Australia $1.60 New Zealand $1.75 Malaysia $4.95

FEBRUARY 1985 · £1·00

PRACTICAL ELECTRONICS

ROBOTICS · MICROS · ELECTRONICS · INTERFACING

8 EXTRA PAGES

MODULAR AUDIO POWER SYSTEM

SPECTRUM DAC/ADC BOARD

SIGNAL GENERATOR F-V CONVERTER

MICROWRITING
The Principle and the Product


Have you one of these?
BBC * COMMODORE 64
DRAGON * VIC 20
ORIC 1/ATMOS
ATARI 400/800
SPECTRUM * ZX81
Then you need one of these
Best Guide to Microcomputer Software
SOFTWARE INDEX
1984 No. 5 £1.50
Now with 5,000 programs
more educational, games, business & personal management listings than ever before!
ON SALE NOW!

PE ROBOTICS MICROS ELECTRONICS INTERFACING

ISSN 0032-6372

VOLUME 21 Nº 2 FEBRUARY 1985

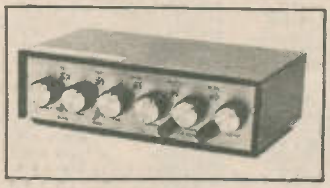
CONSTRUCTIONAL PROJECTS

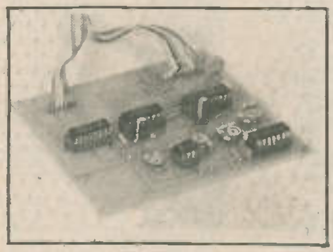
GENERAL FEATURES

NEWS & COMMENT

THIS MONTH'S COVER...

Our cover photograph shows silicon wafers in a furnace during the production of integrated circuits. Photograph courtesy of National Semiconductor.





OUR MARCH ISSUE WILL BE ON SALE FRIDAY, FEBRUARY 1st, 1985 *(see page 47)*

WATFORD ELECTRONICS

33, CARDIFF ROAD, WATFORD, HERTS WD1 8ED, ENGLAND
Tel. Watford (0923) 40588. Telex: 8956095 WAELEC
ORDERS NORMALLY DESPATCHED BY RETURN OF POST

ALL DEVICES BRAND NEW, FULL SPEC. AND FULLY GUARANTEED. SEND CASH, P.O.'s OR CHEQUE WITH ORDER. GOVERNMENT AND EDUCATIONAL INSTITUTIONS OFFICIAL ORDERS ACCEPTED (ACCESS ORDERS BY TELEPHONE 0923-50234). TRADE AND EXPORT INQUIRY WELCOME. P & P ADD 70p TO ALL CASH ORDERS. OVERSEAS POSTAGE AT COST. PRICES SUBJECT TO CHANGE.

VAT Export orders no VAT. U.K. customers please add 15% VAT to total cost incl. p&p. We stock thousands more items. It pays to visit us. We are situated behind Watford Football Ground. Open Monday to Saturday, 9.00am to 6.00pm. Ample FREE Car parking.

POLYESTER RADIAL LEAD CAPACITORS: 250V; 10n, 20n, 15n, 22n, 27n **6p**; 33n, 47n, 68n, 100n **8p**; 150n, 220n **10p**; 330n, 470n **15p**; 680n **19p**; 1µ **23p**; 1µ5 **40p**; 2µ2 **46p**.

ELECTROLYTIC CAPACITORS (Values in µF). **500V:** 10µF **52p**; 47 **78p**; **63V:** 0·47, 1·0, 1·5, 2·2, 3·3, **8p**; 4·7 **9p**; 10 **10p**; 15, 22 **12p**; 33 **15p**; 47 **12p**; 68 **16p**; 100 **19p**; 220 **26p**; 1000 **70p**; 2200 **99p**; **50V:** 68 **20p**; 100 **17p**; 220 **24p**; **40V:** 6·8 **15p**; 22 **9p**; 33 **12p**; 470 **32p**; 1000 **48p**; 2200 **90p**; **25V:** 4·7, 10, 22, 47 **8p**; 100 **11p**; 150 **12p**; 220 **15p**; 330 **22p**; 470 **25p**; 680, 1000 **34p**; 1500 **42p**; 2200 **50p**; 3300 **76p**; 4700 **92p**; **16V:** 2·5, 40 **8p**; 47, 68, 100 **9p**; 125 **12p**; 220 **13p**; 330 **16p**; 470 **20p**; 680 **34p**; 1000 **27p**; 1500 **31p**; 2200 **36p**; 4700 **79p**.

TAG-END TYPE: 64V: 4700 **245p**; 3300 **198p**; 2200 **139p**; **50V:** 3300 **154p**; 2200 **110p**; **40V:** 4700 **160p**; **25V:** 4700 **98p**; 10,000 **320p**; 15,000 **345p**.

TANTALUM BEAD CAPACITORS:
35V: 0·1µ, 0·22, 0·33 **15p** 0·47, 0·68, 1·0, 1·5 **16p** 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 **36p** 33, 47 **50p** 100 **95p** 220 **100p** **10V:** 15, 22 **26p** 33, 47 **50p** 100 **75p**.

POTENTIOMETERS: Carbon Track, 0·25W Log & Linear Values.

500W, 1K & 2K (LIN ONLY) Single	35p
5KΩ-2MΩ single gang	35p
5KΩ-2MΩ single gang D/P switch	95p
5KΩ-2MΩ dual gang stereo	99p

SLIDER POTENTIOMETERS
0·25W log and linear values 60mm track
5KΩ-500KΩ Single gang **80p**

SILVER MICA (pf)
2, 3·3, 4·7, 6·8, 8·2, 10, 12, 18, 22, 27, 33, 39, 47, 50, 56, 68, 75, 82, 85, 100, 120, 150, 180 **15p**. 220, 250, 270, 330, 360, 390, 470, 600, 800 & 820pF **21p**. 1000, 1200, 1800 **30p each** 3300, 4700 **60p each**

SIEMENS mulitlayer miniature capacitors. **250V:** 1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 8n2, 10n, 15n, 22n **7p**; 18n, 27n, 33n, 47n **8p**; 39n, 56n, 68n **9p**, 100nF **11p**. **100V:** 100n, 120n, **10p**; 150n **11p**; 220n **13p**; 330n **18p**; 470n **23p**; 680n **30p**; 1MF **34p**; 2M2 **50p**.

PRESET POTENTIOMETERS

0·1W 50Ω-2·2M Mini Vert. & Horiz.	8p
0·25W 220Ω-4M7 Vert. & Horiz.	12p

RESISTORS Hi-stab, Miniature, 5% Carbon.

	RANGE	Val.	1-99	100+
0·25W	2Ω2 - 4·M7	E24	3p	1p
0·5W	2Ω2 - 4·M7	E12	3p	1p
1W	2Ω2 - 10M	E12	6p	4p
1% Metal Film 51Ω-1M		E24	8p	6p

CERAMIC Capacitors: 50V
Range 1pF to 6800pF **4p**; 10nF, 15n, 33n, 47nF **5p**; 100nF/30V **7p**.

POLYSTYRENE Caps:

10pF to 1nF	8p
1n5 to 12nF	10p

RESISTORS S.I.L. Package: 7 Commoned, 100Ω, 470Ω, 680Ω, 1K, 2K2, 4K7, 10K, 47K, 100K **24p**.
8 Commoned: (9 pins) 150Ω, 180Ω, 270Ω, 330Ω, 330Ω, 1K, 2K2, 4K7, 6K8, 10K, 22K, 47K, 100K **26p**.

TRANSISTORS

AC127/8	35
AC141/2	35
AC176	35
AC187/8	35
AC188	35
AD142	120
AD149	79
AD161/2	42
AF118	95
AF139	40
AF239	55
BC107/8	12
BC107B	14
BC108B	14
BC108C	14
BC109	12
BC109B	14
BC109C	14
BC114/5	30
BC117/8	25
BC140	38
BC142/3	38
BC147/8	12
BC147B	15
BC148C	10
BC149	12
BC149C	15
BC153/4	30
BC157/8	14
BC159	11
BC167A	14
BC168C	12
BC169C	12
BC171/2	12
BC173	15
BC177/8	16
BC179/81	20
BC181	30
BC182/3	10
BC184	10
BC182L	10
BC183L	10
BC184L	10
BC186/7	28
BC212/3	12
BC212L	10
BC213L	12
BC214	10
BC214L	12
BC237/8	15
BC307B	15

BC308B	16
BC327/8	15
BC337/8	15
BC441	34
BC461	34
BC477/8	40
BC516/7	40
BC547/8	12
BC549C	15
BC556/7	15
BC558/9	15
BCY41/42	30
BCY70	18
BCY71	20
BCY72	25
BCY78	30
BD131/2	65
BD133	60
BD135	45
BD136/7	40
BD138/9	40
BD140	40
BD158	68
BD245	65
BD434	70
BD695A	150
BD696A	150
BF115	45
BF154/8	30
BF167	35
BF173	35
BF177	35
BF178	35
BF179	40
BF194/5	12
BF198/9	18
BF200	30
BF224	40
BF244A	28
BF244B	29
BF245	50
BF256B	50
BF257/8	32
BF259	40
BF394	40
BF451	40
BF494/5	40
BF594/5	30
BFR39/40	25
BFR41/79	25
BFR80/81	25

BFR98	105
BFX29/84	35
BFX84	35
BFX85/86	35
BFX87/88	28
BFY50/51	30
BFY52	30
BFY53	35
BFY55	35
BFY56	35
BFY64	40
BFY90	80
BRY39	50
BSX20	30
BSX29	45
BSY26	35
BSY95	35
BU105	180
BU205	190
BU206	200
BU208	200
MJ2955	90
MJE340	54
MJE371	100
MJE2955	99
MJE3055	70
MPF102	40
MPF103/4	30
MPF105	30
MPSA05	30
MPSA06	25
MPSA08	30
MPSA12	32
MPSA55	30
MPSA56	30
MPSA70	40
MPSU02	58
MPSU05	60
MPSU06	60
MPSU52	65
MPSU55	60
MPSU56	60
OC23	170
OC28/36	220
OC41/42	75
OC70	40
OC72	50
OC75/76	55
OC76	50
OC81/82	50
OC83/84	70
TIP29A	32
TIP29C	38
TIP30A	35

TIP30C	37
TIP31A	38
TIP31C	45
TIP32A	43
TIP32C	45
TIP33A	70
TIP33C	75
TIP34A	85
TIP34C	105
TIP35A	120
TIP35C	130
TIP36A	130
TIP36C	140
TIP41A	50
TIP41B	52
TIP42A	55
TIP42B	58
TIP120	70
TIP121	73
TIP141	120
TIP142	120
TIP147	120
TIP2955	70
TIP3055	70
TIS43	50
TIS44	45
TIS88A	50
TIS90	30
TIS91/93	32
VK1010	99
VN10KM	70
VN46AF	95
VN66AF	110
VN88AF	120
VN89AF	120
ZTX107/8	12
ZTX109	12
ZTX212	28
ZTX300	13
ZTX301/2	16
ZTX303	25
ZTX304	17
ZTX320/26	30
ZTX500/1	14
ZTX502/3	18
ZTX504	25
ZTX531	25
ZTX550	25
2N696	30
2N697	23
2N698	40
2N699	48
2N706A	25
2N708	25

2N914/5	32
2N918	40
2N930	20
2N1131/2	40
2N1303/4/5	
2N1307	70
2N1613	30
2N1671B	160
2N2160	325
2N2219A/20A/	
21A/22A	25
2N2369A	18
2N2646	45
2N2846	80
2N2904A/05A/	
06A/07A	26
2N2926G	10
2N3053	25
2N3054	55
2N3055	50
2N3442	140
2N3615	199
2N3663	20
2N3702/3	10
2N3704/5	10
2N3706/7	10
2N3708/9	10
2N3710	10
2N3771	179
2N3772	195
2N3773	210
2N3819	35
2N3820	60
2N3822/3	60
2N3866	90
2N3903/4	15
2N3906/5	15
2N4037	60
2N4058	15
2N4061/2	15
2N4264	30
2N4286	25
2N4289	25
2N4400	25
2N4427	80
2N4859	78
2N5135	30
2N5138	25
2N5172	25
2N5180	45
2N5191	75
2N5194	80
2N5305	24
2N5457	30

2N5458/9	30
2N5485	36
2N5777	45
2N6027	32
2N6109	60
2N6290	70
2SA636	250
2SA671	250
2SA715	75
2SC495/6	85
2SC1061	250
2SC1096	85
2SC1162	45
2SC1172/3	125
2SC1306	100
2SC1307	150
2SC1449	95
2SC1679	190
2SC1678	140
2SC1923	65
2SC1945	225
2SC1953	90
2SC1957	90
2SC1969	165
2SC2028	85
2SC2029	200
2SC2078	170
2SC2091	85
2SC2166	165
2SC2314	85
2SC2335	200
2SC2465	125
2SC2547	40
2SC2612	200
2SD234	75
2SK45	90
2SK288	225
2SJ83	225
2SJ85	225
3N128	115
3N140	115
40251	150
40311	60
40313	130
40361/62	70
40408	76
40412	90
40467	130
40468	85
40594	105
40595	110
40603	110
40673	70
40871/2	90

LINEAR IC's

555 CMOS	95	LM334Z	160
702	75	LM335	135
709C 8 pin	35	LM337	275
710	48	LM339	40
741	16	LM348	60
747C 14 pin	70	LM349	125
748C 8 pin	30	LM358	50
753 8 pin	185	LM377	210
810	159	LM379	495
9400CJ	375	LM380	120
ADC0808	885	LM381N	175
AY-1-1320	225	LM382	200
AY-1-5050	99	LM384	225
AY-1-5051	160	LM386	90
AY-1-6720	210	LM387	200
AY-3-8910	390	LM389	160
AY-3-8912	500	LM393	85
AY-5-1317A	630	LM394CH	385
CA3011	130	LM553	170
CA3012	175	LM725CN	300
CA3014	275	LM733	65
CA3018	86	LM1871	300
CA3019	90	LM1889	350
CA3020	210	LM2907	395
CA3023	210	LM3900	70
CA3028A	130	LM3909	85
CA3035	255	LM3911	185
CA3036	270	LM3914	300
CA3043	275	LM3915	385
CA3045	365	LM3916	300
CA3046	70	LM13600	150
CA3048	220	LS7220	280
CA3059	325	M51513L	230
CA3075	213	M51515L	320
CA3080E	75	M51516L	475
CA3081	190	MB3712	200
CA3085	160	MB3756	440
CA3086	60	MC1204	250
CA3089E	200	MC1301	90
CA3090AQ	375	MC1303	98
CA3123	165	MC1304P	260
CA3130	90	MC1310P	150
CA3140	50	MC1445	250
CA3160	95	MC1455	50
CA3161E	199	MC1458	35
CA3162	525	MC1469	300
CA3189	275	MC1494	694
CA3240	110	MC1495	350
HA1366	175	MC1496L	70
HA1388	235	MC1596	225
ICL7106	690	MC1648	290
ICL7107	975	MC3302	75
ICL7611	99	MC3401	50
ICL7660	248	MC3403	95
ICL8038CC	360	MC3404	85
ICL8211	225	MC3405	150
ICM7205	1150	MC3442	00
ICM7207	475	MC3423P	80
ICM7215	1050	MC3487	00
ICM7216A	£22	MC4016	00
ICM7217A	£11	MF10	350
ICM7224	£11	MFC6040	75
ICM7240	300	ML924	275
ICM7555	105	NE515	275
ICM7556	150	NE529	225
LA3350	250	NE531	140
LA4031P	340	NE543	225
LA4032	295	NE544	200
LA4400	350	NE555	25
LA4422	320	NE556DB	65
LC7120	300	NE558	170
LC7130	320	NE560	350
LC7137	350	NE562B	410
LF347	150	NE564	420
LF351	70	NE565A	120
LF353	90	NE566	155
LF355	90	NE567	140
LF356	90	NE570	410
LF357	100	NE571	400
LF398	495	NE5532	150
LM10	325	NE5534	160
LM301A	30	OM335	650
LM307	45	RC4136D	60
LM308	75	RC4558	60
LM311	60	S566B	225
LM318	150	SAB3209	425
LM319	180	SAB3210	325
LM324	45	SAB3271	485

SAB4209	595
SG3402	295
SL490	350
SL924	00
SL6270	170
SN76013N	350
SN76033	350
SN76488	525
SP0256AL	625
TA7120	140
TA7130	125
TA7204	150
TA7205	90
TA7222	150
TA7310	00
TAA900	395
TAA621	296
TAA661	190
TAA700	275
TAD100	159
TBA120S	70
TBA540	275
TBA550Q	330
TBA641	290
TBA651	190
TBA800	80
TBA810S	95
TBA820	80
TBA920Q	200
TBA990	350
TCA270	350
TCA280A	220
TCA940	175
TCA950	00
TCA965	180
TDA1008	310
TDA1010	235
TDA1022	499
TDA1024	115
TDA1034	350
TDA1054	00
TDA1490	350
TDA2002	325
TDA2003	250
TDA2004	300
TDA2006	330
TDA2020	320
TDA2030	190
TDB0791	420
TL061CP	40
TL062CP	65
TL064CN	98
TL071CP	40
TL072CP	76
TL074CN	150
TL081CP	35
TL082CP	60
TL083CP	75
TL084CP	120
TL091CP	60
TL170	50
TL430C	90
TL507	110
TL509	110
UA2240	120
UA78540	230
UAA170	180
UAA180	180
ULN2003	90
ULN2004	90
ULN2283	100
ULN2803	190
UPC556	00
UPC575	275
UPC1025H	375
UPC1156H	295
UPC1181	00
UPC1182	425
UPC1366	195
XR2206	375
XR2207	400
XR2211	575
XR2216	675
XR2266	360
ZN414	80
ZN423E	130
ZN424E	130
ZN425E-8	345
ZN426E-8	200
ZN427E-8	620

ZN428E	450
ZN429E-8	245
ZN459	245
ZN1034E	200
ZN1040E	695
ZNA234E	925

COMPUTER IC's

2102L	160
2114	325
2147-3	425
2516	350
2532-4	400
25L32	450
2564	700
27L08	450
2716-5V	350
2732	£4
2764-250	475
27C64	1095
26501	75
27128/250n	£16
256K DRAM	£49
3242	675
4027	95
4116	140
4164-150	425
4416-2	475
4532-3	250
4816-100ns	185
4864-15	425
5514	250
6116-150	350
6116L-120ns	375
6117-100n	575
6167-6	795
6264L-15	£19
63A03	£14
6402	350
6502 CPU	355
6502A	545
6503	650
6504	600
6505	650
6520	175
6522 VIA	340
6530 RRIOT	£11
6532 RIOT	650
6545 CRTC	899
6551 ACIA	650
6592	00
6800	220
6802	275
6803	850
6805	670
6808	520
6809E	750
6810	175
68B21	220
6821	175
6840	375
6843	800
6845	650
6845SP	750
6846	625
6847	650
6850	175
6852	250
6854	750
68B54	800
6875	500
68000	£25
8035	525
8080A	400
8085A	600
8088	£15
81LS95	140
81LS96	170
81LS97/98	140
8123	160
8131	475
8154	750
8155	500
8156	400
8202	£25
8212	£3
8214	495

8216	200
8224	£3
8226	£3
8228	270
8243	425
8250	£11
8251	500
8253	585
8255	600
8256A	£15
8257A	400
8259	£7
8271	POA
8272	£25
8279	750
8282	450
8283	450
8284	550
8288	£11
8748	£45
8T26A	99
8T27	150
8T31	350
8T95N	90
8T97N	90
9364AP	550
9602	220
AM26LS31C	125
AM26LS32A	125
AM26LS33	150
AM7910	£30
AY-3-1015	300
AY-5-1013	300
AY-5-1350	388
AY-5-3600	750
CD4724	150
COM8017	275
COM8116	700
DM8131	275
DP8303	450
DP8304BN	350
DS3647	00
DS3691N	495
DS8820	110
DS8830	135
DS8831	125
DS8832	250
DS88LS120	395
E9364	800
E9365	£36
FD1691	£15
FD1771	£15
FD1791	£22
FD1793	£23
FD1795	£28
FD1797	£28
HD26501	75
HM6845	755
IM6402	350
INS8060N	1250
M58174	825
MC1488	100
MC1489	100
MC14411	675
MC14412	725
MC3242	590
MC3446	250
MC3447P	315
MC3486	175
MC3487	175
MK3886-2M	£7
MM5280D	695
MM5303	635
MM5307	1275
MM5387A	865
MM58174	875
RO-3-2513L	700
RO-3-2513U	650
SAA5050	875
SFF96364E	800
SP0256AL2	495
TCM3101J	£13
TMS2716-3	725
TMS4047	100
TMS4164-15	395
TMS4416-2	595
TMS4500A	£12
TMS4532-3	350
TMS5100	600
TMS6011	500

TMS9914	895
TMS9927	£14
TMS9928	£20
TMS9929	£16
TMS9980	£20
TMS9995	£12
ULN2003	75
UPD7002	725
UPD7007	725
WD1691	£14
WD1770	£19.95
WD2143	850
Z80CPU 2·5	300
Z80ACPU4M	375
Z80ACTC	320
Z80B	£11
Z80DART	795
Z80ADART	820
Z80ADMA	900
Z80DMA	795
Z80P10	300
Z80AP10	325
Z80S10-1	850
Z80AS10	900
Z80AS10-2	£9
Z8002CPU	00

74S

74S00	40
74S02	40
74S03	40
74S04	40
74S05	40
74S08	40
74S09	40
74S10	40
74S11	40
74S15	60
74S20	40
74S30	60
74S22	40
74S30	40
74S32	50
74S37	50
74S38	70
74S40	40
74S51	40
74S64	40
74S65	40
74S74	70
74S85	295
74S86	100
74S112	100
74S113	100
74S114	100
74S124	300
74S132	90
74S133	50
74S134	60
74S135	110
74S138	170
74S139	170
74S140	60
74S151	140
74S153	140
74S157	200
74S158	190
74S162	300
74S163	300
74S168	00
74S169	00
74S174	250
74S175	300
74S181	00
74S182	00
74S188	200
74S189	225
74S194	280
74S195	275
74S196	00
74S197	300
74S201	250
74S225	500
74S226	500
74S240	375
74S241	375
74S244	474
74S251	225
745257	225
745258	225

74S260	70
74S262	£10
74S274	00
74S275	00
74S280	00
74S281	00
74S283	00
74S287	200
74S288	180
74S289	200
74S299	540
74S301	350
74S365	250
74S373	375
74S374	375
74S412	380
74S470	325
74S471	600
74S472	400
74S473	00
74S474	400
74S475	425
74S571	300
74S573	450

75

75107/8/9	95
75110	90
75121	00
75150	125
75154	195
75158	150
75159	140
75160	420
75162	650
75182/3	99
75188/9	100
75322	140
75353	00
75361	00
75365	00
75376	00
75450	86
75451/2	52
75454	70
75491/2	65

TTL 74

7400	25	7453	30	74196	120
7401	25	7454	30	74197	100
7402	25	7460	30	74198	200
7403	25	7470	50	74199	200
7404	30	7472	50	74221	200
7405	30	7473	50	74246	130
7406	40	7474	45	74247	120
7407	40	7475	55	74248	145
7408	25	7476	45	74249	175
7409	25	7480	60	74251	90
7410	25	7481	175	74259	150
7411	25	7482	100	74265	260
7412	25	7483	100	74273	180
7413	50	7484	105	74276	130
7414	60	7485	100	74278	160
7416	25	7486	40	74279	80
7417	35	7489	200	74283	100
7420	25	7490	60	74284	440
7421	50	7491	70	74285	300
7422	40	7492	70	74290	80
7423	35	7493	50	74293	80
7425	35	7494	100	74297	175
7426	40	7495	60	74298	160
7427	35	7496	75	74351	180
7428	35	7497	200	74365	70
7430	25	74100	175	74366	70
7432	30	74104	70	74367	70
7433	30	74105	70	74368	70
7437	30	74107	45	74376	120
7438	40	74109	70	74390	100
7440	30	74110	55	74393	100
7441	90	74111	55	74425	60
7442	65	74112	170	74426	60
7443	150	74116	160	74490	100
7444	100	74118	100		
7445	110	74119	160		
7446	110	74120	90		
7447	95	74121	45		
7448	110	74122	65		
7450	30	74123	75		
7451	30	74125	60		
		74126	60		
		74128	55		
		74132	70		
		74136	50		
		74141	85		
		74142	235		
		74143	250		
		74144	250		
		74145	100		
		74147	160		
		74148	130		
		74150	170		
		74151	60		
		74153	70		
		74154	130		
		74155	75		
		74156	90		
		74157	75		
		74159	170		
		74160	100		
		74161	100		
		74162	100		
		74163	100		
		74164	100		
		74165	100		
		74166	130		
		74167	250		
		74170	190		
		74172	400		
		74173	130		
		74174	100		
		74175	100		
		74176	100		
		74177	110		
		74178	130		
		74179	130		
		74180	100		
		74181	300		
		74182	120		
		74184	170		
		74185	170		
		74186	70		
		74188	75		
		74190	120		
		74191	120		
		74192	120		
		74193	120		
		74194	100		
		74195	75		

74C

C244	150
C245	150
C373	180
C374	425
C922	625
C923	645
C925	650

74LS

LS00	25	LS83	70	LS320	210
LS01	25	LS85	80	LS322	360
LS02	25	LS86	35	LS323	360
LS03	25	LS90	50	LS324	150
LS04	25	LS91	90	LS325	150
LS05	25	LS92	55	LS326	290
LS08	25	LS93	59	LS327	290
LS09	25	LS95	70	LS347	120
LS10	25	LS96	90	LS348	140
LS11	25	LS107	45	LS352	110
LS12	25	LS109	45	LS353	110
LS13	35	LS112	45	LS355	220
LS14	55	LS113	40	LS356	200
LS15	25	LS114	40	LS363	150
LS19	45	LS122	70	LS364	150
LS20	25	LS123	100	LS365	50
LS21	25	LS124	125	LS366	50
LS22	25	LS125	50	LS367	50
LS24	55	LS126	50	LS368	50
LS26	25	LS132	60	LS373	100
LS27	25	LS133	50	LS374	100
LS28	25	LS135	28	LS375	70
LS30	25	LS136	50	LS377	130
LS32	50	LS138	60	LS378	110
LS33	25	LS139	60	LS379	130
LS37	25	LS145	115	LS380	310
LS38	30	LS147	165	LS382	310
LS40	25	LS148	130	LS384	460
LS42	55	LS151	70	LS385	330
LS47	90	LS153	70	LS386	50
LS48	90	LS154	200	LS390	80
LS49	100	LS155	70	LS393	100
LS51	30	LS156	70	LS395	110
LS52	25	LS157	60	LS396	300
LS54	30	LS158	60	LS398	195
LS55	30	LS160	70	LS399	140
LS63	55	LS161	70	LS445	125
LS73	30	LS162	70	LS447	80
LS74	35	LS163	70	LS465	140
LS75	45	LS164	80	LS467	120
LS76	40	LS165	110	LS490	150
LS78	40	LS166	150	LS540	140
		LS168	140	LS541	140
		LS169	125	LS624	155
		LS170	160	LS629	130
		LS173	100	LS640	200
		LS174	100	LS641	150
		LS175	70	LS645	195
		LS181	190	LS668	90
		LS183	190	LS669	90
		LS190	85	LS670	170
		LS191	85	LS673	890
		LS192	85	LS674	800
		LS193	85	LS682	250
		LS194	75	LS684	350
		LS195	75	LS687	350
		LS196	85		
		LS197	85		
		LS221	85		
		LS240	95		
		LS241	95		
		LS242	95		
		LS243	95		
		LS244	95		
		LS245	160		
		LS247	105		
		LS248	105		
		LS249	105		
		LS251	75		
		LS253	75		
		LS256	175		
		LS257	75		
		LS258	75		
		LS259	125		
		LS260	70		
		LS261	100		
		LS266	60		
		LS273	120		
		LS275	350		
		LS279	70		
		LS280	185		
		LS283	80		
		LS290	80		
		LS292	850		
		LS293	80		
		LS294	999		
		LS295	140		
		LS297	850		
		LS298	100		
		LS299	225		

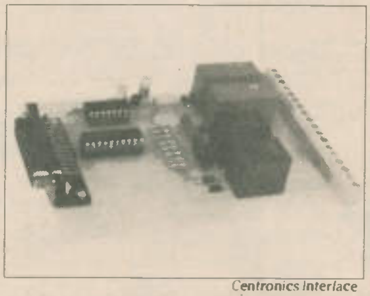
CMOS

4000	20	4035	70	4519	32
4001	25	4036	275	4520	53
4002	25	4037	115	4521	115
4006	75	4038	75	4522	125
4007	25	4039	280	4526	60
4008	60	4040	60	4527	65
4009	45	4041	57	4528	70
4010	40	4042	50	4529	150
4011	25	4043	42	4530	90
4012	25	4044	50	4531	130
4013	60	4045	110	4532	65
4014	60	4046	60	4534	400
4015	60	4047	60	4536	275
4016	40	4048	55	4538	80
4017	60	4049	38	4539	90
4018	60	4050	35	4541	95
4019	58	4051	70	4543	70
4020	90	4052	60	4544	150
4021	58	4053	60	4549	400
4022	67	4054	85	4553	245
4023	30	4055	85	4554	180
4024	50	4056	85	4555	35
4025	22	4057	£10	4556	55
4026	90	4059	435	4557	250
4027	48	4060	68	4558	120
4028	45	4061	£5	4559	395
4029	75	4062	995	4560	160
4030	35	4063	85	4561	104
4031	130	4066	45	4562	350
4032	70	4067	245	4566	165
4033	130	4068	25	4568	250
4034	140	4069	25	4569	175
		4070	25	4572	45
		4071	25	4580	255
		4072	25	4581	125
		4073	26	4582	99
		4075	25	4583	100
		4076	68	4584	60
		4077	25	4585	70
		4078	25	4599	155
		4081	25	40097	45
		4082	25	40098	42
		4085	60	40100	215
		4086	60	40101	130
		4089	125	40102	140
		4093	37	40103	412
		4094	70	40104	120
		4095	95	40105	220
		4096	100	40106	60
		4097	275	40107	55
		4098	80	40108	325
		4099	75	40109	100
		4160	95	40110	235
		4161	99	40114	240
		4162	99	40161	194
		4163	99	40163	75
		4174	99	40174	75
		4175	105	40175	75
		4194	105	40181	220
		4408	850	40192	75
		4409	850	40193	95
		4410	725	40194	90
		4411	750	40195	80
		4412	805	40244	195
		4415	590	40245	195
		4419	280	40257	198
		4422	770	40373	220
		4433	770	40374	220
		4435	850		
		4440	999		
		4450	350		
		4490	450		
		4500	395		
		4501	38		
		4502	60		
		4503	40		
		4504	99		
		4505	385		
		4506	100		
		4507	45		
		4508	130		
		4510	55		
		4511	55		
		4512	55		
		4513	150		
		4514	115		
		4515	125		
		4516	65		
		4517	275		
		4518	48		

JUST PHONE YOUR ORDER, WE DO THE REST. 0923 50234

Cirkit. Making it bigger and better.

Cirkit stock all the components, accessories and tools and the kits you're looking for. Designed and selected to offer the best possible standards at the best possible price.



Centronics Interface

Cirkit Kits

CIRKIT ELECTRONICS TOOL KIT
Contains: 15W Soldering Iron 2 spare bits, heat shunt, solder, pliers, cutter, screwdriver 40-00007 12.00

AUDIO FUNCTION GENERATOR
Versatile waveform generator with sine, triangular and square wave outputs. On board mains PSU 41-01302 27.00

STEREO 40W AMPLIFIER
Single board 40W per channel stereo amplifier 41-01301 38.00

STEREO VU METER
5 LED per channel stereo VU meter for use with stereo amplifiers 41-01401 11.50

5W AUDIO AMP
A very compact audio output stage for use in a wide range of equipment 41-01406 4.60

UNIVERSAL AMP
A universal audio pre-amp with a gain of 10 41-01604 6.45

MONO REVERBERATION UNIT
Single channel, spring line reverb unit to add echo effects to tape recording etc. 41-01602 10.00

TONE GENERATOR AND DETECTOR
Very low distortion tone generator and signal detector for circuit fault finding 41-01603 40.46

10MHz DFM
8 Digit LED digital frequency meter and period measurement 41-01500 54.10

50MHz PRESCALER
Extend the range of the 10MHz DFM to 50MHz 41-01501 8.55

1-5MHz PRE AMP
Low frequency pre-amp and waveform shaper for the 10MHz DFM 41-01502 5.13

70cm PRE AMP
Low noise, miniature pre-amp for the 70cm amateur band 41-01506 4.78

70cm CONVERTER
70cm to 144MHz low noise converter featuring pre-aligned helical filter, schottky diode mixer and low noise transistors 41-01405 21.50

1-30V 1mA-2A PSU
Adjustable 1-30V Power supply with pre-setable current limit from 1mA-2A 41-01600 37.46

5-12V 1A PSU
Adjustable PSU from 5-12V with current protection, 1 amp max output 41-01504 6.45

1-30V 1.5A PSU
1-30 volt adjustable PSU with protected output up to 1.5 Amps 41-01402 10.45

3 DIGIT LED DVM
DVM to read up to 99.9 volts or configured as an ammeter to read up to 9.99 amps 41-01403 17.00

INFRA RED LINK
Single channel IR Link with relay output 41-01300 9.60

TEMPERATURE SENSOR
Thermistor based temperature sensor with relay output 41-01303 6.20

LOCOMOTIVE SOUND GENERATOR
Realistic steam sound and whistle for model railways 41-01304 9.20

LAMP DIMMER
Control lamps and drill speed 41-01305 5.70

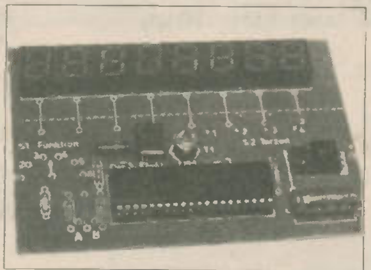
WATER LEVEL ALARM
Alarm to indicate high water level or flooding 41-01601 2.70

3 NOTE CHIME
Doorbell chime with adjustable tones 41-01503 7.00

2M PRE AMP
Miniature low-noise MOSFET pre-amp for the 2m amateur band 41-01307 3.91

2M CONVERTER
Low noise 144MHz-28MHz amateur band converter 41-01306 17.35

2M POWER AMP
20W - 10dB gain - power amplifier for the 2m band. Automatic TX switch over, RX pre-amp, robust construction 41-01404 32.87



10MHz DFM

CRYSTAL CALIBRATOR
Crystal reference calibrator for alignment of receivers, outputs at 4, 2, 1MHZ, 100, 50 AND 10KHz 41-00801 4.32

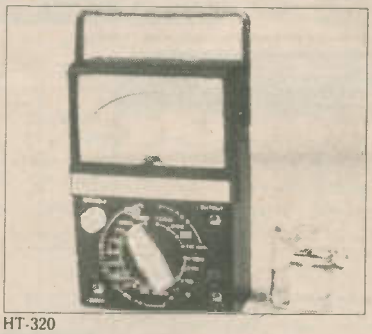
CB NOISE SQUELCH
Improves the mute performance of the majority of CB rigs 41-01605 5.40

CENTRONICS INTERFACE
Connect your personal computer to the outside world via the Centronics printer output 41-01606 22.50

70cm PA
10W Power amp to boost the output of handheld and portable 70cm transceivers 41-01505 33.82

Selected Lines

BBC to Centronics Connect Cable		03-10019	7.25
Dragon to Centronics Connect Cable		03-10017	7.25
C12 Computer Cassette		21-00012	0.55
Interface 84 multiplexed Ram Card		40-84000	59.95
Z80A industrial controller		40-82000	54.95
EPROM Eraser 84T		40-82001	59.95
6502 Micro Controller		40-65020	54.95
6802 Micro Controller		40-68020	54.95
PB2720	80dB Piezo Buzzer	43-27201	0.55
10M15A	10.7 Center Freq.	20-10152	2.10
10M08AA	10.695 Center Freq.	20-11152	3.49
FC177	LCD (Freq.)	39-17700	20.00
CM161	LCD Clock	40-80161	8.25
8 x 0.3"	IC socket	28-00800	0.12
14 x 0.3"	IC socket	28-14000	0.13
16 x 0.3"	IC socket	28-16000	0.13
6V	KUIT-A Relay	46-80000	0.48
9V	KUIT-A Relay	46-80001	0.48
12V	KUIT-A Relay	46-80002	0.48
CX120P	COAX Relay	46-90120	11.96
CX520D	COAX Relay (N-type)	46-90520	26.98
CX540D	COAX Relay (BNC)	46-90540	26.98



HT-320
Multimeter (20kΩ-V) 56-83201 14.00

Please add 15% VAT to all advertised prices and 60p post and packing. Minimum order value £5 please. We reserve the right to vary prices in accordance with market fluctuation.
Just send for our catalogue or visit one of our three outlets at:

200 North Service Road, Brentwood, Essex. CM14 4SG.
53 Burrfields Road, Portsmouth, Hampshire. PO3 5EB.
Park Lane, Broxbourne, Hertfordshire. EN10 7NQ.
Items in stock despatched within 48 hours

To: Cirkit Holdings PLC, Park Lane, Broxbourne, Hertfordshire. EN10 7NQ.
I enclose 85p. Please send me your latest catalogue and 3 x £1 discount vouchers!
If you have any enquiries please telephone us on Hoddesdon (0992) 444111.

Name ______________________

Address ______________________

____

Telephone ______________________

Area of Special Interest ______________________

PE2

Cirkit
Bigger Stock. Better Service

New Winter Catalogue Out Now!

PE VOLUME 21 Nº 2 FEBRUARY 1985

SAFETY

ELECTRONICS has done much to benefit our way of life and standard of living in all areas from entertainment to safety at sea and in the air. Of course it has also enabled development of more sophisticated weapons and defence systems but that is another story. Our exploration of space is totally dependent on electronics and navigation about our own planet is also now based mainly on high technology.

What a pity then that the modes of transport we all use every day have not benefited more from the introduction of electronics to aid safety. The car you drive may have a computer to show fuel consumption, it may have a talking dash panel or even an engine management computer, but have the electronics been used to improve safety? How many vehicles are fitted with an anti-locking braking system? How often do you see vehicles skidding even on dry roads? How often do the back wheels of unladen lorries lock up when they stop? How many motorcyclists come off in the wet when braking or skid into the back of the car in front?

Admittedly many of the skids that do occur result in no damage or injury but of course some do. Surely it is better to make vehicles safer with an electronically controlled failsafe braking system than to get them talking to you? This is one area where the amateur in electronics can do little himself. We would not encourage readers to modify any vehicle braking system, so we cannot fit a system to help ourselves.

The sad thing is that the technology and mechanics to perform the necessary tasks has been around for some years. Perhaps the manufacturers feel we will not pay for the extra safety; maybe they do not feel it is necessary? The next time you see a minor skid that could have been dangerous, a motorcyclist fall off, or a lorry stopping slightly sideways just think about what could have gone badly wrong and see if you feel anti-skid braking would be worth another couple of hundred pounds on the already inflated price of a new vehicle in the UK.

LEGISLATION

Maybe you will even think that legislation would be a good thing, even if it might not save as many lives as compulsory seat belt wearing!

Incidentally, the motorcyclist I saw come off this morning was shaken but not badly injured, although his bike was probably a write-off and the car he ran into badly damaged. Think about it if you buy a new vehicle! The extra cost could be worth the time, trouble and heartache alone.

Mike Kenward

BACK NUMBERS and BINDERS...

Copies of most of our recent issues are available from: Post Sales Department (Practical Electronics), IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at £1 each including Inland/Overseas p&p. Please state month and year of issue required.

Binders for PE are available from the same address as back numbers at £5.50 each to UK or overseas addresses, including postage, packing and VAT

Editor Mike Kenward

Secretary Pauline Mitchell

Editorial Tel: Poole (0202) 671191

Advertisement Manager
David Tilleard 01-261 6676

Secretary
Christine Pocknell 01-261 6676

Classified Supervisor
Barbara Blake 01-261 5897

Ad. Make-up/Copy
Brian Lamb 01-261 6601

Queries and letters concerning **advertisements** *to:*
Practical Electronics Advertisements,
King's Reach Tower,
Stamford Street, London SE1 9LS
Telex: 915748 MAGDIV-G

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

Components are usually available from advertisers; where we anticipate difficulties a source will be suggested.

Old Projects
We advise readers to check that all parts are still available before commencing any project in a back-dated issue, as we cannot guarantee the indefinite availability of components used.

Technical *and* **editorial** *queries and letters to:*
Practical Electronics Editorial,
Westover House,
West Quay Road, Poole,
Dorset BH15 1JG

SUBSCRIPTIONS

Copies of Practical Electronics are available by post, inland for £13, overseas for £14 per 12 issues, from: Practical Electronics, Subsceription Department, IPC Magazines Ltd., Room 2816, King's Reach Tower, Stamford Street, London SE1 9LS. Cheques, postal orders and international money orders should be made payable to IPC Magazines Limited. Payment for subscriptions can also be made using a credit card.

Phone:
***Editorial* Poole (0202) 671191**

We regret that lengthy technical enquiries cannot be answered over the telephone.

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

...NEWS &

HIGH COST INSULATION

Most constructors will be painfully aware of the annoying shrink-back properties of insulation, encountered when soldering wires into place. Over the years manufacturers have developed heat-proof insulation materials for specialised cable applications which eventually filter through industry to the home-constructor—and very welcome they are, too. It.may surprise you to know, however, just how far, and to what expense, manufacturers will go in order to optimise the insulating properties of the materials they use.

B.I.C.C. for instance has just completed the installation of a new electron beam accelerator plant at its Electronic Cables factory in Cheshire, the cost? A staggering £2·5 million. The facility is considered to be the most sophisticated and versatile of its kind in the Western world. The accelerator produces high velocity electrons which have sufficient energy to penetrate the cable insulation.

Once inside a polymeric insulation, the electrons initiate chemical reactions which lead to the formation of chemical bonds or crosslinks. Increasing the number of crosslinks leads to eventual formation of a three-dimensional network which substantially enhances the physical properties of the insulant.

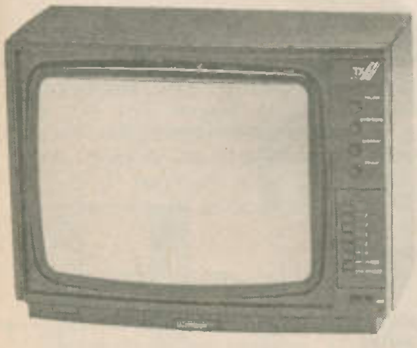
The most obvious effect of crosslinking is that the material loses its thermoplastic characteristics and becomes a non-melting thermoset with a better balance of mechanical properties at both high and low temperatures; chemical resistance is also enhanced.

The whole facility is enclosed in 1500 tonnes of concrete for personnel protection during plant operation. The picture shows the plants computer control room.

TX TELEVISION/MONITOR

The latest in the TX range from Ferguson is a 14 inch monitor/colour television. It will offer those who can afford a second or even third set a very flexible visual display tool.

The MCO1 has separate RGB, composite video and aerial inputs enabling the user to get the best possible display from broadcast TV, video recorders, teletext and home computers.



Perhaps the most interesting of these options is the ability to directly connect a home computer without the modulation/demodulation problems that occur when using a standard TV set. It must be borne in mind that not all currently available home computers have a direct video output. The machines without this facility have on-board modulation/demodulation and were so designed for use with a visual display medium that most people already possessed—a standard TV set.

The provision of separate RGB, composite video and aerial sockets also allows the home computer, video recorder or game and TV aerial to be connected simultaneously; the set senses the signal selected and switches to it automatically.

A range of special connector leads is available to cover the different home computer options. The set is manufactured in the UK at the company's Gosport plant. It is expected to retail at circa £230.

PATENTLY OBVIOUS

All too often the most worrying aspect for the creator of an original design is, how to protect that idea from those who would copy and exploit it for their own gain. This has been the case since the first inventor brought forth a brainchild, only to stand by helplessly as someone else marketed his idea and made a fortune. The laws governing Patents, Trademarks, Designs and Copyright are complex indeed, without guidance the layman may be forgiven for getting confused. Laurence Shaw's recently reprinted guide can be of great help to inventors and innovators alike.

The *Practical Guide for people with a new idea* is a book which explains in clear language how to protect a new idea, product or scheme and exploit it to the full. Market research, approaching a manufacturer, telling the world about an idea without losing your rights and patenting an invention are all covered together with secret patents.

This publication is available from booksellers at £5.50, or by mail order at £5.95 from The Patent Eye, George House, George Road, Edgbaston, Birmingham B15 1PG. (021 454 2165).

MAGIC LANTERN

Question: If you are exposed to radiation do you glow in the dark? Answer: Of course not. Not unless you are first coated with a phosphor of some kind. It is a useful fact that beta particles from a radioactive source will, when they strike a phosphor such as zinc sulphide, cause light to be emitted from it. Battelle's Pacific Northwest Laboratories are testing a novel application of this phenomenon. Scientists are evaluating a portable runway lamp for setting up landing strips in out-of-the-way places, or during emergencies in which the electricity supply is lost.

The lamp comprises a glass tube, its inside surface coated with a phosphor, and which is filled with tritium gas, the radioactive isotope of hydrogen. The lamp can not be turned off, it simply continues to glow for the twelve years half-life of the gas. Keeping the glass clean is the only maintenance operation required during that time. The quantity of radioactive material used is so minute that it is harmless even if the glass breaks, it is claimed.

During field tests in Alaska pilots reported that they perceived light from the radioluminescent lamps differently from that of conventional light, and human response now needs to be assessed to find out how useful these lamps may be.

MARKET PLACE

BT's rumble machine

It's new from British Telecom,
For paging far-off staff.
A little pocket thing,
That could well cause a laugh.

You see instead of 'bleeping',
It's been made to 'vibrate'.
So you're the only one that knows,
HQ and you have got a date.

The waveforms coming through the air,
Will go right through your pants.
And trigger-off this rumble-box,
Like a herd of elephants.

So if you're in a meeting,
Friends might still get the rise.
When they notice that your eyeballs,
Are looking like mince pies.

HEADS-U-WIN

Ensuring peak response and high-quality reproduction, Electrolube's Video Tape Head Cleaner is a safety solvent designed for use on all magnetic tape heads.

The cleaner loosens and removes accumulated deposits of dirt and tape oxide and dries quickly without leaving any residues on the tape. The cleaner is non-flammable, and non-conductive, it will not damage plastics or rubber.

The solvent comes in handy 110 gram aerosols and is conveniently applied by spraying directly onto the heads and mechanisms. In addition, the cleaner is ideal for spraying onto cleaning tapes and other tape cleaning devices, such as cotton buds or felt and chamois leather sticks.

Available on its own at circa £1.20, or with 25 extra long cotton buds at circa £1.60 from electrical retail outlets.

'BBC's go Bang'

Following a tongue-in-cheek comment from Mike Cook, the Technical Editor of Micro User, *several hundred BBC micro owners recently returned their machines to their respective dealers, in the fear that they were about to detonate.*

The unfortunate comment was printed in the magazine's problem page as part of a reply to a reader's query regarding an 'error message'. Mr Cook, believing himself to be the subject of a "wind-up", answered in kind. "Take your computer immediately to the dealer as this error message indicates that it is about to explode."

The manufacturers, Acorn Computers, were not amused, neither was the middle-aged housewife who reportedly surrounded her machine with a bucket of water.

POINTS ARISING...

RING MODULATOR

December, 1984

Alterations to this project must be made as follows:

In Fig. 9 the component marked C35 should be marked R35.

The capacitor C21 should have its +ve terminal connected to R10.

In Fig. 10 the unmarked component mounted between JK1 and JK2 is R47.

A wire link should be connected between JK3 (C25 −ve) and JK4 (C26 +ve).

Countdown . . .

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

International Light Show Jan. 14–28. Olympia. **E6**
British Toy & Hobby Fair Jan. 18–Feb. 2. Olympia. **D6**
Component Fair March 10. Carleton Community Cntr., Pontefract (on A1 to Darrington). **F2**
London Medical March 12–15. Earls Court. **S2**
IFSSEC (fire/security) April 15–19. Earls Court, London. **S**
Cast (Cable & Satellite) April 16–18. NEC, Birmingham **F5**
Communications April 23–25. Olympia. **I**
Photoworld April 23–May 6. Earls Court. **I**
CAD April 26–28. Metropole, Brighton. **K2**
Fibre Optics & Lasers April 30–May 2. Olympia. **E**
Custom Electronics & Design Techniques April 30–May 2. **E**
All Electronics Show/ECIF April 30–May 2. Olympia 2. **E**
Circuit Technology April 30–May 2. **E**
Field Service & Repairs April 30–May 2. Olympia 2. **E**
Automan (manufacturing) May. NEC. **T1**
Scotelex June 4–6. Royal Highland Soc., ex. Hall, Ingliston, Edinburgh. **A1**
Personal Computer World Show Sept. 18–22. Olympia 2. **M**

S2	Fairs & Exhibitions Ltd., ✆ 01-831 8981
D6	✆ 01-701 7127
E	Evan Steadman ✆ 0799 26699
E6	✆ 058 84 658
F2	Pontefract Am. Rad. Soc. N. Whittingham ✆ 0977 792784
F5	✆ 01-487 4397
I	ITF ✆ 021-705 6707
K2	Reed Exhibitions, Surrey Ho., 1 Throwley Way, Sutton, Surrey
M	Montbuild ✆ 01-486 1951
O	Online ✆ 01-868 4466
S	✆ 01-387 5050
A1	Institute Electronics ✆ 0706 43661
T1	Cahners ✆ 0483 38085

MODULAR AUDIO POWER SYSTEM

PART 1

M. TOOLEY BA
D. WHITFIELD
MA MSc CEng MIEE

IN recent years, improvements in semiconductor technology and, in particular, the introduction of a number of highly versatile consumer integrated circuits and power Darlington stages, have resulted in audio equipment which is both compact and very straightforward. This new series deals with the construction of a variety of modules for use in the custom design of sound reinforcing systems and for public address work generally.

We start, this month, with full constructional details of a 50W power amplifier module. This unit forms the basic building block for several complete designs to be described later. Details of suitable pre-amplifiers, line drivers, tone controls and mixers will also be included; the aim being that of affording the individual constructor the widest possible choice of audio system configuration.

