Red	120
FND500	115
.3" Green CA	150
.6" Green CA	215
.3" ±1 Red CA	150
.3" ±1 Green CA	150
DVM176	22
LCD 3½ Digits	495
LCD 4 Digits	530
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PIN DIODE SD4478-002 610p
REFLECTIVE Optical Switch type TIL139 170p
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- Printer Cable for our printers and BBC £12
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- **TEX EPROM ERASER** Erases up to 32 ICs in 15-30 minutes £33
- **TEX EPROM ERASER** with a safety switch £35
- **TEX EPROM ERASER** plus our Solid State ELECTRONIC TIMER £44
- **ELECTRONIC TIMER,** Solid state, 15-30 min. Connects directly to above Erasers. Protects your expensive Chips from overcooking. Our timer pays for itself in no time £15
- **SPARE** 'UV' Lamp bulb £8
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- **MULTIRAIL POWER SUPPLY KIT.** Especially designed for Micros. Tested output: +5V/5A; +12V; +25V; −12V of 1A £37
- **C12 COMPUTER GRADE CASSETTES** in library cases 40p
- 8½" & 9½" Fan Fold paper (1000 sheets) .... £7 + 150p carr

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- **CD50A** — Twin Cased with PSU, 40 Track, 5¼" S/S 200K £350
- **CS50E** — Single Cased with PSU, 80 Track, 5¼" S/S 200K £250
- **CD50E** — Twin Cased with PSU, 80 track, 5¼" S/S 400K £475
- **CS50F** — Single Cased with PSU, 80 track, 5¼" D/S 400K £330
- **CD50F** — Twin Cased with PSU, 80 track, 5¼" D/S 800K £599
- MITSUBISHI SLIM LINE: Uncased, Double track, Double Density One Megabytes. 5¼". Track Density 96TPI, Track to track access time 3mSec £225
- **Drive Cables** for BBC. Single £8; Double £12
- **10 Verbatim Diskettes** 5¼" S.S.S.D. (5 yrs warranty) £20
- **10 Verbatim Diskettes** 5¼" D.S.D.D. (5 yrs warranty) £30
- **10 Verbatim Diskettes** 8" S.S.D.D. (5 yrs warranty) £28

N.B. Carriage is extra on all Disk Drives and Peripherals

NEC PC8023BE-C PRINTER
£320 £7 car)

MICROLINE-82A PRINTER
80 column, 120 CPS bidirectional, Logic seeking Tractor & Friction feed. 9x9 matrix, true decenders, 40,66,80 or 136 colms per line **£325**

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16K and 48K versions available.

MONITORS

- **MICROVITEC 1431.** 14" Colour Monitor. RGB input (as used in BBC prog.) £250
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Carraige on all Monitors is £7 (Securicor)

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Slimline Portable Cassette players specially made for Microcomputers. AC/DC operational. £26

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A highly sophisticated Acorn Utility ROM. Plugs straight into floating point Atom's Utility Socket. Gives many unique BASIC Extensions: Hi-speed Tape INterface. 2 Key rollover Keyboard, Full disassembler, Memory dump modify, Machine code breakpoints: Basic error trapping; READ, DATA & RESTORE: Full BASIC Keyboard scanner (BBC like); Find line & delete; Auto line numbering; Plus: Chain, Cursor movement. Loopaborting; Easily extendible further. Manual supplied.
£14

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WATFORD'S own most versatile MICRO EXPANSION SYSTEM. Ideal for interfacing with APPLE, ATOM, DRAGON, PET, RESEARCH MACHINE, SPECTRUM, SUPERBOARD, VIDEO GENIE, ZX81, etc. Low Cost, High Spec. As published in Practical Electronics starting from November 1982.
Send SAE for details.

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INTERNATIONAL

NEXT MONTH

PSEUDOROM

We know, we know — we promised it *last* month. Well, it's taken us about that long to figure out how to fit it all into that sleek, compact shape you'll notice if you move your eyes a couple of inches to the right. Assuming you did, and have returned, then you have just been looking at 8K of low-power, CMOS RAM plus a bit of address decoding and battery backup which can be write-protected and made to appear as four 2K by 8 blocks, two 4K by 8 blocks, or one 8K by 8. Now you can develop software on a device which is faster than a speeding ROM and a lot easier to reprogram.

SWITCHED MODE POWER SUPPLY

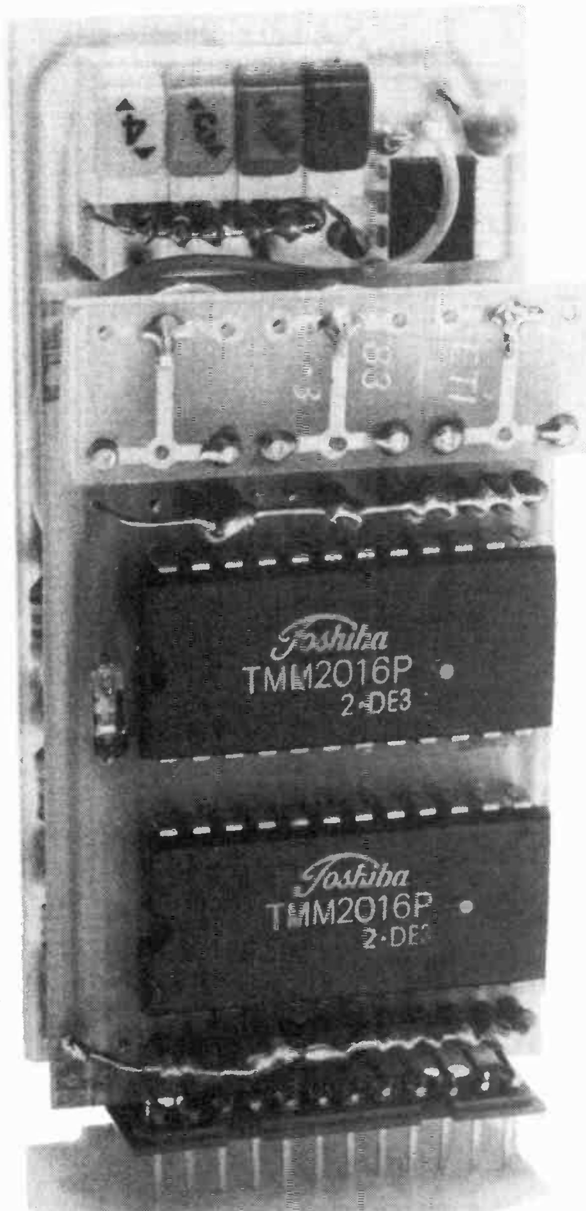
This professionally-designed unit is neat and compact, but it can deliver 12 V at 5 A without straining. Following on from our discussion of switched mode PSUs in the April issue, this project will shed more light on this seldom-discussed subject.

DATA SHEET

With the runaway success of the Victory organ project that has been featured in the last four issues of ETI, have come requests for more information on the special chips used. Ever eager to oblige, next month's ETI contains a Data Sheet on both the M108 and the M208.

COMPASS

This one's really something special. Not only does it display 16 points of the compass using an alphanumeric dot matrix readout, but it uses a new kind of sensor that relies on an apparently new branch of number theory called cyclic binaries. It's pretty stylish and cheap, too. Get the next issue of ETI and you'll never lose your bearings in your boat or car.



DON'T MISS THE JUNE ETI

ON SALE 6th MAY

Articles described here are in an advanced state of preparation. However, circumstances may dictate changes to the final contents.

DIGEST

Disc Jokey?

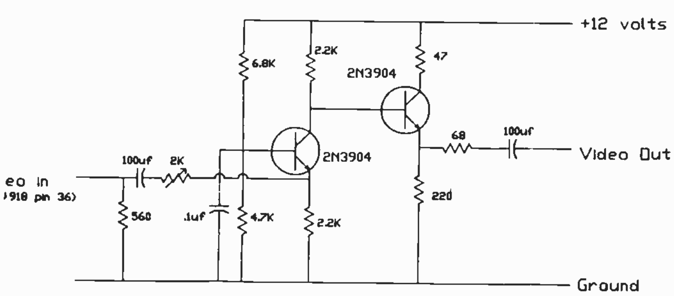
Despite the fact that LP records are a bit bulky when strapped to your waist, Audio Technica will be introducing (in April, or so we're led to believe) their AT 727 Sound Burger. Assuming this is not an April Fool's joke played on gullible journalists, details are as follows: the Sound Burger will play LPs or singles through its own headphones or an external amp and speakers, on any 'reasonably flat' surface, driven by its own batteries or an optional mains adaptor. The turntable is belt driven, the arm is dynamically balanced (we think that means springs), the cartridge is magnetic and the price is £89.95 (recommended, including VAT). As we said, it'll be appearing in April . . .

Drawing The Line Somewhere

AutoCAD is a two-dimensional computer-aided drafting and design package which runs on 8-bit and 16-bit microcomputers under CP/M-80, CP/M-86 or MSDOS/PCDOS. It is a general-purpose package, suitable for a wide variety of applications, including architectural and landscape drawings, mechanical, electrical, chemical, structural, and civil engineering, and printed-circuit design. The AutoCAD package, complete with drivers for all currently-supported devices, is available in the UK from PO Box 100A, Surbiton, Surrey KT5 8HY (01-399 8530) for approximately £630. Special dealer and distributor/OEM prices are also available.

AutoCAD acts like a word-processor for drawings. It lets the user make drawings from simple components such as lines (of any width), circles, arcs, and solid-filled areas. Drawings may be annotated with text of any size, inserted at any point and at any orientation. The drawings can be stored on disc and in turn used as components in other drawings. The ability to define parts libraries simply by drawing them, and to write custom menus (via ordinary text files), allows specialised application systems to be easily developed under AutoCAD. Drawings may be created through keyboard commands, with a light-pen and on-screen menu, or from existing paper drawings via a digitizing tablet. The large set of editing commands allows drawn objects to be moved, copied, modified, erased, rotated, and scaled vertically and horizontally. Repetitive patterns such as brick walls or memory arrays can be generated automatically. A full bi-directional zoom facility allows working on the drawing at any level of detail.

Drawings can be plotted to any desired scale at any point during the drawing process. Each drawing color may be assigned to a plotter pen and line type. Utilities supplied with the package can convert drawings to or from an ASCII text file. This allows user programs to process information entered in graphic form through AutoCAD, or, conversely, the viewing or editing with AutoCAD of drawings produced by data from user programs. If the quality of these samples is anything to go by (originals were A4-sized), then AutoCAD would be useful in our workshop, let alone a design studio.



All resistor values in ohms unless marked

(c) 1978 Frank Lloyd Wright Foundation used by permission

No More Surveys!

We've been overwhelmed at the response to the survey in the February issue — the box containing the replies is too heavy to lift — but if you haven't sent yours back yet, please don't bother, as processing will have taken place by the time you read this and it will be too late to count. A special thank you to all the overseas readers who replied, many of whom went to the trouble of posting their forms by airmail.

Satellite Colloquium

UNISAT-1, Britain's first TV broadcasting and business satellite, is to be the subject of a full day colloquium, organised by the Institution of Electrical Engineers, to be held at the IEE, Savoy Place, London WC2, on Tuesday, 17th May, 1983 (9.15am to 4.45pm). Non-IEE members are very welcome.

Speakers have been invited from BTI, BAe, Marconi, INTELSAT and the BBC. This meeting is designed to have wide appeal and is expected to be very popular. Admission is £17.25 to IEE members, £28.75 to non-members. For further information and booking contact: Karen Kimpton, IEE, Savoy Place, London WC2R 0BL (telephone 01-240 1871 ext. 308).

Make Light Of Soldering

Two new products from Light Soldering Developments Limited are aimed at making soldering easier. First is not entirely new, but a modified version of an old favourite, the LE40 24 V temperature-controlled iron. LSDL say that they have now incorporated proportional control and that this much improves temperature control without temperature swing or overshoot.

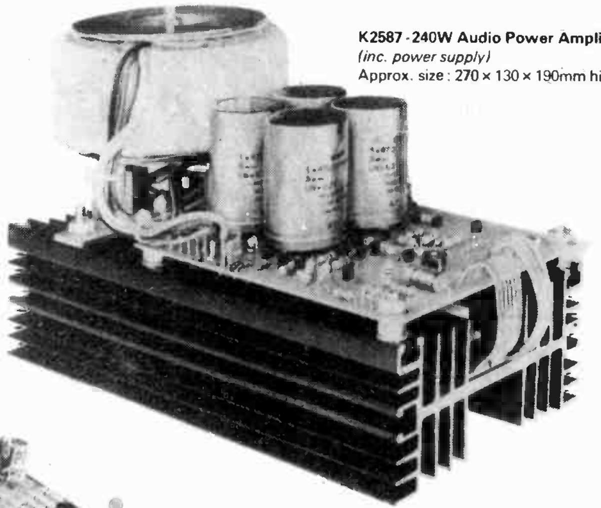
Recently introduced is the SK18 kit which includes an LC18 iron with three bits of different sizes, tweezers, three double-ended soldering tools, de-soldering braid and three metres of cored solder. Ordered direct from Light Soldering Developments Limited, 97/99 Gloucester Road, Croydon CR0 2DN, Surrey, the kit will cost you £14.55.

ELECTRONIC KITS

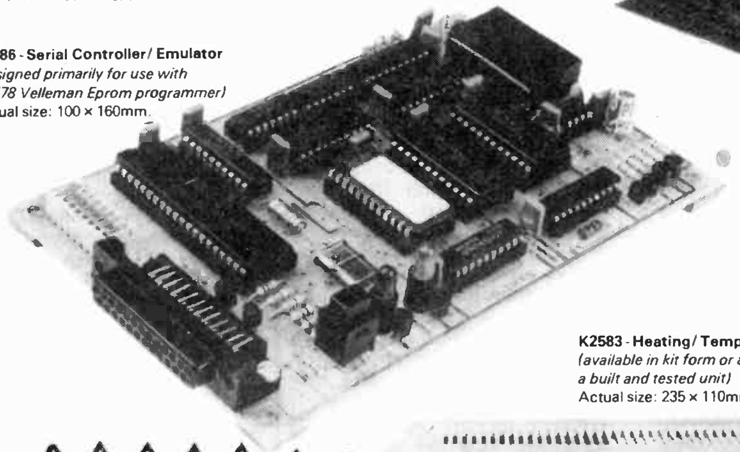
ALL NEW to the VELLEMAN RANGE

Velleman electronic kits have gained respect for their high quality and the varied range which covers many applications in the vast field of electronics. All kits are designed and developed using the latest technology, giving them appeal, not only to the hobbyist and enthusiast but also to the experienced engineer.
The fully illustrated Velleman Kit Journal is available free of charge upon request and has full technical specification on each kit in the range. All kits are graded by difficulty from 1 to 3 and can be purchased direct or from the stockists listed below.
. . . and remember, we have a 'rescue service' for instances where enthusiasm exceeds ability!

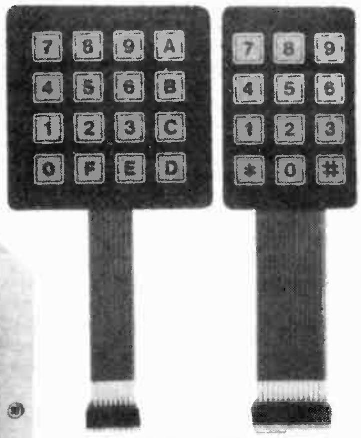
K2584 - Precision timer
(timing from 1 sec to 99 mins 99 secs.)
Actual size: 235 × 110mm



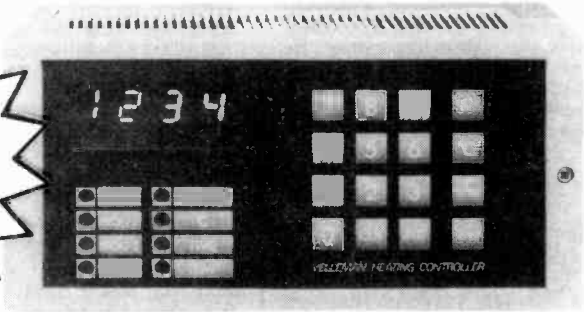
K2587 - 240W Audio Power Amplifier
(inc. power supply)
Approx. size: 270 × 130 × 190mm high



K2586 - Serial Controller/ Emulator
(designed primarily for use with K2578 Velleman Eprom programmer)
Actual size: 100 × 160mm



KBS16 and KBS12 - Membrane Keypads
(available with or without legend)
Actual size:
65 × 100mm
100 × 100mm



K2583 - Heating/ Temperature Controller
(available in kit form or as a built and tested unit)
Actual size: 235 × 110mm

OTHER NEW KITS recently introduced

- K2580 Electronic powerswitch dimmer
- K2581 Stereo volume and tone control
- K2582 Stereo audio input selector
- K2585 Codeclock
- K2588 3 Channel sound to light unit

VELLEMAN UK. Ltd
P.O. Box 30, St. Leonards-on-Sea,
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Telephone: (0424) 753246

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S & R Brewster Ltd., 86-88 Union Street, **Plymouth, Devon.**
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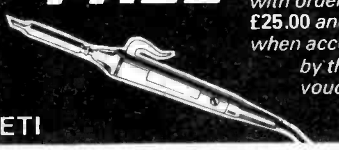
Retail outlets are required in most major towns and cities.
Write for full details, including retail discounts.

FREE SOLDERING IRON
with orders of **£25.00** *and over when accompanied by this voucher*



ETI

Please send me your free catalogue of Velleman electronic kits: ETI

Name. . . . .

Address. . . . .

. . . .

. . . .

Shorts

● For those of you who know what DIN 41612 is, Enclosure Technology Ltd (Unit G, Southampton Airport, Southampton SO2 2HG) have added a wide selection of these standard edge connectors to their range. (Those who don't know what DIN 41612 is might care to take a look at either the Analogue Board or Real Time Clock projects published in the last couple of ETIs).

● Oops! We gave you the wrong address for BICC-Vero's new catalogue. The address we should have given you is: BICC-Vero Electronics Ltd, Industrial Estate, Chandlers Ford, Hampshire SO5 3ZR. Direct your mail thence, please.

● 3D Digital Design and Development, 18/19 Warren Street, London W1P 5DB inform us that they have introduced an interface card for the BBC micro that makes it possible to connect said machine to their low-cost IN-LAB modular interface system. Cards already existed for using Commodore, Apple, Sharp, Sirius and other micros with the system.

● Use your Apple as a storage 'scope. Details of the Applescope made by RC Electronics Inc., are available from Pete & Pam Computers, New Hall Hey Road, Rossendale, Lancs BB4 6JG.

● A new portable computer is on the way from Texas Instruments. Called the CC-40, it features enhanced BASIC, 6K (expandable to 16K) user RAM, expansion port, and TI's Hex-bus expansion peripheral port, all for a suggested price of £169.95.

● Digithurst have added a graphics package to their Microsight computer vision systems. They can be found at Leaden Hill, Orwell, Royston, Herts, SG8 5QH, telephone 0223 208926.

● More news from Texas, this time to say that they have been busy with their M²CMOS process for gate arrays. The first of a new series of products is the SCX6224 (for which a performance evaluation device is available with data sheet) which is a 2400 gate array with internal gate delay times of 1 nanosecond and input frequency capability of 125 MHz.

● Looking for a modem? Thorn EMI have published a shortform catalogue (that means it ain't got many pages) of their range, claimed to be the largest manufactured in the UK. Thorn EMI Datech Ltd, Spur Road, Feltham, Middlesex TW14 0TD.

● Those people at TI *have* been busy — there's another new computer, aimed at beginners and called the TI-99/2. Costing around £75, it will feature an elastomeric keyboard (ugh!), 16-bit processor, 4.2K (expandable to 36.2K) user memory and software on solid state cartridges as well as cassettes. TI Ltd, Manton Lane, Bedford MK41 7PA.

● Norbain Electro-Optics are getting into micros — waves, that is, not computers. They will be marketing the Microwave Associates Communications Inc. range of GaAs Gunn oscillators, transceivers, detectors, and antennae. Norbain Electro-Optics, Norbain House, Boulton Road, Reading, Berkshire RG2 0LT.

● Turn your ZX Spectrum into a word processor using the new Sinclair to Centronics interface that allows you to use high-quality printers. Some software is provided with the device, that comes from Euroelectronics, Zin House, Oakfield Street, Cheltenham, Glos GL50 2UJ.

● Order one for your living room: Control Data's CYBER 205 Series 600 computer is capable of 792 million calculations per second, has eight million 64-bit words of real memory (two trillion words of virtual storage), and models start at the bargain price of a mere £3 million.

● RAM Electro Acoustics Ltd, The Granary, Bracondale, Norwich NR1 2EG have been appointed sole UK agents for the Harksound range of audio turntables.

● 'Good morning campers' will probably not be the way you'll be woken up on one of Southampton University's Computer Holiday Camps. Details from Dr Lionel Wardle, Computer Holidays, 37 University Road, Southampton, SO2 1TL (send a large SAE).

● Salford University is also getting in on the act by organising machine-specific short courses. Details and dates from the Microprocessor Short Courses Unit, Dept. of Electronics and Electrical Engineering, University of Salford, Salford M5 4WT.

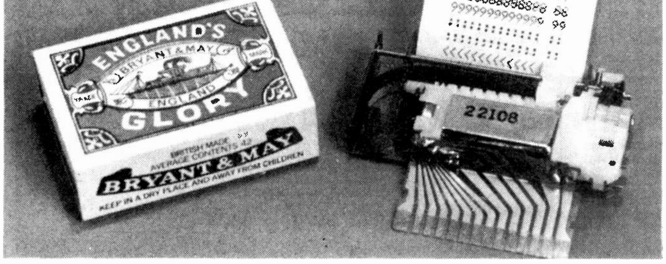
North Sea Sun

On the West German North Sea island of Pellworm the construction of the largest solar power plant of Europe has started: from July 1983 the sun will provide the recreation centre and surrounding houses with electricity. On an area of 16,000 square metres, (the area needed for two football fields), AEG-Telefunken (West Germany) will build up the 300 kW solar generator which will directly convert the sunlight into electricity. In order to be able to continue to farm the island's valuable grassland the solar generators will be installed on structures with a minimum height of one metre above the ground. This DM 11 million (£3 million) project is financed mainly by the German ministry for research and development and the EEC. During the test phase the plant will provide technical data necessary for planning of future solar power plants up to the MW range. To this end, the economy and low maintenance requirements are very important criteria. Until now the solar experts of AEG-Telefunken have derived their experience mainly from solar plants in countries of the Third World.

As the recreation centre needs most energy in the summertime, it is very well suited for the utilization of solar energy. Battery storage provides the power during the night and during bad weather periods. As there will be more energy available than required by the recreation centre the surplus energy will be fed into the utility grid of the Schleswag. Nowadays the price for one kilowatt-hour "solar energy" is still about DM 2 (55p). The scientists of AEG-Telefunken researching on solar energy at Wedel near Hamburg are confident to cut the cost by building up a mass production between 1986 and 1988. Altogether the EEC is supporting 16 projects on the development of photovoltaic sources of energy. Apart from the complete solar power plant on Pellworm, AEG-Telefunken is building solar generators for a dairy farm in Ireland (50 kW) and for a navigational school on the Netherland island Terschelling (50 kW). It all sounds good, but who gets the job of cleaning off the bird droppings?

Pico Print?

Datac Limited of Altrincham have recently renewed their agreement to distribute the Epson range of mini-printers which includes the world's smallest thermal printer, the M-30 series. Measuring 60.2 mm wide x 32.9 mm deep x 10.8 mm high and weighing just 30 g, the 16 column M-30 makes it possible to manufacture ultra thin, pocket-size calculators and other hand held devices with a printing funciton. Also available from Datac is the Epson M-25 13 column model which has a similar specification. For further information on either the M-30 or the M-25 contact Datac Limited, Tudor Road, Altrincham, Cheshire, WA14 5TN. Telephone: 061-941 2361.



Free File

Forget about catalogues — Elkan Electronics have produced the Elkan File, which contains details of all the items they sell. Sounds rather like a catalogue, doesn't it? The difference is that there are no staples! This is a very cunning move because it means that the contents spread themselves all over your desk making it impossible to ignore them.

Featured in the catalogue, I mean file, are the Nanos quick reference cards for the ZX80 and the ZX81. It is claimed that the format of a card, as opposed to a book, makes it easier to locate information when you're actually sitting in front of the computer. This does depend on how many cups of coffee you've spilt over them. Cards for other computers are available or in the pipeline from Elkan Electronics, 11 Bury New Road, Prestwich, Manchester M25 6LZ, telephone 061-798 7613 (24 hours). The cards cost £3.50 each, but the file is free.

ELECTROVALUE

- 24 HOUR NORMAL DESPATCH TIME
- ESTABLISHED 1965
- ALL GOODS GUARANTEED BRAND NEW AND TO SPECIFICATION
- APPOINTED SIEMENS DISTRIBUTORS

DIGITAL & ANALOGUE I.C. SECTION

COMPUTER

74LS

74LS00	11
74LS02	11
74LS04	12
74LS05	12
74LS08	12
74LS10	12
74LS11	12
74LS14	25
74LS20	13
74LS30	12
74LS32	13
74LS37	14
74LS38	14
74LS42	28
74LS47	36
74LS51	14
74LS73	18
74LS74	16
74LS75	18
74LS76	15
74LS85	40
74LS86	18
74LS90	22
74LS92	30
74LS93	22
74LS107	20
74LS112	20
74LS123	34
74LS125	24
74LS126	25
74LS132	34
74LS136	23
74LS137	90
74LS138	25
74LS139	27
74LS145	70
74LS148	75
74LS151	40
74LS153	40
74LS155	30
74LS156	36
74LS157	27
74LS161	36
74LS163	36
74LS164	30
74LS165	50
74LS166	60
74LS173	56
74LS174	45
74LS175	40
74LS191	36
74LS193	40
74LS195	39
74LS196	48
74LS197	60
74LS221	48
74LS240	56
74LS241	56
74LS242	56
74LS243	56
74LS244	56
74LS245	70
74LS251	30
74LS253	30
74LS257	30
74LS259	56
74LS266	20
74LS273	56
74LS279	30
74LS299	150
74LS367	30
74LS368	26
74LS373	60
74LS374	55
74LS378	60
74LS393	45

7400

7400	11
7401	11
7402	11
7403	12
7404	13
7405	15
7406	20
7407	20
7408	14
7409	14
7410	14
7413	18
7414	20
7420	16
7430	14
7440	14
7442	32
7443	60
7444	60
7447	36
7448	40
7450	14
7451	14
7453	14
7454	14
7460	14
7470	24
7472	24
7473	26
7474	20
7475	25
7476	25
7480	36
7482	65
7483	38
7485	60
7486	18
7489	159
7490	20
7491	35
7492	25
7493	25
7494	35
7495	35
7496	34
74100	80
74104	45
74107	20
74121	24
74123	34
74125	29
74126	33
74141	52
74151	30
74154	50
74155	39
74156	35
74157	30
74190	45
74191	45
74192	45
74193	45
74393	78

CMOS

4000	10
4001	10
4002	12
4006	50
4007	14
4008	32
4009	24
4010	24
4011	11
4012	15
4013	20
4014	46
4015	40
4016	20
4017	32
4018	45
4019	25
4020	42
4021	40
4022	39
4023	14
4024	32
4025	13
4026	80
4027	20
4028	39
4029	45
4030	15
4041	40
4042	40
4043	40
4044	40
4046	46
4049	23
4050	23
4060	45
4069	13
4070	13
4071	13
4072	13
4081	13
4082	13
4093	20
4510	45
4511	45
4514	110
4516	53
4518	40
4520	50
4543	75
4583	90

Many other types in stock — see current price list.

All above prices are NET and shown in pence.

ANALOGUE

709C5	49
709C14	44
723C14	36
741C5	57
741C8	16
741S	56
741C14	47
741S	56
741C14	65
748C8	35
1458C5	62
1458C14	40
7106	450N
7107	500N
555	18N
7555	80
556	46
CA3046	70
CA3080E	70N
CA3130E	90
CA3140E	45
LM301AN	25
LM308N	60
LM317K	295
LM324N	32
LM348N	65
LM380N	66
LM380N8	80
LM381N	145
LM382N	115
LM3900N	50
LM3914N	200
LM3915N	200
NE555V	23
NE556A	45
NE567N	104
RC4151NB	80
S041E	290
S041P	121
S042E	364
S042P	138
S89	11.23
S178A	16.60
S187	13.28
S556B	214
S576A	236
S576B	236
S576C	236
S576D	226
S1469	468
SAB0600	425
SAB3209	425
SAB3210	311
SAB3211	188
SAB3271	329
SAB4209	497
SAB8256C	35.40
SDA2007	985
SDA2008	676
SDA3205	724
SDA3206	406
SAD1024	900
SAJ131	238
SAJ141	278
SAJ205	810
SAS231W	260
SAS251	142
SAS580	198
SAS590	196
SDA5680A	15.55
TAA761	104
TAA761A	49
TAA765A	62
TAA861	103
TAA865A	59
TAA2761A	72
TAA4761A	113
TAA4765A	120
TAB1041K	187
TBA120AS	62
TBA120U	72
TBA800	75
TBA10S	75
TBA820	75
TBB1458	62
TBB1458B	40
TCA105	120
TCA105B	108
TCA105G	140
TCA250A	186
TCA205K	200
TCA335A	68
TCA345A	108
TCA345W	177
TCA671	131
TCA780	211
TCA871	114
TCA955	228
TCA965	136
TCA965K	120
TCA971	92
TCA991	80
TCA991K	100
TDA2002	120
TDA2003	128
TDA2030	150
TDA4050B	144
TDA4290	169
TDA4600	184
TDA4700A	546
TDA4718A	436
TFA1001W	252
TL071CP	25N
TL072CP	45N
TL074CN	100N
TL081CP	25N
UAA170	165
UAA170L	152
UAA180	165
UAA190	141
XR2206	300N
ZN414	80N
ZN424P	99
ZN425E	360

CRYSTALS

(in MHz)

0.032768	102	4.433	128
0.100000	453	4.915	157
1.000	453	5.000	157
1.8432	320	5.026	128
2.000	268	6.000	157
2.4576	268	6.144	157
3.2768	188	6.5536	128
3.579	128	8.000	1.88
4.000	102	8.867	128
4.194	128	10.000	157
		18.432	188

ZENER DIODES

400mV/2.7-35V 7p; 1.3W/303-100V 15p; 20W/7.5-75V £1.98

REGULATORS

7805, 7806, 7808, 7812, 7815, 7818, 7824 each 40p. 78L05, 78L12, 78L15 78L24 each 32p. 7905, 7906, 7908, 7912, 7915, 7918, 7924, 79L05, 79L12, 79L15, 79L24 each 50p.

CONNECTORS

DIN AUDIO

Pins	plug	skt
2	8p	8p
3	17p	8p
4	17p	14p
5 (180°)	17p	11p
5 (240°)	18p	8p
6	20p	20p
7	20p	30p

PARALLEL TYPE

	Plug	Skt
16 way	1.10	1.30
20 way	1.25	1.45
26 way	1.50	1.70
34 way	1.65	1.95
40 way	1.85	2.10

Plugs have retainers. Sockets have strain relief.

JACK PLUGS, SKTS

MONO 25" chrome P1	53p	34p	42p
plastic P2	32p	14p	20p
STEREO 25" chrome P3	81p		52p
plastic P4	80p	15p	20p
Mono 3.5mm	18p		14p
Stereo	23p		42p

IC SOCKETS

pins	each	25 for
8	6	1.20N
14	8	1.60N
16	9	1.80N
18	11	2.20N
20	12	2.40N
22	14	2.80N
24	15	3.00N
28	18	3.60N
40	25	6.00N

D-SERIES

9	64p	96p	92p
15	88p	140p	96p
25	128p	206p	110p
37	176p	296p	122p

IDC Connectors DIL

14 way	103p
16 way	117p
24 way	170p
40 way	285p

CAPACITORS

Polystyrene, Siemens 5% Tolerance 160V 5, 7, 10, 12, 15, 18, 22, 27, 33, 39pF 15p; 47, 56, 68, 82, 100, 120, 150, 180, 220, 270, 330, 390, 470, 560, 680, 820pF, 1n, 1n2, 1n5, 1n8, 2n2, 2n7, 3n3, 3n9, 4n7, 10p; 5n6, 6n8, 8n2, 10n, 13p

Ceramic Very small 1.8, 2.2, 2.7 etc. up to 1n 5p each. 1n5, 2n2, 3n3, 4n7, 6n8, 5p; 10n, 22n, 6p; 33n,47n,7p; 100n, 8p

Polyester, Siemens Layer Type 7.5mm lead spacing 100V 1n, 1n5, 2n2, 3n3 4n7, 6n8, 6p; 8n2, 10n 12n, 15n, 18n, 22n, 33n, 47n, 7p 56n, 68n, 7p; 82n, 100n, 9p 120n, 150n, 11p; 180n, 220n, 12p; 270n, 330n, 330n, 390n, 470n, 15p; 560n, 680n, 24p; 10mm spacing 1uF 25p; 15mm spacing 2u2 35p; 22.5mm, spacing 1uF 400V 56p; 3.33uF 100V 69p; In depth stocks.

ELECTROLYTICS

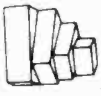
1/63	9	1000/10	19
2.2/25	13	1000/16	26
2.2/63	9	1000/25	36
4.7/63	9	1000/40	44
4.7/100	14	1000/63	76
6.8/40	9	2200/6	09
10/6	8	2200/16	44
10/25	9	2200/25	
10/40	11	2200/40	73
10/63	12	4700/16	72
10/100	15	4700/25	90
22/10	9		
22/25	11		
22/40	12		
22/63	15		
22/100	16		
47/3	2		
47/10	11		
47/25	12		
47/40	15		
47/63	17		
47/100	18		
100/3	2		
100/10	12		
100/16	12		
100/25	12		
100/40	15		
100/63	20		
100/100	27		
220/10	16		
220/16	16		
220/25	16		
220/40	20		
220/28	28		
220/100	42		
470/10	19		
470/16	19		
470/25	19		
470/40	27		
470/63	45		
470/100	73		

TANTALUM BEADS

0.1/35	13
0.22/35	13
0.47/35	13
1.0/35	13
2.2/16	13
2.2/35	16
4.7/16	16
4.7/35	15
6.8/16	16
10/6.3	16
10/16	18
10/25	18
22/6.3	18
22/16	30
22/25	30
33/6.3	24
33/10	30
47/6.3	30
100/3	30
100/10	66

For full ranges of very many other types please see Cat 82 and/or current price list.

BOXES



High quality Black ABS plastic or die-cast plain or stove grey.

L	W	D	ABS		Plain		Stove Gr	
50	50	25	—		5001P	90p	5001	123p
100	60	25	2002	96p	5002P	117p	5002	154p
113	63	31	2003	109p	5003P	143p	5003	184p
121	66	40	2004	115p	5004P	162p	5004	210p
152	82	50	2005	134p	5005P	216p	5005	268p
192	113	61	2006	236p	5006P	314p	5006	401p

VERO RANGE plastic boxes

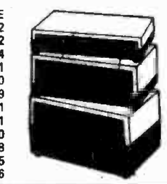
L	W	D		
72	47	25	21024	54p
120	50	35	21390	87p
180	110	55	21391	160p

G RANGE professional Instrument Cases

134	90	44	21089	£7.68
224	140	64	21090	£11.62
302	170	84	21091	£15.78

VEROBOX CASES

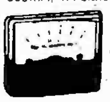
to give a completely professional finish to a much valued project.
ABS, light grey top; dark grey bottom + 2 anodised panels



L	D	H	TYPE	PRICE
205	140	40	21034	£4.52
205	140	75	21035	£5.02
205	140	110	21036	£6.54
180	120	39	21037	£4.11
180	120	65	21038	£4.40
180	120	90	21039	£4.69
155	85	39	21040	£3.31
155	85	60	21041	£3.31
155	85	80	21042	£4.30
125	65	30	21047	£2.48
125	65	39	21048	£3.15
125	65	50	21049	£3.56

METERS

Large range of types in stock; also probes, leads, accessories, etc.
PANEL MOUNTING in 50, 100, 500μA; 1, 5, 10, 50, 100, 500mA; 1A either model.



MU Range 50 × 45mm £2.68

T Range 60 × 45mm £5.95

MULTIMETERS

NH56A NEW — 20KΩ/V AC/DC/-RES/dB in 23 ranges: 130 × 88 × 37mm **£11.20N**

YN360TR 20KΩ/V: AC/DC/R/dB/Transistor Test: in 21 ranges: 145 × 96 × 45mm **£16.45N**

SEMICONDUCTORS

1N914	03
1N914B	10
1N916	5
1N4007	06
1N4148	03
1N5402	14
1N5407	18
2N697	23
2N706	18
2N930	20
2N1132	23
2N1302	110
2N1303	58
2N1304	62
2N1305	62
2N1306	90
2N1307	67
2N1308	147
2N1309	98
2N1599	100
2N1613	26
2N1711	26
2N1893	32
2N2218A	31
2N2219A	25
2N2222A	25
2N2369A	21
2N2484	26
2N2646	45
2N2904	26
2N2904A	26
2N2905A	26
2N3053	23
2N3054	56
2N3055	48
2N3405	64
2N3663	15
2N3702-11	08
2N3771	180
2N3794	21
2N3819	22
2N3820	40
3823	60
2N3904	15
2N3906	15
2N4036	48
2N4058-62	09
2N4124	26
2N4126	25
2N4284	30
2N4286	18
2N4289	23
2N4291	24
2N4292	21
2N4991	82
2N5062	32
2N5192	110
2N5195	106
2N5457	32
2N5458	32
2N5459	36
2N6050	380
2N6057	375
6F40	152
16F40	186
40HF40	225
40362	86
40406	71
40408	96
40412	108
40430	100
40594	123
40595	123
40636	147
40673	145
A9903	16
AA113	13
AA116	9
AA117	13
AA118	9
AA119	9
AC126	25
AC127	25
AC128	25
AC151R	56
AC153K	20
AC176	25
ACY17	156
ACY18	120
ACY19	99
ACY20	90
ACY21	86
ACY39	170
ACY41	10
AD136	150
AD142	90
AD149	88
AD161	35
AD162	35
AF114	37
AF115	37
AF116	57
AF117	64
AF124 AF125	37
AF126	37
AF127	37
AF200	10
AF239	114
AF279	30
AFY12	204N
AFY16	327N
AFY180	310N
AFY18E	615N
AFY42	461N
AU106	240
AU111	(use AU116)
AUY22	10.95
BO140	25N
BO146	30N
BO226	45N
B1906	38
BA379	25
BAS40-03	38
BAS70-03	41
BB105 B	32
BB204	57
BB409	33
BC107A,B	16
BC108A,B,C	16
BC109B,C	18
BC121W	30N
BC122Y	100
BC125	20
BC125	20
BC140	25
BC141	30
BC147A	10
BC149	10
BC154	25
BC160	25
BC161	30
BC167A	09
BC167B	09
BC168A	09
BC168B	09
BC169B	09
BC169C	09
BC177B	16
BC178B	16
BC179B	18
BC182	09
BC182L	09
BC183	09
BC183L	09
BC184	09
BC184L	09
BC202Y	120
BC212	09
BC212L	09
BC213	09
BC213L	09
BC214	09
BC214L	09
BC238C	09
BC239C	09
BC258B	09
BC267B	16
BC300	32
BC301	24
BC303	30
BC327	16
BC328	11
BC337	14
BC338	11
BC413	09
BC414	09
BC477	24
BC546	10
BC547	09
BC548	09
BC549	09
BC550	10
BC556	10
BC557	09
BC558	09
BC559	09
BC560	10
BC879	38
BC880	43
BCY31A	157
BCY58	18
BCY70	18
BCY71	18
BCY72	18
BD130	45N
BD131	48
BD132	48
BD135	27
BD136	27
BD139	30
BD140	32
BD644	42N
BD679	62
BD680	64
BF115	35
BF167	25
BF173	25
BF177	25
BF178	25
BF244B	40
BF254	14
BF255	14
BF420	31
BF421	34
BF457	35
BF458	35
BF459	35
BF597	12N
BFR34A	87
BFR39-41	23
BFR79-81	23
BFT65	119
BFT66	192
BFX29	24
BFX84	24
BFX85	24
BFX87	28
BFX88	26
BFY50	24
BFY51	24
BFY52	24
BFY90	143
BR34	70
BR64	110
BRY39	45
BSX20	22
BSX26	22
BSX63	160
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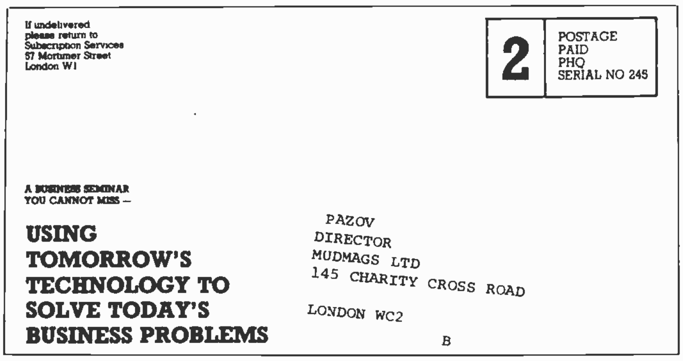
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The above envelope was received by us at our offices a few days ago. We don't think further comment is necessary.

A Code To Bank On

An unbreakable code, which should prove of great interest to banks, businesses and other institutions requiring the confidential transmission of information, has been developed by Professor Adi Shamir of the Weizmann Institute's Department of Applied Mathematics and Dr Ronald L. Rivest and Leonard Adelman of MIT in the States, reports Bank Hapoalim, the leading Israeli bank. The cryptographic system is based on an idea originally suggested by computer scientists Whit Diffie and Martin Hellman of Stanford University in the United States.

