Australia $1.50 New Zealand $1.80 Malaysia $4.95 IR £1.38 (inc. VAT)

PRACTICAL ELECTRONICS

DECEMBER 1983

90p

ZAP GUN

...A FUN PROJECT!

CUT FUEL COSTS...

WITH THE **GAS SAVER**

DINORWIG

Pumped Storage Power Station

PRACTICAL
ELECTRONICS

VOLUME 19 No. 12 DECEMBER 1983

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

DUE TO LACK OF SPACE PART TWO OF SIMPLE SPEECH AND MICRO-FILE HAVE BEEN HELD OVER TILL NEXT MONTH

OUR JANUARY ISSUE WILL BE ON SALE FRIDAY, DECEMBER 2nd, 1983
(for details of contents see page 65)

WATFORD ELECTRONICS

33, CARDIFF ROAD, WATFORD, HERTS WD1 8ED, ENGLAND

Tel. Watford (0923) 40588. Telex: 8956095 WAELEC

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POLYESTER RADIAL LEAD CAPACITORS: 250V; 10n, 20n, 15n, 22n, 27n **6p**; 33n, 47n, 68n, 100n **7p**; 150n, 220n **10p**; 330n, 470n **13p**; 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**; 330, 470 **32p**; 1000 **46p**; 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.

500Ω, 1K & 2K (LIN ONLY) Single	34p
5KΩ-2MΩ single gang	34p
5KΩ-2MΩ single gang D/P switch	80p
5KΩ-2MΩ dual gang stereo	90p

SLIDER POTENTIOMETERS
0·25W log and linear values 60mm track 5KΩ-500KΩ Single gang **70p**

PRESET POTENTIOMETERS

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

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 multilayer 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**; 1µF **34p**; 2µ2 **50p**.

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

TRANSISTORS

AC127/8	35
AC176	28
AC187/8	32
AD142	120
AD149	79
AD161/2	42
AF118	95
AF139	40
AF239	55
BC107/8	10
BC107B	12
BC108B	12
BC108C	12
BC109	10
BC109B	12
BC109C	12
BC147/8	9
BC147B	10
BC148C	10
BC149	9
BC149C	12
BC157/8	10
BC159	11
BC167A	10
BC168C	10
BC169C	10
BC171/2	11
BC173	11
BC177/8	16
BC179/81	20
BC182/3	10
BC184	10
BC182L	10
BC183L	10
BC184L	10
BC186/7	26
BC212/3	10
BC212L	10
BC213L	10
BC214	10
BC214L	10
BC237/8	14
BC307B	14
BC308B	16
BC327/8	15
BC337/8	15

BC441	34
BC461	34
BC477/8	40
BC516/7	40
BC547/8	12
BC549C	14
BC556/7	15
BC558/9	15
BCY70	16
BCY71/2	20
BD131/2	48
BD133	60
BD135	45
BD136/7	40
BD138/9	40
BD140	40
BD245	45
BD695A	125
BD696A	125
BF194/5	12
BF198/9	18
BF200	30
BF224	25
BF244A	28
BF244B	29
BF256B	35
BF257/8	32
BF259	35
BF594/5	30
BFR39/40	23
BFR41/79	23
BFR80/81	25
BFR98	105
BFX29/84	28
BFX85/86	28
BFX87/88	28
BFY50/51	23
BFY52	23
BFY56	32
BFY90	80
BRY39	40
BSX20	20
BSX29	34
BU105	170
BU205	190
BU206	200

BU208	200
MJ2955	70
MJE340	54
MJE371	100
MJE2955	99
MJE3055	70
MPF102	40
MPF103/4	30
MPF105	30
MPSA05	25
MPSA06	25
MPSA12	32
MPSA55	30
MPSA56	30
MPSA70	30
MPSU02	58
MPSU05	55
MPSU06	55
MPSU52	65
MPSU55	60
MPSU56	60
OC23	170
OC28/36	220
OC41/42	75
OC70	40
OC76	50
OC81/82	50
OC83/84	40
TIP29A	32
TIP29C	38
TIP30A	35
TIP30C	37
TIP31A	38
TIP31C	37
TIP32A	38
TIP32C	42
TIP33A	65
TIP33C	78
TIP34A	74
TIP34C	88
TIP35A	110
TIP35C	128
TIP36A	130
TIP36C	140
TIP41A	50
TIP41B	52
TIP42A	55
TIP42B	58
TIP120	70
TIP121	73