THE 50W POWER AMPLIFIER MODULE

The power amplifier module is electrically robust, is simple to construct, and uses low-cost readily available components. In its basic form, the module is capable of delivering a continuous r.m.s. sine wave output of 50W into a 4 ohm load. The design may be easily modified for operation with alternative output transistors and/or supply rails, as shown in Table 1.

Whilst every effort has been made to avoid the pitfalls, it should be stated at the outset that this project, together with its higher power derivatives, is not for the faint hearted. Indeed, the prototype amplifier was not developed without a few disasters, including four output transistors which literally melted during the testing stage!

An important requirement of this project (and one which readers ignore at their peril) is that the loudspeaker systems employed should be capable of handling the full amplifier output power. However, readers who do not have immediate access to correctly rated loudspeakers need not despair since we shall, next month, be describing a calibrated test load rated at continuous r.m.s. powers well in excess of 100W. A dummy load of this type should prove to be an invaluable accessory for those wishing to "run-up" the amplifier without destroying their ear drums.

Having started on a cautionary note it is perhaps worth saying that, provided readers carefully follow the setting-up procedure and observe the recommendations concerning heat sinks, component ratings, and supply rails, there should be few, if any, problems.

CIRCUIT DESCRIPTION

A simplified block schematic of the power amplifier module is shown in Fig. 1. The corresponding circuit diagram is shown in Fig. 2. The module consists essentially of a differential input stage followed by a driver and complementary power Darlington output stage. The unit runs from balanced (i.e. separate positive and negative) supply rails with a common 0V rail at earth potential.

The input stage is formed by TR1 and TR2 which are connected as a long-tailed differential pair with TR3 acting as a constant current source. The emitter currents of TR1 and TR2 are determined by VR1 which provides a range of adjustment from about 1·5mA to 3·0mA total current. The signal input is applied to the base of TR1, via a switched d.c. blocking capacitor arrangement, whilst negative feedback (both d.c. and a.c.) is applied to the base of TR2. The overall voltage gain of the module is determined by the amount of feedback applied and is approximately equal to the ratio of

Max. r.m.s. output power	Rec. supply rail voltages	Max. rec. heatsink thermal resistance	TR6 (npn)	TR7 (pnp)	T1 sec. rating 2 ×
30W	± 30V	4 deg.C/W	TIP121	TIP126	20V/1·5A
45W	± 30V	2 deg.C/W	TIP141	TIP146	20V/2A
80W	± 40V	1 deg.C/W	10K80	11K80	25V/2·5A
			MJ3001	MJ2501	
			2N6058	2N6051	
120W	± 50V	0·5 deg. C/W	MJ11016	MJ11015	32V/3A

Table 1. Output device selection table

CUSTOM DESIGN YOUR OWN HIGH POWER AUDIO SYSTEM

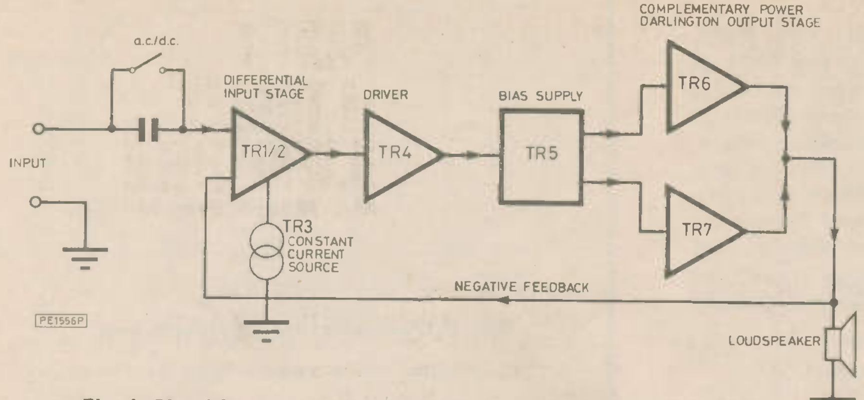


Fig. 1. Simplified block schematic of the Power Amplifier Module

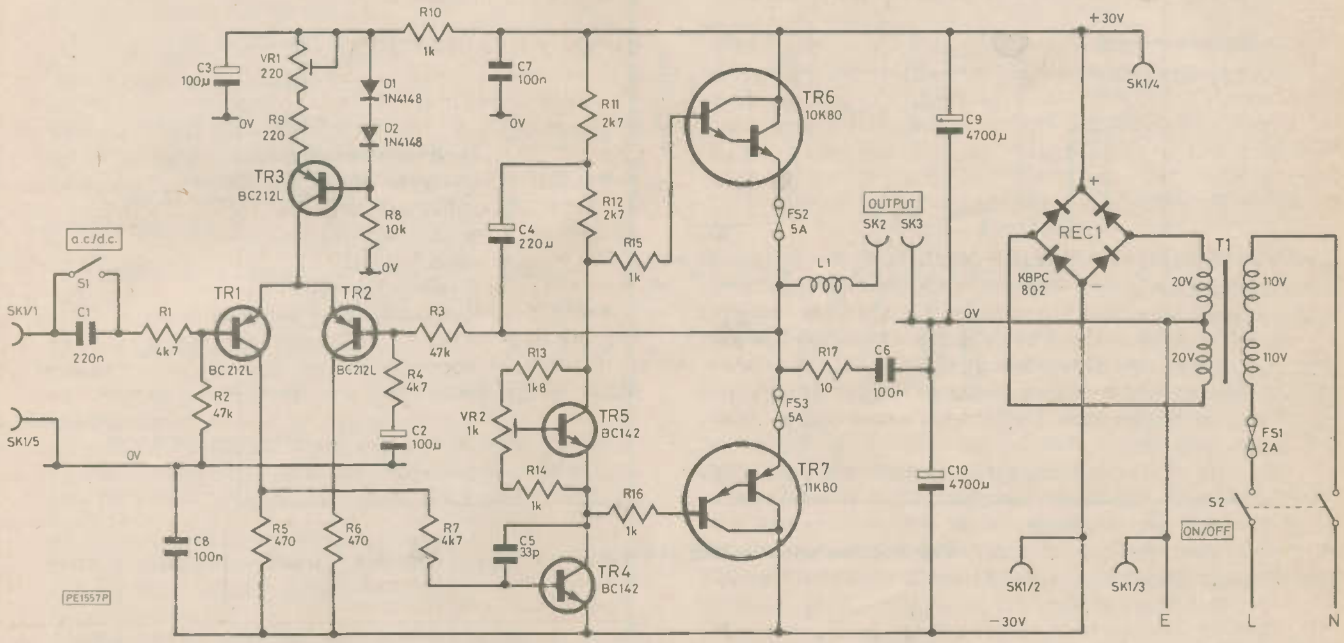


Fig. 2. Complete circuit diagram of the Power Amplifier Module

R3 to R4.

Direct coupling of input signals is provided by means of S1 which bypasses the d.c. blocking capacitor, C1. In order to preserve symmetry of the differential stage, the following resistors are made equal: R2 and R3, R5 and R6, R1 and R4 (note that the latter assumes that the amplifier is fed from a relatively low-impedance source).

TR4 forms a conventional common emitter driver stage using an npn transistor. Since the quiescent power dissipation for this stage is in the region of 125mW, a metal cased TO5 style device is much to be preferred. Bias for the output transistors is provided by TR5 which acts as a constant voltage source, adjustable by means of VR2. The output stage is a conventional complementary symmetrical arrangement using Darlington pairs, TR6 and TR7. A variety of different devices may be employed in the output stage depending upon output power requirements and the available supply voltage rails. These configurations are summarised in Table 1. The output stage is protected by means of two 5A quick-blow fuses, FS2 and FS3. It should perhaps be mentioned that this form of protection is not completely foolproof but will normally cope with a short-circuited load or failure of one of the output Darlingtons.

C6 and R17 form a Zobel network whilst L1 ensures unconditional stability of the amplifier when operating into a severely capacitive load. Bootstrap feedback is applied via C4 in order to raise the effective impedance of the collector load for TR4. C5 provides high-frequency roll-off since the bandwidth of the amplifier is otherwise somewhat excessive. The power supply arrangement is fairly conventional and

SPECIFICATION

Maximum power output: **(measured at 1kHz)**	60W r.m.s. into 3ohm 50W r.m.s. into 4ohm 40W r.m.s. into 8ohm 25W r.m.s. into 15ohm
Minimum recommended load impedance:	3ohm
Voltage gain:	10
Input voltage for max. rated output:	less than 2V r.m.s.
Input impedance:	50k approx.
Recommended source impedance:	600ohm
Total harmonic distortion:	0·05% typical at 30W output into 8ohm
Frequency response (a.c. coupled):	15Hz to 50kHz at −3dB
(d.c. coupled):	d.c. to 50kHz at −3dB
Hum and noise:	less than −85dB related to max. rated output

provides symmetrical supply rails of nominally +30V and −30V.

CONSTRUCTION

With the exception of the power supply (T1, FS1, REC1, C9 and C10) and the output transistors (TR6 and TR7), all components are mounted on a single-sided p.c.b. measuring approximatly 65mm x 115mm. The component overlay of the p.c.b. is shown in Fig. 3. Components should be assembled on the p.c.b. in the following sequence: terminal pins, resistors, capacitors, transistors, pre-set resistors, fuse clips, and inductor. The latter component consists of 20 turns of 20 s.w.g. wire wound with an inside diameter of 8mm. Care should be taken to carefully remove the enamel at each end of this component in order to facilitate an effective soldered connection to the p.c.b.

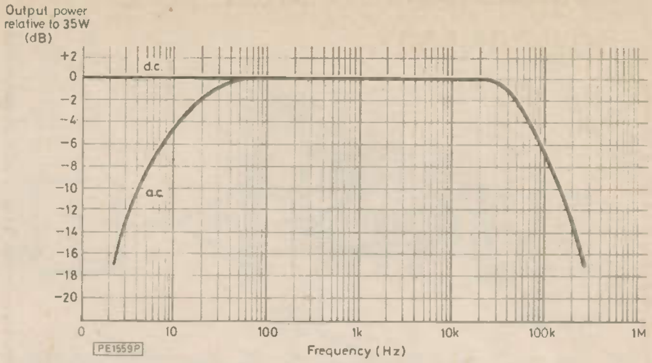


Fig. 5. Frequency response (8ohm load)

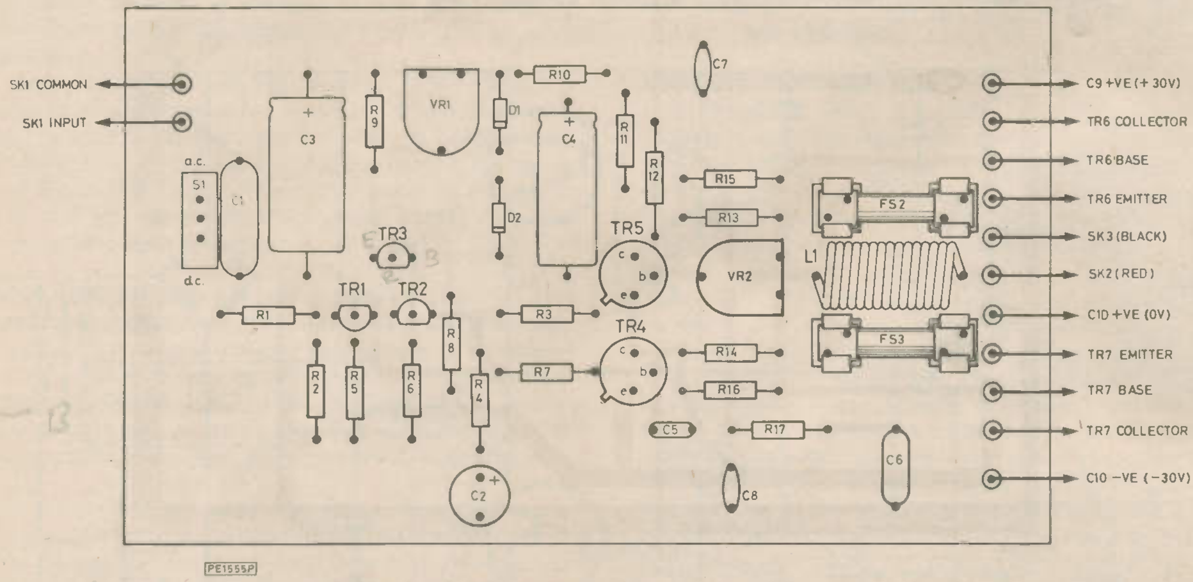


Fig. 3. Component layout of the p.c.b.

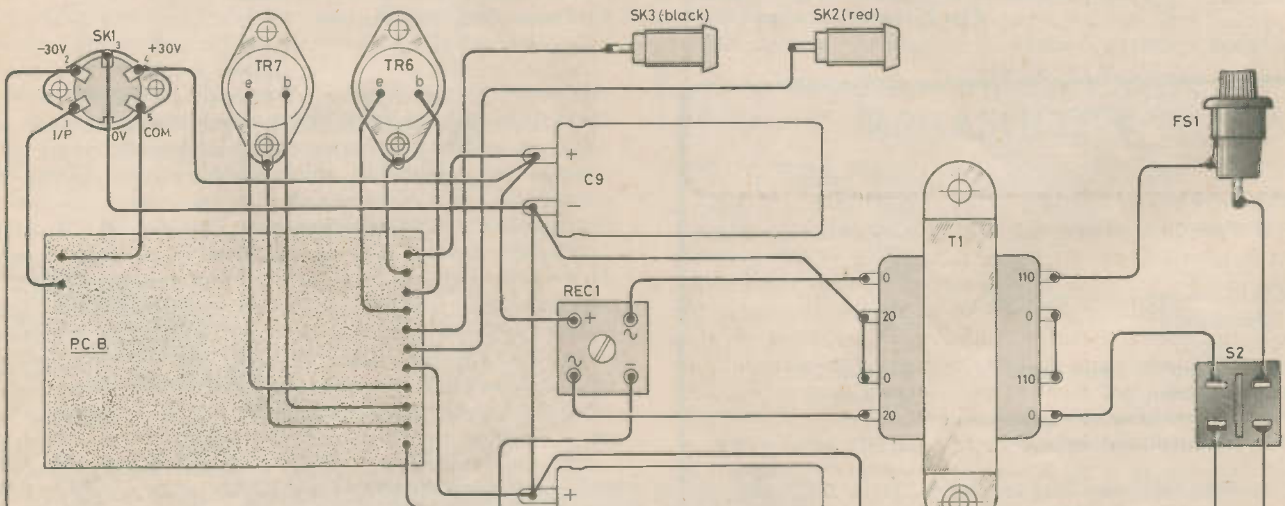


Fig. 4. Wiring diagram for the Power Module

COMPONENTS . . .

Resistors

R1,R4,R7	4k7 (3 off)
R2,R3	47k (2 off)
R5,R6	470 (2 off)
R8	10k
R9	220
R10,R14,R15,R16	1k (4 off)
R11,R12	2k7 (2 off)
R13	1k8
R17	10 0·5W 5% carbon

VR1 220 min. hor. skeleton pre-set
VR2 1k min. hor. skeleton pre-set

Except where otherwise stated, all fixed resistors are 0·25W 5% carbon.

Capacitors

C1	220n 250V polyester
C2	100µ 16V p.c. electrolytic
C3	100µ 63V p.c. electrolytic
C4	220µ 25V tubular electrolytic
C5	33p ceramic
C6	100n 250V polyester
C7,C8	100n 100V disc ceramic (2 off)
C9,C10	4700µ 63V can elect. (2 off)

Semiconductors

D1,D2	1N4148 (2 off)
TR1,TR2,TR3	BC212L (3 off)
TR4,TR5	BC142 (2 off)
TR6	10K80 (see Table 1)
TR7	11K80 (see Table 1)
REC1	KBPC802 (200V/6A)

Miscellaneous

p.c.b. s.p.d.t. miniature p.c. slide switch
T1 80VA mains transformer with 220V primary and two secondary windings each rated at 20V/2A minimum (see Table 1)
L1 (see text) p.c. mounting fuse clips (4 off)
FS1 2A 20mm quick-blow mains fuse and holder
FS2 and FS3 5A 20mm quick-blow fuses
Heatsinks (see text)
Silicone impregnated heatsink washers (thermal resistance 0·33 deg.C/W) and bushes (two sets required)
Terminal pins (13 required)
SK1 5-pin 270 deg. DIN socket
SK2 and SK3 4mm sockets (1 red and 1 black)
Mains connector
Printed circuit board (502–01)

The Darlington transistors must be mounted on a substantial heatsink of no more than 1 deg.C/W thermal resistance. To facilitate effective heat transfer the use of silicone impregnated washers is highly recommended (it should be noted that the collector connections of the Darlington power transistors are formed by their respective cases and these will have to be insulated from a heatsink which will invariably be at earth potential).

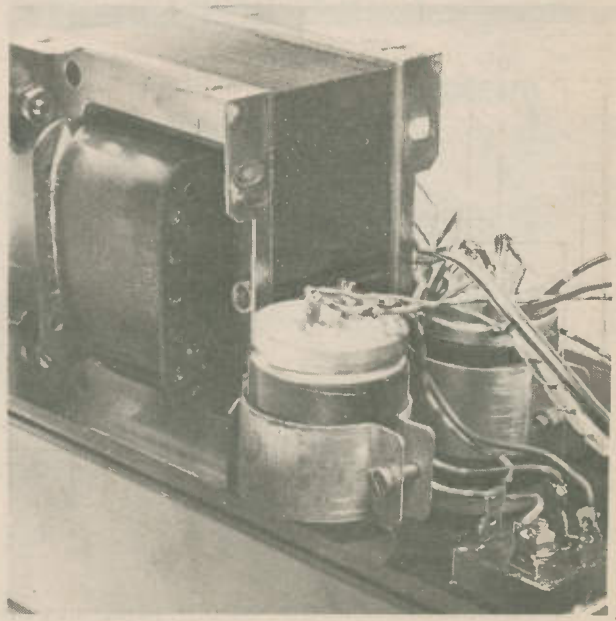
The encapsulated bridge rectifier, REC1, also requires mounting on a heatsink. The requirement for this heatsink is somewhat less stringent than that needed for the output transistors and a rating of 5 deg.C/W (or approx. 110mm x 110mm 16 s.w.g. aluminium) should prove to be quite adequate. Happily, with this component, there is no need for an insulating washer but a liberal application of silicone grease is recommended before assembly. For most practical purposes the rectifier heatsink can simply be provided by the external case or chassis of the equipment. This expedient will, however, not normally apply to the output transistors unless the case is specially designed with heat sinking in mind!

TR1	c	−28·4V
	b	0V
	e	+0·6V
TR2	c	−28·4V
	b	0V
	e	+0·6V
TR3	c	+0·6V
	b	+20·8V
	e	+21·4V
TR4	c	−1·0V
	b	−28·5V
	e	−29·2V
TR5	c	+1·0V
	b	−0·5V
	e	−1·0V
TR6	c	+29·2V
	b	+1·0V
	e	0V
TR7	c	−29·2V
	b	−1·0V
	e	0V

All test voltages measured with a 20k ohm/V multimeter.
Table 2. Test voltages

When the p.c.b. wiring is complete, the underside of the board should be carefully checked for solder bridges and dry joints, whereas the component side should be examined, paying particular attention to the correct placement and orientation of polarised components.

Connections to the heatsink mounted components (TR6, TR7 and REC1) and reservoir capacitors (C9 and C10) should be made by short lengths (typically not more than 150mm) of 16/0·2mm (0·5mm²) stranded pvc covered wire. A typical wiring layout is shown in Fig. 4.



Internal view of the Power Amp

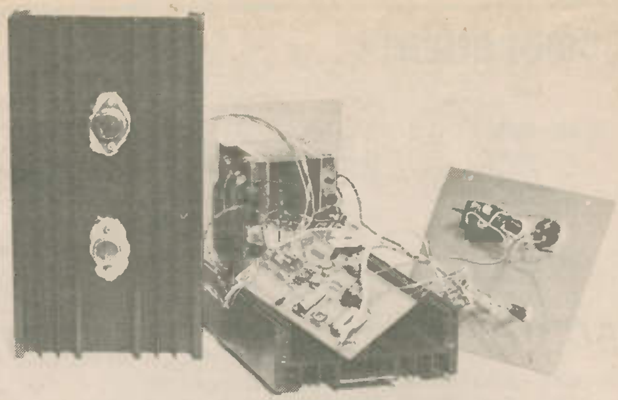
INITIAL TESTS AND SETTING-UP

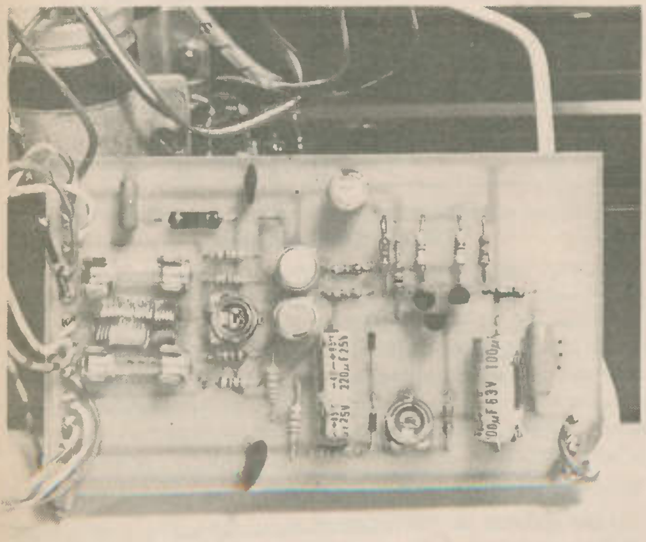
Before connecting to the mains supply and switching 'on' it is important to observe the following procedure:—

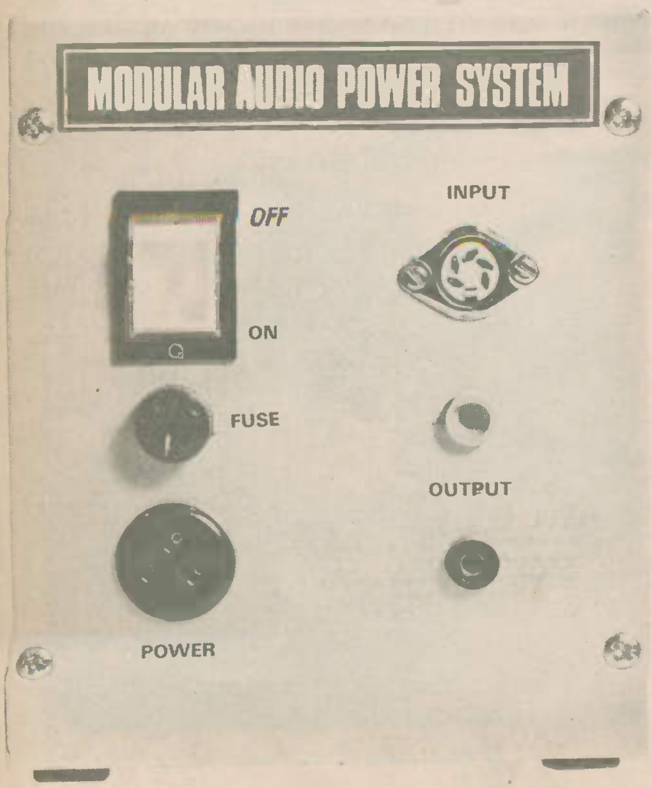
1. Adjust VR1 and VR2 so that they are both in the fully clockwise position.
2. Switch S1 to d.c. and temporarily short-circuit the signal input connector, SK1.
3. Connect the loudspeaker (or dummy load described next month). The loudspeaker should have an impedance in the range 4ohm to 16ohm and should be rated for a continuous power dissipation of 50W.
4. Switch 'on' and measure the positive and negative supply rail voltages. These measurements can be most conveniently made using the terminal voltages developed across C9 and C10, respectively. The supply rail voltages, in the quiescent state, should be in the range ± 27V to ± 30V. If the voltages differ appreciably, or if FS1 blows on switching 'on', the wiring of the transformer and bridge rectifier should be carefully checked.
5. Switch-off and disconnect from the mains supply. Temporarily insert two 10ohm 1W resistors in place of FS2 and FS3. This can be done quite simply by trimming and folding back the leads of the resistors so that the body of the resistor is gripped firmly by the fuse clips whilst electrical connection is achieved without the need to solder.
6. Transfer the d.c. voltmeter to the output terminals, SK2 and SK3. Reconnect the mains supply and switch 'on'. Adjust VR1 for exactly 0V. If the adjustment has no effect or if the resistors get hot, carefully check the p.c.b. and wiring to the output transistors.
7. Switch 'off' and transfer the d.c. voltmeter to the 10ohm resistor fitted in place of FS2. Switch 'on' and adjust VR2 to produce a reading of 0·2V. Check that a similar reading is obtained across the 10ohm resistor fitted in place of FS3.
8. Switch 'off' and disconnect from the mains supply. Replace FS2 and FS3 and remove the shorting link from SK1. Finally, select normal operation by switching S1 to the 'a.c.' position.

This completes the setting-up procedure and the amplifier is now ready for use. It is advisable to check the adequacy of the heat sinking arrangements by observing the temperature rise of the output transistor after, say, 15 minutes continuous operation at a reasonable output level (i.e. 10W or more). If the rise in temperature is more than 25 deg.C above ambient, the heatsinking should be improved.

NEXT MONTH: We shall provide constructional details of a 100W dummy load and a simple pre-amplifier/line driver.







Spectrum DAC/ADC Board

R.A. PENFOLD

WITH something like a million ZX Spectrum computers now in circulation there are, no doubt, a great many in the possession of electronics enthusiasts who would like to use them in computer based measurement and control applications. One of the ZX Spectrum's main shortcomings is a lack of built-in interfaces, and there are no ports ready fitted to the machine that are suitable for applications of this type. However, it is quite easy to fit interfaces onto the expansion port, and an analogue interface is one of the most useful from the electronics enthusiasts' point of view.

The port featured in this article gives both analogue-to-digital and digital-to-analogue conversion. Both have 8 bit resolution, which is more than adequate for most practical applications. The analogue output has an output voltage range which is adjustable from 0 to 2·55 volts to about 0 to 10 volts, but with additional circuitry the output voltage range could easily be converted to any desired span within reason. The analogue input has adjustable sensitivity, with the full scale value variable from 2·55 volts to about 25 volts. Again, with suitable additional circuitry practically any input voltage range could be accommodated. The maximum rate of conversion is guaranteed to be no less than 66000 per second, and in most cases in excess of 100000 per second can be achieved. Even the guaranteed rate is fast enough for most high speed applications such as digitising audio signals.

SYSTEM OPERATION

The block diagram of Fig. 1 helps to explain the overall way in which the unit functions. The digital-to-analogue converter is the more simple of the two converters. This consists basically of a precision 2·55 volt reference source, a resistor network (known as an R-2R network) and eight electronic switches. The electronic switches are controlled by the eight digital inputs, and when activated they connect the precision reference source through to the output via some or all of the resistors in the R-2R network. Things are arranged so that each input, when set high, causes the output to be incremented by the appropriate amount. The operation of this type of converter has been covered in past issues of this magazine, and will not be considered in more detail here.

In order to drive the DAC from the data bus of the Spectrum an 8 bit latch is needed, so that data written to the converter can be stored in the latch and used to drive the inputs of the converter. The converter then gives a continuous output, and ignores signals on the data bus that are intended for other devices. The converter used in this project has a built-in data latch, and it can therefore be fed direct from the computer's data bus. An address decoder circuit provides the latching pulse when data is written to the converter.

The DAC has a 2·55 volt reference source, which sets the maximum output voltage at the same figure. This gives a nominal 0 to 2·55 volt output range in 10 millivolt (0·01 volt) steps. A variable gain amplifier enables higher maximum output voltages to be obtained, up to a maximum of a little over 10 volts. Of course, with a higher maximum output voltage there are still only 256 different output levels, and the output increments in steps of more than 10 millivolts. However, for most applications, such as motor speed controllers and even audio applications, the resolution of an 8 bit converter is at least adequate. The amplifier gives the unit a low output impedance, but without additional buffering output currents of no more than a few milliamps should be drawn.

The analogue-to-digital converter is of the successive approximation type. This incorporates a digital-to-analogue converter which is driven by a fairly complex control logic circuit. The eight outputs of this control circuit constitute the

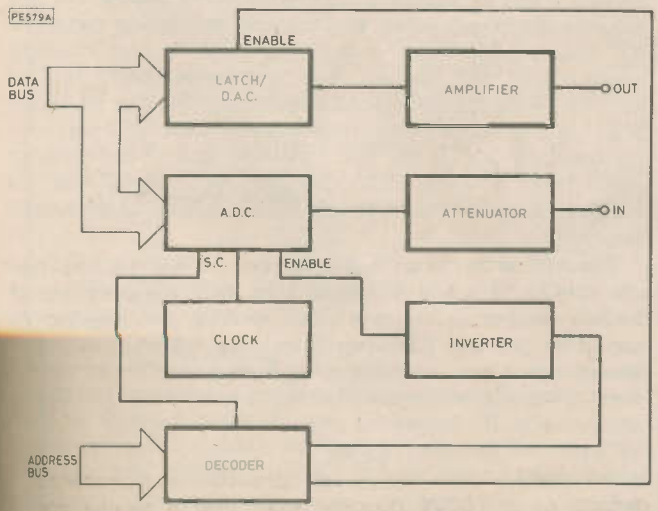
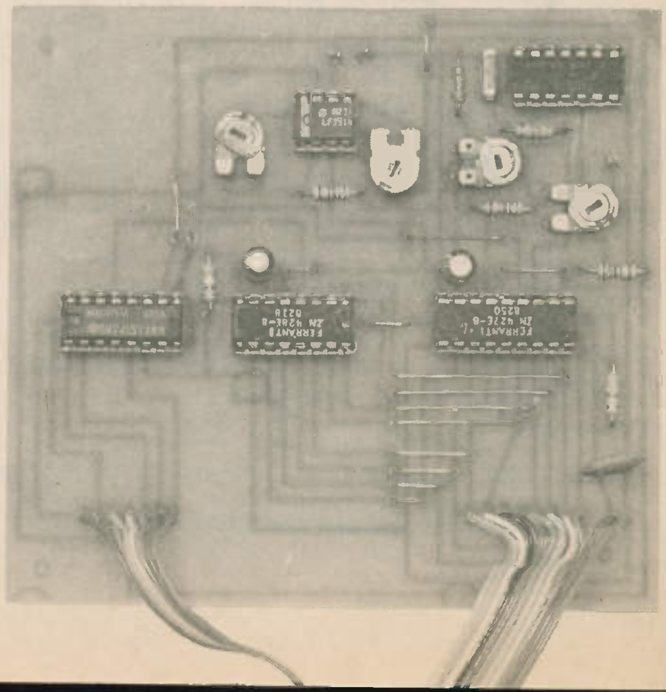


Fig. 1. Block diagram



output of the ADC. The output of the DAC is fed to one input of a comparator, and the input signal is fed to the other input of the comparator. When a trigger pulse is received at the "start conversion" input the most significant bit is set at one, but the other bits are all set at zero. If the output from the DAC is at a higher potential than the input signal the most significant bit is left at one, otherwise it is reset to zero. On the next clock cycle bit 6 is set to one, and, as before, it is either left at one or reset to zero depending on whether or not the output of the DAC is at a higher voltage than the input signal. On the next clock cycle bit 5 is set to one, and the process is repeated with this bit. In fact the same process is used for all eight bits, and at the end of this procedure the 8 bit binary number fed to the DAC is a valid digital representation of the input voltage. This method is reasonably fast, with the conversion taking no more than nine clock cycles, but successive approximation converters are reasonably inexpensive.

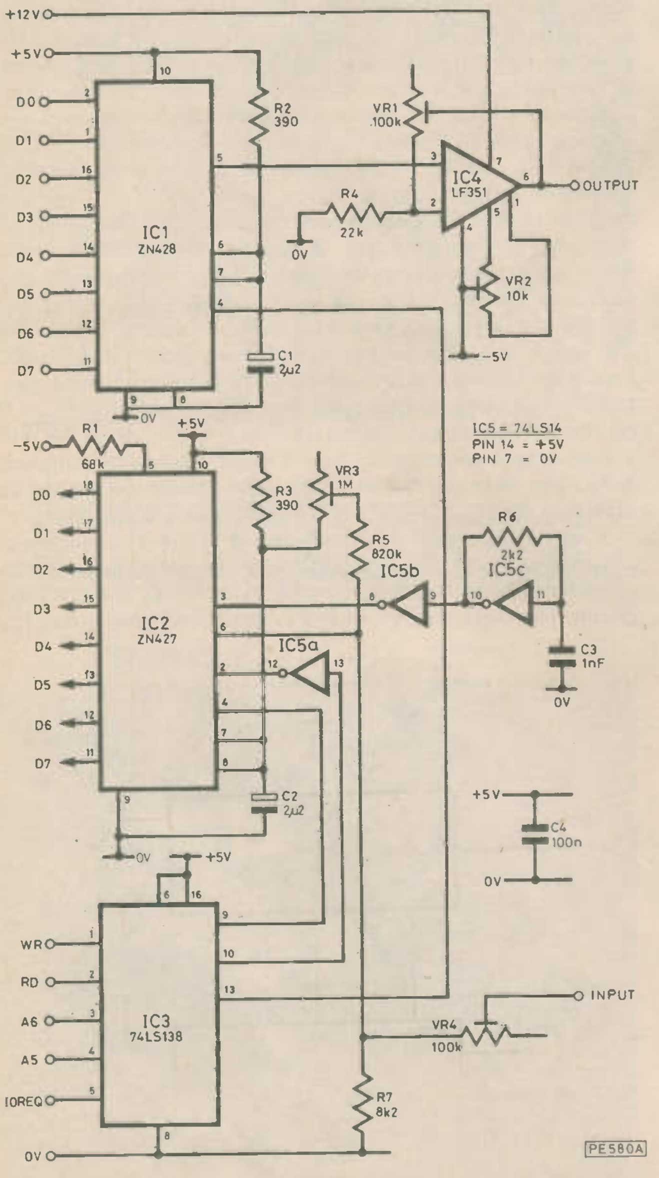


Fig. 2. Circuit diagram of the DAC/ADC board

The device used in this project does not have a built-in clock oscillator, and a simple C-R oscillator is used to provide the clock signal. The "start conversion" pulse is provided by the address decoder. The converter provides its output via an 8 bit buffer which has three-state outputs, and it can therefore be connected direct to the Spectrum's data bus. The "enable" pulse for the outputs is obtained from the address decoder, but an inverter is needed to give a signal of the right polarity. The converter has a nominal full scale sensitivity of 2·55 volts, but a variable attenuator at the input of the unit enables this to be reduced somewhat if required.

CIRCUIT DESCRIPTION

The full circuit diagram of the Spectrum Analogue Board appears in Fig. 2.

All the address decoding is carried out by IC3 which is a 74LS138 3 to 8 line decoder. The Spectrum has a Z80A microprocessor, but it uses a non-standard method of input/output mapping. The general scheme of things is to have the address lines normally high, with one of the lower lines being taken low to activate an input/output device. Some of the upper address lines are occasionally used to provide additional information to an input/output device. This leaves address lines A5 to A7 free for user add-ons. In this case A5 and the IORQ lines are fed to the negative enable inputs of IC3, and A5 must be taken low when reading from or writing to either section of the port (the IORQ line automatically goes low when a BASIC IN or OUT instruction is used).

The three main inputs of IC3 are fed from the read (RD) and write (WR) lines plus address line A6. This gives four usable outputs from IC3, two when reading and two when writing (four outputs are always high since the read and write lines never go low simultaneously). This is adequate for our purposes as only two write outputs and one read output are needed in this application. When writing data to the DAC the instruction OUT 65439,X is used, where X is the value written to the converter. This takes the write and A6 lines low while the value written is present on the data bus, giving an output pulse from output 2 (pin 13) of IC3. Other addresses can in fact be used, but it is best to use 65439 as this places the address lines apart from A5 and A6 high, so that unwanted operation of any internal input/output circuits is avoided.

IC1 is the DAC device, and this is the popular Ferranti ZN428. It has an integral 2·55 volt reference source, but this requires discrete load resistor R1 and decoupling capacitor C1. IC4 is an ordinary operational amplifier non-inverting mode circuit, and this amplifies and buffers the output of IC1. VR1 enables the closed loop voltage gain to be varied from unity to about 5 or so, but in practice the +12 volt supply used for IC4 limits the maximum output potential to about 10 or 11 volts. VR2 is the offset null control, and this is adjusted to trim the minimum output voltage of the unit to zero volts.

The ADC is based on IC2 which is a Ferranti ZN427. Like the ZN428, this has a built-in 2·55 volt reference source which requires a discrete load resistor and decoupling capacitor (R3 and C2 respectively). R1 is part of the high speed comparator, and this is fed from a negative supply so that comparator will respond properly to voltages right down to zero volts. R7 biases the input of IC2 to the earth rail and VR3 plus R5 are used to provide a small positive bias which gives improved accuracy at low input voltges. VR4, together with the input resistance of the circuit, acts as a variable attenuator.

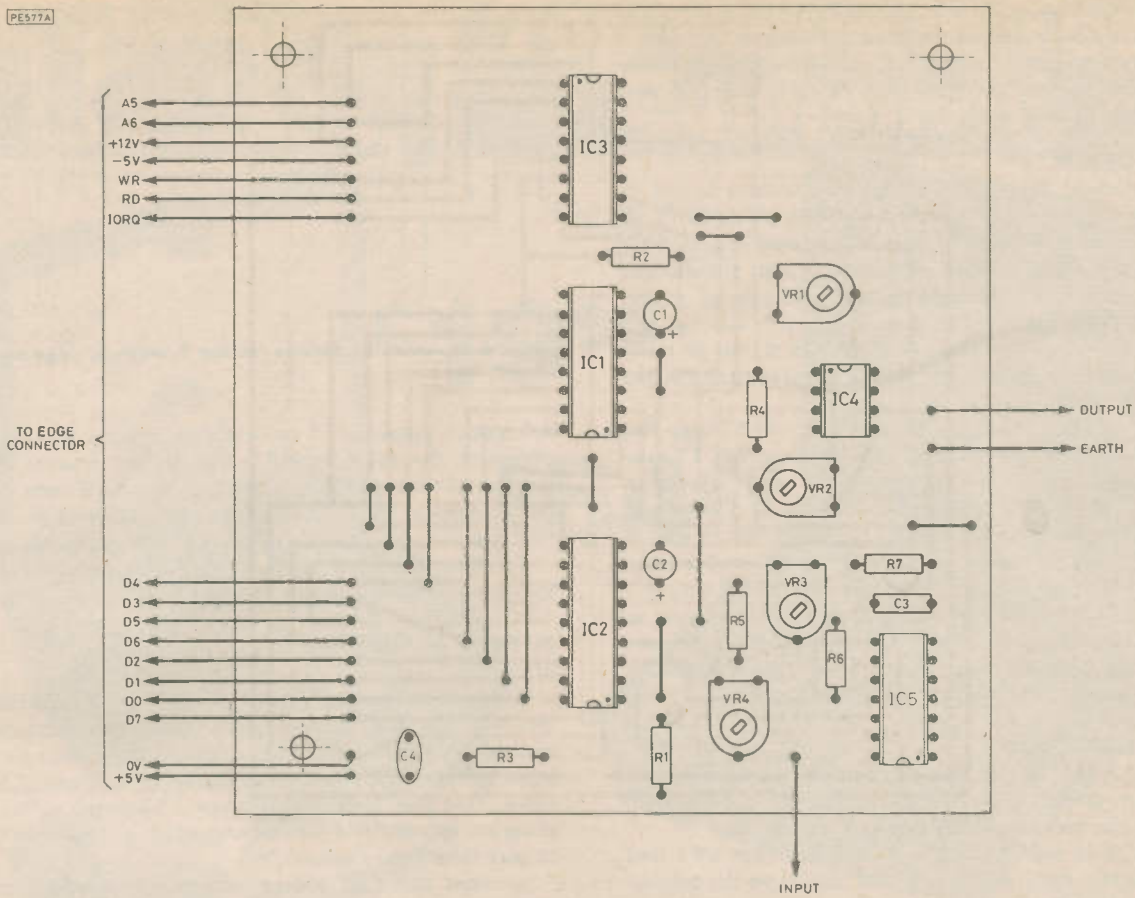


Fig. 3. Component layout of the p.c.b.

COMPONENTS . . .

Resistors

R1	68k
R2, R3	390 (2 off)
R4	22k
R5	820k
R6	2k2
R7	8k2
VR1, VR4	100k 0·1W hor. pre-set (2 off)
VR2	10k 0·1W hor. pre-set
VR3	1M 0·1W hor. pre-set

All fixed resistors are 0·25W 5% carbon

Capacitors

C1, C2	2µ2 63V radial elect (2 off)
C3	1nF carbonate
C4	100nF ceramic

Semiconductors

IC1	ZN428E
IC2	ZN427E
IC3	74LS138
IC4	LF351
IC5	74LS14

Miscellaneous

Printed circuit board (502-02)
2 x 28 way 0·1 inch pitch edge connector
8 pin d.i.l. i.c. socket
14 pin d.i.l. i.c. socket
Two 16 pin d.i.l. i.c. sockets
18 pin d.i.l. i.c. socket
Ribbon cable, wire, Veropins, solder, etc.

IC5 is a 74LS14 hex inverting Schmitt Trigger, but in this circuit only three sections of IC5 are utilised. One of these (IC5c) acts as the clock oscillator in conjunction with feedback resistor R6 and timing capacitor C3. IC5b merely acts as a buffer at the output of IC5c. The clock frequency is approximately 600kHz, which is the maximum guaranteed clock frequency for the ZN427. However, with most devices a substantially higher clock frequency is quite acceptable, and where high operating speed is essential using a somewhat lower value for C3 to give a higher clock frequency of up to about 1MHz should give satisfactory results.

The "start conversion" pulse is taken from output 6 (pin 9) of IC3, and is generated using the instruction "OUT 65503,0" (the value written can be any valid quantity since the pulse is obtained direct from the address decoder and not from the data bus). The port is read using the instruction "IN 65503". This gives a negative pulse from output 5 (pin 10) of IC3, but this is inverted by IC5a to give the required positive pulse to IC2.

At least nine clock cycles must be allowed to elapse between sending the "start conversion" pulse and reading the port, to ensure that the circuit has had time to complete the conversion. There is no problem in BASIC since the slow speed of this language means that the conversion will always have been comfortably completed before the port is read. The situation is different when using machine code, and it may them be necessary to use a delay loop to prevent a premature reading of the converter from being taken. The ZN427 has an "end of conversion" status output, but no means of reading this have been included in this unit, and as the length of time taken for a conversion is virtually constant a delay loop is a perfectly practical way of doing things.

The circuit requires +5, +12, and −5 volt supplies. These are all provided by the Spectrum from its expansion bus, and no other power source is required.

CONSTRUCTION

The component layout of the printed circuit board is shown in Fig. 3. There are a number of link wires and it is probably best to fit these first. 22 s.w.g. tinned copper wire is suitable for the links. None of the integrated circuits are MOS types, but it is advisable to use sockets for these, especially in the cases of IC1 and IC2 which are not the cheapest of devices. The integrated circuits do no all have the same orientation, so be careful to fit them onto the board the right way round.

Connection to the Spectrum is via a piece of 17 way ribbon cable about 0·5 metres long. It is unlikely that 17 way cable will be available, but it is easy to cut down a piece of 20 way cable to the required number of ways. Connection to the board should not prove to be difficult provided the end of each lead first has a small amount of insulation removed and is tinned with a small amount of solder. A 2 by 28 way 0·1 inch edge connector is needed to make the connections to the expansion bus of the Spectrum. Suitable connectors complete with a polarising key are now readily available. Fig. 4 gives connection details for the edge connector.

ADJUSTMENT

Connect the unit to the Spectrum prior to switching on. The Spectrum should then operate normally — switch off immediately and recheck all the wiring if it does not.

Assuming all is well, adjust the DAC first. Set VR1 and VR2 at a roughly midway setting, and then type the following command into the computer:—

OUT 65439,0

This should give a low output voltage from the unit, and by adjusting VR2 it should be possible to trim the output potential to precisely zero volts. Next type into the computer the command:—

OUT 65439,255

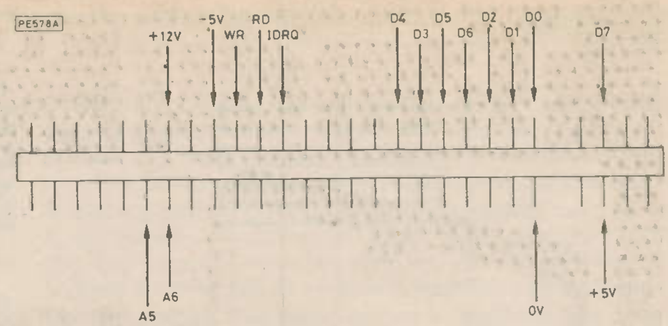


Fig. 4. Connection details for the Spectrum edge connector

An output potential of around 7 to 8 volts should then be obtained. By adjusting VR1 any desired maximum output voltage of between 2·55 volts and about 10 volts or so can be set. Repeat this procedure a couple of times to make sure that everything is set up as accurately as possible.

To check the ADC and facilitate its adjustment type in the following short test program:—

```
10 OUT 65503,0
20 PRINT IN 65503
30 GOTO 10
```

When the program is run it should return a series of very low readings (0 or 1). Set VR4 at maximum resistance (fully counterclockwise), VR3 at a midway setting, and connect an input voltage to the unit that is equal to the desired full scale value. This should be in the range 2·55 to 25 volts. Run the program and set VR4 just far enough in a clockwise direction to give returned values of 255.

In order to adjust VR3 an input voltage that produces 5 millivolts at pin 6 of IC2 should be applied to the cirrcuit. In other words an input potential that is 1/510th of the full scale input voltage is required. VR3 is then adjusted to give a series of reading that (more or less) alternate between 0 and 1. It is not essential to carry out this procedure, and accurate results will be obtained if VR3 is simply set for about half maximum resistance. ★

BAZAAR

Tandy® Top Value In Test Equipment

Select the Function and It Selects the Range Automatically

[A] **£19.95**

[B] **£64.95**

- **Folds Into Compact Case With Wrist Strap**

- **Automatic Power Off When Case Is Shut**
- **Automatic Polarity**

[A] **25-Range Folding Multimeter.** Features include fuse and surge-absorber protection, banana-type probe jacks and 4" 3-colour mirrored meter with automatic shunt protection (when folded shut). DC Volts: 0 to 1200. AC Volts: 0 to 1200. DC Current: 0-60μA, 3-30-300 mA. Resistance: 0-2-20-200K-2 megohms (centre scale 24). dB; −20 to +63 dB. Requires "AA" battery. **22-211** **£19.95**

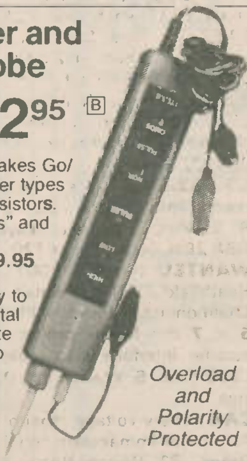
[B] **Folding LCD Multimeter With Autoranging.** Features extra large 11/16" non-glare display with adjustable viewing angle, a "beep" indicator for quick continuity testing, and zero-ohms adjust for super-accurate low resistance measurements. DC volts to 1000. AC volts to 500. Up to 10 amps AC and DC. Resistance to 2 megohms. Open: 10⅞ x 4⅝ x 1½". Requires two "AA" batteries. **22-193** .. **£64.95**

Transistor Checker and Digital Logic Probe

[A] **£9.95** **£12.95** [B]

[A] **Dynamic Transistor Checker.** Makes Go/No-Go tests on small-signal and power types and allow you to match similar transistors. Indicates relative current gain, "opens" and "shorts". Requires "AA" battery.
22-025 .... **£9.95**

[B] **Digital Logic Probe.** The fast way to "peek inside" TTL, LS and CMOS digital circuits. Colour-coded LEDs indicate high, low or pulsed logic states (up to 10 MHz). Minimum detachable pulse width: 50 ns. 36" leads with clips obtain power from circuit under test. Low current drain.
22-302 .... **£12.95**



Overload and Polarity Protected

Reference Books

[A] [B] [C]

[A] **Semiconductor Reference Guide.** 1985 edition! Exclusive cross-reference and substitution section lists over 80,000 types.
276-4008 .... **£3.49**

[B] **Getting Started In Electronics.** The perfect introduction to the exciting world of electronics. Learn to build your own circuits. 128 pages. **276-5003** **£2.49**

[C] **Timer IC Mini-Notebook.** An excellent reference and hobby book. Large schematic diagrams. 32 pages. **276-5010** **99p**

Take A Look At Tandy, Today!

Visit your local store or dealer and see these and many more bargains. We service what we sell - over, 2,800 exclusive lines!

See Yellow Pages For Address Of Store Nearest You

Ask about Your Tandy Personal Charge Card Today!

OVER 9,000 STORES & DEALERSHIPS WORLDWIDE

Prior to this advertisement, all quoted regular prices have been charged during the last six months at the Tandy Store, Tameway Tower, Bridge Street, Walsall, West Midlands. WS1 1LA.

Known As Radio Shack In The U.S.A.

Prices may vary at Dealers
Offers subject to availability

Mail order & shop:

SKYBRIDGE

441 PRINCES ROAD, DARTFORD, KENT DA1 1RB Telephone: (0322) 91454

ORDERING INFORMATION: P/P 50p on orders less than £20 in value otherwise post free. All components full spec & guaranteed. Discounts available on orders over £50 — phone for details. For unlisted components phone for price. Goods normally despatched by return post.