The idea was to develop a coding system where different keys would be required for encryption and decryption. In this way, a subscriber could reveal his encryption (encoding) key, so that all users could send him messages, while the decryption (decoding) key would be known only to the receiver, ensuring complete secrecy. The new system uses very large prime numbers. It takes only a fraction of a second for a microcomputer to multiply two 100-digit prime numbers to obtain their 200-digit product. On the other hand, it would require four billion years to solve the reverse problem: that is, to determine which two 100-digit prime numbers were used to yield a given product.

According to the system, a directory of registered subscribers will supply the public numbers of users. At the other end, the receiver will take the concealed communication and use his secret decryption key to obtain a comprehensible message. Because no prior exchange of secret information is necessary, the system is very convenient for widespread public usage. It also enables the transmission of legally binding 'signatures' to a message, so that contracts, purchase orders and cheques can be exchanged via telex.

With all conventional coding systems, both receiver and sender must possess the same confidential key. The new system, according to Professor Shamir, "is an entirely novel concept of public communication, one which we hope soon to see widely used." A prototype computer chip is now undergoing extensive testing in Boston. For further information contact: Department of Applied Mathematics, Weizmann Institute of Science, Rehovot, Israel.

Inductive Loop Amp

Reder Sound Ltd have just introduced their model DL1 Inductive Loop Amplifier. The DL1 is the smallest in their range and is primarily intended for use in the home. It features a current output stage, which ensures a constant current into differing load impedances, internal AGC and inputs for tape recorder/TV or high impedance microphone. The only front panel control is the on/off switch with an indicator LED. The unit is designed to operate in rooms up to 4 metres wide.

The range is completed by the LA2 and LA3 amplifiers. Both feature current output stages, inputs for microphone (low impedance), auxiliary and loudspeaker line (all balanced and floating), internal limiter and full thermal protection. The LA2 is a 30 W 2 A maximum output unit and the LA3 is a 60 W 3 A maximum output unit.

Reder Sound also manufacture PA equipment and accessories as well as inductive loop equipment. All inductive loop equipment is designed to be used in accordance with BS 6083 pt4. Reder Sound Ltd are at Premier Works, High Street, Sutton, Ely, Cambridge CB6 2RB (telephone Ely (0353) 777252).

Tech-Deck

Technics is expanding its range of cassette decks with the RS-M235X, which has three noise reduction systems. The new cassette deck features Dolby B and C and dbx noise reduction systems, making it compatible with any type of recording and offering excellent sound reproduction. In addition, the RS-M235X offers a built-in dbx disc decoder, increasing its versatility.

dbx, the most powerful noise reduction system on the market, yields a signal to noise ratio of 92 dB with 100 dB dynamic range — more than enough to record any live performance, even a jet engine at take off! For simple operation, an auto-tape selector choses the correct bias and equalisation for the type of tape being used. In addition, a new system of level and balance control features in the RS-M235X. A single master level slider adjusts both channels, while a separate control balances left and right channels when necessary, permitting smooth fade-in/fade-out effects. Colour-coded, soft touch controls aid easy operation and wide range FL meters indicate signal response.

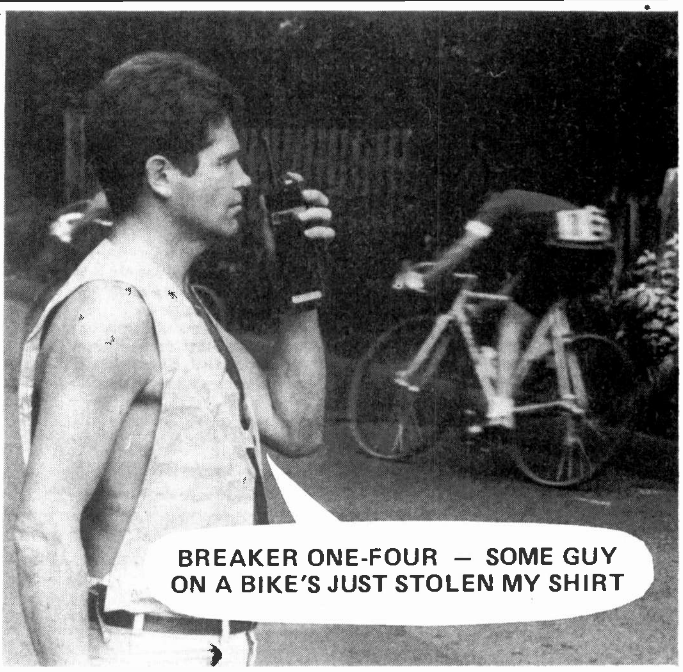
Slim in style, the RS-M235X is available in silver or black finish and is designed to co-ordinate with the new range of Technics hi-fi separates. Retailing at £176.95 the RS-M235X can be obtained from the Technics network of authorised dealers.

A Thorn In The Swede

A Swedish nuclear power station is to be equipped with the latest British radiation monitoring systems for routine personnel contamination checks under an order worth several million Swedish crowns (sounds much more impressive than £s) placed with Nuclear Enterprises Limited, of Beenham, near Reading.

As the world's most sensitive contamination monitoring system of its type, the Nuclear Enterprises IPM7 establishes Britain's leadership in this exacting technology. The system permits highly accurate checks to be carried out extremely rapidly to ensure personnel are free from contamination when leaving control areas. In a matter of seconds, workers' hands, feet and clothing are scanned by banks of electronic detectors inside the IPM7's specially designed 'walk-through' cubicle.

Nuclear Enterprises is a subsidiary of Thorn EMI Technology, one of the major divisions of Thorn EMI's Engineering Group.



ETI

The power supply can make the difference between an adequate amplifier and a great one. In this article, J. Linsley Hood explains the advantages of a stabilised PSU, and concludes with a simple and novel circuit to upgrade your hi-fi.

STABILISED HI-FI PSU

If you look inside the boxes of some of the top name hi-fi power amplifiers — the ones that get the rave reviews from the 'golden-eared' fraternity — you will find, more often than not, that the power supply units are stabilised, rather than being of the simple transformer, rectifier, reservoir capacitor variety. The reason for this is twofold. First, the presence of a stabilised PSU is an indication of the rather greater care that has gone into the building of these amplifiers, and if you aim at the top, as a hi-fi manufacturer, this is a necessary part of your philosophy; and second, because the stabilised PSU really does confer some valuable advantages in the operation of the equipment. Let us look at some of these.

The amount of power one can get from a power amplifier, for any given load impedance, increases rapidly as the DC power line voltage is increased. However, so does the cost of the output power transistors (in fact, all the transistors), as well as the capacitors used in the design. As an aside, the fact that 50 V capacitors cost a lot less than half that of the equivalent 100 V ones is the main reason for the popularity among the high power amplifier manufacturers of direct coupled (two power supply lines of half the voltage) output stages. If Joe Public thinks that they also sound better, so be it!

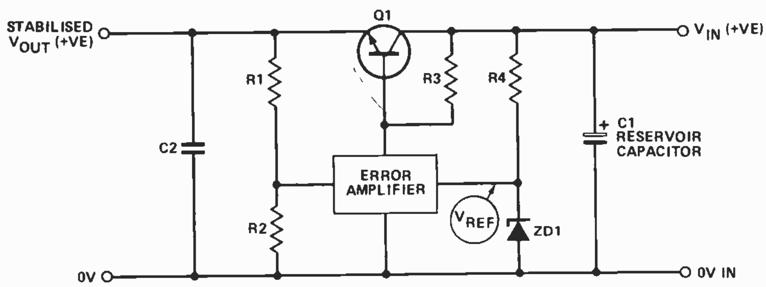


Fig. 1 Simple stabilised power supply.

Unfortunately, the realities of life are not on our side. From the point of view of the power output, what is important is the actual supply line voltage at maximum load, but what the transistors have to support is the worst case condition of line voltage off-load, and the on-load voltage will always be a good bit less than this. If, on the other hand, one has a constant DC supply, one only needs to make sure that the transistors and capacitors will stand this, and this will also be the voltage available when one is driving to full power.

Just doing a cost assessment of stabilised versus cheap-and-cheerful gives a small overall cost advantage in favour of the simple system, which is why it is more commonly used. However, the stabilised PSU has other, more subtle, advantages which are of value to the discriminating user. These are those which follow from the low ripple level on the supply line of any properly designed stabiliser circuit, and its low supply line impedance. The first of these ensures that hum breakthrough is eliminated, not just at low power levels, which is easy, but also at high powers, when the voltage ripple on the reservoir capacitor is becoming significant. The second feature, that of the low line impedance, not only gives a lower degree of LF breakthrough from one channel to another (at frequencies where the impedance of the reservoir capacitors is significant) but also gives a more firm and solid bass response. In fact, in my view, this is a more important contribution to the firmness of bass response than the absence of an output coupling capacitor in a 'direct coupled' system.

So, having reviewed the propaganda in favour of the use of constant, stabilised power supply lines two questions remain: can one upgrade an existing amplifier this way, and how simply could one be built? The answer to the first question is almost certainly 'yes' provided that one uses some care. The second I propose to explore. Since this will be done by starting with a basic circuit and adding components, the usual practice of numbering components from left to right and top to bottom will not be followed, so as to achieve continuity from figure to figure.

The Stabilised PSU

These are normally designed along the lines shown in Fig. 1. In this a 'pass' transistor (Q1) is connected as an emitter follower

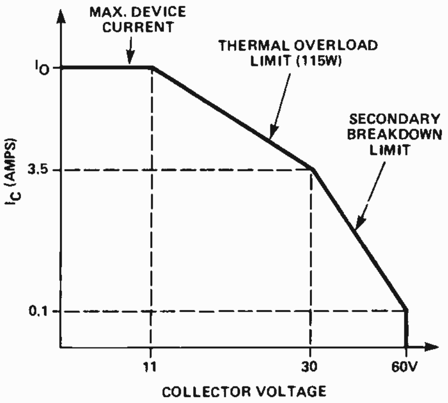


Fig. 2 Power transistor limiting values.

between the unstabilised DC input and the required stabilised DC output. The base drive current to this pass transistor is controlled by some form of error amplifier which compares some proportion of the output DC voltage with a reference voltage derived, perhaps, from a zener diode (ZD1) supplied through R4. Depending on the zener voltage, the controlled DC output can be adjusted, within the limits set by the DC input and the reference voltage, by a suitable choice of R1 and R2. A small capacitor is usually connected across the output to make sure that the output impedance remains low at HF.

This is a very good circuit arrangement, and is used in a very wide range of designs. Indeed, with a little more internal craftiness, very similar systems are employed in the 'three terminal' IC voltage regulators one can now buy for around fifty pence. However, there are snags.

In the case of the IC voltage regulators the main snags are that they are usually limited to input voltages less than 50 V, that the maximum output voltages are usually less than 35 V and that at these voltages the available output currents will probably be less than 0.5 amps, which is rather too low to be of much use for audio power amplifiers. Nevertheless, where these can be used, they are the best possible solution in terms of performance in relation to cost.

In the case of DIY units of this kind built up from discrete components, though higher voltage and current operation can be organised, the most immediate problem is that of the 'safe operating area rating' or SOAR as shown in Fig. 2. This graph, which is that for a typical power transistor of the 2N3055 type, shows that there are limits on the permissible conditions of operation, and that, as a general rule, you cannot allow the transistor to pass much current at voltages above some 30 V without it blowing up, due to what is known as 'secondary breakdown'. (This arises because silicon diodes have a forward voltage which decreases as they get hotter. So, if enough current, at enough voltage, flows through the transistor the resultant heating will inevitably cause some localised area of the base-emitter 'diode' to get hotter than the remainder, and then all the transistor current will plough through this small area, with expensive and inconvenient results!)

Two ways of safeguarding against this snag are possible. The first (and simpler, if the amount of current needed is less than that permissible at the given input voltage V_{IN}), is simply to include a current limit circuit as shown in Fig. 3.

In this, Q2 is added, with R5. If the output current taken exceeds the amount needed for the voltage drop across R5 to turn on Q2, then this will 'steal' the base current from Q1 and hold the output current to the chosen limiting value.

However, circumstances often arise where this simple answer just isn't good enough, and then it is necessary to organise a rather more cunning scheme, known as 're-entrant' short-circuit protection. In this, the protection circuit is arranged so that the full, but limited, output current is allowable up to some prearranged voltage drop across the pass transistor Q1, which is known to be within safe operating limits. If the voltage across the pass transistor exceeds this value, some supplementary circuit comes into operation to instantaneously limit the current through the transistor to some lesser value appropriate to its new collector-emitter voltage drop.

This type of arrangement is a much better scheme, and allows stabilised PSUs to be built which will give quite large current outputs at the sort of voltages which would be of use in audio amplifier systems. Moreover, the fact that the output voltage and current will both collapse rapidly in the event of an overload can allow a good measure of protection, if the limit levels are set correctly, for both the amplifier itself and also things like loudspeakers used with it.

Of course, the usefulness of a stabilised power supply is not limited to improving audio amps. This was just one of the possible uses which might appeal to the hi-fi enthusiast in pursuit of an economical and sensible route to a rather higher-fi. Also, as it happens, it is an ingredient I have in mind for a future audio amplifier design for ETI, since I don't think that perfection in this field has yet been reached, or that the last word in cost effectiveness has yet been spoken.

An Improved PSU

So — we want a simple PSU

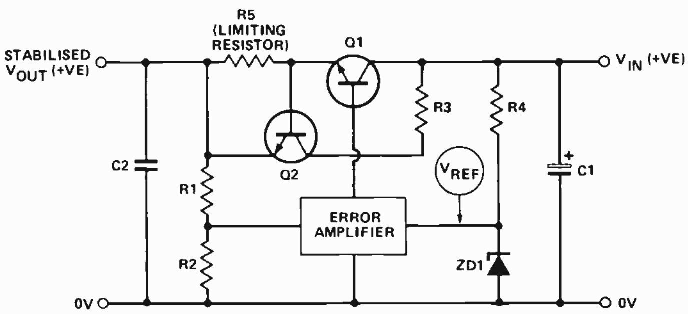


Fig. 3 A stabilised power supply with current limiter.

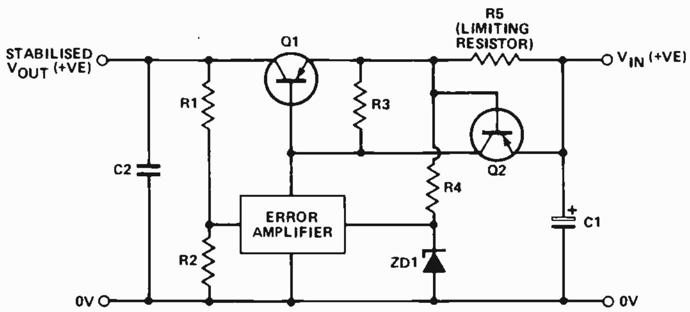


Fig. 4 An alternative arrangement to Fig. 3.

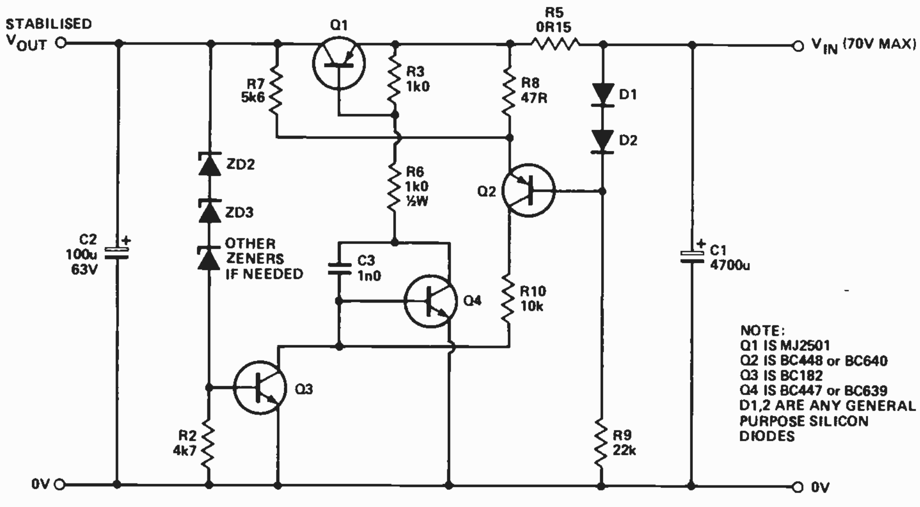


Fig. 5 A stabilised power supply unit with re-entrant short-circuit protection.

system, with an adequate degree of voltage stabilisation, and a re-entrant overload limit characteristic. How best can this be done?

The general scheme shown in Figs. 1 and 3 has several inherent snags, in spite of its popularity in the PSU circuit league. Of these snags, the first is that there must be a sufficient difference in voltage between V_{IN} and V_{OUT} for Q1 to be functional, and for an adequate current to flow through R3 to give the necessary output maximum current, with the lowest likely current gain in Q1. This would lead, say, in a 3 amp PSU to a value of R3 being chosen which would pass 100 mA at a 10 V input/output voltage drop. If we now have an input voltage of, say, 60 V, then when Q1 isn't asking for the full base bias current — as, for example, when the PSU was off load — the error amplifier will have to dissipate 60 − 10 V x 100 mA = 5 W, with a further 1 W being dissipated in R3.

If, however, we turn Q1 the other way round, as in Fig. 4, then the base bias current can be supplied from the '0 V' line, which will mean that the minimum necessary voltage drop between V_{IN} and V_{OUT} can be reduced to, say, 3 V, which will reduce Q1's dissipation. Also, only as much current is fed into Q1's base as the output current calls for. This greatly reduces the quiescent dissipation in the error amp circuitry as well. Of course, we would then have to put the current limit transistor on the input side, if we were going to use the same kind of limiting system. We can, however, do a bit better than this — using the final circuitry in Fig. 5.

In this circuit, I have shown a two-transistor error amplifier (Q3 and Q4) which uses the 0 V line as its voltage reference, allowing us to delete the reference voltage circuit R4 and ZD1. In this circuit, Q4 is turned on by current flowing into its base through R8, Q2 and R10. This causes an amplified current to flow in Q4's collector circuit and turn on Q1. However, when the output voltage rises to a high enough level, the zener diodes ZD2 and ZD3 conduct and start feeding base current into Q3. This promptly gobbles up the current that was previously flowing into the base of Q4 and prevents the voltage from rising further.

The use of one or more zener diodes in a chain to provide the necessary output voltage — the actual output controlled voltage will be about 0V5 greater than the sum of the zener voltages — gives a simple system if one specific output voltage is required. However, zener

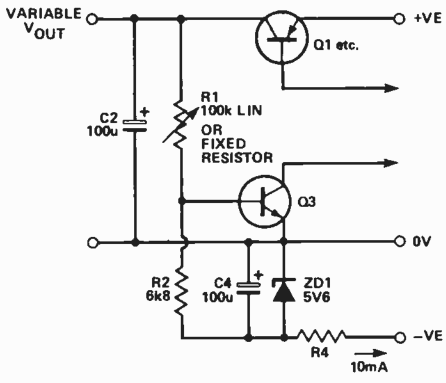


Fig. 6 This modification to the circuit of Fig. 5 allows a variable output voltage.

diodes are a bit noisy (especially if their individual breakdown voltages are high, which makes it preferable to use several lower voltage units in a string), so it may be advantageous to use the modified system shown in Fig. 6, if a convenient negative line is available, which would then allow the output voltage to be adjusted between 0V5 and some 3 V less than the available voltage.

Since the total amount of gain in the feedback circuit consisting of Q1, Q3 and Q4 is quite high, it is necessary to incorporate some HF stabilising element. In this case this function is performed by C3. The other part of the circuit, that of the 're-entrant' short circuit protection and current limiting action, is performed by Q2 with its associated resistors. The way this works is quite simple.

Assuming that there is no significant voltage drop across R8 and R5, Q2 will be turned on by current fed into its base by R9 (or R4 in Fig. 7), and an amplified current will be fed from the positive line into the base of Q4 via R5, R8, Q2 and R10. (R10 serves to limit the maximum current which can flow, and to reduce the amount of dissipation in Q2). The maximum forward bias potential which can be applied to Q2 is held to about 1V1 by the two forward biased diodes D1 and D2. So — if we try to take more current from the circuit than would produce a 0V6 drop across R5 then Q2 will lose its operating forward bias and no more current will be fed into Q4 or Q1, which will limit the possible output current to a level just a little less than this value.

However, this has ignored the contribution made by R7 and R8. If there is too much voltage across Q1, which, as we have seen above, would reduce its ability to handle large currents safely, part of this voltage will also appear across R8, and this will also tend to turn off Q2, or at least make it current-limit at lower levels of voltage drop across R5. This has the required effect of tying the output current limiting value to the voltage drop across Q1, and means that, under something approaching short-circuit conditions, only a much reduced output current will flow.

Using The Circuit

So, here we have a fairly

simple, low quiescent dissipation stabiliser circuit which uses standard discrete components and transistors, and which can be used to stabilise a single positive DC supply line (or if its 'mirror image' circuit is built, as in Fig. 7, a negative supply line too!) up to the maximum input voltages and currents which the components can stand. How, then, can we use this to improve an existing audio amplifier, which just uses a simple transformer-rectifier-reservoir capacitor system, as envisaged at the start of this article?

A single line stabilised supply is shown in Fig. 5 and a twin positive and negative supply is shown in Fig. 7: the DC output voltages and currents can be determined from the values shown in the tables. Now let us envisage a possible application. Measurement shows that on a hypothetical amplifier 'A', all of the internal DC supplies are drawn from a single power supply source which has a quiescent output voltage level of 66 V, dropping to 55 V on full load. If, at half load, which is the worst case condition, the heatsinks don't get alarmingly hot (as we must hope), and the HT line voltage is, shall we say, 60 V, then we could assume that a fixed voltage input supply somewhere between 60 and 65 V would not over-stress the amplifier components, and we could build this output voltage into the circuit of Fig. 5 by the use of an appropriate string of zener diodes.

Such a separate DC supply could then be housed in its own small box, with the DC feed being taken to the amplifier with which it is used. (This is assuming that there isn't room within the existing box for the larger, higher voltage transformer which will be needed, or for the other components.) What sort of benefits will this bring?

First, one would expect a significant reduction in the existing amplifier 'hum' level, if it is less than perfect in this respect. Second, one could expect an improvement both in the 'solidity' of the bass response, due to the lower LF dynamic impedance of the HT line in comparison with even a large value of supply line reservoir capacitor, and this should also give a lower level of LF channel crosstalk. This latter feature is also important because most of the crosstalk signal components are heavily distorted in typical transistor output stages. Third, one would obtain a greater immunity from consequential damage, such as loudspeaker units burning out if failure in the amplifier caused it to switch over to some unwanted high current mode; and finally, one would get more power output from it.

This last consequence arises from the fact that output power is determined by the equation $P = V^2/R$, where V^2 is the square of the RMS output signal voltage, and R is the loudspeaker load impedance. For a 30 W amplifier with an 8 ohm load and the HT supply voltage characteristic shown above, a change in full load HT voltage from 55 V to 65 V would give an increase in power from 30 to 45 W without the need for the replacement of any other components.

PCB Layouts

It makes a tidier and more professional looking unit if the necessary small components are mounted on a printed circuit board, so I have shown two such suitable layouts, complete with component overlay, in Figs. 8 and 9. The circumstances in which a PSU of this type might be used to upgrade an existing audio amplifier are rather too varied for anything other than general guidance to be given. However, these circuit layouts also allow the experimentally inclined user to build himself a useful short-circuit protected bench supply, which is literally a unit with dozens of uses.

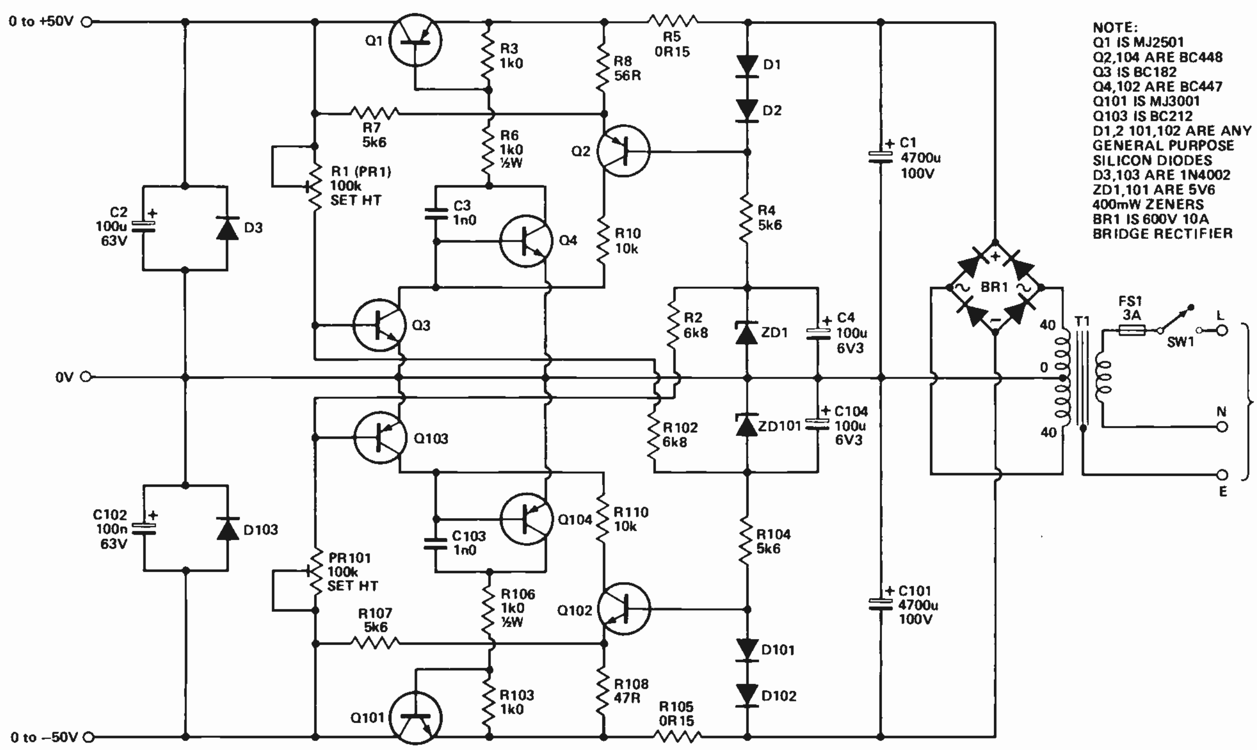
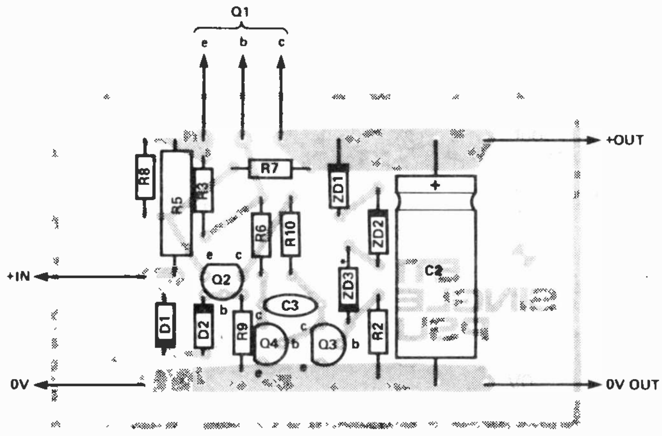


Fig. 7 Complete circuit for a twin stabilised power supply unit (current output 3 amps at 45 V).



* = OR LINK AS REQUIRED

Fig. 8 Overlay for the circuit of Fig. 5.

TABLE 1

Maximum output voltage	Transformer voltage (per winding)	C1 minimum working voltage	R8
30	25	40	56R
40	33	50	56R
50	40	63	47R
60	48	80	43R

TABLE 2

Output current (amps)	Transformer secondary current rating (amps per winding)	R5
0.5	0.7	1R0
1	1.5	0R5
2	3	0R25
3	4.5	0R15
4*	6	0R12

* (not recommended above 40 V)

PARTS LIST

Resistors (all ¼W, 5% except where stated)

R2	4k7
R3	1k0
R5	see Table 2
R6	1k0 ½W
R7	5k6
R8	see Table 1
R9	22k
R10	10k

Capacitors

C1	4700uF electrolytic (see Table 1 for working voltage)
C2	100uF 63 V axial electrolytic
C3	1n0 ceramic

Semiconductors

Q1	MJ2501
Q2	BC448 or BC640
Q3	BC182
Q4	BC447 or BC639
D1,2	general-purpose silicon diodes, eg 1N4148
ZD2,3,etc	zeners to suit (see text)

Miscellaneous
PCB (see Buylines); heatsink to suit.

See text for an explanation of the unusual component numbering.

BUYLINES

Two companies that can supply the transistors used in this project are Bradley Marshall, who advertise in this magazine, and Hart Electronics Ltd. of Oswestry, Shropshire. As a guide to price, Hart charge £1.50 plus VAT each for the MJ2501 and MJ3001, while the BC447 costs 20p plus VAT and the BC448 22p plus VAT. The PCBs can be obtained using the form on page 87.

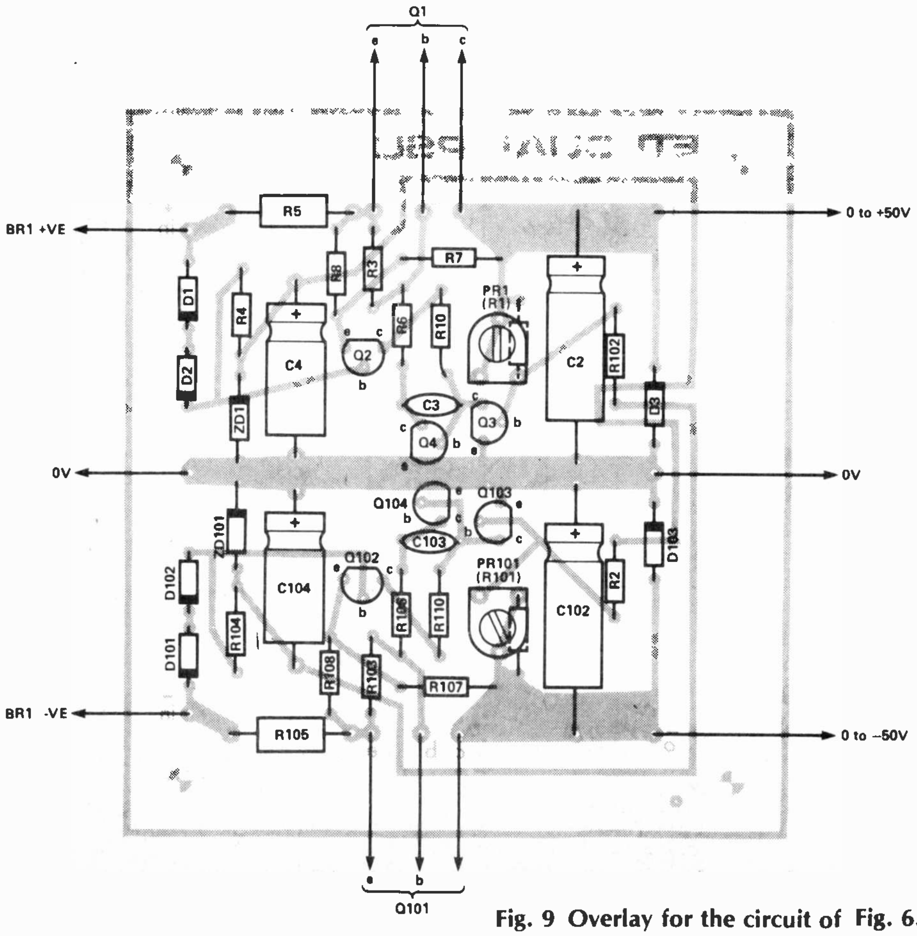


Fig. 9 Overlay for the circuit of Fig. 6.

PARTS LIST

Resistors (all ¼W, 5% except where stated)

R1,101 (PR1,101)	suitable fixed resistor or 100k miniature horizontal preset or off-board pot
R2,102	6k8
R3,103	1k0
R4,104,7,107	5k6
R5,105	see Table 2
R6,106	1k0 ½W
R8,108	see Table 1
R10,110	10k

Capacitors

C1,101	4700uF electrolytic (see Table 1 for working voltage)
C2,102	100uF 63 V axial electrolytic
C3,103	1n0 ceramic
C4,104	100uF 6V3 axial electrolytic

Semiconductors

Q1	MJ2501
Q2,104	BC448
Q3	BC182
Q4,102	BC447
Q101	MJ3001
Q103	BC212
D1,2,101,102	general purpose silicon diodes eg 1N4148
D3,103	1N4002
ZD1,101	5V6 400 mW zener
BR1	600 V, 10 A bridge rectifier

Miscellaneous
PCB (see Buylines); heatsink to suit; centre-tapped transformer (see Tables 1 and 2); mains switch; 3 amp fuse and fuseholder.

ETI

60W NDFL AMPLIFIER

Following last month's article on nested differentiating feedback loops, here is a practical amplifier design, presented as a module, with very low distortion. Design by Edward M. Cherry, Associate Professor, Dept of Electrical Engineering, Monash University.

This amplifier will perhaps be of most interest to home constructors who want to rebuild an existing system and upgrade its performance without the expense of new major components. The power output transistors employed are the well-known types MJ802 and MJ4502 which have been around for several years and have proved their reliability. Indeed, the whole design is mature and home constructors should have no difficulty in making it work.

The theoretical basis for this amplifier was discussed in last month's ETI.

Grounding

In any amplifier where the basic distortion has been reduced to a few parts per million, several distortion mechanisms not ordinarily considered may become significant. One such mechanism is associated with currents circulating in the ground leads and power-supply wiring.

Figure 1 explains the origin of this distortion. The current in each power transistor of a class B stage is a half-wave rectified version of the output. The two currents, drawn

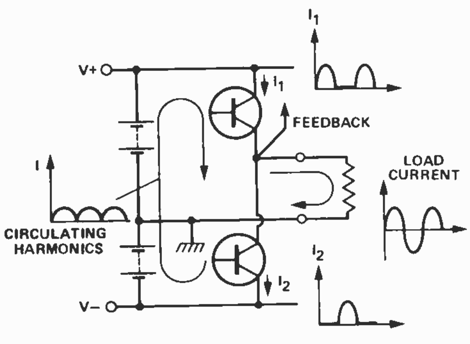


Fig. 1 Circulating even-harmonic current in a Class-B ouput stage.

HOW IT WORKS

Figure 2 is the complete circuit of one channel of the amplifier; equations referred to in the explanation refer to last month's feature. The circuit is clearly based on Fig. 10 (last month's ETI), with major parameters

$$1/\beta = 32.9$$
$$\tau_x = 800 \text{ nS}$$

The value of β is set by the overall feedback resistors R11 and R12 (470R and 15k — see Equation 1). τ_x is set by:

a) R4 and R5 (330R) plus C6 and C8 (68p) in conjunction with the chosen value of β (see Equation 13);

b) R15 and C7 (1k8 and 470p — see Equation 14);

c) R32 and C14 (8R2 and 100n) plus the 8 ohm nominal load and L3 (6u8 H);

d) R12 and C4 (15k and 33p) via the other constants in Equation 15.

The first stage requires little comment. Q1 and Q2 operate at 1.5 mA each, Q3 is a current source, Q4 is a common-base stage to equalise the quiescent voltages on Q1 and Q2; Q5 and Q6 constitute a current mirror. R1 and C2 form a 200 kHz low-pass filter against RF interference.

The Rush current amplifier operates at 3 mA, set by R18, and it incorporates a catching diode (D1) to accelerate recovery from overdrive. The pre-driver, Q10, operates at 8 mA; Q9 protects the stage against damagingly large currents under fault conditions. Driver quiescent current is 25 mA, set by R28.

Transistors Q12 and Q13 provide short-term protection for the power transistors. Short-circuit current is limited to about 4 A, and peak signal current is limited to 7 A. Long-term protection is provided by 2 A fuses in each supply rail; these should be 'ordinary' types, rather than delay or quick-blow. In the unlikely event of transistor failure, these fuses limit the loudspeaker current to 2 A, corresponding to 32 W into 8 ohms.

The common alternative of a single fuse in the loudspeaker lead is less satisfactory: it provides less protection for the amplifier; it provides less protection for the loudspeaker as the fuse must be rated to carry the full signal current, and it introduces distortion on large-amplitude, low-frequency signals.

LOW FREQUENCY COMPENSATION

A feature of Fig. 2 not discussed so far is a low-frequency compensating circuit, R13 and C5.

Amplifiers of the basic circuit topology of Fig. 2 (last month) have a group delay which is different for different signal frequencies. Some frequencies take longer or shorter times than others to pass through the amplifier. High-frequency group delay in NDFL amplifiers can be corrected, as described last month, by a small capacitor in the feedback network (see Equation 15). Errors in low-frequency group delay, in both Figures 2 and 10 (last month) are associated with the input coupling capacitor and the capacitor in series with R_{F1}. Low-frequency square-wave inputs are reproduced with a 'tilt' as in Fig. 3a.

One approach to this problem is to use a truly direct-coupled amplifier, with no capacitors in series with the signal path; commercial audio power amplifiers of this type appeared in the 1970s. Unfortunately, such amplifiers are prone to drift. A significant DC voltage may appear at the output even when there is no input. Although it is possible to reduce drift in a power amplifier to an acceptable level, it is not possible with today's technology to build a system that is truly direct-coupled from pick-up input, through the RIAA network and the power amplifier.

In the last few years a generation of amplifiers has appeared which include some form of servo amplifier to correct the drift. All circuits known to the author re-introduce the problem of group delay, albeit in a lesser form.

The approach adopted in the design is to retain the coupling capacitors and thereby eliminate drift, but include a group-delay correcting circuit. Figure 4 shows the outline. Group delay is optimally compensated if:

$$R_{F3} = 2\,R_{F2}\,, \qquad (16)$$
$$R_{F2}C_{F2} = R_{F1}C_{F1} \qquad (17)$$

Figure 3b shows the improvement in square-wave response.

Low-frequency group-delay compensation could well be included in audio power amplifiers and preamplifiers other than NDFL types.

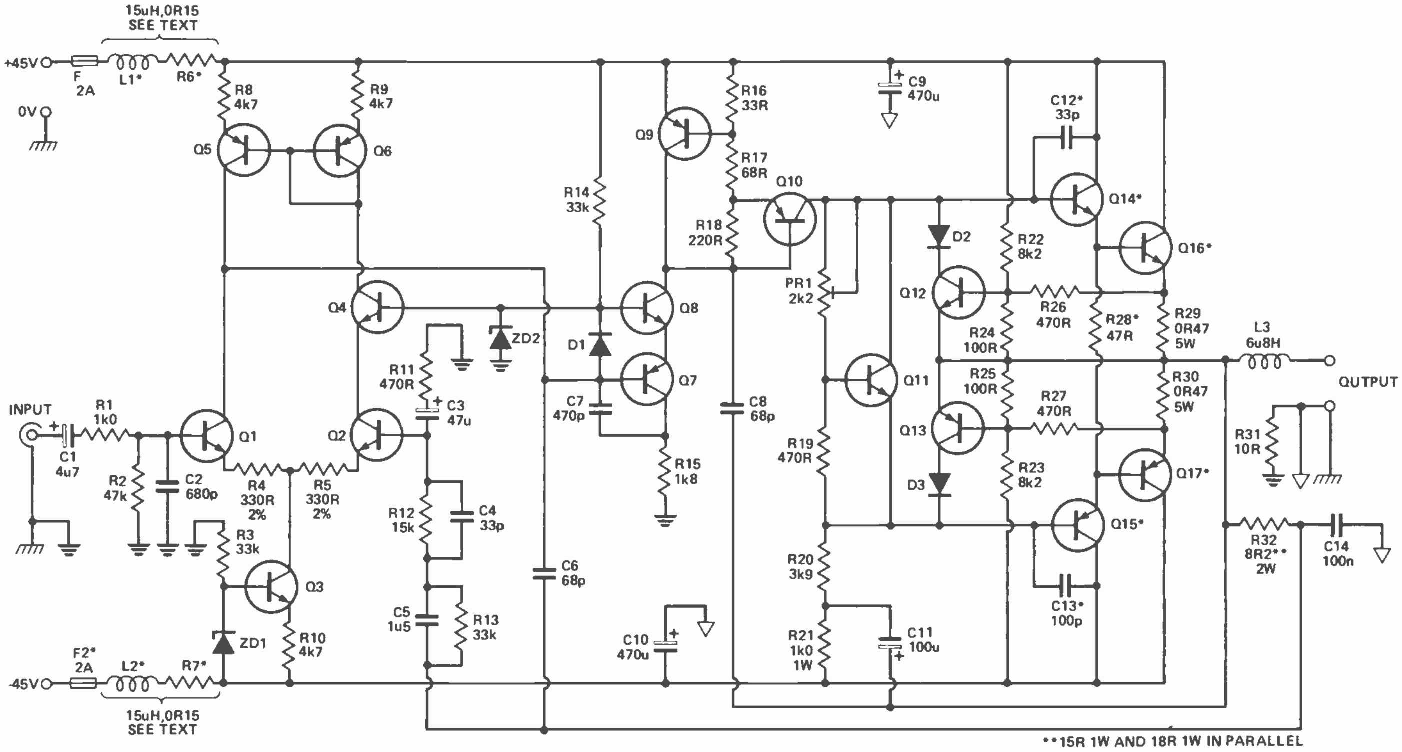


Fig. 2 Circuit diagram of the 60 W power amp. Components marked with a single asterisk are not mounted on the PCB.