TIP141	105
TIP142	105
TIP147	120
TIP2955	60
TIP3055	60
TIS43	32
TIS44	45
TIS88A	50
TIS90	30
TIS91/93	32
VK1010	99
VN10KM	70
VN46AF	95
VN66AF	110
VN88AF	99
VN89AF	120
ZTX107/8	11
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	19
2N708	19
2N914/5	32
2N918	35
2N930	20
2N1131/2	24
2N1303/4/5	
2N1307/8	65
2N1613	30
2N1671B	160
2N2160	295
2N2219A/20A/21A/22A	25
2N2369A	18
2N2646	45
2N2846	80

2N2904A/05A/06A/07A	26
2N2926G	10
2N3053	25
2N3054	58
2N3055	40
2N3442	140
2N3615	199
2N3702/3	10
2N3704/5	10
2N3706/7	10
2N3708/9	10
2N3710	10
2N3771	179
2N3772	195
2N3773	210
2N3819	22
2N3820	38
2N3822/3	45
2N3866	90
2N3903/4	15
2N3906/5	15
2N4427	80
2N4859	78
2N5172	18
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	60
2SC495/6	70
2SC1061	250
2SC1096	85
2SC1162	30
2SC1172	125
2SC1173	125
2SC1306	100
2SC1307	150
2SC1449	85
2SC1679	190
2SC1678	140

2SC1923	50
2SC1945	225
2SC1953	90
2SC1957	90
2SC1969	140
2SC2028	85
2SC2029	200
2SC2078	170
2SC2091	85
2SC2166	165
2SC2314	85
2SC2465	125
2SC2547	30
2SD234	75
2SK45	90
2SK288	225
2SJ83	225
2SJ85	225
3N128	112
3N140	112
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	80
702	75
709C 8 pin	35
710	48
741	14
747C 14 pin	65
748C 8 pin	36
753 8 pin	185
810	159
9400CJ	350
AY-1-1320	225
AY-1-5050	99
AY-1-5051	160
AY-1-6720	210
AY-3-1270	730
AY-3-8910	420
AY-3-8912	625
AY-5-1230	450
AY-5-1317A	630
CA3011	130
CA3012	175
CA3014	275
CA3018	86
CA3019	80
CA3020	210
CA3023	210
CA3028A	95
CA3035	255
CA3036	270
CA3043	275
CA3045	365
CA3046	70
CA3048	220
CA3059	285
CA3075	213
CA3080E	70
CA3081	190
CA3086	48
CA3089E	200
CA3090AQ	375
CA3123	165
CA3130	90
CA3140	40
CA3160	95
CA3161E	160
CA3162E	450
CA3189	200
CA3240	110
HA1366	175
HA1388	255
ICL7106	690
ICL7107	975
ICL7204	550
ICL7611	99
ICL7660	248
ICL8038CC	300
ICL8211	350
ICM7205	1150
ICM7207	475
ICM7216	1050
ICM7216A	£22
ICM7217A	750
ICM7224	785
ICM7240	300
ICM7555	80
ICM7556	150
LA3350	250
LA4031P	340
LA4032	295
LA4400	350
LA4422	320
LC7120	300
LC7130	340
LC7137	395
LF347	150
LF351	48
LF353	95
LF355	85
LF356	95
LF357	110
LF398	475
LM10	325
LM301A	24
LM307	45
LM308	95
LM311	55
LM318	150
LM319	195