CABLE Per metre
wire wrap ... 6p
Red/white/black solid ... 1/.6
11 colours ... 4p
Hook-up ... 7/.2
11 colours ... 3p
Heavy duty .. 32/.2
4 colours ... 15p
Extraflex red/black ... 15p
Tinned copper per 4oz reel
SWG16 ... 80p
SWG18 ... 85p
SWG20 ... 95p
SWG22 ... 95p
SWG24 ... 95p
En copper per 20z reel SWG14 ... 70p
SWG16 ... 80p
SWG18 ... 90p
SWG20 ... 90p
SWG22 ... 90p
SWG24 ... 105p
SWG26 ... 105p
SWG28 ... 105p
SWG30 ... 110p
SWG33 ... 110p
SWG34 ... 115p
SWG36 ... 125p
SWG38 ... 125p
SWG40 ... 150p
Figure 8 per metre 7/.25 ... 13p
Coloured ribbon per foot
10 way ... 20p
20 way ... 40p
34 way ... 80p
Mains per metre 2 core Oval 3A .. 20p
Round 6A ... 45p
3 core Round 3A 35p
Round 6A ... 50p
Round 13A ... 80p

Power
1 mm T&E ... 40p
1.5 mm T&E ... 45p
2.5 mm T&E ... 60p
6 mm T&E ... 150p
TV COAX ... 40p
Screened Single round ... 17p
Twin round ... 20p
Figure 8 min ... 20p
Figure 8 std ... 30p
4 Core ... 70p
Spiral wrap
1/8" ... 15p
¼" ... 20p
½" ... 45p
Wide range of cable markers, sleeving, ties, fixings in stock. Phone for details.

CAPACITORS
Plate ceramic
1.8pF — 22nF .. 8p
Disc
10pF ... 10p
47pF ... 15p
100pF ... 15p
470pF ... 15p
1000pF ... 11p
2200pF ... 11p
.01µF ... 5p
.022µF ... 5p
.047µF ... 8p
.1µF ... 8p
.47µF ... 15p
Polystyrene
22pF ... 13p
47pF ... 8p
68pF ... 8p
100pF ... 8p
150pF ... 8p
220pF ... 8p
330pF ... 8p
470pF ... 8p
560pF ... 8p
680pF ... 8p
1000pF ... 8p
1500pF ... 8p
2200pF ... 8p
3300pF ... 8p
4700pF ... 8p
5600pF ... 10p
6800pF ... 10p
.01µF ... 14p
.022µF ... 19p
.047µF ... 25p
.1µF ... 49p
Polyester
.01µF ... 8p
.015µF ... 8p
.022µF ... 8p
.033µF ... 9p
.047µF ... 9p
.068µF ... 9p
.1µF ... 9p
.15µF ... 15p
.22µF ... 11p
.33µF ... 16p
.47µF ... 16p
.68µF ... 26p
1µF ... 26p
2µF ... 49p
Electrolytic µF/V 1/63 ... 8p
2.2/50 ... 9p
4.7/63 ... 9p
10/16 ... 8p
10/25 ... 8p
10/35 ... 10p
10/63 ... 13p
22/10 ... 8p
22/16 ... 10p
22/25 ... 10p
22/35 ... 11p
22/63 ... 15p
47/10 ... 10p
47/16 ... 11p
47/25 ... 13p
47/35 ... 15p
47/63 ... 24p
100/10 ... 11p
100/16 ... 13p
100/25 ... 15p
100/35 ... 19p
100/63 ... 25p
220/16 ... 15p
220/25 ... 20p
220/35 ... 23p
220/63 ... 33p
470/16 ... 23p
470/25 ... 27p
470/35 ... 31p
470/63 ... 48p
1000/10 ... 24p
1000/16 ... 29p
1000/25 ... 41p
1000/35 ... 45p
1000/63 ... 75p
2200/10 ... 39p
2200/16 ... 46p
2200/25 ... 56p
2200/35 ... 74p
3300/25 ... 74p
3300/35 ... 92p
4700/10 ... 59p
4700/16 ... 74p
4700/25 ... 103p
Non-polarised
1µF ... 25p
2.2µF ... 25p
3.3µF ... 25p
4.7µF ... 25p
6.8µF ... 50p
10µF ... 25p
22µF ... 35p
33µF ... 40p
47µF ... 40p
100µF ... 70p
Thousands of other capacitors in stock i.e. Silvered Mica, 1% Polystyrene, Polycarbonate, Mylar, Tantalum, Trimmer, Variable etc. etc.

CRYSTALS
100k ... 460p
1M ... 600p
2M ... 220p
3.2768M ... poa
4M ... 180p
4.19304M ... 320p
4.433619M ... 320p
6.144M ... 130p
10M ... 200p
18.432M ... 270p
26.54M ... 200p
26.59M ... 200p
26.64M ... 200p
26.69M ... 200p
26.74M ... 200p
26.79M ... 200p
26.8M ... 200p
26.995M ... 200p
27.045M ... 200p
27.095M ... 200p
27.145M ... 200p
27.195M ... 200p
27.245M ... 200p
27.255M ... 200p

CONNECTORS
Croc clips ... 10p
Terminal post ... 40p
1mm plug ... 20p
1mm socket ... 15p
2mm plug ... 20p
2mm socket ... 15p
3mm plug ... 20p
3mm socket ... 15p
4mm plug ... 15p
4mm socket ... 15p
Phono plug ... 10p
Phono line skt .20p
Jack plug 2.5mm ... 15p
Jack plug 3.5mm ... 15p
Jack skt 2.5mm ... 15p
Jack skt 3.5mm ... 15p
Jack skt line 2.5mm ... 30p
Jack skt line 3.5mm ... 25p
Jack plug ¼" mono ... 20p
Jack plug ¼" stereo ... 30p
Jack skt ¼" mono ... 25p
Jack skt ¼" stereo ... 35p
Jack skt line mono ... 25p
Jack skt line stereo ... 30p
COAX plug ... 15p
COAX skt surf 30p
COAX skt flush25p
COAX line skt .45p
COAX coupler 45p
CAR aerial plug ... 15p
FM aerial plug .20p
BNC plug ... 100p
BNC round skt ... 100p
BNC square skt ... 100p
BNC free skt .110p
BNC str. adapt. 140p
BNC T adapt. 300p
VHF plug PL259 ... 50p
Small reducer .20p
Large reducer .20p
PL259 rt.ang. .90p
VHF round skt.50p
VHFsquare skt 50p
Elbow adapt. .. poa
Straight adapt. 60p
VHF T adapt. 160p
Female T adapt. ... 180p
XLR line plug 180p
XLR chassis skt ... 330p
XLR line skt .. 230p
XLR chassis plug ... 160p
DIN plugs 2 pin ... 10p
DIN plugs 3 pin ... 15p
DIN plugs 4 pin ... 35p
DIN plugs 5 pin A ... 15p
DIN plug 5 pin 240° ... 20p
DIN plug 5 pin 360° ... 30p
DIN plug 6 pin 40p
DIN plug 7 pin 20p
DIN plug 8 pin 60p
DIN skts 2 pin .10p
DIN skts 3 pin .20p
DIN skts 4 pin .15p
DIN skts 5 pin A ... 16p
DIN skts 5 pin B ... 20p
DIN skts 6 pin .20p
DIN skts 7 pin .20p
DIN line skt 2 pin ... 15p
DIN line skt 5 pin ... 30p
D-type plug 9 W ... 80p
D-type plug 15 W ... 150p
D-type plug 25 W ... 150p
D-type skt 9 W ... 140p
D-type skt 15 W ... 200p
D-type skt 25 W ... 450p
D-type rt ang. skt 9 W ... poa
D-type rt ang .skt 15 W ... poa
D-type rt ang. skt 25 W ... poa
D-type rt ang. plug 9 W ... poa
D-type rt ang. plug 15 W ... poa
D-type rt ang. plug 25 W ... poa
Covers 9 ... 120p
Covers 15 ... 120p
Covers 25 ... 130p
Latches 9 ... 30p
Latches 15 ... 50p
Latches 25 ... 60p
Power plug 2.1mm ... 15p
Power plug 2.5mm ... 15p
IEC line skt ... 95p
IEC chassis plug ... 90p
IEC chassis skt 90p
IEC line plug ... 70p
Bulgin P429 ... 50p
Bulgin P646 ... 165p
Bulgin P430 ... 125p
Bulgin P649 ... 135p
Bulgin P650 ... 110p
Bulgin P635 ... 100p
Bulgin P636 ... 130p
Bulgin P551 ... 300p
Bulgin P552 ... 100p
Bulgin SA2403 ... 160p
Bulgin SA2404 95p
Bulgin SA2190 50p
Bulgin SA1862 50p
Bulgin SA2111 ... 200p
Bulgin SA2019A ... 150p
Bulgin SA2020 ... 140p
Bulgin SA2367 ... 180p
Bulgin SA2368 95p
Many other connectors, adapters & leads in stock.

FUSEWARE
20mm panel holder ... 45p
1¼" panel holder ... 59p
20mm chassis holder ... 14p
1¼" chassis holder ... 17p
Line holder ... 14p
Fuse clips ... 3p
20mm fuses 100mA, 150mA, 250mA, 500mA, 1A, 1.5A, 2A, 3A, 5A ... 9p
20mm antisurge fuses 500mA, 1A, 2A ... 12p
1¼" fuses 100mA, 150mA, 250mA, 500mA, 1A, 2A, 3A, 5A, 10A, 13A, 15A ... 9p
1" fuses 2A, 3A, 5A, 13A ... 16p

RESISTORS
½ W 5% E24 ... 2p
.4W 1% E24 ... 7p
1W 5% E12 ... 10p
3W ww L22-1R 30p
3W ww 2R2 ... 20p
7W ww ... 30p
10W ww ... 35p
25W ww ... 170p
Ww Pots. 3W High quality ... 275p
10R, 25R, 50R, 100R, 250R, 500R, 1k, 5k, 10k, 50k.

SEMICONDUCTORS
So extensive is the range of listed semiconductors Please send large S.A.E. for details.
Transistor mounts
TO3 ... 10p
TO66 ... 10p
DIL sockets 8 pin ... 9p
14 pin ... 11p
16 pin ... 12p
18 pin ... 16p
20 pin ... 17p
22 pin ... 20p
24 pin ... 21p
28 pin ... 24p
40 pin ... 35p

OPTO
LED Std red ... 10p
LED Std green 18p
LED Std yellow15p
LED Min red ... 10p
LED Min green 18p
LED Min yellow ... 18p
LED clip std ... 3p
LED clip min ... 3p
Large range of panel lampholders, de luxe LEDs, etc.

Range of heat sinks available — Phone for quotation.

SPEAKERS
Miniature buzzer 6V or 12V ... 90p
Ultrasonic ... 600p transducers ... pair
Elliptical 5"x3" 198p
Elliptical 6"x4" 262p
Elliptical 7"x4" 314p
Elliptical 7"x5" 338p
Elliptical 8"x5" 5W ... 386p
Elliptical 8"x5" 8W ... 521p
Elliptical 9"x6" 431p
Miniature 1" ... 90p
Miniature 1½ ... 90p
Miniature 1¾ ... 90p
Miniature 2" ... 90p
Miniature 2¼ ... 90p
Miniature 2½" 8R 90p
Miniature 2½" 64R ... 100p
Round 5" 4W 174p
Round 5" 25W 409p
Round 5" 60W 1587p
Round 5¼" 10W 476p
Round 5¼" 15W 771p
Round 6" 5W 297p
Round 6" 60W 1632p
Round 6½" 7W ... 423p
Round 8" 6W 359p
Round 8" 10W ... 423p
Round 8" 20W ... 963p
Round 8" 60W ... 1346p
Round 10" 10W ... 700p
Round 10" 20W ... 1113p
Round 10" 30W ... poa
Round 12" 60W ... 2862p
Round 12" 100W ... 4073p
Round 12" 150W ... 4336p
Round 15" 150W ... 7185p
Round 15" 200W ... 8735p
Round 18" 200W ... £108
Motorola piezo tweeters 2" ... 231p
3½" ... 697p
2"x6" horn ... 938p
2"x5" horn ... 795p
2½" horn ... 457p
3¾" ... 624p
4"x10" ... 1435p
Crossovers
2 way 15W ... 188p
2 way 100W ... 690p
3 way 25W ... 193p
3 way 40W ... 338p
3 way 60W ... 502p
3 way 100W 1346p
4 way 80W ... 628p

SWITCHES
Toggle Std SPST ... 47p
Toggle Std DPDT ... 62p
Toggle Min SPST ... 68p
Toggle Min SPDT ... 70p
Toggle Min SPDT c/off ... 83p
Toggle Min DPDT ... 85p
Toggle Min DPDT c/off ... 117p
Toggle Min 4PDT ... 209p
Toggle Min 4PDT c/off ... 244p
Push to make .20p
Push to break .20p
Key sw spst .. 259p
Rotary 1P 12W 62p
Rotary 2P 6W 62p
Rotary 3P 4W 62p
Rotary 4P 3W 62p
Sude min DPDT ... 22p
Sude std DPDT ... 22p
DIP 4W ... 105p
DIP 6W ... 128p
DIP 8W ... 156p
DIP 10W ... 184p
Microswitch ... 83p

TRANSFORMERS
6-0-6 V, 100mA 167p
6-0-6 V, 250mA ... 185p
9-0-9 V, 100mA ... 167p
9-0-9 V, 250mA ... 185p
12-0-12 V, 50mA ... 155p
12-0-12 V, 100mA ... 171p
12-0-12 V, 250mA ... 188p
0-12/0-12 V, 500mA ... 369p
9-0-9 V, 1A ... 283p
12-0-12 V, 1A 350p
15-0-15 V, 1A 433p
20-0-20 V, 1.5A ... 538p
0-12-15-20-24-30 V, 1A ... 666p
6-0-6 V, 2A ... 440p
9-0-9 V, 2A ... 476p
12-0-12 V, 2A 538p
0-12/0-12 V, 2A ... 538p
0-12-15-20-24-30 V, 2A ... 900p
20-0-20 V, 2A 745p
30-0-30 V, 2A 933p
12-0-12 V, 3A 721p
0-15 V, 3A ... 647p
6-0-6 V, 4A ... 538p
9-0-9 V, 4A ... 687p
12-0-12 V, 4A 845p
0-15 V, 6A ... 949p
6-0-6 V, 8A ... 980p
12-0-12 V, 8A ... 1615p
Toroids: 30VA
6V ... 950p
30VA 9V ... 950p
30VA 12V ... 950p
30VA 15V ... 950p
30VA 18V ... 950p
50VA 6V ... 1150p
50VA 9V ... 1150p
50VA 12V ... 1150p
50VA 15V ... 1150p
80VA 18V ... 1200p
80VA 22V ... 1200p
80VA 30V ... 1200p
120VA 30V ... 1300p
160VA 35V ... 1500p
300VA 35V ... 2000p
500VA 35V ... 2650p
All toroids have two isolated secondaries at voltages shown.

10% DISCOUNT VOUCHER

SEND THIS VOUCHER WITH YOUR ORDER OR BRING IT WITH YOU!

DIGITAL CAPACITANCE METER (UK C/P 65p)

Large LCD display 8 ranges 0.1pf to 2500 mfd (£69 50)
WITH VOUCHER £62.55

DC POWER SUPPLIES

220/240 AC input (UK C/P £1.00)
1203 13.8 volt 3 Amp DC output (For all 12 volt DC equipment) £11.95 **WITH VOUCHER £10.76**
241 Meter indicator Amps/Volts 0/30 Volt 0/1 Amp (£37.95) **WITH VOUCHER £34.16**
243 3 Amp version (£59.95) **WITH VOUCHER £53.96**

ANALOGUE MULTIMETERS

(UK C/P 65p)
HC 1015 10K/volt 15 Range pocket (£8.95) **WITH VOUCHER £8.06**
NH56R 10K/volt 22 Range (£12.95) **WITH VOUCHER £11.66**
102BZ 20K/volt 22 Range 10A DC (£15.95) **WITH VOUCHER £14.36**
YN360TR 20K/volt 19 Range plus Hfe test (£14.50) **WITH VOUCHER £13.05**
5001 50K/volt Range doubler 10A DC 20M ohm (£21.95) **WITH VOUCHER £19.76**
830A 30K/V 26 range 10A AC/DC 10 ohm (£24.95) **WITH VOUCHER £22.46**

Prices correct at time of press approximately 6 weeks prior to publication. E&OE

DIGITAL MULTIMETERS

(UK C/P 65p)
S = Slide switches
R = Rotary
PB = Push button
• KD305 (S) 14 Range 10A DC 2M ohm (£29 80) **WITH VOUCHER £26.82**
6010 (PB) 28 Range 10A AC/DC 20M ohm (£43 50) **WITH VOUCHER £39.15**
• KD 55C (R) 26 Range 10A AC/DC 20M ohm (£44 50) **WITH VOUCHER £40.05**
• 3510 (R) Range 10A AC/DC 20M ohm Hfe tester cont. buzzer (£46.52) **WITH VOUCHER £41.89**
ME540 (R) Man/Auto 19 Range 10A AC/DC 20M ohm (£47 77) **WITH VOUCHER £42.99**
• OM3350 (R) Autorange 18 Range 10A AC/DC 2M ohm Cont. Buzzer (£49.95) **WITH VOUCHER £44.96**
• WITH CARRY CASE

TRANSISTOR TESTER

(UK C/P 65p)
Direct reading of Hfe and leakage for NPN/PNP transistors & diodes (£27 95) **WITH VOUCHER £25.16**

PROBE KIT (UK C/P 45p)

For all scopes etc. BNC connector switchable X1-X10 in wallet (£11.50) **WITH VOUCHER £10.35**

SIGNAL INJECTOR (UK C/P 45p)

Pencil type AF/RF output 1000's sold (£4.95) **WITH VOUCHER £4.46**

10% DISCOUNT VOUCHER C

NOTE: Offer closes 31.1.85. Applies only for goods as above (while stocks available, prepaid by post or for callers (one voucher per total order). Voucher **must** accompany order (UK C/P extra as indicated)

HENRY'S

301 EDGWARE ROAD LONDON W2 1BN
TELEPHONE: 01-724 3564
404 EDGWARE ROAD LONDON W2 1ED
TELEPHONE: 01-724 0323

All prices include VAT

Open 6 days a week

THE START OF SOMETHING NEW

If you are leaving college and planning a career in modern communications or if your present job lacks interest and challenge then why not join us in government communications headquarters? We are recruiting RADIO OFFICERS who after initial training will become members of an organisation that is in the forefront of communications technology. Government Communications Headquarters can offer you a satisfying and rewarding career in the wide field of communications.

Training involves a 32 week course (38 weeks' if you come straight from nautical college) which will fit you for appointment to RADIO OFFICER.

Not only will you find the work as a RADIO OFFICER extremely interesting but there are also good prospects for promotion, opportunities for overseas service and a good salary. Add to this the security of working for an important government department and you could really have the start of something new.

The basic requirement for the job is two years' radio operating experience or hold a PMG, MPT, MRGC or be about to obtain MRGC. Registered disabled people are welcome to apply.

For full details and application form 'phone 0242 32912/3 or write to the Recruitment Officer, Room A1108, GCHQ, Priors Road, Cheltenham, Glos.

GCHQ

Recruitment Office, Government Communications Headquarters, Oakley, Priors Road, Cheltenham, Gloucestershire, GL52 5AJ.

INDUSTRY NOTEBOOK

By Nexus

Outlook

Everyone in business breathed a sigh of relief once the US presidential election was over. The two-year run-up is almost unbearable for its unsettling effect.

All indications are that 1985 will be a good, though possibly hard year for the electronics industry. In 1983 the number of small companies starting up provided a net gain of 47,000, The 1984 figures, not yet available, are expected to beat this record and there is no reason why 1985 should be worse. A significant number of the new start-ups will be in or associated with the electronics industry.

Foreign investment in the UK continues at a high level. The prolonged miners' strike was apparently seen overseas as a one-off out-of-character industrial relations problem and not typical of the 'new realism' in British industry. In any case no foreign companies would want to invest in coal mining and potential investors may be impressed by the relative ease with which British industry carried on through what was intended to be a crippling exercise.

Expansions and new starts planned last year will begin to take effect. If we look at Scotland's Silicon Glen there are now nearly 300 electronics companies employing more than 40,000 people. Inward investment since the *Locate in Scotland* agency was founded in 1981 has now topped £1,000 million, most of it finding its way into high-tech projects. And substantial investment is similarly going into other areas. Even so they will not create many new jobs, one recent estimate being for 10,000 in the electronics industry this year.

Intense competition in personal computers will force prices down so intending buyers would probably profit by delaying purchase. Alternatively, prices could stabilise but the product improved in the classic "more-bits-per-buck" context. But despite all the difficulties it will still be possible to score well in the consumer market as proved by Alan Sugar's Amstrad whose pre-tax profits topped £9 million in its last financial year.

Information Technology

Information Technology which seemed so novel (although hardly new) only three years ago has now become accepted as the norm and no more exciting than radio or television. Some pessimists are already saying that Britain has been losing ground in this growing sector of industry. Their fears are based on the increase in imported equipment compared with indigenous production.

At the higher levels of the technique the Alvey programme is now gaining momentum. Two new major contracts were awarded towards the end of last year. One carries the painfully contrived acronym of ADMIRAL derived from ADvanced Mega Internet Research for ALvey. The other is merely called the Speech Recognition Project.

The ADMIRAL contract is a £3 million joint venture being coordinated by GEC Research Laboratories. Partners are University College, London, The University of London Computer Centre and British Telecom Research Laboratories.

The system will link local area networks (LANS) through a 'mega internet overlay' to produce a single large system of data networks. The key feature is to allow high speed intercommunication between dissimilar equipment. It appears to be a re-jig of part of the Project Universe programme originally initiated by the Department of Trade and Industry and later transferred to the Alvey Directorate.

The voice recognition project is funded with £2 million and is centred on British Telecom Research Laboratories with collaboration from Cambridge University and Logica. Although most schoolchildren are acquiring keyboard skills it is also recognised that speech is the most natural form of communication between people and the same applies between people and computers.

Present voice recognition systems are primitive and generally respond only to single-word voice commands. It is hoped to expand into true verbal dialogue between person and computer so that anyone who can talk can, for example, find what is required from a data base without necessarily having any keyboard skill.

Time for Schools

It is heartening to see that schools are now to be networked through The Times Network for Schools (TTNS) which will give any school access to more than 200,000 pages of information by the end of the year. Secondary schools of which there are 6,500 will be first to join, followed by 27,000 primary schools.

Future plans exist to network British schools to those on the continental mainland. Joining the network will be optional but the fees are modest and the scheme should prove popular and exciting.

Then we have the proposal for a university devoted entirely to information technology. It has the backing of a host of leading electronics companies but students will have to pay fees to make the university self-financing.

Fears have already been expressed by egalitarians that the university will be anti-social because it will create an elite of the already advantaged who can afford the fees. Nonsense, of course. We need more, not less, centres of educational excellence.

Improvisation

I remember at a press conference organised by a Ministry of Defence electronics establishment asking how we would get on in a real war when the time scale of equipment development stretched over a period of years even when the equipment was comparatively simple. I had in mind the very few weeks which elapsed in 1940 between the alarming discovery that the Germans were using magnetic mines and the countermeasure (degaussing of ships) devised and implemented. And this was only one example of many rapid developments of that war.

I contrasted this with over 10 years of development of the Clansman radio system before it came into service. I was not very impressed with the reply which was more or less that we would probably muddle through as we always had done in the past.

My confidence has now been restored (well, almost) by Alfred Price in his new book 'Harrier & Sea Harrier at War', published by Ian Allan Ltd. In it he describes 'Blue Eric', an electronic countermeasure system needed urgently for the Falklands war. If Harriers were to be operationally successful in the South Atlantic they would need self-protection against Argentine radar installations.

The threat was evaluated from normal military intelligence which already had details of the characteristics of radar equipment in service with Argentine forces. Existing electronic warfare pods (e.g. for Tornado and Buccaneer) were too large and heavy for the Harrier so it was decided to use elements of the Sky Shadow equipment and fit them in a modified gun pod which would meet the weight and size requirements as well as the jamming capability.

Marconi Defence Systems were prime contractors and completed the design, testing and delivery of operational units within 15 days instead of an estimated two years at normal pace and at a quarter of the cost.

Blue Eric (named after its MOD project officer Squadron Leader Eric Annal) was never used in the Falklands. When the EW-equipped Harriers arrived they were grounded for four days by bad weather and by the time they got airborne the conflict was virtually over, the Harriers then being used for front line ground attack where the radar threat was negligible or non-existent.

While it is comforting to know that the improvisational skills of yesterday have not been lost, one is still left wondering why an EW pod for Harrier was not already available and why, in peacetime conditions, equipment development times are so long and the cost so great.

Microwriter...

The Principle and the Product

Tom Gaskell BA(Hons) CEng MIEE

THE electronics industry is one of extremely rapid change. New products, ideas, and standards spring up continually, promoting a continuous state of flux and development. As a fairly young industry it is successful in discarding old and outdated principles in favour of newer, more beneficial ones; if change can be shown to be worthwhile in any specific situation, then that change is almost invariably made.

It comes as somewhat of a surprise, therefore, that for the production of documentation, text, correspondence, and computer programs, the primary means of interface between the human being and the machine is still a QWERTY keyboard. QWERTY is the standard layout of typewriter keys which was devised very many years ago with the principle intention of *Slowing Down* the typist to prevent jamming of the mechanism. In this age of mechanical sophistication and electronic keyboards the same requirement is no longer true since we can easily prevent jamming by other means. Hence, we are left with a legacy from a bygone age. The QWERTY layout is slow and complex to learn, with months of training being required before any proficiency is achieved. For many people such training is impractical, so they are reduced to 'two finger' typing, which is usually a slow and frustrating exercise.

A NEW IDEA

When a company brings-forth a new idea for entering text into machines, it is bound to attract considerable interest. A few years ago a device called the 'Microwriter' appeared. It is a small, self-contained machine with only six keys, which is used with one hand only. The Microwriter company has been producing these devices in modest quantities ever since, and has recently started to advertise and promote the product in a more aggressive way, with various options and accessories now available.

WHAT IS A MICROWRITER?

A Microwriter is no less than a battery powered portable word processor. It is just a little larger than a paperback book and has very few controls—some connectors, an ON/OFF switch, a liquid crystal display, and six keys. It is placed on a desk or held in the left hand, and typed on with the right hand. (As yet there isn't a left handed version since there would be problems connected with the way that the 'alphabet' of letter shapes are formed, as we shall see later.) The Microwriter can communicate over a bi-directional RS232 serial link with printers, full-sized word processors, computers, etc., and can store text either internally on battery backed-up RAM, or on any conventional external cassette recorder.

Characters or numerals are entered into the machine by pressing combinations of keys, rather than one key at a time as in the case of the QWERTY system. There are no markings on the keys since they can have different functions at different times, so the user is immediately forced into the excellent principle of touch typing, and looks at the display rather than at the keys being pressed. The user, therefore, has to learn all the sequences of keys to be pressed before being able to type correctly. This is the make-or-break aspect of the Microwriter—many people are immediately put off by having to learn a potentially complex typing language. Fortunately, the people at Microwriter Ltd. have been very clever indeed in the choice of keys to be pressed per character. The right hand is always held in the same place above the keyboard, one finger above each key, and the shape formed by the fingers pressing the keys bears a relationship with the shape, or some aspect, of the character which becomes entered into the machine. That relationship is sometimes obvious and direct, sometimes humorous, sometimes very corny, but inevitably is easily memorable. Fig. 1 shows some of these relationships, based on a slightly stylised layout of keys. The manufacturers suggest that they can be memorised in typically one hour, and certainly I have found this to be the case as far as friends, colleagues, and myself have been concerned. It is very easy indeed to learn to Microwrite; far, far easier than touch typing, and I have tried both!

USING THE MACHINE

As each character is entered from the keyboard it is displayed on a single line liquid crystal display which can show up to 14 characters and two control symbols. The display acts as a 'window' on the text, and can be moved around within the text, either following new characters entered or to review what has already been written under the control of special commands. The text, as shown by the display, normally appears to shift to the left as each new character is entered by the keyboard and appears at the right hand end of the display. The sixth key on the Microwriter is a second thumb key, a little below the normal one, and it acts as a control key, allowing comprehensive control of the machine's functions. It is used either on its own, or with other keys in place of the normal thumb key. For example, entering the letter 'f' (the First Four keys pressed), but using the control key instead of the thumb key, moves the display window in the text Forward one position; 'f' for Forward—it is corny, but it works! Doing the same thing with the letter 'k' moves the window backwards. In this case, 'k' stands for Korrect, so you use it when Korrecting errors!

Pressing the control key once, on its own, puts the Microwriter into upper case characters for just one entry, after which it reverts to lower case. Pressing it twice in succession, on the other hand, locks the machine into upper case continuously until the two thumb keys are pressed together to revert to lower case. The status of the machine is continuously shown by two control symbols in a yellow coloured area at the right of the display.

Simple punctuation is provided as part of the normal lower case letter set, but more complex punctuation and numerals have to be accessed by a 'numerals shift' function. Entering the letter 'n', but with the control key pressed at the same time, shifts the Microwriter into the numerals mode for one character only; entering this combination twice in succession locks in the numerals mode, just like the upper case mode. There's another set of character/key relationships for the punctuation, with numbers being entered by a 'count on the fingers of one hand' type of technique. The requirement to shift for numerals is acceptable for word processing applications, but would make the Microwriter somewhat laborious for writing computer programs, for example.

To avoid timing problems when keys are pressed together, the Microwriter works on a key accumulation principle, and the character is only entered when all the keys have been released. Hence, you can start to press keys in any order, so long as at least one of them is being held down at any given time. When all the keys are eventually released, the result is as if all the keys that were depressed in that sequence, irrespective of their chronological order, were pressed simultaneously. This makes the keyboard action very 'forgiving', and allows characters to be entered very slowly and deliberately when required. The speed which can be obtained after only a few weeks' use is very high—not as fast as touch typing, but certainly up to twice as fast as handwriting.

EDITING AND WORD PROCESSING

When text has been written it can be edited (both deletion and insertion) and reviewed by appropriate use of the control key. To read through the written material, the user has to Jump back to the beginning (control + j) then scroll Forwards (control on its own, followed by control + f); this then moves the display window along the text one word at a time, at a user selectable slow or fast rate, until you tell it to stop. The machine automatically enters 'carriage returns' at the end of each line, and ensures that these are between words, not in the middle of them. Via the control key the user can access tabulation, margin indents, document markers, page separators, alter line length, and do many other complex word processor functions. These become very difficult to memorise, and even more difficult to implement, and I would have thought that they would have only limited usefulness to most people.

The control key is also used to suitably configure the RS232 link. Although this can be used to load text into the Microwriter, its primary use is to transmit text to a computer, word processor, or printer from the Microwriter. Full handshaking is provided, and there are user selectable baud rates, data lengths, etc., so it will interface with most RS232 based systems. All settings and text are stored in RAM with battery back-up, so nothing is lost when the power is turned off. The machine even turns the power off itself if it is not used for a few minutes, to

Fig. 1. Sometimes corny, but inevitably memorable

conserve battery life. The batteries are rechargable types, and a suitable charger is provided with the machine. Up to 1600 words, or typically 5 pages of A4 size, can be stored in the memory of the machine. (Much more if cassettes are used.)

THE HARDWARE

The packaging of the Microwriter inspires confidence! It is housed in a very solid injection moulded plastic case. The keys are ultra-low activating-force microswitches with moulded keys. Their action is light but positive, and their positioning is ergonomically spot-on. Inside there is just one main p.c.b. holding the RCA CDP1802A CMOS microprocessor, four HM6116 CMOS 2k Byte static RAMs, and a 2564 8k Byte CMOS EPROM, along with an 'intelligent' liquid crystal display above it as a sub-assembly, and other assorted CMOS i.c.s. The batteries are housed between the microswitches in the upper half of the case. It's a well laid out and professionally built product.

With the Microwriter itself comes a good quality soft carrying case, a battery charger, a cassette recorder connecting lead, some 'crib cards' giving a quick reference to control codes, characters, punctuation, etc., and two instruction manuals; a new user's guide, and a more complex systems manual for setting up communications protocol and the like. The new user's guide is effectively the main instruction manual for the machine, and without doubt is the best manual that I have seen for a piece of consumer electronics. The cartoon characters used might annoy some, but they will drive the points firmly home to just about anybody, whatever age or ability. Other product manufacturers would do well to study this manual and compare its high standards with their own!

There is an optional television interface unit available for the Microwriter which I'm somewhat less happy with. It interfaces to the RS232 port, and allows the display of text on a domestic television set or a composite video monitor. It is expensive (around the £100 mark) and gives very limited facilities. Writing onto the screen as you enter text works reasonably well, but if you just want to dump a letter, for example, onto the screen to check its layout, the use of the Microwriter becomes somewhat more contrived. It's very difficult to put a letter onto the screen without the top of the letter scrolling off the screen as soon as the bottom of the screen is reached. The unit that I tested also failed to get the ends of the lines correct when dumping onto the screen; parts of words were left at the end of some lines, then the whole word reappeared again on the next line. For the majority of potential Microwriter users I would question the necessity for the television interface unit—when you've got the hang of Microwriting you probably don't need it. It seems to be more suitable as a shared facility between several users, and generally seems to be somewhat of an afterthought rather than an integral part of the Microwriter system.

THE QUINKEY

For many people, the cost of a Microwriter (£299 plus VAT), although low by office equipment standards, is too high for them to consider it as a personal purchase. However, they could consider investing in a 'Quinkey'. This appears to be an ordinary Microwriter at first glance, but lacks most of the connectors and the display. In fact, it contains no electronics, just a set of microswitches and resistors which enables up to four of them, ingeniously, to plug into the analogue inputs of a BBC microcomputer. For just under £50 the full Quinkey package provides good value, consisting of the the Quinkey itself, a manual, some crib cards, a connecting lead, and the software to run the system. Further Quinkeys on their own cost around £30.

The software enables the Quinkey to be used as well as the standard BBC QWERTY keyboard, not only with software within the BBC micro such as BASIC, the Acorn DFS, etc., but also with software packages such as Wordwise and similar. A version for the Spectrum is soon to be made available, and Microwriter are working on versions for other popular personal computers too. All this helps to bring the unique qualities of Microwriting to the private individual, schools, colleges, etc.

APPLICATIONS—WHO USES IT?

The most obvious market for the Microwriter is with professionals on the move—salesmen, executives, engineers, and anybody who does an amount of documentation, report writing, letter writing, etc. On the train or 'plane they can write their meeting reports, or they can keep notes in the field or by their work benches, and either print the results out so that they are legible to themselves and to their colleagues, or if necessary dump them onto the office computer or word processor to be tidied up before final printing. There's no duplication of effort, the typists no longer having to work from handwritten notes.

The small size, portability, and ease of use of the Microwriter are attractions which a QWERTY keyboard has never had. Microwriting can never be as fast as good touch typing, so it will not be used to replace QWERTY keyboards in typing pools or secretarial offices, but for thousands of unqualified typists it offers a refreshing alternative to the two-fingered struggle, so it should be of great interest to small businesses, the police, sales personnel (especially those working from home), budding novelists, and even to the writers of magazine articles! For schools it has the advantage of allowing the connection of four Quinkeys to each BBC microcomputer, which immediately shares out normally limited resources to many more children. If accepted for these applications, it can only help establish Microwriting as a world-wide standard in years to come.

THE FUTURE OF MICROWRITING

Until recent months the promotion of the Microwriter was a very low-key process, although some rather more prominent advertising is now being seen. Over 7000 have been sold, which can only be the very tip of the potential iceberg. I must express reservations, however, about the approach that Microwriter are making on the market place, which seems to be rather uncertain and lacking in self-confidence. I first saw a Microwriter 'in the flesh' in the latter part of 1983, when I had a demonstration and a loan from a distributor for a couple of weeks. I expressed a great interest when I returned the machine to him, and was promised more information and a follow-up call shortly. I never heard from him, or another distributor I contacted, ever again. At the end of January 1984 I approached Microwriter themselves for information and a review sample to help prepare this article. I also ordered two Quinkeys for my own use. I am writing this article in mid August; the review sample only arrived three weeks ago! The Quinkeys arrived in the middle of June, some 19 weeks after they were ordered, and only after telephone calls at the rate of once per fortnight for most of that period. I persevered—I wonder how many others did not?

I hope that the future is very rosy for Microwriting. Amongst friends and colleagues the Microwriter has created more interest than any other piece of equipment that I can remember. The concept of the Microwriter is a work of genius. The market is potentially vast, the product works well, and the presentation is superb. The price is a little high, but should not deter the professional market, with the lower cost market being satisfied by the Quinkey. Let's just hope that Microwriter can improve on the delivery and planning side of it, put some more aggression into the marketing, and produce a commercial, not just a technical winner. What a great shame it would be if the Microwriter concept was lost to an overseas supplier, as has happened to so many other viable products from the UK.

More information can be obtained from Microwriter Ltd., 31 Southampton Row, London WC1B 5HJ. (01-831 6801).

THE LEADING EDGE

DIGITISATION

Everyone talks about the information explosion. The key is digitisation. With digital telephone systems what goes down the line is a series of PCM pulses, rather than analogue waves. Once you have that situation, the sky's the limit.

PCM pulses can carry telephone quality speech, high quality stereo radio, TV pictures, computer data, teletext, viewdata; in fact any information that can be converted into an electrical signal. Switching is by microchip, instead of the primitive Strowger electro-mechanical relay which phone systems have used for the best part of a hundred years.

By interleaving different calls in the same data stream, the capacity of a link goes up around 15 times, i.e. a pair of copper wires that normally carry one analogue telephone call, can carry fifteen digitals. With optical fibres, and the signals carried as light pulses rather than electrons, capacity rises much, much higher.

The British Post Office started working on PCM phone links 20 years ago. Few people know that the PO installed an experimental digital exchange at Earl's Court in 1968 and had it running until 1975. That was when talk about System X started.

Cynics say that the System was called X because no-one really knew what it was going to do or how it was going to do it. Essentially it's a computer switching service for PCM streams and there are now six System X exchanges working in London. One is at Baynard House in the City of London. The first five were prototypes.

Once data streams are digitally switched and connected, the options available open up wide. There is no problem in providing conference calls, automatically re-directing calls to other numbers or displaying the telephone number of origin when you receive a call.

ELECTRONIC MAIL

Already many people in Britain are using electronic mail, which is a hybrid system of sending digital data down an analogue telephone line. I'm one of them and there are quite a few stories to tell about how the system works in practice, as opposed to theory!

More of that in a future month. At the moment I am trying to find out why the main computer used by Telecom Gold for electronic mail keeps going wrong and leaving users like me stranded!

Why worry about information technology? There's a very short answer. *It is always far cheaper to send electronic data down a telephone line, or over a wireless link, than shift people or bits of paper from town to town or country to country.*

The best example of this is what happens at the *Economist* magazine. This London-based publication also prints in America and the Far East. Printing master plates are sent by airline courier to the Orient. Until a year ago they were also sent to America.

The plum job on the *Economist* was to take a day trip on Concorde to New York and back, with the print plates, for safe keeping. Now the magazine text is converted to digital data and sent by satellite direct to a Connecticut printing works, which publishes virtually simultaneously with London.

Wisely the *Economist* still sends a back up text by 'plane just in case the satellite link breaks down. But no-one gets the plum job of going along with them any more.

VIDEO NEWS

Polaroid has joined Kodak in 8mm video. Sony may follow next year but so far everyone else is sticking with their existing VHS and Beta formats. Ironically by joining Kodak, Polaroid may well have helped its rival succeed. The extra name gives the new format credibility.

At the Chicago Consumer Electronics Show both companies were demonstrating NTSC camcorders using the 8mm cassette. Picture quality was good and sound, using f.m. mono, seemed OK. The big question mark is over tape supply.

Video writing speed is very low; 3.8 metres a second for NTSC and 3.1 metres a second for PAL and SECAM. So packing density must be very high. You can get it either from tape coated with metal powder (MP) and coercivity around 1600 oersted. But this needs video heads which are expensive and may be short lived. The other way is to use lower coercivity tape coated by evaporation of cobalt-ferric metal in a vacuum (ME). No one has yet succeeded in making ME tape reliably in bulk.

Kodak started shipping 8mm camcorders to US traders last September. A 90 minute cassette costs $24 and the system $2000. There is no sign yet of a PAL or SECAM prototype. Although 8mm video almost certainly comes too late and too expensive to catch the domestic market, it could well form the basis of a new professional camcorder format.

Sony has both domestic and pro interests. Kodak and Polaroid are paying Matsushita, Toshiba and TDK to get the technology right for domestic use. Professional use is the logical follow on.

CLEAN CUT

I have now seen inside several compact disc and videodisc manufacturing plants in Britain, Germany and Japan. They all have one thing in common with a microchip factory, that is absolute cleanliness.

Exactly the same situation exists in magnetic tape factories, where any dirt in the atmosphere will end up as non-magnetic blemishes in the coating and cause dropout.

Air in the so-called "clean areas" is filtered to Class 100, that is to say less than 100 particles of less than 0·5 micron size in every cubic foot of air. The pressure of air inside these clean areas is higher than the atmosphere outside, so when a door opens clean air blows out and dirty air leaks in.

The staff must wear full length lint-free jump suits, like space clothing, and only a few visitors are allowed in. Usually there is an air shower, where blasts of clean air flush dirt, dust, dead skin and dandruff off every human passing through.

If only, I think every time I visit one of these plants, factories which press ordinary records would take even remotely comparable steps to preserve cleanliness. The official answer is that it's not necessary.

Certainly, by comparison, the technology of LP production looks like a blunt instrument. But it is easy to forget that a vinyl LP record is by far the most precise product mass produced from plastics!

The groove of an LP record is specified by IEC standard to be never less than 25 microns (or millionths of a metre) wide and preferably not less than 35 microns wide. As a "yardstick" a human hair is around 50 microns in width. The IEC puts stylus tip radius at between 15 and 18 microns.

Now let's look at a Laservision videodisc, and a compact disc digital audio record. Both have a spiral of information pits with a track pitch of 1·6 microns.

For videodisc the pits are 0·5 microns wide, and for compact disc they are 0·6 microns wide. Video pit depth is 0·1 micron and CD depth 0·12 microns.

In other words there is very little difference in the dimensions; both are at least 50 times smaller than the LP groove. The laser spot for videodisc playback is focused to a circle of 0·9 micron diameter and for compact disc it is 1 micron. The layer of protective lacquer in a compact disc has to be exactly 1·2 millimetres thick, or it will affect the laser focus.

PARTY TURN

If you collect useless information to bring out of the bag at boring cocktail parties, here's one for the bag. A CD player rotates the disc at a speed which varies between 3·5 revolutions a second and 8 revolutions a second, to give a constant tracking velocity of 1·25 metres a second.

That means that for a one hour disc there are 4·5 kilometres of track on a single side. For a laser videodisc the track length is 31 kilometres!

BARRY FOX

TERMS OF BUSINESS

- ★ All prices exclude V.A.T. and carriage. Please add carriage to order total before adding V.A.T.
- ★ Carriage charges extra on all orders as follows:
  - Components £0.75
  - Books/Data/Software £2.00
  - Printers, Monitors, Disc drives, etc. £4.50
- ★ Strictly cash with order or credit card (Access or VISA) only.
- ★ Delivery is normally from stock but please allow up to 28 days.
- ★ Any query or complaint regarding an order should be made in writing within 7 days of receipt of the order. No telephone queries will be entertained.
- ★ Goods incorrectly ordered cannot be accepted for replacement without our prior agreement. Due to high processing costs, a minimum of 15% handling charge may be levied on any returns or cancelled orders.
- ★ We will issue a full immediate refund, if requested, for out of stock items.
- ★ All items carry full manufacturers warranty.
- ★ A V.A.T. receipt will be supplied with all orders.
- ★ Prices quoted are correct at the time of going to press but we reserve the right to effect changes without prior notice.

Hi-Tech

HI-TECH COMPONENTS,

6502 FAMILY

6502	3.50
6502A	4.95
6520	2.25
6520A	2.45
6522	3.40
6522A	4.45
6532	5.45
6532A	5.95
6551	5.95

6800 FAMILY

6800	2.15
6802	2.70
6803C	8.40
6809E	6.25
6809P	6.25
6810	1.70
6821	1.70
6840	3.70
6845	6.45
6850	1.70
6862	3.75
6875	4.95
68B00	4.30
68B09	9.95
68B10	1.88
68B21	3.70
68B40	6.60
68B50	1.58
68B54	7.95

6805 FAMILY

MC1468052P	12.60
MC146818P	7.20
MC146823P	8.80
MC68705KT3	75.00
MC68705R3L	40.00
MC68705U3L	36.00

68000 FAMILY

MC68000G10	50.00
MC68000L8	50.00
MC68008L8	45.00
MC68230L8	19.50
MC68451L8	67.00
MC68901P	75.00

TI 9900 FAMILY

TMS9901-95	4.50
TMS9902	4.50
TMS9918	35.00
TMS9927	11.60
TMS9928	13.00
TMS9929	13.00
TMS9937	6.70
TMS9980	17.20
TMS9995	13.70

8086 FAMILY

8086	29.50
8088-2	22.50
8216	0.75
8237A-5	23.50
8251A	7.50
8253-5	7.50
8255A-5	7.00
8259A	6.60
8272	35.00
8284A	9.50
80C86	46.65
80C88	46.65
82C52	15.68
82C54	19.04
82C55A2	12.98
82C59A	15.22
82C82	6.26
82C84A	8.94
82C88	16.80

Z80 FAMILY

Z80ACPU	1.99
Z80ACTC	1.99
Z80ADMA	7.95
Z80APIO	1.99
Z80ASIO-0	6.70
Z80ASIO-1	7.95
Z80ASIO-2	7.95
Z80BCPU	5.95
Z80BCTC	5.95
Z80BPIO	5.95
Z80BSIO-0	19.95
Z80BSIO-1	19.95
Z80BSIO-2	19.95
Z80SIO-0	6.00
Z80SIO-1	6.00
Z80SIO-2	6.00

Hi-Tech components

0379 4131

MEMORIES — EPROM

2532-300ns	4.95
2532-450ns	3.95
2564-300ns	6.95
2708-450ns	3.95
2716-450ns	3.50
2716-3 RAIL	7.95
2732-350ns	4.95
2732-450ns	4.45
2764-200ns	7.95
2764-250ns	5.15
2764-300ns	4.75
27C64-250ns	10.95
27C64-300ns	10.45
27128-250ns	19.00
27128-300ns	16.00

MEMORIES RAM

4116-150ns	1.28
4116-200ns	1.20
4164-150ns	4.45
4416-200ns	4.70
4532-200ns	2.45
4564-150ns	4.45
8118-100ns	1.95
81256-150ns	25.00
8416-200ns	6.00
8416-LP-200ns	6.40
8417-200ns	6.00
8417-LP-200ns	6.40

MEMORIES — RAM *ZERO POWER ZKXB CMOS*

MK48Z02B-150ns	32.00
MK48Z02B-200ns	24.00
MK48Z028-250ns	23.00

BIPOLAR PROMS

TBP18S030N	1.54
TBP18SA030	1.38
TBP24S10N	2.06
TBP24S41N	6.68
TBP24S81N	5.50
TBP24SA10N	1.40
TBP24SA41N	4.40
TBP28L22N	3.10
TBP28LA22N	4.14
TBP28S166N	19.00
TBP28S42N	4.50
TBP28S46N	4.50
TBP28S86N	5.00
TBP28SA42N	4.50
TBP28SA46N	4.50
TBP28SA86N	8.62
AM27S13PVC	3.74
AM27S19PC	1.92
AM27S191DC	15.00
AM27S25DC	15.00
AM27S29DC	6.46
AM27S35DC	22.00

MEMORIES E2 PROM

X2804AP-300ns	14.95
X2804AP-350ns	13.45
X2804AP-450ns	12.75
X2816AP-300ns	29.95
X2816AP-350ns	25.00
X2816AP-450ns	22.50

LINEAR/INT. DEV.

4702	8.90
HCI-55564-5 (Speech Synthesis)	10.66
AM7910DC	34.88
AM7911DC	34.88
25LS2518PC	3.60
25LS2521PC	3.28
25LS2538PC	2.72
25LS2539PC	2.72
26L531PC	2.62
26L532PC	2.62
6402	6.40
75107BN	0.69
75110AN	0.86
75150P	0.86
75154N	1.05
75159	2.30
75160AN	2.60
75161AN	2.82
75162AN	4.08
75172NG	1.96
75173N	1.44
75174	2.82
75175	1.96
75182	0.50
75183	0.50
75188	0.86
75189	0.86
75451BP	0.22
75452BP	0.29
75453BP	0.22
75454BP	0.22
75468N	0.88
75491N	0.31
75492N	0.41
AY-3-1015	3.50
AY-3—1270	9.40
AY-3-8910	6.40
AY-5-3600	8.84
DP8304	4.50
L203	0.99
LF398	3.80
LM301AN	0.30
LM308AN	0.94
LM308N	0.56
LM311N	0.60
LM317MT	0.80
LM317T	1.06
LM319N	3.30
LM324N	0.50
LM337T	1.20
LM339	0.48
LM339N	0.48
LM348N	0.64
LM350T	3.12
LM358N	0.60
LM3900	0.68
LM393N	0.48
LM725CN	3.00
741CP	0.16
LM747CN	0.60
LM748CN	0.30
MC1413P	0.80
MC1416	0.80
MC14411	10.10
MC14412	14.20
MC1458CPI	0.35
MC1495L	6.30
MC1496P	0.70
MC1723P	0.40
MC3242A	6.30
MC3302P	0.48
MC3340P	2.36
MC3357P	1.90
MC3423PL	0.81
MC3441AP	2.90
MC3446AP	2.90
MC3447P	4.30
MC3448A	3.99
MC3470P	6.44
MC3480	7.76
MC3487	1.80
NE555P	0.25
NE556CP	0.65
RO32513-L	9.40
RO32513-U	9.40
TL010-CP	0.44
TL061-CLP	0.28
TL062-CP	0.47
TL064-CN	0.95
TL066-CP	0.28
TL071-CP	0.28
TL072-CP	0.56
TL074-CN	1.10
TL081-CP	0.29
TL082-CP	0.49
TL084-CN	1.02
TL091-CP	0.39
TL092-CP	0.72
TL094-CN	1.30
TL487-CP	0.59
TL489-CP	0.59
TL494-CN	1.99
TL496-CP	0.59
TL507-CP	1.22
ZN450-E	6.08
ZN451-E	7.40
ZN451-KIT	29.95

F.D. CONTROLLERS

8272	35.00
FD1771P	30.00
FD1791	15.50
FD1791-02	11.00
FD1793	18.40
FD1793-02	11.00
FD1795	25.00
FD1797	21.00
WD1691	14.00
WD2143	12.00

DATA CONVERTERS

ZN425E-8	3.76
ZN425J-8	8.00
ZN426E-8	1.90
ZN427E-8	6.68
ZN427J-8	12.50
ZN428E-8	5.10
ZN428J-8	9.70
ZN429E-8	1.60
ZN432CJ-10	20.79
ZN432E-10	13.00
ZN433CJ-10	25.00
ZN434	0.98
ZN435	4.38
ZN436E	1.26
ZN440	55.00
ZN441	46.80
ZN447	7.80
ZN448E	6.66
ZN448J	12.48
ZN449	2.72
ZNA134J	22.50
ZNA234E	9.40

VOLTAGE REF.