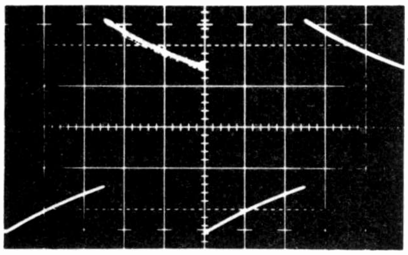


Fig. 3a Square wave response of the amp without group-delay compensation.

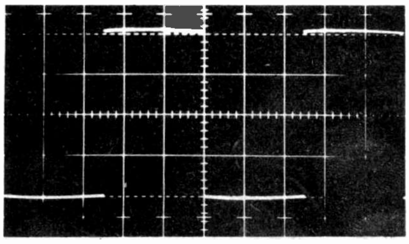


Fig. 3b Square wave response of the amp with group-delay compensation — note the improvement over Fig. 3a.

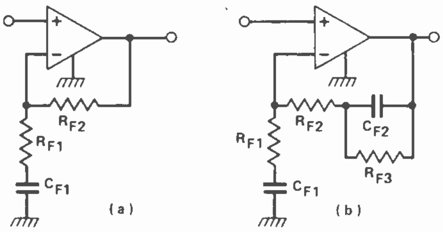


Fig. 4 Circuit for compensating low frequency group delay: (a) basic uncompensated circuit; (b) compensated circuit.

alternatively from the positive and negative supplies, are equivalent to a circulating full-wave rectified current and this is basically an even-harmonic distortion of the signal output. If there is any mutual inductance between the power-supply wiring (including the grounds) and the signal wiring (also including the grounds), then an even-harmonic distortion is induced in the amplifier and feedback is powerless to correct it.

The circuit board has been laid out so as to minimise this effect. The areas enclosed by some tracks are critical, and home constructors making their own PCBs are cautioned to follow the layout exactly; use the foil pattern on page 84, or, better still, purchase a ready made board.

Note that the circuit uses three distinct ground symbols.

a)  is the *quiet ground* track on the circuit board (one per channel).

b)  is the *noisy ground* track on the circuit board (one per channel).

c)  is the metal chassis ground (there are six connections to the chassis in total).

Each channel is connected to chassis ground at two points. The input socket is connected to the chassis (rather than insulated from it), the input lead from socket to circuit board is screened, and the quiet ground track is connected to chassis ground at the input socket via the screen. Similarly, the ground output terminal is screwed into the chassis, the leads from the circuit board to the output terminals are a twisted pair and the noisy ground track is connected to chassis ground at the output terminals via the ground output lead. The remaining two connections to chassis are in the power supply (Fig. 5).

Note that a 10 ohm resistor, R31, links the quiet and noisy ground tracks. This resistor is short circuited at low frequencies by the input screen and neutral output wiring to chassis ground. However, the resistor takes over at high frequencies where wiring inductance become significant.

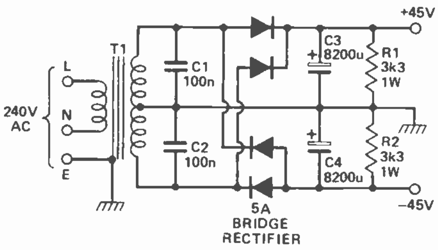


Fig. 5 Suggested PSU for the amplifier. Alternatively, see next month's ETI for a better choice.

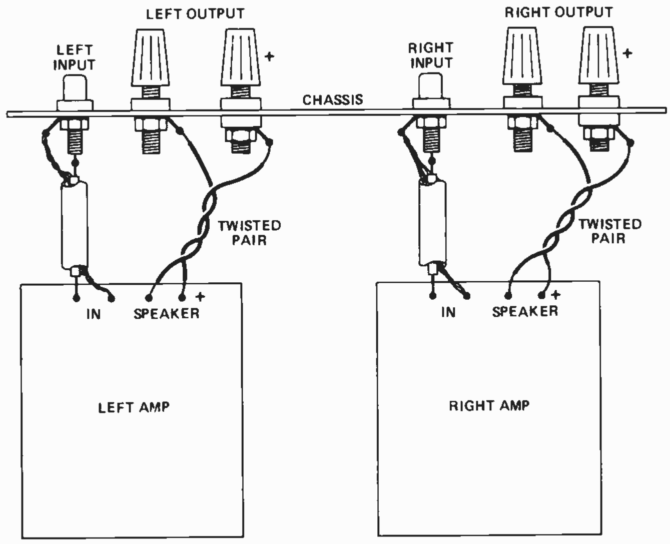


Fig. 6 Showing the general technique for connecting inputs, outputs and grounds to a stereo pair of modules.

The 15μH filter inductors in the supply rails are also for suppressing circulating currents (R6 and R7 represent the winding resistances of L1 and L2).

This amplifier employs only two nested differentiating feedback loops and its distortion is not down to the ultimate limit. The benefit of including the filter inductors is therefore marginal. The author is not blessed with 'golden ears' and cannot hear the effect of removing the filters, although the difference is clearly measurable. The filters should certainly be included in amplifiers that use three or more NDFLs. As the inductors must be home-made, and therefore cost nothing but time, and as they do make a measurable (if small) improvement, most home constructors will probably wish to include them. Winding data is given in Table 1.

The precise values of inductance and resistance are not important — ±50% is good enough — but do not use the 1.25 mm wire from L3 as something like 0.1 ohm series resistance is essential. For a similar reason, do not parallel the 470μF bypass capacitors C9 and C10 with high-frequency types. Brass or steel mounting screws are perfectly satisfactory for the filter inductors, as linearity is not important.

Critical Components

The majority of the components in this amplifier are not critical. Almost any small-signal diodes will do, such as the 1S44, 1N914, and 1N4148. Q1 and Q2 should be high-gain, low-noise types — BC109 and BC549 are among the cheapest available. The others could be almost any small signal types: BC107 and BC547 are readily available NPN types, the BC177 and BC557 are suitable PNPs. The driver and output transistors should be the types shown: BD139 and BD140 for the drivers, MJ802 and MJ4502 for the power transistors. The biasing transistor, Q11, could be any NPN in a TO-126 pack that can be mounted on the heatsink: the BD135 and BD139 are readily available types that would suit.

Unless the contrary is indicated on the Parts List, resistors can be standard ½W types and the capacitors can be the lowest available working voltage. A few components, however, do require special mention. A feedback amplifier cannot be more linear than its feedback network, so the various components that constitute the feedback network should have small voltage coefficients. Specifically:

a) The overall feedback resistors R11 and R12 should be high-stability types, such as metal oxide or metal film;
b) C4, C6 and C8 should be NPO ceramics, not high-K types (NPO means negative-positive zero, a low-K capacitor with a very low temperature coefficient; metallised plate ceramics, for example. Silvered mica capacitors are also suitable);
c) C5 and C14 should be polycarbonate, polystyrene or polypropylene types, but not polyester (eg mylar types);
d) C3 should be an ordinary cheap aluminium electrolytic, definitely not one of the relatively expensive resin-dipped tantalum types (this is not a misprint!).

TABLE 1

Formers
If a suitable type is not to hand, these may be turned from 25 mm diameter polystyrene rod to give 12 mm internal bobbin diameter with 7.5 mm winding space between cheeks.
Wire & Winding L1, 2
Take two 1680 mm lengths of 0.75 mm diameter enamelled copper wire and wind onto each former leaving 20 mm or so lead length at start and finish.
Wire & winding L3
Take a 1190 mm length of 1.25mm diameter enamelled copper wire and wind it onto the former. Leave 20 mm or so lead length at start and finish.

HARMONIC ANALYSIS AT 1 kHz

Harmonic	Rated output 21V9 60 W	- 20 dB 2V19 600 mW
2nd	19 ppm	5 ppm
3rd	14	3.5
4th	2.5	2.5
5th	3.0	1.5
6th	<1	<1
7th	1.8	1.8
8th	<1	<1
9th	1.0	<1
10th	1.8	<1

Notice how the harmonics drop away at small signal amplitude. In this regard a class-B NDFL amplifier is more like a conventional class-A amplifier than a class-B amplifier.
1 ppm = 0.0001%

HARMONIC ANALYSIS AT 6 kHz

Harmonic	Rated output 21V9 60 W	-20 dB 2V19 600 mW
2nd	115 ppm	40 ppm
3rd	100	25
4th	32	15
5th	40	9

Harmonics higher than the 3rd are ultrasonic and hence inaudible.

BUYLINES

Amongst the semiconductors, only Q16 (MJ802) and Q17 (MJ4502) could possibly present problems: these are both available from Bradley Marshall, Cricklewood and Technomatic.

Some care will be needed in ordering the capacitors mentioned as critical, though the types should not be that hard to find. The PCB is available through the ETI PCB service on page 87.

PATENT PROTECTION

The principle of nested differentiating feedback loops, on which this amplifier depends, is patented in Britain and principal overseas countries. Commercial enquiries should, in the first instance, be directed to the Legal Office, Monash University, Clayton, Victoria 3168, Australia.

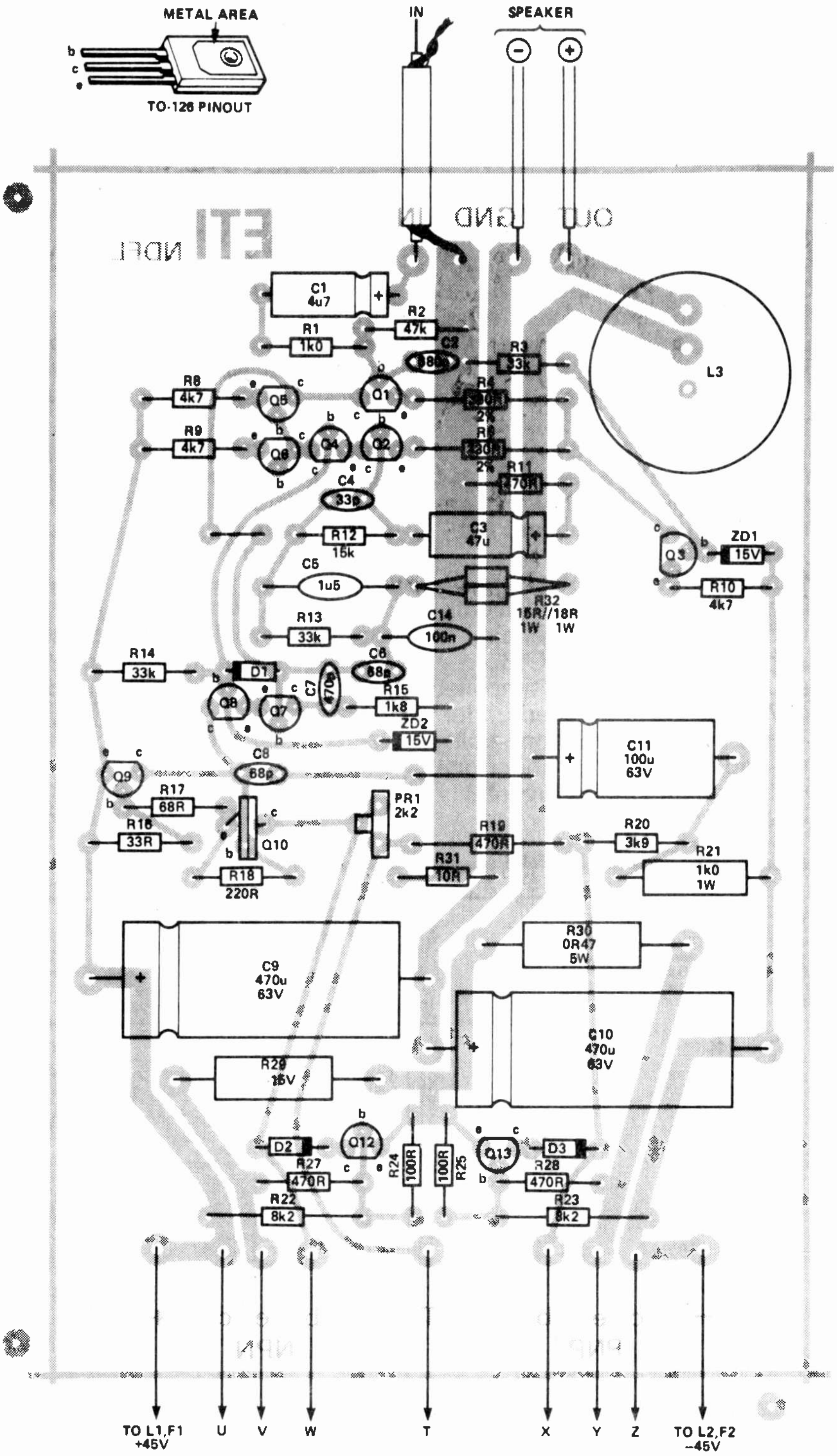


Fig. 7 Component overlay for the power amplifier.

PARTS LIST

Resistors (all ¼W, 5% except where stated)	
R1	1k0
R2	47k
R3,13,14	33k
R4,5	330R 2%
R6,7	see text
R8-10	4k7
R11	470R metal oxide or metal film
R12	15k metal oxide or metal film
R15	1k8
R16	33R
R17	68R
R18	220R
R19,26,27	470R
R20	3k9
R21	1k0, 1 W
R22,23	8k2
R24,25	100R
R28	47R
R29,30	0R47, 5 W
R31	10R
R32	8R2, 2 W or 15R//18R, each 1 W
Potentiometer	
PR1	2k2 miniature vertical preset
Capacitors	
C1	4u7 axial electrolytic
C2	680pF ceramic
C3	47uF axial electrolytic
C4	33pF 100 V NPO ceramic
C5	1u5 polycarbonate
C6,8	68pF 100 V NPO ceramic
C7	470pF ceramic
C9,10	470uF 63 V axial electrolytic
C11	100uF 63 V axial electrolytic
C12,13	33pF 100 V ceramic
C14	100nF 100 V polycarbonate
Inductors	
L1, 2	15uH (see text and Table 1)
L3	6u8 H (see Table 1)
Semiconductors	
Q1,2	BC109, BC549 etc
Q3,4,8,12	BC107, BC547 etc
Q5-7,9,13	BC177, BC557 etc
Q11,14	BD139
Q10,15	BD140
Q16	MJ802
Q17	MJ4502
D1-3	1N4148, 1N914, 1S44 etc
ZD1,2	15 V 400 mW zener
Miscellaneous	
F1,2	2 A standard fuse

PCB (see Buylines); one 4-way and one 5-way tagstrip; heatsink to suit (see text); PCB stakes; bobbins for inductors; wire, etc.

The 6u8 H inductor (L3) needs to be home-made. Winding data is given in Table 1. The bobbin should be mounted on the circuit board with a nylon screw; brass or steel must not be used, because of non-linear eddy current losses.

Construction

Assembly of the PCB is quite straightforward. It is probably best to commence by soldering all the resistors in place. Note that R32 could be either a 2 W type (not common) or two 1 W resistors (15R and 18R) in parallel. Note that the emitter ballast resistors of Q16 and Q17 (R29 and R30) should have very low inductance and if you have trouble with high frequency instability, these resistors are likely to be the culprit. The best solution may be several carbon resistors in parallel. Mount R29 and R30 a few millimetres above the board.

Assemble the diodes next, making sure you get them all the right way round. Install the links next. Follow with the capacitors. Note that C5 and C14 must be polycarbonate types and C4, 6 and 8 must be NPO ceramics. None of the other ceramic capacitors should be hi-K types, as mentioned earlier. When mounting C9 and C11, see that there is three or four millimetres between the capacitor body and the adjacent 5 W resistors (R29 and R30) to allow for

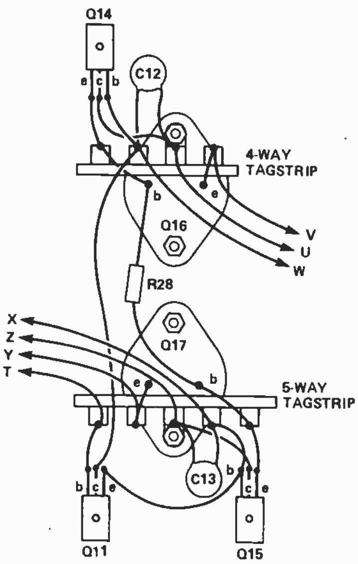


Fig. 8 Wiring diagram for the components mounted on the heatsink.

convection around the latter.

The transistors may be mounted now. See that each is oriented correctly. Wind L3 next and mount it on the board. Details are given in Table 1. It is not necessary to strictly follow the former dimensions given, but the inductance needs to be close to 6u8 H and wound from 1.25 mm wire at least, for low resistance.

Assembly of the components mounted to the heatsink comes next. The heatsinks in the original were a standard type sold by many companies and masquerading under such names as type 6W-1 (Maplin) or RS 401-807. Each heatsink has a thermal resistance to ambient of about 1°C/W, and other types could, of course, be substituted. The specified thermal resistance permits continuous operation at full power: smaller heatsinks (up to 2°C/W) could be substituted if the amplifier is to be used only for domestic sound reproduction. Use one heatsink per channel.

Three small components are mounted on the heatsink adjacent to the transistors to keep certain leads short: R28, C12 and C13. Construction is very much simplified if a 4-way tagstrip is installed under one of the collector mounting bolts of Q16 and a 5-way strip under one of Q17's mounting bolts. Figure 8 shows details.

The collector and emitter leads from each power transistor to the circuit board should be twisted. The base leads to Q14 and Q15 could be twisted in with the corresponding collector and emitter leads (although this is not necessary) and the base lead of Q11 can be kept separate. Note that all transistors must be insulated from the heatsink. Note also that the BD140 specified for Q10 needs its leads dressed to fit the board.

Quiescent current in the power transistors should be set to 40-60 mA by PR1. *Be warned* that this quiescent current is almost zero until PR1 is about three-quarters of its maximum resistance, after which the current increases very rapidly; be sure that PR1 is set to *minimum resistance* when the amplifier is turned on for the first time.

A convenient way to check the quiescent current is by means of the voltage drop across R29 and R30; this should be 40-60 mV (total) for zero signal input to the amplifier.

See the June ETI for details of a complete NDFL amplifier system. **ETI**

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2732 350ns	*D1*	5.45
2764 300ns	*D1*	5.99
4116 150ns	*D2*	0.85
4116 200ns	*D2*	0.80
4118 150ns	*D1*	3.25
5516 200ns	*D2*	9.45
6116 150ns	*D1*	3.30
6116 Low Power 150ns	*D2*	4.95
4164 150ns TI	*D3*	4.45
4164 200ns TI	*D3*	3.95
4164 150ns Mostek	*D3*	4.45
4516/4816 100ns	*D2*	2.25
4532 200ns	*D2*	2.95

6800 FAMILY

6800	*D7*	2.25
6802	*D5*	2.50
6809	*D6*	6.30
6810	*D1*	1.15
6821	*D3*	1.00
6840	*D4*	3.75
6845	*D5*	6.50
6850	*D2*	1.10
68488	*D2*	7.30
68B00	*D7*	5.25
68B09	*D6*	12.00
68B10	*D1*	2.26
68B21	*D3*	2.20
68B40	*D4*	6.00
68B50	*D2*	2.20

Z80 FAMILY

Z80ACPU	*D2*	2.99
Z80BCPU	*D2*	9.00
Z80ACTC	*D1*	2.60
Z80BCTC	*D1*	9.00
Z80ADART	*D1*	5.50
Z80ADMA	*D2*	6.95
Z80AP10	*D1*	2.75
Z80BP10	*D1*	9.00
Z80AS10	*D4*	9.00

8080 FAMILY

8085A	*D4*	3.50
8212		1.10
8216		1.00
8224		2.10
8228		3.27
8251A	*D5*	2.50
8253		4.00
8255A	*D5*	2.25

6500 FAMILY

6502	*D3*	3.25
6502A	*D3*	5.00
6520	*D1*	2.50
6520A	*D1*	3.16
6522	*D5*	3.19
6522A	*D5*	5.50
6532	*D2*	5.50

FLOPPY DISC CONTROLLERS

8271		36.00
FD1771	*D5*	15.00
FD1791	*D6*	22.00
FD1793	*D6*	23.00
FD1795	*D6*	28.00
FD1797	*D6*	28.00
W01691	*D2*	12.00
WD2143-01	*D2*	6.99

INTERFACE DEVICES

6402	3.80
75107	0.47
75110	0.56
75150	0.64
75154	0.77
75160	2.56
75161	2.80
75162	3.95
75172	1.95
75173	1.44
75174	1.95
75175	1.44
75182	0.50
75183	0.50
75188	0.37
75189	0.37
75451	0.22
75452	0.22
75453	0.22
75454	0.22
75468	0.88
75491	0.31
75492	0.42
AY31015 *D2*	3.00
AY31270	6.47
AY38910 *D6*	4.40
AY53600 *D2*	6.70
DP8304 *D1*	2.50
MC1488 *D1*	0.37
MC1489 *D1*	0.37
MC3242A	6.30
MC3446 *D1*	2.50
MC3448A *D1*	3.75
MC3480 *D5*	7.30
MC3487 *D1*	2.00
MC14411 *D1*	7.65
MC14412	9.45
R03251 3L *D1*	6.50
R032513U *D1*	6.50

UHF MODULATORS

UM1111 6MHz	*D1*	2.60
UM1233 8MHz	*D1*	3.90

BUFFERS

81LS95	0.80
81LS96	0.80
81LS97	0.80
81LS98	0.80
8T26A	0.90
8T28A	0.90
8T95	0.90
8T97A	0.90
8T98	0.90

LINEARS

L203	0.65
LF398N	4.75
LM301AN	0.24
LM308N	0.48
LM311P	0.50
LM319N	1.99
LM324N	0.30
LM348N	0.60
NE555P	0.16
NE556CP	0.45
TL010	0.39
TL011	0.32
TL012	0.34
TL014	0.36
TL021	0.34
TL061	0.29
TL062	0.49
TL064	0.98
TL066	0.29
TL068	0.32
TL071	0.29
TL072	0.47
TL074	1.00
TL081	0.26
TL082	0.46
TL084	1.58
TL091	0.40
TL092	0.58
TL094	1.34
TL487	0.62
TL489	0.62
TL494	1.63
TL496	0.60
TL507	1.33
725	1.80
741	0.14
747	0.48
748	0.27

REGULATORS

78L05	0.30
78L12	0.30
78L15	0.30
7805	0.40
7812	0.40
7815	0.40
7905	0.45
7912	0.45
7915	0.45
LM309K	1.20
LM317K	2.40
LM323K	4.50
LM338K	6.25

DATA CONVERTERS

UPD7002	*D1*	4.26
ZN425	*D1*	3.45
ZN426	*D1*	3.00
ZN427	*D1*	5.99
ZN428	*D1*	4.75
ZN429	*D1*	2.10
ZN432	*D1*	13.00
ZN449	*D1*	2.55

CRYSTALS

1M	2.75
1.008M	2.75
1.8432M	1.92
2.4576M	2.00
3.6864M	1.86
4M	0.64
6M	0.86
8M	0.86
9.8304	1.68
19.6608	2.48

DIL SOCKETS (TEXAS)

PINS	TIN	GOLD	WW
8	7	16	25
14	10	26	35
16	10	29	40
18	13	33	50
20	15	37	60
22	17	38	65
24	21	46	70
28	24	55	80
40	30	76	99

ZIF SOCKETS (TEXTOOL)

24 pin	5.75
28 pin	8.20
40 pin	9.75

CMOS 4000

4000	0.10
4001	0.10
4002	0.12
4006	0.42
4007	0.14
4008	0.32
4009	0.24
4010	0.24
4011	0.10
4012	0.16
4013	0.20
4014	0.40
4015	0.36
4016	0.20
4017	0.32
4018	0.36
4019	0.36
4020	0.36
4021	0.40
4022	0.40
4023	0.13
4024	0.32
4025	0.13
4026	0.74
4027	0.20
4028	0.32
4031	0.94
4033	1.80
4034	0.94
4035	0.38
4040	0.36
4041	0.36
4042	0.34
4043	0.36
4044	0.36
4045	1.35
4046	0.42
4047	0.70
4048	0.36
4049	0.23
4050	0.23
4051	0.38
4052	0.44
4053	0.44
4054	0.85
4055	0.85
4060	0.39
4063	0.85
4066	0.24
4068	0.14
4069	0.14
4070	0.13
4071	0.13
4072	0.13
4073	0.14
4075	0.13
4076	0.43
4077	0.13
4078	0.15
4081	0.13
4082	0.13
4085	0.50
4086	0.44
4093	0.20
4502	0.46
4507	0.32
4508	0.96
4510	0.40
4511	0.41
4512	0.40
4514	0.96
4515	0.96
4516	0.40
4518	0.40
4519	0.27
4520	0.40
4521	0.90
4522	0.52
4526	0.52
4527	0.52
4528	0.41
4532	0.72
4541	0.50
4543	0.50
4553	1.57
4555	0.35
4556	0.35
4585	0.75

74LS SERIES

00	0.11
01	0.11
02	0.11
03	0.12
04	0.12
05	0.12
08	0.12
09	0.12
10	0.12
11	0.12
12	0.12
13	0.12
14	0.25
15	0.12
20	0.12
21	0.12
22	0.12
26	0.12
27	0.12
28	0.12
30	0.12
32	0.12
33	0.12
37	0.12
40	0.12
42	0.28
47	0.35
48	0.45
49	0.12
51	0.12
54	0.12
55	0.12
73	0.18
74	0.16
75	0.18
76A	0.17
78A	0.18
83A	0.36
85	0.42
86	0.16
90	0.22
91	0.60
92	0.32
93	0.22
95B	0.40
109A	0.27
112A	0.20
113A	0.20
114A	0.22
122	0.28
123	0.34
125A	0.24
126A	0.25
132	0.34
136	0.25
138	0.25
139	0.27
145	0.57
148	0.70
151	0.40
153	0.40
155	0.30
156	0.35
157	0.25
158	0.30
160A	0.32
161A	0.35
162A	0.35
163A	0.35
164	0.40
165A	0.50
166A	0.60
173A	0.55
174	0.40
175	0.38
181	0.90
190	0.35
191	0.35
192	0.35
193	0.35
194A	0.35
195A	0.35
196	0.45
197	0.45
221	0.46
240	0.55
241	0.55
242	0.55
243	0.55
244	0.55
245	0.70
248	0.55
249	0.55
251	0.30
253	0.35
257A	0.30
258A	0.35
259	0.55
261	1.00
266	0.20
273	0.54
279	0.30
283	0.40
290	0.39
293	0.39
365	0.27
366	0.27
367	0.27
368	0.27
373	0.62
374	0.62
375	0.35
377	0.60
378	0.60
379	0.90
386	0.35
390	0.45
393	0.45

DIL JUMPERS

Single Ended 24"

14 PIN	1.45
16 PIN	1.65
24 PIN	2.40
40 PIN	3.80

Double Ended

	6"	12"	18"
14 PIN	1.85	1.98	2.42
16 PIN	2.05	2.15	2.68
24 PIN	3.00	3.15	3.96
40 PIN	4.65	4.90	6.18

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10 PIN	0.86
14 PIN	1.22
16 PIN	1.34
20 PIN	1.46
26 PIN	1.76
34 PIN	2.06
40 PIN	2.32
50 PIN	2.35
60 PIN	3.20

IDC SOCKETS
Fitted with 36" cable

10 PIN	1.40
14 PIN	1.82
16 PIN	2.10
20 PIN	2.46
26 PIN	3.24
34 PIN	3.80
40 PIN	4.90
50 PIN	5.48
60 PIN	6.38

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COMPRESSOR/ LIMITER

When it comes to compressing those troublesome signals that are prone to overload, this ETI project really is the limit! Design by Ian Martin B.Sc.

Compressors and limiters have many uses in professional recording and broadcasting, and they can also be pretty useful to the amateur. Perhaps the single most important use is for overload protection: the limiter is set up so as to remain inactive until a signal occurs which would overload following circuits (perhaps a radio transmitter or power amplifier), at which point gain reduction cuts in and, without being very noticeable about it, the unit prevents blown fuses, gross distortion or worse.

The circuit described here has been designed to be capable of both the compressing and limiting actions — it all depends on the signal size you apply and the gains you set in the circuit. With the component values shown, the specification of this unit is very similar to devices currently in use in stereo radio broadcasting in the UK.

On The Attack

In this circuit the attack has been made very fast indeed, the time constant being 220 microseconds: hence the time taken for the limiter to react fully to an

HOW IT WORKS

The left and right channels of the unit are identical, so this description will be confined to the left-hand channel.

IC1 forms a buffer, and its gain is adjustable by PR1 so that it can be used to set the input sensitivity. The variable gain cell is made up from IC2 and IC7a and their associated components. The configuration used is slightly unusual: IC2 forms a conventional inverting amplifier, its gain being determined by R_{FB}/R_{IN} in the usual way. However, while R_{IN} is simply R2, R_{FB} is made up from R4 and IC7a which, as an operational transconductance amplifier, can be used as a current-controlled resistor. With the addition of a voltage-to-current converter to drive the control input of the LM13600, a complete VCA is formed which will produce a gain inversely proportional to the control voltage.

The first stage of the gain-control side chain is a full-wave rectifier made up from IC3a and IC6a. Q1 boosts the output current drive capability of the rectifier in order to produce a fast attack characteristic when charging C11.

From C11 onwards until the final voltage-to-current converters for the VCA, the two side chains are combined into one channel, the highest of the left or right input signals being registered on C11. In this way stereo ganging is achieved, and this prevents the stereo image from wandering from side to side during gain reduction (if the overload signal is in one channel only). The adjustment of the decay time and limiting threshold for both left and right channels is achieved easily and equally by R32 and PR5. IC8b is used as a high impedance buffer for the control voltage held on C11, which is discharged by R31. The output of this buffer is fed to PR5, which controls the side chain gain and hence the limiting threshold.

The only problem with the particular VCA configuration chosen is that should the control voltage (and hence control current being fed to IC7a) fall to zero, the gain of the VCA will increase to the open-loop gain of IC2, probably resulting in the VCA output reaching one of the supply rails (as is usually the case when an IC amplifier loses its feedback). In order to prevent this from happening, the control voltage V_C is prevented from going below 0V5 by zener ZD1 and preset PR6. Thus the higher of either V_{MIN} or the output of PR5 is passed via D11 or D12 to the law-shaping amplifier IC8a.

The diode D13 and resistors R35, 36 are configured to make up for the voltage drop across D11 and D12, and maintain a tight compression ratio, typically 10:1. The output of the shaping amplifier provides a low source impedance to drive the voltage-to-current converter IC9a and Q3 (note that the left and right channels split again at this point).

TABLE 1

Measured performance of the prototype.

Gain:	0 dB (adjustable)
Bandwidth (3 dB points):	10 Hz and 30 kHz approximately
Input impedance:	22k
Output impedance:	100R
Limiting threshold:	0 dB (adjustable)
Compression ratio for signals exceeding the threshold:	10:1

Crosstalk with non-speaking channel terminated with 600R (left-to-right or right-to-left):

100 Hz	1 kHz	10 kHz	20 kHz
−70 dB	−70 dB	−68 dB	−65 dB

Noise with input terminated as above: −70 dB
(this is the gain required to make noise at the output peak to 0 dB on a standard broadcast peak program meter, ie this is the peak noise. Should a measurement be made with an RMS reading meter, this measurement may improve by as much as 6 dB).

Control voltage breakthrough onto non-speaking channel with 20 dB of gain reduction occurring on the other channel:

100 Hz	1 kHz
−68 dB	−68 dB

Tracking between channels during gain reduction: better than 0.3 dB

Distortion at 1 kHz:

Input	Output	Distortion
−8 dB	−8 dB	−66 dB
0 dB	−1 dB	−60 dB
+10 dB	0 dB	−58 dB

Distortion at 100 Hz:

Input	Output	Distortion
−8 dB	−8 dB	−58 dB
0 dB	−1 dB	−45 dB
+10 dB	0 dB	−38 dB

NB. These figures for 100 Hz distortion were measured with a recovery time constant of 100 milliseconds (total recovery time approximately 220 milliseconds), hence a certain amount of distortion due to the compression of individual waveforms is to be expected. Increasing the recovery time constant as in the final design will improve the low frequency distortion measurements, until for long recovery times (greater than 3 seconds) they will approach the values obtained for 1 kHz.

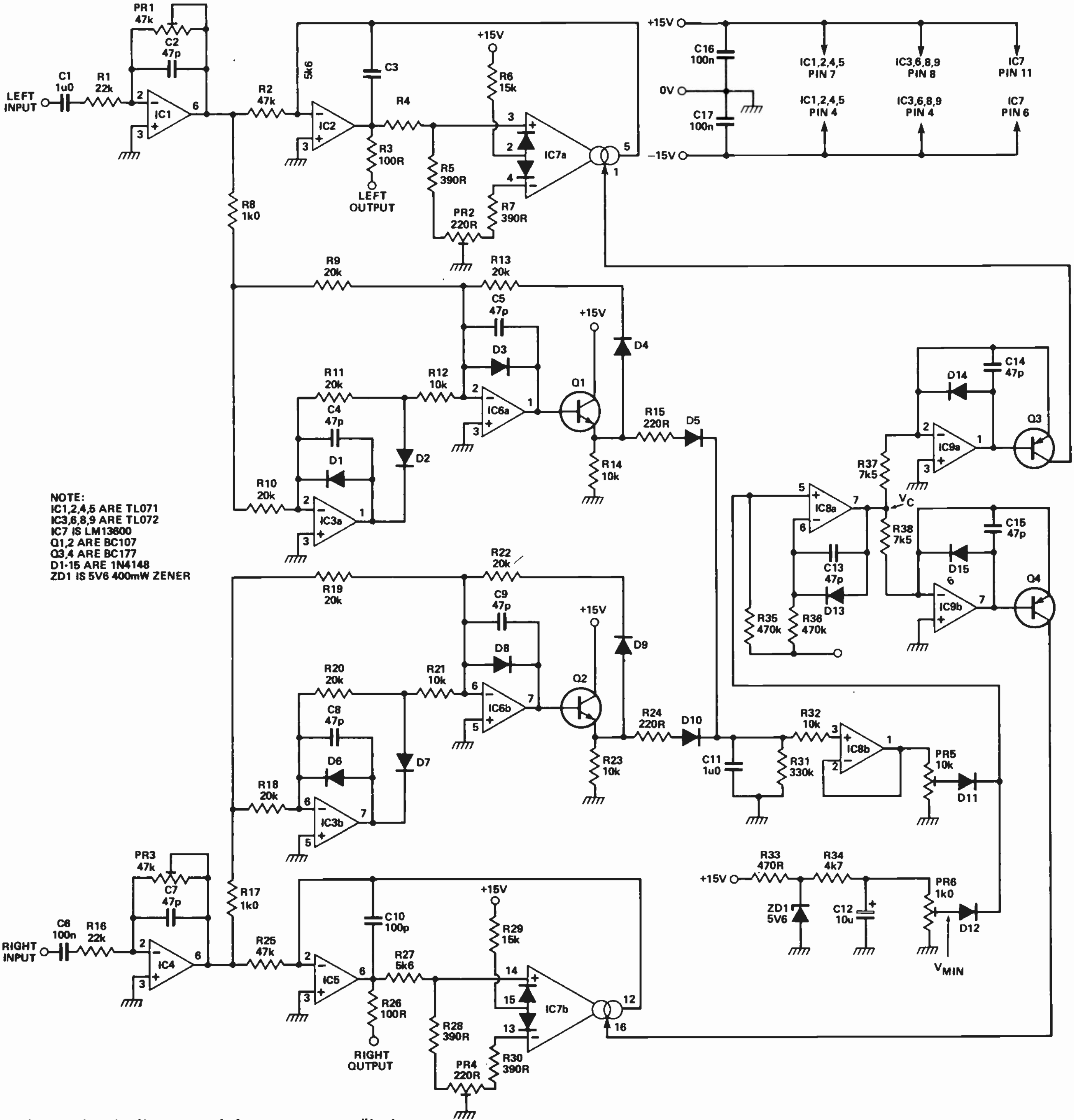


Fig. 1 Circuit diagram of the compressor/limiter.

overload above the limiting threshold is approximately 500 microseconds. The decay time was chosen to be 330 milliseconds; hence full recovery takes place approximately 700 milliseconds after the overload has been removed from the input. This recovery time was chosen after much subjective assessment, and is the fastest possible without undue distortion of low frequencies (this being a common problem in all compressor/limiters). However, as this is a simple one-resistor adjustment it is easy to experiment and find the best compromise for different uses.

Shaping Up

The need for the shaping amplifier built around IC8a arises because the side chain is, like most professional designs, an open loop system deriving its input from the incoming programme material and not from the VCA output. This has the advantage that the limiting threshold and other dynamic characteristics may be altered easily and, if desired, other functions may be included. For example, de-essing could be implemented, where a treble boost in the side chain would lead to the gain reduction of high-energy, high-frequency sounds such as sibilants. It would also be possible to build a feedforward or overshoot limiter, by including a suitable delay

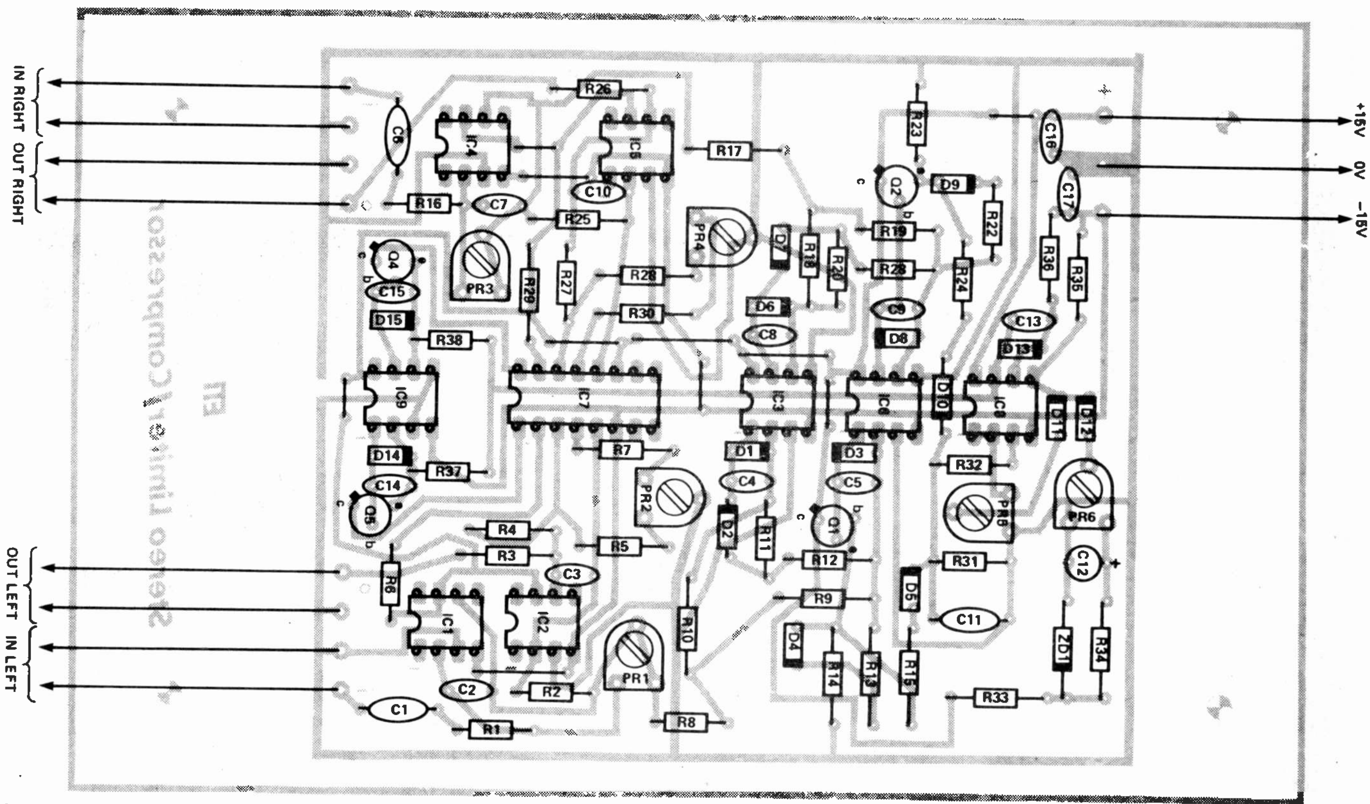


Fig. 2 Component overlay for the unit.

line in the main chain before the VCA. In this way gain reduction would take place before the programme material reached the VCA via the delay line and even the sharpest transient would be prevented from exceeding the limiting threshold at the output. However, in most applications this is not necessary, except in cases such as disc-cutting or radio broadcasting where an overload of even the shortest duration would have dire results.

The setting up procedure is very simple indeed. PR6 should be adjusted so that V_C is held at 0V5 with no input signal. PR1 and PR3 should then be adjusted to give the required gain from each channel (usually 0 dB). That concludes the static setting-up, except for PR2 and PR4 which should be adjusted for zero offset at the output of the VCA. This ensures minimal control voltage breakthrough onto the audio output during gain reduction.

To set the compression threshold, a high level signal (for example, +10 dB) should be applied to the input, and PR5 adjusted to give 0 dB at the limiter output.

If the above sequence is followed, the limiter will act as a normal unity-gain amplifier for all signals below 0 dB, and will reduce the gain of all signals above this threshold such that the output at no time exceeds 0 dB. Should the limiting threshold need to be reduced to, say, −10 dB to be more compatible with domestic equipment, then all that is required is an increase in the gain of the side channel by that amount. This is easily achieved by increasing R13 and R22 from 20k to, say, 47k. Should an indication of gain reduction be required, this is easily provided by buffering off V_C, the control voltage, by 1k0 or so to prevent any fault on the metering equipment affecting the operation of the limiter (for my own unit this metering equipment consists of a simple bargraph driver and LEDs).