ZN404	0.50
ZN423	0.98
ZN458	0.92
ZN458A	0.92
ZN458B	1.12
ZNREF 025	1.90
ZNREF 040	1.90
ZNREF 050	1.90
ZNREF 062	1.90
ZNREF 100	3.05

BUFFERS

81LS96	0.80
81LS97	0.80
81LS98	0.80
8T26A	0.80
8T28	0.80
8T28A	0.80
8T95	0.80
8T97A	0.80
8T98	0.80

OPTOISOLATORS

4N25	0.75
4N26	0.75
4N33	0.90

UHF MODULATORS

UM1111	2.95
UM-1233	3.45

VOLTAGE REG.

7805	0.75
7812	0.75
7815	0.75
78H05SC	7.50
78H12ASC	8.95
78HGASC	9.95
78L05	0.30
78L12	0.30
78L15	0.30
78S40DM	7.50
78S40PC	3.00
7905	0.95
7912	0.95
7915	0.95
LM309K	0.95
LM317K	2.45
LN323K	4.95
LM338K	4.50

FAIRCHILD FAST

74F00PC	0.60
74F04PC	0.60
74F08PC	0.65
74F109PC	0.65
74F11PC	0.52
74F138PC	0.52
74F138PC	1.26
74F139PC	1.26
74F151	1.26
74F153	1.26
74F157	1.30
74F158	1.17
74F161	2.34
74F164	1.68
74F175	1.82
74F181	3.90
74F189	5.10
74F190	3.20
74F191	3.20
74F194	1.68
74F20PC	0.52
74F240	3.16
74F241	2.42
74F243	2.80
74F244	2.96
74F245	6.08
74F251	1.26
74F253	1.26
74F257	1.26
74F258	1.34
74F280	1.74
74F283	1.74
74F32PC	0.52
74F352	1.26
74F353	1.26
74F373	3.16
74F374	3.16
74F379	1.83
74F381	6.62
74F382	4.22
74F398	3.16
74F399	2.70
74F521	2.76
74F533	3.16
74F534	3.16
74F537	6.02
74F538	4.38
74F539	4.38
74F64PC	0.52
74F74PC	0.58
74F86PC	0.77

HIGH SPEED CMOS

74HC00N	0.42
74HC02N	0.42
74HC03N	0.64
74HC04N	0.44
74HC08N	0.42
74HC107N	0.78
74HC109N	0.50
74HC10N	0.64
74HC112N	0.86
74HC113N	0.86
74HC132N	1.28
74HC137N	1.81
74HC138N	1.20
74HC139N	0.78
74HC151N	1.16
74HC153N	0.90
74HC157N	1.02
74HC158N	1.02
74HC160N	0.90
74HC161N	0.90
74HC162N	1.51
74HC163N	1.51
74HC164N	0.95
74HC165N	2.24
74HC173N	1.35
74HC174N	0.80
74HC175N	0.78
74HC194N	1.28
74HC195N	1.28
74HC20N	0.40
74HC237N	1.80
74HC240N	1.38
74HC241N	1.34
74HC242N	2.24
74HC243N	2.24
74HC244N	1.32
74HC251N	1.03
74HC253N	1.03
74HC257N	1.03
74HC266N	0.92
74HC273N	2.24
74HC27N	0.80
74HC280N	3.26
74HC32	0.40
74HC373N	2.40
74HC374N	2.40
74HC393N	1.78
74HC4002	0.64
74HC4017	1.16
74HC4020	1.46
74HC4024	1.20
74HC4040	1.46
74HC4060	1.46
74HC4075	0.64
74HC42N	0.90
74HC4511	2.51
74HC4514	3.76
74HC4538	2.36
74HC4543	3.04
74HC51N	0.64
74HC533N	2.40
74HC534N	2.40
74HC589N	1.72
74HC58N	0.64
74HC595N	1.84
74HC597N	1.72
74HC73N	0.84
74HC74N	0.84
74HC75N	0.92
74HC76N	0.64
74HC85N	2.02
74HC86N	0.80
74HCU04N	0.80

TTL

74LS00	0.17
74LS01	0.17
74LS02	0.17
74LS03	0.17
74LS04	0.25
74LS05	0.25
74LS08	0.17
74LS09	0.25
74LS10	0.17
74LS109	0.27
74LS11	0.17
74LS112	0.54
74LS113	0.27
74LS114	0.44
74LS12	0.25
74LS122	0.42
74LS123	0.53
74LS124	2.30
74LS125	0.49
74LS126	0.29
74LS13	0.17
74LS132	0.73
74LS136	0.46
74LS138	0.77
74LS139	0.77
74LS14	0.28
74LS145	1.23
74LS148	1.50
74LS15	0.25
74LS151	0.36
74LS153	0.36
74LS155	0.24
74LS156	0.77
74LS157	0.24
74LS158	0.62
74LS160	0.80
74LS161	0.34
74LS162	0.80
74LS163	0.80
74LS164	1.10
74LS165	0.61
74LS166	1.95
74LS173	0.63
74LS174	1.30
74LS175	0.96
74LS181	2.09
74LS190	0.98
74LS191	0.75
74LS192	0.36
74LS193	1.10
74LS194	0.28
74LS195	0.78
74LS196	1.10
74LS197	1.10
74LS20	0.17
74LS21	0.17
74LS22	0.17
74LS221	0.62
74LS240	1.40
74LS241	0.48
74LS242	1.36
74LS243	1.36
74LS244	1.40
74LS245	1.95
74LS248	0.39
74LS249	1.16
74LS251	0.78
74LS253	0.25
74LS257	0.78
74LS258	0.27
74LS259	0.42
74LS26	0.30
74LS261	2.60
74LS266	0.19
74LS27	0.17
74LS273	1.35
74LS279	0.77
74LS28	0.17
74LS283	1.00
74LS290	0.29
74LS293	0.29
74LS30	0.17
74LS32	0.25
74LS33	0.17
74LS365	0.33
74LS366	0.33
74LS367	0.34
74LS368	0.36
74LS37	0.17
74LS373	1.50
74LS374	0.52
74LS375	0.26
74LS377	0.46
74LS378	1.22
74LS379	1.50
74LS38	0.25
74LS386	0.50
74LS390	1.10
74LS393	0.52
74LS40	0.25
74LS42	0.25
74LS47	0.30
74LS48	0.35
74LS49	0.34
74LS51	0.17
74LS54	0.17
74LS55	0.17
74LS670	2.30
74LS73	0.30
74LS74	0.35
74LS75	0.28
74LS76	0.17
74LS78	0.19
74LS83	0.28
74LS85	0.39
74LS86	0.42
74LS90	0.21
74LS91	1.30
74LS92	0.22
74LS93	0.21
74LS95	0.77

CMOS 4000 Series

4000	0.16
4001	0.15
4002	0.16
4006	0.55
4007	0.16
4008	0.50
4009	0.25
4010	0.25
4011	0.19
4012	0.16
4013	0.29
4014	0.40
4015	0.50
4016	0.29
4017	0.40
4018	0.40
4019	0.30
4020	0.41
4021	0.56
4022	0.42
4023	0.23
4024	0.40
4025	0.16
4026	0.74
4027	0.52
4028	0.34
4031	0.93
4033	2.40
4034	1.00
4035	0.54
4040	0.41
4041	0.36
4042	0.40
4043	0.41
4044	0.43
4045	2.00
4046	0.55
4047	0.50
4048	0.40
4049	0.50
4050	0.29
4051	0.40
4052	0.48
4053	0.50
4054	1.30
4055	0.72
4060	0.50
4063	0.60
4066	0.50
4068	0.16
4069	0.23
4070	0.23
4071	0.23
4072	0.23
4073	0.23
4075	0.46
4076	0.48
4077	0.23
4078	0.25
4081	0.23
4082	0.25
4085	0.66
4086	0.40
4093	0.23
4099	0.50
4502	0.55
4507	0.47
4508	0.96
4510	0.45
4511	0.50
4512	0.40
4514	1.00
4515	1.84
4516	0.45
4518	0.40
4519	0.25
4520	0.64
4521	1.32
4522	0.84
4526	0.52
4527	0.52
4528	0.48
4532	0.68
4541	0.82
4543	0.60
4553	2.00
4555	0.36
4556	0.44
4585	0.48

CRYSTALS

A111B	1MHz	4.50
A112A	1.008MHz	2.70
A113A	1.8432MHz	3.50
A116A	2.4576MHz	2.00
A120B	4MHz	1.25
A132A	6MHz	1.30
A140A	8MHz	1.25
A169A	3.6864MHz	2.00
A173A	9.8304MHz	2.75
A182A	19.6608MHz	2.50

DIL SKTS TIN

		1+	100+
07070802	8 PIN	0.07	0.05
07071402	14 PIN	0.09	0.07
07071602	16 PIN	0.09	0.07
07071802	18 PIN	0.15	0.10
07072002	20 PIN	0.19	0.14
07072202	22 PIN	0.21	0.15
07072402	24 PIN	0.24	0.16
07072802	28 PIN	0.26	0.17
07074002	40 PIN	0.29	0.18

DIL SKTS GOLD

06060802	8 PIN	0.16
06061402	14 PIN	0.20
06061602	16 PIN	0.21
06061802	18 PIN	0.22
06062002	20 PIN	0.28
06062202	22 PIN	0.32
06062402	24 PIN	0.42
06062802	28 PIN	0.46
06064002	40 PIN	0.66

DIL SKTS W/WRAP TURNED PIN

9090802	8 PIN	0.36
9091402	14 PIN	0.75
9091602	16 PIN	0.86
9091802	18 PIN	0.96
9092002	20 PIN	1.08
9092202	22 PIN	1.18
9092402	24 PIN	1.28
9092802	28 PIN	1.50
9094002	40 PIN	1.70

ZIF SOCKETS

08082402	24 PIN	5.70
08082802	28 PIN	6.90
08084002	40 PIN	8.25

components

GILRAY ROAD, DISS, NORFOLK. TEL: 0379 4131

INSULATION DISPLACEMENT CONNECTOR SYSTEM

HEADERS

	SHROUDED 90°	OPEN 90°	OPEN — STRAIGHT PINS
10 way	0.86	0.65	0.47
14 way	1.22	0.83	0.59
16 way	1.34	0.92	0.65
20 way	1.36	1.13	0.77
26 way	1.70	1.40	0.95
34 way	2.04	1.78	1.19
40 way	2.28	2.07	1.37
50 way	2.70	2.54	1.67
60 way	3.20	3.02	1.96

SOCKETS

10 way	0.88
14 way	1.06
16 way	1.16
20 way	1.38
26 way	1.66
34 way	1.94
40 way	2.08
50 way	2.78
60 way	3.34

CARD EDGE

10 way	1.84
20 way	3.14
26 way	3.80
34 way	4.90
40 way	5.52
50 way	6.68
60 way	8.06

DIP PLUGS

14 way	0.92
16 way	1.06
24 way	1.60
40 way	2.40

TRANS. CONNS.

10 way	0.86
16 way	1.17
20 way	1.37
26 way	1.67
34 way	1.87
40 way	2.23

D-TYPE SOCKETS

9 way	1.47
15 way	2.02
25 way	2.90
37 way	3.97

D-TYPE PLUGS

9 way	1.38
15 way	1.85
25 way	2.52
37 way	3.34

CABLE ASSEMBLIES

IDC JUMPERS SINGLE ENDED

36" cable	IDC socket
10 way	1.72
14 way	2.07
16 way	2.22
20 way	3.14
26 way	3.75
34 way	3.98
40 way	4.23
50 way	5.36
60 way	6.36

DIP JUMPERS

Single Ended

	— 24" cable
14 pin	1.73
16 pin	1.90
24 pin	2.73
40 pin	3.96

Double Ended

	6" cable	12" cable	18" cable
14	2.74	2.84	2.94
16	3.03	3.14	3.25
24	4.18	4.36	4.55
40	5.89	6.18	6.47

DISC DRIVE CONNECTING CABLES

34 way card edge to 34 way card edge 1M	11.30
34 way card edge to 2 × 34 way card edge 1.5M	18.00
34 way card edge to 34 way IDC SKT (BBC) 1M	8.50
34 way card edge to 2 × 34 way IDC KT (BBC) 1.5M	14.50
BBC Power Cable — Single Drive	3.50
BBC Power Cable — Dual Drive	4.75

RIBBON CABLE (PRICED PER FOOT)

	GREY	RAINBOW
9	0.16	0.25
10	0.16	0.25
14	0.21	0.35
15	0.22	0.37
16	0.23	0.39
20	0.28	0.48
25	0.34	0.60
26	0.35	0.62
34	0.45	0.80
40	0.52	0.92
50	0.64	1:14
60	0.76	1.35

BBC MICRO CONNECTORS

DIN PLUG 7 PIN	0.40
DIN PLUG 6 PIN	0.40
DIN PLUG 5 PIN 180°	0.40
DIN PLUG 5 PIN DOMINOE	0.40
POWER PLUG (36" CABLE)	3.00
ANALOGUE INPUT PLUG	2.25
5 WAY DIN SKT 180°	0.90
5 WAY DIN SKT DOMINOE	0.90
6 WAY DIN SKT	0.90
7 WAY DIN SKT	0.90
15 WAY DIN SKT	2.15

Connecting cables for personal computers

A comprehensive range of high quality interconnecting cables for popular micro computers. All cables utilise high quality connectors and are individually tested to ensure trouble free use.

Video cables

Part number	Description	Computer	
CON100	Phono plug to phono plug (2M)		1.20
CON101	Phono plug to BNC plug (2M)		2.95
CON102	BNC plug to BNC plug (2M)		3.95
CON107	6 pin DIN to open end (1M)	BBC	1.05
CON108	6 pin DIN to 6 pin DIN (1M)	BBC	1.50
CON119	Phono plug to coax plug		1.35
CON160	DIN plug to 2 phono plugs	Dragon	1.20

Cassette recorder cables

Part number	Description	Computer	
CON109	7 pin DIN to open end	BBC	1.25
CON110	7 pin DIN to 2 × 3.5mm + 1 × 2.5mm J/plug	BBC	2.50
CON111	7 pin DIN to 5 pin DIN + 2.5mm J/plug	BBC	2.50
CON118	5 pin DIN to 2 × 3.5mm J/plugs	Spectrum/ZX	2.50
CON117	5 pin DIN to 2 × 3.5mm + 1 × 2.5mm J/plug	Dragon	2.50

Parallel printer cables

Part number	Description	Computer	
CON130	36 way plug to 36 way plug (2M)	Sirius/Apricot	18.00
CON131	36 way plug to 36 way plug (5M)	Sirius/Apricot	26.50
CON132	36 way plug to 36 way socket (2M)		18.00
CON133	36 way plug to 36 way socket (5M)		26.50
CON144	36 way plug to 25 way male D type (2M)	IBM/TI PC	19.00
CON145	36 way plug to 25 way male D type (5M)	IBM/TI PC	27.50
CON134	36 way plug to 25 way male D type (2M)	RML/Apple	19.00
CON135	36 way plug to 25 way Male D type (5M)	RML/Apple	27.50
CON142	36 way plug to 20 way IDC socket (2M)	Dragon	13.95
CON139	36 way plug to 26 way IDC socket (2M)	BBC	9.95
CON140	36 way plug to 26 way IDC socket (5M)	BBC	22.95
CON141	36 way plug to 34 way card edge (2M)	TRS80 Lev 1	18.50
CON143	36 way plug to 34 way IDC socket (2M)	TRS80 Lev 2/ Memotech	10.95

RS232 Cables

Part number	Description	Computer	
CON106	25 way male D type to 5 pin DIN	BBC	5.85
CON128	'Universal' RS232 cable (pins 1-8, 20 connected and 20 jumpered as required) 2M		15.95
CON164	'Universal' RS232 cable as above but 5M		20.95
CON120	25 way male to male 1-25 connected (2M)		16.95
CON121	25 way male to male 1-25 connected (5M)		22.50
CON122	25 way male to male 1-25 connected (10M)		32.50
CON123	25 way male to male 1-25 connected (30M)		68.00
CON124	25 way male to female 1-25 connected (2M)		15.45
CON125	25 way male to female 1-25 connected (5M)		21.00
CON126	25 way male to female 1-25 connected (10M)		31.00
CON127	25 way male to female 1-25 connected (30M)		66.50
CON129	25 way male to 9 way male	Spectrum	15.95
CON162	25 way male to 9 way male	Mackintosh	15.95
CON163	25 way male to 5 pin DIN	RML 480Z	14.95

PART NO.	DESCRIPTION	MAIL ORDER PRICE
BBC MICROS AND ACCESSORIES		
ANB01	BBC Model B Micro	£325.00
ANB02	BBC Model B Micro with Econet I/F	£385.00
ANB03	BBC Model B Micro with Disc I/F	£406.00
ANB04	BBC Model B Micro with Disc & Econet	£445.00
ANB21	DNFS ROM	£17.91
ANB23	Disc Interface Kit (Excl DNFS ROM)	£84.00
ANB14	Speech Interface	£40.00
ANK01	IEEE488 Interface Adaptor	£283.00
ANB22	Econet I/F Kits	£35.00
BBC 45	2 BBC Joysticks	£8.00
STAND	Monitor Stand	£7.50
SRE1	Sideways ROM Expansion Board for BBC Micro	£25.95
BBC DISC DRIVES		
HC1	Single 100k 40 track single sided	£75.00
HC15	Single 100k (expandable to dual) 40 track	£90.00
HC1D	Dual (2 × 100k) 40 track single sided	£160.00
BBC44	Single 400k 80 track double sided	£156.50
BBC445	Single 400k (expandable to dual) 40/80 track switchable double sided	£180.00
BBC445W	Single 400k 40/80 track switchable double sided	£159.00
BBC44D	Dual (2 × 400k) 40/80 track switchable double sided	£310.00
MECHANISMS		
	100k single sided Alps	£70.00
	400k double sided Epson	£140.00
FLOPPY DISCS		
MD-1C/B	Nashua single sided, single density 40 track (10 discs)	£12.00
MD-1DC/B	Nashua single sided, double density 40 track (10 discs)	£13.00
MD-2DC/B	Nashua double sided, double density 40 track (10 discs)	£15.50
MD-2FC/B	Nashua double sided, quad density 80 track (10 discs)	£17.85
SPECIAL OFFER		
BBC40TD	BASF double sided, double density 40 track (10 discs)	£14.00
DISC STORAGE BOXES		
MDT25/3	3½" Flip 'N' file Micro disc box (cap. 25)	£7.75
DT25/5	5¼" Flip 'N' file lockable disc box (cap. 25)	£18,77
DT60/5	5¼" Standard lockable disc box (cap. 60)	£10.65
MONITORS		
9MON	9 inch green screen high resolution NEC high quality monitor	£125.00
12MON	12 inch green screen high resolution NEC high quality monitor	£135.00
1431	Microvitec 14" RGB colour monitor	£175.00
1441	Microvitec 14" RGB colour monitor high resolution	£410.00
1451	Microvitec 14" RGB colour monitor medium resolution	£295.00
1431/AP/MS	Microvitec 1431 PAL & RGB inputs and sound facility	£225.00
EPSON COMPUTERS AND ACCESSORIES		
PX-8	Epson portable computer (incl. CP/M and s/w) 64k	£798.00
PX-8/120	120k RAM	£998.00
CX-21	Acoustic coupler	£160.00
PF/10	Disc drive for PX-8	£360.00
P40	Thermal printer for PX-8 and HX-20	£86.91
HX-20	Epson portable computer	£411.00
MATRIX PRINTERS		
RX80	Epson RX80 100cps matrix printer	£204.00
RX80F/T	Epson RX80F/T 100 cps matrix printer friction or tractor feed	£231.00
FX80	Epson FX80 150cps matrix printer	£328.50
MT80SP	Mannesmann Tally MT80 matrix printer friction or tractor feed with film ribbon and tear off facility	£217.00
LETTER QUALITY PRINTERS		
HR5	Brother HR5 Thermal printer A/C mains or battery	£130.00
HR15	Brother HR15 Daisy wheel printer (13cps)	£326.00
HR25	Brother HR25 Daisy wheel printer (23cps)	£550.00
UCHIDA	Uchida DWX305 Daisy wheel printer (20cps)	£227.00
PRINTER SUPPLIES		
11241P160	11×9½ 1 part plain listing paper (2,000)	£12.56
11241P2CI	11×9½ 2 part (otc) plain listing paper (1,000)	£15.93
11241P3CI	11×9½ 3 part (otc) plain listing paper (700)	£17.86
11370R160	11×14½ 1 part ruled listing paper (2,000)	£16.20
11370R2NC	11×14½ 2 part (ncr) ruled listing paper (1,000)	£22.50
11370R2CI	11×14½ 2 part (otc) ruled listing paper (1,000)	£15.00
12235P160S	12×9½ 1 part plain listing paper with side perfs. (2,000)	£12.00
HR1R	Brother HR1 ribbon	£2.20
RIB119	Diablo Hytype II Multistrike film ribbon	£1.75
GP205	Diablo Hytype II fabric ribbon	£2.50
MX80	Epson MX80, RX80, FX80, fabric ribbon	£3.00
MT80	Mannesmann Tally MT80 film ribbon	£6.50
RIB117	Uchida DWX305 multistrike film ribbon	£2.75
HR5R	Brother HR5 ribbon	£2.20
HR15R	Brother HR15 multistrike ribbon	£4.00
HR25R	Brother HR25 multistrike ribbon	£4.00
	Brother daisy wheels	£14.00
	Uchida/Qume daisywheels	£4.00
LAB089361C	3½×1 7/16 Labels — 1 wide (8,000)	£20.00
LAB0893615	3½ 1 7/16 Labels — 1 wide (2,000)	£13.00
LAB070363F	2¾ 1 7/16 Labels — 3 wide (1/10") (2,000)	£8.00

SEMICONDUCTOR CIRCUITS

TOM GASKELL BA(Hons) CEng MIEE

POWER OP-AMPS (TCA365 and TCA2365)

ONE of the most important components available to the analogue circuit designer is the operational amplifier, or 'op-amp'. The majority of these, however, are somewhat limited in their load driving capabilities. Simple devices such as the 741 can only output 25mA under short circuit conditions, or 10mA in normal operation. For much higher currents it is usually necessary to add extra driving transistors to a conventional op-amp.

The TCA365 and TCA2365 are power op-amps which allow the designer to use a single i.c. in high power applications rather than the more cumbersome 'op-amp plus components' approach. In practice, they behave as fairly ordinary op-amps with the exception that their output stages can drive up to 3 amps in the case of the TCA365, or 2·5 amps *per amplifier* in the case of the dual op-amp TCA2365. The two i.c.s are very similar, with both sets of specifications being given in Fig. 2. The main points to watch are supply voltage maxima, output currents, and power dissipation; these all vary between the 365 and the 2365. (Note that the output current shown for the TCA2365 is 2·5A per amplifier, not for the whole i.c.) Fig. 1 shows the pinouts of the i.c.s. For moderate to high power applications, heatsinks should be used. These should be insulated from the i.c.s' tabs if the internal connections to the –ve supply could cause short circuits or problems.

The TCA2365 has an 'inhibit' input which can be used to turn the outputs of the op-amps off, ie. high impedance (approximately 4k). Inhibiting is effective when pin 6 is taken to the –ve supply rail, and the amplifiers operate normally when pin 6 is taken above 3·0V referred to the –ve supply, or left unconnected. Both the TCA365 and the TCA2365 have extensive protection; they are d.c. short circuit proof and have thermal overload and safe operating area protection. The internal current limiting makes them ideal for driving complex loads, and especially for driving filament lamps, whose low resistance in the 'cold' state can cause problems with other types of driver.

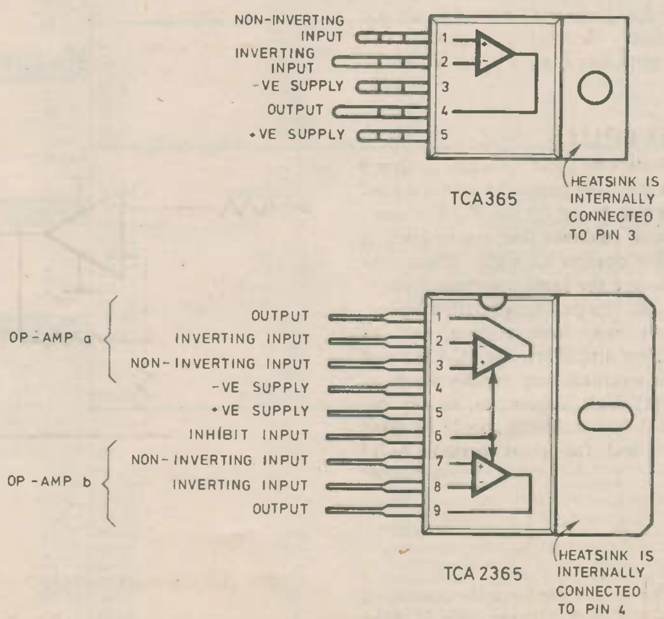
BASIC CIRCUITS

Some basic circuits for use with these power op-amps is shown in Fig. 3. In all cases there is an external Zobel network (sometimes known as a Boucherot network) fitted between the output and 0 volts to help to maintain stability under widely varying load conditions. The 1 ohm resistor does not have to be high power ($\frac{1}{4}$ watt will do) and the capacitor must be 100nF for the TCA365, or 220nF for the TCA2365. It is unimportant which way up the network is fitted; the capacitor can be connected to 0V and the resistor to the output, or vice versa. Both power op-amps can be used with either split or single rail supplies, just as would be possible with most conventional op-amps.

Figs. 3a and 3c are very straightforward conventional op-amp circuits, and apply perfectly well to the TCA365 and TCA2365. For minimum offsets, R_g in Fig. 3a and R_i in Fig. 3c should be included as shown, although in many circuits these are unnecessary and can be replaced by short circuits for economy. Both these circuits, however, should really only be used for higher gain circuits; +10dB or more, or preferably +20dB. For lower gain circuits, and certainly for anything less than 10dB (approximately ×3), the configurations of Figs. 3b and 3d should be used. For unity gain, use typically between 10k and 100k for both R_i and R_f, with R_o approximately one tenth of that value, in Fig. 3b, and typically between 10k and 100k for R_f in Fig. 3d, with R_o one tenth of that and R_g an open circuit. The reason for all this is concerned with stability.

STABILITY

There are many factors influencing stability in operational amplifiers. These tend to be involved, complicated, steeped in complex-plane mathematics, and certainly beyond the scope of *Semiconductor Circuits!* Empirically, most electronics engineers and enthusiasts learn some straightforward rules of thumb about how to keep amplifiers stable and prevent problems of self-oscillation at several megahertz. A common 'cure-all' is to connect a small value capacitor, typically less than 100pF, between the output and the inverting (–ve) input. Don't do this to a TCA365 or 2365! Even if it doesn't actually cause oscillation (which it probably will) it will certainly make oscillation much more likely. This is basically due to the fact that the op-amps have poor stability at low gains, and a capacitor across the feedback loop ensures low gains at high frequencies. For gains of more than 20dB (×10 gain) the i.c.s are normally quite stable, assuming that the Zobel network is fitted and that P.S.U. decoupling is taken care of. More than 10dB (×3 gain) is normally acceptable, but below this there can be problems with transient response



PE53M

Fig. 1. Pin outs for the TCA365 and TCA2365

Characteristic	Notes	TCA365 (Single Op-Amp) Minimum Value	Typically	Maximum Value	TCA2365 (Dual Op-Amp) Minimum Value	Typically	Maximum Value	Units
Supply voltage	All spec's quoted at ±15V for TCA365 and ±10V for TCA2365	±4 *(or 8V)	±15	±18 *(or36V)	±4 *(or 8V)	±10	±13 *(or26V)	V
Quiescent current	In normal operation:		20	40		30	50	mA
	with amps inhibited: (TCA2365 only)	—	—	—		5	8	mA
Temperature range		0		+70	−25		+85	°C
Maximum O/P current	Per amplifier			3·0			2·5	A
Maximum I/P voltage	(Differential)			Supply rails			Supply rails	
I/P offset voltage		−10		+10	−10		+10	mV
I/P offset current		−0·2		+0·2	−0·1		+0·1	µA
Temperature coefficient	(Of input offset current)			0·1				nA/°C
Input current			0·2	1·0		0·25	1·0	µA
Input resistance	At 1kHz				1·0	5		MΩ
Output voltage	Load resistance = 470Ω at 1kHz	±13·0	±13·2					V
	Load resistance = 4·7Ω 1kHz	±11·7	±12·0		±8·0	±8·5		
Slew rate			4			4		V/µs
Voltage gain	Open loop, at 100Hz		90		70	80		dB
I/P common mode voltage range	Load resistance = 470Ω	+13·4 −15·0	+13·5 −15·0		+7·0 −10	+7·5 −10·5		V
Common mode rejection ratio	Load resistance =470Ω	75	83		70	80		dB
Supply voltage rejection ratio	Gain = ×100, frequency =20Hz	50	62					dB
	Gain = ×10, frequency =100Hz				70	80		
Power dissipation	Total for package, at 90°C			15·0			6·0	W
Equivalent I/P noise	Gain = ×11, I/P resistor = 10k					3·0		µV
Inhibit input	For i.c. turned off	—		—	0		1·0	V
(TCA2365 only)	For i.c. turned on	—		—	3·0		(+ve supply)	V

*= For single supply rail operation

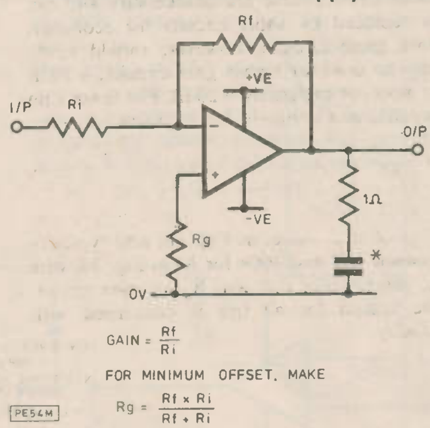
Fig. 2. Specifications (note different supply rails used in measuring spec's.)

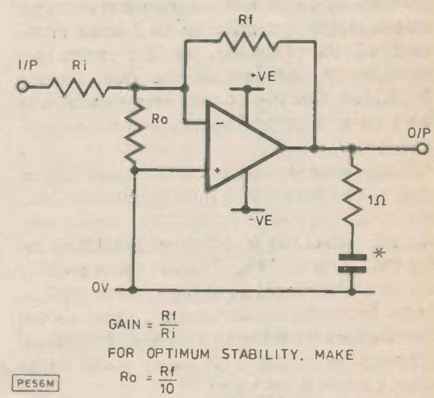
(overshoot of the output on square waves) and stability.

Hence, the circuits of Figs. 3b and 3d should be used for low gain applications. Although the actual voltage gains of these circuits are exactly the same as the equivalent gains of Figs. 3a and 3c, the inclusion of R_o actually causes the op-amps to be working in a 'high gain' way. Normally, this is rather undesirable, since there is no apparent benefit to the user and the amplifier has a much noisier output voltage, but in this application the 'pseudo gain' helps to ensure stability at low real gains, and is to be recommended for use with any circuitry demanding a gain of less than ×4, or even less than ×10 to be on the safe side.

POWER SUPPLIES

The capabilities of these op-amps to dump several amps from the supply rails into a load puts considerable strain on the P.S.U.s used. The best general guidance that can be given is to consider the devices as audio power amplifiers, and to use the same constraints about removing earth loops, supply decoupling, keeping inputs away from outputs, etc. As with audio power amplifiers, the TCA365 and TCA2365 will overheat very rapidly when oscillating at very high frequencies, so any debugging of stability problems should be done very rapidly, and for short periods only! Specifically, it is good practice to take the 0V connection to the feedback resistor, input resistors, input decoupling, etc, as appropriate, to the power supply as a separate connection from the load, Zobel network, etc, to isolate the input as far as possible from the output. In all cases, each power op-amp should have





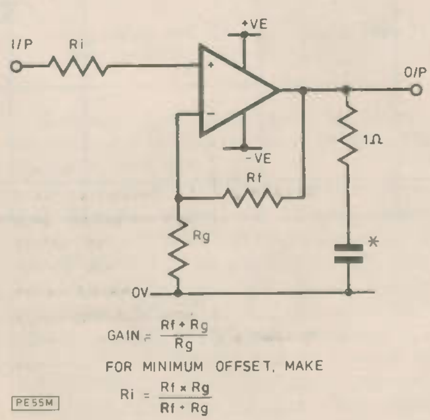


Fig. 3c. Non-inverting, high gain

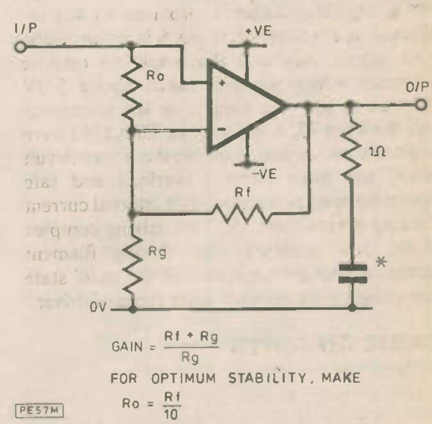


Fig. 3d. Non-inverting, low gain

Fig. 3. Basic power op-amp circuits

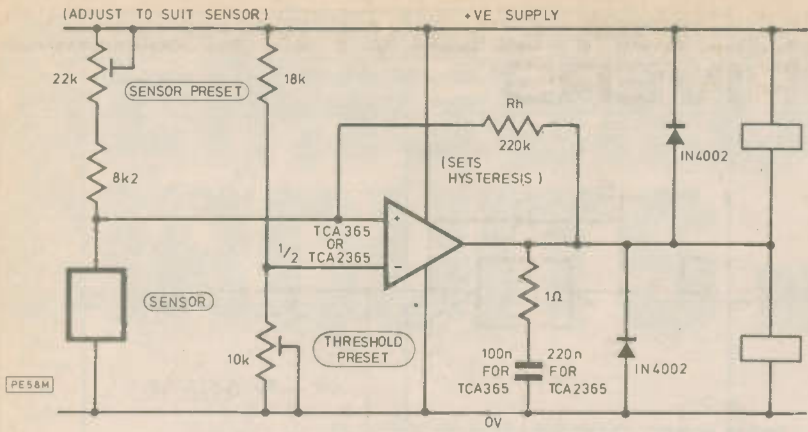


Fig. 4. Simple sensor detector and switch

100μF capacitors between its supply rails and 0 volts, or simply across its rails in the case of single supply systems.

When inductive loads are to be driven, diodes should be connected between the op-amp output and the supply rails, as shown in Figs. 4, 6 and 8. This protects the op-amp's driver transistors from the huge back e.m.f. spikes generated when inductive loads are suddenly turned off.

APPLICATIONS

The uses for these i.c.s fall mostly into the realms of control and switching. They *will* amplify and drive audio signals, but not with the fidelity that can be achieved by audio power amplifiers specifically designed for the task. Essentially, these i.c.s are excellent for use on many occasions when an ordinary op-amp simply runs out of drive capability. Some examples of switching applications are shown in Figs. 4, 5 and 6.

A simple sensor circuit is shown in Fig. 4 using the power op-amp as a comparator and directly driving relays 1 and 2. The sensor can be any device which varies in resistance in proportion to a required effect. For example, a light dependent resistor (e.g. ORP12) or thermistor would allow the sensing of light level or temperature respectively. The sensor preset scales the voltage range produced by the sensor at the op-amps non-inverting input, while the threshold preset alters the level at which the op-amp changes state. R_h provides some hysteresis to stop the op-amp 'hunting' or 'chattering' when the sensed value is just on the threshold point.

A square wave oscillator is formed by the power op-amp in Fig. 5. The mark/space ratio potentiometer adjusts the charge and discharge paths for C_T such that their sum is always constant (i.e. the frequency does not vary) but the mark/space ratio can be adjusted over a wide range. The frequency itself is set by a combination of the value of C_T and the setting of the 100k 'frequency' potentiometer. This circuit is capable, by virtue of the power op-amp, of driving pulses of several amps into any suitable load. Output diodes should be added, as shown in the other circuits, if the load is to be an inductive one.

DIFFERENTIAL DRIVING

Finally, Fig. 6 shows two power op-amps driving a d.c. motor in a 'bridge', or differential drive mode. This allows the direction of rotation of the motor to be changed. IC1 and IC2 are arranged as comparators with R_H and R_L setting the threshold voltage V_T, and are designed to be driven by logic signals A and B. If both inputs A and B are at a low level (logic 0), both sides of the motor will be at a low level (0V). If both inputs are high (logic 1), then both sides of the motor will be at a high level, near to the +ve supply rail. In both these cases the motor will not run, since there is no differential voltage across it—both terminals of the motor are at the same voltage. However, if one input is high, and the other low, the motor will run in one direction or the other. Normally, V_T should be set to a suitable level for the logic family which is used to control IC1 and IC2; ideally, R_H and R_L should be taken from the logic's power supplies, not the +ve power supply as shown, to ensure accuracy of the threshold voltage.

The TCA365 and TCA2365 are ideal for use in controlling motors, relays, magnetic valves, and solenoids. They can also make a good basis for the design of regulated power supplies. Their current limiting makes them especially suitable for driving filament lamps and other unusual loads, and their op-amp configuration makes for easy interfacing of these loads with both analogue and digital circuitry. When stability is taken into consideration these are easy and effective to use, and provide an economic solution to many power driving problems. Both i.c.s are available from **Electrovalue, 28 St. Jude's Road, Englefield Green, Egham, Surrey.**

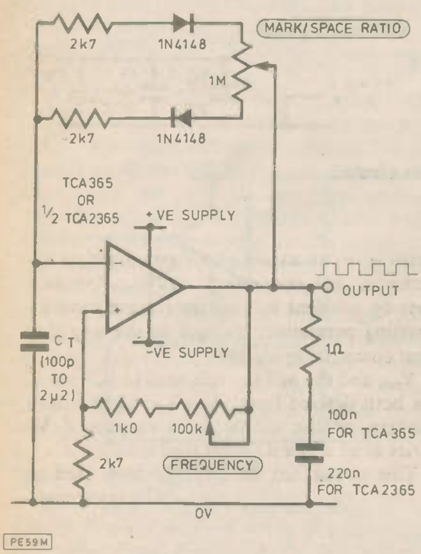
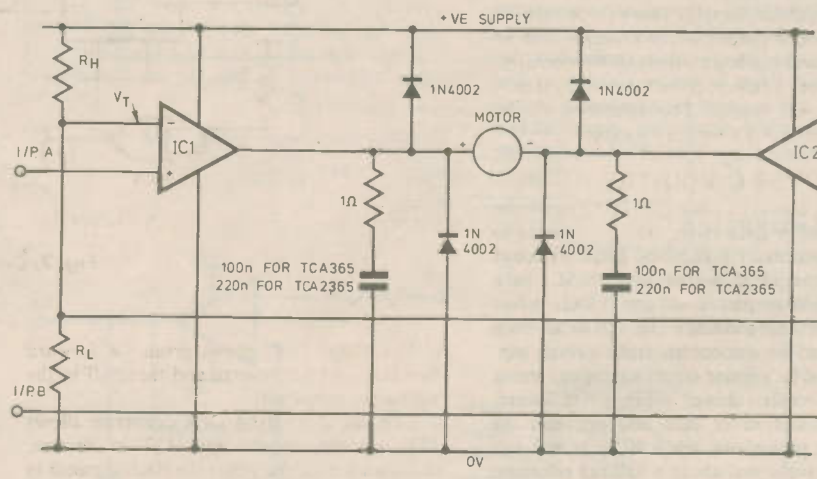


Fig. 5. Power pulse generator



INPUTS		
B	A	EFFECT
0	0	STOPPED
0	1	RUN CLOCKWISE
1	0	RUN ANTICLOCKWISE
1	1	STOPPED

Fig. 6. Bi-directional motor control

MICROPROCESSOR CONTROLLED DC MOTOR DRIVERS

LAST month we looked at a timer circuit triggered by a microprocessor. This month we have another microprocessor based project, to allow the analogue driving of d.c. motors. Again, the circuit assumes the use of the Z80 microprocessor, although it is very easily adaptable for other devices. The circuitry is shown in Figs. 7 and 8 and the Veroboard layout in Fig. 9. The circuit consists of two separate sections; the decoder, and the driver. Up to 8 drivers can be operated by one common decoder.

The address decoding is done in a similar way to last month's project. IC1 compares the most significant nibble (4 bits) of the 8 bit port address with the settings of S1 to S4. Each switch is turned off to correspond to a logic 1, and on for a logic 0. The comparison is only enabled when both $\overline{IORQ}$ and $\overline{WR}$ are at logic 0 (determined by IC5c), corresponding to the microprocessor performing an I/O write instruction. IC2 is a 3-to-8 line decoder used for the least significant nibble of the port address. Address line A3 must be held at logic 0 and the other 3 lines then provide the address of the driver circuit required. The least significant nibble of the driver address will therefore be Ø to 7, as determined by the latch output of IC2 used. The outputs of IC2 are inverted, and are wired to the $\overline{LATCH}$ inputs of any required driver circuits. Hence, if one particular driver circuit $\overline{LATCH}$ input was connected to $\overline{LATCH}$ output 3 of IC2, switch S1 was off and switches S2 to S4 were all on, that driver circuit would respond to address 13H (i.e. 19 in decimal). Driver circuits can thus be provided at port addresses ØØH to Ø7H, 1ØH to 17H, 2ØH to 27H, 3Ø to 37H, etc.

IC3, with associated components, provides a 5 volt regulated supply. This can be omitted if the microcomputer's own 5V supply is to be used to power the logic supply to the circuitry. IC4 provides a reference voltage which tracks the Vp power supply. This reference will be approximately 1·8V for a 12V supply.

THE DRIVER CIRCUITRY

IC6 is a digital to analogue (D/A) converter with a built-in data latch, which connects to the microprocessor's data bus. Data is latched in by the required output of IC2. IC7 is a TCA2365 dual power op-amp which drives the motor differentially to provide both forward and reverse control from a single supply voltage. (It's based on an analogue version of the differential driver in Fig. 6). IC7a amplifies the output of IC6 and provides the positive output phase, while IC7b inverts this positive drive signal about a half-rail reference voltage set by R17, R18 and VR2, and provides the negative output phase.

When the output of IC6 is at 0V, pin 1 of IC7a is near to 0V and pin 9 of IC7b is near to the +ve supply. When the output of IC6 is at V_{ref}, the reverse is true. When IC6's output is at half V_{ref}, both power op-amp outputs are at half the supply rail and the motor is stationary. Presets VR1 and VR2 alter the gain and offset of the output voltages, and D1, a 'Bi-Colour' l.e.d., glows green for forward direction, red for reverse and turns off in the stationary condition.

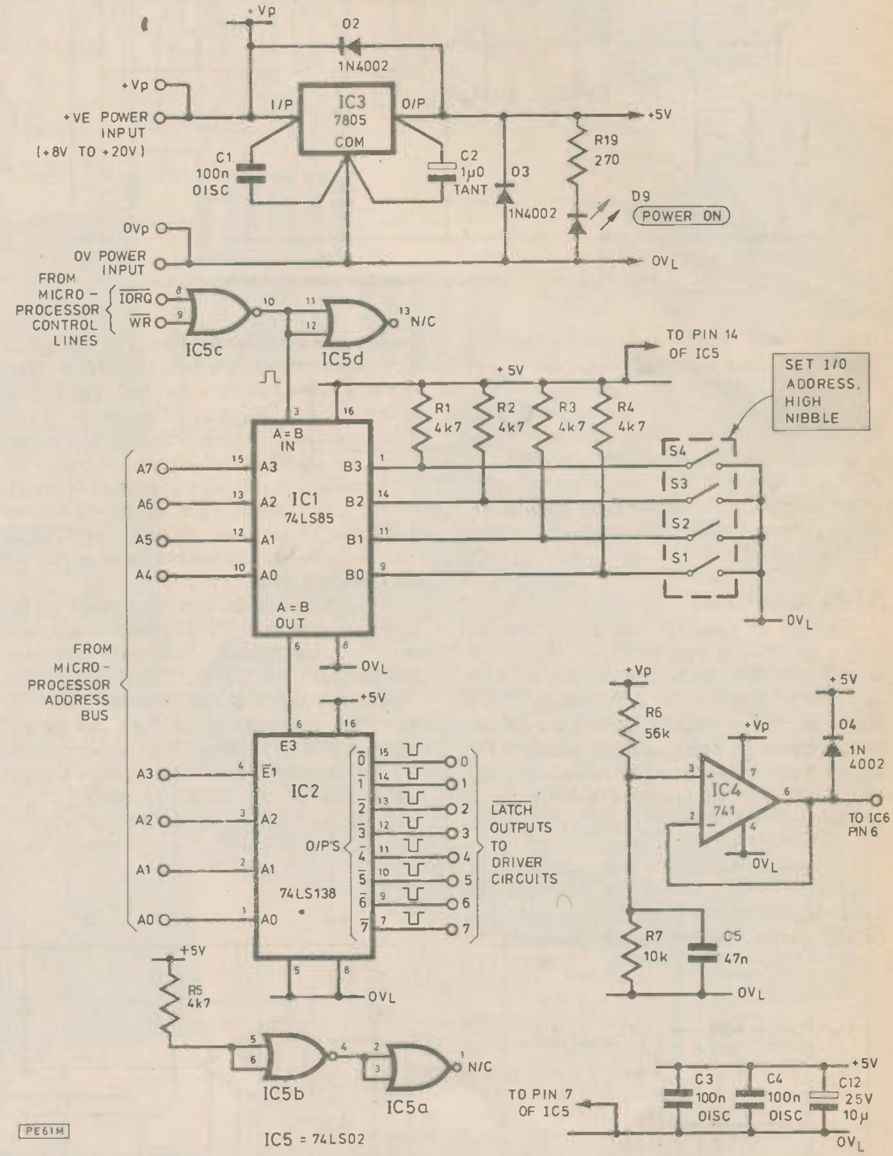


Fig. 7. Decoder circuit

The use of an 8 bit D/A converter allows 127 forward speeds and 127 in reverse, although it is unlikely that the electric motor in use will operate all the way down to 0V. Note that $0V_L$, the logic zero volts supply, and the power zero volts $0V_P$, have been wired back separately to the power input area around IC3 to help ensure stability and an absence of noise problems with the logic supplies. GREAT CARE must be taken when wiring up the circuitry and assembling components on the Veroboard, and tests should be done prior to connecting to the computer as far as possible. I can assure you, from practical experience, that connecting +12V to the data lines by accident will certainly cause some interesting permanent changes to the way that your computer operates!

V_{ref}, and the half rail reference to IC7 pin 7, are both derived from the +Vp rail to ensure tracking of the motor drive outputs if Vp varies at all under different load conditions.

This circuit has successfully been used to control a 12 volt model train set by microcomputer. The only programming requirement is to output the relevant motor speed values to the port or ports in question. Hence, for a port address of 24 (Hex) for example, the assembled Z80 machine code for full speed forwards

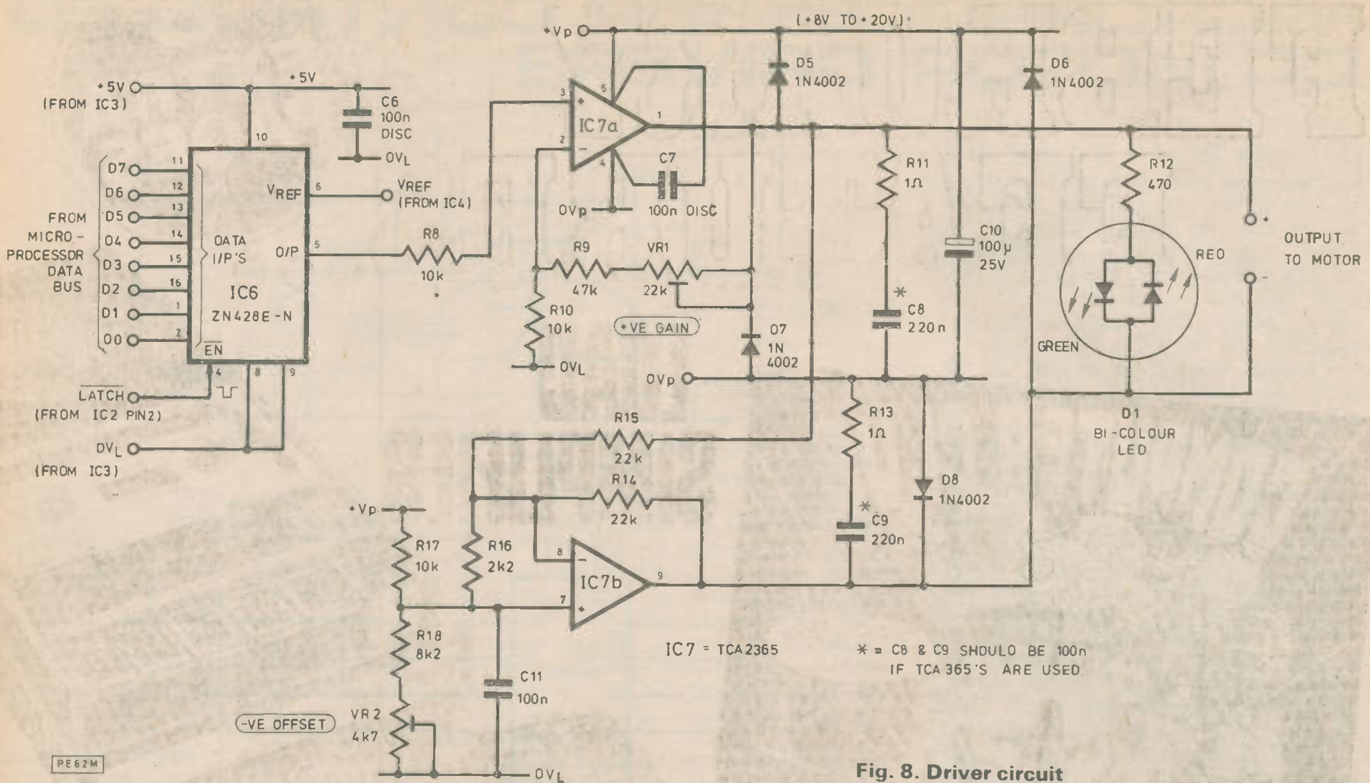


Fig. 8. Driver circuit

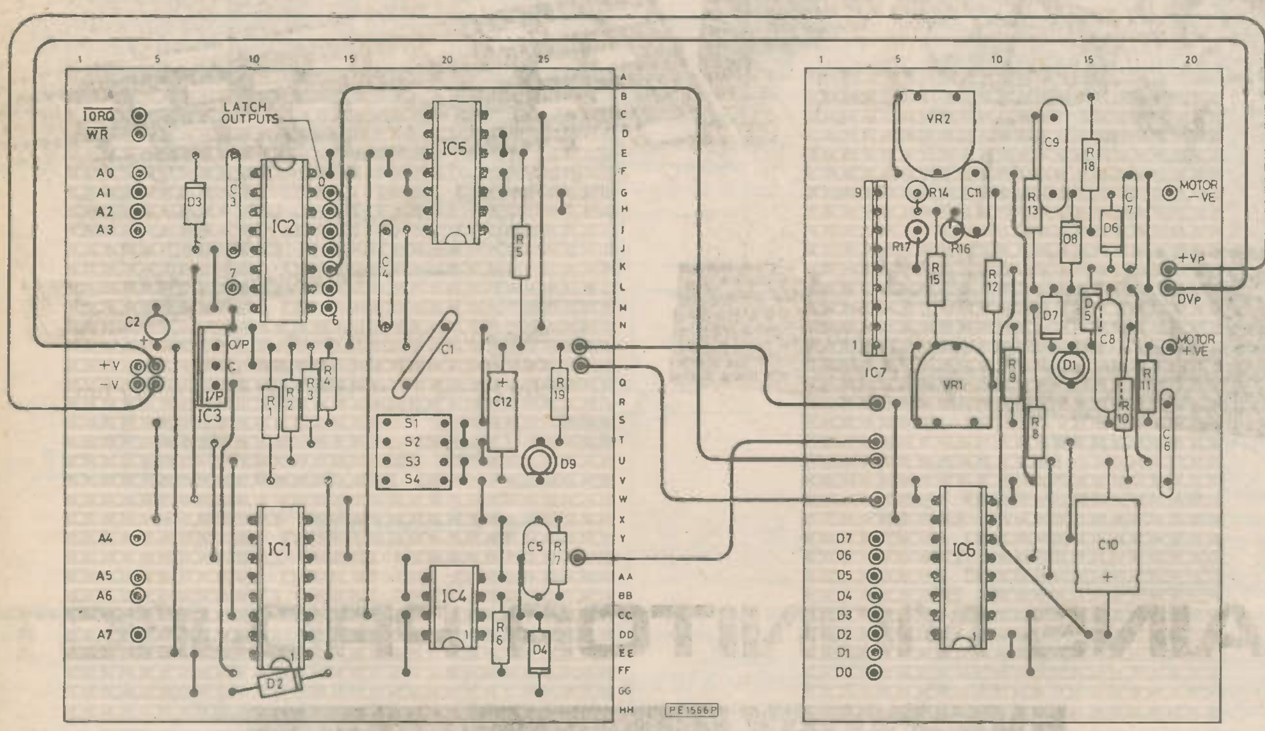


Fig. 9. Veroboard layout

could look like this:

3E ØØ LD A,ØFFH
; Put required value in Accumulator.
D3 24 OUT (24H),A
; Output the Accumulator to the port.

In BASIC, the simple instruction OUT 36, 255 would suffice. (36 is the decimal equivalent of 24H, the port address, and 255 the decimal equivalent of ØFFH.) For full speed reverse use the value ØØH (Ø decimal), for stopped use Ø7FH (127 decimal), and for slower speeds use values in between. Finally, don't forget the heatsink on IC7! The i.c. has been placed at the edge of the board to allow for this. The resulting motor speed control provides a simple illustration of a typical use for power op-amps, either as two single devices or a pair as used specifically in Fig. 9.

FEBRUARY FEATURES...

8 EXTRA PAGES

LOAD SIMPLIFIER

See and hear software coming down the line and get the LOAD level right first time, every time

Solid State Reverb

MAINS MONITOR PROJECT

EVERYDAY ELECTRONICS and computer PROJECTS

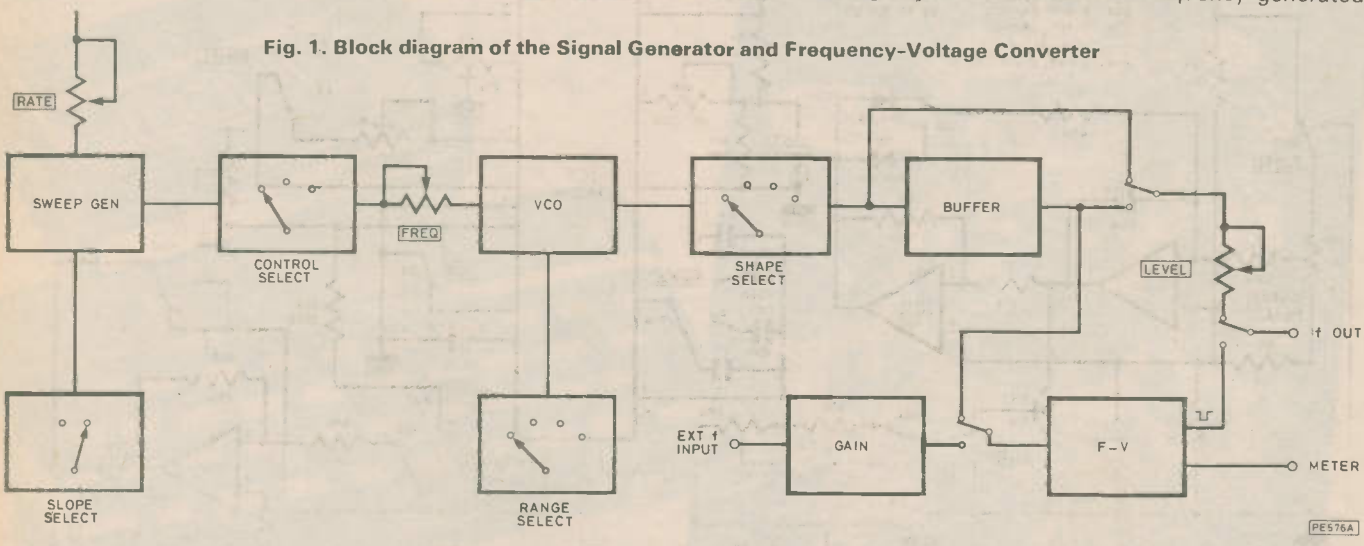
FEBRUARY 1985 ISSUE ON SALE FRIDAY, JANUARY 18

Signal Generator & F-V Converter

JOHN M. H. BECKER

ANY electronics enthusiast needs a signal generator and frequency meter nearly as much as a soldering iron and multimeter. The last two should be part of anyone's workshop but the degree of enthusiasm does not necessarily warrant the expense of highly accurate generators and counters. Often only an indication of approximate frequencies is required, together with a unit that makes readily controllable sounds with suitably shaped waveforms.

Fig. 1. Block diagram of the Signal Generator and Frequency-Voltage Converter



This unit has been designed as a reasonable quality, moderate cost, dual purpose unit suitable for average and addicted constructors alike. It produces well shaped waveforms of frequencies ranging from 2Hz to 78kHz in four tunable ranges, and includes automatic ramp control of a frequency sweep, both upwards and downwards. Additionally it includes a frequency to voltage converter that can be coupled to an ordinary multimeter, or digital voltmeter to give a direct read out of the approximate frequency being generated, or fed in from an external source. It is intended for use with an existing power supply or, for short periods with batteries, from 9V up to 18V dc. Provision has also been made to mount discrete power supply components directly onto the p.c.b. so that the unit can be fully independent of other equipment.

GENERATOR CHIP

An XR2206 function generator chip has been chosen in preferance to the normally selected type 8038 as it has a greater variety of waveforms available, together with a wider sweep range on each selected setting. The oscillograms show the wide range of waveforms available. The basic frequency range is selected by S1, bringing in the desired frequency setting capacitor C4–C7. The frequency generated can then be controlled by either a varying voltage or a varying current. For normal manual selection of the desired frequency, current control is used, and is relative to the resistance of the total of VR4, VR5 and R8. In this mode VR5 is taken directly to ground by S5. As the resistance of these potentiometers decreases, so the output frequency rises in relation to the formula: $f = 1/(R \times (C/1000)) \times 1000$, where C is the value of the selected capacitor C4 to C7 in microfarads, and R is the total resistance in circuit with pin 8 of IC2.

VR4 provides coarse tuning of the frequency, and VR5 fine tuning. The maximum resistance range that is permissible with IC2 is from 1K to 2M, though is limited to a maximum of about 1M in this unit. This allows a reasonable overlap between the switched ranges, without making the

Photograph illustrating the external assembly of the Signal Generator and F-V Converter

SPECIFICATION...

TOLERANCE

The figures quoted refer to those obtained on the prototype and may vary slightly in other units in accordance with normal component tolerance factors.

FREQUENCY TO VOLTAGE CONVERTER

Good linearity from 200Hz to 30kHz directly readable on a standard multimeter or digital voltmeter. Accessible internally and externally.

FREQUENCY GENERATOR

Basic switched frequency ranges = (1) 2Hz to 81Hz, (2) 20Hz to 851Hz, (3) 200Hz to 8400Hz, (4) 1970Hz to 78800Hz. Coarse and fine tuning of selected frequency range. Switch selected waveforms—sine, triangle, square, ramp, pulse, and variations (see photographs 1–6). Sweep modulator—rising and falling ramps, switch selectable, rate 6 to 40 cycles per minute. Frequency outputs—switched, buffered or unbuffered via amplitude control from nil to 5V peak to peak. Fixed 0V/+5V amplitude square wave derived from internal oscillator or external source up to about 80kHz. Four switched reference frequencies.

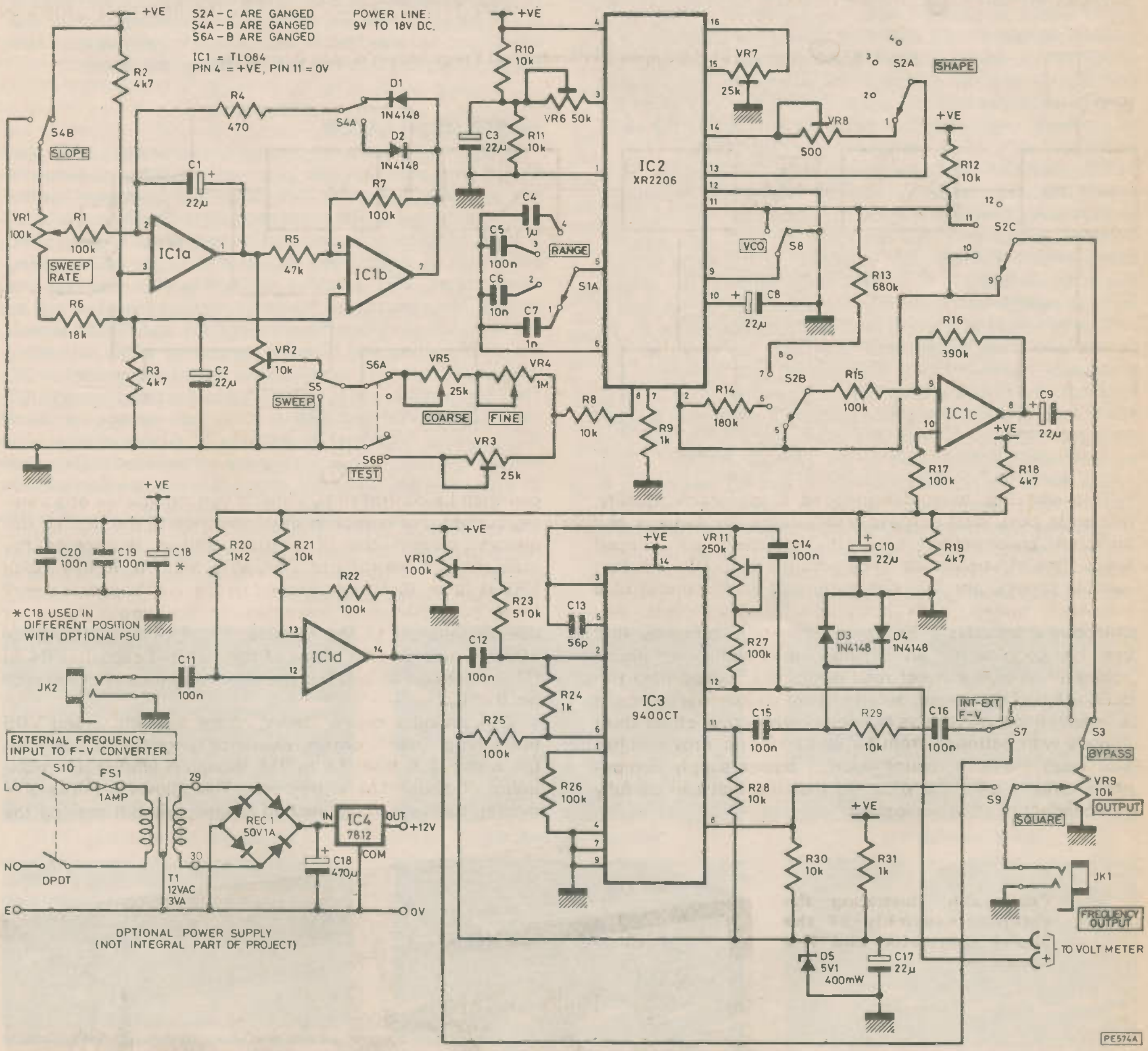


Fig. 2. Complete circuit diagram of the Signal Generator and Frequency-Voltage Converter

fine tuning too coarse. Switching in VR3 by S6 instead of VR4 and 5, a preset reference frequency can be selected. The i.c. contains its own current controlled amplifier and the amplitude of the signal generated as seen at pin 2, is presettable by VR6. This controls the sine, triangle, and ramp waveform maximum levels. The squarewave however is derived from a different section and is at approximately full line level amplitude as determined by the current through the load resistor R12. The shape of the triangle and ramp waveforms is predetermined within IC2 itself. For sine wave related waveforms, shaping is preset by VR8, and the symmetry trimmed by VR7.

WAVEFORM SELECTION

Three basic waveform selections can be chosen with S2. With S8 open, the choice is sine, triangle and square. In position 1 (sinewave) the output comes from pin 2 of IC2, and VR8 is in circuit, controlling the sine shape. In position 2, (triangle wave), the output again is from pin 2, but at a level approximately twice that of the sine wave and VR8 is out of circuit. In position three (squarewave), the output is taken from pin 11 IC2. With S8 closed the squarewave is directly fed to the control pin 9, and internal circuitry of the chip is automatically switched by it to produce ramp related waveforms in the first two positions of S2. In this mode the frequency of oscillation now becomes affected by the value of R9 and the formula changes to: $f = (2/C/1000) \times (1/R) \times 1000$, using the same parameters as before. Effectively this means that the frequency with S8 closed will be approximately twice that with it open. In position S2, looking at the inverted output of IC1C, the rising ramp is sine shaped, followed by the steep drop. In position 2 the rising ramp is linear, again followed by a steep drop. Study of the second formula though will show that the steepness of the drop is related to values of R9, and the controlling resistance on pin 8. As the two resistances approach equality, so the steepness lessens, and a falling ramp also develops. The best ramps are thus created with the resistance on pin 8 at the greater end of the scale. In position 3 the output is again from pin 11, but consists of a mark-space pulse, the duty cycle of which determined by the formula: $RA/(RA + RB)$, where RA is the resistance on pin 7, and RB that on pin 8. The negative going pulse length is moderately constant throughout the range for the same capacitance selection. The mark-space factor is also reflected in the shape of the ramps with a flattening of the apex, but is really only noticeable at small values of capacitance.

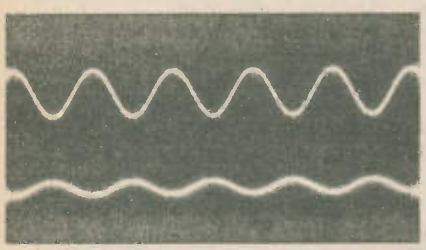
OUTPUT ROUTING

In most instances it is preferable for the amplitude of the different waveforms seen at the final output to be roughly equal. As previously seen there is an inherent level difference between the three main waveform ranges, IC1C is thus included to even these out. The gain of this stage is of course dependent upon the relationship of the total input resistance to the value of the feedback resistor R16. The choice of resistors R13–R15 ensures a reasonable match of the levels. The inverted phase output from IC1C is decoupled by C9, taken via S3 to the level control VR9 and then to the output via S9. However the frequency pass range of IC1C is less than that of the range available from IC2. For normal audio applications, the frequency response of IC1C is sufficiently adequate, but distortion becomes more prevalent as the frequency rises above about 30kHz, as shown in the oscillograms.

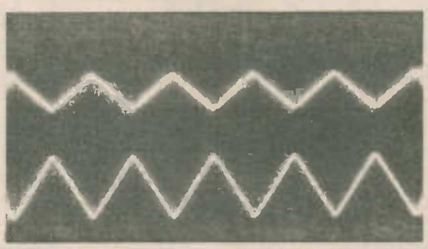
Additionally the loading of C9 causes square wave distortion at lower frequencies. S3 is thus included to bypass IC1C so that the output is unbuffered allowing the full range of IC2 to be used. Note though that the unbuffered output also contains a d.c. bias that is approximately half line level with S2 in positions 1 & 2, and that the phase is inverted.

SWEEP OSCILLATOR

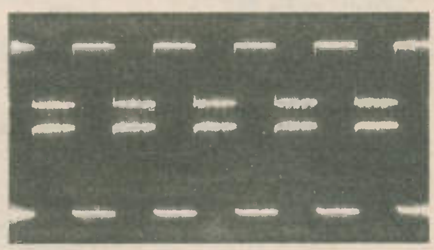
When testing out some circuits it is sometimes preferable for the frequency range to be swept upward or downwards at a controlled automatic rate rather than by manual control of a potentiometer. The ramp generating circuit around IC1A & IC1B provides this control. The frequency range of ramp generation is determined by C1 with larger values giving slower rates. VR1 provides the tuning of the sweep rate setting. The direction of the ramp produced is governed by the direction of voltage flow through D1 and D2. S4 selects the diode routing, and reverses the polarity of the controlling voltage through VR1 in relation to the reference level at C2. The changing d.c. voltage produced by the ramp controls IC2 via VR2, S9, VR4 and VR5. In this mode voltage control of IC2 is being employed in addition to current control. For correct operation of IC2 the voltage sweep seen at the wiper of VR2 must lie below 3V, above this and the oscillator of IC2 will cease. VR2 thus needs adjustment to keep the sweep voltage within this range. The frequency control range provided by the varying voltage is less than that produced in the manual mode, and VR4 and VR5 are used to select the desired band width.



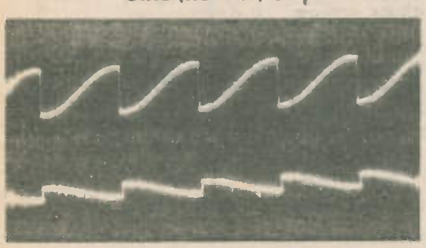
Sine (normal) $S2_1$



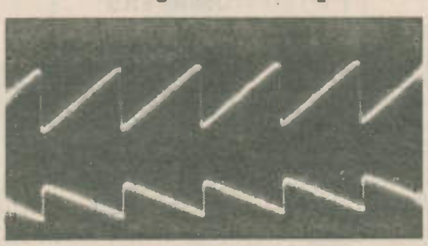
Triangle (normal) $S2_2$



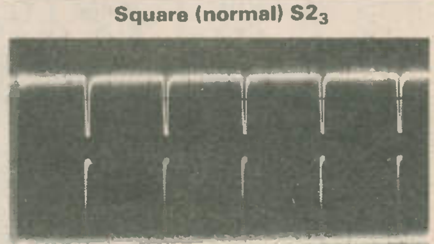
Square (normal) $S2_3$



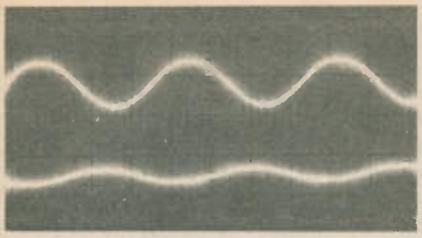
Sine (ramp) $S2_1$



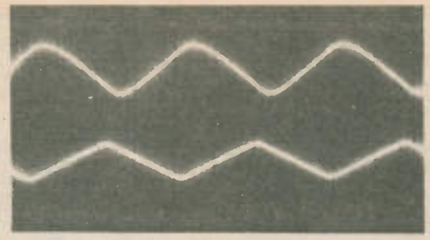
Triangle (ramp) $S2_2$



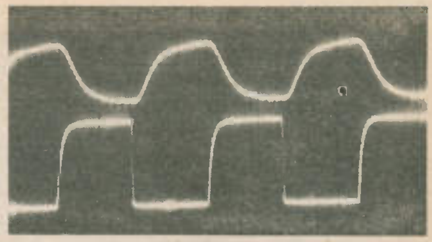
Square (pulse) $S2_3$



Sine (high freq) $S2_1$



Triangle (high freq) $S2_2$



Ramp (high freq) $S2_3$

FREQUENCY TO VOLTAGE CONVERTER

IC3 performs the f-to-v conversion, producing an output voltage that, within the range, is related linearly to the frequency fed in. The range available is determined by the gain given to the feedback via R27 and VR11, with a slew rate and ripple reduction level set by C14. High values for C14 will give reduced ripple for lower frequency signals, but will increase the time taken for the voltage to stabilise when the frequency is changed. The relative minimum output voltage in the absence of an input frequency should be as close to zero as can be set by the bias control VR10. VR11 is used to set the maximum range. The output voltage is referenced to an intermediate level of about 5V as set by Zener diode D5. The negative lead of the meter used to monitor the voltage is taken to this level, and the positive lead to the output from pin 12, IC3. If the meter negative lead were to be taken to the normal 0V or ground line then the reading would also contain the reference voltage of 5V and inaccurate readings would result. For stable operation of the conversion, the input frequency seen at pin 11, IC3 should be at a constant level of about 1V p-p. To maintain this amplitude even for low level input signals, the signals are taken via the gain stage IC1D for external signals which gives an amplification of about, a little over 100. The signal is then attenuated to the optimum level by diodes D3 & D4. For internal frequency reading, the signal is taken direct from the output of IC1C, and similarly attenuated. S7 selects the choice of internal or external frequency monitoring. In addition to producing a frequency related voltage, IC3 also produces a square wave output of 5V amplitude. There is a slight time lag between the edges of the input frequency and of the output 5V squarewave. S9 can switch in this frequency output in place of that produced directly by IC2. This means that an external frequency of indifferent level and shape can be converted for controlling circuits that require a 5 volt squarewave. The external loading permissible though is limited by the value of R30 and too great a load will reduce the voltage.

POWER SUPPLY

Most enthusiasts probably already have power supplies in their workshop capable of driving this unit, and so a separate one is not included. The minimum voltage requirement is 9V, and the maximum permissible +18V as dictated by the limits of IC3. The current drawn is about 30mA, up to 20mA of which is consumed by IC2. This current is a bit too high for the unit to be powered for long periods from a battery supply, though one could be used briefly in an emergency. Alternatively a battery eliminator might be suitable, providing it can tolerate the current without the voltage dropping below 9V and that the ripple content is negligible. The printed circuit board though includes positions for the mounting of the rectifier and voltage regulator as shown in the suggested optional 12V power supply circuit. This supply was not used in the prototype and is not regarded as an integral part of the project. The transformer should be bolted to the metal box, and normal mains electricity safety precautions observed. Note that with this suggested power supply C18 has its positive end connected to a different track position, and it may be necessary to mount it vertically rather than horizontally. The use of a heat sink with the regulator i.c. should not be necessary.

COMPONENTS . . .

RESISTORS

R1,R7,R15,R17,R22, R25–R27	100k (8 off)
R2,R3,R18,R19	4k7 (4 off)
R4	470
R5	47k
R6	18k
R8,R10,R11,R12,R21 R28–R30	10k (8 off)
R9,R24,R31	1k (3 off)
R13	680k
R14	180k
R16	390k
R20	1M2
R23	510k

All resistors $\frac{1}{4}$W ±5%

CAPACITORS

C1–C3,C8–C10,C17	22μ, 10V elect. (7 off)
C4	1μ, 63V elect.
C5,C11,C12,C14–C16, C19,C20	100n *polyester* (8 off)
C6	10n polystyrene
C7	1n polystyrene
C13	56p polystyrene
C18	470μ, 25V elect.

SEMICONDUCTORS

IC1	TL084 (quad op-amp)
IC2	XR2206
IC3	9400CT (R.S. 307 070)
D1–D4	1N4148 (4 off)
D5	5V1 Zener, 400mW

POTENTIOMETERS

VR1	100k mono rota
VR2	10k skeleton
VR3,VR7	25k skeleton (2 off)
VR4	1M mono rota
VR5	25k mono rota
VR6	50k skeleton
VR8	500 skeleton
VR9	10k mono rota
VR10	100k skeleton
VR11	250k skeleton

MISCELLANEOUS

P.c.b. and p.c.b. clips (4 off)
Round knobs (6 off)
I.c. sockets, 16 pin, 14 pin (2 off)
Jack socket, 3·5mm
Jack sockets mono (2 off)
Box and rubber feet
Meter terminals (2 off)

SWITCHES

S1,S2	3P4W (2 off)
S3,S5,S7–S9	SPDT (5 off)
S4,S6	DPDT (2 off)

Constructor's Note

A complete kit of parts is available from: **Phonosonics**, 8 Finucane Drive, Orpington, Kent BR5 4ED. Price £54·00, inclusive of VAT. Post and packing £1·00.

ASSEMBLY

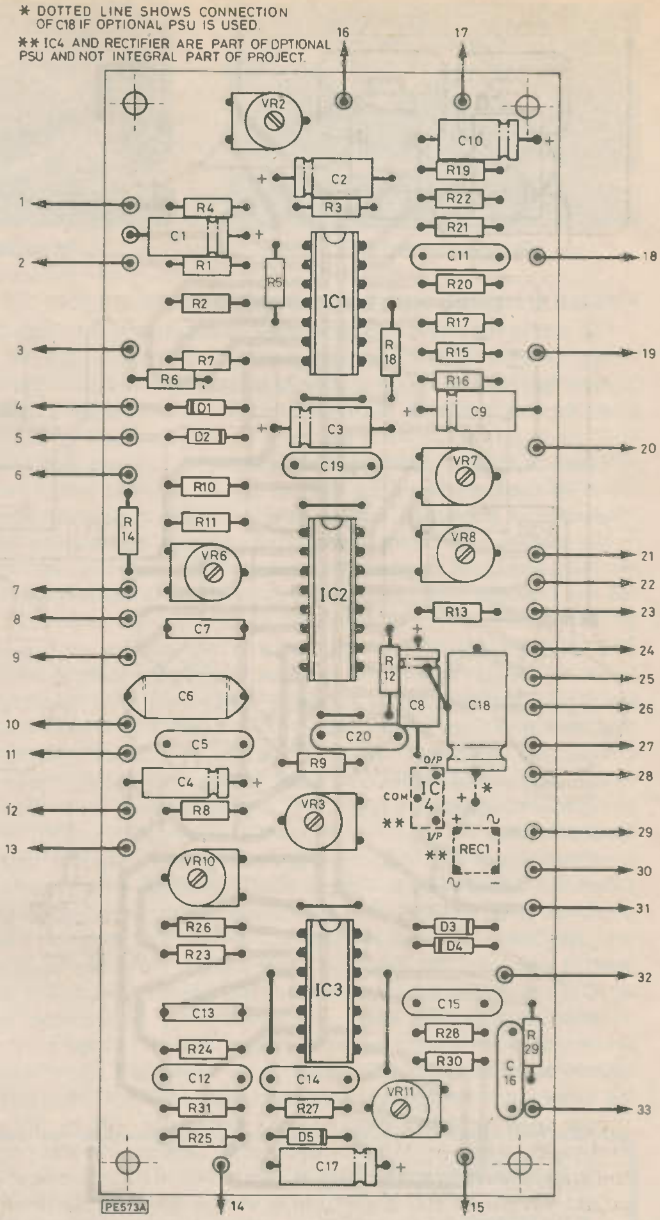
After the straight forward component assembly and subsequent joint checking procedure has been carried out, wiring should be commenced in a methodical fashion, ticking off each wire on the wiring diagram as connections are made. First connect up all the panel controls between themselves. Secondly wire up to all the p.c.b. points closest to the front panel. Finally connect up the rear and remaining connection points. These latter wires should preferably be brought under or round the edges of the p.c.b. Taking them over makes the wiring untidy. Keep the wiring short, but long enough for turning the board over for examination without over straining the connections (too much flexing of taut wires can cause breaking at the joins). The prototype has the meter terminals on the front, but with hindsight, mounting them on the back would be better.

The regulator IC4, and the rectifier REC1, are part of the optional power supply, together with the transformer T1. These components may be omitted if not required as the unit will run quite efficiently from any 9V battery.

SETTING UP

A fair selection of presets has been included to enable the maximum accuracy to be obtained throughout the unit. The only really critical one is VR2, as the sweep control may not operate if this is incorrectly set. Inadequate setting of the others will only cause lack of linearity. If an oscilloscope is not available intelligent decisions will need to be made, listening to the sounds while adjusting the presets.

First, S1 position 1 (lowest freq), S2 position 1 (sine), S3 on (buffered output), S4 either way, S5 off (sweep off), S6 off (manual freq control), S7 off (internal f-v), S8 off (standard waveforms), S9 off (vco output), VR1–3 midway, VR4–5 max clockwise (highest freq), VR6–8 midway, VR9 max, VR10–11 midway. Switch on and check that pin 3 IC1A, pin 3 IC2 are at approximately half line voltage, and that the positive end of D5 is at about 5V. Plug in to normal amplifier. If no sound is heard then check the wiring, and that the switches are wired the correct way up. Assuming that sound is heard, check that VR4 and 5 vary the frequency, and that S1 changes the ranges. Switch on S6, and adjust VR3 to the desired fixed frequency on the second range of S1. In the author's unit this was set for approximately 440Hz. Check that S8 brings in the ramp associated



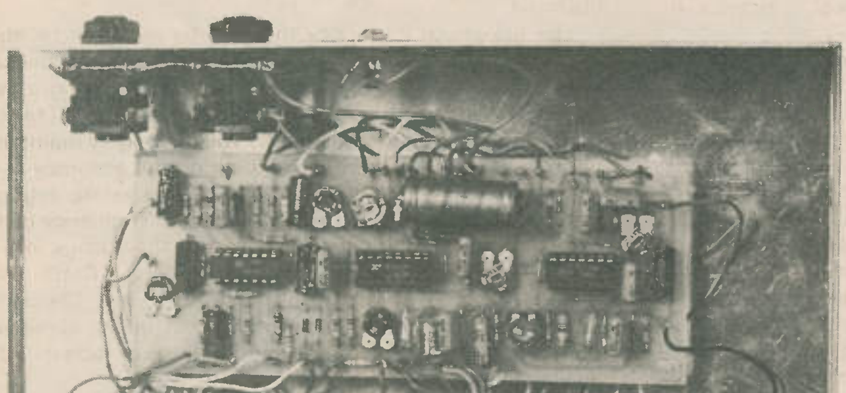


Fig. 3. (Above) Showing the p.c.b. design and component layout of the Signal Generator. (Left) Photograph illustrating the internal view of the chassis assembly showing the switch, sockets and p.c.b. layout

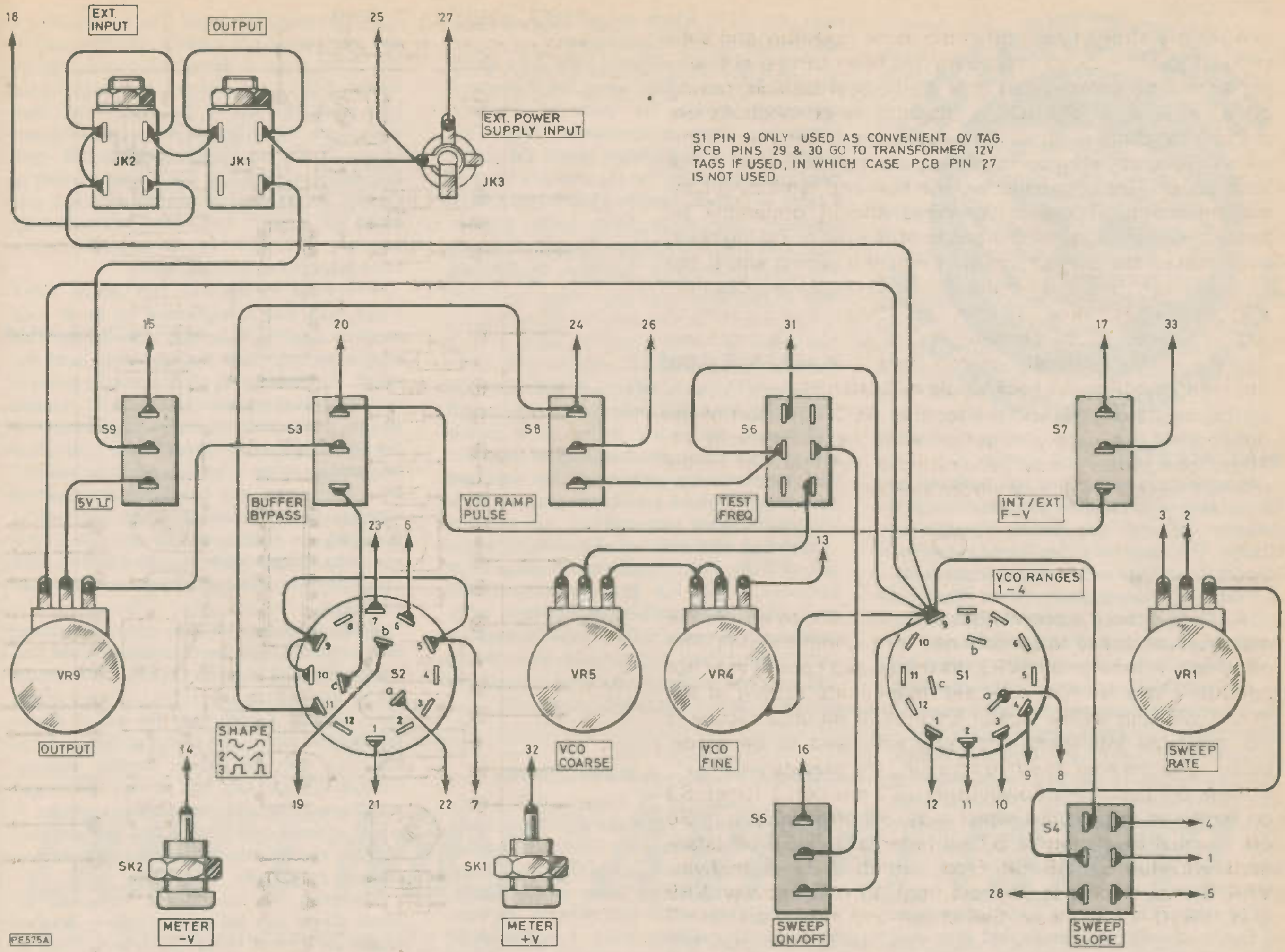


Fig. 4. Wiring diagram of the Signal Generator

ranges of waveforms, then switch back to the normal range, and to squarewave. Monitor the output jack socket and note the squarewave amplitude level. Switch to triangle wave and adjust VR6 until the amplitude is similar without flattening of the waveform peaks. Switch to sine wave and adjust VR8 for the best sine shape, then VR7 for the best symmetry. If necessary readjust VR8.

Switch S3 to bypass and check all waveforms can be switched in, though as previously stated they will be at widely varying levels. Switch S6 back to manual control, then S5 to sweep control. Check that a ramp waveform appears at pin 1 IC1A, and that switching S4 varies the direction, also that VR1 varies the rate with the ramp in both directions. Return scope probe to the output jack socket, and adjust VR2 for the smoothest sweep response. If the wiper is too far to the 0V end the generator frequency will dwell at the high end, with it too far towards IC1 the generator will cut out at the low frequency end. With careful adjustment a smoothly varying rising or falling sweep range can be set. Switch off the sweep control and set a frequency output from IC2 of precisely 10kHz. Check that an attenuated version of this frequency reaches pin 11 IC3 via S7. With the external input jack socket grounded (as it will be without a jack plug in), switch S7 to external. Connect a multimeter across the meter output terminals and adjust VR10 for a reading of exactly zero volts. Start off with a meter range of about 5 volts, then after the initial adjustment has been made the meter can be switched to its lowest range for greater precision. Set meter to a range for monitoring exactly 1V. Switch S7 back so that the 10kHz signal reaches IC3. Very carefully adjust VR11 until a precise voltage of 1 volt is obtained.

The maximum frequency that can be read will be about 30kHz to 35kHz, beyond this IC3 will fail to respond and show a constant reading of around 3·5V. Applying a 1kHz signal should produce approximately 0·1V. Tracking downwards in frequency, linearity will be roughly maintained until about 200 Hz or so, depending on the accuracy of the setting of VR10 and VR11. Once the boundary extremes have been established, a direct reading of frequency can be taken from the multimeter by converting the voltage into the readily calculable frequency. Thus if 1V = 10kHz, 3V = 30kHz, 0·5V = 5kHz, 0·05V = 500Hz, etc. Check that an external frequency can be monitored in the same way, then finally that a squarewave output of about 5V is available from pin 8 to IC2.

After setting up the f-v converter the frequency controls of the unit can be calibrated and control legends applied to the panel, using a rub down lettering like letraset or similar, then coating them with a suitable spray protector. If care has been taken in the setting up, the end result will be a marvellously versatile dual purpose new unit for the workshop. ★

RING MASTER

Perhaps the most interesting development during the past few months has been the visual detection of the ring-system surrounding Uranus. The rings were first found indirectly, because they produced a series of occultations of a faint star; subsequently, D. A. Allen and J. Crawford, at Siding Spring Observatory in Australia, photographed them in infra-red.

Studies of them have now been carried out by Richard Terrile and Bradford Smith, using the 2·5-metre reflector at the Las Campanas Observatory in Chile together with a highly sensitive CCD or Charge-Coupled Device. The ring-system is clearly shown, together with all five known satellites—Miranda, Ariel, Umbriel, Titania and Oberon. The pictures show the great power of the CCD, which is at least thirty times more sensitive than any photographic plate.

The rings of Uranus are quite unlike those of Saturn. Terrile and Smith find that their albedo or reflecting power is only about 2 per cent, so that they are blacker than coal-dust. They are also narrow; there are at least eight rings, not all of which are perfectly circular, and their composition is unknown.

If all goes well, we should learn more about them in January 1986, when the *Voyager 2* spacecraft makes its pass of Uranus. Meanwhile, there is speculation about the possibility of a ring-system round the outermost giant, Neptune, but the presence there of a large retrograde satellite (Triton) may have prevented any rings from being formed. Again, we pin our hopes on *Voyager 2*, which will rendezvous with Neptune in the late summer of 1989.

HALLEY'S COMET

Halley's Comet is, of course, still much too faint to be detected except with very powerful instruments, but recent studies show that it may prove to be somewhat brighter than had been expected. Unfortunately, this does not mean that it will be a brilliant spectacle, as it has been on many past returns.

It should become a naked-eye object at the end of 1985, before perihelion passage on 9 February, 1986, but British observers will need clear skies. When at its best, after perihelion, the comet will be in the far south—well placed for Australians and South Africans, but not for Europeans, who will not see it at all until it has faded considerably.

NOVA CYGNI—A NEW LOOK

On the evening of 29 August, 1975, I went into my observatory to make some routine observations of variable stars. When I looked up at the familiar constellation of Cygnus, I had a surprise. There, shining down unmistakably, was a bright star which had certainly not been there on the previous night. I estimated its magnitude as 2·4, slightly fainter than Gamma Cygni, the central star of the "cross" of Cygnus.

Having satisfied myself that it really was a new star or nova, I made a telephone call to the observatory at Herstmonceux. I was, of course, fairly sure that the star had already been reported—and so it proved; it had been discovered some hours earlier by Kentaro Osada in Japan, before darkness fell over England. I imagine that I was about sixtieth in the list of independent discoverers; the star could not possibly have been overlooked by anyone with more than a rudimentary knowledge of the constellations.

The most remarkable fact about Nova Cygni was that it brightened up by at least nineteen magnitudes in only a few hours. This was a record, both for amplitude and for speed. Its decline was also unusually quick. I estimated its magnitude as 1·8 on 30 August, so that it was then much the brightest star in the constellation apart from Deneb; but it had dropped to below 3 by 1 September, below 5 by 4 September, and faded below naked-eye visibility by 7 September, when I saw it as fiery red—in fact, as red as any star I have ever seen. Within a few months it had become too faint to be observed except with powerful telescopes.

Apart from Nova Cygni, only three novae seen since 1930 have attained the first magnitude: DQ Herculis (1934), CP Lacertae (1936) and CP Puppis (1942), though others have become visible with the naked eye—notably HR Delphini, which was discovered in 1967 by the well-known English amateur George Alcock and had a very prolonged maximum of around the fourth magnitude. It is still above magnitude 13, and probably will not fade much further, as this was also its pre-outburst magnitude.

However, the exceptional behaviour of Nova Cygni has led to particularly detailed studies of it, and efforts have been made to detect a cloud of débris round it. This has now been a successful operation.

THE SKY THIS MONTH

Winter skies are always glorious, thanks to the presence of Orion, the Hunter, and his magnificent retinue, but at the moment the dearth of bright planets continues—apart from Venus, which is at its very best in the evenings. Mercury is, in theory, a morning object, and may indeed be glimpsed just before sunrise, but it is well south of the celestial equator, so that European observers are unfavourably placed.

Mars may be seen in the south-west during the early evening, and moves from Aquarius into Pisces by the end of the month, but its magnitude is now only 1·2, and no telescope will show much upon its surface. Saturn, in Libra, rises well before the Sun, but is low down and by no means prominent, while Jupiter passes through conjunction on 14 January and is therefore out of view altogether. There are no eclipses this month, and no bright comets are expected. The Moon is full on 7 January, and new on the 21st.

During winter evenings the brilliant yellow star Capella is almost overhead (a position occupied by the equally brilliant Vega during evenings in summer). Close beside Capella lie the three fainter stars making up a triangle. They have been nicknamed the Haedi or 'Kids', and two of them are very remarkable objects.

Epsilon Aurigae, at the apex of the triangle, is an extremely luminous supergiant, at least 60,000 times as powerful as the Sun. Every 27 years it fades down by almost a magnitude, not because it is intrinsically variable but because it is being eclipsed by a companion which has never been seen at all.

The nature of the invisible secondary is still a matter for debate. It was once believed to be a very young star, not yet hot enough to shine; there were also suggestions that it might be a black hole, but it now seems more likely that it is a relatively small, hot star with an associated extensive shell of material. The last eclipse ended in 1984, so that for more than two decades nothing further will be happening.

Look at the 'Kids' and you will see that Epsilon is now the brightest member of the trio. The faintest, Sadatoni or Zeta Aurigae, is also an eclipsing binary with a period of 972 days, but we know much more about it; the primary is a red supergiant, while the secondary is a much smaller and hotter star.

It is sheer coincidence that these two exceptional eclipsing binaries lie side by side in the sky. There is no true connection between them; Epsilon is much further away from us than Zeta.

Using the 82-inch reflector at the McDonald observatory in Texas, G. and A. de Vaucouleurs have recorded the débris unmistakably. The cloud shows up as an elliptical blur, 3·5 × 2·5 seconds of arc across, with an integrated magnitude of about 16½. Presumably it is expanding; and if the distance of the nova is 4,500 light-years, as seems likely, the expansion rate is approximately 800 miles per second.

BINARY SYSTEM

According to modern theory, a nova is a binary system, made up of an ordinary main sequence star together with a white dwarf. White dwarfs are stars far advanced in their evolution; they have used up their nuclear "fuel", and have become very small and almost incredibly dense.

In a nova, the white dwarf pulls material away from its larger, less dense companion, and there is a build-up of material around the dwarf, leading eventually to instability and a violent, usually short-lived outburst. Associated débris is only to be expected, and has been detected with many former novae—such as Nova Persei 1901 and Nova Aquilae 1918, both of which became much more brilliant than Nova Cygni. Indeed, for a brief period Nova Aquilae outshone every star in the sky with the exception of Sirius.

SUPERNOVAE

There is a fundamental difference between ordinary novae and the much more powerful supernovae, which are much less common. Only four supernovae have been seen in our Galaxy during the past thousand years; those of 1006, 1054, 1572 and 1604—all before the invention of the telescope, though supernovae are so luminous that they may be detected in external galaxies many millions of light-years away.

From the few accounts which have come down to us, the 1006 supernovae, in the southern constellation of Lupus, became as bright as the quarter-moon, while the other three outshone Venus. The 1054 supernova has left the gas-cloud of the Crab Nebula, which contains a pulsar.

For many years the Crab was regarded as unique, but recently a very similar supernova remnant, including a pulsar, has been found in the Large Cloud of Magellan, more than 150,000 light-years from us. Pulsars are rapidly-spinning neutron stars which slow down as they age. From the measured slowing-down of the Large Cloud pulsar, it has been estimated that the outburst occurred about a thousand years before our present-day view of it.

The rapid increase of Nova Cygni 1975 raised initial hopes that it might be a supernova—something which astronomers would warmly welcome, because it cannot be said that our knowledge of supernova mechanism is at all reliable (there seem, indeed, to be two quite different types of supernovae, one of which involves the collapse of a massive star while the other indicates the complete destruction of a white dwarf).

We could learn much more if we had the opportunity to study a relatively nearby supernova with modern equipment. Nova Cygni was therefore something of a disappointment; but it is still extremely interesting, and it will be important to find out how the newly-discovered cloud of débris develops.

There is one rather sobering thought. When we look out into the Galaxy, we are also looking into the past. Nova Cygni exploded well over four thousand years ago; the expanding cloud we see today was produced long before astronomy had become a true science!

Ingenuity Unlimited

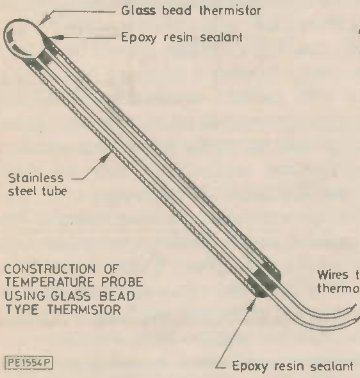
A selection of readers' original circuit ideas.

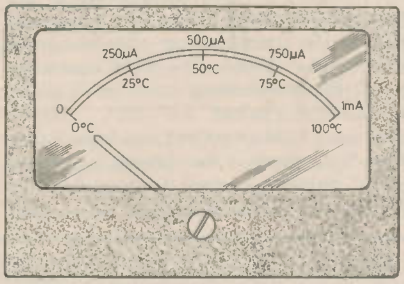
Why not submit *your* idea? Any idea published will be awarded payment according to its merits.

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

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

THERMISTOR THERMOMETER





CALIBRATION OF METER 1mA F.S.D.

Construction and calibration of the Thermistor Thermometer

RT	R1	R2	R5	R6	R7
JA-03	7k5	5k6	22k	1k2	O.C.
VA3704	10k	6k2	10k	1k	10k

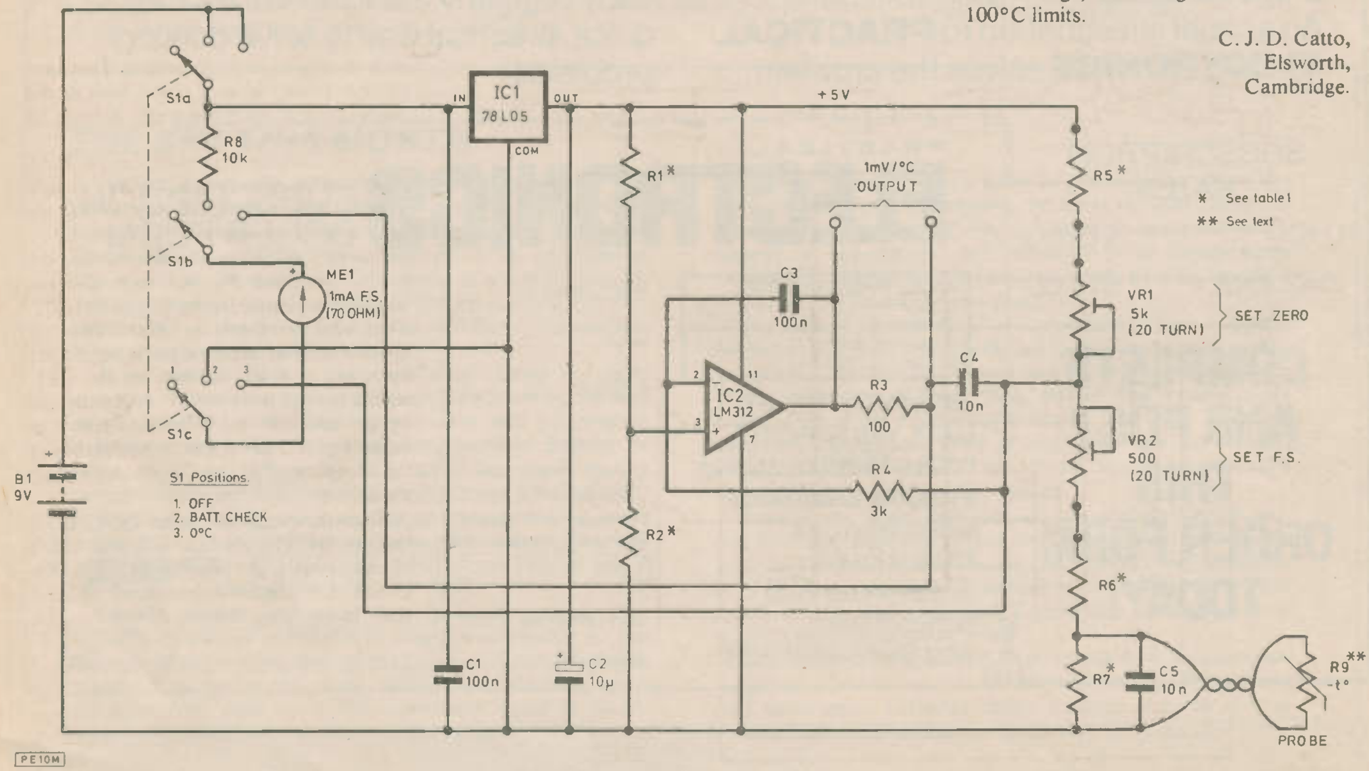
TABLE 1

	0	30	70	100
°C ERROR AT	+3·3	-2·0	+1·7	-2·6
	+4·0	-2·5	+2·2	-3·2
TABLE 2	10	30 50	70	90

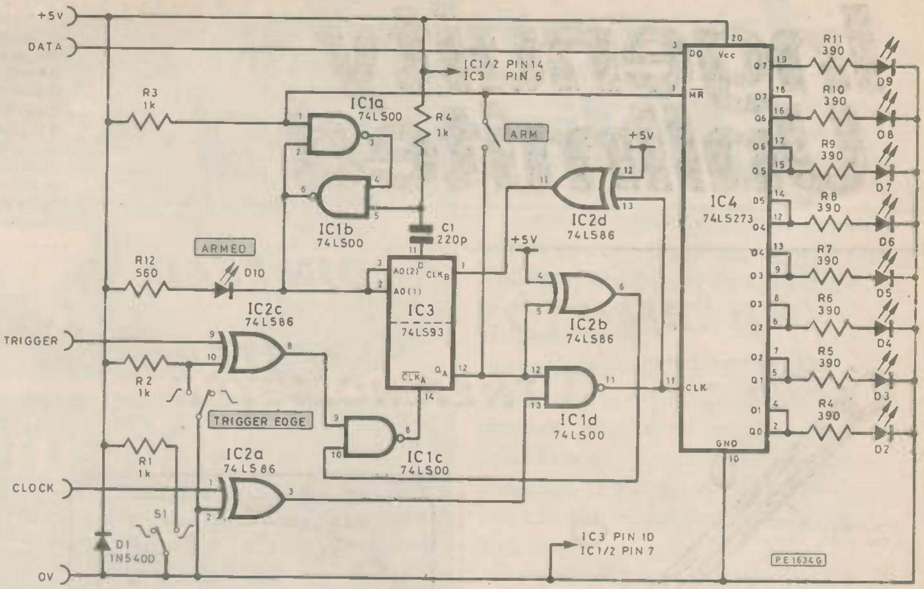
THE conventional bridge circuit recommended for thermistors is somewhat inaccurate. Better results can be obtained using the arrangement shown here. The op.amp, IC2 acts as a voltage source, with current measured by the meter ME1. This configuration corrects for most of the thermistor's non-linearity. An offset current flows through R5 and VR1, and sensitivity is set by VR2 and R6. Assuming a full-scale current of 1mA, an output of 1mV/°C is conveniently obtained at the output and this can be used to drive a chart recorder, for example. The supply voltage is regulated by IC1, and a 3-way switch allows the battery to be checked. Resistor values for two types of NTC thermistor are given in Table 1. JA-03 is metal-sheathed (RS no. 151-120) and VA3704 (Mullard no. 2322-627-11472) is a glass-bead device. Both have a resistance at 50°C, of the order of 1k7.