PARTS LIST

Resistors (all ¼W, 5%)

R1,16	22k
R2,25	47k
R3,26	100R
R4,27	5k6
R5,7,28,30	390R
R6,29	15k
R8,17	1k0
R9-11,13, 18-20,22	20k
R12,14,21, 23,32	10k
R15,24	220R
R31	330k
R33	470R
R34	4k7
R35,36	470k
R37,38	7k5

Potentiometers

PR1,3	47k miniature horizontal preset
PR2,4	220R miniature horizontal preset
PR5	10k miniature horizontal preset
PR6	1k0 miniature horizontal preset

Capacitors

C1,6,11	1u0 polycarbonate
C2,4,5,7-9, 13-15	47pF ceramic
C3,10	100pF ceramic
C12	10uF 16 V tantalum
C16,17	100nF polycarbonate or ceramic

Semiconductors

IC1,2,4,5	TL071
IC3,6,8,9	TL072
IC7	LM13600
Q1,2	BC107
Q3,4	BC177
D1-15	1N4148
ZD1	5V6 400 mW zener

Miscellaneous

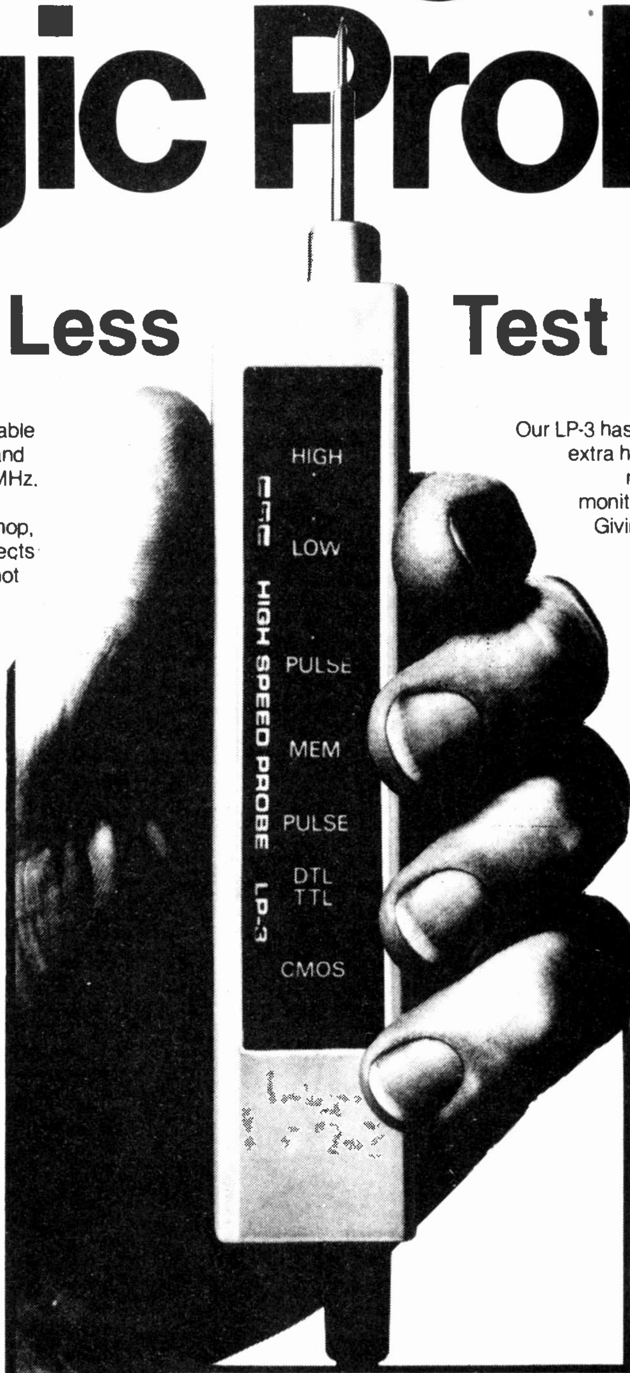
PCB (see Buylines); screened cable etc.

BUYLINES

Although the design of this project results in top-notch performance, it uses components that are readily available and you should be able to find everything in the adverts in this issue. The PCB can be purchased from us using the order form on page 87.

ETI

The Logic Probes



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Model LP 3 illustrated

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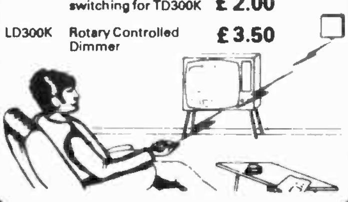

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PACK 3	60 Polyester Capacitors 0.01 to 1µF/250V — 5 per value £5.55
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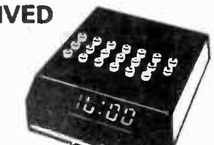

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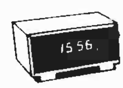

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BALANCED INPUT PREAMP

This versatile little preamp has a host of applications in the audio-and-beyond range, not the least of which would be as a balanced mike preamp. Design by David Tilbrook.

Many transducers require a balanced or differential preamplifier rather than the simpler single input unbalanced type. Balanced microphones, for example, require a balanced preamplifier to ensure minimal susceptibility to extraneous noise sources. The concept in the balanced approach is fairly simple: the microphone, for example, is connected to the balanced preamp using three wires instead of two. Two of these wires carry signals and the other is a ground connection. The balanced source, in this case a microphone, generates a signal voltage on the two signal wires such that one of the signals is 180 degrees out of phase with the other. The two active lines are twisted together with the earth line, or a two-wire shielded cable is used to connect the mike to the preamplifier.

In this way any external noise or hum source will affect both inputs equally, producing a signal that is in phase on both of the signal wires. Such a signal is called a *common mode* signal. The balanced preamplifier however, is configured in such a way as to amplify only a differential signal. The preamp produces an output signal that is proportional to the difference between its two inputs. Since the signal is generated out of phase, it is amplified. The noise source, however, is a common signal and is the same in both input wires. The difference between the noise signals on each of the input wires is therefore zero, and is not amplified. With this technique small signals can be sent over long lines, an otherwise impossible task due to the susceptibility of these lines to mains hum in particular.

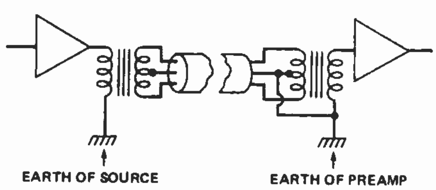

Fig. 1 Balanced line with transformer coupling.

SPECIFICATIONS

Frequency response (10k load):	12 Hz — 60 kHz ±0.1 dB
THD (at 5 V RMS output):	<0.007% at 100 Hz <0.006% at 1 kHz <0.012% at 10 kHz

Distortion figures can be expected to decrease further at more realistic signal levels but become difficult to measure.

Total equivalent input noise: (20 kHz bandwidth)	—124 dB (approx)
Input impedance:	Nominally 560 ohms to ground from each input.
Output impedance:	Nominally 260 ohms.
Common mode rejection ratio:	Depends on calibration but easily adjusted to 80 dB.

A Transformation

In audio the most common method employed to implement a balanced line is with transformers. The basic approach is shown in Fig. 1. The source may be a microphone or a small preamplifier inside the microphone, or simply the output from a mixer or other electronic device. This is connected to the input of a balancing transformer that is wound to represent the correct load to the driving stage. The output of this transformer consists usually of a bifilar-wound secondary connected as shown in Fig. 1. A similar transformer is used at the other end of the line to convert the differential signal back into one that can be amplified by the single input preamp.

This technique has the advantage that the signal earth of the source need not be connected to that of the preamplifier. This can be a *very* useful feature at times, particularly when large numbers of cables are connected together at a common point such as at a mixing console. The ability to isolate the input earths of the various inputs enables complete freedom from hum loops, which otherwise can become almost impossible to remove.

Transformers have disadvantages, however. First, good ones are expensive as they must be carefully wound and shielded from external hum fields. Since the transformer is a coil of wire, wound specifically for good response over the complete audio spectrum, they are particularly susceptible to magnetic fields produced by power transformers and so on. The problems associated with isolating the transformers from power supply hum fields can be very real, if not impossible in some instances.

It is often said that a transformer's ability to reject a common mode signal is inferior to that of a balanced preamplifier such as the one to be described in this project. Although this is true it is largely irrelevant, since the limit to common mode rejection is usually set by the shielded cable used to connect the input devices. Even the best quality cables seldom allow common mode rejections greatly in excess of 60 dB, a figure which is easily surpassed by most input transformers. The main advantage of differential preamps over transformers is cost and relative lack of susceptibility to hum fields. This makes it substantially easier to mount the preamp within the equipment to avoid degradation of the signal-to-noise ratio by hum pickup. Another advantage of the preamp over transformers is that even the best transformers generate significant amounts of harmonic distortion in comparison to distortion figures easily obtained with an op-amp based balanced design.

Construction

Construction of the unit is straightforward if the ETI PCB is used, since all components are mounted on the board. The usual precautions should be taken. The circuit employs several electrolytic capacitors so be certain these and the diodes and ICs are inserted with the correct orientation. The circuit is shown to run from a nominal ±20 V supply. This ensures a clean ±15 V supply to the op-amps giving the circuit good headroom. If this voltage is not available, however, the circuit will run perfectly well on a lower supply voltage. If the supply is clean regulated DC the on-board zeners can be eliminated. If not, replace them with a lower voltage type to suit the supply voltage.

Close tolerance resistors (1% or 2%) are specified for R6, 7, 8 and 9 so that any DC inbalance between the input stages, IC1 and IC2, can be balanced out by PR1.

It is a good idea to use low noise metal oxide resistors for the input resistors, R3 and R4, to get good noise performance. They cost little more than standard carbon deposition types. Indeed, metal oxide resistors could well be used

DESIGN THEORY

The differential input needed is easy to implement with the help of operational amplifiers, since these have inverting and non-inverting inputs already. The simplest circuit that could be used and one that is adequate with microphones is shown in Fig. 2. This circuit is the standard differential op-amp circuit and offers good performance with most balanced sources. The resistor from the non-inverting input to ground is made the same value as the feedback resistor. In this way the gain of the stage is determined by the ratio of the resistors R2/R1. With the inverting input grounded, the gain of the op-amp is given by the standard formula

$$(R2 + R1)/R1.$$

In this case, however, the input resistor in series with the non-inverting input and the resistor from this input to ground form a potential divider and attenuate the signal by an amount given by:

$$V_i = V\ (R2/(R1 + R2))$$

So the total gain of the stage at the con-inverting input is

$$((R2 + R1)/R1)(R2/(R1 + R2))$$

or R2/R1, which is the same as the inverting input.

This circuit, however, has the disadvantage that the impedance to earth from each of the two inputs is very different. The impedance at the non-inverting input can usually be regarded as approximated by the series combination of the two resistors, ie R1 + R2. The impedance at the inverting input is simply that of the input resistor, since the inverting input is a virtual earth once feedback is applied in this way. This does not bother most balanced sources, since a true balanced source works independently of the ground connection.

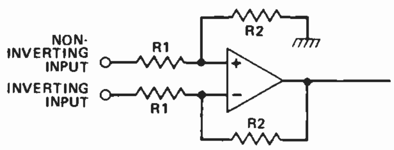

Fig. 2 Preamp stage with a simply-balanced input.

The impedance seen by the balanced source is a result of that due to both input resistors and the internal impedance from base to base of the input differential pair within the op-amp. In most circuits the resistance of the input resistors completely dominates and it is sufficiently accurate to quote the input impedance to balanced sources as 2 × R1.

A major disadvantage of this circuit is that the ability to reject common mode signals can be seriously degraded with some sources by differences in the source impedance to the two inputs. Remember that it is the matching of the two sets of resistors that determines the common mode rejection ratio. This is the ratio of the input signal to the output signal when a common mode signal is applied. It is usually quoted in dB. The value quoted earlier for shielded cables of around 60 dB is a relatively easy figure to obtain with the op-amp circuit so long as the driving source impedance is the same for both inputs. A mismatch of only one per cent will degrade the common mode rejection ratio(CMRR) of an otherwise well designed preamp by around 20 dB, and result in a figure that could easily be unsatisfactory.

Another disadvantage of this circuit is that it is not capable of delivering the full gain needed of the preamplifier and still give satisfactory distortion figures. If we take a nominal output signal level from a balanced microphone to be around 0.2 mV and the required output from the preamp to be around 100 mV, then a gain of 500 is required, or around 54 dB. The distortion figure obtained using the best op-amps available would be unsatisfactory. For example, an NE5534A at a gain of 500 would have a distortion figure around 0.15%, a poor figure by modern standards and well outside the capabilities of a good transformer. The solution is simply to decrease the gain of the stage and add a second stage to make up the difference. This, however, does not solve the problem of degradation of the CMRR on some sources. The real solution is to add a *third* op-amp to the design and implement a full instrumentation amplifier.

The basic circuit for an instrumentation amplifier is shown in Fig. 3. The second stage, formed by IC3, is the same

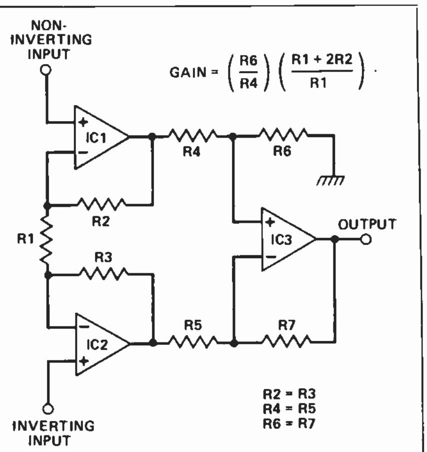

Fig. 3 The solution to the problem.

as the simple differential amplifier in Fig. 2, but its inputs are buffered by the input stages formed by ICs 1 and 2. Resistor pairs R2, R3 and R4, R5 and R6, R7 are made equal. The gain of the second stage is simply R6/R4 as derived above, but the gain of the first stage is given by the slightly more complex formula:

$$(R1 + 2R2)/R1$$

The overall gain is therefore

$$\frac{R6}{R4} \times \frac{R1 + 2R2}{R1}$$

If the value of R4 and R5 is made large in comparison to the estimated difference in the output impedances of the two input op-amps and if the gain of these two op-amps is the same then good CMRR will result.

A problem can occur on many instrumentation amplifiers in ensuring that the gains of the input op-amps are as close as possible to being the same. One feature of this circuit is that the CMRR is affected to a lesser extent by the matching of the resistors around the first stage. Furthermore, this will not be degraded by mismatch of the source impedance to the two inputs. The overall gain of the preamplifier is divided into two stages ensuring sufficient amounts of negative feedback to provide low distortion.

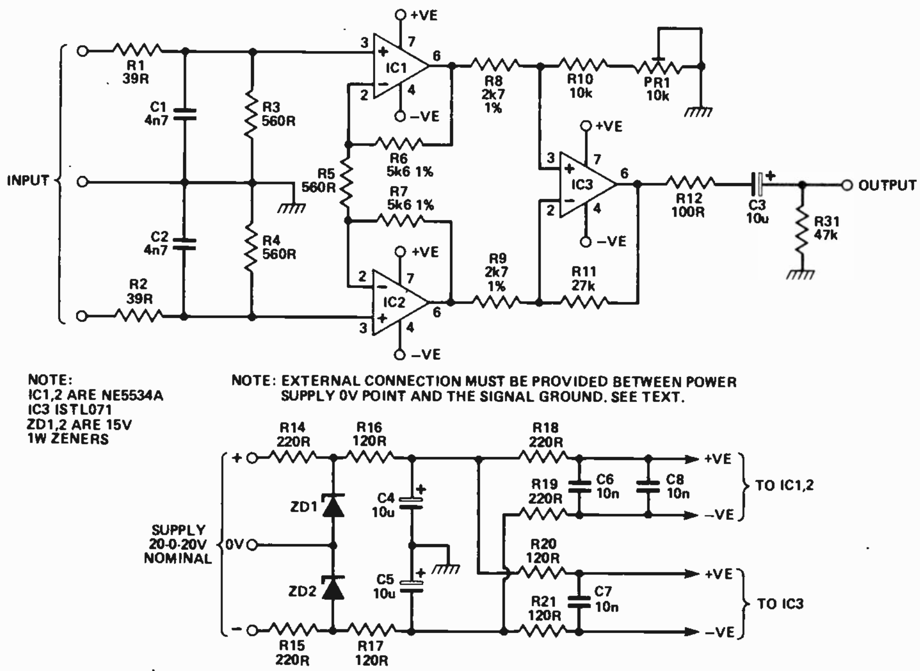

Fig. 4 Circuit diagram.

HOW IT WORKS

The circuit is a relatively straightforward instrumentation amplifier. The main differential stage is formed by IC3, the TL071. This is a biFET op-amp with good common mode rejection ratio (CMRR) figures. This stage is buffered from the inputs by a pair of NE5534A op-amps that also provide additional gain and determine the overall noise performance of the preamp. As mentioned in the other box, the overall gain of the preamp is determined by the gain of the first and second stages. The gain of the second stage is determined by the ratio of R11 to R9, and is around 10. The gain of the first stage is approximately 20, giving an overall gain of about 200, or 46 dB. If you require a different gain to this, try to keep the ratios of gain in the first and second stages the same. The amount of gain provided here should be suitable for most microphones, providing around 100 mV output from a 0.5 mV input signal level.

The circuit is DC-coupled at the input. This assumes that the driving source will be transformer or capacitively coupled at the output, which should be a safe assumption. The input impedance of the stage is set by the two input resistors R3 and R4. To increase the input impedance, simply increase the value of these resistors.

The RC networks consisting of R1-C1 and R2-C2 are high frequency filters to reduce the circuit's susceptibility to RF interference.

The split power supply is provided either from two zener regulators or from a well-regulated and filtered DC source. The supply pins to each IC are decoupled by 1k0 resistors and 10n capacitors to prevent IC-to-IC interaction and possible feedback via the supply rails.

throughout, without a significant cost penalty.

The PCB has been designed so that an external connection must be provided between the 0 V point on the PCB and the signal earth. The correct place for this connection is at the input to the preamplifier, ie on the input socket. A separate wire is run from the 0 V point to the signal earth point of the input socket. The signal leads from the input socket to the PCB should be shielded cable with the earth braid connected at both ends. The signal earth should not be connected to the chassis directly. RF shielding can be accomplished by connecting a 100nF capacitor between the signal earth at the input socket and the chassis. This will eliminate any problems with hum loops that might otherwise be formed around the mains earth line.

BUYLINES

We haven't used anything in this project that isn't commonplace in the advertisements of the mail order companies: even the NE5534A is becoming fairly well-stocked. The PCB can be ordered from our PCB Service on page 87.

PARTS LIST

Resistors (all ¼W, 5% except where stated)

R1,2	39R
R3-5	560R
R6,7	5k6 1%
R8,9	2k7 1%
R10	10k
R11	27k
R12	100R
R13	47k
R14,15, 18,19	220R
R16,17, 20,21	120R

Potentiometer

PR1	10k miniature vertical preset

Capacitors

C1,2	4n7 ceramic
C3	10u 35 V PCB electrolytic
C4,5	10u 16 V PCB electrolytic
C6-8	10n ceramic

Semiconductors

IC1,2	NE5534A (see text)
IC3	TL071
ZD1,2	15 V, 1 W zener

Miscellaneous

PCB (see Buylines)

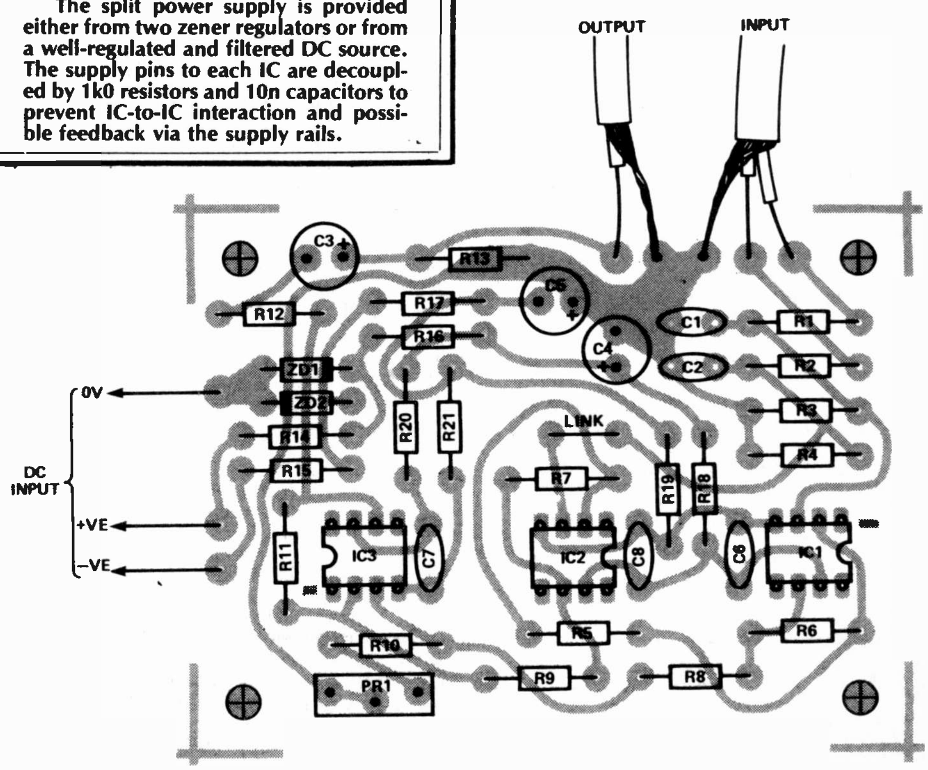

Fig. 5 Component overlay for the differential preamp.

Play the AMBIT numbers game ......

The long awaited implementation of on-line order processing is with us at last, and whilst this means that orders for in-stock items can now be processed more efficiently, it also means that orders should be submitted using stock codes for best results. Our current catalogue (75p) includes all order codes (watch out for the new expanded Spring edition), but here's an abstract from some of the more popular lines to use as a quick reference.

Remember that you can also access our catalogue via REWSHOP on REWTEL, which now includes on-line current price and delivery information. You need a 300 baud MODEM and RS232 terminal, (various suitable configurations based on popular micros have been published in recent past issues of Radio and Electronics World).

Prices shown here exclude VAT, and the P&P charge is currently 60p per order (unless otherwise indicated). Remember that our tele-sales service operates with human beings (not 'dumb' machines) from 8am to 7pm (and frequently later) Monday to Friday, and 9am to 6pm on Saturdays. REWSHOP operates 24 hours a day, 365 days a year with full price and delivery information.

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4017	23 04017	0.40
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4021	23 04021	0.55
4022	23 04022	0.55
4023	23 04023	0.15
4024	23 04024	0.33
4025	23 04025	0.15
4027	23 04027	0.28
4028	23 04028	0.50
4029	23 04029	0.55
4035	23 04035	0.87
4040	23 04040	0.88
4042	23 04042	0.50
4043	23 04043	0.60
4044	23 04044	0.68
4046	23 04046	0.60
4049UB	22 04049	0.24
4050	23 04050	0.24
4051	23 04051	0.55
4052	23 04052	0.55
4053	23 04053	0.55
4060	23 04060	0.75
4066	23 04066	0.30
4068	23 04068	0.16
4069UB	22 04069	0.14
4070	23 04070	0.16
4071	23 04071	0.16
4072	23 04072	0.16
4073	23 04073	0.18
4075	23 04075	0.18
4076	23 04076	0.55
4077	23 04077	0.18
4078	23 04078	0.18
4081	23 04081	0.18
4082	23 04082	0.18
4093	23 04093	0.30
4099	23 04099	0.80
4175	23 04175	0.80
4502	23 04502	0.60
4503	23 04503	0.50
4506	23 04506	0.70
4507	23 04507	0.37
4508	23 04508	1.50
4510	23 04510	0.55
4511	23 04511	0.45
4512	23 04512	0.55
4514	23 04514	1.25
4515	23 04515	1.25
4516	23 04516	0.60
4518	23 04518	0.35
4520	23 04520	0.60
4521	23 04521	1.30
4522	23 04522	0.89
4526	23 04526	0.60
4527	23 04527	0.80
4528	23 04528	0.65
4529	23 04529	0.70
4531	23 04531	0.65
4532	23 04532	0.80
4534	23 04534	4.00
4536	23 04536	2.50
4538	23 04538	0.85
4539	23 04539	0.80
4543	23 04543	0.80
4549	23 04549	3.50
4553	23 04553	2.70
4554	23 04554	1.20
4555	23 04555	0.35
4556	23 04556	0.40
4557	23 04557	2.30
4558	23 04558	0.80
4559	23 04559	3.50
4560	23 04560	2.50
4561	23 04561	1.00
4562	23 04562	2.50
4566	23 04566	1.20
4568	23 04568	1.45
4569	23 04569	1.70
45672UB	23 04572	0.32
4580	23 04580	3.25
4581	23 04581	1.40
4582	23 04582	0.70
4583	23 04583	0.80
4584	23 04584	0.27
4585	23 04585	0.45
4702	23 04702	4.50
4703	23 04703	4.48
4704	23 04704	4.24
4705	23 04705	4.24
4706	23 04706	4.50
4720	23 04720	4.00
4723	23 04723	0.95
4724	23 04724	0.95
4725	23 04725	2.24
40014	23 40014	0.54
40085	23 40085	0.99
40098	23 40098	0.54
40106	23 40106	0.69
40160	23 40160	1.05
40161	23 40161	1.05
40162	23 40162	1.05
40163	23 40163	1.05
40174	23 40174	1.05
40175	23 40175	1.05
40192	23 40192	1.08
40193	23 40193	1.08
40195	23 40195	1.08

74LSXX

Type	Stock No.	Price
74LS00	31 07400	0.11
74LS01	31 07401	0.11
74LS02	31 07402	0.11
74LS03	31 07403	0.11
74LS04	31 07404	0.14
74LS05	31 07405	0.14
74LS08	31 07408	0.14
74LS09	31 07409	0.14
74LS10	31 07410	0.14
74LS11	31 07411	0.14
74LS12	31 07412	0.14
74LS13	31 07413	0.32
74LS14	31 07414	0.32
74LS15	31 07415	0.14
74LS20	31 07420	0.14
74LS21	31 07421	0.14
74LS22	31 07422	0.14
74LS26	31 07426	0.14
74LS27	31 07427	0.30
74LS28	31 07428	0.18
74LS30	31 07430	0.14
74LS32	31 07432	0.14
74LS33	31 07433	0.14
74LS37	31 07437	0.18
74LS38	31 07438	0.14
74LS40	31 07440	0.18
74LS42	31 07427	0.30
74LS47	31 07447	0.75
74LS48	31 07448	0.40
74LS49	31 07449	0.80
74LS51	31 07451	0.14
74LS54	31 07454	0.14
74LS55	31 07455	0.14
74LS74	31 07474	0.21
74LS75	31 07475	0.21
74LS76	31 07476	0.25
74LS78	31 07478	0.19
74LS83	31 07483	0.33
74LS85	31 07485	0.44
74LS86	31 07486	0.15
74LS90	31 07490	0.24
74LS91	31 07491	0.38
74LS92	31 07492	0.32
74LS93	31 07493	0.24
74LS95	31 07495	0.38
74LS107	31 74107	0.31
74LS109	31 74109	0.25
74LS112	31 74112	0.21
74LS113	31 74113	0.21
74LS114	31 74114	0.21
74LS122	31 74122	0.27
74LS123	31 74123	0.38
74LS125	31 74125	0.27
74LS126	31 74126	0.27
74LS132	31 74132	0.27
74LS133	31 74133	0.24
74LS136	31 74136	0.20
74LS138	31 74138	0.30
74LS139	31 74139	0.30
74LS151	31 74151	0.30
74LS153	31 74153	0.34
74LS155	31 74155	0.30
74LS156	31 74156	0.33
74LS157	31 74157	0.27
74LS158	31 74158	0.27
74LS160	31 74160	0.34
74LS161	31 74161	0.38
74LS162	31 74162	0.38
74LS163	31 74163	0.38
74LS164	31 74164	0.40
74LS165	31 74165	0.80
74LS166	31 74166	0.58
74LS168	31 74168	0.89
74LS170	31 74170	0.83
74LS173	31 74173	0.47
74LS174	31 74174	0.37
74LS175	31 74175	0.40
74LS181	31 74181	0.87
74LS183	31 74183	1.05
74LS190	31 74190	0.39
74LS191	31 74191	0.39
74LS192	31 74192	0.39
74LS193	31 74193	0.39
74LS194	31 74194	0.39
74LS195	31 74196	0.39
74LS196	31 74196	0.39
74LS197	31 74197	0.47
74LS221	31 74221	0.50
74LS240	31 74240	0.80
74LS241	31 74241	0.60
74LS242	31 74242	0.55
74LS243	31 74243	0.55
74LS244	31 74244	0.80
74LS245	31 74245	1.00
74LS251	31 74251	0.36
74LS253	31 74253	0.36
74LS257	31 74257	0.36
74LS258	31 74258	0.38
74LS259	31 74259	0.51
74LS260	31 74260	0.28
74LS266	31 74266	0.20
74LS273	31 74273	0.70
74LS279	31 74279	0.35
74LS283	31 74283	0.40
74LS290	31 74290	0.40
74LS293	31 74293	0.40
74LS298	31 74298	0.54
74LS365	31 74365	0.34
74LS366	31 74366	0.40
74LS367	31 74367	0.30
74LS368	31 74368	0.30
74LS373	31 74373	0.72
74LS374	31 74374	0.72
74LS375	31 74375	0.31
74LS377	31 74377	0.60
74LS378	31 74378	0.44
74LS379	31 74379	0.44
74LS385	31 74385	1.30
74LS386	31 74386	0.27
74LS390	31 74390	0.51
74LS393	31 74393	0.48
74LS398	31 74398	0.80
74LS399	31 74399	0.85
74LS490	31 74490	0.80
74LS670	31 74670	1.15

74CXX

Type	Stock No.	Price
74C00	29 07400	0.35
74C02	29 07402	0.35
74C04	4069C	
74C08	29 07408	0.35
74C10	29 07410	0.35
74C14	4584C	
74C20	29 07420	0.35
74C30	29 07430	0.35
74C32	29 07432	0.35
74C42	29 07442	1.05
74C48	29 07448	1.50
74C73	29 07473	0.75
74C74	29 07474	0.75
74C76	29 07476	0.60
74C83	29 07483	1.30
74C85	29 07485	1.30
74C86	29 07485	1.30
74C89	29 07489	3.60
74C90	29 07490	1.05
74C93	29 07493	1.05
74C95	29 07495	1.25
74C107	29 74107	0.80
74C151	29 74151	2.10
74C154	29 74154	3.05
74C157	29 74157	2.10
74C160	40160	
74C1610	40161CM	
74C1620	40162CM	
74C1630	40163CM	
74C164	29 74164	1.05
74C165	29 74165	1.10
74C173	4076C	
74C1740	40174CM	
74C1750	40175CM	
74C1920	40192CM	
74C1930	40193CM	
74C1950	40195CM	
74C200	29 74200	6.50
74C221	29 74221	1.55
74C901	29 74901	0.55
74C902	29 74902	0.55
74C903	29 74903	0.55
74C904	29 74904	0.55
74C905	29 74905	6.50
74C906	29 74906	0.55
74C907	29 74907	0.55
74C908	29 74908	1.10
74C909	29 74909	2.10
74C910	29 74910	5.00
74C914	29 74914	1.10
74C918	29 74918	1.30
74C925	29 74925	8.00
74C926	29 74926	8.00
74C927	29 74927	8.00

74HCXX

Type	Stock No.	Price
74HC00	30 07400	0.58
74HC02	30 07402	0.56
74HC04	30 07404	0.68
74HC10	30 07410	0.58
74HC20	30 07420	0.56
74HC86	30 07486	0.74
74HC132	30 74132	1.28
74HC266	30 74266	0.81
74HC4002	30 04002	0.56
74HC4075	30 04075	0.56
74HC242	30 74242	2.00
74HC243	30 74243	2.00
74HC74	30 07474	0.74
74HC109	30 74109	0.66
74HC175	30 74175	1.08
74HC373	30 74373	2.40
74HC374	30 74374	2.40
74HC533	30 74533	2.40
74HC534	30 74534	2.40
74HC165	30 74165	1.96
74HC173	30 74173	1.20
74HC160	30 74160	1.33
74HC161	30 74161	1.33
74HC162	30 74162	1.33
74HC163	30 74163	1.33
74HC4538	30 74538	2.10
74HC85	30 74280	2.95
74HC280	30 74280	2.95
74HC42	30 07442	1.00
74HC138	30 74138	1.08
74HC139	30 74139	1.08
74HC4514	30 04514	3.40
74HC4543	30 04543	2.75
74HC157	30 74157	0.92
74HC158	30 74158	0.90
74HC257	30 74257	0.90

LINEAR ICs

Type	Stock No.	Price
LM10CN	61 00010	3.88
MF10	61 00011	5.05
L149	61 00149	1.88
ZNA234	61 02340	6.50
U237B	61 00237	1.28
U247B	61 00247	1.28
U257B	61 00257	1.28
U267B	61 00267	1.28
LM301AH	61 03010	0.67
LM301AN	61 03011	0.27
LM308H	61 03080	0.70
LM308CN	61 03081	0.65
LM324	61 03240	0.45
LM339N	61 03390	0.68
LF347	61 00347	1.80
LM348	61 03480	0.90
LF351	61 03510	0.49
LF353	61 03530	0.76
LM380N	61 00380	1.00
LM381	61 00381	1.81
LM382	61 00382	1.81
ZN419CE	61 00419	1.98
ZNA423	61 04230	1.00
ZN425E/8	61 04250	3.50
ZN426E/8	61 04260	3.00
ZN427E/8	61 04270	6.28
ZN428E/8	61 04280	4.78
ZN429E/8	61 04290	2.10
ZN432CJ10	61 04320	28.00
ZN433CJ10	61 04330	22.59
ZN440J	61 04400	0.80
ZN450E	61 04500	7.61
NE542	61 05420	1.20
NE544	61 00544	1.80
NE555N	61 05550	0.20
NE556N	61 05560	0.50
SL560C	61 05600	1.88
NE562	61 00562	4.05
NE564	61 00564	4.29
NE565	61 00565	1.00
NE566	61 00566	1.30
NE567	61 00567	1.30
NE570N	61 00570	3.85
SL624	61 00624	3.28
uA709HC	61 07090	0.64
uA709PC	61 07091	0.38
uA710HC	61 07100	0.64
uA710PC	61 07101	0.59
uA711CN	61 07110	0.85
uA733CN	61 07330	0.89
uA741CH	61 07410	0.86
uA741CN	61 07411	0.20
uA747CN	61 07470	0.70
uA748CN	61 04780	0.30
uA758	61 00758	2.35
TBA820M	61 00820	0.78
TDA1028	61 01028	2.11
TDA1029	61 01029	2.11
ZNA1034	61 01034	2.10
LM1035	61 01034	2.10
TDA1054M	61 01054	1.45
TDA1062	61 01062	1.95
TDA1072	61 01072	2.89
TDA1074A	61 01074	5.04
TDA1083	61 01083	1.85
TDA1090	61 01090	3.05
HA1137	61 12411	1.20
HA1196	61 01196	2.00
HA1197	61 01197	1.00
TDA1220	61 01220	1.40
LM1303	61 01303	0.99
LM1307	61 01307	1.55
MC1310P	61 01310	1.90
MC1330	61 01330	1.20
MC1350	61 01350	1.20
HA1370	61 11370	1.80
HA1388	61 01388	2.75
LM1458N	61 14580	0.45
MC1496P	61 01496	1.25
SL1610	61 01610	1.92
SL1611	61 01611	1.80
SL1612	61 01612	1.80
SL1613	61 01613	2.08
SL1620	61 01620	2.50
SL1621	61 01621	2.50
SL1623	61 01623	2.44
SL1625	61 01625	2.50
SL1626	(SL6270)	
SL1630	61 01630	1.82
SL1640	61 01640	2.25
SL1641	61 01641	2.25
MC1648	61 01648	3.25
TDA2002	61 02002	1.25
ULN2240	61 02240	3.25
ULN2242	61 01090	3.05
ULN2283	61 02283	1.00
CA3080	61 03080	0.70
CA3089	61 03089	1.84
CA3123	61 03123	1.40
CA3130E	61 31300	0.80
CA3130T	61 31301	0.90
CA3140E	61 31400	0.46
CA3189E	61 03189	2.20
CA3240E	61 32400	1.27
MC3357	61 03357	2.85
MC3359 (see ULN3859)		
ULN3859	61 03859	2.95
KM3701	61 03701	85.53
KM3702	61 03702	74.84
LM3900	61 39000	0.80
LM3909N	61 39090	0.68
LM3914N	61 03914	2.80
LM3915N	61 03915	2.80
KB4400	61 04400	0.80
KB4412	61 04412	1.95
KB4413	61 04413	1.95
KB4417	61 04417	1.80
KB44208	61 04420	1.09
TDA4420	61 14420	2.85
TDA4421	61 14421	2.85
KB4423	61 04423	2.30
KB4424	61 04424	1.85
XB4430	61 04430	2.30
KB4431	61 04431	1.95
KB4432	61 04432	1.95
KB4433	61 04433	1.52
KB4436	61 04436	2.53
KB4437	61 04437	1.75
KB4438	61 04438	2.22
KB4441	61 04441	1.35
KB4445	61 04445	1.29
KB4446	61 04446	2.75
KB4448	61 04448	1.85
NE5044	61 05044	2.26
MC5229	61 05229	9.80
NE5532	61 55320	1.85
KM5624	61 05624	4.35
SO6000	61 06000	3.75
SL6270	61 06270	2.03
SL6310	61 06310	2.45
SL6440	61 06440	3.38
SL6600	61 06600	3.75
SAS6610	61 06610	1.48
SL6640	61 06640	2.75
SL6690	61 06690	3.75
SL6700	61 06700	2.75
SAS6710	61 06710	1.48
LS7225	61 07225	3.85
ICM7555	61 75550	0.80
CL8038CC	61 08038	4.50
MSL9362	61 09362	1.75
MSL9363	61 09363	1.75
X10170	61 10170	1.87
TK10321	61 10321	2.75
HA11223	61 11223	2.15
HA11225	61 11225	1.45
HA12002	61 12002	1.22
HA12017	61 12017	0.80
HA12402	61 12402	1.95
HA12411	61 12411	1.20
HA12412	61 12412	1.55
LF13741	61 13741	0.33
MK50366	61 50366	3.35
MK50375	61 50375	3.85
MM53200	61 53200	3.90

PRESCALER

Type	Stock No.	Price
U264	61 02640	2.27
U265	61 02650	3.18
U266	61 02660	2.43
11C90DC	61 01190	12.95
MSL2312R	61 02312	3.94
MSL2318	61 02318	3.84
MSM5523	61 05523	11.30
MSM5524	61 05524	11.30
MSM5525	61 05525	7.85
MSM5526	61 05526	7.85
MSM55271	61 55271	9.75
ICM7106CP	61 07106	8.55
ICM7107CP	61 07107	8.55
LC7137	61 07137	7.50
ICM7216B	61 72161	19.50
ICM7216C	61 72162	19.85
ICM7217A	61 07217	8.50
SP8629	61 08629	3.85
SP8647	61 08647	6.00
SP8793	61 08793	7.70
95H90	61 09590	7.80
HD10551	61 10551	2.45
HA12009	61 12009	6.00
HD44015	61 44015	4.45
HD44752	61 44752	8.00
MC145151P	61 14151	6.00
MC145152P	61 14151	8.80
MC145156P	61 14156	4.80

SMALL SIGNAL AUDIO

Type	Stock No.	Price
BC182	58 00182	0.10
BC212	58 00212	0.10
BC237	58 00237	0.08
BC238	58 00238	0.08
BC239	58 00239	0.08
BC307	58 00307	0.08
BC308	58 00308	0.08
BC309	58 00309	0.08
BC327	58 00327	0.13
BC337	58 00337	0.13
BC413	58 00413	0.10
BC414	58 00414	0.11
BC415	58 00415	0.10
BC416	58 00416	0.11
BC546	58 00546	0.12
BC550	58 00550	0.12
BC556	58 00556	0.12
BC560	58 00560	0.12
BC639	58 00639	0.22
BC640	58 00640	0.22
MPSA13	58 04013	0.30
MPSA63	58 04063	0.30
ZTX108	58 01108	0.10
ZTX212	58 01212	0.10
ZTX653	58 01653	0.20
ZTX753	58 01753	0.20
2N2904	58 02904	0.25
2N2905	58 02905	0.25
2N3905	58 03905	0.10
2SB646A	58 03646	0.30
2SB648A	58 03648	0.40
2SD666A	58 03666	0.30
2SD668A	58 03668	0.40
2SA872A	58 02872	0.16
2SA1084E	58 01084	0.25
2SA1085E	58 01085	0.25
2SC1775A	58 01775	0.19
2SC2546E	58 02546	0.24
2SC2547E	58 02547	0.24

AUDIO POWER

Type	Stock No.	Price
BD139	58 15139	0.29
BD140	58 15140	0.31
BD165	58 15165	0.46
BD166	58 15166	0.48
BD179	58 15179	0.38
BD180	58 15180	0.41
TIP31A	58 15031	0.35
TIP32A	58 15032	0.35
MJ2955	58 12955	0.88
2N3055	58 13099	0.58
2SB720	58 15720	0.80
2SD780	58 17600	0.80
2SJ49	60 01049	3.10
2SJ50	60 01050	4.25
2SJ83	60 01083	3.55
2SK134	60 00134	3.10
2SK135	60 00135	4.25
2SK227	60 00227	3.55
2SD753	58 03753	2.34