Kettles and ice-buckets are unpredictable gadgets! Calibration was done at 10, 50 and 90°C, using a water-bath and laboratory-grade mercury thermometer. The error curve is cubic, with a deviation within 2 or 3 degrees centigrade over most of the range, increasing near the 0° and 100°C limits.

C. J. D. Catto,
Elsworth,
Cambridge.



LOGIC RECORDER



THE logic recorder is designed to fill the gap between the logic probe and the logic analyser by displaying a sequence of eight data bits on a bank of l.e.d.s. Data is stored synchronously with the system clock after a trigger pulse from the circuit under test.

Data is fed into IC4, an octal D-type flip-flop wired as a shift register, though a 74LS164 shift register could be used instead. D2 represents the most recent data.

Suppose that latch IC1a/b is set so that D10 is unlit. IC1 pin 6 is high so IC3 is reset, its 'A' output is low, IC1d is disabled and IC1c is enabled via IC2b. When the ARM button is pressed the latch sets, lighting D10 and freeing IC3 to count. On the rising edge of IC2c pin 8, the single-bit counter in IC3 clocks, disabling IC1c and the ARM button and enabling IC1d to clock IC4 and, via IC2d, the 3-bit section of IC3.

After eight clock pulses from the system under test, IC3 pin 11 goes low, resetting the latch via C1. Provided that the ARM button has been released the logic recorder resets and displays the data received until it is rearmed.

IC2a and IC2c are used as programmable inverters to select the desired trigger and clock edges. D1 protects the recorder against reverse polarity on its power supply leads which are connected to the test circuit.

G. Strange,
Loughborough,
Leics.

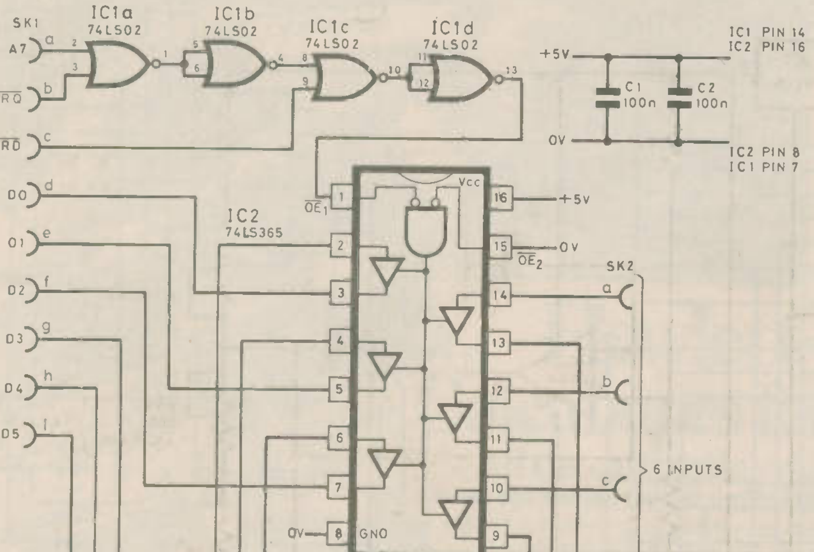
May be 1 or 0

D7	D6	D5	D4	D3	D2	D1	D0
1	1	X	X	X	X	X	X
128	64	32	16	8	4	2	1
1	1	1	0	1	0	1	1

e.g. D2 and D4 are low
128 + 64 + 32 + 0 + 8 + 0 + 2 + 1=235

Table 1. Showing example of IN127 command

ZX SPECTRUM BUFFERED INPUT PORT (6 BIT)



MOST designs for input ports use devices such as the 74LS245 octal transceiver, but during the current chip shortages, these devices are either impossible to obtain or very expensive. There are other possible buffering chips, such as the 74LS126, but these are more difficult to design a circuit layout for.

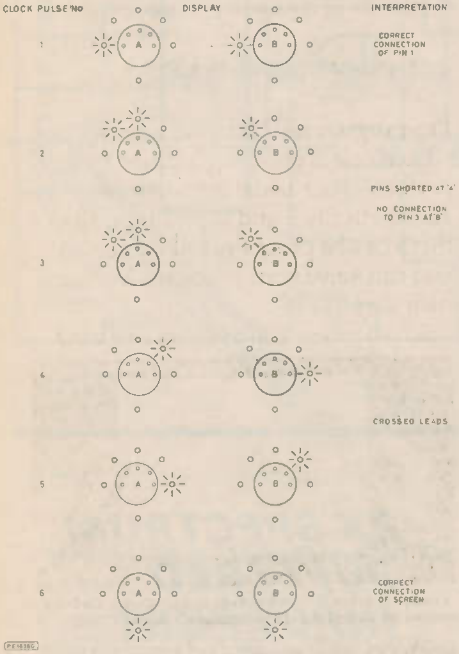
In my design I have used the 74LS365 Hex buffer/driver with gate enable inputs—the only disadvantage is that we now have only 6 inputs.

The circuit itself is very simple: the port is I/O mapped by A7 and address decoding is performed by IC1, a 74LS02. Thus when the following control lines are low—$\overline{IORQ}$ to indicate an input output operation and $\overline{RD}$ to indicate the CPU wishes to read from the I/O port indicated by the address on the address bus. The outputs of IC2 are put onto the databus of the computer. C1 and C2 are decoupling capacitors.

Since the circuit is mapped by A7 being low, an IN127 command will give 255 if all inputs are high (logic 1), as will be the case if they are left unconnected. If bit 1 (DØ) is low then the result will be 254. Possible results are summarised in Table 1. Thus the result of an IN127 command in this case would be 235.

A. Moran,
Reading,
Berks.

Ingenuity Unlimited



DIN LEAD TESTER

HAVE you ever wondered whether all your problems might just be due to a faulty DIN lead? If so, you'll no doubt have discovered what an awkward operation it can be to test one; but here is a simple solution.

The following design will test DIN leads for open circuit, short circuit and wrong connections all in one go. Whereas with a continuity tester you need to test each pin individually, this circuit gives an immediate indication of the connections (or lack of connections) between pins at either end.

IC1 is a 4017, which is a decade counter with decoded outputs. It sends each pin high, in sequence, moving on to the next one every time it receives a clock pulse. For a 5 pin DIN, the sixth output is connected to reset and thus counts through 0,1,2,3,4 and 5. Six pulses are allowed to enable the screen to the tested separately (note however that this is often connected to the middle pin). The clock used to drive IC1 is produced by a standard CMOS oscillator based around IC2 (a 4011 quad NAND), the NAND inputs being shorted together as shown to act as inverters. This i.c. type was chosen merely so that fewer gates were left unused. A hex inverter would serve just as well. IC3 and IC4 are 4050 hex buffers used to drive the l.e.d.s.

The clock frequency is normally about 1kHz, providing an apparently constant display. In this mode any broken connections will immediately show up as unlit l.e.d.s. at 'B'. By pressing switch S1 the 68k resistor R1, is disconnected and the clock frequency reduced so that a more detailed representation of the condition of the DIN lead is given. Two common types of 5 pin DIN lead exist; straight through and mirror image.

STRAIGHT THROUGH—L.e.d.s at 'A' and 'B' should light in the same order.

MIRROR IMAGE—L.e.d.s at 'A' and 'B' should light in opposite orders. Crossed leads can thus be detected by incorrect orders at 'B'.

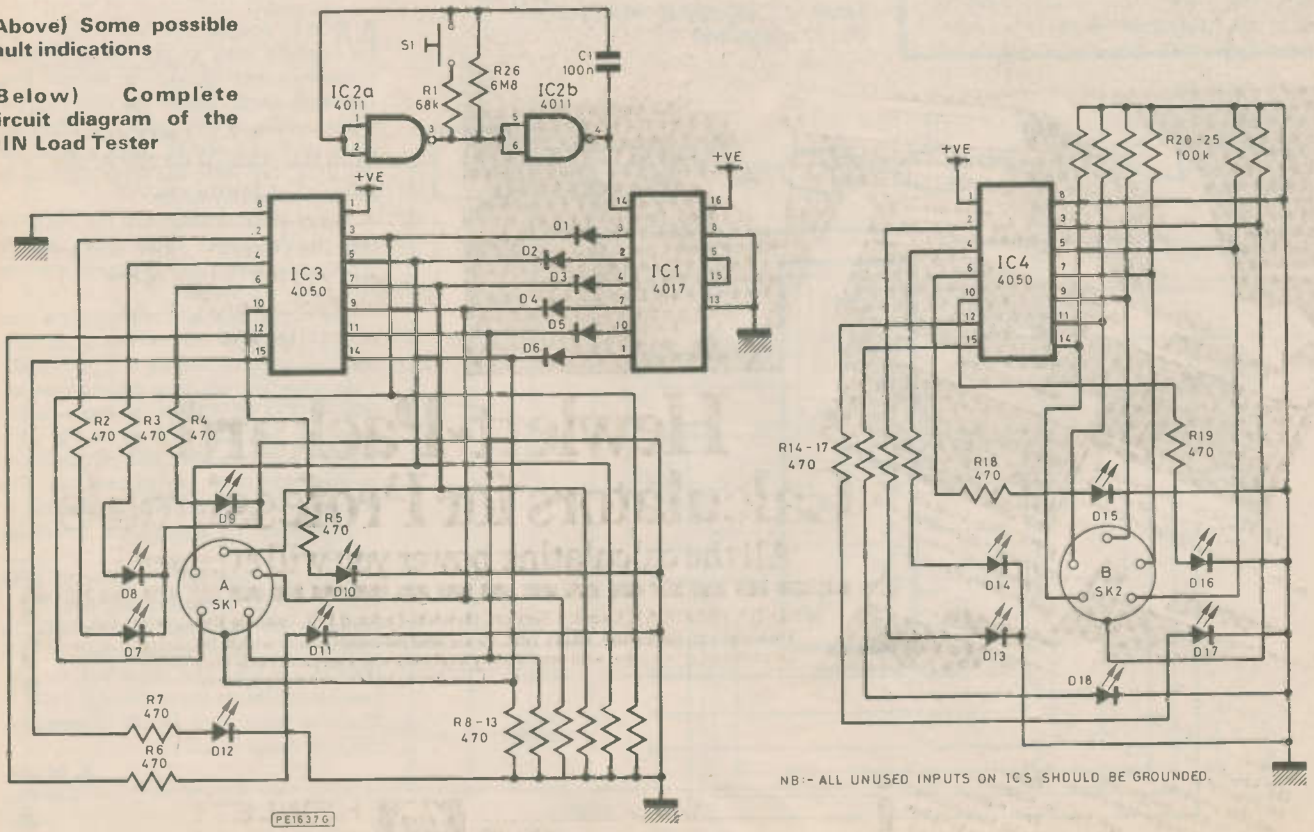
Any two l.e.d.s lit simultaneously at one end in this mode indicate shorted leads at that end.

Some sample displays are given. Using CMOS logic, the unit can be readily powered by a 9V (PP3) battery.

C. Walden,
Selby,
S. Yorks.

(Above) Some possible fault indications

(Below) Complete circuit diagram of the DIN Load Tester



FREE! READERS' ADVERTISEMENT SERVICE

PE BAZAAR

RULES Maximum of 16 words plus address and/or phone no. Private advertisers only (trade or business ads. can be placed in our classified columns). Items related to electronics only. No computer software. PE cannot accept responsibility for the accuracy of ads. or for any transaction arising between readers as a result of a free ad. We reserve the right to refuse advertisements. Each ad. must be accompanied by a **cut-out valid** "date corner". Ads. will not appear (or be returned) if these rules are broken.

WANTED service manual or circuit for Cossor 1049 MK4 'scope, to borrow or buy please. J. Rudrum, 2 Princes Road, Eastbourne, Sussex BN23 6HG. Tel: Eastbourne (0323) 29440.

WANTED Watford Ultimum system any condition. Phone Burntwood (05436) 6043 evenings—ask for Steve.

WANTED MCP40, Tandy or similar graphics printer and Thandar PFM200A frequency meter or similar. Cheapish please! Dr. Andrew Brown, Department of Oral Surgery, John Radcliffe Hospital, Oxford OX3 9DU. Tel: Oxford (0865) 65164.

Z80A computer system including 10MB Winchester back-up cartridge drive. Can be seen working. £170 or split. Tel: 0223 277272.

DISCS! DD/SS £1.35. DD/DS for SS drives £1.45. Disc boxes: 50 disc £8, 10 disc £1.95. Martin Harlow, 194 Old Woking Road, Woking, Surrey GU22 8HR.

FLUKE 8000A DMM £40, p.s.u. and many unused i.c.'s and components. For more information send SAE. Mr. T. Pomphrey, 347 Church Road, Redfield, Bristol BS5 8AA. Tel: 0272 558980.

PYE 'Westminster' 70cm TX/RX fitted 5 repeater channels +2 Simplex, 15W TX O/P, tone burst. £75. D. C. Chapman, 6 Pickhurst Green, Hayes, Bromley, Kent. Tel: 01-462 2178.

48K ZX Spectrum and full size keyboard now fails to output logo when switched on £40. Ralph Lovelock, 14 Knightley Road, Exeter EX2 4SR. Tel: Exeter 75892.

WANTED, loan or purchase, handbook/service sheets Waltham music centre STM 50 or photostat. Costs paid. Mr. W. Hammond-Haley, 'Holmeleigh', Sleaford Road, Dunston, Lincoln LN4 2EZ. Tel: Metheringham (0526) 20661.

PE Quasar cassette deck, not working, £15 ZX81, 16K Ram, tapes £35, two unused TDM 1010's £5. Mr. J. C. D. Darwent. Tel: Dronfield 413667.

UK101 with Cegmon and 8" disk system. Needs memory expansion. £200 or best offer. Mr. S. Morgan, 17 Willenhall Road, Bilston, West Midlands WV14 6NW. Tel: Bilston 403416.

TEXAS TI-53 17 months old, working, £7. L. Stewart, 32 Cross House, Wolverhampton WY2 3EX.

WANTED PE January, March, April 1984; July 1983, April 1980, February 1978 and all before July 1977. Kenny Robertson, 82 Willow Drive, Airdrie, Lanarkshire, Scotland ML6 8JX.

TELEPRINTERS Creed 7B, 54R and 54N. Also two C37 and J37 tape recorders. Offers invited or why? Mr. John Radley, 81 Drayton Avenue, West Ealing, London W13 OLE. Tel: 01-997 4835.

SYNTHESISER, 4600, mostly working (not completely finished). Large wooden case. Internal amps/speakers. Large patchboard £180. Mr. Gaskell. Tel: Cambridge (0223) 893593.

SAFGAN 12 MHz dual beam oscilloscope, unused, as new conditon, with manual and X10 probe set £150. Peter Cunningham, 11 Berwyn Avenue, Penyffordd, Nr. Chester. Tel: Caergwrle 760172.

FOR sale PE August 1977 to October 1983. ETI February 1978 to March 1982. Offers to: R. M. James, Yew Tree House, Preston Wynne, Hereford HR1 3PE.

WANTED high resolution graphic board for UK101 (Sprite from Premier). J. Ockier, Mgr. Christiaensstraat 16, 8880-Tielt, Belgium.

300 watt switched mode PSU. Set to 60 amps 5 volts. 6" x 5" x 14". Diagrams available. Mr. P. Kirton, 4 The Grove, Shaw Heath, Stockport, Greater Manchester SK2 6QU. Tel: 061 480 4690.

TECHTRONICS 515A 15MHz single beam oscilloscope £50. Advance SG66 audio generator £40. Eddystone 830 Receiver £95. Tel: Peterborough 235042.

TELEQUIPMENT double beam oscilloscope model D43. Full working order. Also instruction manual. £60. Buyer collects. Mr. Naylor, 26 Highfield Road, Stretford, Manchester M32 8NF. Tel: 061 865 4320.

PE November 64 to December 81 less five. Some extras. Plus most 82-83. All mint. Offers. Phil Simpson, 37 Larkholme Parade, Fleetwood FY7 8LL. Tel: 03917 6317.

WANTED PE December 1975 or copy of Minimix item from that issue. Call weekday evenings only. John Colson 01-253 3176.

PRACTICAL Electronics from 1967 to 1983. Instruction manual for Tektronics 545B oscilloscope. Offers. Buyer collects. Mr. L. T. Cowell, 69 Crew Road, Haslington, Crewe, Cheshire. Tel: 0270 581157.

RANGER P.E.C.B. two for sale working order. Offers invited. Will separate if required, 27MHz legal. Mr. G. T. McDermid, 4 Aspian Drive, Coxheath, Maidstone, Kent ME17 4JZ. Tel: 0622 46354 (evenings).

TANDON disc drive D/S D/D 80 track 640k £99 each. Acron DFS £80. Tel: 01-892 1909.

MONO valve amplifier, 3 watt, and motor, in portable timber cabinet. Two available. £10 each if collected. Tel: Oxford (0865) 779855.

AVAILABLE BD139–140, BC146 Micro TR 7806, 09 and 12 vol. reg.s all new for less than half price + p&p. Write to: Saied Z. Fathy, No. 25, Alric Avenue, Neasden, London NW10.

FOUR mains PCB relays type 265/4A/G2v. D.P.C.O. £5 or £1.40 each including postage. David White. Tel: 0248 722697 (evenings).

'NIGHTRIDER' car lights sequencers, drives nine channels vari-speed. Easy wiring all negative-ground cars £40 complete. Mr. S. M. Budzinski, 16 Laburnum House, Malpas Road, London SE4 1BL.

OSCILLOSCOPE Heath 10–4555 £150 ono also other instruments P.C. bridge etc. Offers, good condition, sold separately. Mr. A. Ewing, 9 Croft Crescent, Markinch, Glenrothes, Fife KY7 6EH, Scotland.

WANTED AY–3–1270 linear i.c. or RS–3–1270. Mr. J. F. Wilso, 233 Broomlee Close, Newton Aycliffe, Co. Durham. Tel: Aycliffe 312130.

WANTED two track record head for B & O record 1800 RTOR deck. Mr. C. Bressington, 17 Station Road, Ystrad Mynach, Mid-Glamorgan. Tel: 0443 813005.

EIGHT Philips LVC 150 2½hr. video tapes. Hardly used. Offers plus postage. Mr. L. T. Hill, 14 Rothesay Terrace, Bedlington, Northumberland. Tel: Bedlington 825967.

WANTED data or specimens of early transistor types. Good prices paid. Write for full details: Mr. Andrew Wylie, 18 Rue de Lausanne, 1201 Geneva, Switzerland.

MICROSYNTH Synthesiser built and tested with speakers and homemade stand £150. 8 Stourton Road, Witham, Essex. Tel: Witham 514556.

COMPONENTS transistors mainly OC/AC/BC, capacitors, resistors, chips, pots, relays, motors and other. 16 lb. £20. Mr. Turner, 4 Mill Fields, Newtown, Powys. Tel: 0686 27862.

WANTED service circuit diagrams Sugden C51 A51 purchase hire to copy. Good price paid. Richards, Maesyffnnon, Caehopkin Road, Abercrave, Swansea. Tel: 0639 730629.

10 x 8255A £70 the lot or £8 each. Also printer leads for Dragon 32, BBC £9.95 each. R. Vowles, 3 Orchard Waye, Uxbridge, Middx. U88 2BN. Tel: 0895 54720.

Please publish the following small ad. FREE in the next available issue. I am not a dealer in electronics or associated equipment. I have read the rules. I enclose a **cut-out valid** date corner.

Signature ....Date ....

Please read the RULES then write your advertisement here—one word to each box. Add your name, address and/or phone no.

COUPON VALID FOR POSTING BEFORE 1 FEBRUARY 1985 (One month later for overseas readers.)

SEND TO: PE BAZAAR, PRACTICAL ELECTRONICS, WESTOVER HOUSE, WEST QUAY ROAD, POOLE, DORSET BH15 1JG.

BLOCK CAPITALS PLEASE

Name & Address:

For readers who don't want to damage the issue send a photostat or a copy of the coupon (filled in of course) with a **cut-out valid** "date corner"

PE BAZAAR FEBRUARY '85

RICHARD B. H. BECKER — SYSTEM DESIGN AND MECHANICAL ENGINEERING.

TIM ORR — COMPUTER INTERFACE AND CONTROL ELECTRONICS.

ROBOTS

neptune and mentor

PART SIX

THE ELECTRO-MECHANICS and the electronics of both robots have now been explained in previous parts, and the p.c.b.s and parts lists have been published. The actual construction and computer control of the robots is the last thing to be considered, beginning this month with NEPTUNE.

CONSTRUCTION

Construction starts with axis 0 and progresses upwards from there. The hydraulic cylinders of the NEPTUNE are supplied pre-assembled. First axis 0 cylinder is fitted to its sensor potentiometer, on a bracket beneath it, and then to the base plate and front plate (Fig. 6.1). There are support brackets to ensure a rigid structure and there are triangular brackets with feet on them to prevent the robot from tipping over when under load. The top slot in the rear plate is for fitting the computer interface leads to the edge connectors on the interface board. The slot beneath it is for the cables leading to the power supply which fit onto the rear plate later.

Next the top plate is fitted. Being 3mm steel this is quite heavy but this is necessary to ensure rigidity. On top of axis 0 cylinder goes the shoulder rotating axle with axis 1 mounting plate on top of it (Fig. 6.2). The weight of the arm is carried by a large thrust ball race fitted round the axle. Through the axle passes the plumbing/wiring harness which is secured to axis 1 cylinder fitted to the mounting plate.

Onto mounting rings on axis 1 cylinder the lower arms are fitted and to the upper end of these are fitted axis 2 cylinder with the upper arms attached to it (Fig. 6.3). To the end of the upper arms is fitted axis 3 cylinder which provides the wrist raising function.

A pair of mounting plates is used to secure axis 4 cylinder to the front end of axis 3 cylinder (Fig. 6.4). This applies to NEPTUNE II only, where it provides wrist yaw, a function immensely useful when picking up objects lying flat or in other difficult positions. It also greatly assists spraying into corners. Yaw is a feature usually found on only the most expensive of robots used in industry. Axis 5, the wrist rotation cylinder fits to the axle of axis 4 cylinder by means of a short plate. On NEPTUNE I where there is no wrist yaw, axis 5 fits to the top of axis 3 cylinder. The gripper clamps onto the axle of axis 5 cylinder with a single set screw enabling it to be rapidly changed. The NEPTUNES are supplied with a choice of gripper types. The robot is now ready for plumbling and wiring.

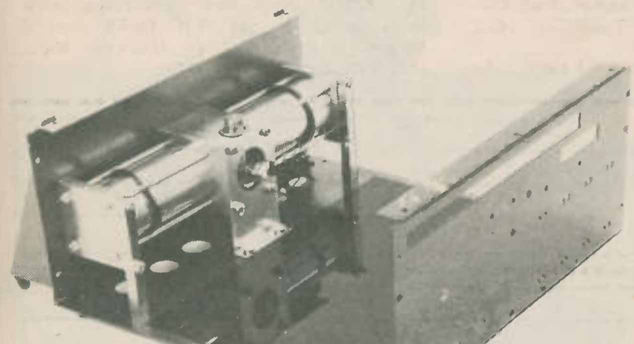
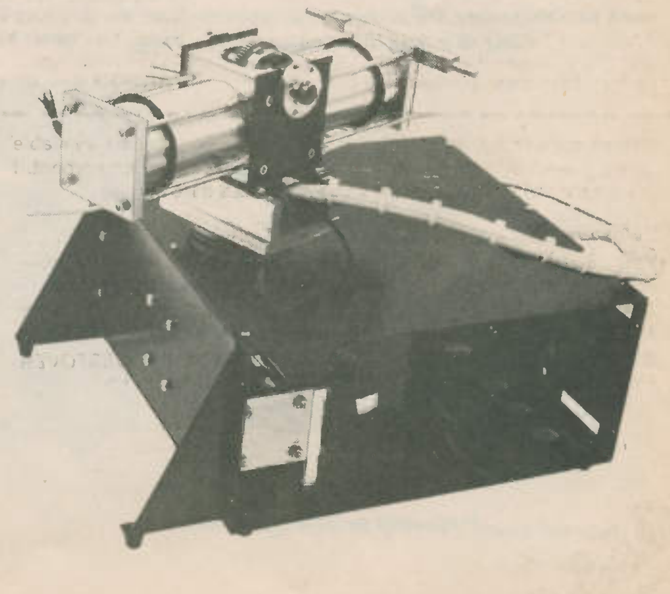


Fig. 6.1. (above): base plate and axis 0 cylinder

Fig. 6.2. (opposite): shoulder-rotating axle with axis 1 cylinder fitted to the mounting plate



The harness is strapped onto the arms at the fixing holes with cable ties. The position for these is marked, with dabs of paint, on the harness. The pipes press into 'banjo' fittings attached to the cylinder ends with Delrin hollow bolts and the cables are trimmed and soldered to the sensor potentiometers (Fig. 6.5).

The solenoid operated valves, which control the water flow, fit with hollow bolts to a Delrin manifold (Fig. 6.6) which acts like a printed circuit board routing the water to the correct valve. The other end of the valves fit to bored Delrin bars to which the restrictors and flow rate control valves also fit (Fig. 6.7). Brackets to which the solenoid driver boards will fit are screwed to the solenoids and ensure correct alignment for the boards which clip onto the connector tags of the solenoids (Fig. 6.8). This arrangement avoids soldering to the solenoids and greatly simplifies maintenance in that the boards can be rapidly unplugged from the system. Connections to the plumbing harness again are made with "banjo" push-on fittings and hollow bolts.

After wiring up the power supply (Fig. 6.9) and connecting to the computer interface board (no need to connect to a computer yet) the system is ready for commissioning. The sump of the hydraulic power pack is filled with water and the pump is operated with its outlet and inlet connected together with one of the plug-in pipes. This expels the air from the pipe which, after switching off the pump, is plugged into the manifold as the pressure source; the return pipe is taken from the outlet of the manifold to the sump. After pressurising the system and checking that there are no leaks the axes are tested one at a time by plugging in a solenoid driver board and the axis operated by means of a potentiometer on CN401 extend-contract connector. This will drive out most of the air. The rest of it will gradually disappear by dissolving in the water when under pressure. It then comes out of solution when returned to the sump.

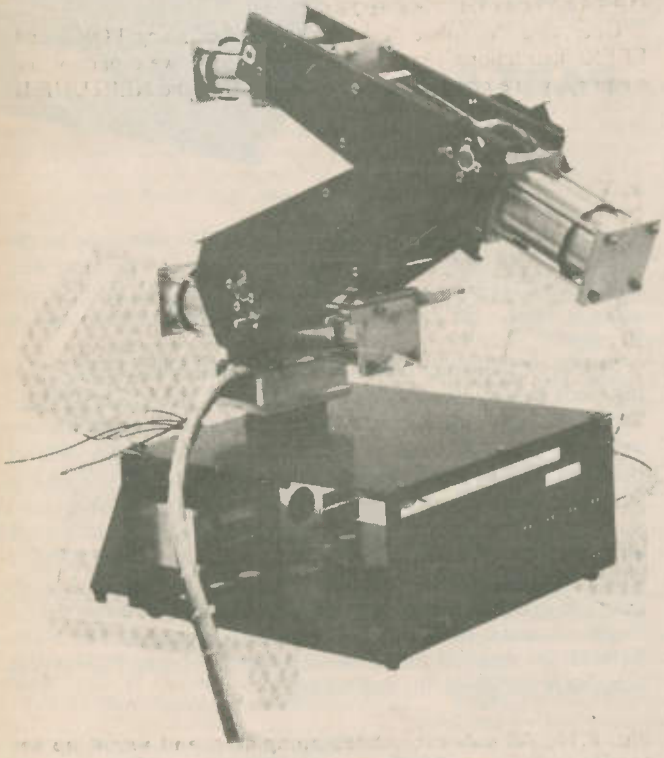


Fig. 6.3. Lower and upper arms fitted

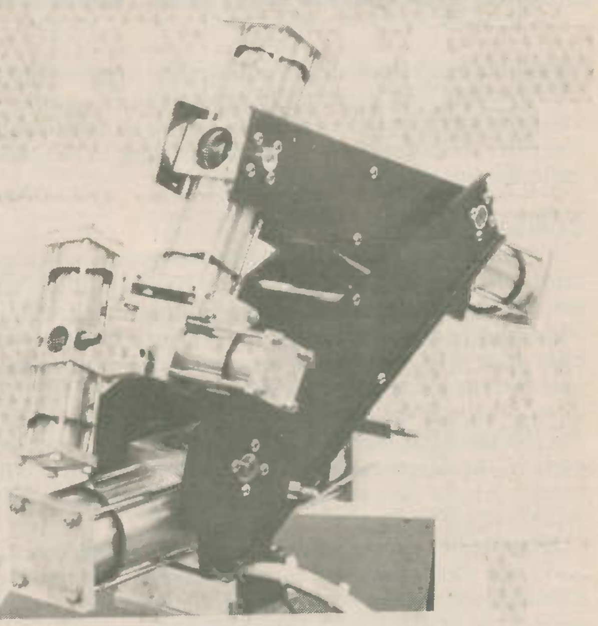
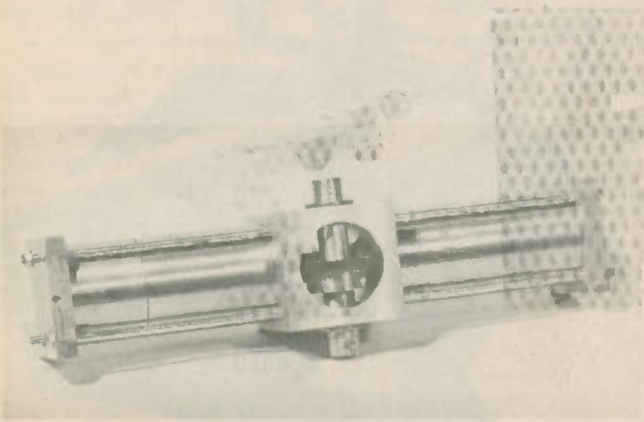


Fig. 6.4. Shoulder, upper arm and wrist assembly



Hydraulic cylinder assembly

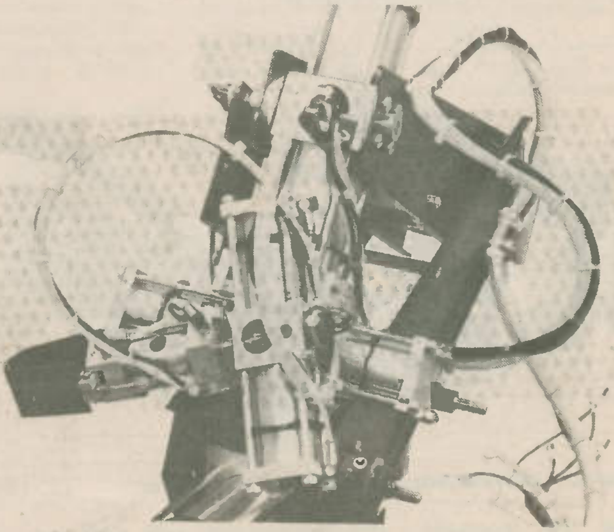


Fig. 6.5. Plumbing and wiring loom

Fig. 6.6. Hydraulic control manifold

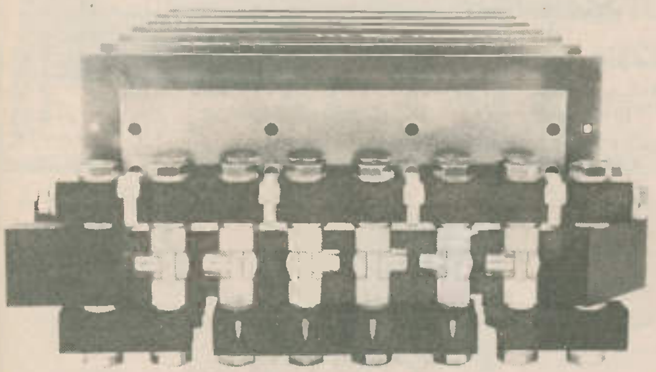


Fig. 6.7. Assembly showing restrictors and flow-rate control valves

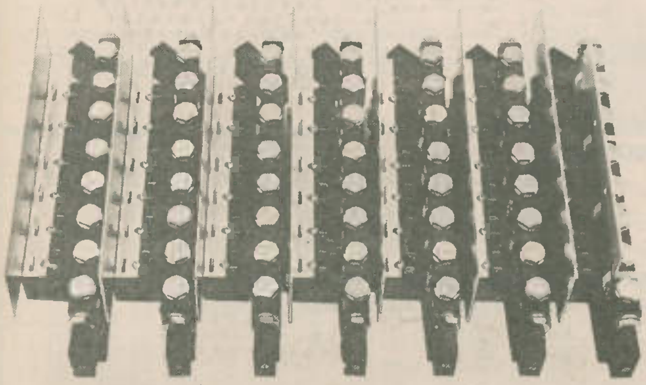


Fig. 6.8. Completed hydraulic flow-control sub-system for all seven axes

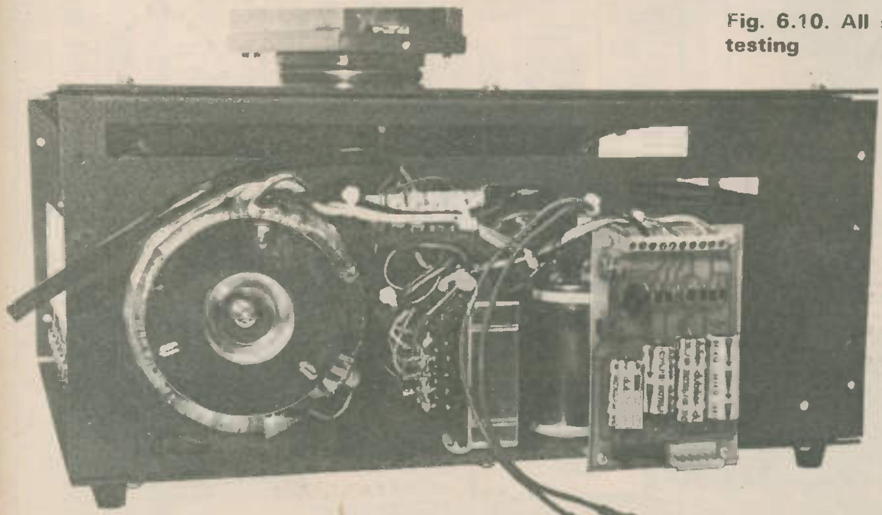


Fig. 6.9. Power supply

All the solenoid driver boards may now be fitted (Fig. 6.10), the computer interface board connected to the computer and the "NEPDYN" program run. This sends and returns the chosen axis between 2 points and generates, on the monitor screen, a graph of error in the axis position against time. The error is the difference between where the axis is, as measured by the ADC, and where the axis has been told to go. With the aid of this program the restrictors are set to achieve rapid convergence of the send and return graphs without any overshooting.

After setting the restrictors of each axis, the pre-sets on the solenoid driver boards are set so that sending position 0 from the computer, by means of the "NEPTROL" program, sends each axis to just before the end of its travel. The pre-sets on the interface board are set to match the positions of the simulator (Fig. 6.11) with the positions of the robot.

The interface board is next mounted over the manifold assembly (Fig. 6.12) which is then slid into the robot base and bolted down. Following fitting of side plates and covers the robot is then ready for use.

OPERATION OF THE ROBOT

Operating the robot basically consists of using POKE and PEEK instructions sent to the robot as if it were part of the memory of the computer. To move axis 0 of the NEPTUNE II

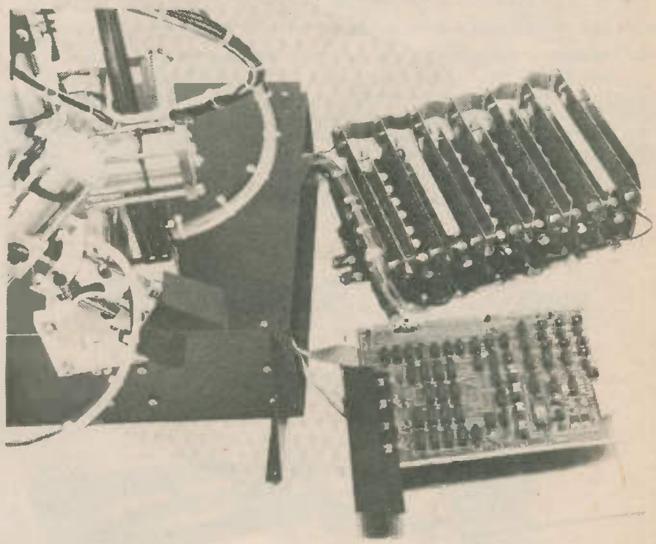


Fig. 6.10. All sub-assemblies completed and wired up for testing

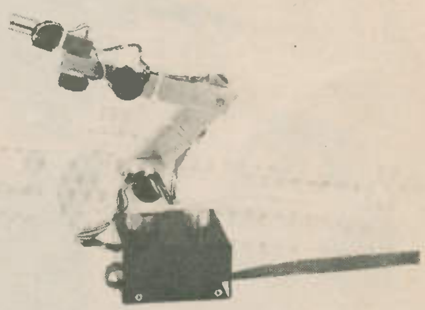


Fig. 6.11. NEPTUNE simulator arm

to position DO, the start of the 'memory' is first defined. This is also the address for the most significant byte of axis 0. The least significant byte is at the next address. On the BBC, POKE and PEEK are represented by '?' and hexadecimal numbers are indicated by '&'.

```
10 A=&FCOO
20 ?A=DO DIV 16
30 ?(A+1)=(DO MOD 16)*16
```

The data DO can be any integer from 0 to 4095 ($2^{12}-1$) because it is a 12-bit control system. On the NEPTUNE I it is an 8-bit system so the range is 0 to 255 ($2^{8}-1$) so only one byte is sent for each axis move. For the msb the data is divided by 16 and the remainder ignored. For the lsb this remainder is multiplied by 16 because it is the top 4 bits of the lsb that are used.

The addresses of the axes follow successively so to move axis 4 to position D4 the instructions are as below.

```
40 ?(A+8)=D4 DIV 16
50 ?(A+9)=(D4 MOD 16)*16
```

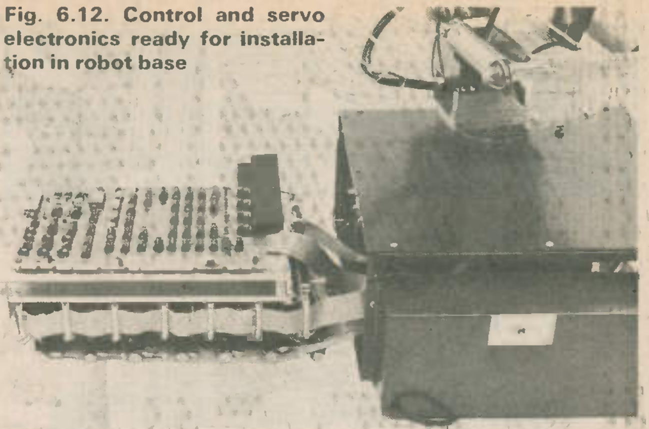
Similarly for axis 5

```
60 ?(A+10)=D5 DIV 16
70 ?(A+11)=(D5 MOD 16)*16
```

The servo system of the robot then makes the axis go to this position with no further computer intervention but with the ADC the position of the axis can be followed as it is moving. To operate the ADC it is written to at A+14. Data bit 7 is toggled and the multiplexer axis address set up. The axis address is in the bottom 4 data lines (see Table 1 October 1984). Axis 0 is at address 0000. The msb is read at A+17 and the lsb at A+16.

```
 80 ?(A+14)=128
 90 ?(A+14)=0
100 ?(A+14)=128
110 DAO=?(A+17)*16+?(A+16)/16
```

Fig. 6.12. Control and servo electronics ready for installation in robot base



Similarly for axis 4

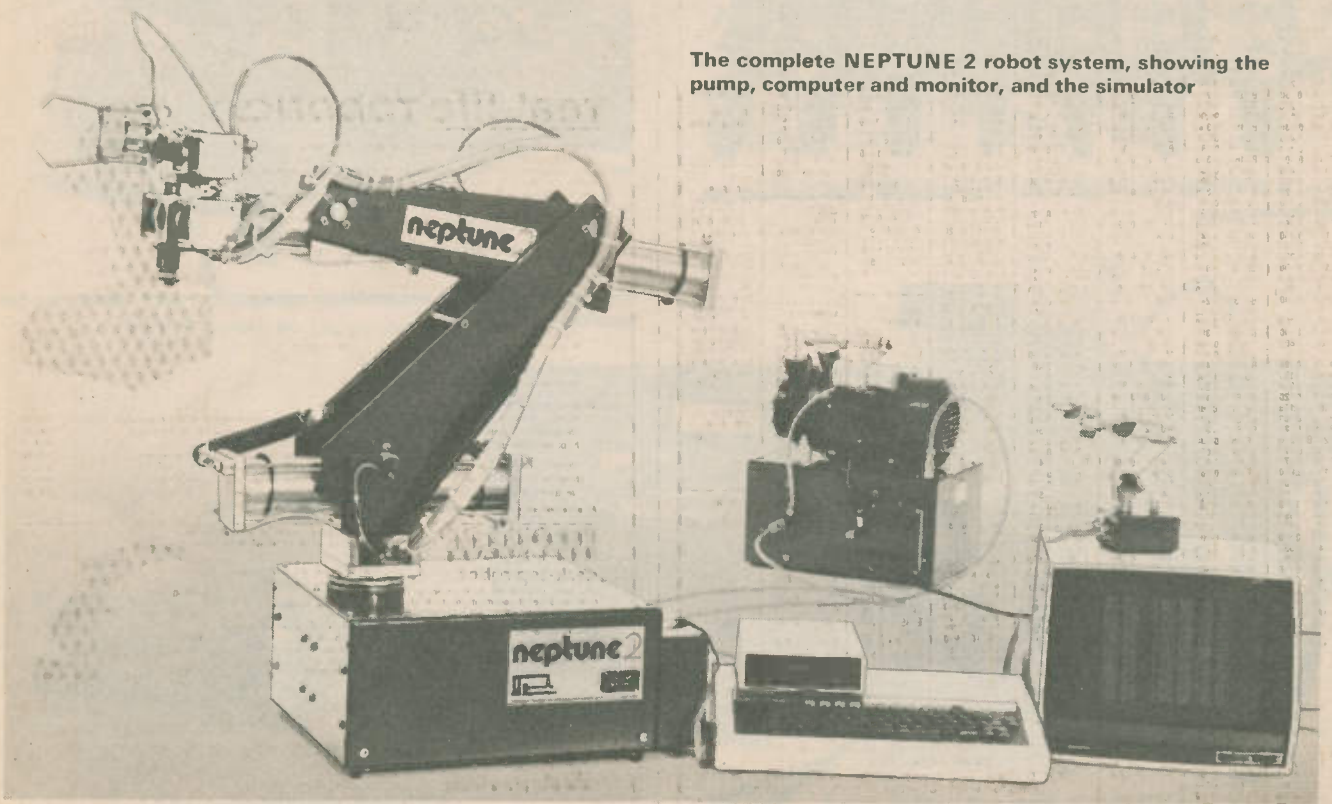
```
120 ?(A+14)=132
130 ?(A+14)=4
140 ?(A+14)=132
150 DA4=?(A+17)*16+?(A+16)/16
```

Reading the simulator is performed similarly but at the multiplexer axis address 8 bits higher so to read simulator axis 0:

```
160 ?(A+14)=136
170 ?(A+14)=8
180 ?(A+14)=136
190 DSO=?(A+17)*16+?(A+16)/16
```

If the simulator is constantly read and the data returned to the robot then the robot will follow the movement of the simulator.

NEXT MONTH: details of the assembly and use of MENTOR.



The complete NEPTUNE 2 robot system, showing the pump, computer and monitor, and the simulator

TOOLTRONICS

MINIATURE TOOLS

PRECISION JEWELLERS' TOOLS

Rustproof Tempered Handles and Blades. Chrome Plated Handles. Swivel Heads for use on Precision work.

5T21 SCREWDRIVER SET
6 precision screwdrivers in hinged plastic case. Sizes – 0.8, 1.4, 2, 2.4, 2.9 and 3.8mm **£1.75**

5T31 NUT DRIVER SET
5 precision nut drivers in hinged plastic case. With turning rod. Sizes – 3, 3.5, 4, 4.5 and 5mm **£1.75**

5T41 TOOL SET
5 precision instruments in hinged plastic case. Crosspoint (Philips) screwdrivers – H0 and H1 Hex key wrenches Sizes – 1.5, 2 and 2.5mm. **£1.75**

5T51 WRENCH SET
5 precision wrenches in hinged plastic case. Sizes – 4, 4.5, 5, 5.5 and 6mm **£1.75**

SIGNAL INJECTOR

Simple push button operation. Oscillates at 700–1kHz with harmonics to 30MHz. 1.4V p/p output. Impedance 10Ω. Ideal for trouble shooting with audio equipment. One "AA" penlight battery supplied. O/No VP96 **£2.50**

LOGIC PROBE

Automatic levelling. White LED indication. Minimum width of measuring pulse 30 millisecs. Maximum input frequency 10MHz.

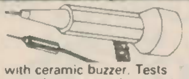
Input impedance:	100kΩ
Power consumption:	40mA maximum
Power supply:	4.5–18 V d.c.

ORDER No. VP97 **£10.50**

CURRENT/POL CHECKER

Heavy duty test prods with built-in indicators for testing polarity: indicates whether a.c. or d.c. 3.5V to 400V. O/No. VP98 **£3.00**

TESTER



Universal tester with ceramic buzzer. Tests diodes, transistors, resistors, capacitors and continuity. One "AA" penlight battery included.

Test current:	Max 2μA
Test voltage:	1.2V
Response range:	100MΩ
Max voltage:	500V
Internal resistance:	390kΩ
Length:	135mm

£5.00 O/No. VP99

CIRCUIT TESTER

D.C. continuity tester for circuit checking on all low voltage equipment and components. Diode checking also possible. Takes two AA batteries. 90cm lead has crocodile clip. Body length 145mm. O/No. VP100 **75p**

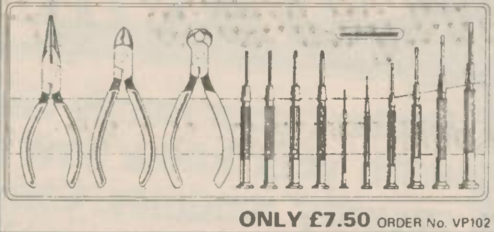
MINIATURE VICE

Miniature plastic and metal vice with strong suction base for portability. Single action to secure or release suction. Plastic jaws with rubber pads 20mm wide, open out to 40mm. Dims. 85 x 65 x 60mm approx.
FANTASTIC VALUE
O/No. VP95 ONLY **£1.60**

METRIC & BRITISH MEASURES

Steel tapes in sturdy ABS plastic case. Silk wrist strap. These yellow coated convex tapes have inch and metric graduations. Automatic push-button return. 2m long × 13mm wide. O/No. VP89 **£1.75**

13 PIECE TOOL KIT AND CASE



13-piece tool set housed in attractive moulded plastic case with clear sliding cover ● 1 off 5" snipe nose "radio" pliers with side cutters ● 1 off 4½" side cutters ● 1 off 4½" end cutters ● 2 off hex. "Allen" key drivers 2mm and 2.5mm. 2 off cross-point "Philips" drivers No. 0 and No. 1 (with tommy bar) ● 6 off precision screwdrivers. Sizes from 1mm to 3.5mm ●

ONLY £7.50 ORDER No. VP102

LOW COST CUTTERS/PLIERS – SPECIAL DRIVERS

Miniature round nose cutters – insulated handles 4½ inch length. Order No. YO43.