SMALL SIGNAL RF

Type	Stock No.	Price
BFY50	58 06500	0.22
BF241	58 06241	0.18
BF273	58 06273	0.18
BF274	58 06274	0.20
BF362	58 06362	0.49
BF440	58 06440	0.21
BF441	58 06441	0.21
BF479	58 06479	0.88
BF6795	58 06679	0.55
BFR91	58 07091	1.33
BFT95	58 10095	0.89
BFW92	58 08092	0.60
BFY90	58 09090	0.90
NE21936	58 21936	5.00
ZTX323	58 06232	0.60
2N2369A	58 02369	0.38

RF POWER

Type	Stock No.	Price
BFW16A	58 08016	0.85
MRF237	58 14237	3.20
MRF238	58 14238	16.50
MRF245	58 14245	40.00
MRF449A	58 14449	16.50
MRF472	58 14472	1.25
MRF475	58 14475	4.60
MRF629	58 14629	4.69
PT8811	58 18811	9.50
TP2320	58 12320	10.24
VN66AF	60 02066	0.95
ZTX3866	58 03866	0.45
2N3866	58 13866	1.20

SMALL SIGNAL FET

Type	Stock No.	Price
BF256	59 00256	0.38
BF960	60 06960	0.99
BF961	60 06961	0.70
BF963	60 06963	0.99
J310	59 02310	0.89
J176	59 02176	0.65
2SX55	59 01055	0.32
2SK168	59 01168	0.37
3SK45	60 04045	0.49
3SK51	60 04051	0.54
3SK60	60 04060	0.58
3SK88	60 04088	0.99
40673 see 3SK51		
40822 see 3SK51		
40823	60 03823	0.65
3SK112	60 04112	4.60

DIODES

Type	Stock No.	Price
AA112	12 01126	0.25
BA244	12 02447	0.17
BA379	12 03797	0.35
ND4981 7E	12 49817	0.51
OA91	12 00916	0.07
OA47	12 00476	0.10
PW02	12 62006	0.75
SO4	12 24006	0.45
W005	12 10506	0.28
1N4001	12 40016	0.06
1N4002	12 40026	0.07
1N4004	12 40046	0.07
1N4148	12 41486	0.05
1N5404	12 54046	0.16
1N6263	12 62637	0.82

VARICAPS

Type	Stock No.	Price
BA102	12 01025	0.30
BA121	12 01215	0.30
BB105B	12 01055	0.30
BB109B	12 01095	0.27
BB204B	12 02045	0.38
BB212	12 02125	1.85
ITT210	12 02105	0.30
MVAM115 see KV1236		
MVAM125 see KV1225		
KV1210	12 12105	2.45
KV1211 see KV1236		
XV1225	12 12255	2.75
KV1235	12 12355	2.75
KV1236	12 12365	2.55
KV1310	12 13105	0.40
KV1310	12 13205	0.40

ZENER DIODES

BZY88C 400mW. 5%

Type	Stock No.	Price
2V7	12 00278	0.10
3V3	12 00338	0.10
3V9	12 00398	0.10
4V7	12 00478	0.10
5V1	12 00518	0.10
5V6	12 00568	0.10
6V8	12 00688	0.10
8V2	12 00828	0.10
9V1	12 00918	0.10
10	12 01008	0.10
11	12 01108	0.10
12	12 01208	0.10
15	12 01508	0.10
18	12 01808	0.10
22	12 02208	0.10
27	12 02708	0.10
33	12 03308	0.10

SCRS TRIACS

Type	Stock No.	Price
BRY55 100	52 55100	0.50
C106D1	52 00106	0.78
C122D1	52 00122	1.46
2N6403	52 06403	2.22
2N6073A	58 06073	0.88

BALANCED MIXERS

Type	Stock No.	Price
SBL1	12 00003	4.88
SBL1-8	12 00013	5.00
SBL1-X	12 00023	8.33
SRA1	12 00033	10.80
SRA1-1	12 00043	12.77
SRA1H	12 00053	16.34
SRA3	12 00063	15.35

LEDs

3mm round types

Type	Stock No.	Price
COX25 Red/Clr	15 20250	0.15
V178P-Red	15 01780	0.15
COX26-Gr/Clr	15 20260	0.16
V179P-Green	15 01790	0.16
COX27-Yel/Clr	15 20270	0.18
V180P-Yellow	15 01800	0.18
COX41A Or/Rd	15 20410	0.19

Standard 5mm DIA LEDs

Type	Stock No.	Price
COY40L Red	15 10400	0.12
COY72L Green	15 10720	0.15
COY74L Yellow	15 10740	0.16
COX38A Or/rd	15 20380	0.28
COX39B Or/cl	15 20390	0.28

Rectangular 2.5 x 5mm LEDs

Type	Stock No.	Price
COX10 Red	15 20100	0.17
COX11 Green	15 20110	0.20
COX12 Yellow	15 20150	0.20
COX40 Or/Red	15 20400	0.24

Infra-Red LEDs

Type	Stock No.	Price
COY99 Emit	15 10990	0.56
BPW41 Det	15 30410	1.51

R Optocoupler

Type	Stock No.	Price
BNY37	15 40370	1.44

FLAT DIFFUSED

Type	Stock No.	Price
V320	15 03200	0.17
V321	15 03210	0.28
V322	15 03220	0.20
V323	15 03230	0.20
V330	15 03300	0.17
V331	15 03310	0.28
V332	15 03320	0.20
V333	15 03330	0.20
V340	15 03400	0.17
V341	15 03410	0.28
V342	15 03420	0.20
V343	15 03430	0.20
V510	15 05100	0.17
V511	15 05110	0.28
V512	15 05120	0.20
V513	15 05130	0.20
V520	15 05200	0.17
V521	15 05210	0.28
V522	15 05220	0.20
V523	15 05230	0.20
V530	15 05300	0.17
V531	15 05310	0.28
V532	15 05320	0.20
V533	15 05330	0.20
V540	15 05200	0.17
V541	15 05410	0.28
V542	15 05420	0.20
V543	15 05430	0.20
V550	15 05500	0.17
V551	15 05510	0.28
V552	15 05520	0.20
V553	15 05530	0.20

TRI COLOUR

Type	Stock No.	Price
V518	15 05180	0.80

Ambit international
200 North Service Road
Brentwood, Essex
CM14 4SG

Telecom directory:
Consumer 0277-230909
Industrial 0277-231616
Telex 995194 AMBIT G
DATEL 0277-232628

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BUYER'S GUIDE TO HI-FI SYSTEMS

And now we proudly present the Thinking Man's Guide to Buying Hi-fi. That is, ETI has done the thinking, now you go out and do the buying! Bring your own wallet (all sizes catered for).

Buying a hi-fi system is a harrowing experience, especially the first time out. After you've bought all the hi-fi mags for six months, thoroughly digested the conflicting and often lunatic advice given therein, listened to all your 'expert' friends disagreeing with each other and dared to cross the threshold of a shop . . . what then?

One word — LISTEN. It matters not a jot what anyone else tells you — us included — if you don't agree with the choice, don't buy it! You're going to have to live with it. However, it is a good idea to have a shortlist based upon reviews, price, but don't forget, most important of all are your own auditionings.

Reading the specialist audio press can be enlightening — but it can be mystifying too. At one time you could read through two or three different magazines and still be told that whether you were spending £500 or £5000 on a system, unless you bought a particular £300 turntable you were wasting your money! The field has to some extent sobered up of late, since crashing circulations and retreating advertisers have brought with them a certain measure of common sense. If you want a magazine reviewer's recommendation for 'which magazine' — mine would be *Hi-Fi For Pleasure*. It is a title that is not only a good read but has consistently demonstrated a sound technical understanding and displayed a commendable intelligence, when all around it were losing theirs!

(It's fun being an electronics-based magazine sometimes — we could never get away with saying things like that in the hi-fi press!)

In this supplement we're taking a different approach to the overall compatibility 'table' approach. Instead we have listed out eight full systems, from £350 to £8500 in price and which we have personally tried and tested (except one — and you'll see why . . .)

In this way each forms a perfectly good buy in itself — assuming you like the sound yourself, of course — or at the least will make a good starting point in the demonstration room when you're down to the final choice.

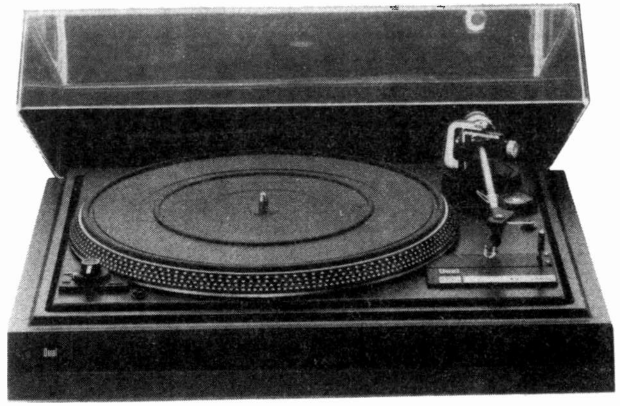
Each of the systems is for records only: no allowance is made in price for tape or tuner. Additions such as these we left until later. We have some advice to offer on those too, but in the form of a list of models which we have had through our hands at some point and have found to be good. A number of people have very expensive record playing systems but have tacked onto the end of them cassette decks of considerably lower-fi, to use as background music and so on. Because of this we have made no attempt to assign tape and tuner to the primary systems. You pick and choose as you like to fit your own individual needs.

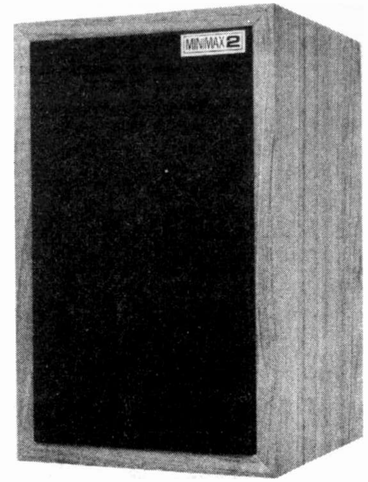
A word of explanation about the system tables to be found overleaf. The first column contains details of our recommended system and the retail price (as far as we know — do shop around for bargains). The order of components is record deck, arm (if not included with the deck), cartridge, preamp/power amp combination, and speakers. Any alternatives are given in the second column with their prices bracketed.

We've also illustrated each of the systems to the best of our ability, but some companies were as compliant as concrete cantilevers, and the 'first class' post wasn't, so there are some unfortunate omissions. C'est la vie . . .

SYSTEM 1 £325

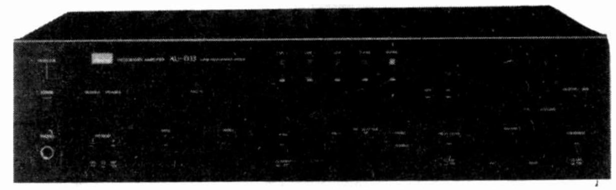
Dual CS505	80	There
Coral MC88E	25	Is
Sansui AU-D33	145	No
Videotone Minimax 2	75	Alternative!
TOTAL	£325	



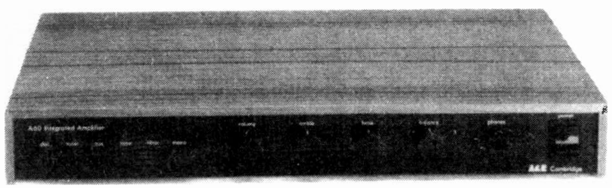


With the rising costs of even the most basic system, the Dual CS505 is a godsend to the first time buyer. It offers very good performance for a reasonable cost. The Coral MC88E is a lively sounding moving coil unit, which needs a careful choice of speaker to make the most of its performance, and the new Minimax is an ideal match.

Overall the system provides a clean and slightly forward sound, with a good bass performance for its size. The Sansui offers a sound technical performance allied to a good power delivery and is ideal as the centre of a sound system designed for a wide range of music but a narrow wallet.

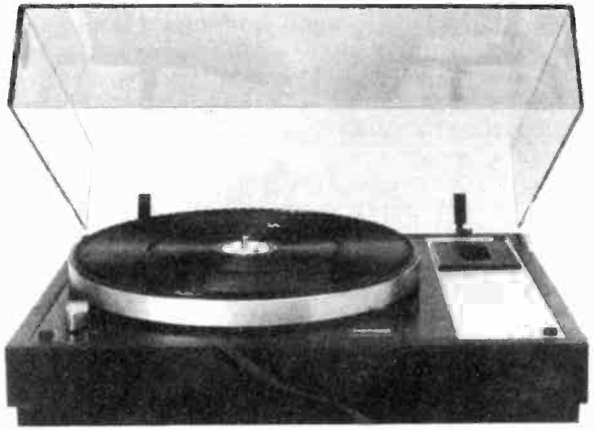


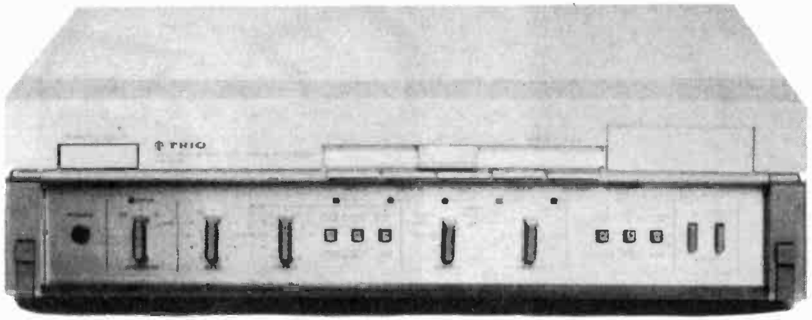
SYSTEM 2 £504

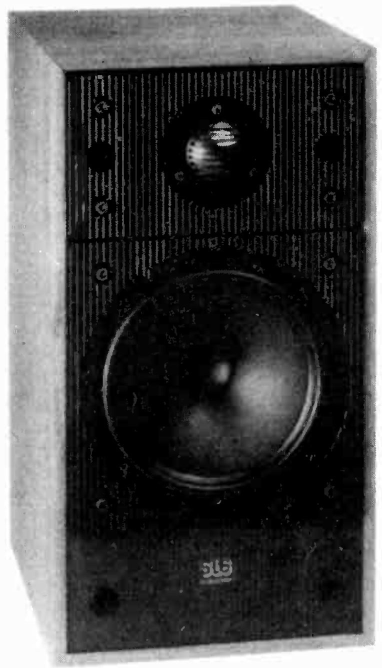


Systemdek II	115	Michell Focus 1 (105)
Linn Basik LV X	74	
A & R A60	195	NAD 3150 (98)
KEF Cantor 2	120	Mordaunt Short Festival 3 (150)
TOTAL	£504	

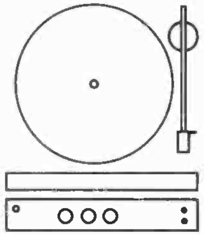
The Systemdek II is an individual approach to design — you'll either love it or hate it! Either reaction is catered for here by the use of the Focus One as an alternative. The Basik is well established as a cheap way of obtaining a good pickup. It will work well with the Cantor loudspeakers to provide as neutral result as can be obtained for this outlay. The A60 is a classic design and needs little introduction. It is probably the best of its kind for around £200 and you'll need to lay out a couple of hundred more to better this system for overall performance.

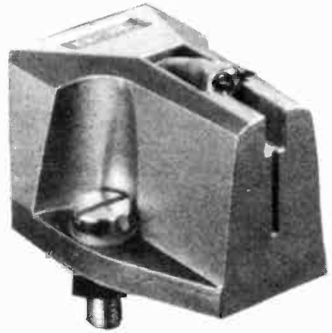






SYSTEM 3 £970





Thorens TD160S	175	
SME Series III	100	SME Series IIIS (80)
Shure V15V	105	Coral MC82 (120)
Trio KA-900	295	
Celestion SL6	295	Heybrook HB2 (185)
TOTAL £970		

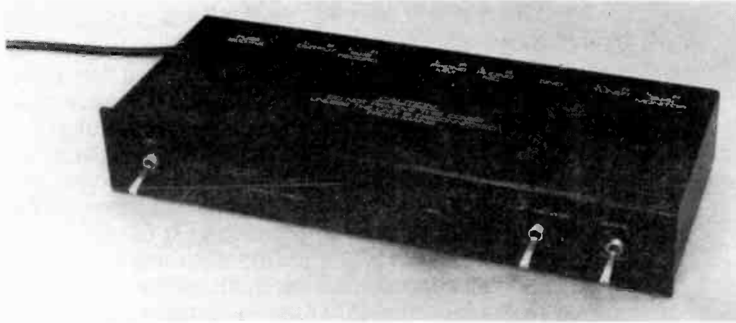
The Thorens TD 160S is the basis for this system and although it does need very careful setting up — which any good dealer will carry out — it returns a performance which is far above that promised by the price of £175. It will consistently outperform decks costing £350 or more and as such is used in our next system upwards as well as in this one. The SME has become rather unfashionable of late, but is still THE best universal arm available. It matches high compliance designs particularly well and the V15V in particular.

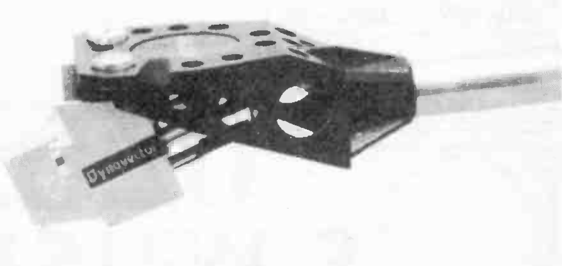
With the Trio and the SL6, this adds up to a compact system capable of very high sound quality indeed and with a staggering bass response for its size (a trait born of the combination of V15V and SL6s). The alternative system is perhaps slightly smoother and would suit classical orientated taste a little better, although you will not get quite the same dynamics from the HB2s as with the Celestions.

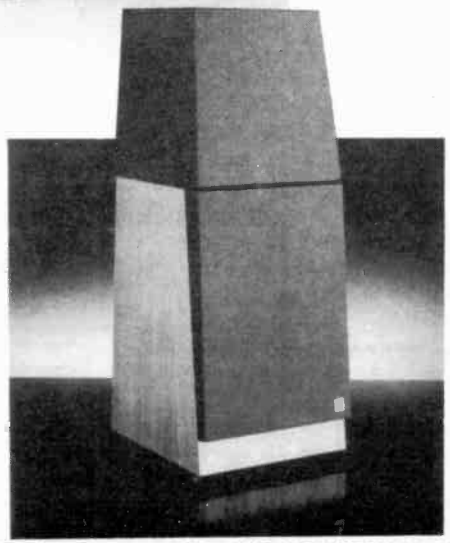
Using the 'S' version of the SME will save you £20 or so and with the MC82 it is a better match anyway. Don't use this cartridge with SL6's, however; they do not work well together. The V15V, on the other hand, is a perfect compliment.

SYSTEM 4 £1368

Thorens TD160S	175	
SME Series III	100	
Dynavector Karat Ruby	150	Shure V15V (105)
The Preamp/Carver M-400 (the Cube)	550	
Heybrook HB3	393	KEF 105 IV (500)
TOTAL	£1368	







Using the 160S/SME III combination once more, it is possible to construct a more 'up market' system which will provide greater power delivery and a much-improved bass response. Changing the speakers to Heybrook HB3s allows the use of the Karat Ruby from Dynavector and this will open out the mid-range to provide greater detail than before.

The Carver M-400 or 'Cube' is well-known for its phenomenal power delivery and miniscule dimensions. Unfortunately Carver do not yet market a preamp which is its equal in sound quality. The unit from Musical Fidelity is very well-designed and provides a good match.

If you have another £100 floating about spare, you could improve the system still further by substituting the excellent KEF 105 IV for the HB3. These are the smaller version of the illustrious 105 II and have many of that unit's admirable traits.

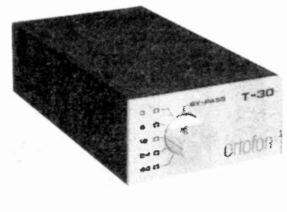
SYSTEM 5 £2840

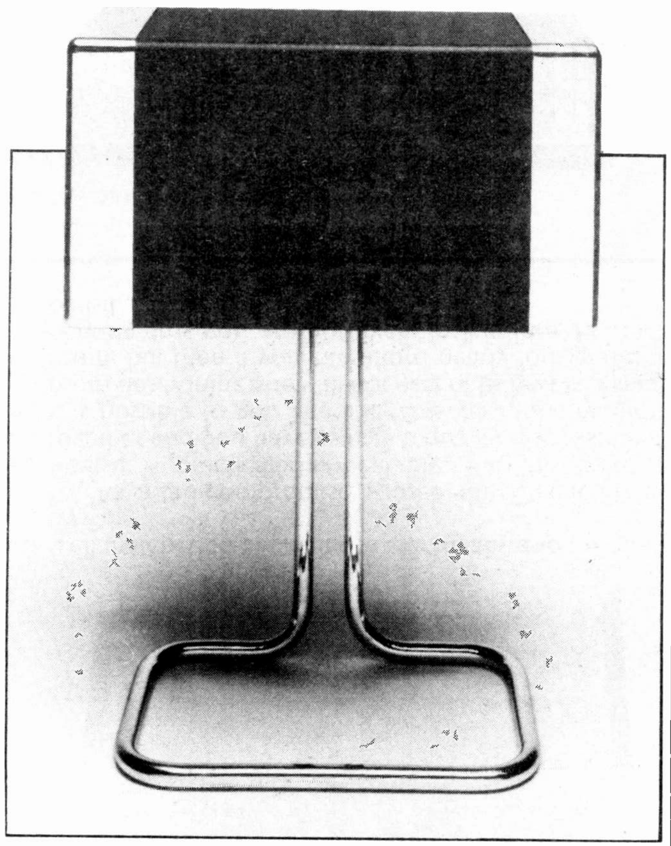
Oracle	600	
SME Series III	100	
Ortofon MC30/T-30	550	
Elite 600/660	890	NAC 32/NAP 20 (1100)
Gale 401	700	KEF 105 II (900)
TOTAL	£2840	

The Oracle is now accepted in many circles as the best-sounding turntable on the market. It is also one of the most expensive, at around £600. To obtain the absolute best from it, you need around £700 worth of cartridge and arm (see System 7) but the Oracle will still serve to improve less bank-breaking ambitions, provided care is exercised.

The Ortofon MC30 is a high compliance moving-coil unit of the highest quality. In our experience it does not work very well with the newer high-mass arms designed for moving-coil pickups. It does work superbly with the faithful SME Series III, however, with only the addition of the headshell weight. Use Ortofon's own step-up, the T-30, for optimum performance.

The KEF 105 II will provide a more neutral rendition than the Gale, but at a cost of around £200 more. Either speaker soaks up power like a sponge, and you may find the extra punch of the Naim more to your tastes, especially with the KEF.



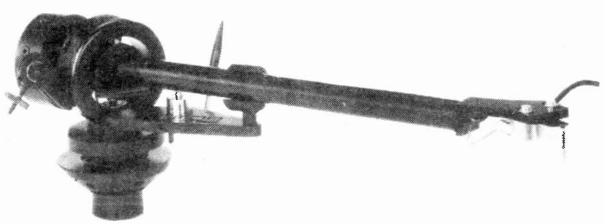


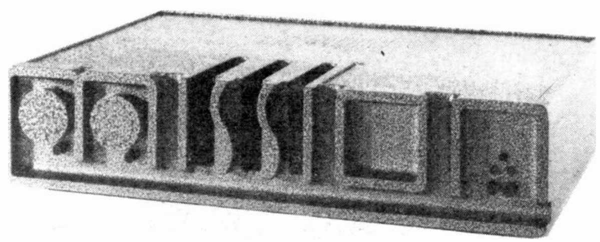
SYSTEM 6 £3071

Pink Triangle	398	
Mission 774SM	157	Alphason HR100S (195)
Dynavector Karat Diamond	516	
NAIM NAC 32/ NAP 20	1100	Mission 776/777 (1000)
KEF 105 II	900	
TOTAL	£3071	

Based upon the Naim/105 combination this set-up brings you the benefits of the ultra-low compliance Dynavector Karat Diamond. This has a solid diamond cantilever and provides as good a way of extracting music from a disc as can be found anywhere. The Pink Triangle and Mission arm allow it to give of its best — no mean feat.

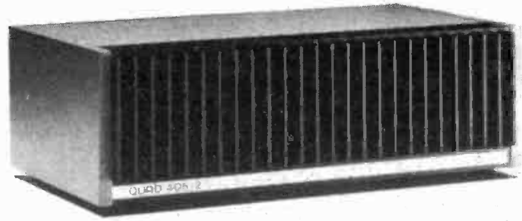
As an alternative amplifier, consider the Mission 776/777 combination. This is fairly new, but has already acquired an enviable reputation. The power amp in particular is excellent for the price.

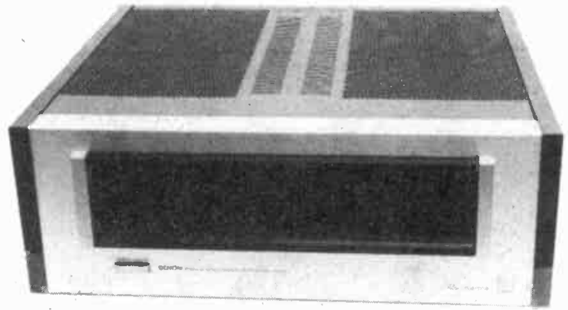


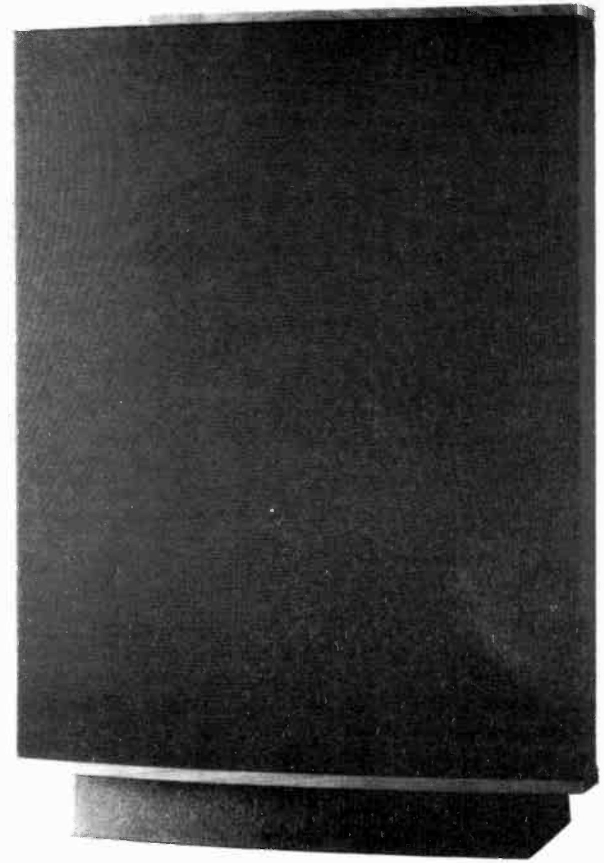


SYSTEM 7
£3393

Oracle	600	
Fidelity Research FR 64	270	Linn Ittok (273)
Koetsu Silver	573	Linn Asak (207)
NAIM NAC 32/ Quad 405 II	750	NAC 32/Denon POA-3000 (2000)
Quad ELS-63	1200	
TOTAL	£3393	







Enter the Quad ELS-63 at £1200 the pair. If you want the best possible reproduction in the home, regardless of convenience or price then this is it. To drive them Quad's own 405 (now in Mk. 2 livery) takes some beating. It would appear that these two are designed to work together, since the 405 will lose units costing three or four times the price into the ELS-63's, and yet turn in a mediocre performance with some other speakers which are regarded as an easier load!

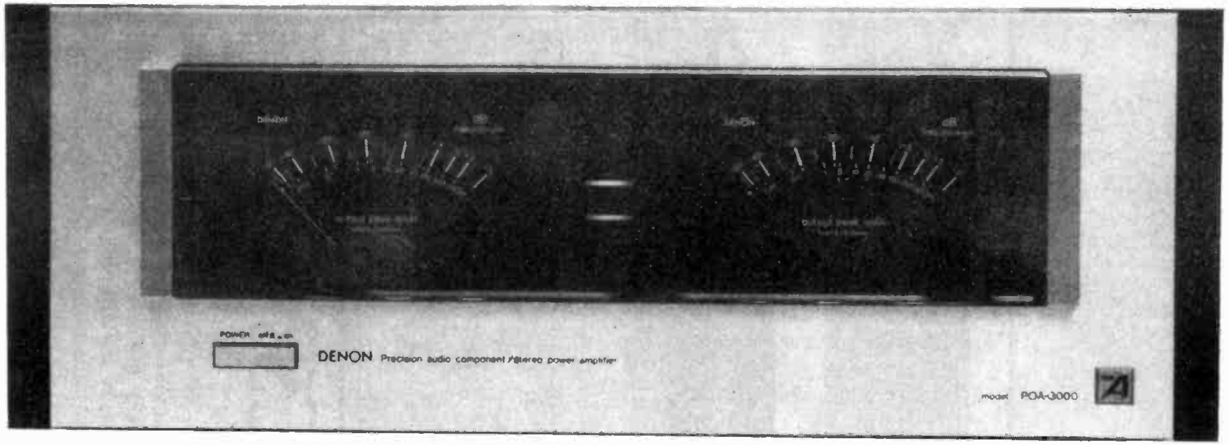
As an alternative the Class A Denon POA—3000 is well matched to ESL-63 both electrically and for quality.

As a no-compromise source the Oracle/FR 64 Koetsu is practically unbeatable. Put this little lot together and you have as high a quality disc system as it is possible to get. The ESL-63 is very touchy about room positioning and will not give of its best in a small room, but then if you can afford nearly four grand to play records you are not likely to live in a 12 × 12 bedsit . . . are you?

And just to be *really* silly . . .

SYSTEM 8
£8498

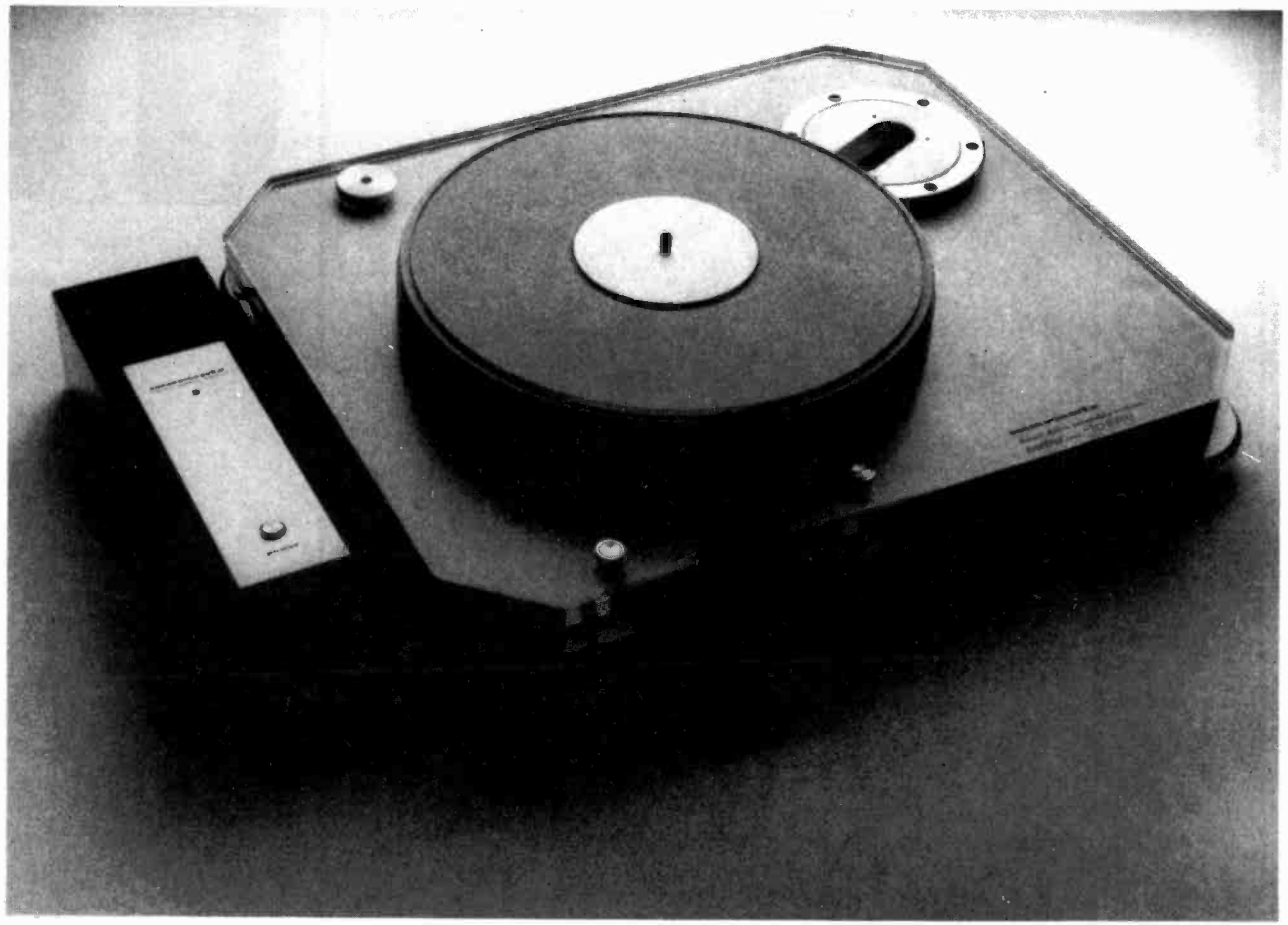
Marantz Esotec 1000	1000	
Sumiko The Arm	798	
Koetsu Gold	900	
Threshold FET1/5500	4600	Denon PRA-2000 POA-3000 (3500)
Quad ELS-63	1200	
TOTAL	£8498	



If you thought £3500 was expensive, try £8500! We must stress that we've never *heard* this precise arrangement of components and think it unlikely anyone else has either!

The Threshold amp is very highly regarded and on the occasions we've heard it, it is a very impressive piece of work indeed. Magnificent in all but generosity. £4600 is a lot of cash.

The (Sumiko) Arm is another supreme example of 'That Which Is Possible' — given no constraints on price as a starting point. If you ever get this system together we'd be only *too* pleased to come and have a listen — we'll even bring the beer!



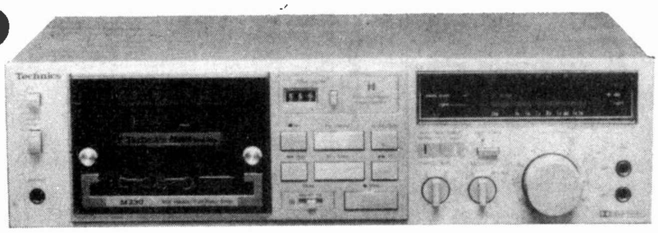
CASSETTES AND TUNERS

Once you move away from the basic record playing system into tape and/or radio, then technical compatibility assumes a greater-than-ever importance. Without going through every amplifier input and *every* tape/tuner output, there is no real way to guarantee complete compatibility. The only useful advice is to check the model you want against the amplifier you're thinking of using it with.

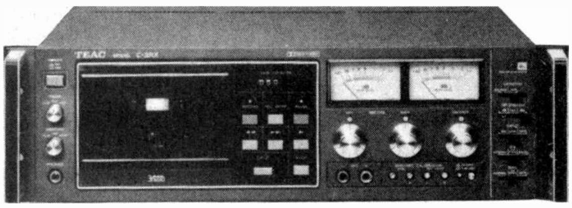
Feeding a low impedance into a high(er) value is OK. Anything else is not. Look for approximately equal sensitivity and output levels, so that you are not flogging some poor little input stage to death somewhere to obtain the level you want.

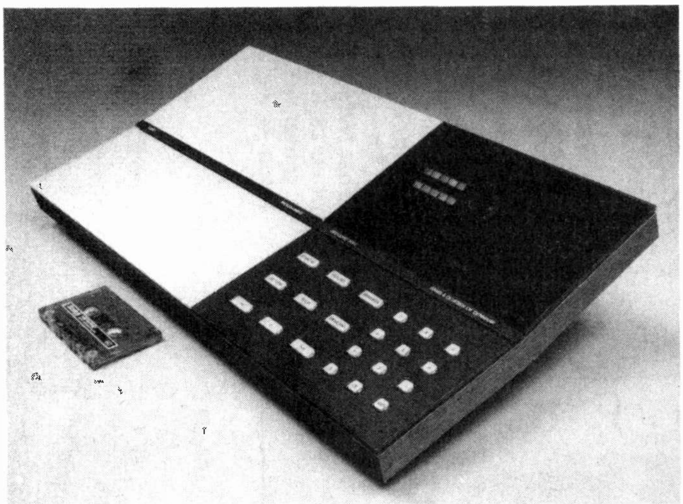
Here we are presenting a list of ETI approved models — which is not to say that nothing else is approvable! These just happen to be components of which we have had experience and can thoroughly recommend as good performers and good value. Check them over if you're buying into this market. How much you need to pay is entirely dependent upon how much you value that particular source. The more you pay, the better they get.

CASSETTE DECKS

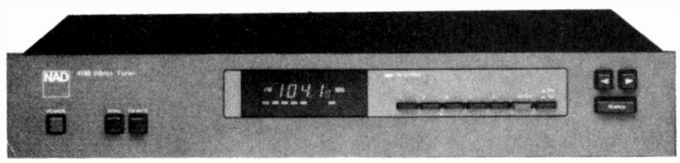


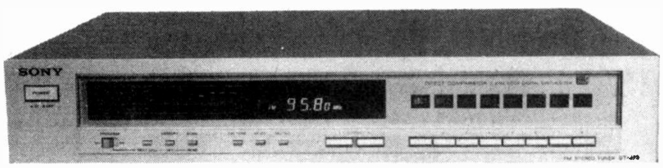
MODEL	£
Sony TEF 44	110
Technics RSM230	155
Alpage AL-100	173
Akai GX-F51	200
Pioneer CT7R	260
Teac C3X	360
Alpage AL-300	372
Bang and Olufsen Beocord 8002	459
Revox B710 II	943
Nakamichi 1000 ZXL	1000





TUNERS





MODEL	£
Yamaha 7760	143
NAD 4150	159
Sugden T48 II	161
Lux T115	170
A & R T21	190
Sony ST-J75	200
Pioneer F9	200

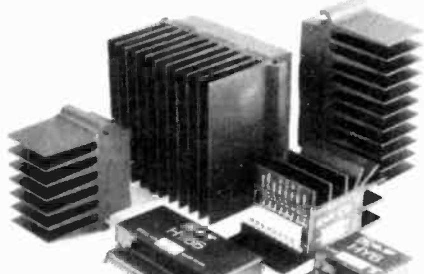
COMPACT DISCS?

Perhaps the most relevant question at present is whether or not you should buy an analogue disc system now at all, or go straight for the incoming Compact Disc systems. Our advice would be to wait. While the Compact Disc is of undoubtedly higher quality than any vinyl spinner, the price is horrendous at present, and the records are expensive and very limited in choice.

In about a year the players will be cheaper by far, the choice much wider and the software library five times the size. If you like the music offered and love the gadgets — go buy it. Which one you get is probably irrelevant, as there should not be a whole lot of difference in performance between properly designed units, despite the ad claims.

ETI

GET BIG POWER



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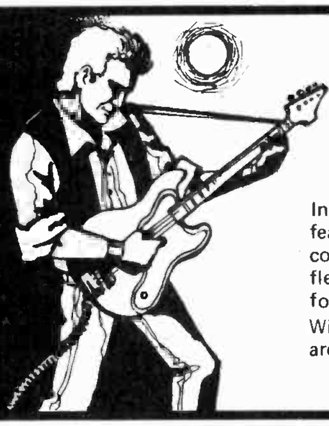

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BIPOLAR MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	DISTORTION I.M.D. 60Hz/7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
HY30	15	4-8	0.015%	<0.006%	± 18	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	± 25	76 x 68 x 40	240	£9.55
HY6060	30 + 30	4-8	0.015%	<0.006%	± 25	120 x 78 x 40	420	£18.69
HY124	60	4	0.01%	<0.006%	± 26	120 x 78 x 40	410	£20.75
HY128	60	8	0.01%	<0.006%	± 35	120 x 78 x 40	410	£20.75
HY244	120	4	0.01%	<0.006%	± 35	120 x 78 x 50	520	£25.47
HY248	120	8	0.01%	<0.006%	± 50	120 x 78 x 50	520	£25.47
HY364	180	4	0.01%	<0.006%	± 45	120 x 78 x 100	1030	£38.41
HY368	180	8	0.01%	<0.006%	± 60	120 x 78 x 100	1030	£38.41

Protection: Full load line. Slew Rate: 15v/μs. Risetime: 5μs. S/N ratio: 100db.
Frequency response (−3dB) 15Hz — 50KHz. Input sensitivity: 500mV rms.
Input Impedance: 100K Ω . Damping factor: 100Hz >400.

PRE-AMP SYSTEMS

Module Number	Module	Functions	Current Required	Price inc. VAT
HY6	Mono pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble	10mA	£7.60
HY66	Stereo pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble/Balance	20mA	£14.32
HY73	Guitar pre amp	Two Guitar (Bass Lead) and Mic + separate Volume Bass Treble + Mix	20mA	£15.36
HY78	Stereo pre amp	As HY66 less tone controls	20mA	£14.20

Most pre-amp modules can be driven by the PSU driving the main power amp. A separate PSU 30 is available purely for pre amp modules if required for £5.47 (inc VAT). Pre-amp and mixing modules in 18 different variations. Please send for details.