Miniature long nose pliers – insulated handles 5½ inch length. Order No. YO44.

Miniature bend nose pliers – insulated handles 5½ inch length. Order No. YO45.

Miniature end nippers – insulated handles 4½ inch length. Order No. YO46.

Miniature snipe nose pliers with side cutter and sorrated jaws – insulated handles 5 inch length. Order No. YO42.

FLEXY DRIVER
A flexible shaft screwdriver for those awkward to get at screws. Overall length 8¾ inch. Order No. FS-1 Flat blade 4mm FS-2 Cross point No. 1 **£1.75 each.**

GRIP DRIVER
8 inch long screwdriver with spring loaded grip on and to hold screws in position while reaching into those difficult places.
Order No. SD-1 Flat blade 4mm
SD-2 Cross point No. 1 **£1.20 each.**

ALL AT **£1.55** each

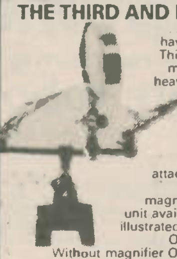
ANTEX SOLDERING IRONS

MODEL		O/NO.	PRICE
SX	25 watt	1931	**£5.40**
CX230	17 watt	1972	**£5.30**
CX250	15 watt	1948	**£5.20**

ANTEX ST4 IRON STAND
Chromium plated steel spring – in plastic base insulated, with wiper pad. O/No. 1939 **£1.75**

PORTABLE SOLDERING IRON
12vlt. 25 watt. Works from car battery. 2 core cable with heavy duty croc clips. O/No. 1971 **£5.60**
Ideal outdoor motorist, boat, caravan-owner. SK1 SOLDERING KIT – for miniature work. Kit consists of: 1–15w iron (C240) 3 bits: 3.32", 5/32", 3/16". Solder & heat shunt + Booklet "How to Solder". O/No. 1938 **£8.00**

THE THIRD AND FOURTH HAND

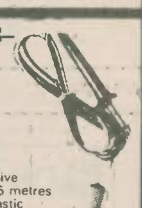


... you always need but have never got until now. This helpful unit, with rod mounted horizontally on heavy base, crocodile clips attached to rob ends. Six ball & socket joints give infinite variations and positions through 360° also available attached to rod, 1 2½" dia. magnifier giving 2.5x magnification. Helping hand unit available with magnifier as illustrated.
ORDER NO. T402 **£5.50**
Without magnifier ORDER NO. T400 **£4.75**

UNIVERSAL STAND

A combined Third & Fourth Hand with magnifier and Soldering Iron Stand, all in one unit. *A must for all who solder and need hands free!* O/No. 403 **£5.50**

BI-PAK SOLDER–DESOLDER KIT



Kit comprises: O/No. VP80
1 High-Quality 25 Watt General Purpose Lightweight Soldering Iron 240v mains incl. 3/16" (4.7mm) bit. 1 Quality Desoldering Pump High Suction with automatic ejection. Knurled anti-corrosive casing and Teflon nozzle. 1.5 metres of De-Soldering braid on plastic dispenser. 2 yds (1.83mm) Resin Cored Solder on Card. 1 Heat Shunt too tweezer Type.
Total Retail Value over £12.00.
OUR SPECIAL KIT PRICE £9.95

AUTOMATIC WIRE STRIPPER

Will clamp 5 different sizes of wire, strip and remove the insulation in one single operation. Accepts wires of dia., 1mm, 1.6mm, 2mm, 2.6mm and 3.2mm. Has hardened steel cutting surfaces, spring loaded insulated handles. O/No. 1997 **£5.45**

BA BOX SPANNER SET

Contains one of each size: 0BA, 2BA, 4BA, 6BA, 8BA. Fixed Chrome Vanadium Steel Shaft in Plastic Handle. O/No. 2057 **£4.00**

DESOLDERING PUMP

High suction pump with anti-corrosive casing & Teflon nozzle. O/No. 1936 **£4.50**
Spare nozzle. O/No. 1937 **50p**

CRIMPING SET

A crimping tool set consisting of a crimping tool suitable for insulated terminals. Supplied with 34 assorted terminals in a plastic tray with hinged, transparent lid. O/No. 1966 **£3.75**

PICK-UP TOOL

Spring-loaded "Pearl grip" pick-up tool for small components. Four fingers extend to 14mm dia. when plunger is pressed and close up when retracted. Chrome metal. Pocket clip. O/No. VP139 **£1.75**

IC EXTRACTION TOOL

IC Extraction is made relatively easy with this tool. The IC is held by specially designed teeth. O/No. 2015 **50p**

MAINS NEON TESTER/DRIVER

Has strong transparent handle with insulated screwdriver blade & pen type pocket clip – rated at 500v max. Length 140mm (5½"). O/No. 2016 **55p**

SUB-BOX

A neat swivelling disc provides close tolerance substitution resistors of 36 preferred values from 5 ohms to 1Kohm. Simply fix clips into circuit and swivel until optimum result is achieved. O/No. VP112 **£4.75**

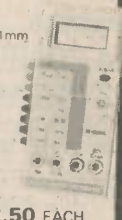
BATTERY TESTER

Tests all types of battery including standard, NICAD, Alkaline, etc. Takes all standard sizes including 6V lantern batteries and watch/hearing aid cells. Also tests fuses and lamps by means of internal 9V (PP3) battery. Can also be used to recharge NICAD batteries by means of external 3-12V d.c. power supply (not included). Dims. 185 × 103 × 30mm (approx.). Full instructions provided. O/No. VP101 **£7.00**

POWER SUPPLY

Power supply fits directly into 13 amp socket. Fused for safety. Polarity reversing socket. Voltage switch. Lead with multi plug input – 240V AC 50Hz, Output – 3, 4, 5, 6, 7.5, 9 & 12V DC Rating – 300ma MW88. O/No. 137 **ONLY £3.75**

BRAND NEW LCD DISPLAY MULTITESTER



RE 188m
LCD 10 MEGOHM INPUT IMPEDANCE
• 3½ digit • 16 ranges plus hFE test facility for PNP and NPN transistors • Auto zero, auto polarity • Single-handed, push-button operation • Over range indication • 12.5mm (½-inch) large LCD readout • Diode check • Fast circuit protection • Test leads, battery and instructions included.

Max. indication	1999 or −1999
Polarity indication	Negative only. Positive readings appear without − sign
Input Impedance	10 Megohms
Zero adjust	Automatic
Sampling time	250 milliseconds
Temperature range	5 C to 50 C
Power Supply	1 × PP3 or equivalent 9V battery
Consumption	20mW
Size	155 × 88 × 31mm

RANGES
DC Voltage 0-200mV
0-2-20-200-1000V. Acc. 0.8%
AC Voltage 0-200-1000V
Acc. 1.2% DC Current 0-200uA
0-2-20-200mA, 0-10A. Acc. 1.2%
Resistance 0-2-20-200k ohms
0-2 Megohms. Acc. 1%
BI-PAK VERY LOWEST PRICE
£45.00 each
Leather case for 188m **£2.50** EACH

MULTITESTER

1,000 opv including test leads & Battery
AC volts – 0-15-150-500-1,000
DC volts – 0-15-150-500-1,000
DC currents – 0 1ma-150ma
Resistance – 0-25 K ohms 100 K ohms
Dims – 90 × 61 × 30mm
O/No. 1322 OUR PRICE **£6.80** ONLY

HT320 MULTITESTER

Facilities for testing transistors. Mirror Scale, leads and batts.

SPEC.

DC Volt:	20,000 O.P.V
AC Volt:	8,000 O.P.V
DC Volt:	0-0.1-0.5-2.5-10-50-250-1000v
AC Volt:	0-10-50-250-1000v
DC Current:	0-50uA-2.5mA-25mA-0.25A
Resistance:	2K-20K-2M-20M Ohms
AF Output: (dB)	-10dB to + 22dB for 10v AC
	As a Trans Tester tests Leakage, Current (Iceo), DC Current, Amplification, Factor (Hfe)
Dims:	146 × 95 × 55mm

Order No. 1323 **£15.40**

BI-PAK PCB ETCHANT AND DRILL KIT

Complete PCB Kit comprises
1 Expo Mini Drill 10,000RPM 12V d.c. incl. 3 collets & 3 × Twist Bits
1 Sheet PCB Transfers 210mm × 150mm
1 Etch Resist Pen
1 ½lb pack FERRIC CHLORIDE crystals
3 sheets copped clad board
2 sheets Fibreglass copper clad board
Full instructions for making your own PCB boards
Retail Value over £15.00
ORDER NO. VP81
OUR BI-PAK SPECIAL KIT PRICE
£9.95

RATCHET SCREWDRIVER KIT

Comprises 2 standard screwdriver blades 5 & 7mm size, 2 cross point size 4 & 6. 1 Ratchet handle 5-in-1 Kit. O/No. 329B **£1.45 each.**

BI-PAK

Send your orders to Dept PW9 BI-PAK PO BOX 6 WARE, HERTS
SHOP AT 3 BALDOCK ST. WARE, HERTS
TERMS CASH WITH ORDER. SAME DAY DESPATCH. ACCESS. BARCLAYCARD ALSO ACCEPTED. TEL (0920) 3182. GIRO 388 7006
ADD 15% VAT AND 75p PER ORDER POSTAGE AND PACKING

Use your credit card. Ring us on Ware 3182 NOW and get your order even faster. Goods normally sent 2nd Class Mail.
Remember you must add VAT at 15% to your Total order.
Postage add 75p per Total order.

Sequential Logic Techniques Part 5

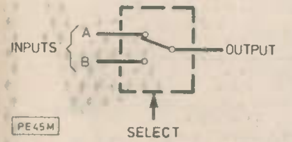
M.TOOLEY BA and D.WHITFIELD MA MSc C Eng MIEE

LAST month we carried out a detailed investigation of the operation of a universal shift register. This month we shall turn our attention to another device which finds a wide range of applications in the digital world, the data multiplexer.

Data multiplexers, or data selectors as they are sometimes known, generally have one output and several inputs. Any one of the inputs can, by placing appropriate logic levels on its control inputs, be routed to its output. Data multiplexers thus provide us with a means of sending several different digital signals along a common signal line.

In essence the data multiplexer acts as a multi-way switch however, by virtue of its internal logic and unlike its conventional analogue counterpart, the device will only operate with digital signals.

The switch equivalent of the simplest form of data multiplexer is shown in Fig. 5.1. This two-way arrangement



SELECT	OUTPUT
0	A
1	B

Fig. 5.1. Simplified switch equivalent of a two-way data multiplexer

is equivalent to a single-pole double throw (SPDT) logic switch. The two switch states are controlled by means of a third select input. When a logic 0 appears on the SELECT input the switch moves to position A whereas, when a logic 1 appears on the SELECT input the switch moves to position B.

The internal logic of the two-way data multiplexer is shown in Fig. 5.2.

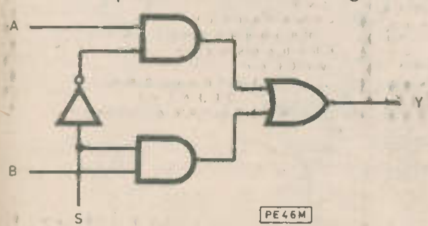


Fig. 5.2. Logic arrangement of a two-way data multiplexer

This simply consists of two two-input AND gates, a two-input OR gate and an inverter. The truth table for this arrangement is given in Table 5.1. As

A	B	S	Y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1

Table 5.1. Truth table for simple two-way data multiplexer

can be seen, whenever the SELECT input is at logic 0 the output, Y, takes the state of the A input wheras, when the SELECT input is at logic 1, the output takes the state of the B input.

By grouping together the states for which the output remains unaffected by one or other of the inputs (we shall, for obvious reasons, call these the "don't care" states!), the truth table of the two-way multiplexer can be reduced to that shown in Table 5.2.

A	B	S	Y
0	x	0	0
1	x	0	1
x	0	1	0
x	1	1	1

x = **don't care**

Table 5.2. Simplified version of table 5.1

This truth table shows rather more clearly than its predecessor how the SELECT input operates; the X's in the truth table being used to denote the "don't care" states.

The switch equivalent of a four-way data multiplexer is shown in Fig. 5.3.

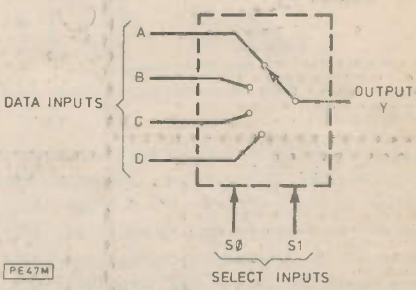


Fig. 5.3. Simplified switch equivalent of a four-way data multiplexer

Here the output, Y, can be connected to any one of the four data input lines, A to D, by means of an appropriate input on the two select lines, S0 and S1. The truth table for the four-way data multiplexer is shown in Table 5.3. The corresponding Boolean expressions are:-

Output	Select Inputs
Y = A	$\overline{S0} . \overline{S1}$
Y = B	$\overline{S0} . S1$
Y = C	$S0 . \overline{S1}$
Y = D	$S0 . S1$

We shall now investigate the operation of a practical four-way data multiplexer, the 74LS153.

DATA INPUTS				SELECT INPUTS		OUTPUT
A	B	C	D	SØ	S1	Y
0	x	x	x	0	0	0
1	x	x	x	0	0	1
x	0	x	x	0	1	0
x	1	x	x	0	1	1
x	x	0	x	1	0	0
x	x	1	x	1	0	1
x	x	x	0	1	1	0
x	x	x	1	1	1	1

x = **don't care**

Table 5.3. Truth table for a four-way data multiplexer

THE 74LS153

The 74LS153 contains two four-way data multiplexers which have common select inputs. The pin connections of the 74LS153 are shown in Fig. 5.4. The two halves of the device

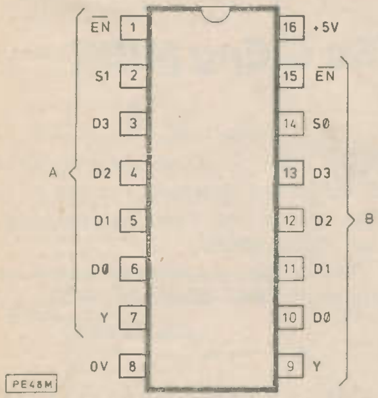


Fig. 5.4. Pin connections for the 74LS153

(referred to as A and B) are conveniently brought out to pins on opposite sides of the package; the A-side using pins 1 to 7 whilst the B-side uses pins 9 to 15. Supply connections, using the conventional pins 8 (0V) and 16 (+5V), are common to both halves of the device.

Each half of the 74LS153 has its own active low enable, EN, input. When these inputs are taken to logic 1 the corresponding outputs immediately go to logic 0 irrespective of the state of any of the data (D0 to D3) or select (S0 and S1) inputs.

The internal logic of the 74LS153 is shown in Fig. 5.5. This clearly shows how the EN inputs are gated with the select, inverted select, and data inputs at each of the four four-input AND gates on both sides of the device. The outputs of each set of AND gates are then combined in a four-input OR gate. The 74LS153 is effectively nothing more complex than a two-pole four-way switch!

The complete truth table for the 74LS153 is shown in Table 5.4. This truth table is, of course, identical for each half of the device. When both select inputs (S0 and S1) are at logic 0, the output (Y) reflects the state of the D0 input. With S0 at logic 1 and S1 at logic 0, the output takes the state of the D1 input, and so on.

The circuit used for our practical investigation of the 74LS153 data multiplexer is shown in Fig. 5.6. It should

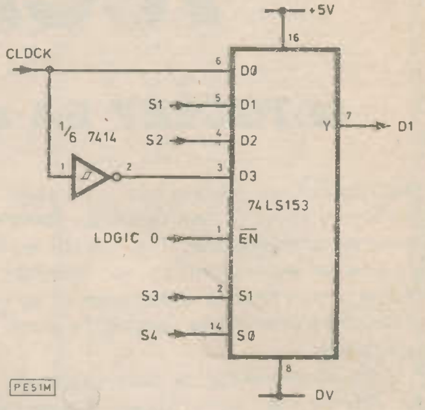


Fig. 5.6. Practical arrangement used to demonstrate the action of the 74LS153

SELECT INPUTS		DATA INPUTS				ENABLE	OUTPUT
SØ	S1	DØ	D1	D2	D3	EN	Y
×	×	×	×	×	×	1	0
0	0	0	×	×	×	0	0
0	0	1	×	×	×	0	1
1	0	×	0	×	×	0	0
1	0	×	1	×	×	0	1
0	1	×	×	0	×	0	0
0	1	×	×	1	×	0	1
1	1	×	×	×	0	0	0
1	1	×	×	×	1	0	1

× = **don't care**

Table 5.4. Truth table for the 74LS153 data multiplexer

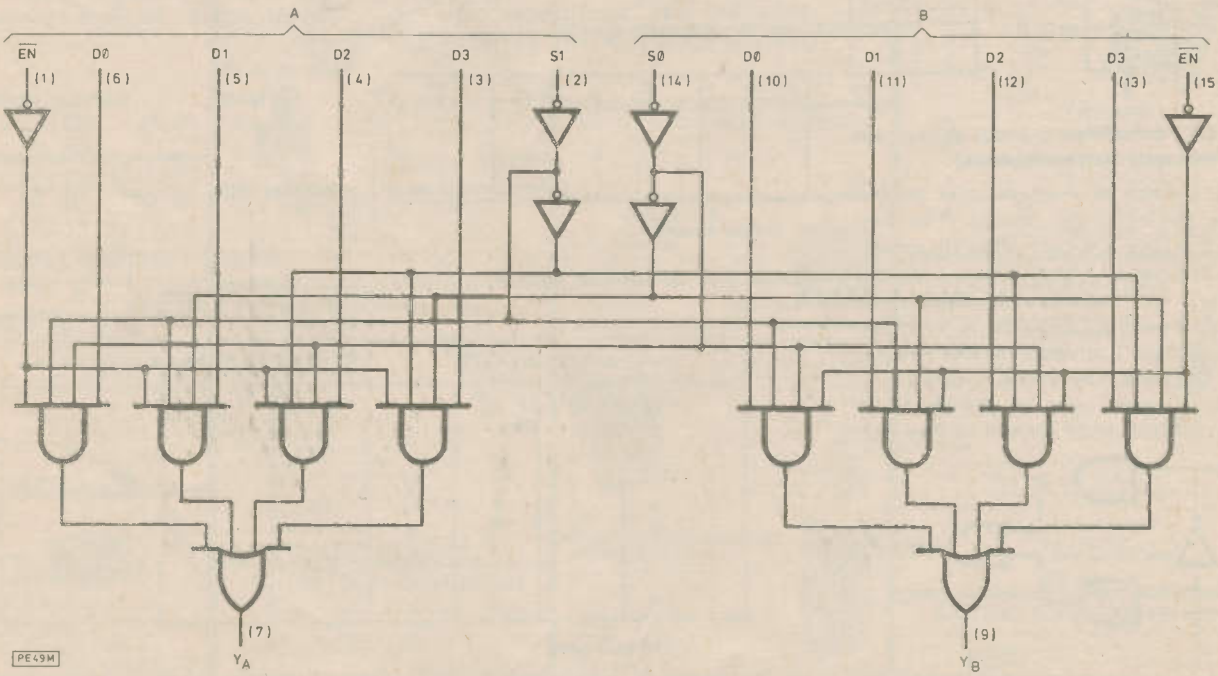


Fig. 5.5. Internal logic of the 74LS153

be noted that only one half of the device is used. In order to provide four different data inputs which may be readily distinguished from one another, D0 is fed from the clock whilst D1 and D2 are fed from the Logic Tutor's momentary push buttons, S1 and S2 respectively. The remaining data input, D3, is fed from an inverted clock signal derived from a 7414 inverter. The relevant half of the device is enabled by hard wiring the $\overline{EN}$ input to logic 0 whilst the two latching Logic Tutor switches, S3 and S4, are used to determine the state of the select inputs, S1 and S0 respectively.

The 7414 should be inserted into socket D whilst the 74LS153 should be inserted into socket E with the usual orientation convention (pin-1 of each device to the respective connection marked on the Logic Tutor PCB) being observed. The following links are required:-

D1	to clock	
D2	to E3	(data input D3)
D7	to 0V	(common)
D16	to +5V	(supply)
E1	to logic 0	(active low enable)
E2	to S3	(select input S1)
E4	to S2	(data input D2)
E5	to S1	(data input D1)
E6	to clock	(data input D0)
E7	to D1	(D1 indicates the output)
E8	to 0V	(common)
E14	to S4	(select input S0)
E16	to +5V	(supply)

(A total of 13 links)

The select inputs should initially both be set to logic 0 by appropriate adjustment of S3 and S4. The output indicator, l.e.d. D1, should then be seen to flash 'on' and 'off' in sympathy with the clock which is connected to the D0 input line.

S4 should now be adjusted to produce a logic 1 on the S0 line whilst S3 remains at logic 0. In this condition the l.e.d. will stop flashing and become extinguished. Now depress S1 to produce a logic 1 on the D1 input. The l.e.d. will become illuminated whilst S1 is held down and will become extinguished again when S1 is released.

S3 and S4 should now be adjusted to produce logic 1 and logic 0 on the S1 and S0 select inputs respectively. S2 should now be depressed to produce a logic 1 on the D2 input. The l.e.d. input will become illuminated for as long as S2 is held down.

Finally, S4 should be adjusted to produce a logic 1 input whilst S3 remains at logic 1. In this condition D1 should be seen to flash 'on' and 'off' in sympathy with the inverted clock. (i.e. when the clock l.e.d. is 'on', the output l.e.d. is 'off', and vice versa). We can summarise these observations as shown in Table 5.5.

SELECT INPUTS S1 (S4)	S0 (S3)	OUTPUT (D1)
0	0	D0 (CLOCK)
0	1	D1 (S1)
1	0	D2 (S2)
1	1	D3 $\overline{\text{(CLOCK)}}$

Table 5.5. Outputs provided by the circuit of Fig. 5.7. (Note: brackets indicate Logic Tutor functions)

A PRACTICAL APPLICATION OF THE 74LS153

We shall now turn our attention to a simple practical application of the 74LS153 four-way data multiplexer. Let's assume that we wish to provide digital selection of the output frequencies of a four-stage binary counter. The four Q outputs of the binary counter can be fed to the four data inputs of the multiplexer whilst the two select inputs are fed with a two-bit control signal.

The circuit of a suitable arrangement is shown in Fig. 5.7. IC1a forms a simple relaxation oscillator in which the output frequency is determined by the time constant, C×R. IC1b forms an inverting buffer, the output of which is a rectangular pulse wave having a duty cycle of approximately 1:2 and a frequency of approximately 32Hz. This signal is then fed to the CLOCK input of IC2, a 7493 four stage binary counter. In order to enable the normal counting sequence, the two master reset inputs, MR1 and MR2, are taken to logic 0 and the four Q outputs then have frequencies of 16Hz, 8Hz, 4Hz and 2Hz approximately.

The 7414 and 74LS153 devices should be left in sockets D and E whilst the 7493 should be inserted in socket B checking, as usual, that pin-1 aligns with B1. The following links should then be made:-

B1	to B14	
B2	to B3	
B3	to logic 0	
B5	to +5V	(supply)
B10	to E4	
B11	to E5	
B12	to 0V	(common)
B13	to E3	
B14	to E6	
B16	to D4	
D1	to logic 0	(via a 47µF 25V cap)
D1	to D2	(via a 470 ohm 0·25W)
D2	to D3	
D7	to 0V	(common)
D16	to +5V	(supply)
E1	to logic 0	
E2	to S3	
E7	to D1	(D1 shows o/p freq.)
E8	to 0V	
E14	to S4	
E16	to +5V	(supply)

(A total of 20 links and 2 components)

The two select inputs should first be set to logic 0 using S3 and S4. The output indicator (l.e.d. D1) should then be seen to flash rapidly 'on' and 'off' with a frequency of approximately 16Hz. The three other possible settings of S3 and S4 should then be tested.

NEXT MONTH: De-multiplexers and time domain multiplexing.

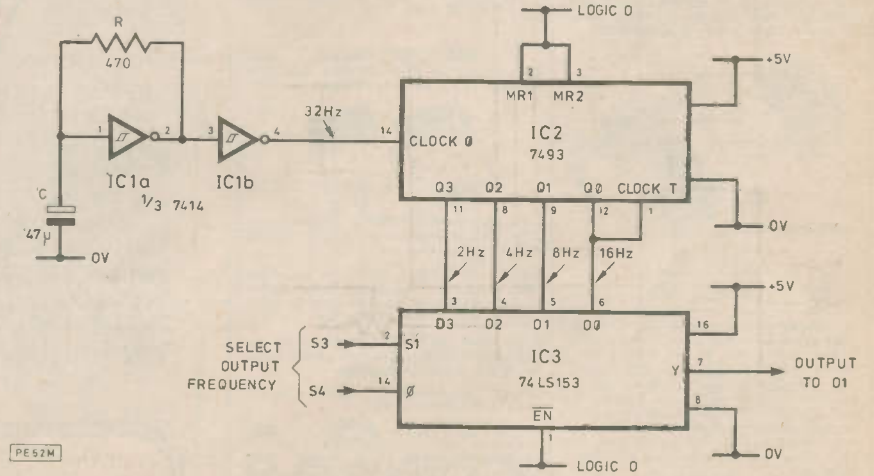


Fig. 5.7. Simple application of the 74LS153

Mono/Stereo Chorus & Flanger

JOHN M.H.BECKER PART TWO

THE clock signal that causes the delay chips to sample and transfer their charges from stage to stage is produced by IC9 (Fig. 6). This is a standard linear voltage controlled oscillator chip that produces a squarewave output the frequency of which is related to the value of C24, the current through VR9, and the voltage present on pin 9. The single output from IC9 needs to be split into two opposing phases as required by the delay chips. If a normal phase split were to be given then the opposing edges of the antiphase square waves would coincide. This overlap is prone to causing system noise from the delay chip outputs even though the TDA1097 is basically a low noise device, capable of a 77dB signal-to-noise ratio at a 100kHz clock frequency, though this degrades slightly with lower clock rates. The overlap on the edges of the clock is eliminated by the flip flop stage IC10 in conjunction with the NAND gates IC11a–b. C25 and R83 slow down the mutual triggering of the flip flop and gates, resulting in a twin phase output having a short delay between the respective squarewave edges. Oscillograms Fig. 7a to 7c show the 'with' and 'without' effect of the overlap elimination.

Varying the voltage applied to pin 9 of IC9 varies the clock frequency. For the automatic modulation of the clock a constantly varying voltage is produced by the low speed triangle wave oscillator around IC8a–b, and having a frequency governed by the resistance of VR7 and the value of C22. (Oscillogram Fig. 8.) Decreasing either increases the output frequency. The modulation can be switched in and out by S4, and the level varied from nil to full by the depth control VR8. C23 slightly rounds off the triangle peaks at faster modulation speeds. The modulating frequency range is controllable between about 50 milliseconds and 30 seconds, the clock frequency range is between about 12kHz and 100kHz. For a single delay chip the delay time range is thus about 64ms to 7·68ms, cascading two delays doubles the delay times. With the modulating oscillator switched out of circuit the unit can of course be used as a standard reverb or short-echo unit, though these effects will not be so pronounced as those obtainable with the *September 1984 PE Echo-Reverb* unit.

POWER SUPPLY

The unit has been designed to operate from two 9 volt batteries producing +9V/0V/−9V, and drawing between 13mA and 20mA, depending on the clock oscillator rate. IC2 and IC3 though do not like a total voltage drop across them in excess of 16V, which also means that controlling voltages must not exceed this either. The positive voltage delivered to IC2, 3, 9, 10 and 11 is thus reduced to a more suitable level by the drop across the resistor R62 in the delay line bias divider network. The voltage at R62 is within limits with all i.c.s in circuit, but may rise if any of the said 5 are not in their sockets when power is applied. IC9–11 will not mind, but IC2 and 3 may object. The unit may be operated from a stabilised power supply if preferred. The acceptable range is from +5V/0V/−5V to +9V/0V/−9V. If it is necessary to run from a power supply greater than +9V/0V/−9V then two voltage regulator devices should be inserted between the power supply and the unit as shown in Fig. 9. The voltage drop across the regulators must be greater than 2V, and R62 may be replaced by a link wire.

CONSTRUCTION

The component layouts for both boards are shown in Figs. 10 and 11. The short link wires on the p.c.b.s can be made from resistor cut-off leads shaped to the correct spacing with thin nosed pliers. Sockets should be used with all i.c.s. The wiring diagram for the unit is shown in Fig. 13. Bring the

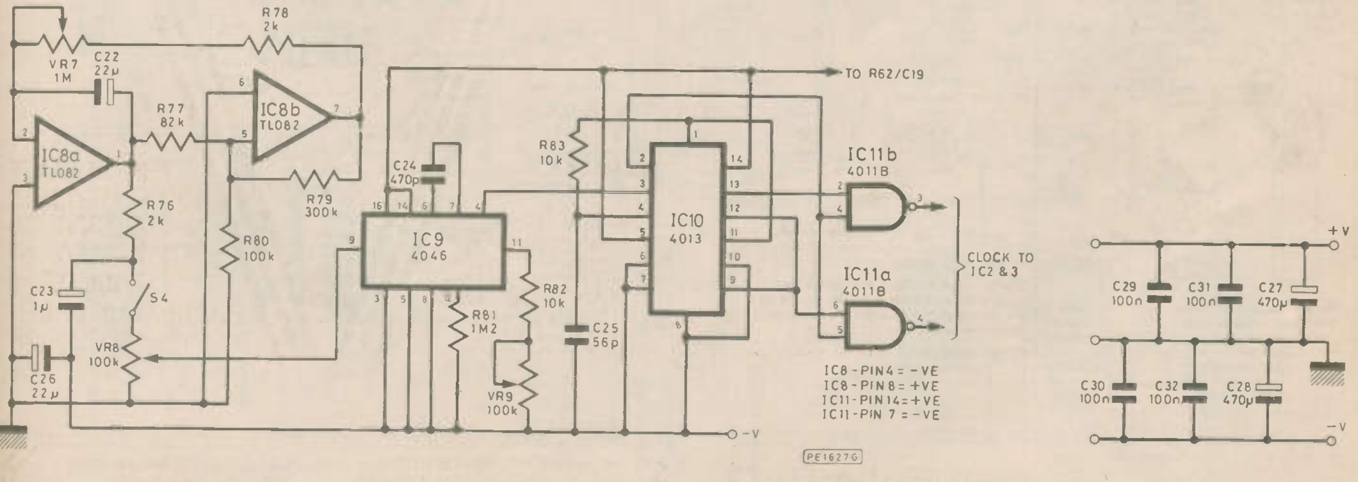


Fig. 6. Circuit diagram of the Clock Circuit

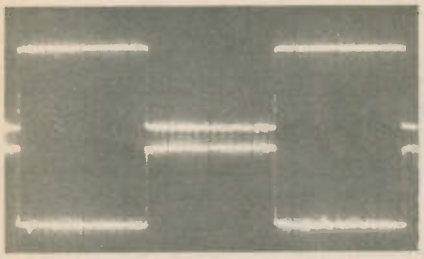


Fig. 7a. Usual appearance of two square-waves without overlap removal

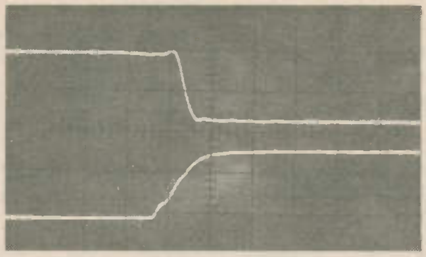


Fig. 7b. Close up of overlap

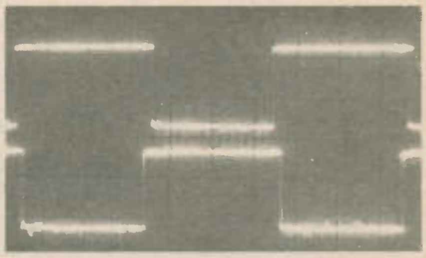


Fig. 7c. Accentuated overlap removal as used in unit

Fig. 7. Clock edge overlap of two anti-phase square-waves

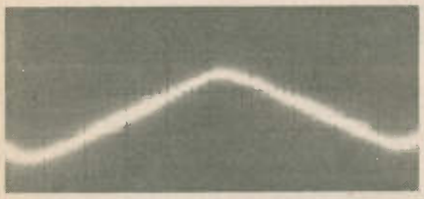


Fig. 8. Modulation oscillator waveform

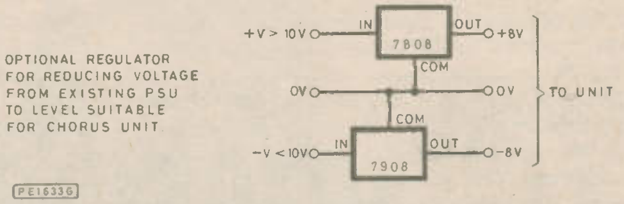


Fig. 9. Optional regulator circuit

connecting wires neatly around the edges of the p.c.b.s to the controls. The clock leads to IC2 and IC3 should be brought forward past C19, turn left at the front panel, then along to the small p.c.b., turn right and connect. Do not take them on what appears to be the shorter route across the main p.c.b. as this would direct them across some parts that might pick up any stray radiation signal. Unless you have the eyes of an eagle, thoroughly check all the p.c.b. joins with a magnifying glass. Only after all checking has been done should the i.c.s be inserted into their sockets, remembering that IC2, 3, 7, 9, 10 and 11 are MOS devices and require the normal handling precautions. The main point being to keep yourself and equipment free of static electricity by touching a grounded source before handling them.

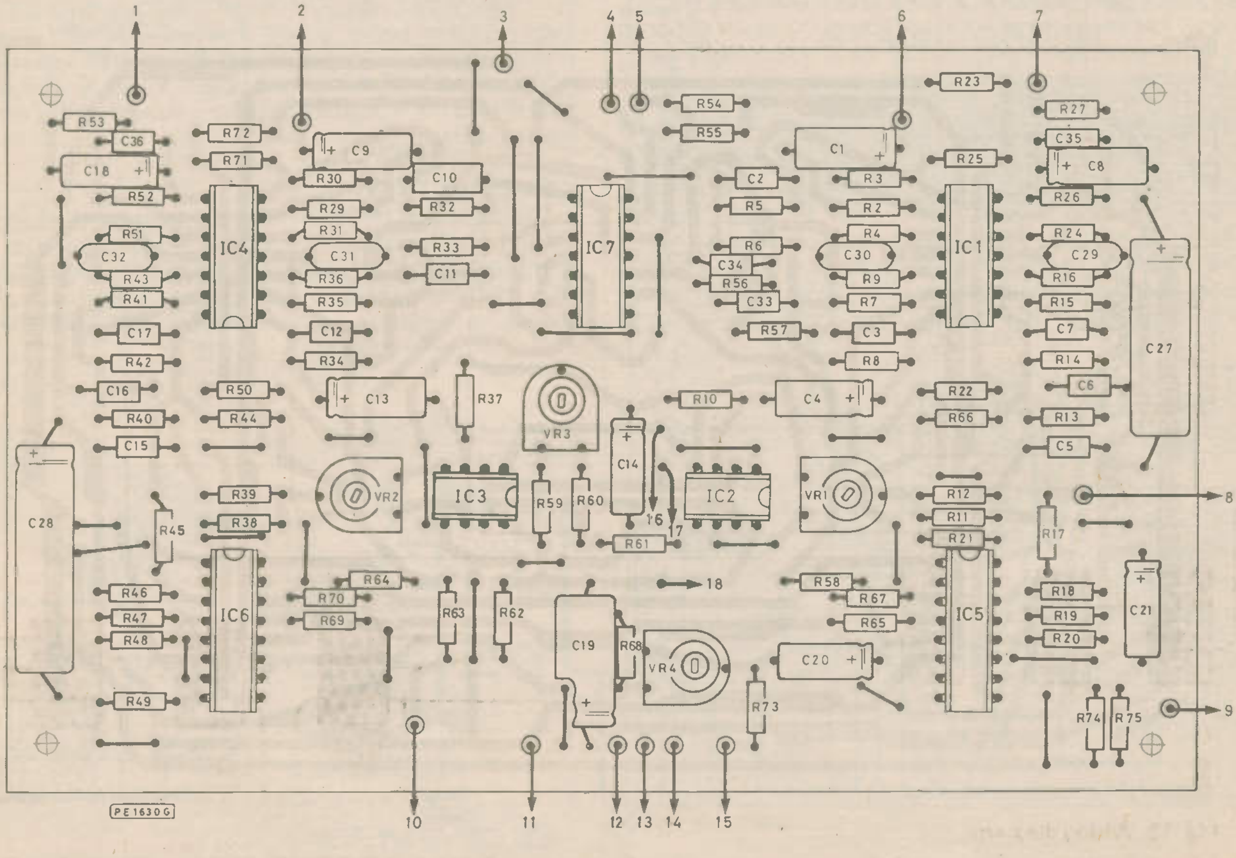


Fig. 10. Component layout of the Main Board

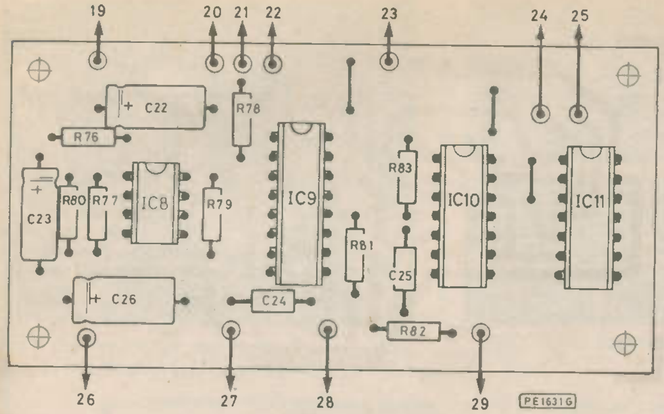


Fig. 11. Component layout for the Clock Board

SETTING UP

This is quite straightforward and specialised equipment is not needed. First, VR1 to VR3 midway, VR4 max resistance (anticlockwise), VR5 and VR6 min, VR7 to VR9 max, S1 to S4 off. Plug in a music signal from a prerecorded source into the X1 socket. Check that the output level reaching the main amplifier used is the same as the original. Switch on S3 enabling the VCA, and bringing up VR6 a change in amplitude and tonal quality should increase. Rotating the clock oscillator speed control VR9 to its maximum resistance will slow down the delay and emphasise the double tracking effect. This will be more apparent with staccato sounds rather than mellow drawn out notes. Adjust VR3 around its midway point until minimum waveform distortion is heard, which will also coincide with the best delay effect. If an oscilloscope is available, the waveform balance will be obvious when monitoring the output at VR1 and VR2 in the presence of a strong input signal. (Oscillograms Figs. 12a and 12b.)

Switch on S4 bringing in the sweep modulator. Varying VR8 will vary the modulation depth, and VR7 will vary the modulation rate. Switch off S4, reset VR9 to slowest clock speed, VR6 to maximum level, switch on S2 for feedback enabling. Slowly bring up VR5 and a hollowness to the signal should come in. Maximise VR5 and carefully reduce the resistance of VR4 until the circuit almost goes into full feedback howl. If howl occurs, sharply

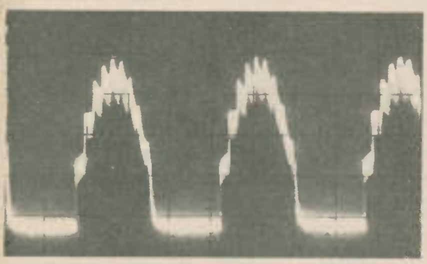


Fig. 12a. Sine-wave with VR3 unbalanced but VR1 correct

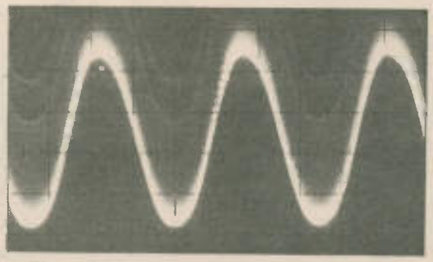


Fig. 12b. Sine-wave with both VR1 and VR3 correct

Fig. 12. Traces seen at the wiper of VR1

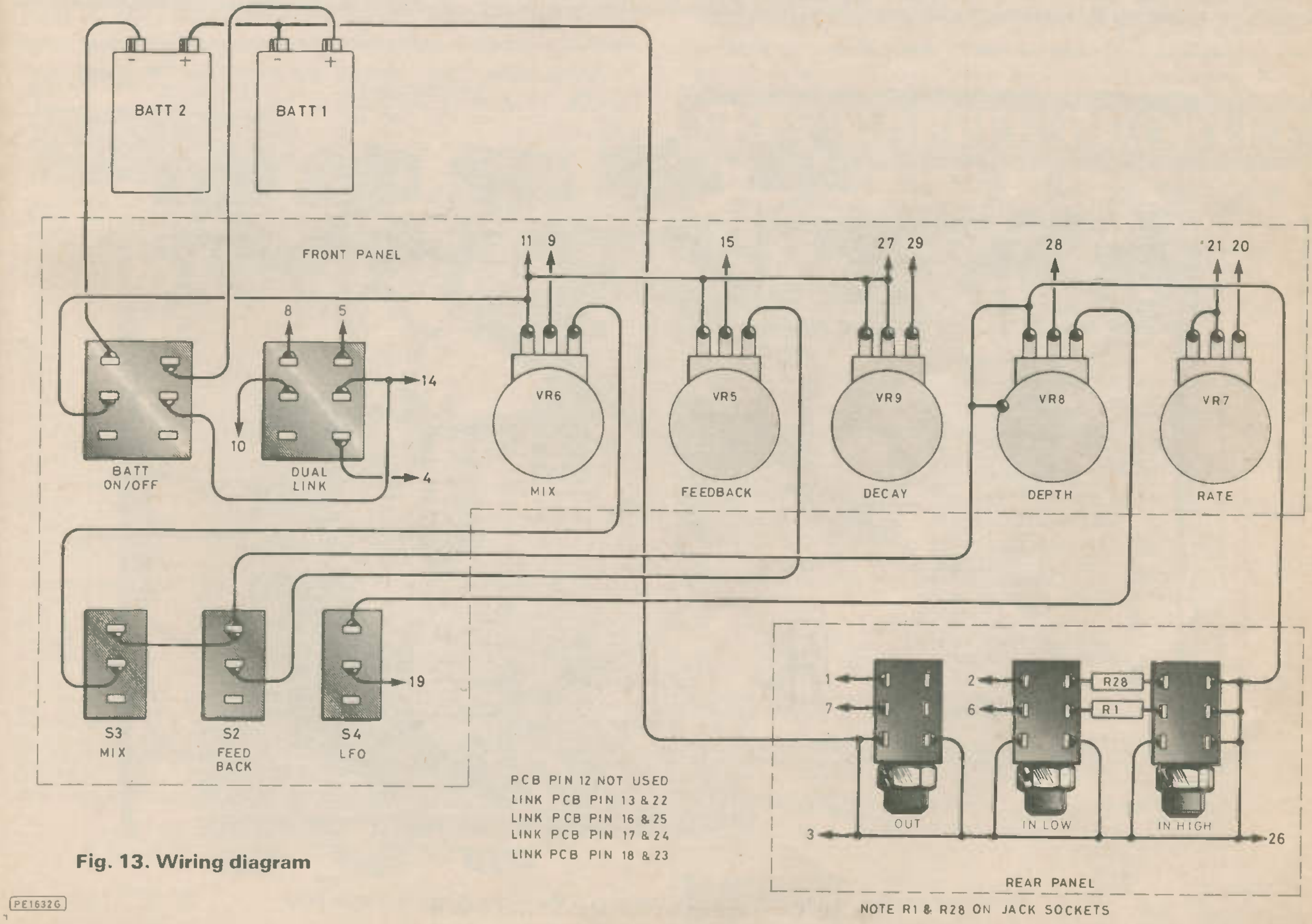


Fig. 13. Wiring diagram

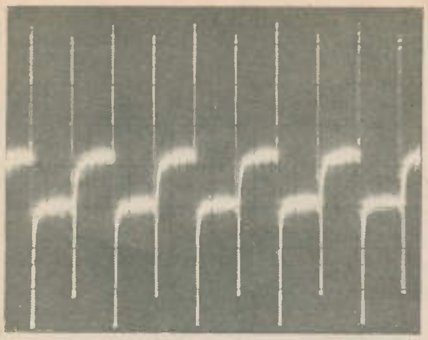


Fig. 14a. Clock residual with VR1 unbalanced (no signal)

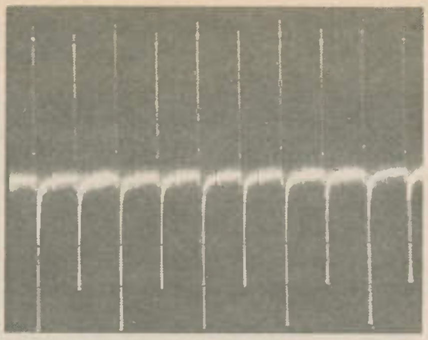


Fig. 14b. Clock residual with VR1 balanced (no signal)

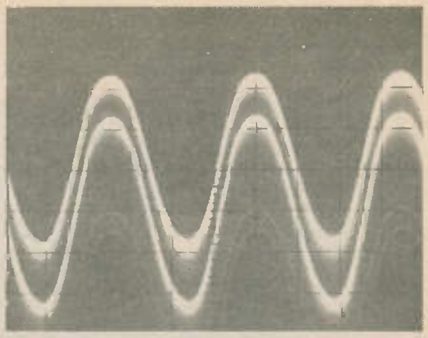


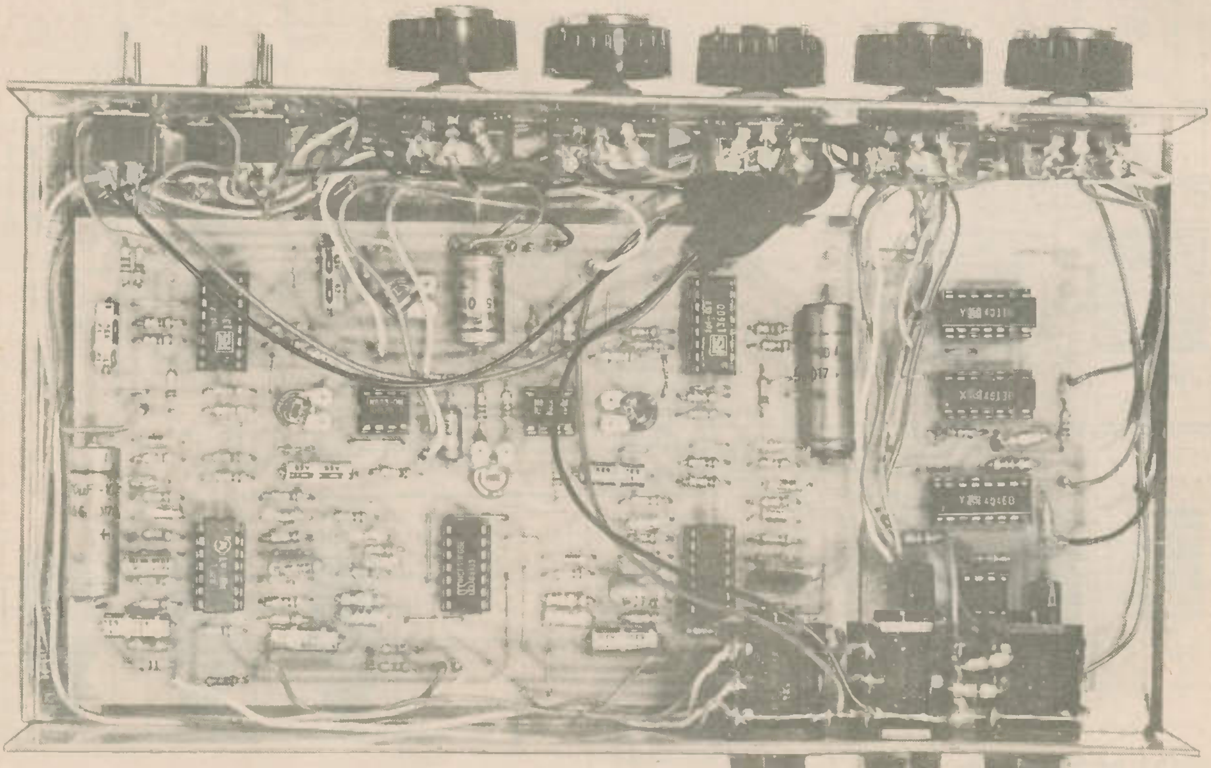
Fig. 14c. Sine-wave signal with VR1 unbalanced but VR3 correct

Fig. 14. Traces seen at the wiper of VR1

reduce VR4 and start again. Aim for the closest possible to the howl point. Howl is more likely to occur with strong bass notes. Switch on S1 to couple the two delay circuits in series and so produce the double emphasis. If necessary back off VR4 slightly as the increase in level may kick the circuit into howl again. If an oscilloscope is not available VR1 and VR2 should be left midway and ignored, otherwise adjust them for the best balance point of the residual clock frequency in the absence of an input signal. (Oscillograms Figs. 14a to 14c.) Switch on S4 and experiment with the various settings until familiar with the control options available, if necessary readjusting VR3 or VR4.

USE

There are no restrictions to the type of signal fed in provided that the amplitude is less than the distortion level, and that the type of music lends itself to enhancement within the factors discussed earlier and summarised below. It will soon become obvious which type of music requires which particular control setting for the best effect. This is a matter of personal preference, but the author feels that as with any effects unit, moderation is the keyword. Certainly overemphasis of an effect is dramatic, but it is easier to become tired of an over dramatic effect than one which produces a discrete change. In general terms music having a high harmonic content, but otherwise of a simple nature, will benefit most. Mellow or full orchestral sounds will not show the same degree of change. In the first case there is insufficient harmonic information available in the signal for the effect to fully develop. In the second case, the sound is already so full that the effect will probably be lost amongst the tonal complexity unless the original sound is full of spiky waveforms. The harsher sounds of voice, drums, harmonically rich synthesiser and organ music produce excellent effects as the waveforms involved are complex. Pure sine tones and muted waveforms, especially in the lower octaves, will be less apparent. For the chorusing effect a slower clock oscillator speed is preferable as the delay time is greater, for flanging, faster clock speeds are better as the phase shift occurs then at a more marked rate and spacing. ★

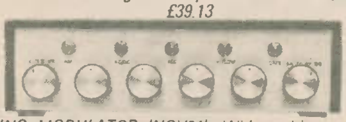


Photograph illustrating the internal details of the Chorus and Flanger Unit

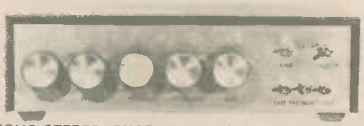
P.E. AUDIO EFFECTS AND OTHER SUPER SOUND KITS!