Mounting Boards
For ease of construction we recommend the **B6** for modules HY6—HY13 £1.05 (inc. VAT) and the **B66** for modules HY66—HY78 £1.29 (inc. VAT).

MOSFET MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	DISTORTION I.M.D. 60Hz/7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£30.41
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	1025	£45.54

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).
Slew rate: 20v/μs. Rise time: 3μs. S/N ratio: 100db
Frequency response (−3dB): 15Hz — 100KHz. Input sensitivity: 500mV rms
Input impedance: 100K Ω. Damping factor. 100Hz >400.

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Input Sensitivity and impedance (selectable) 700mV rms into 15KΩ 3V rms into 8Ω
Size 95 x 48 x 50mm. Weight 256 gms.

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Stereo version of C15.
Size 95 x 40 x 80. Weight 410 gms.

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POWER SUPPLY UNITS (Incorporating our own toroidal transformers)

Model Number	For Use With	Price inc. VAT
PSU 21X	1 or 2 HY30	£11.93
PSU 41X	1 or 2 HY60, 1 x HY6060, 1 x HY124	£13.83
PSU 42X	1 x HY128	£15.90
PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

Model Number	For Use With	Price inc. VAT
PSU 52X	2 x HY124	£17.07
PSU 53X	2 x MOS128	£17.86
PSU 54X	1 x HY248	£17.86
PSU 55X	1 x MOS248	£19.52
PSU 71X	2 x HY244	£21.75

Model Number	For Use With	Price inc. VAT
PSU 72X	2 x HY248	£22.54
PSU 73X	1 x HY364	£22.54
PSU 74X	1 x HY368	£24.20
PSU 75X	2 x MOS248, 1 x MOS368	£24.20

Please note: X in part no. indicates primary voltage. Please insert "O" in place of X for 110V, "1" in place of X for 220V, and "2" in place of X for 240V.

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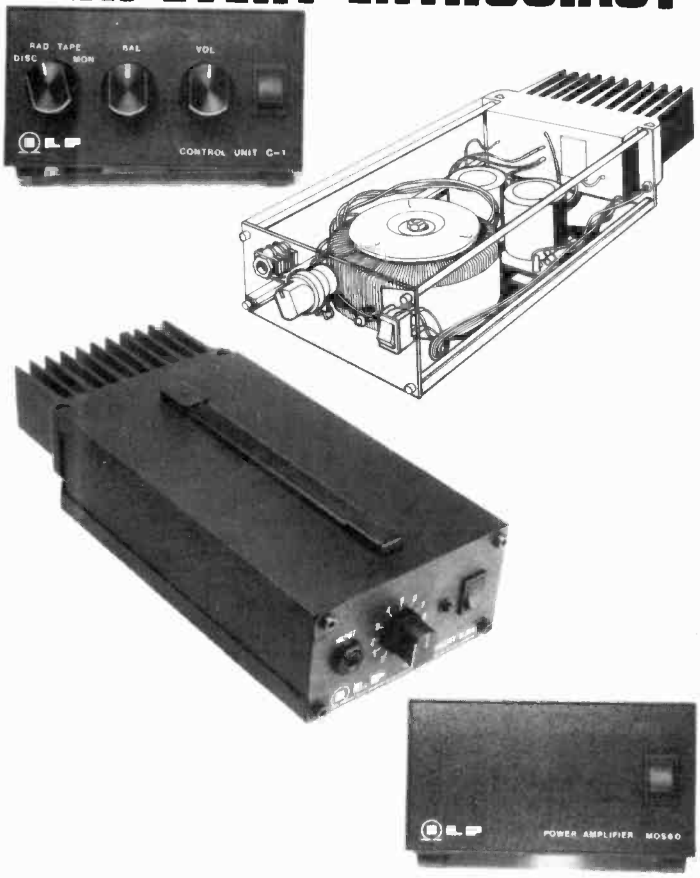

Unicase

Over the years ILP has been aware of the need for a complete packaging system for it's products, it has now developed a unique system which meets all the requirements for ease of assembly, adaptability, ruggedness, modern styling and above all price.

Each Unicase kit contains all the hardware required down to the last nut and bolt to build a complete unit without the need for any special tools.

Because of ILP's modular approach, "open plan" construction is used and final assembly of the unit parts forms a compact aesthetic unit. By this method construction can be achieved in under two hours with little experience of electronic wiring and mechanical assembly.

Hi Fi Separates

UC1 PRE AMP UNIT: Incorporates the HY78 to provide a "no frills", low distortion, (<0.01%), stereo control unit, providing inputs for magnetic cartridge, tuner, and tape/monitor facilities. This unit provides the heart of the hi fi system and can be used in conjunction with any of the UP Unicase series of power amps. For ultimate hum rejection the UC1 draws its power from the power amp unit.

POWER AMPS: The UP series feature a clean line front panel incorporating on/off switch and concealed indicator. They are designed to compliment the style of the UC1 pre-amp. Performance for each unit which includes the appropriate power supply, is as specified on the facing page.

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Our power slaves, which have numerous uses i.e. instrument, discotheque, sound reinforcement, feature in addition to the hi fi series, front panel input jack, level control, and a carrying handle. Providing the smallest, lowest cost, slave on the market in this format.

UNICASES

HIFI Separates					**Price inc. VAT**
UC1	Preamp				£29.95
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UP2X	60W/4Ω	Bipolar	Mono	HiFi	£54.95
UP3X	60W/8Ω	Bipolar	Mono	HiFi	£54.95
UP4X	120W/4Ω	Bipolar	Mono	HiFi	£74.95
UP5X	120W/8Ω	Bipolar	Mono	HiFi	£74.95
UP6X	60W/4–8Ω	MOS	Mono	HiFi	£64.95
UP7X	120W/4–8Ω	MOS	Mono	HiFi	£84.95
Power Slaves					
US1X	60W/4Ω	Bipolar	Power	Slave	£59.95
US2X	120W/4Ω	Bipolar	Power	Slave	£79.95
US3X	60W/4–8Ω	MOS	Power	Slave	£69.96
US4X	120W/4–8Ω	MOS	Power	Slave	£89.95

Please note X in part number denotes mains voltage. Please insert 'O' in place of X for 110V, '1' in place of X for 220V (Europe), and '2' in place of X for 240V (U.K.) All units except UC1 incorporate our own toroidal transformers.

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ZX81 MUSIC BOARD

With the circuit and construction covered last month, we now turn to the software routines that enable you to use this project to the full. Design and development by M. P. Moore.

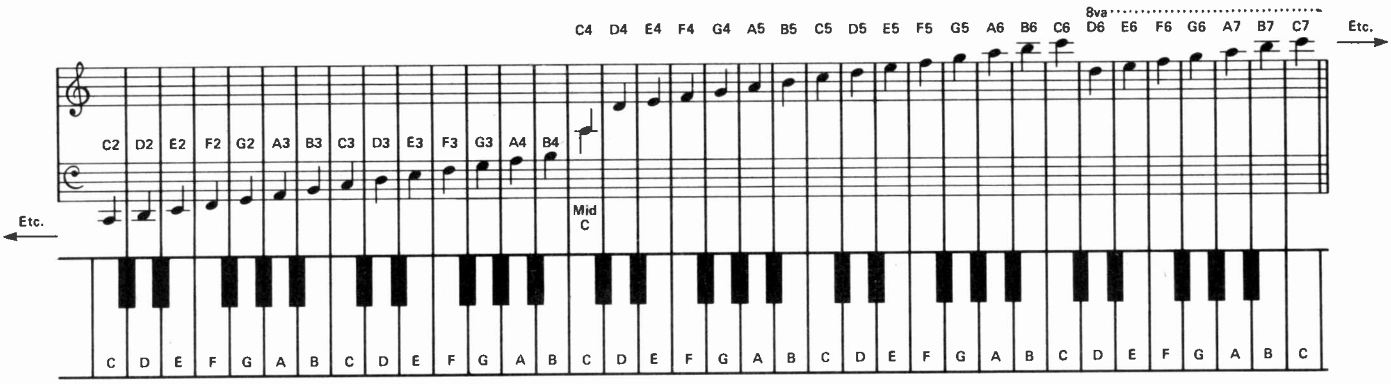


Fig. 1 Table of notes as used by the input routine.

THE MUSIC

```
1    REM (our machine code)
2    CLS
5    DIM H(7)
10   FOR N = 1 TO 7
15   LET H(N) = 76
20   NEXT N
25   PRINT "CLEAR MUSIC SPACE
     (Y OR N) OR PLAY (P) OR
     LIST (L)?"
30   IF INKEY$ = "N" THEN
     GOTO 55
31   IF INKEY$ = "P" THEN
     GOTO 200
33   IF INKEY$ = "L" THEN
     GOTO 350
35   IF INKEY$ < >"Y" THEN
     GOTO 30
36   FAST
40   FOR N = 16670 TO 21670
45   POKE N,255
50   NEXT N
51   SLOW
55   PRINT "SHARPS?";
60   LET Z = 78
65   GOSUB 1150
100  PRINT "FLATS?";
105  LET Z = 74
110  GOSUB 1150
136  CLS
137  PRINT "EDIT FROM LINE
     NO.";
140  INPUT Z
141  PRINT Z
142  PRINT AT 21,0;Z; " [3 SPC]";
143  LET X = 0
144  FOR D = (Z - 1)*6 + 16670
     TO 21670 STEP 2
148  SLOW
149  GOSUB 1000
150  IF N$< >"5" THEN GOTO
     155
151  LET Z = Z - 2
152  LET D = D - 8
153  LET X = 2
154  GOTO 170
155  IF N$ = "R" THEN GOTO
     510
156  IF N$ = "E" THEN GOTO
     136
157  IF N$ = "P" THEN GOTO
     200
158  IF N$< >"0" THEN GOTO
     163
159  POKE D,0
160  POKE (D + 1),0
161  PRINT "[6 SPC]";
162  GOTO 170
163  IF N$ = "L" THEN GOTO
     350
164  POKE D,N
165  POKE (D + 1),H
170  GOSUB 2000
185  NEXT D
200  CLS
201  PRINT "SET VOLUMES (Y OR
     N), EDIT (E)", "OR LIST (L)?"
202  SLOW
205  IF INKEY$ = "Y" THEN
     GOTO 215
206  IF INKEY$ = "E" THEN
     GOTO 136
207  IF INKEY$ = "L" THEN
     GOTO 350
208  IF INKEY$ = "N" THEN
     GOTO 265
210  GOTO 205
215  PRINT "A=";
220  INPUT S
225  POKE 16540,S
230  PRINT S; "B=";
235  INPUT S
240  PRINT S;" C=";
245  POKE 16541,S
250  INPUT S
255  POKE 16542,S
260  PRINT S
265  PRINT "SPEED?"
270  INPUT S
271  PRINT "PLAY FROM LINE
     NO.?"
272  INPUT D
275  LET D = (D-1)*6+16670
276  CLS
280  RAND USR 16514
281  FAST
282  IF PEEK D = 255 THEN
     GOTO 299
283  POKE 16561, (PEEK D)
284  LET D = D + 1
285  POKE 16562, (PEEK D)
286  LET D = D + 1
287  POKE 16563, (PEEK D)
288  LET D = D + 1
289  POKE 16564, (PEEK D)
290  LET D = D + 1
291  POKE 16565, (PEEK D)
292  LET D = D + 1
293  POKE 16566, (PEEK D)
294  LET D = D + 1
295  RAND USR 16543
296  PAUSE S
297  POKE 16437,22
298  GOTO 282
299  LET X = 16561
300  FOR D = 1 TO 6
305  POKE X,0
306  LET X = X + 1
307  NEXT D
308  SLOW
310  RAND USR 16543
315  GOTO 200
350  CLS
351  PRINT "LIST FROM LINE
     NO.";
355  INPUT Z
360  PRINT Z
365  PRINT AT 21,0;Z"[3 SPC];
366  FAST
370  LET X = 0
371  LET K = (Z - 1) * 6 + 16734
372  FOR D = (Z - 1) * 6 +
     16670 TO (Z - 1) * 6 +
     16734 STEP 2
375  LET Y = 1
380  LET L = PEEK D
385  LET M = PEEK (D + 1)
386  IF L = 255 AND M = 255
     THEN PRINT " STOP "
387  IF L = 255 AND M = 255
     THEN GOTO 491
388  IF L = 0 AND M = 0 THEN
     PRINT "[3 SPC];
389  IF L = 0 AND M = 0 THEN
     GOTO 470
390  LET L = L + M * 256
395  IF L< 1966 THEN LET Y = Y
     + 1
400  IF L< 1966 THEN LET L = L
     * 2
405  IF L< 1966 THEN GOTO 395
410  LET M = L/256
415  LET M = INT M
```

The music program allows the ZX81 to play up to three notes simultaneously. The range is from A octave 1 upwards, where middle C is C4 (see Fig. 1). There is sufficient memory space with a 16K expansion to enter 833 chords of music. Everything possible has been done to facilitate the entering of music. The key signature (sharps or flats) is set to begin with and remains set until changed; changes may be made during the entering of music; each of the three channels has an independently set volume; the same note repeated on one channel will give a continuous note, but if played on alternating channels, will give a repetitive note.

The symbols used are + (sharp), – (flat) and = (natural). The functions available are **EDIT,** which is used for entering and editing music already entered, and includes **BACKSPACE** and **REPEAT** functions; **LIST,** which allows you to read the music entered, and **PLAY.**

Program "M" is very long and takes about five minutes to load. Having loaded the program the sequence of operations is as follows:-

Type **GOTO 2 NEWLINE.**
The computer will ask: **CLEAR MUSIC SPACE (Y OR N) OR PLAY (P) OR LIST (L)?**
The second and third functions don't interest us at the moment, and since the music space is clear to start with, type **N.**
The computer now asks **SHARPS?**
If the key signature contains sharps, type them in (in any order) followed by **NEWLINE.**
If there are no sharps type **0 NEWLINE.**
The computer now asks **FLATS?**
Deal with the question as for sharps.
The computer asks **EDIT FROM LINE NO.**
Since you are starting from scratch enter **1 NEWLINE.**
The computer is now ready to accept up to 833 'lines' of music. A

BUYLINES

Petron Electronics supply a full kit of parts for this project; we must apologise to them and any purchasers of the kit for the incorrect price given last month. The complete kit including PCB, all components, comprehensive user's manual and the software cassette containing this month's programs, costs £24.95 all inclusive. The board is also available ready-built together with manual and cassette, for £29.95, or in a smart ABS plastic case for only £34.90. Please state whether you require the board to be wired for mono or stereo. A demonstration cassette is available for 95p all inclusive, while the manual may be purchased separately for £1.25, refunded upon subsequent purchase of a kit. Petron Electronics may be found at 1 Courtlands Road, Newton Abbot, Devon.

PROGRAM

```
420   IF L > = 256 THEN LET L = L
      - 256
425   IF L> = 256 THEN GOTO
      420
430   POKE 16619,L
435   POKE 16620,M
440   LET L = USR 16608
445   LET L = L/4
450   LET M = INT L - 19
454   LET M = INT M
455   IF M = 37 AND INT
      L< >L THEN LET Y =
      Y - 1
456   IF M = 37 THEN LET M = 44
460   PRINT CHR$ M;
465   IF INT L<   L THEN PRINT
      "+";
466   IF INT L = L THEN PRINT
      "=";
468   PRINT Y;
470   PRINT "[3 SPC]";
471   IF D = K THEN GOTO 491
472   GOSUB 2000
490   NEXT D
491   SLOW
495   PRINT AT 0,0;
496   IF INKEY$ = "E" THEN
      GOTO 136
500   IF INKEY$ = "P" THEN
      GOTO 200
501   IF INKEY$ = "L" THEN
      GOTO 350
505   GOTO 496
510   PRINT "REPEAT FROM LINE
      NO.?"
511   SCROLL
515   INPUT C
516   LET E = D
517   FAST
520   FOR C = C TO (Z - 1)
525   LET Q = (C-1) * 6 + 16670
530   FOR E = E TO E + 5
531   IF E = 21670 THEN GOTO
      200
535   POKE E,PEEK Q
540   LET Q = Q + 1
545   NEXT E
550   PRINT "DITTO";
552   LET X = 2
555   GOSUB 2000
560   NEXT C
561   LET D = (E - 2)
562   SLOW
565   GOTO 185
1000  INPUT N$
1001  IF N$ = "R" OR N$ = "5"
      OR N$ = "0" OR N$ = "P"
      OR N$ = "L" OR N$ = "E"
      THEN RETURN
1002  IF N$(1) < "A" OR
      N$(1) > "G"THEN GOTO
      1000
1005  IF LEN N$ <2 THEN GOTO
      1000
1008  FAST
1009  LET H = CODE N$ — 37
1010  IF LEN N$ 2 THEN GOTO
      1030
1015  IF N$ (2) = "—" THEN LET
      H(H) = 74
1020  IF N$(2) = "+" THEN LET
      H(H) = 78
1025  IF N$(2) = " = " THEN LET
      H(H) = 76
1030  LET N = CODE N$
1035  LET N = N * 4
1036  IF N = 160 AND H(H) = 74
      OR N = 172 AND H(H) = 74
      THEN LET N = N - 2
1040  LET N = N + H(H)
1045  POKE 16581,N
1050  LET N = USR 16567
1055  PRINT N$(1);
1057  IF H(H) = 78 THEN PRINT
      "+";
1058  IF H(H) = 76 THEN PRINT
      "=";
1059  IF H(H) = 74 THEN PRINT
      "_";
1060  IF LEN N$ = 2 THEN LET H
      = CODE N$(2)
1065  IF LEN N$ = 3 THEN LET H
      = CODE N$(3)
1066  PRINT CHR$ H; "(3 SPC)";
1067  LET H = H - 28
1070  LET H = H-H-H
1075  FOR H = H TO -1
1080  LET N = N/2
1085  NEXT H
1086  LET N = N * 2
1090  LET N = INT N
1095  LET H = N/256
1100  LET H = INT H
1105  IF N> = 256 THEN LET N =
      N - 256
1110  IF N> = 256 THEN GOTO
      1105
1115  RETURN
1150  INPUT H$
1155  IF H$ <"A" AND H$<>"0"
      OR H$ > "G" THEN GOTO
      1150
1160  IF H$ = "0" THEN RETURN
1165  FOR N = 1 TO LEN H$
1170  LET H = CODE H$(N)
1175  LET H = H - 37
1180  LET H(H) = Z
1185  NEXT N
1190  PRINT H$
1195  RETURN
2000  LET X = X + 1
2005  IF X<3 THEN RETURN
2010  LET X = 0
2015  LET Z = Z + 1
2020  SCROLL
2025  SCROLL
2030  PRINT Z; "[3 SPC]";
2035  RETURN
```

Machine code at line 1:-

```
3E  07  D3  FF  3E  38  D3  F7
21  9C  40  01  08  03  79  D3
FF  0C  5E  7B  D3  F7  23  10
F5  C9  xx  xx  xx  21  B1  40
01  00  06  5E  79  D3  FF  7B
D3  F7  23  0C  10  F5  C9  xx
xx  xx  xx  xx  xx  3E  07  D3
FF  3E  78  D3  F7  3E  0E  D3
FF  01  FB  xx  78  04  D3  F7
3E  0F  D3  FF  ED  58  3E  0E
D3  FF  78  D3  F7  3E  0F  D3
FF  ED  50  D5  C1  C9  3E  07
D3  FF  3E  78  D3  F7  06  FE
21  xx  xx  7D  E6  80  6F  3E
0E  D3  FF  78  D3  F7  3E  0F
D3  FF  DB  FB  E6  80  BD  28
05  05  05  18  EA  00  3E  0E
D3  FF  04  78  D3  F7  3E  0F
D3  FF  DB  FB  BC  20  E9  05
48  06  00  C9
```

Approximately 5,000 memory positions are reserved here for music.

HOW IT WORKS — MUSIC PROGRAM

Array H is a one-dimensional seven-position array which is used to keep a record of whether each note A - G is natural, sharp or flat. Lines 5 to 20 load the value for natural (76) into each position of array H. Lines 25 to 35, depending on the answer typed in, make the computer jump accordingly or continue from line 36. Lines 36 to 51 clear the memory space set aside for music by POKEing the stop code 255 to each memory location reserved. In conjunction with the BASIC subroutine at lines 1150 to 1195, lines 55 to 110 set the initial key signature by making the value of the appropriate position of H equal 78 for sharps and 74 for flats. Lines 137 to 142 make Z equal to the current line number for entering and editing music. Variable X is used to keep a record of which channel note you are currently entering. Line 144 sets up a loop using D where D starts with the address of the memory space corresponding to line number (Z) and ends with the value 21670, which is the last available music space. Line 149 calls the BASIC subroutine at line 1000. This subroutine inputs a key-press or series of key-presses which will either be note data, silence or one of the five available functions: REPEAT (R), BACKSPACE (5), PLAY (P), LIST (L) or EDIT (E). If silence or one of the functions is entered the computer returns to line 150.

If note data was entered the computer continues at line 1002 with a check that the data entered was in fact valid note data. Line 1009 makes variable H equal to the code of the note entered minus 37. If the data entered does not contain an appending sharp, flat or natural sign, line 1010 makes the computer jump to line 1030. Lines 1015 to 1025 adjust array H accordingly (sharp, flat or natural) depending on the second character of N$ (ie N$ (2)). Lines 1030 to 1040 load the variable N with the code of the note entered (ie N$(1)) and adjust this value together with corrective maths depending on the note (sharp, flat or natural) stored in array H to provide the address of the basic note data in the pre-programmed PROM. Lines 1045 to 1050 POKE this data to memory position 16581 and a machine code subroutine based at 16567 returns N with the basic tone period value of this note, ie the lowest octave. Lines 1055 to 1059 print the note and its sign on the screen. Lines 1060 to 1065 make variable H equal to the code of the octave number entered depending on whether N$ is two or three characters long. Line 1066 prints the octave. Lines 1067 to 1075 correct the value of H and set up a loop using H where H = H to – 1. This loop is used to divide the basic data in N by 2 (this has the effect of raising the note one octave each time N is divided by 2) until the correct tone period data is obtained. Line 1086 corrects the tone period value of N, otherwise it would be one octave too high. Lines 1095 to 1110 set H to equal the most significant byte of the note and N to equal the least significant byte.

Line 115 returns the computer from this subroutine at line 1001 because:-

1) BACKSPACE function (5) was entered; it runs through lines 151 to 154 adjusting the values of Z, D and X to effect a backspace. Lines 155 to 157 check to see if the computer was returned with functions R, E or P and if so, it jumps accordingly.
2) If 0 was entered, the computer runs through lines 159 to 162 entering silence in the current note position and printing spaces in that note position on the screen.
3) If L was entered, the computer jumps to line 350 to list data.
4) If P was entered, the computer jumps to line 200 to play the music.
5) If E was entered, the computer goes back to line 136 to restart the edit function.
6) If R was entered, the computer jumps to line 510.
7) If note data was entered, the computer runs through lines 164 and 165 which POKE the tone period data in the current memory position.

Line 170 calls a BASIC subroutine located at 2000. This subroutine simply checks whether or not the data just dealt with was the third note of a chord, and if so, scrolls the screen up two lines and prints a new line number before returning. Line 185 causes the computer to loop back to line 144 ready to enter the next string of music data. If all the available memory space were taken up, the computer would fall through line 185 and actuate the section of the program which plays music from line 200.

Had the R function returned the computer from the subroutine at 1002 the computer would have jumped to line 510 which puts the question FROM CHORD NO. ? Lines 511 to 565 perform a block copy of the lines specified and adjust the display accordingly. Lines 200 to 210 ask whether you want to set channel volumes, or edit or list. If the answer is E the computer jumps back to the EDIT program at line 136; if L is entered the computer jumps to the LIST program at line 350; if you didn't want to set the volumes so that the answer was N, the computer jumps to line 265. Lines 215 to 260 input volumes for the three channels A, B and C and POKE the volumes required to memory locations 16540, 16541 and 16542 respectively. Lines 265 to 270 input the value of the pause used in line 296 to regulate the speed at which music is played. Line 276 sets D to the address of the first memory position containing music data. Line 280 calls a machine code subroutine based at line 16514 which initialises the PSG for three channels of sound. This subroutine programs the PSG with the volumes held in memory locations 16540 to 16542. Line 282 checks the current music memory position for the STOP code (255) and if this position equals 255 it identifies this as the end of the music, and the computer jumps to 299. Lines 283 to 294 POKE to memory positions 16561 to 16566 the six bytes of tone period data for the next chord to be played.

It may be thought that memory space could have been saved by making lines 283 to 294 a loop. This proved, however, to have an unacceptable slowing effect on the maximum speed available (ie 0). Line 295 calls a machine code subroutine which relays the data in memory position 16561 to 16566 to the PSG, thus producing the next chord. Line 296 is the pause regulating the speed using the variable S and, since this program section is run in the FAST mode, line 297 POKEs Sinclair's obligatory 255 to memory position 16437. Line 298 causes the computer to jump back to line 282 to continue with the next chord. As we have seen, when the end of the music is reached, the computer jumps to line 299. Lines 299 to 307 load the silence value 0 to memory positions 16561 through 16566 and line 310 outputs this last set of data to the PSG using the above-mentioned machine code subroutine located at 16543. Line 315 then causes the computer to jump back to line 200.

The LIST (L) function starts at line 350. Lines 351 to 365 input and print the line number that is being listed which is held in variable Z. Variable X is used to keep a record of which channel data is being calculated. Line 371 sets the variable K to the memory address of the last note data to be listed in one full screen (providing a STOP code 255 is not encountered first). Line 372 sets variable D up in a loop, where D starts with the value of the first music location to be listed and thereafter holds the current memory position of data being calculated. Variable Y is used to keep a record of the octave as it is being calculated in lines 395 to 405. Lines 380 to 385 set variables L and M to the value of the data for the current note being listed. Lines 386 and 387 check for the STOP code 255 in variables L and M, and if it is detected the computer prints STOP and jumps to line 491. Lines 388 and 389 check for silence (0) and if detected the computer prints spaces and then jumps to line 470. Line 390 sets variable L to the value of the complete tone period. Lines 395 to 405 calculate the octave in Y by multiplying the value of L by 2 until it is within range of the basic octave values (ie greater than or equal to 1966).

Lines 410 to 425 reconstitute this new data into variables L and M. At this point the number held in L and M will be the same as a number in the basic octave of notes in the pre-programmed PROM. Lines 430 to 435 POKE this data to memory positions 16619 and 16620. Line 440 calls up a machine code subroutine which returns with L set to the memory position of the PROM where the note data POKEd in lines 430 and 435 is to be found. Lines 445 to 455 reconstitute the value of L in variable M so that M contains the Sinclair code for the correct note A to G. Line 456 runs a check on variable M, so that if M = 37 (ie G sharp) the computer, rather than printing 9, prints G (code 44). Line 460 prints the note thus calculated. Line 465 checks the value of L to see if it is a whole number. If it is not, due to the maths in lines 445 to 455, the note will be a sharp and line 465 prints + (sharp). Line 466 likewise checks to see if L is a whole number, and if it is, prints the sign for natural (=). Line 467 checks for the note being G sharp and corrects the octave value in Y accordingly. Lines 468 to 470 print the octave and the next three spaces. When a screen-full of data has been listed, D will equal K. Line 471 checks for this and if D = K the computer jumps to line 491. As with the EDIT function (E), the LIST function uses the subroutine at line 2000 to keep the VDU display correct. When it has finished listing music the computer continues at line 491. At lines 495 to 505 the computer waits for a further command EDIT (E), PLAY (P) or LIST (L), and jumps accordingly.

THIS BAR SHOULD BE ENTERED AS FOLLOWS

LINE No.	Ch1	Ch2	Ch3
1	E4 NEWLINE	0 NEWLINE	0 NEWLINE
2	C5 NEWLINE	0 NEWLINE	0 NEWLINE
3	C5 NEWLINE	0 NEWLINE	0 NEWLINE
4	E4 NEWLINE	0 NEWLINE	0 NEWLINE
5	C5 NEWLINE	0 NEWLINE	0 NEWLINE
6	C5 NEWLINE	0 NEWLINE	0 NEWLINE
7	E4 NEWLINE	0 NEWLINE	0 NEWLINE
8	C5 NEWLINE	0 NEWLINE	0 NEWLINE

Fig. 2 Calculation of the number of lines in a bar.

'line' of computer music is a note (or silence) entered in each of the three channels A, B and C. Channels A and B are played through one audio output and C through the other if a stereo amplifier is used.

When copying music you must find the shortest note in the score: longer notes must be converted to the equivalent multiple of the shortest note to find the number of computer 'lines' in a bar (see Fig. 2). Notes 1, 3, 5 and 6 in the example are half the length of notes 2 and 4. The total number of computer 'lines' in the bar is therefore 8.

A note repeated on the same channel will sound as one continuous note. If the notes are to sound distinct, you must change from one channel to another (see Fig. 3).

Let us go back to our instruction
1 NEWLINE.
The computer is now displaying 1 at the bottom left-hand corner of the screen. It is waiting for notes to be entered in channels A, B and C. Supposing you wish to enter A below middle C in channel A, silence in channel B, and E below middle C in channel C. Type:-

A4 NEWLINE
0 NEWLINE
E3 NEWLINE

The computer now displays on the screen:-

```
1  A = 4            E = 3
2
```

It is now waiting for the second 'line' of music.
Supposing the key signature has been set as 2 sharps (F and C) and the following is now entered:-

C4 NEWLINE
A3 NEWLINE
F3 NEWLINE

The computer now displays on the screen:-

```
1  A = 4            E = 3
2  C + 4   A = 3    F + 3
3
```

The computer has automatically made F and C into sharps, and is now waiting for 'line' 3 of music. If you now want to make C and F natural, type:-

C=4 NEWLINE
A3 NEWLINE
F=3 NEWLINE

The computer now displays on the screen:-

```
1  A = 4            E = 3
2  C + 4   A = 3    F + 3
3  C = 4   A = 3    F = 3
4
```

The computer is waiting for 'line' 4 of music. The same procedure applies, of course, for changing notes from flat to natural and vice-versa.

The **BACKSPACE** function enables you to backspace as required from any point in the music. The instruction is:-
5 NEWLINE.
The **REPEAT** function allows the repetition of line(s) from the line specified to the line you have reached. Instruction:- **R NEWLINE.**
The computer will ask:-
FROM CHORD NO.
Type in the line number from which you wish to repeat, followed by **NEWLINE.**
The computer will now repeat the line(s) requested.

PLAYING of music is effected through the instruction:-
P NEWLINE
Wait for the screen to clear. The computer will now print:-
SET VOLUMES (Y OR N) OR EDIT (E) OR LIST (L)?
If you want to play the music and have not already set the volumes, type **Y.**
The computer now prints:- **A =**
Volumes range from 0 (silence) to 15 (loudest).
Type in the volume you require for channel A, followed by **NEWLINE.**
The computer repeats the question for channel B, and when dealt with, C. It will then print:- **SPEED?**
Speeds vary from 0 (fastest) upwards where 50 is approximately one second per computer 'line' or chord. Type in the speed you require, followed by **NEWLINE** and the computer will ask **PLAY FROM LINE NO. ?**
This question is answered by typing in the line number you wish the computer to start playing from. To start at the beginning type **1** followed by **NEWLINE:** the computer will now play the music you have entered.

When the music ends, the computer will ask:-
SET VOLUMES (Y OR N) OR EDIT (E) OR LIST (L)?

LINE No.	Ch1	Ch2	Ch3
1	G4 NEWLINE	0 NEWLINE	0 NEWLINE
2	G4 NEWLINE	0 NEWLINE	0 NEWLINE
3	0 NEWLINE	G4 NEWLINE	0 NEWLINE
4	G4 NEWLINE	0 NEWLINE	0 NEWLINE
5	G4 NEWLINE	0 NEWLINE	0 NEWLINE
6	0 NEWLINE	G4 NEWLINE	0 NEWLINE
7	G4 NEWLINE	0 NEWLINE	0 NEWLINE
8	G4 NEWLINE	0 NEWLINE	0 NEWLINE
9	G4 NEWLINE	0 NEWLINE	0 NEWLINE

Fig. 3 Example of repetitive notes.

If you want to play the music again without changing the volumes, type **N** and the computer asks:- **SPEED?**
Enter the speed as before and the music will be played again.
If however you wish to change the volumes or one or more channels, type **Y** and proceed as before.

LISTING of music entered is effected by typing **L NEWLINE** and the computer will ask:- **LIST FROM LINE NO.** Type in the line you wish to start listing from, followed by **NEWLINE.**
The screen will go grey for about 20 seconds and then the computer will have printed 11 lines of music, starting from the line number you typed. You may now type **P** or **E** or **L** depending on which function you wish to use; to continue listing type **L** and give the line number that would carry on from where the first listing ended; to make alterations to the music or to enter more music, type **E,** and to play the music, type **P.**

Devising Your Own Sound Effects

The third program on the software cassette effectively gives you direct access to the registers in the PSG. These registers are programmed with data to build up sound effects. The following is a short summary of the registers used and their functions.

Registers 0 to 5 determine the pitch (frequency) of the three notes on channels A, B and C. Registers 0, 2 and 4 are used to fine-tune the frequency of A, B and C respectively. Registers 1, 3 and 5 coarse-tune the frequencies. Data to the fine tune registers can vary from 0 to 255, and data to the coarse tune registers from 0 to 15. Register 6 can vary from 0 to 31. This sets the pitch of any white noise to be included. Register 7 is the enable register. Bits D0 to D5 enable noise and/or sound on channels A, B and C. 0 in a bit of

D7	D6	D5	D4	D3	D2	D1	D0
0	0	C	B	A	C	B	A
		WHITE NOISE			NOTES		

Fig. 4 The functions of the bits in PSG register 7.

this register enables a function, 1 disables it (see Fig. 4).
Registers 8, 9 and 10 set the volumes of channels A, B and C respectively. These can vary from 0 (off) to 15 (loudest). If you send the number 16 to any of these registers, the volume of channels thus set will be varied according to data in registers 11, 12 and 13, the envelope generator, as follows.
Register 11 is used to fine-tune the envelope period; data sent to this register can vary from 0 to 255.
Register 12 is used to coarse-tune the envelope period and data to this register can also vary from 0 to 255.
Register 13 selects the shape of the envelope generator's waveform (Fig. 5).

Now, connect up your amplifier, keeping the volume fairly low, and load the third program ("D") from the software cassette.
Type **GOTO 2 NEWLINE.** The computer will now print:-

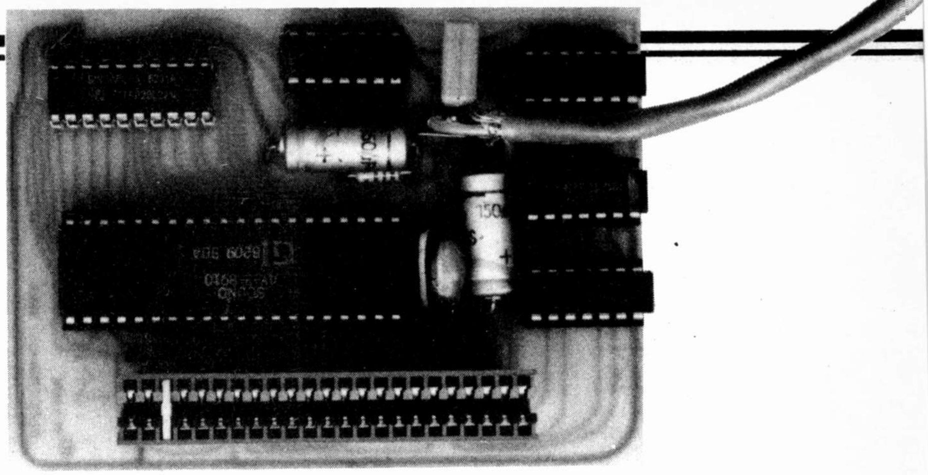
YOU HAVE A CHOICE OF:
A (TO HEAR THE SOUND AGAIN)
R (TO ENTER ALL NEW DATA)
C (TO CHANGE SPECIFIC DATA)
L (TO LIST DATA)
S (TO SILENCE THE PSG)

Since you have not yet entered any data, type **R.** The screen will clear and the computer now prints:-
REGISTER 0 DATA?
Type in **0** as the data for register 0, followed by **NEWLINE.**
The computer will respond:-
REGISTER 1 DATA?
Type in **0** as the data for register 1, followed by **NEWLINE.** The computer will continue to request data for all registers in this manner.
As an example, give it the following:-

Reg.	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Data	0	0	0	0	0	0	31	7	16	16	16	255	40	9

If you examine the data you have just entered, you will see how the computer generated the sound of cannon_fire. This data for cannon fire is contained in the PROM. The computer now repeats the question at the beginning of the program. If you type **A**, the computer will repeat the sound and will again ask the same question.

Now type **C**. The computer will respond with:- **REGISTER?**



This little board does all the hard work.

Type **6 NEWLINE.** The computer will now ask:- **DATA?**
Type **8 NEWLINE.** In response to the next question **REGISTER?** type **12 NEWLINE** and in response to **DATA?** type **5 NEWLINE.**
Now type **99 NEWLINE.**
You have just changed the data in the computer to generate a rifle shot. If you now type **L** the computer will list the data for you.
You can silence a continuous sound by entering 0 into all register locations. Since doing this would wipe out your sound data, the function **S** for silence is included which will switch the sound off without altering your data.
If you wish to start the sound again, type **A.**

When you have perfected your sound, use the LIST function and copy out the data. You can use your own sounds in your own programs using the fourth program ("G") on the software cassette.

Mixing User And PROM Effects

Having loaded program "G", type **GOTO 10 NEWLINE.** This runs a short program which simplifies the entering of your sound data. The computer asks **HOW MANY SOUNDS?** Type in the number of different sounds of your own that you wish to include in your program, followed by **NEWLINE.**
The computer display will now look like this:-
HOW MANY SOUNDS?
SOUND No. 1
REG.0 DATA?
Type in the data for register 0 in your first sound followed by **NEWLINE.** The display will now read:-
HOW MANY SOUNDS?
SOUND No. 1
REG.1 DATA?
Type in the data for register 1, sound 1 as before. When you have entered data for all 14 registers, the display will read:-
HOW MANY SOUNDS?
SOUND No.2
REG.0 DATA?
Continue entering data as before. When all the data for all your sounds has been entered the program will stop.

The user sound data is held in an array called A; in order not to lose this data do *not* use **CLEAR** or **RUN.** When you wish to run a program use the **GOTO** function. Do not use an array called A in your program and don't use variables Y and Z.

The fourth program consists of lines 1 to 9 and 10 through 21. DO NOT ALTER LINES 1 through 9, though if you wish, when you have entered your sound data, you can delete lines 10 through 21. When you wish to use your own sounds in your program simply insert the following two lines:-
LET Z = x
where x is the number of your sound,
GOSUB 2
when your sound will be heard.
You can of course mix your own sounds with the on-board sounds in your programs. Use the on-board sounds in the manner previously described — it is not necessary to load program "S" to do this if you have loaded program "G".

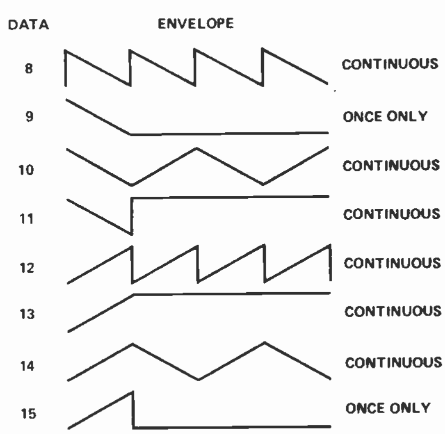


Fig. 5 Envelope diagram for register 13.

HOW IT WORKS — USER EFFECTS

Line 2 dimensions a one dimensional array with 14 positions called A. This array is used to hold the data for the sound effects you are devising. Line 4 makes the computer jump to 200 where it is instructed to print the selection menu. Line 225 makes the computer jump to line 60. Lines 60 to 75 wait for an answer to this question and the computer jumps accordingly. If the function selected was R the computer jumps to line 5. Line 6 sets up a loop using variable D where D = 1 to 14. Line 10 prints the current register number which is held in D and asks what data you wish to go to that register. Lines 15 to 20 input and print the data. Line 25 causes the computer to loop back to line 6 until data for all 14 registers (0 to 13) has been entered. Line 35 again sets up a FOR NEXT loop using D where D equals from 1 to 14 (the PSG register numbers). Line 40 POKEs the register number to memory position 16515 and line 45 POKEs the data for that register to 16519. Line 46 calls a machine code subroutine based at 16514 which outputs to the PSG register (16515) data (16519). Line 50 causes a loop back to line 35 which continues until the data for all 14 registers (0 to 13) has been relayed to the PSG. Line 55 then causes a jump to 200 and a repeat of the initial question.

If the answer to the question at 200 is A, the computer again runs through lines 31 to 55 causing the PSG to repeat the sound. If the answer is C, the computer jumps to line 100. Lines 102 to 110 ask you the number of the register whose data you wish to alter. Line 110 inputs your answer in D and line 111 checks to see if your answer was 99, which would indicate that you had finished altering data for the time being and wished to hear the sound again — in which case the computer would jump to line 30. If your answer was not 99, the computer continues and lines 115 to 125 input and print your new data for the register you gave. Line 130 causes the computer to jump back to line 102 for you to change more data. If your answer was L, you wished the computer to list register data and it would jump to line 150. At line 155 a loop is again set up using D. Line 160 prints the register number (D-1). Line 165 prints the data for that register. Line 170 causes the computer to loop back to line 160, which it continues to do until data for all 14 registers have been displayed. Line 180 makes the computer wait for you to type F, when it will jump to line 30 and your sound will again be heard. If your answer was S, ie the PSG was maintaining a continuous sound and you wished to silence it without losing your data, the computer would jump to 230. Lines 230 to 234 comprise yet another loop using D to output 0 to all PSG registers causing the PSG to become silent.

NOTE: (5 SPC) MEANS "5 SPACES"

```
1    REM (our machine code)
2    DIM A(14)
3    CLS
4    GOTO 200
5    CLS
6    FOR D = 1 TO 14
10   PRINT "REGISTER";
     D-1;"DATA?";
15   INPUT A(D)
20   PRINT A(D)
25   NEXT D
31   CLS
35   FOR D = 1 TO 14
40   POKE 16515,(D-1)
45   POKE 16519,A(D)
46   RAND USR 16514
50   NEXT D
55   GOTO 200
60   IF INKEY$ = "A" THEN
     GOTO 30
61   IF INKEY$ = "S" THEN
     GOTO 230
65   IF INKEY$ = "R" THEN
     GOTO 5
70   IF INKEY$ = "C" THEN
     GOTO 100
71   IF INKEY$ = "L" THEN
     GOTO 150
75   GOTO 60
100  CLS
101  PRINT "TYPE 99 AS A
     REGISTER
     NUMBER [5 SPC] WHEN
     YOU WISH TO HEAR THE
     SOUND."
102  PRINT "WHICH REGISTER?";
110  INPUT D
111  IF D = 99 THEN GOTO 30
112  LET D = D + 1
115  PRINT D - 1; " DATA? ";
120  INPUT A(D)
125  PRINT A(D)
130  GOTO 102
150  CLS
155  FOR D = 1 TO 14
160  PRINT "REGISTER ";D - 1,
165  PRINT "DATA ";A(D)
170  NEXT D
175  SLOW
176  PRINT "PRESS ""F"" WHEN
     YOU HAVE FINISHED"
180  IF INKEY$ <> "F" THEN
     GOTO 180
190  GOTO 30
200  PRINT "YOU HAVE A
     CHOICE OF:"," A (TO HEAR
     THE SOUND AGAIN)"," R
     (TO ENTER ALL NEW
     DATA)"," C (TO CHANGE
     SPECIFIC DATA)"," L (TO
     LIST DATA)"," S (TO
     SILENCE THE P.S.G.)"
225  GOTO 60
230  FOR D = 1 TO 14
231  POKE 16515, (D-1)
232  POKE 16519,0
233  RAND USR 16514
234  NEXT D
235  CLS
236  GOTO 200
```

Machine code in line 1:

```
3E 07 D3 FF 3E 78 D3 F7
21 B4 40 E5 01 FB 0E C5
16 xx 3E 0E D3 FF 7A D3
F7 14 3E 0F D3 FF ED A2
20 F0 C1 E1 16 00 7A D3
FF 5E 7B D3 F7 23 14 10
F5 C9 xx xx xx xx xx xx
xx xx xx xx xx xx xx xx
3E xx D3 FF 3E xx D3 F7
C9
```

HOW IT WORKS — USER/PROM SOUNDS PROGRAM

This program comprises a line of machine code, a subroutine at line 2 and a program to facilitate the entering of user sound data. This latter program is from line 10 to line 21. It sets up an array called A whose size depends on the number of different user sounds to be provided for. Lines 13 through 19 comprise a double loop which inputs the user's sound data into the appropriate position of array A.

The subroutine at line 2 is called when a sound, whose data is in array A, is to be heard. As has been explained, variable Z is set to the number of the user's sound. Line 2 sets up a loop using variable Y where Y = 1 to 14. Line 4 POKEs the register number (Y − 1) to memory position 16579 and line 5 POKEs the data for that PSG register which is already in array A(Z,Y) to memory position 16583. Line 6 calls a machine code subroutine based at 16578. This subroutine outputs the number at memory location 16579 to the PSG to select a register and the number at memory location 16583 to the PSG as data for this register. Line 7 causes the computer to loop back to line 4 until data for all 14 PSG registers has been output. The user can insert instructions 3 FAST and 8 SLOW, but we recommend leaving these out since the operation of a program in FAST mode causes the computer to discontinue maintaining the video display. This would be annoying, especially in games programs.

```
1    REM our machine code
2    FOR Y = 1 to 14
4    POKE 16579, Y - 1
5    POKE 16583, A(Z,Y)
6    RAND USR 16578
7    NEXT Y
9    RETURN

10   PRINT "HOW MANY
     SOUNDS?"
11   INPUT S
12   DIM A (S,14)
13   FOR N = 1 TO S
14   FOR R = 1 TO 14
15   PRINT AT 1,0;"SOUND
     NO.";N
16   PRINT AT
     2,0;"REG."R-1;" DATA? "
17   INPUT A(N,R)
18   NEXT R
19   NEXT N
20   CLS
21   STOP
```

Machine code at line 1:

```
3E xx D3 FF 3E xx D3 F7
C9
```

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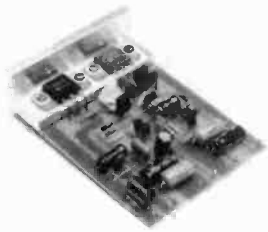

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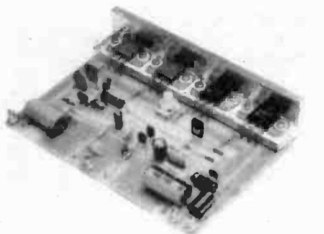

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CONFIGURATIONS

And so to solid state switches. In this month's Configurations Ian Sinclair looks at the basic techniques involving the thyristor and its close relatives.

As a component, the thyristor is so closely related to the diode that thyristor circuits just had to follow the treatment of power supplies last month. Technically, the thyristor is a four-layer diode, but as far as we are concerned, it's a silicon diode that is switched into conduction by a signal at a third electrode, the **gate**, as shown in Fig. 1. In many respects, however, the action is very much that of a normal silicon diode; for example, it will not conduct in the reverse direction (cathode positive), and it has about 0V6 forward drop across the anode-cathode terminal when it conducts. The distinguishing feature is that the start of forward conduction only occurs when a **trigger** pulse arrives at the gate and **fires** the thyristor. Whatever you subsequently do to the gate, the thyristor will continue to conduct until the forward current falls below a value known as the **holding current,** at which point the thyristor will turn off. However, while the thyristor is on, it is as fully conducting as a silicon diode would be.

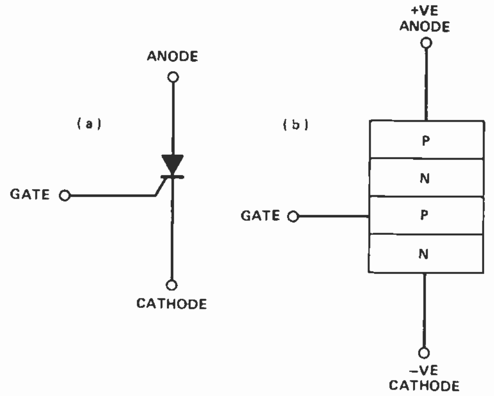


Fig. 1 The thyristor: (a) circuit symbol, (b) arrangement of semiconductor layers.

Triggers Fingered

One point that is not always sufficiently understood is that the triggering requirements can vary enormously from one type of thyristor to another. A lot of small thyristors will trigger for a gate current of only a fraction of a microamp, so that interference signals will trigger the thyristor if the gate terminal is not 'earthed' to the cathode by a low-value resistor. A lot of false triggering of burglar alarms seems to be due to thyristor circuits in which the gate has too high a resistance to the cathode, making the gate circuit a very efficient aerial for any radiated energy! Even when quite low resistance values are used, thyristors can trigger in lightning storms or because of static discharges, so that some careful design of the gate circuit and extensive testing is needed if you are in the alarm business. The combination of low resistance and a suppressor ferrite bead placed at the gate terminal helps a lot! Large thyristors need rather more in the way of gate current, but even these can be triggered by a fraction of a milliamp.

Thyristors are most at home in circuits which use DC or unsmoothed (but rectified) AC. The use of rectified AC is particularly popular (Fig. 2) because the thyristor will

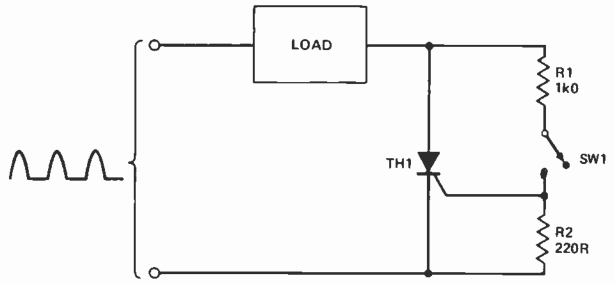


Fig. 2 Elementary switching circuit for use with rectified AC. When the switch is on, current will flow through the load.

switch off each time the supply voltage reaches zero, and all that we need to concentrate our attention on is the triggering which switches it on again. Where a thyristor is used in a DC circuit, there is the extra complication of reducing the voltage across the thyristor to zero in order to switch it off (Fig. 3).

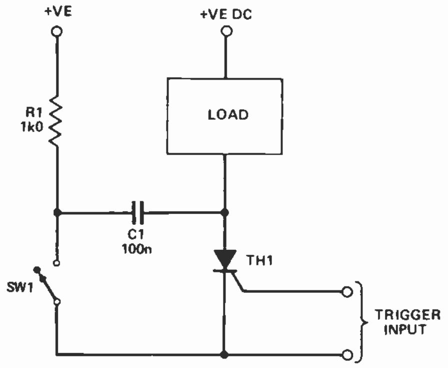


Fig. 3 Turning off a thyristor which is operated from DC. Pressing the switch will discharge the capacitor, pulsing the anode of the thyristor and so stopping the current. This is enough to prevent conduction until the gate is pulsed again.

A Passing Phase

Down to configurations. The most useful basic triggering circuit is the phase-controlled thyristor fed with rectified AC as illustrated in Fig. 4. The load can be placed in the leads to the bridge rectifier, in which case the thyristor will control the average power dissipated in the load,

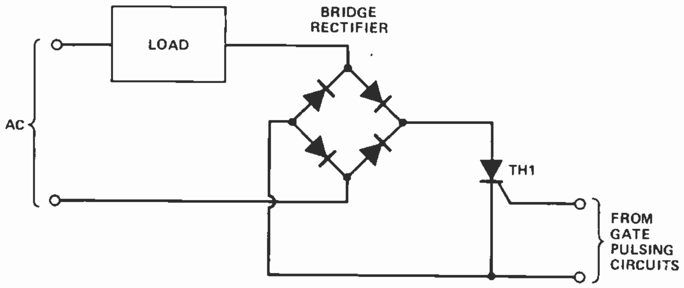


Fig. 4 Basic circuit for thyristor control of an AC circuit, using a bridge rectifier to supply the thyristor. The load, however, operates from AC.

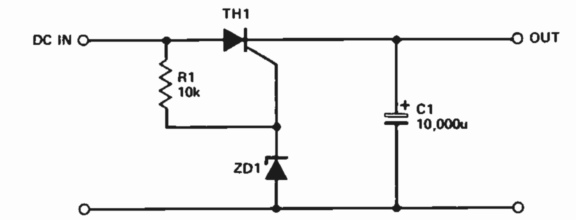


Fig. 5 A thyristor regulator. This makes a very useful pre-stabiliser circuit, or can be used as a stabiliser in its own right where very precise stabilisation is not needed.

despite the fact that the load is working on AC and the thyristor is controlling a rectified supply. An interesting option is to place a reservoir capacitor on the cathode side of the thyristor, giving a low-cost and low-dissipation form of voltage regulation (Fig. 5). The gate control can be obtained from a charging capacitor, as demonstrated in Fig. 6, or from a zener diode as in Fig. 5 — remember that there is no triggering until the gate voltage is about 0V6 above the cathode voltage.

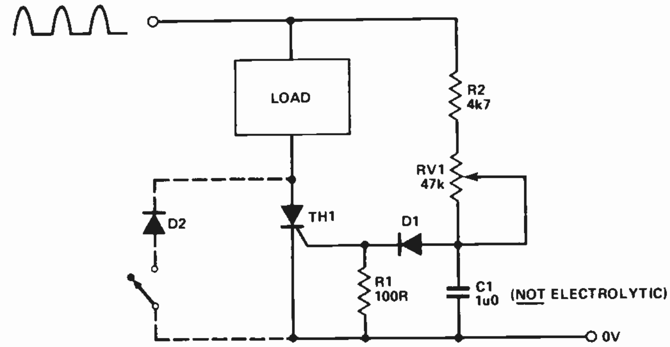


Fig. 6 A typical phase control circuit for AC. The thyristor will conduct on only half of the input wave, so that a 'power-doubler' circuit, which switches a diode across the thyristor in the reverse conduction direction may be needed for a larger range of power control (shown dotted).

Simple triggering from a charging capacitor is never entirely satisfactory, because the thyristor cannot be relied upon to fire at exactly the same stage of charging in each cycle. To get round this, the simpler circuits make use of a trigger diode or **diac** which ensures more reliable triggering. The trigger diode has the curious characteristic that it will remain non-conducting while the voltage across it in either direction builds up, suddenly conduct at some voltage level which is determined by its construction, and remain fully conducting until the voltage across it has dropped almost to zero (Fig. 7). A diac wired between a charging capacitor and the gate of the thyristor, with a load of a few hundred ohms connected between the gate and the cathode to avoid unwanted triggering will serve nicely to make the triggering much more reliable. What you then have to be sure of is that you have enough voltage around to operate the diac — depending on type, you may need up to 15 V across it before it starts to conduct.

The very simple phase-control system operates well enough for a lot of applications, particularly for light dimming, but more care is needed where electric motors are being controlled, mainly because of the back-EMF that motors of the AC/DC type will generate. When any motor of this type is spinning, it will act as a generator of DC (even if the supply to the motor is AC), and the thyristor must be capable of withstanding a reverse voltage which consists of the peak reverse AC plus this additional voltage generated by the motor.

The methods that are used for thyristor control of the

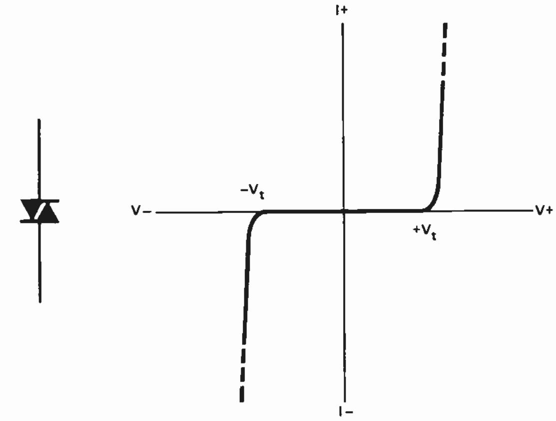


Fig 7. The diac, and its typical characteristic.

larger motors, larger than your domestic power drill/food mixer motor, are a lot more specialised. For these circuits, charging capacitors are simply not precise enough as a method of triggering the thyristor at the correct point in the waveform: more elaborate trigger circuits, synchronised to the mains frequency, have to be used. These pulse-generating circuits can be coupled to the thyristor circuitry by using small pulse transformers, so that the timing circuits need not be connected to the circuits that the thyristor controls. This is particularly important when thyristors are used in high-voltage three-phase circuits, because the thyristors may be operating at voltages well above or below earth, yet the control box needs to be earthed.

Radio interference is a continual problem for any thyristor circuit which makes use of phase control. Because the thyristor is being switched on when there is a substantial voltage across it, there are large current pulses which can be devastating for radio or TV receivers in the neighbourhood and which can also trigger other thyristors. It's essential, therefore, to design really effective pulse-transient suppression into the gate and anode circuits, and to ensure in the practical construction that the suppressors are placed as close as possible to the terminals of each thyristor. In general, small series inductors and

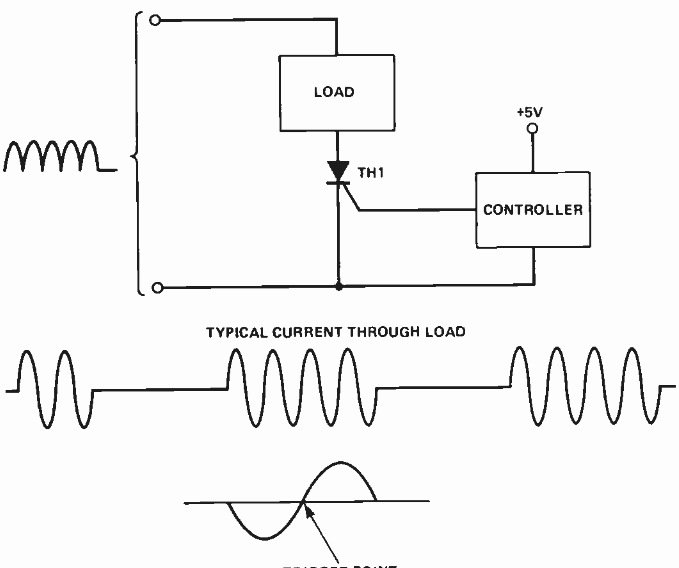


Fig. 8 Principles of zero-voltage switching circuits. The controller (usually an IC) will switch the thyristor on at the point when the AC wave passes through zero. This ensures minimal RF interference, unlike the phase-control method.

parallel capacitors will do all that is needed, but they have to be capable of taking high peak currents, and must be wired close enough to prevent any wiring from acting as a radiating aerial.

The Zero Option

The other way of controlling thyristors in energy-control circuits is seen much less in the small-scale circuits that we tend to be more familiar with. This alternative is zero-voltage switching, and it involves switching the thyristors on at the instant when the voltage between anode and cathode is zero. This has the advantage of generating no more interference than a silicon diode would, which is very much less than is generated by the phase-control circuit: but it can be used only with loads like water-heaters which have very long time constants. If you switch your electric drill motor on for 100 mS in each second, the speed will be rather erratic to say the least, but a water or room heater switched in this way does not cause noticeable fluctuations of temperature because the temperature does not shoot up rapidly when the heater is on, nor shoot down when the heater is off. Figure 8 shows an outline of a typical zero-voltage control circuit — there is an IC which can be used to govern the whole operation.

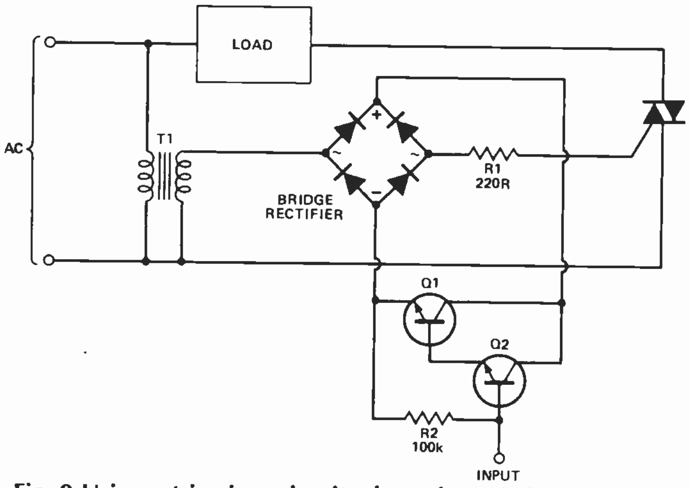


Fig. 9 Using a triac in a circuit where the switching signals are very small. Note that the whole circuit is live to mains.

For My Next Triac . . .

The triac is a two-way equivalent of the thyristor, with the main circuit terminals labelled MT1 and MT2 rather than anode and cathode, since current can flow in either direction through the triac. Like the thyristor, the triac remains non-conducting until it has been triggered by a pulse at its gate terminal; the pulse can be of either polarity, but the minimum amplitude for firing is not the same for the two possible polarities. Again like the thyristor, the triac ceases to conduct when the current through it becomes too low to sustain conduction. Triacs are extensively used to switch raw AC because a triac circuit represents a considerable saving on components as compared to a small thyristor circuit, even if the equivalent triac is more expensive than two thyristors. Figure 9 shows a typical triac circuit for AC use that can operate using a very small triggering input, such as from a microphone or photocell. The transformer supplies a low voltage for the gate circuit, and the rectifier bridge is arranged so that an unsmoothed full-wave rectified voltage is fed to the transistor amplifier circuit. When the transistor conducts, the current flowing in the bridge rectifier will also flow through the gate of the triac, triggering the triac on each half-cycle. The trigger current is AC because the gate is wired in the AC side of the transformer. Note that the whole circuit is connected to mains — if an isolated low-voltage circuit is needed, then the gate must be triggered by a circuit using a pulse transformer rather than directly as in this example, and the part-circuit shown in Fig. 10 is needed.

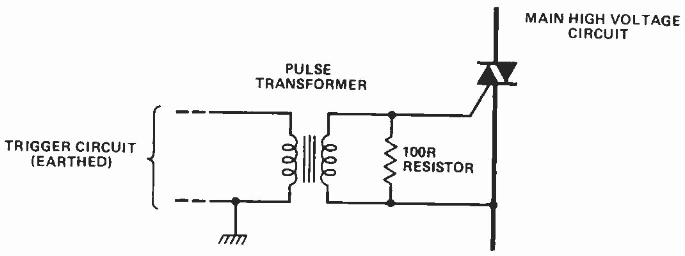


Fig. 10 Isolating the mains part of the circuit from the control part by using a pulse transformer.

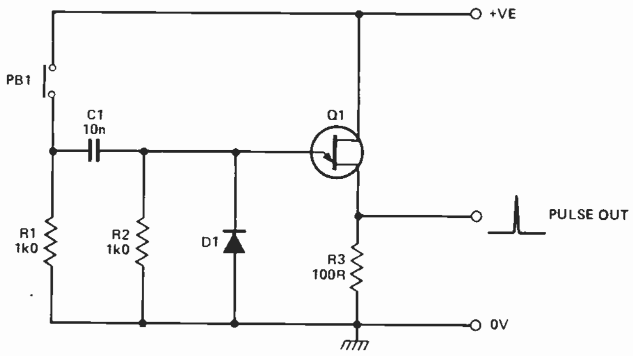


Fig. 11 The unijunction connected to provide a short pulse when a switch is pressed.

Triggering thyristors or triacs via a pulse transformer needs a fairly sharp spike waveform, and one of the devices that has traditionally been used to provide this type of waveform is the unijunction. As the name suggests, this uses one junction on an N-type silicon base whose doping normally ensures that the conductivity is low (resistance high). The junction is placed so as to provide an emitter terminal, and when the emitter voltage is raised to the conducting level, the injection of holes into the bar will make it highly conductive. This is the triggered state, which can be maintained only if a current continues to flow through the emitter. Unijunction circuits are arranged so as to prevent this continuous current, so ensuring a clean sharp pulse.

A unijunction 'one-shot' pulse generator is illustrated in Fig. 11. With the switch open, the emitter of the unijunction is earthed, and the device is non-conducting. Closing the switch contacts changes the voltage on one side of the capacitor from earth to the positive supply voltage, and the voltage on the other side will increase similarly, so triggering the unijunction. The conducting unijunction generates a positive-going spike at the earthy end of its circuit, and also charges the capacitor so that the end of the capacitor connected to the emitter is at about earth voltage. This process is very brief, and when the switch opens again, the emitter of the unijunction is protected from negative pulses by a diode.

The triggering voltage for a unijunction is a fixed fraction of the total voltage applied across the main terminals — the fraction is known as the 'intrinsic stand-off ratio', and is usually around 0.6, implying that the device will trigger when the emitter voltage is about 60 per cent of the supply voltage. Because this ratio is fixed, changes in the supply voltage do not make much difference to the frequency of the output. ETI

ORGAN PART 4

We conclude this excellent musical project with the constructional and setting up details, as well as the pricing for all the various bits and pieces. Design by Richard Watts.

Before starting on the construction details for the organ, there is one section of circuitry remaining that needs to be explained — that of the swell pedal and glide control. Figure 2 in the February article contains the circuity in question. The swell pedal performs the function of volume control for the whole organ and acts upon the signal which is output from the main mixer to the power amplifier. It operates by using an LDR (light dependent resistor), which is connected between ground and the signal line and which has a 12 V MES bulb mounted facing it. As the swell pedal is moved up and down, an optical filter is moved in the light path, allowing more or less light to reach the LDR and thus altering its resistance. This method of control is far superior to using potentiometers, which go noisy with age and wear and can produce fearful noises when connected to an amplifier input. The light operation ensures noise-free performance.

Attached to the side of the swell pedal is the glide switch. When operated, this switch causes the organ tuning to go flat by a semitone; when released, it allows it to slowly return to its original state. This effect is useful on all the voices and brings particular realism to those such as Hawaiian guitar and trombone.

When operated, the glide switch grounds the junction of D13 and D14: this discharges C18 through R34 (100R) and results in an immediate reduction in clock frequency, therefore flattening any audio currently being output. When released, the D13/D14 junction is again left open circuit, and C18 is allowed to return to its former state. The rate at which it returns is determined by the value of C18 and the amount by which the tuning is varied is determined by R33. The connection of D13 to the glide switch also causes the vibrato, if selected, to be disabled by switching off IC8a for the duration of the glide switch operation. This adds to the effect of the glide.

Construction

The main PCB is screen-printed with the component overlay and should present no constructional problems. A block diagram of the organ showing how all the remaining sections are interconnected to the main board is given in Fig. 1 as a guide to assembly.

The keyboard assembly comes as a complete unit, requiring only the contact assembly to be fitted. The keyboard chassis is fitted with end supports upon which both keyboards may be hinged up to facilitate access to the underside, where the contact assembly (the keyboard PCB) is fitted.

The keyboard is assembled as follows. First install and solder all the 1N4148 diodes with the cathodes (ringed) facing away from the bus bars. Next, with the board trackside up, install and solder all the track pins; one per diode and one per bus bar section. Ensure that the pins are pushed far enough into the PCB — the widest part of the pin should be in contact with the track. Now, with the board 'diode side up', put a small solder blob on each of the pins just installed — this will help later. Next the Molex connector, through which all connections are made to the contacts and bus bars, is to be fitted and soldered. Install the connector from the component side, leaving the longest part of the pins uppermost, and solder the underside.

The finished organ.

Now the bus bars can be fitted in turn as follows. Put two bus bar supports onto each bus bar section as shown in the diagrams and photograph. Use the upper of the two holes in the support. Align the bus bar supports with their locating holes in the PCB and mount the supports. A touch with a hot soldering iron to the protrusion below the board will secure the support; a spot of glue on the topside of the board is an alternative measure but take care not to get glue on the bus bars. Also keep your handling of the bus bars and contacts to a minimum as these are silver compounds and can get tarnished. Now slide the bus bar so that its left-hand end meets its associated pin and solder the bar to the pin. Take care not to use an excess of solder here since solder or flux running along to the contact area of the bus bar will impair the contact surface.

Insert the other 12-key bus bar sections and the 7-key section in the same way as described above. The top C key bus bar, since it handles one key only, has no bus bar support and is soldered directly to its pin at 90°. Check that no section of bus bar is touching any other section and check all joints on the underside of the board, as it is now to be mounted onto the keyboard chassis for insertion of the key contacts.

Insert the keyboard PCB spacers in the underside of the PCB as

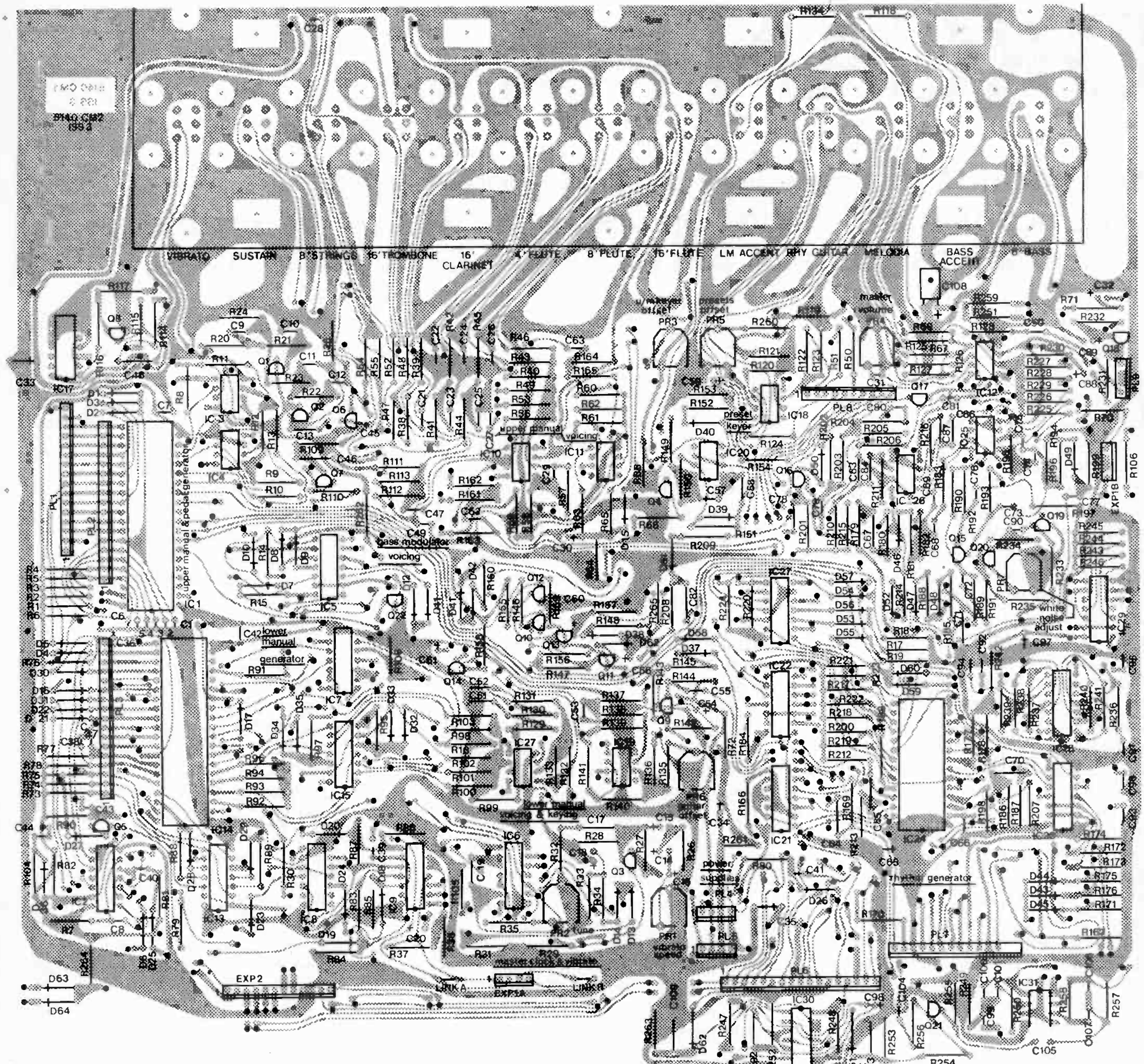
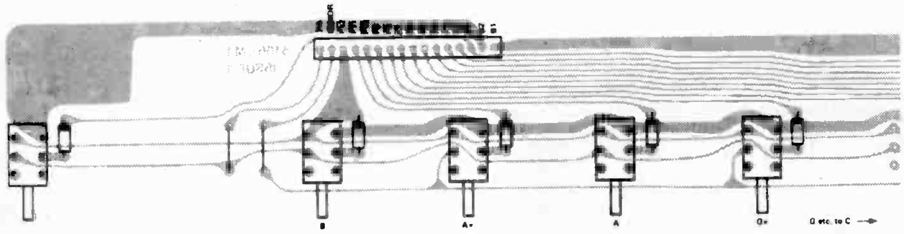


Fig. 2 (Above) The overlay for the main board. This is silk-screened on the finished item.

Fig. 3 (Below) The keyboard overlay.



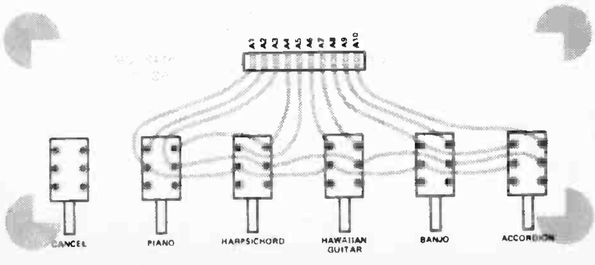
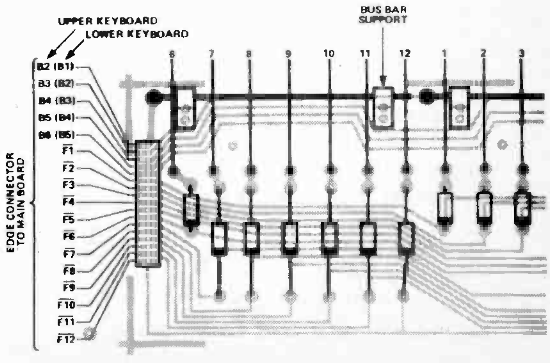


Fig. 1 The pedalboard overlay, which extends for 13 switch/diode pairs, (above) and a sample switchbank overlay (right). All three switchbanks are similar: this is the preset voice.



PARTS LIST

Resistors (all ¼W, 5%)

R1-6,71,73, 74,76,90, 148	6k8
R7,14,16,30,60,63, 67,85,95,97,108, 111-113,126,127 135,159,167, 170-176,201, 260,265	100k
R8-10,69,164,262	15k
R11,28,32,40,50,57, 70,99,105,110,116, 141,180,199,204, 213,225,227,232, 235,243-246,256	47k
R12,20-25,36,38,39, 41-46,53,55,68,83, 87,109,115,124,138, 146,147,155,156, 158,162,168,177-179, 181,184,186-188,193, 194,198,200,207-209, 212,214,217-224,226, 228,230,247,264	22k
R13,17,19,26,47,49, 54,58,75,77-79,88, 122,129,131,137,161, 165,169	10k
R15,72,206,255,261	4k7
R27,80-82,104,144, 151,185,203,205, 254,263	1M0
R29,66,91-94,96, 100-103,152,182, 215	1k0
R31,37,234	2M2
R33,130,133,134, 145,153,197	68k
R34,210,242	100R
R35,89	12k
R48,52,62,114,120, 140,251	150k
R51,154,229	33k
R56,64,84,86,142, 150,157,189,211,233, 236,237,252,259	220k
R59,61,121,123, 136,139,166,196	470R
R65,98,106,117,119, 160,192,202,231	2k2
R118,125	27k
R128	18k
R143,163,249,257	1k5
R149	820R
R183,216,253,258	470k
R190	4M7
R191	330k
R238-241	270k
R248	39k
R250	820k

Potentiometers (all miniature horizontal presets)

PR1,2	4k7
PR3,5,6	47k
PR4	220k
PR7	10k

Capacitors

C1-6,36-38,43,96	220pF
C7,23-26,40-42,44, 62,66,79	47nF
C8,28,53,68,69,76, 81,90,91,105	10nF
C9,11,21,22,27,39,47, 49,50,55,63,104	22nF
C10,12,29,72-75,99	2n2
C13,51,52,58,70,71, 78,83,84,86,87,103	100nF
C14-16,20,32,45,54, 59,88,89,98	1u0
C17,46,48,64,82,85	470nF
C18,30,56,60,61	10uF
C19	27pF
C31	100pF
C33,35	1000uF
C34,57,65,97	100uF
C67,102	220nF
C77,80,100,101,106, 107	4n7
C92	270pF
C93	1n8
C94	180pF
C95	3n3

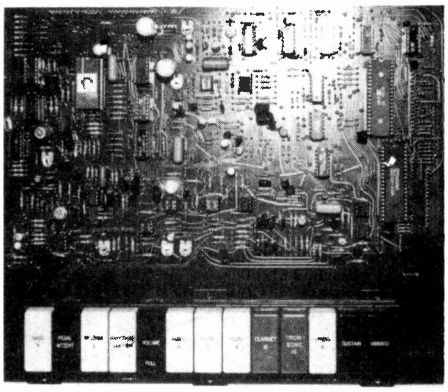
Semiconductors

IC1	M208
IC2,7,8,15	4016B
IC3,4,10,12,16,25, 26,31	1458
IC5,22,27,30	4001B
IC6,21	4069UB
IC9	4081B
IC11,18,19	3080E
IC13	4071B
IC14	M108
IC17	4013B
IC20	555
IC23	4025B
IC24	M258EP2
IC28	40106B
IC29	4070B
Q1-5,7,8,10-14, 16-22	2N3704
Q6,9,15	2N3703
D1-61	1N4148
ZD1	6V2 400mW zener

Miscellaneous

PL1	16-way Molex
PL2,3,6	17-way Molex
PL4,5,9	
EXP1A,EXP1B	4-way Molex
PL7,EXP2	12-way Molex
PL8	10-way Molex

PCB; 13-way rocker tab unit, PCB-mounting.



A picture of the assembled main board.

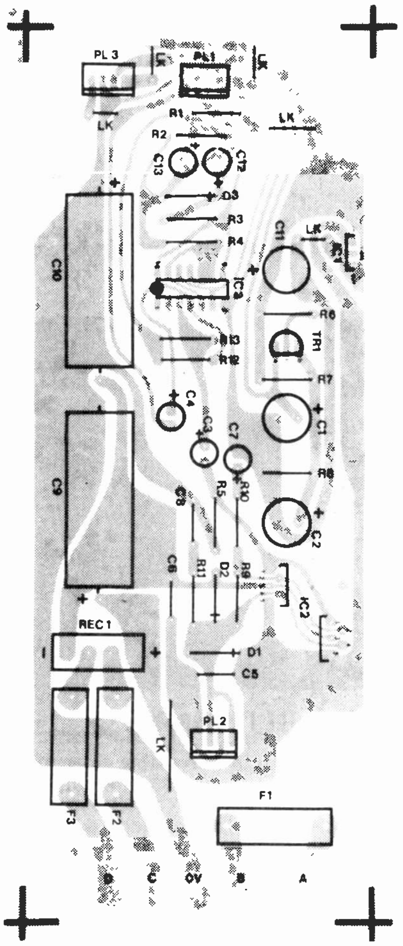
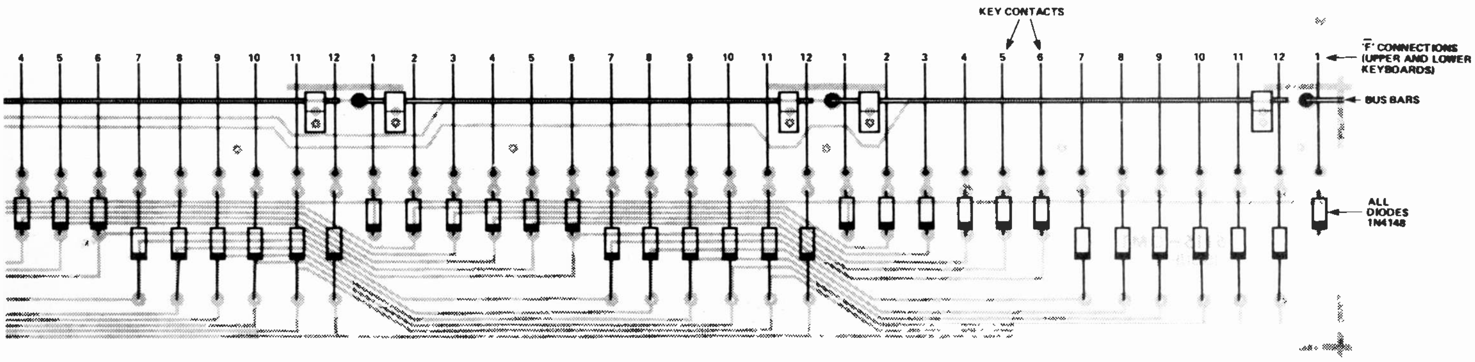


Fig. 4 (Above) The component overlay for the amplifier/power supply.