P.E. MONO-STEREO ECHO-REVERB (SEP84) 200ms echo, lengthy reverb, multi-tracking kit as published – BLK box: SET 218 £55.66

P.E. FILTER-SHIFT PHASER (OCT84). Enhanced Phasing with modulated filter shifting. Kit as published – BLK box: SET 226 £39.13



P.E. RING MODULATOR (NOV84). With multi-waveform VCO, Noise Gate & Auto-level Control. Kit as published – BLK box: SET 231 £39.99



P.E. MONO-STEREO CHORUS FLANGER (JAN85). Superb dual mode music enhancement. Kit as published – BLK box: SET 235 £55.66

BLK BOX – steel & aluminium, black plastic finish. STD BOX – plain aluminium, lipped lid.
SET codes include PCBs, parts, instructions, boxes, wire, solder.
More details & kits in catalogue – send S.A.E. (Overseas £1 or 5 IRC's).

	CODE	STD BOX	BLK BOX
BASS BOOST: Increases volume of lower octaves	SET 138B	£8.46	£11.46
BLOW BOX: Voice operated VCF & VCA for fascinating effects	SET 214	£24.33	£28.33
CHORUS (SIMPLE): Multiplied solo enhancement	SET 162	£31.40	£34.90
COMPRESSOR: Limits & levels maximum signal strength	SET 133	£10.86	£13.86
ENVELOPE SHAPER: Note triggered ADSR unit with VCA	SET 174	£17.15	£20.65
EQUALISER: Variable combinations of Low, Mid, Top & Notch	SET 217	£22.33	£25.83
EQUALISER: 10 Channels fully variable	SET 134	£37.83	£41.83
FADER: Voice operated with 5 response controls	SET 167	£14.21	£17.21
FLANGER (SIMPLE): Fascinating phased resonance effects	SET 153	£22.74	£26.24
FREQUENCY CHANGER: Tunable note & waveform modifier	SET 172	£34.46	£37.96
FREQUENCY DOUBLER: Guitar octave raiser & tone changer	SET 98	£9.80	£12.80
FUNKY-WOBULO: Modulates a singing voice	SET 149	£12.40	£15.40
FUZZ: Smooth distortion, retains attack & decay	SET 91	£10.57	£13.57
GUITAR OVERDRIVE: Heavy fuzz with selectable qualities	SET 56	£19.73	£23.23
GUITAR SUSTAIN: Extends note decay time, with noise gate	SET 222	£22.81	£25.31
GUITAR TO SYNTH INTERFACE: With voltage & trig outputs	SET 173	£32.87	£36.37
HAND CLAPPER: Auto & manual variable clap effects	SET 197	£22.69	£25.69
HEADPHONE AMP: 2 watts into phones or speaker, variable	SET 156M	£12.03	£15.53
JABBERVOX: Voice disguiser with reverb & tremolo	SET 150	£23.84	£27.34
METRONOME: With audio output & visual beat & downbeat	SET 143	£13.81	£16.81
MIC PRE-AMP: Variable again & switched tone response	SET 147	£7.13	£10.13
MIXERS: Several in catalogue			
MOCK STEREO: Splits mono signal into stereo simulation	SET 213	£19.87	£23.37
MULTIPROCESSOR: Flng, Rvb, Faze, Fuzz, Wah, Trem, Vib	SET 189	£57.14	£61.14
MUSIC MODULO: 8 variable tremolo & wah guitar effects	SET 196	£18.79	£21.79
MUSICAL CALL SIGN: Programmed call sign generator	SET 121	£12.91	£16.41
NOISE GATE: Reduces tape & system noise	SET 145	£9.97	£12.97
PHASER (SIMPLE): Auto & manual rate & depth controls	SET 164	£18.40	£21.90
REVERB: (SIMPLE) Mono/stereo, variable depth & delay	SET 203	£25.54	£29.54
RHYTHM GENERATOR: Computer driven, 9 drum effects	SET 185	£30.64	£34.64
RHYTHM GENERATOR: 15 pre-programmed rhythms, 9 effects	SET 170	£35.64	£39.14
ROBOVOX: Versatile robot type voice modifier	SET 165	£21.03	£24.53
SPEECH PROCESSOR: Clearer speech and level control	SET 110	£9.68	£12.68
STORMS EFFECTS: Auto & manual wind, rain & surf effects	SET 154	£15.86	£19.36
SWEEP GENERATOR: Auto sine wave 20Hz-15KHz, variable	SET 169	£16.41	£19.91
TOM-TOM SYNTH: Sound triggered, multivariable	SET 190	£15.05	£18.05
TONE CONTROL: Bass, mid, treble, gain & cut	SET 139	£13.17	£16.67
TREBLE BOOST: Increases volume of upper octaves	SET 138T	£8.13	£11.13
TREMOLO: Mono variable rate & depth modulation	SET 136	£9.71	£12.71
VOLTAGE CONTROLLED FILTER: 12dB, variable modes	SET 178	£17.02	£20.52
VOCODAVOX: Modular vocoder, 7 chans, extendable	SET 152	£64.31	£68.31
VODALEK: Robot type voice modulator	SET 155	£12.44	£15.44
VOICE OP SWITCH: Variable sensitivity & delay	SET 123L	£13.41	£16.41
WAH-WAH: Auto, manual & note triggered	SET 140	£17.26	£20.76

MAIL ORDER: Add 15% VAT & £1 P&P to all orders (overseas details in cat). Payment CWO, CHQ, PO, ACCESS, VISA. Details correct at press. E&OE. Despatch usually 10-14 days.

PHONOSONICS, DEPT PE52, 8 FINUCANE DRIVE, ORPINGTON, KENT, BR5 4ED.

Tel: Orpington 37821 (STD 0689, London 66), Mon-Fri 10-7.

ORIC AND SINCLAIR COMPUTERS

Oric 1 computer 48K £85 (£82) £92. Oric Atmos computer 48K £171 (£158) £168. Oric Colour Printer £134 (£123) £140. Sinclair flat screen TV (£113) (£105) £115. Sinclair Spectrum Plus Computer £182 (£176) £187. Sinclair QL Computer £406 (£385) £410. Sinclair Spectrum 48K £131 (£131) £143. Microdrive £51 (£50) £60. RS232 interface 1 £51 (£50) £60. Special offer:- Microdrive + Interface 1 + 4 cartridges £102 (£100) £120. Blank microdrive cartridges £5.50 (£6) £7. Standard floppy disc interface for Spectrum £102 (£92) £112. (See Cumana disc section for suitable disc drives). Fuller FDS keyboard for spectrum £52 (£52) £62. Fuller master unit £56 (£56) £62. Interface 2 £20.45 (£20) £24. 32K memory upgrade kit for 16K spectrum (issue 2 and 3 only) £31 (£28) £30. Spectrum Centronics printer interface £51 (£47) £52. ZX printer has been replaced by the Alphacom 32 £71 (£69) £82. 5 printer rolls (state whether Sinclair or Alphacom) £13 (£16) £21. ZX81 computer £45 (£44) £54. 16K ram packs for ZX81 £28 (£25) £30.

COMMODORE COMPUTERS

Commodore C16 Starter Pack £145 (£142) £162. Commodore Plus/4 £305 (£281) £301. Commodore 64 £222 (£215) £235. Convertor to allow most ordinary mono cassette recorders to be used with the Vic 20 and the Commodore 64: £9.78 (£9) £11. Bargain package:- cassette convertor + compatible cassette recorder £37 (£38) £44. Commodore cassette recorder £43 (£44) £50. Printer interfaces for Vic 20 and the Commodore 64:- Centronics £45 (£41) £46. RS232 £45 (£41) £46. Disc drive £233 (£209) £234. 1520 printer/plotter £165 (£149) £159. MPS801 Printer £235 (£220) £245. Light pen £29 (£29) £33.

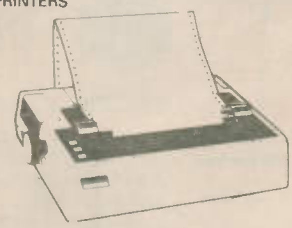
ACORN COMPUTERS

Electron £173 (£179) £199. BBC Model B £404 (£357) £387. Kenda double density disk interface system £149 (£131) £141. See below for suitable disc drives.

CUMANA DISC DRIVES

To suit disc interfaces of Sinclair spectrum, BBC B and Videogenie. Single:- 40 track single sided £176 (£158) £178, 40 tr double sided £218 (£195) £215), 80tr ss £207 (£186) £206. 80tr ds £234 (£209) 229. Dual:- 40tr ss £299 (£280) £320, 40tr ds £395 (£353) £393, 80tr ss £372 (£334) £374, 80tr ds £437 (£390) 430.

PRINTERS



Oki Microline 80 £138 (£135) £165. Brother HR5 £162 (£146) £170. Shinwa CTI CP80 £225 (£218) £248. Cannon PW1080A £332 (£299) £329. Epson RX80 £277 (£251) £282. Epson RX80F/T £314 (£286) £316. Epson FX80 £399 (£358) £388. Combined matrix printers and electric typewriters:– Brother EP22 £173 (£166) £186. Brother EP44 £258 (£235) £260. MCP40 Oric colour printer/plotter £134 (£123) £140. Interfaces to run the above printers from Vic and the Commodore 64 £45 (£41) £46. We can supply interfaces to run the above printers from Sharp computers £58 (£52) £55.

UK101, SUPERBOARD AND VIDEOGENIE

We still support these Computers. Write for our list.

COMPUTER REPAIRS

We offer a world-wide repair service. Write for a quotation.

SWANLEY ELECTRONICS
The Computer Export Specialists
Dept PE, 32 Goldsel Rd., Swanley, Kent BR8 8EZ, England.
Please allow 7 days for delivery.

Tel: Swanley (0322) 64851. *Official orders welcome. UK prices are shown first and include post and VAT. The second price in brackets is for export customers in Europe and includes insured air mail postage. The third price is for export customers outside Europe (including Australia etc) and includes insured airmail postage.*

FREE CAREER BOOKLET

Train for success, for a better job, better pay

Enjoy all the advantages of an ICS Diploma Course, training you ready for a new, higher paid, more exciting career. Learn in your own home, in your own time, at your own pace, through ICS home study, used by over 8 million already! Look at the wide range of opportunities awaiting you. Whatever your interest or skill, there's an ICS Diploma Course there for you to use. Send for your FREE CAREER BOOKLET today — at no cost or obligation at all.

GCE Over 40 'O' and 'A' Level subjects from which to choose. Your vital passport to career success. ☐

COMPUTER PROGRAMMING ☐	RADIO AMATEUR'S LICENCE ☐
ELECTRONICS ☐	INTERIOR DESIGN ☐
COMMERCIAL ART ☐	WRITING FOR PROFIT ☐
TV, RADIO & AUDIO SERVICING ☐	CAR MECHANICS ☐

BOOK-KEEPING & ACCOUNTANCY ☐

Please send FREE DETAILS for the course ticked above.

Name ____________________

Address ____________________

____________________ P.Code ______

ICS Dept. EDS 25
8 Elliot Place
Clydeway Centre
Glasgow G3 8EF

041 221 2926
or 01 622 9911
(all hours)

CACC

MICRO-BUS

and MICROPROMPT

ECONOMIC DIGITISER

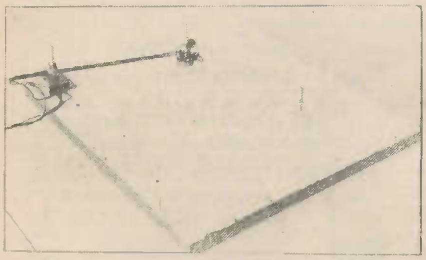
Sir—Here is a low cost, easy to make project for use with an X/Y plotter, that can be connected to the expansion interface of the UK 101, or virtually any other micro.

The *system* consists of a flexible arm, equipped with two linear potentiometers and a pointer. This pointer moves over a limited surface of 20 × 20cm. The voltages, generated by the movement are a measure of the position of the pointer. Those potentials cannot be used directly for X/Y plotting, because of their non-linear output.

A solution of that problem is found, by the application of the formula, which gives the relationship between X, Y and the angles of rotation V and H.

If now the analogue values of these angles are translated to digital, the calculation with a BASIC program becomes possible.

The BASIC program can be perceived as a limited loop with continuous conversion, so that the manual movement of the pointer can be digitally stored in memory. It permits also direct writing to a high resolution display.



Prototype digitiser

Table 1 shows a typical BASIC program for illustration, and the following notes apply:

5–30 Initialisation of the PIA (A and B) for input.

VIA (A and B) for output.

40–180 Loop for storing data in memory.

190–280 Loop for playback to X/Y recorder.

If the digitiser is used with the UK 101, it may be used with the PE–Expansion Interface published in Jan–July 1981.

I do not use the internal A/D and D/A converters, because I wanted a binary indication for the D/A output and also there is only one output in the interface. You will find the schematics joined.

The potentiometers must be of good quality and very linear. A resolution of approximately 2mm is possible on a surface of 20 × 20cm.

During storing in memory, the values of X and Y are continually displayed, and must be integer, positive and between 0 and 255.

The value of L (line 100) is a multiplication constant to certify an optimum sweep between 0 and 255.

The number 255 (line 110) is added to invert the value of Y, which is negative in this area.

Line 50 in the program is the number of points you wish to fix. The movement of the pointer shall not exceed 3cm/sec.

Line 255 defines the speed of playback, and

```
  5 REM : X/Y PLOTTING ROUTINE
 10 P=61340:Q=61342
 15 U=61344:W=61345
 17 POKEU+2,255:POKEW+2,255
 20 POKEP+1,0:POKEP,0:POKEP+1,255
 30 POKEQ+1,0:POKEQ,0:POKEQ+1,
    255
 40 INPUT "READY FOR START";A$
 45 R=5000:S=6000
 50 FOR N=1 TO 200
 60 POKEP+1,60:POKEP+1,52
 70 V=PEEK(P)/100
 80 POKEQ+1,60:POKEQ+1,52
 90 H=PEEK(Q)/100
100 L=150
110 Y=L*COS(V)+L*COS(V+H):Y=
    INT(Y)+255
120 X=L*SIN(V)+L*SIN(H+V):X=
    INT(X)
130 PRINT X,Y
140 POKER,X:POKES,Y
145 POKEU,X:POKEW,Y
150 R=R+1:S=S+1
160 NEXT N
180 PRINT"END OF LOOP"
190 INPUT"DO YOU WANT A
    PLAYBACK";B$
195 IF B$="Y" THEN 210
200 IF B$="N" THEN 40
210 R=5000:S=6000
220 FOR N=1 TO 200
230 X=PEEK(R):Y=PEEK(S)
240 POKEU,X:POKEW,Y
250 R=R+1:S=S+1
255 FOR D=1 TO 50:NEXT
260 NEXT N
270 PRINT"END OF PLAYBACK"
280 GOTO 190
```

Table 1. Suggested software for calculating the angular co-ordinates

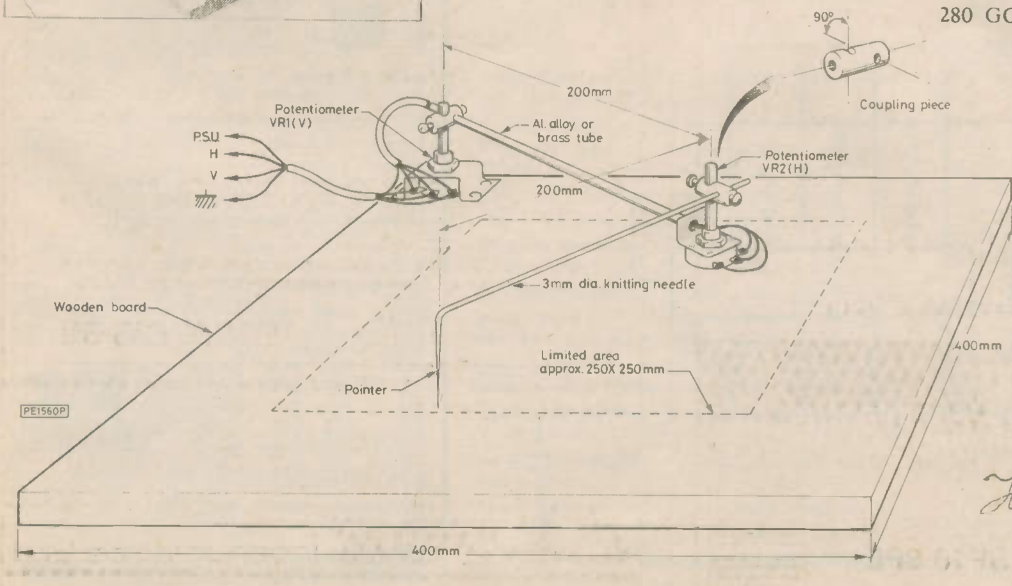
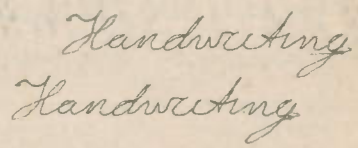


Fig. 1. Mechanical construction of the digitiser

Fig. 2. Sample of handwriting traced and stored from the digitiser



MICRO-BUS

and MICROPROMPT

depends on the type of X/Y recorder (graphic, scope, screen).

J. Ockier,
Belgium.

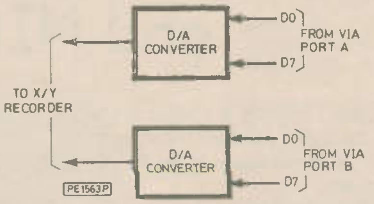


Fig. 3. Block diagram of principle

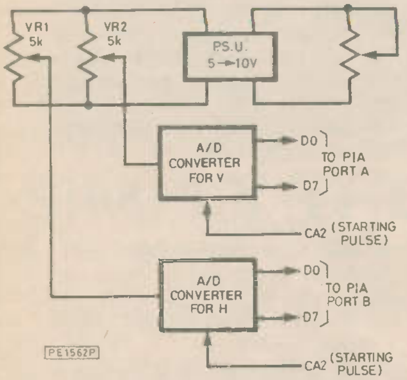


Fig. 4. Block diagram of the digitiser

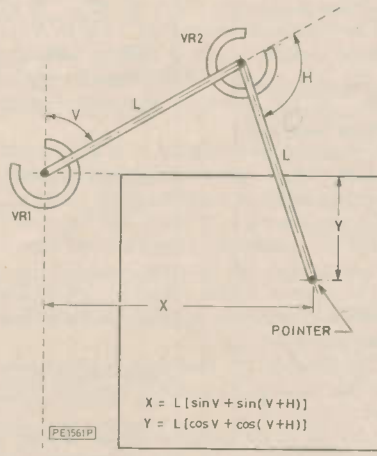


Fig. 6. A plan view showing the geometrics of the digitiser. Good quality highly linear potentiometers must be used to obtain a resolution of around 2mm

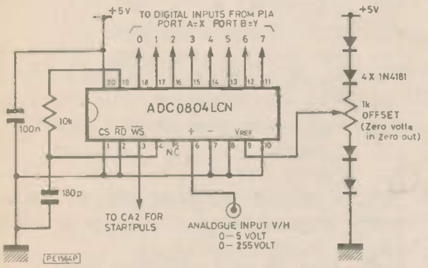


Fig. 5. The ADC channel

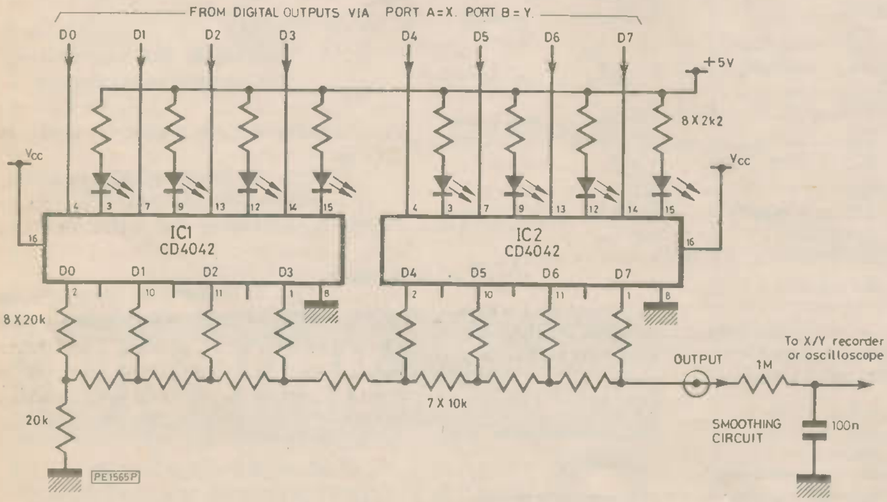


Fig. 7. Converting back to analogue for driving a plotter

VERNON TRENT *at Large!*

V.T.'s views and opinions are entirely his own and not necessarily those of PE

I'VE JUST had an idea. It doesn't happen all that often. So when it does I like to tell somebody about it.

I've been thinking that as we become more and more a button-pushing civilisation, our ability to communicate with each other, in the way we have been doing since the dawn of mankind, is going to take a nasty knock.

Here's an extreme instance. If and when we reach the stage where we wish our workmates good morning by punching up the salutation on a keyboard—even though we may be no more than an office apart—then sooner or later there can only be one consequence: total atrophy of the vocal chords. There's a lot in the old saying, if you don't use it you'll lose it.

And think what that could lead to in the years after you and I are laid in earth.

The end of live theatre as we know it. The death of opera. The finish of slanging matches in the House of Commons. The demise of spicy revelations at posh cocktail parties. Wholesale redundancy of bingo callers. No more air-cleaning rows between married couples. No more whispered exchanges of sweet nothings between young lovers. The start of mute TV and the passing of radio. The amputation of vocal links with people of other lands . . . Try that little lot for starters. Of course, cynics will say that out of such evil there comes much good.

No more screeching prima donnas. The end of pompous party political gas. The boon of being able to get happily stoned at social functions without having to endure a load of inconsequential chitchat. No more having to bear—though Mum might be upset—the twice-weekly yap of Coronation Street. No more having to study impossible foreign languages. Enhanced matrimonial bliss, made possible by the blessing of mutual silence. Goodbye, the saints be praised, to Russel Harty and Michael Parkinson; and a merciful deliverance from all that is worst in imported American TV.

★ ★ ★ ★

There's another aspect worth considering, now that we're diving at an ever-increasing pace into the electronic age. How is the keyboard syndrome going to affect the way we educate our children? What, for example, is to be the fate of the good old three Rs?

If you can bear a moment of near-geriatric nostalgia, let me recall Miss Richardson. She was a grey-haired lady who was totally dedicated to thumping the rudiments of good English into the skulls of her elementary school charges. She had no time for anyone unwilling to share her love of the glories of language and gems of literature. We went through hell with the old girl. But we emerged with enriched minds.

Then there was old Bandy Andrews. I take off my hat to him as well. He firmly believed that the only worthwhile subjects in the curriculum were simple addition, division, multiplication and subtraction. These were the intellectual vitamins on which he thrived. Anyone who resisted the same diet was beyond the pale.

Finally there was Charlie Atkinson—long since departed for that great big college of calligraphy in the sky. It was he who trained us to express our callow thoughts in splendidly-rounded hands that were a joy to behold. It was his good luck to pass on before the ballpoint pen—which some people feel killed individual style stone dead—came into universal use.

"We must all accept, indeed embrace, progress as our sires did the wheel."

I agree that our education in those days was pretty elementary. But it had soul and substance. It nurtured the development of latent talents and equipped us for the years ahead. Some of us even got places on the strength of it.

★ ★ ★ ★

Leaving aside the emotional ramblings, let's look at things in perspective.

The computer, the microprocessor and all their derivatives, with us and yet to come, cannot fail to play an enormous part in our future lives. Nobody but an idiot would deny that. We must all accept, indeed embrace, progress as our sires did the wheel.

But I can't help feeling that we still need the basic support of established educational practices as a preliminary to hurling ourselves headlong into the fresh technologies. There is no substitute for a grounding in the three Rs. Nothing can replace the human larynx as a channel for human understanding.

Someone is bound to say that writing as I do for an electronics journal I ought to be more aware of which side my wafer is diffused. Point taken. As I said at the beginning, it's just an idea. But I still reckon that Miss Richardson, Bandy Andrews and Charlie Atkinson still have a job to do.

★ ★ ★ ★

We're all TV critics. Whenever we moan from our armchairs we're carrying out the function, even though it's without an audience or a reward.

I'm no exception. The other night I was watching a programme called "It'll Be Alright On The Night". Presented by that brilliant jester, Denis Norden, it purports to be a collection of rejected sequences resulting from cockups by distinguished performers while recording their programmes.

It is passable entertainment and moderately funny. And, I suppose, acceptable to the gullible. But, because I have that kind of mind, I suspect that some of these boobs are specifically produced in order to provide a relatively inexpensive spin-off. Alright, such conning is perfectly legitimate if it keeps people happy and laughing.

On the other hand, if these lapses from professional standards, which betray a rather irresponsible approach to the job, are genuine, then ought we not to be just a little concerned?

Television is a voracious consumer of time, talent and, above all, money. Money, by the way, which you and I help to provide by passing our crisp oncers across the Post Office counter every year.

Thinking along those lines, it's not easy to accept as a matter of mirth—perhaps even affectionate sympathy—the banalities which such programmes offer.

Sorry Denis. I'm sure it's not your fault.

★ ★ ★ ★

According to a recent newspaper report, the robots of the future are going to be a lot more cuddly. Apparently 'not tonight darling' will not be a feature of their synthesised vocabulary. Sounds promising.

A spokesman for Cardiff University claims that whispering words of love and affectionate snuggling-up will present no problems for these romantic devices.

Moreover, he promises us, they will be endowded with limitless energy. Sounds even more promising.

But will there be anything in the circuitry to handle that well-known limitation—the headache?

★ ★ ★ ★

In the meantime, it is reported that America has added a new category to census statistics:—Robots.

The first robot count is underway this month and will be aimed at robots on factory assembly lines. The special census form also has a section to collect information about home robots.

A more frightening rumour is the news that special robots are being seriously considered for duties as "personal" and home security guards. These robots are, it is claimed, programmed to deliver varying degrees of bodily harm; from simple electric shocks to "dismemberment".

It appears that the only obstacle is the expected multi-million dollar lawsuits that could be lodged by injured parties.—A case for Robot against Robot?

PRACTICAL ELECTRONICS
PRINTED CIRCUIT BOARD SERVICE

Printed circuit boards for certain PE constructional projects are now available from the PE PCB Service, see list. They are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for overseas airmail. Remittances should be sent to: ***PE PCB Service, Practical Electronics Editorial Offices, Westover House, West Quay Road, Poole, Dorset BH15 1JG.*** Cheques should be crossed and made payable to IPC Magazines Ltd.

Please note that when ordering it is important to give project title, order code and the quantity. Please print name and address in Block Caps. Do not send any other correspondence with your order.

Readers are advised to check with prices appearing in the current issue before ordering.

NOTE: Please allow 28 days for delivery. We can only supply boards listed here or in the November 1984 issue.

PROJECT TITLE	Order Code	Cost
FEB '81		
Slave Light Dimmer	102–01	£1.88
MAR '81		
27/28MHz Converter	103–01	£1.79
Microphone Mixer	103–02	£1.83
Period Power Tester	103–03	£2.25
APRIL '81		
Speech Processor	104–01	£1.55
Mini Drill	104–02	£1.50
MAY '81		
Digisounder	105–01	£6.65
Thermometer	105–02	£1.49
JUNE '81		
pH Meter	106–01	£2.06
SEPT '81		
Horologicum	109–01	£3.16
,,	109–02	£3.11
,,	109–03	£2.97
Analogue Frequency Meter	109–04	£2.87
Ignition System	109–05	£2.47
	109–06	£2.28
APRIL '82		
Med. Resolution Equaliser (UK 101)	204–01	£1.73
Enlarger Timer	204–02	£4.02
AUG '82		
Automatic Photographer	208–01	£1.94
Home Alarm	208–02	£3.21
SEPT '82		
Waveform Digitiser	209–01	£8.24
FEB '83		
Radio Booster	302–02	£1.80
MAR '83		
Into the Real World	303–01	£3.99
Accessory PSU	303–02	£1.35
4½ Digit Frequency Meter	303–03	£3.69
APRIL '83		
Phaser	304–01	£3.41
JUNE '83		
Program Conditioner	306–01	£2.30
SEPT '83		
Guitar Active Tone Control	309–01	£2.27
Ground Communication System	309–02	£2.13
	309–03	£2.31
DEC '83		
Expanding the Vic 20	312–01	£5.18

PROJECT TITLE	Order Code	Cost
MAR '84		
Spectrum Autosave	403–01	£1.83
APRIL '84		
Microstepper	404–01	£10.74
MAY '84		
Sustain Unit	405–02	£2.82
Audio Signal Generator	405–03	£4.28
,,	405–04	£2.51
JUNE '84		
Cross Hatch Generator	406–01	£3.52
JULY '84		
Simple Logic Generator	407–01	£7.73
EPROM Duplicator	407–02	£3.74
Alarm System	407–03	£3.19
Oscilloscope Calibrator	407–04	£4.23
AUG '84		
Comm. 64 RS232C Interface	408–01	£3.02
Field Measurement	408–02	£3.19
,,	408–03	£2.76
Digital Dice	408–04	£4.23
Simple Logic Analyser	408–05	£2.93
Alarm System	408–06	£4.24
,,	408–07	£3.14
,,	408–08	£3.23
SEPT '84		
Parallel to Serial Converter	409–01	£2.92
Through the Mains Controller	409–02	£2.88
,,	409–03	£2.71
OCT '84		
Logic Probe	410–01	£1.90
NOV '84		
Computer DFM Adaptor	411–01	£2.76
DEC '84		
Ni-Cad Charger	412–01	£2.40
JAN '85		
Outrider Car Computer (Set of 2 boards)	501–01/2	£9.10
FEB '85		
Modular Audio Power System		
Pt-1: Power Amp Board	502–01	£4.19
Spectrum DAC/ADC Board	502–02	£3.69

PE PRINTED CIRCUIT BOARD SERVICE
Please send me the following p.c.b.s.

BLOCK CAPITALS PLEASE

Order Code	Quantity	Price
....	....	....
....	....	....
....	....	....
....	....	....

I enclose cheque /PO for £ ....

Name ....

Address ....

....

....

SMALL ADS

The prepaid rate for classified advertisements is 36 pence per word (minimum 12 words), box number 60p extra. Semi-display setting £12.00 per single column centimetre (minimum 2·5 cms). All cheques, postal orders etc., to be made payable to Practical Electronics and crossed "Lloyds Banks Ltd". Treasury notes should always be sent registered post. Advertisements, together with remittance, should be sent to the Classified Advertisement Dept., Practical Electronics, Room 2612, IPC Magazines Limited, King's Reach Tower, Stamford St., London, SE1 9LS. (Telephone 01-261 5846).

NOTICE TO READERS

Whilst prices of goods shown in classified advertisements are correct at the time of closing for press, readers are advised to check with the advertiser to check both prices and availability of goods before ordering from non-current issues of the magazine.

When replying to Classified Advertisements please ensure:

(A) That you have clearly stated your requirements.

(B) That you have enclosed the right remittance.

(C) That your name and address is written in block capitals, and

(D) That your letter is correctly addressed to the advertiser.

This will assist advertisers in processing and despatching orders with the minimum of delay.

RECEIVERS AND COMPONENTS

HOME SECURITY

HOME SECURITY CONT.

ORDER FORM PLEASE WRITE IN BLOCK CAPITALS

Please insert the advertisement below in the next available issue of Practical Electronics for ....

insertions. I enclose Cheque/P.O. for £..................

(Cheques and Postal Orders should be crossed Lloyds Bank Ltd. and made payable to Practical Electronics)

NAME ....

ADDRESS ....

....

....

PRACTICAL ELECTRONICS
Classified Advertisement Dept., Room 2612,
King's Reach Tower, Stamford Street,
London SE1 9LS. Telephone 01-261 5846
Rate:
36p per word, minimum 12 words. Box No. **60p** extra.

2/85

EDUCATIONAL/TUITION

IMPROVE YOUR PROSPECTS

with skills that employers want – learn the easy way with modern home study courses from Ideal Schools.

MODERN ELECTRONICS
Train for success in the fastest ever growing industrial sector.

COMPUTER PROGRAMMING
The demand for Programmers is increasing constantly – don't miss out!

For free booklet write today to

IDEAL

IDEAL SCHOOLS
(Ref. PE2)
60 St. Enoch Sq
Glasgow G1 UK.
Tel: 041-248 5200

COURSES

FULL-TIME TRAINING COURSES

15 MONTHS
B-TEC NATIONAL CERTIFICATE in TELEVISION & VIDEO SERVICING

15 MONTHS
B-TEC NATIONAL CERTIFICATE in COMPUTING TECHNOLOGY

9 MONTHS
B-TEC HIGHER CERT (HNC) in COMPUTING TECHNOLOGY & ROBOTICS

- PRINCIPLES OF ELECTRONICS
- TELEVISION (MONO/COLOUR)
- VIDEO CASSETTE RECORDERS & CCTV
- COMPUTERS & MICROPROCESSORS
- INDUSTRIAL ROBOTICS

Short courses (from 6 weeks) with previous electronics knowledge.

Courses commence Jan '85, April '85, September '85.

Prospectus from:

LONDON ELECTRONICS COLLEGE

Dept: AA, 20 Penywern Road, London SW5 9SU. Tel: 01-373 8721.

SERVICES

INVENTORS
Think of something new? Write it down! –

American industry offers potential royalties for your innovations and new products. We offer free confidential disclosure registration and initial consultation in London regarding your idea's potential value. Write without delay for your free information package.

American Inventors Corporation
82, Broad Street, Dept PT
Westfield, Massachusetts 01086
United States of America.

A fee based marketing company.

BOOKS AND PUBLICATIONS

FULL SIZE, top quality service sheets £2.50 + l.s.a.e. CTV/ Music Centres £3.50 + l.s.a.e. Repair data almost any named TV-Video £10.50 inc. circuits. L.s.a.e. brings any quote free magazine/price lists. TISPE, 76 Churches, Larkhall, Lanarkshire. 0698 883334.

FOR SALE

P.E. BACK NUMBERS May '76 to February '82. Offers: Tadley 3743.

PRACTICAL ELECTRONICS MAGAZINES. Believed to be complete set. From issue one. Offers. 01-642 4029.

OSCILLOSCOPES: Tektronix 516 (dual) £140, RM17 £65, Dumont 50MHz dual £140-£260. Try-out welcome. Insured delivery + £7. PDP11/05 system £370. Teletypes £40. SINCLARE 01-316 1779.

SPECIAL OFFERS. SE250C signal injector £2.20. 15 watt amplifier board £7.65. Antex C s/iron £5.95 P&P 40p. Thousands of components in stock. Phone or write for price list. SPECTRUM RADIO & ELECTRONICS LTD, 36 Slater Street, Liverpool L1 4BX. 051-709 4628.

MISCELLANEOUS

ADAPTORS – Power supplies for calculators, TV games, computers etc. Send for details. RTE ELECTRONICS, Britania Mill, Rossendale, Lancs. BB4 8BA.

BURGLAR ALARM EQUIPMENT. Ring Bradford (0274) 308920 for our catalogue or call at our large showroom, opposite Odsal Stadium.

SUPERB INSTRUMENT CASES by Bazelli, manufactured from PVC. Faced steel. Vast range, competitive prices start at a low £1.50. Punching facilities at very competitive prices. BAZELLI, (Dept. 23), St. Wilfreds, Foundry Lane, Halton, Lancaster LA2 6LT.

THE SCIENTIFIC WIRE COMPANY
811 Forest Road, London E17. Telephone 01-531 1568

ENAMELLED COPPER WIRE

SWG	1 lb	8 oz	4 oz	2 oz
8 to 34	3.63	2.09	1.10	0.88
35 to 39	3.82	2.31	1.27	0.93
40 to 43	6.00	3.20	2.25	1.61
44 to 47	8.67	5.80	3.49	2.75
48	15.96	9.58	6.38	3.69
SILVER PLATED COPPER WIRE				
14 to 30	9.09	5.20	2.93	1.97
TINNED COPPER WIRE				
14 to 30	3.97	2.41	1.39	0.94
Fluxcore Solder	5.90	3.25	1.82	0.94

Prices include P&P VAT. Orders under £2 add 20p.
SAE for list of copper and resistance wire.
Dealer enquiries welcome.

COMPUTER LEADS, made to order. Please send S.A.E. with requirements to: S & A LEADS, 94 Ladies Grove, St Albans AL3 5UB.

ELECTRONIC ORGAN KEYBOARDS and other parts being cleared out as special offer. ELVINS ELECTRONIC MUSICAL INSTRUMENTS. 40a Dalston Lane, London E8. Tel. 01-986 8455.

CLEARING LABORATORY, scopes, generators, P.S.U.'s, bridges, analysers, meters, recorders etc. Tel. 0403-76236.

HEATHKIT. U.K. spares and service centre. CEDAR ELECTRONICS, Unit 12, Station Drive, Bredon, Tewkesbury, Glos. Tel. (0684) 73127.

CABINET FITTINGS

Fretcloths, Coverings, Handles, Castors, Flight Case Locks & Parts, Jacks, XLRs, Bulgins, Reverb Trays, P & N mic Stands, ASS Glassfibre Horns, CELESTION POWER Speakers.

ADAM HALL SUPPLIES LTD.

Send 30p cheque/ P.O. for illustrated catalogue: Adam Hall (PE Supplies), Unit G, Carlton Court, Grainger Road, Southend-on-Sea.

leader of the packs

AC/DC COMPONENT PACKS

Pack No.	Qty	Description	Price
TF 11	12	RED 5mm LED	£1.00
TF 12	30	500mz ZENERS 5%	£1.00
TF 15	50	1 amp Rect. Diodes in 4000 series	£1.00
TF 16	6	1 amp Bridge Rect.	£1.00
TF 17	100	Transistor pads	£1.00
TF 18	20	A/S Fuses 20mm	£1.00
TF 19	10	3A Rect. Diodes	£1.00
TF 110	2	ORP 12	£1.00
TF 111	5	BR 100 DIAC	£1.00
TF 112	10	BC109B	£1.00
TF 113	10	LC's all different	£1.00
TF 114	50	BFR 86	£1.00
TF 115	12	8 pin DIL sockets	£1.00
TF 116	20	10mm Horiz. Pre set (10 values)	£1.00
TF 117	10	Slide Pots – 3K all the same	£1.00
TF 118	10	Mixed Pots	£1.00
TF 119	10	Feed throughs	£1.00
TF 120	25	Electrolytic Caps	£1.00
TF 121	50	Polyester Caps	£1.00
TF 122	100	Mixed Resistors – Incl. Wire Wound	£1.00
TF 123	100	Mixed Transistor Hardware	£1.00
TF 124	25	5mm LED clips and rings	£1.00
TF 125	10	BC 107	£1.00
TF 126	10	BC 108	£1.00
TF 127	6	Green 5mm LED	£1.00
TF 128	6	Yellow 5mm LED	£1.00
TF 129	150 approx.	Mixed nuts/bolts/washers/ self tapper	£1.00
TF 130	25	Mixed Electrolytics Axial	£1.00
TF 131	25	Mixed Electrolytics Radial	£1.00
TF 132	50	Mixed Polyester Axial	£1.00
TF 133	50	Mixed Polyester Radial	£1.00
TF 134	15	BC 337	£1.00
TF 135	20	500MA A/S 20mm Fuse	£1.00
TF 136	50	Mixed Ceramic Discs	£1.00
TF 137	50	Mixed Ceramic Plates	£1.00
TF 21	200	47 pf 160V Polystone Cap	£2.00
TF 22	10	LM 3900 N	£2.00
TF 23	10	Mixed DTL	£2.00
TF 24	5	4700 mf 25V Tag Elect 2"×1"	£2.00
TF 25	10	1000 mf 63V Ax Elect	£2.00
TF 26	50	.022 mf 400V RAD POLY	£2.00
TF 27	10	100 mf 250V Ax	£2.00
TF 28	10	2.2 mf 160V Polyester RAD	£2.00
TF 29	10	VDR's	£2.00
TF 210	10	Mixed TTL (74 series)	£2.00
TF 211	4	2N 3055 H(RCA)	£2.00
TF 213	200	IN 4151 Diodes	£2.00
TF 214	200	IN 4148 Diodes	£2.00
TF 51	100	White/Red 5mm LED	£5.00
TF 52	50	BC 108C	£5.00
TF 54	½KG	Reel 22g ersin multicore	£5.00
TF 55	10	2N3055 H(RCA)	£5.00
TF 56	5	OCP71	£5.00
TF 57	3	10,000 mf 40V Comp. grade elect	£5.00
TF 58	720	¼W Carbon film 1w–10Mw ten values	£5.00
TF 59	25	1,000 mf 25V Axial	£5.00
TF 510	25	1,000 mf 25V Radial	£5.00

ALL PRICES INCLUDE VAT – ALL GOODS BRAND NEW & NORMALLY DESPATCHED BY RETURN POST.
TERMS: Cash with order. POST & PACKING: Please add 75p to total order.

AC/DC ELECTRONICS COMPONENTS

DEPT P.E., 45 CHURCH STREET, ENFIELD, MIDDLESEX.

OVERSEAS ORDERS

Overseas readers are reminded that unless otherwise stated, postage and packing charges published in advertisements apply to the United Kingdom only.
Readers wishing to import goods from the United Kingdom are advised to first obtain from the advertiser(s) concerned an exact quotation of the cost of supplying their requirements carriage paid home.

INDEX TO ADVERTISERS

Published on approximately the 7th of each month by IPC Magazines Limited, Westover House, West Quay Road, Poole, Dorset BH15 1JG. Printed in England by Chapel River Press, Andover, Hants. sole Agents for Australia and New Zealand – Gordon and Gotch (Asia) Ltd.; South Africa – Central News Agency Ltd. Subscriptions INLAND £13 and OVERSEAS £14 payable to IPC Magazines Ltd., "Practical Electronics" Subscription Department, Room 2816, King's Reach Tower, Stamford Street, London SE1 9LS. PRACTICAL ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

29 Windsor

All new in the 1985 Catalogue

From a gentle purr to a mighty roar, the tightly controlled power of the beast is yours to command!

PROFESSIONAL QUALITY HIGH POWER LOUDSPEAKERS

A new range of superb quality loudspeakers.

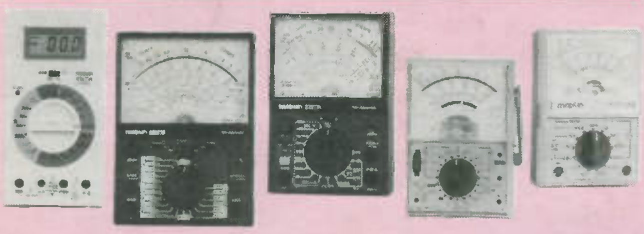
- ★ *Virtually indestructible high temperature voice-coil reinforced with glass-fibre*
- ★ *100% heat overload tolerance*
- ★ *Advanced technology magnet system*
- ★ *Rigid cast alloy chassis*
- ★ *Linen or Plastiflex elastomer surrounds*
- ★ *5-year guarantee (in addition to statutory rights)*

Available in 5, 8, 10, 12, 15 and 18 inch models with 8Ω and some 16Ω impedances and with input powers ranging from 50W to 300W e.g.

5in. 50W 95dB 8Ω: XG39N / 16Ω: XG40T £17.95§
8in. 100W 98dB 8Ω: XG43W £29.95§
10in. 100W 100dB 8Ω: XG46A £29.95§
12in. 100W 101dB 8Ω: XG49D £29.95§
12in. Twin Cone 100W 100dB 8Ω: XG50E / 16Ω: XG51F £31.95§

Note - the output power doubles for each 3dB increase (ref 1W @ 1m).

PRECISION GOLD MULTIMETERS



A new range of very high quality multimeters offering truly amazing quality at the price.

Pocket Multimeter, 16 ranges, 2000Ω/V DC/AC £6.95§ (YJ06G)
M-102BZ with Continuity buzzer, battery tester and 10A DC range, 23 ranges, 20,000Ω/V DC £14.95§ (YJ07H)
M-2020S with Transistor, Diode & LED tester and 10A DC range, 27 ranges 20,000Ω/V DC £19.95§ (YJ08J)
M-5050E Electronic Multimeter with very high impedance, FET input, 53 ranges including peak-to-peak AC, centre-zero and 12A AC/DC ranges £34.95§ (YJ09K)
M-5010 Digital Multimeter with 31 ranges including 20Ω and 20μA DC/AC FSD ranges, continuity buzzer, diode test, and gold-plated PCB for long-term reliability and consistent high accuracy (0.25% +1 digit DCV) £42.50§ (YJ10L)

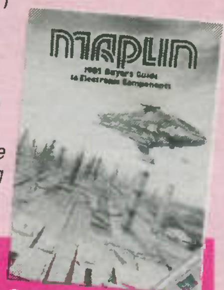
Our huge range of top quality electronic components at very competitive prices are all detailed in our catalogue, and with well over 600 new lines in our 1985 edition and many design improvements, it's well worth getting a copy. Here are just a few examples from the catalogue. (The items below are NOT kits).

★ Most phono and jack plugs now with integral strain relief sleeve - gold-plated types also available from 14p (gold from 70p)
★ Stereo Disco Mixer with cross-fade, talk-over, cue monitoring, aux input, slide controls. Only £58.95 (AF99H)

★ 10-Channel Stereo Graphic Equalisers - 3 models - basic; with peak level meter; and with spectrum analyser - from £77.95

★ Digital Delay Line permits Slap-back, Doubling, Flanging, Chorus and Echo. 11 controls. Only £195.00 (AF98G)
★ Video Enhancer improves picture quality when recording from one VTR to another, and with TV's with monitor input. Only 28.95 (XG59P)
★ Detailed descriptions of the exciting new 74HC range of IC's which combine the advantages of CMOS and TTL. From 46p
★ Keyboards: sloping keys, two-tone grey, mounted in steel frame, very smart cases (extra) available. 61 keys, only £33.95 (YJ12N)
79 keys, only £37.95 (YJ13P)
★ 1% Resistors now 50ppm/°C, 0.4W, only 2p each!
★ Auto transformers 120/240V 50VA, £10.75§ (YJ56L). 100VA £14.95§ (YJ57M). 150VA £16.95§ (YJ58N). 250VA £21.95§ (YJ59P).
★ Digital Clinical Thermometer. Only £13.95 (FK51F)

Check our 1985 Catalogue for all our other fascinating new lines.



AMERICAN EXPRESS · ACCESS · VISA

☎ ***Phone before 2pm for same day despatch.***

1985 CATALOGUE

Pick up a copy now at any branch of W.H. Smith or in one of our shops. The price is still just £1.35, or £1.75 by post from our Rayleigh address (quote CA02C).

N.B. All our prices include VAT and Carriage. A 50p handling charge must be added if your total order is less than £5 on mail order (except catalogue).

MAPLIN ELECTRONIC SUPPLIES LTD.

Mail Order: P.O. Box 3, Rayleigh, Essex SS6 8LR. Tel: Southend (0702) 552911

SHOPS
- BIRMINGHAM Lynton Square, Perry Barr, Tel: 021-356 7292.
- LONDON 159-161 King Street, Hammersmith, W6. Tel: 01-748 0926.
- MANCHESTER 8 Oxford Road, Tel: 061-236 0281.
- SOUTHAMPTON 46-48 Bevois Valley Road, Tel: 0703 25831.
- SOUTHEND 282-284 London Rd, Westcliff-on-Sea, Essex. Tel: 0702-554000

Shops closed all day Monday.

Post this coupon now for your copy of the 1985 catalogue.
Price £1.35 + 40p post and packing. If you live outside the U.K. send £2.40 or 11 International Reply Coupons. I enclose £1.75.

Name ....
Address ....
....
....

PE 2/85

§ Indicates that a lower price is available in our shops. ***All offers subject to availability.*** ***Prices firm until Feb 9th 1985.***

Featured in Electronics & Music Maker

TAKE COMPLETE CONTROL OF YOUR MUSIC with the MCS-1

professional quality MIDI-controlled sampling unit

Once again, Powertran and E&MM combine to bring you versatility and top quality from a product out of the realms of fantasy and within the reach of the active musician.

The MCS-1 will take *any* sound, store it and play it back from a keyboard (either MIDI or lv/octave). Pitch bend or vibrato can be added and infinite sustain is possible thanks to a sophisticated, looping system.

All the usual delay line features (Vibrato, Phasing, Flanging, ADT, Echo) are available with delays of up to 32 secs. A special interface enables sampled sounds to be stored digitally on a floppy disc via a BBC microcomputer.

The MCS-1 gives you many of the effects created by top professional units such as the Fairlight or Emulator. But the MCS-1 doesn't come with a 5-figure price tag. And, if you're prepared to invest your time, it's almost cheap!

Specification

Memory Size: Variable from 8 bytes to 64K bytes.

Storage time at 32 KHz sampling rate: 2 seconds.

Storage time at 8 KHz sampling rate: 8 seconds.

Longest replay time (for special effects): 32 seconds.

Converters, ADC & DAC: 8 bit companding. Dynamic range: 72 dB.

Audio Bandwidth: Variable from 12 KHz to 300 Hz.

Internal 4 pole tracking filters for anti-aliasing and recovery.

Programmable wide range sinewave sweep generator.

MIDI control range: 5 octaves.

+1/V/octave control range: 2 octaves with optional transpose of a further 5 octaves.

Digital Delay Line

Introduced in 1982, Powertran's DDL has brought digital quality effects to thousands of musicians. Still available in kit form at only £179.00 + VAT.

KIT £499 + VAT

BUILT £699 + VAT

Write or phone now to place an order.
Powertran Cybernetics Limited,
Portway Industrial Estate,
Andover, Hants, SP10 3PE.
Telephone: 0264 64455

VISA

Access

POWERTRAN cybernetics ltd