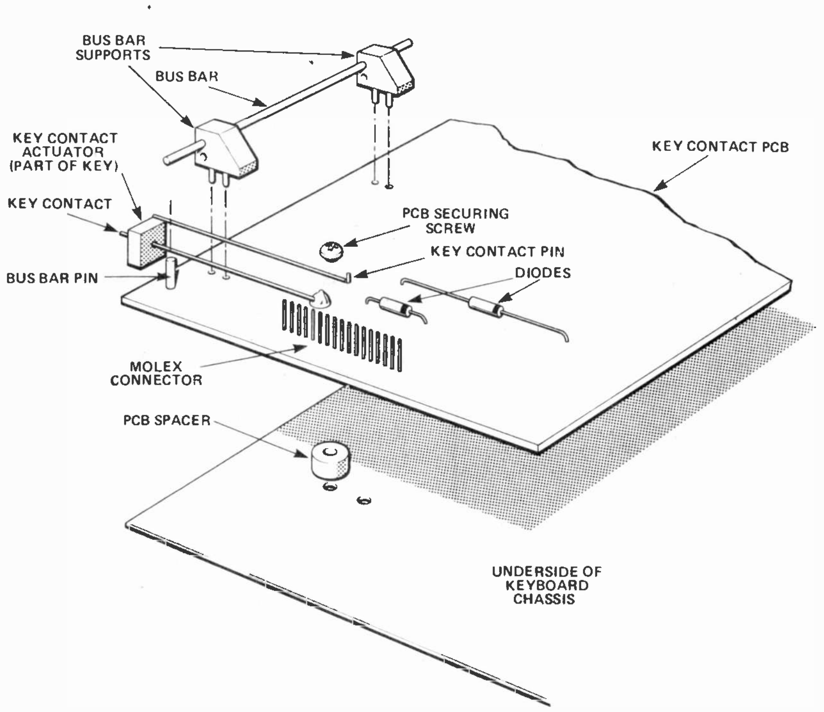
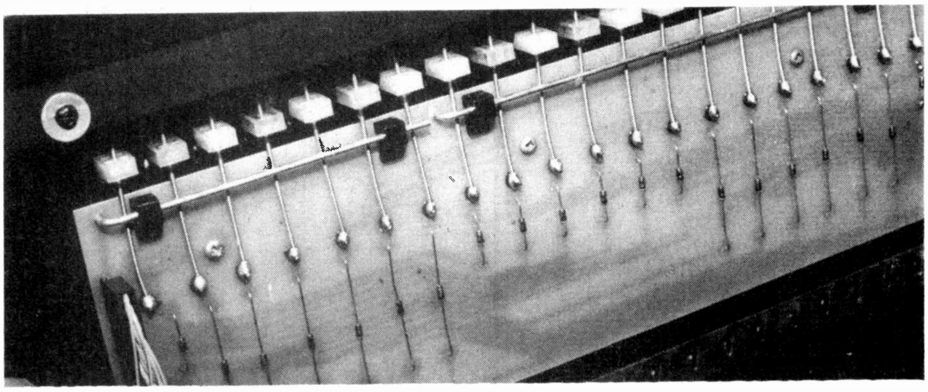
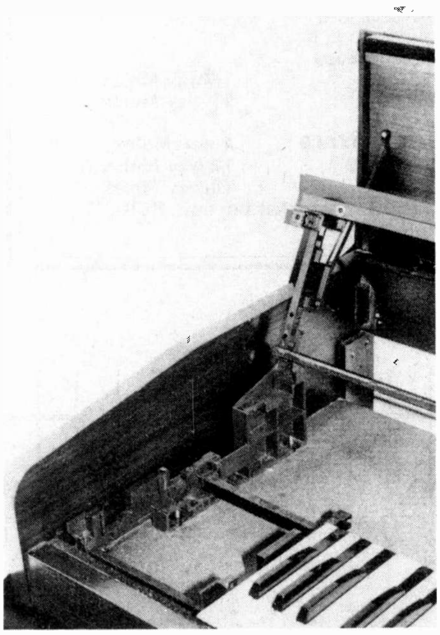


Fig. 5 Diagram showing the keyboard assembly. Compare with the photograph below.



BUYLINES

The Victory organ is available either as a complete kit or as sub-kits. The sub-kits are as follows: Starter kit (all parts for upper manual organ sounds); £98.80: Presets kit (upper manual preset voices); £14.54: Lower manual and bass kit (the lower manual and bass voices); £71.64: Pedal board kit; £30.84: Rhythm unit kit (includes ROM with programmed rhythm and bass patterns); £24.74: Amp and power supply unit; £36.96: Swell pedal and speakers; £34.54. VAT must be added to all prices. The total for all the sub-kits is £312.06 plus VAT but if the complete Victory kit is ordered at one time the price is reduced to £280.54 plus VAT. If you wish to build the organ in the cabinet shown in the photographs, it costs £143 and is supplied ready assembled with pre-drilled holes for the keyboard assemblies. A demonstration tape is available for £1.70 plus VAT. Carriage on all kits is extra, and individual components may also be ordered: a leaflet from the suppliers contains full details of the prices. Contact Leighton Electronic Services Ltd, 17 Bridge Street, Leighton Buzzard, Beds. LU7 7AH (telephone 0525 382504, telex 826717) for more information.



For easy construction, the keyboards hinge up and lift off.

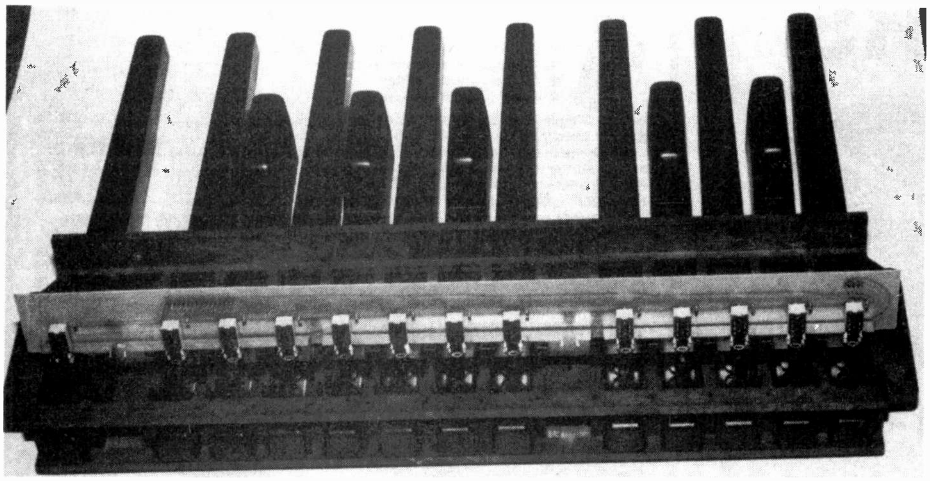
shown. These will force-fit the holes in the PCB but may be glued or held against the board by using a small amount of Vaseline if the force fit proves difficult. Insert a spacer in each hole. Next, invert the keyboard and support it at the ends. This protects the surface of the keys and also ensures that the black keys are not depressed, as would be the case if the keyboard were just inverted and placed on a surface. It can now be seen that there are two rows of PCB securing holes in the keyboard chassis running along its length. Using the row nearest the front of the keys, lower the contact PCB onto the chassis and secure it with the screws supplied.

Finally the contacts can be fitted. Place a contact through the hole in the key contact actuator and move the wider end of the contact alongside its associated pin. Position the contact such that any excess length is through the contact's actuator and not at the pin end. Solder the contact to the pin. Repeat with all the contacts. Mechanical noise from the keyboard can be kept to a minimum by the insertion of a small amount of silicon grease or similar lubricant into the key contact actuator prior to the contact insertion.

Cheeky Comments

The sidecheeks (the bits on the end of the keyboards) are injection mouldings supplied with the correct cut-outs, where required, for the mounting of the various switches and pots. The preset voices, rhythm and automatic function switchbanks are each mounted on a small PCB with a connector, and these assemblies are screwed onto mouldings on the underside of the sidecheek. The push-on button caps are secured to the switches with glue. It should be noted that the 'preset voices' switches have a slightly wider spacing than the other two switchbanks and have correspondingly larger push-buttons: be sure to have the correct ones before using the glue!

The voices/effects switchbank is mounted directly onto the main PCB; it comes complete with coloured and printed switch covers. The complete assembly of board and switchbank is then screwed to its sidecheek. The sidecheeks fit simply onto the keyboard chassis by clipping them in at the front and securing them at the back edge by two screws.

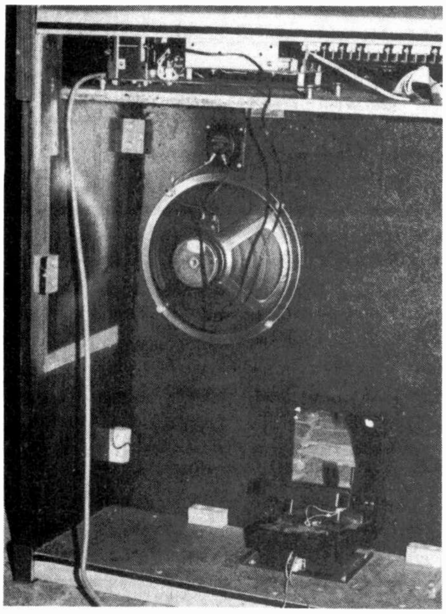


Here you can see the pedalboard PCB mounting arrangement.

All interboard connections are made using ribbon cable and insulation displacement connectors (IDC).

The pedalboard is a complete assembly requiring only the contacts to be fitted. These are in the form of two pole changeover switches (13 in all) which are mounted on a PCB with the associated pedal diodes and connector plug. The switches are then screwed to the pedalboard and the pedalboard bolted into the cabinet using four bolts (see the photograph).

The swell pedal assembly requires only the wiring of power (+12 V) to the bulb, and the coaxial signal lead from the preamp output to be connected across the LDR. This unit is then secured by four screws through its base plate: these need not be removed for access to the swell pedal as the pedal can be slid out from the front of the organ. The single pole glide switch is part of the swell pedal assembly and requires only ground to one contact and the glide circuitry to the other.



A view inside the organ cabinet showing the tweeter, and speaker and swell pedal.

The amplifier assembly consists of the chassis, the PCB and the mains transformer. The latter two items are mounted on the former, which is also used as the heatsink for the +12 V regulator and the power amplifier IC. The regulator does not need to be electrically isolated from the chassis as its tab is at ground, but the amplifier IC must be electrically isolated using a mica washer.

The output signal from the amplifier is taken via the headphone socket to the speaker and piezo tweeter. No crossover is necessary with this type of tweeter.

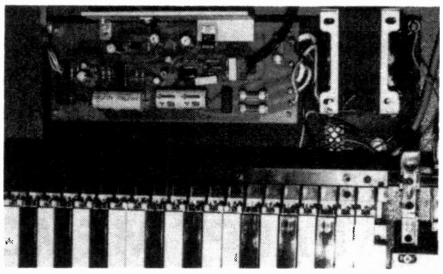
The cabinet to be supplied needs no assembly and readily accepts all the subassemblies described above. It has integral mounting nuts for the bolts that secure the pedalboard assembly and speaker; a cut-out for mounting the tweeter is incorporated, as is a headphone socket mounting hole. The cabinet is finished in real wood veneer and has a removable back and lid for easy access.

Setting Up

The simplest method of tuning the organ is to select A above middle C (that's the sixteenth note down from the top) on the upper keyboard with 8′ flute selected. The frequency of this note should be 440 Hz. It may be adjustable either by using an A tuning fork and listening for beats, or by monitoring pin 1 of IC4a with a scope or frequency counter. The tuning control is PR2. Alternatively, IC6d pin 8 may be monitored for 1000.12 kHz.

The vibrato oscillator frequency is not critical and is usually about 6 Hz. Adjustment is made using PR1 and it may be monitored at the collector of Q3. Alternatively you can select, say, clarinet with vibrator and play individual notes, adjusting PR1 for the most pleasing effect.

The upper keyboard VCA, in common with the other two (preset voices and rhythm guitar), needs to be balanced as the control current envelope does not automatically centre around signal ground. The result of any imbalance on the upper keyboard VCA is to produce an undesirable thump when a key is depressed. So, with no upper keyboard voice selected, depress any upper key and adjust PR3 to one end of its travel. Then, while repeatedly depressing the key, move PR3 through its travel. It will be noted that at the extremes of the preset travel the thump will be loudest and there will be a point on the preset where it is minimal. The VCA is balanced at this point.



The amplier/PSU board.

The preset voices VCA is balanced by selecting the banjo voice and playing any upper key. Adjustment of PR5 will eliminate the thump which will occur with the voice at the banjo oscillator rate.

The rhythm guitar VCA can be balanced by using PR6 while the rhythm guitar voice is selected and any rhythm is selected. It is not necessary to play any keys and the task will be made easier by turning the rhythm volume right down and also having the lower manual accent on.

To adjust the noise volume preset (PR7), select swing on the rhythm unit and set the tempo to mid-range. Turn PR7 fully clockwise, then turn it anticlockwise until the white noise tends to sound continuous. Now turn it back slightly until the organ is making the normal sound of a snare drum. PR7 may be further adjusted clockwise to suit individual taste.

Finally, the overall volume of the organ can be adjusted by using PR4. **ETI**

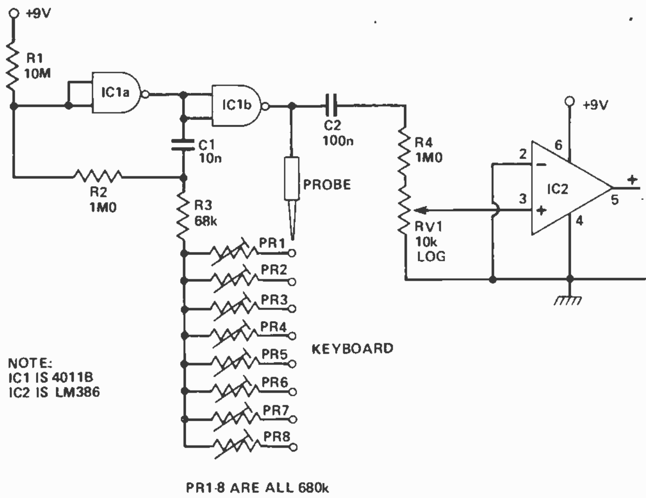
TECH TIPS

Simple Organ

J. P. Macaulay, Crawley

With the financial climate being what it is the following circuit may be of interest to harassed parents whose children want a stylophone. A simple oscillator is formed with two CMOS NAND gates (half a 4011B). Under quiescent conditions no sound is emitted. When the stylus is placed on the keyboard the circuit is made through the selected preset and the oscillator produces a square wave which is coupled to the output stage, an LM386. This IC is ideally suited to this application since its maximum output is limited to 200 mW and its quiescent current consumption is 3 mA. This, together with the fact that both ICs will work with battery voltages as low as 4 V, means that a fairly long battery life can be expected.

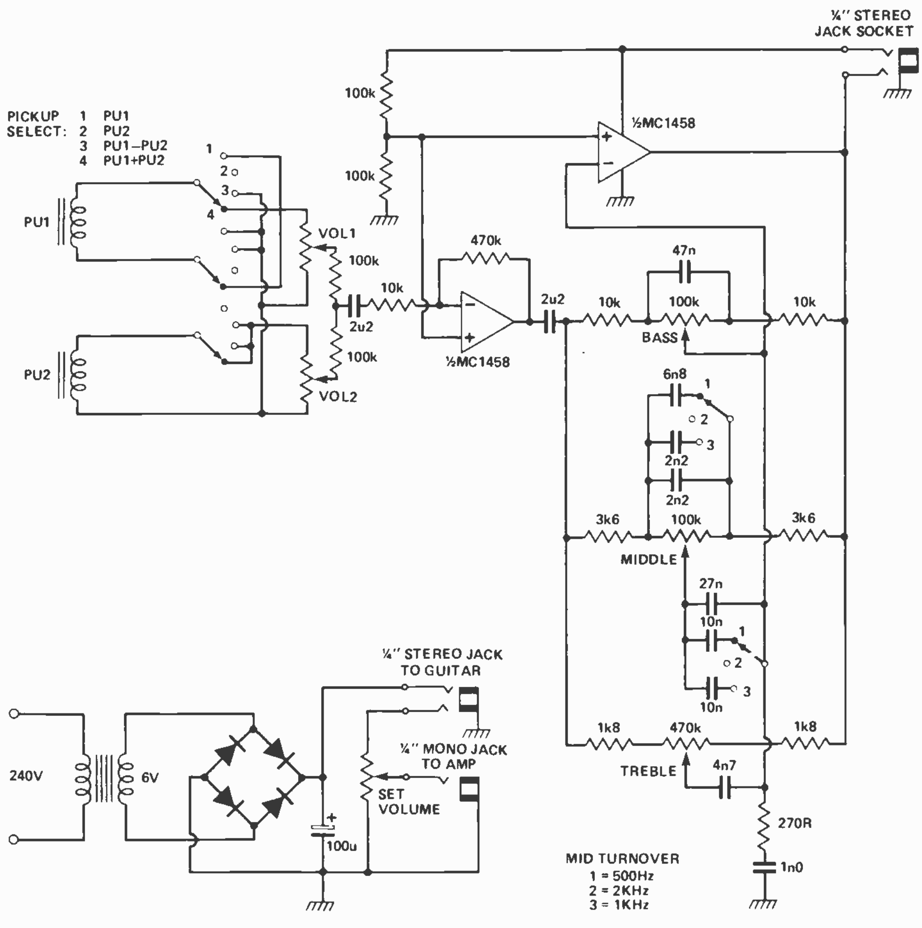
The organ will obviously require some form of keyboard. A simple one can be made from a piece of 0.15" matrix Veroboard with alternate tracks removed. Tuning is most easily done with the aid of a digital frequency meter; if all else fails the instrument can be tuned by ear against a piano.



Electronic Guitar

Quentin Rice, Mitcham

The circuit shown here was fitted inside a friend's Rickenbacker bass to increase the versatility of the guitar. Its controls are as follows: pickup/phase select, volume 1 and 2, bass, middle and treble tone controls and middle turnover frequency. It has low current consumption and can be used either with a battery, or with the 'phantom' power supply connected to the jack socket. It seems likely that most guitars will feature active circuitry in the future, giving musicians greater flexibility during a live performance.



Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items. ITI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for at a competitive rate.
Drawings should be as clear as possible and the text should be typed. Text and drawings must be on separate sheets. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS, Electronics Today International, 145 Charing Cross Road, London WC2H 0EE.

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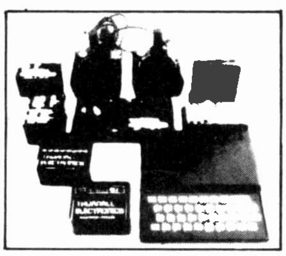

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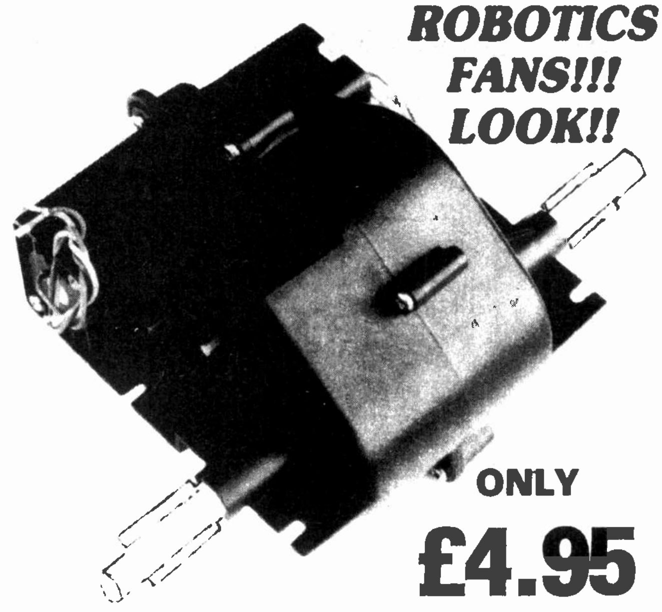

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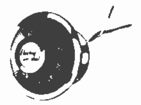

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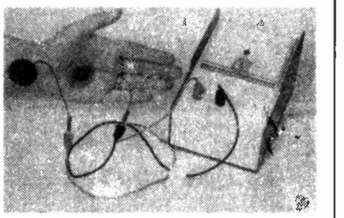

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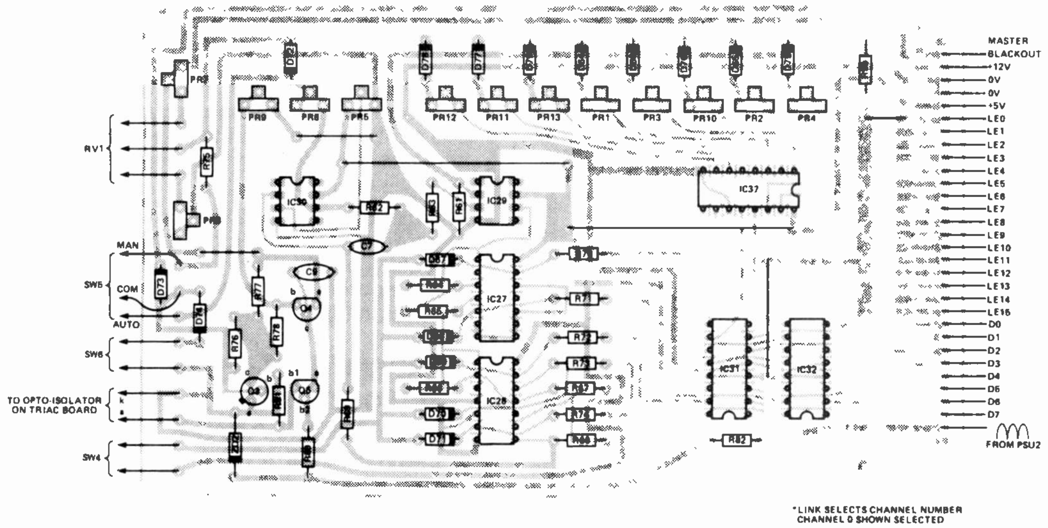

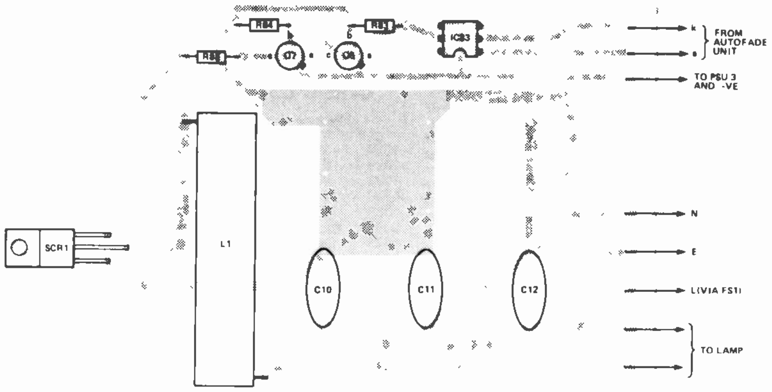

Above is the overlay for one autofade card and left, the overlay for one of the triac boards.
No PCBs are given for the power supplies as these consist of little more than strings of capacitors in parallel and methods such as Veroboard are cheap and easy to employ.

PARTS LIST

Resistors (all ¼W, 5%)

R61,84	4k7
R62,77	470R
R63,75	100k
R64,76	10M
R65	4M7
R66,78	2M2
R67	1M2
R68	560k
R69	270k
R70-74	10k
R79	47k
R80	330R
R81,85	100R
R82	1k0
R83	120k

Potentiometers

RV1	10k linear
PR1-4,10-13	2k2 miniature vertical preset
PR5	470k miniature vertical preset
PR6,7	1M0 miniature vertical preset
PR8	10k miniature vertical preset
PR9	47k miniature vertical preset

Capacitors

C7	4u7 16 V tantalum
C9	100nF polycarbonate or similar
C10	100nF mains-rated capacitor (eg IS or mixed dielectric)
C11,12	47nF mains-rated capacitor

Semiconductors

IC27,28	4016B
IC29,30	741
IC31,32	74LS75
IC33	opto-isolator eg CNY17
IC37	4028B
Q3,6,7	BC108
Q4	BC214L
Q5	TIS43
SCR1	TIC246D
D64-79	1N4148
ZD2	12 V 400 mW zener

Miscellaneous

SW4,6	SPST toggle switches
SW5	SPDT toggle switch
L1	14 turns of 15 A cable on a 3/8" ferrite rod
LP1	lamp to suit
FS1	10 A fuse and fuseholder
PCBs	(see page 87)

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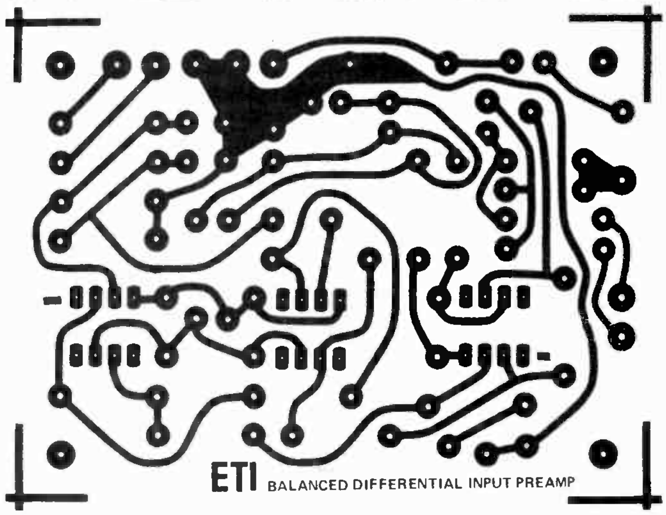
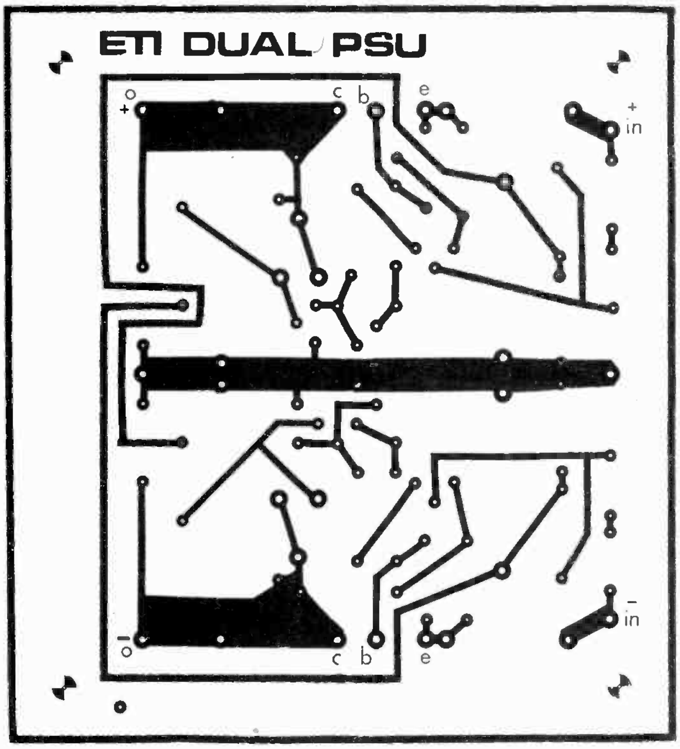
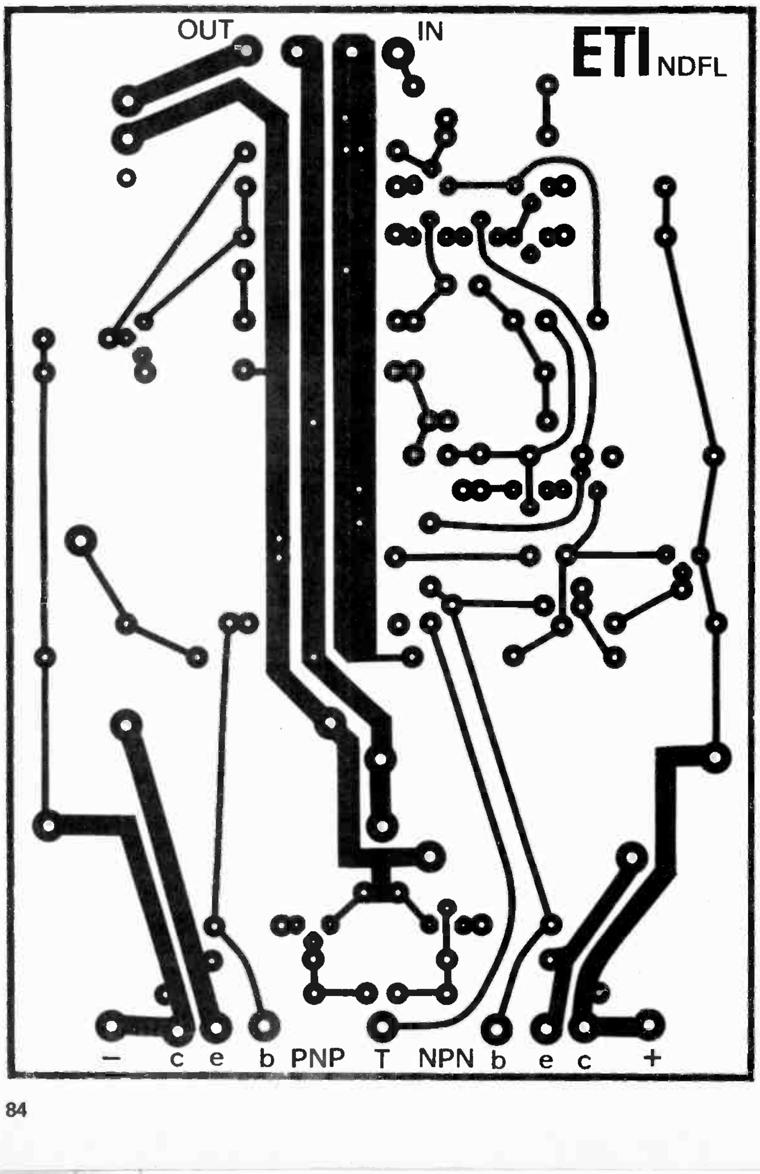
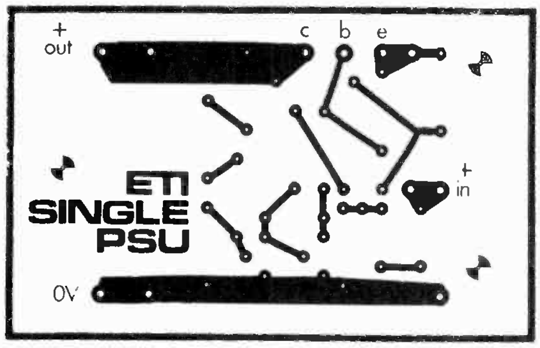
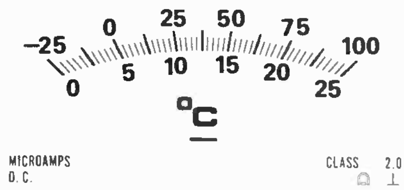


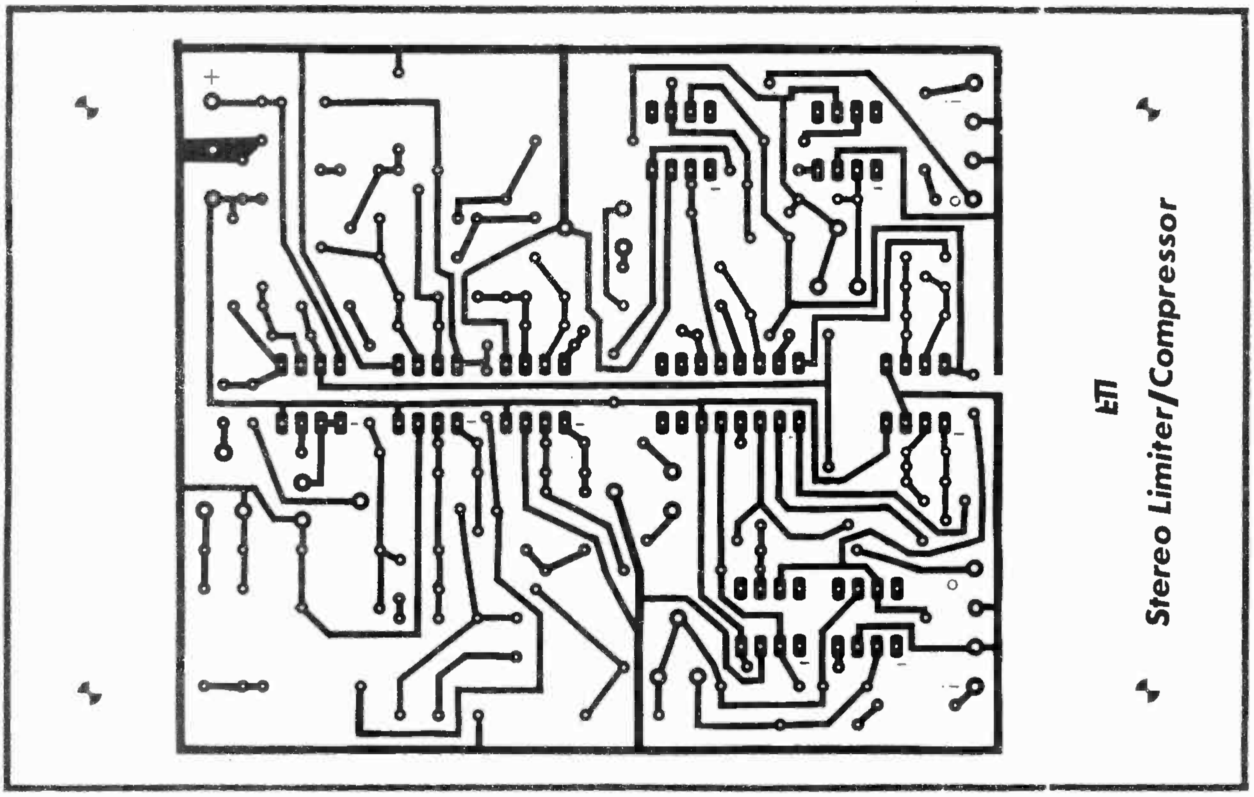








Above: the elusive meter scale artwork for last month's Max/Min Thermemeter.



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E.T.I. — MAY 83 ADVERTISERS INDEX

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In addition to the PCBs for this month's projects, we are making available some of the more popular designs from our recent past. See the list below for details. Please note that NO OTHER BOARDS ARE AVAILABLE. If it's not listed, we don't have it!

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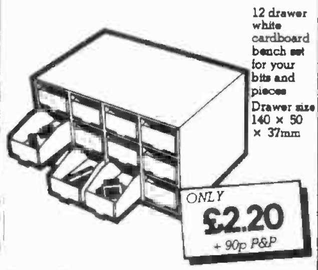

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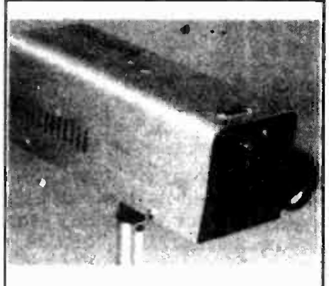

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Get moving with these new developments in UK Robotics

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

Hebot II is a turtle-type robot which takes programming out of the two dimensional world of the VDU into the real three dimensional world. Given a DC supply of 9-15V it can perform a bewildering number of moves under computer control — forwards, backwards, left and right — with each wheel independently controlled. It has blinking eyes, bleeps with a choice of two tones and has a solenoid operated pen to chart its progress. Touch sensors coupled to its shell return data, about its environment, to the computer for it to calculate evasive or exploratory action. Hebot II connects directly to an I/O port or alternatively with the universal interface board to the expansion bus of a ZX81 or other computer.

Robotic experience is becoming as essential a subject as computing. MICROGRASP provides the lowest cost means of acquiring that experience but despite its ultra low price the robot has considerable versatility. There are 5 axes each using a servo motor and there is feedback from each of the arm movements. Control is by any computer with an expansion bus - the ZX81 being particularly suitable. Servoing is achieved with hardware on the interface board to keep programming simple and the robot is operated under BASIC commands with no computer specific software required. The interface board is memory mapped using only 64 bytes at any of 1024 switch selectable locations.

MICROGRASP robot kit with power supply	£145.00
Universal computer interface board kit	£48.50
23 way edge connector	£2.50
ZX81 peripheral/RAM Pack splitter board	£3.00

MICROGRASP, INTERFACE BOARD AND ZX81

HEBOTT II

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

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

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

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

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

6 axis system READY BUILT	£1950.00
Powertran CORTEX 16 bit 64K computer Kit £295.00 READY BUILT	£395.00

(Electronics Today International December issue on CORTEX)

GENESIS P102 PROCESSOR BOX, HAND HELD CONTROLLER AND CORTEX COMPUTER

Example prices and specifications

Genesis S101
Base: 19.5" × 11" × 7.5"
Lifting capacity: 1500gm
Arm lift: 6.6"
Weight: 29Kg

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

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

4 axis model in kit form	£675
6 axis model in kit form	£595

Complete Systems as shown in Photograph above

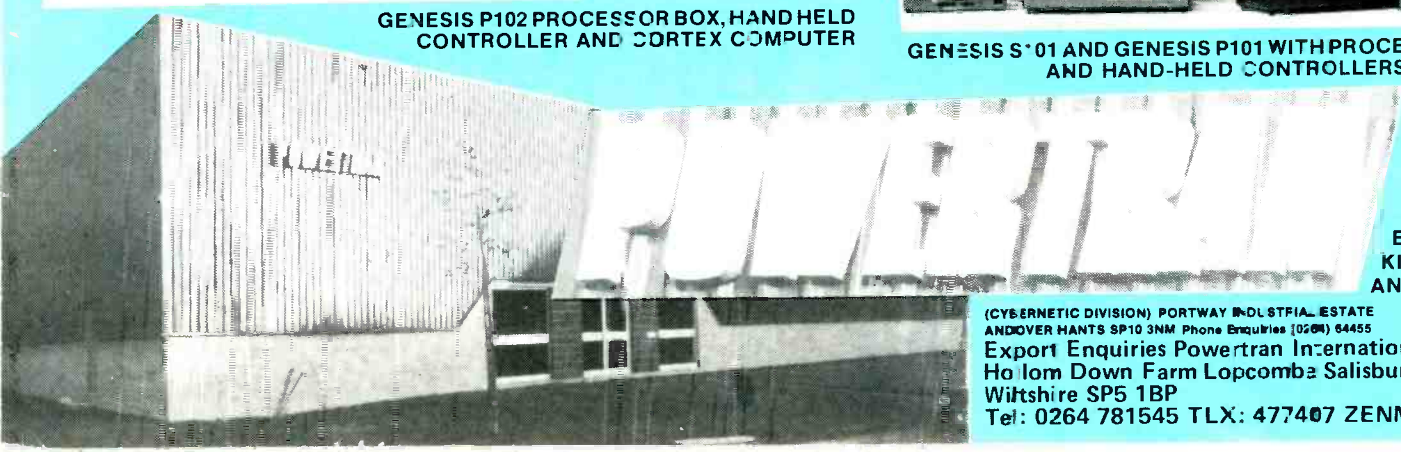
Genesis S101
4 axis system in kit form £681.50
5 axis system in kit form £737.50
5 axis system Ready Built £1450

Genesis P101
6 axis system in kit form £945.00
6 axis system Ready Built £1650

All prices exclusive of VAT

With prices starting below £1,000 the Genesis range of general purpose robots provide a first rate introduction to robotics for both education and industry. Each has a self-contained hydraulic power source, which enables loads of several pounds to be smoothly handled. The system operated from a single phase 240 or 120V AC supply or a 12V DC supply. The machine can be supplied with up to 6 axes each of which is fully independent but capable of simultaneous operation. Position control is achieved by means of a closed-loop feedback system based around a dedicated microprocessor. Movement sequences can be entered, stored and replayed by use of a hand held controller, alternatively the systems can also be interfaced to an external computer via a standard RS 232C link.

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



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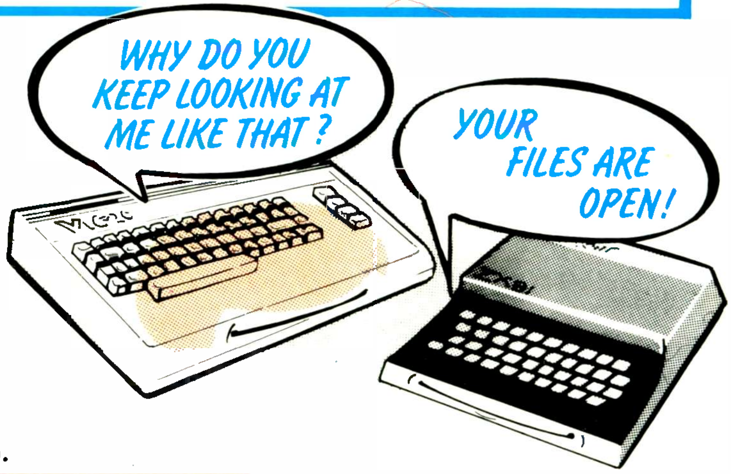
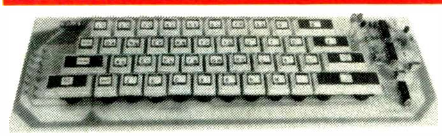
★In VIC20 version, speech output is direct to TV speaker with no additional amplification needed.
★Allows speech to be easily included in programs.

Complete kit only £24.95.
Order As LK00A (VIC20 Talk-Back).
LK01B (ZX81 Talk-Back).
Full construction details in Maplin Projects Book 6.
Price 70p. Order As XA06G (Maplin Mag Vol. 2 No. 6).



KEYBOARD WITH ELECTRONICS FOR ZX81



★Full size, full travel keyboard that's simple to add to your ZX81 (no soldering in ZX81).
★Complete with electronics to make "Shift Lock", "Function" and "Graphics 2" single key selections.
★Powered (with adaptor supplied) from ZX81's own standard power supply.

Full details in Project Book 3 (XA03D) Price 60p.
Complete kit (excl. case) £19.95. Order As LW72P.
Case £4.95. Order As XG17T.
Ready built-in case £29.95. Order As XG22Y.

OTHER KITS FOR ZX81

3-Channel Sounds Generator (Details in Book 5). Order As LW96E. Price £10.95.

ZX81 Sound On Your TV Set (Details in Book 6). Order As LK02C. Price £19.95.

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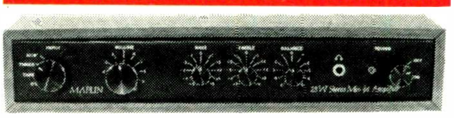
25W STEREO MOSFET AMPLIFIER



★Over 26W/channel into 8Ω at 1kHz both channels driven.
★Frequency response 20Hz to 40kHz ± 1dB.
★Low distortion, low noise and high reliability power MOSFET output stage.
★Extremely easy to build. Almost everything fits on main pcb, cutting interwiring to just 7 wires (plus toroidal transformer and mains lead terminations).
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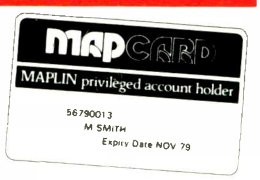

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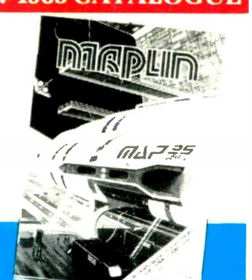

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