LM324	30
LM334Z	90
LM335	128
LM339	47
LM348	60
LM349	115
LM358	60
LM377	175
LM379	475
LM380	75
LM381N	145
LM382	115
LM384	160
LM386	90
LM387	120
LM389	95
LM393	45
LM394CH	290
LM725CN	325
LM733	70
LM1871	325
LM2917	195
LM3302	75
LM3900	50
LM3909	85
LM3911	125
LM3914	200
LM3915	200
LM3916	250
LS7220	750
M51513L	230
M51515L	230
M51516L	475
M706B1	125
MB3712	220
MB3756	440
MC1204	250
MC1303	98
MC1304P	260
MC1310P	150
MC1445	250
MC1455	50
MC1458	35
MC1469	300
MC1494	694
MC1495	350
MC1496L	70
MC1596	225
MC1648	290
MC3302	90
MC3401	65
MC3403	75
MC3405	150
MC3432	00
MC3442	00
MC3423P	80
MC4016	00
MF10	350
MFC6040	75
ML924	275
NE515	275
NE529	225
NE531	140
NE534	150
NE543	225
NE544	210
NE555	16
NE556DB	45
NE558	140
NE560	325
NE561	395
NE562B	410
NE564	420
NE565A	120
NE566	155
NE567	140
NE570	410
NE571	400
NE5532	145
NE5534	105
OM335	750
RC4136D	60
RC4558	45
S566B	225
SAB3209	425
SAB3210	325
SAB3271	485
SAB4209	595

SG3402	295
SL490	350
SL6270	150
SN76013N	350
SN76023N	350
SN76033	350
SN76477	420
SN76488	480
SP8629	350
SP0256AL	850
TA7120	125
TA7130	125
TA7204	150
TA7205	175
TA7222	150
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
TBA950	225
TBA990	350
TC9109	750
TCA270	350
TCA280A	220
TCA940	175
TCA965	145
TDA1004	290
TDA1008	310
TDA1010	198
TDA1022	499
TDA1024	115
TDA1034	350
TDA1490	350
TDA2002	325
TDA2003	250
TDA2004	495
TDA2006	330
TDA2020	320
TDA2030	295
TDB0791	420
TL061CP	40
TL062CP	60
TL064CN	98
TL071CP	25
TL072CP	45
TL074CN	100
TL081CP	24
TL082CP	45
TL083CP	75
TL084CP	90
TL091CP	55
TL170	50
TL430C	90
TL507	110
TL509	110
UA2240	120
UA78540	230
UAA170	180
UAA180	180
UGN3020T	160
ULN2001	80
ULN2003	75
ULN2004	75
ULN2068	290
ULN2802	200
ULN2804	150
ULN2283	100
UPC575	275
UPC1025H	375
UPC1032	95
UPC1156H	270
UPC1182	320
UPC1366	195
XR2206	300
XR2207	375
XR2211	575
XR2216	675
XR2266	360
ZN414	80
ZN419CE	180

ZN423E	130
ZN424E	130
ZN425E-8	345
ZN426E-8	300
ZN427E-8	590
ZN428E	410
ZN429E-8	210
ZN459	325
ZN1034E	200
ZN1040E	665
ZNA234E	850

COMPUTER IC's

2102L	100
2114L-200n	95
2147-3	425
2532-3	300
25L32	450
27L08	450
27L32	550
2716-5V	270
2732	320
2764	425
2813	200
26501	75
27128-4	£18
27128/250n	£20
3242	590
4027	95
4116-150	100
4118-250	325
4164-200	425
4334	00
4416-2	475
4532-3	220
4816-100ns	250
5101	220
5514	250
6116-150ns	340
6116L-120ns	525
6117-100n	490
6167-6	795
6402	350
6502 CPU	325
6502A	450
6503	00
6504	00
6505	00
6520	100
6522 VIA	285
6530 RRIOT	£11
6532 RIOT	570
6545 CRTC	899
6551 ACIA	650
6592	00
68B54	780
6800	220
6802	250
6803	850
6805	670
6808	520
6809	630
6810	115
6820	100
68B21	220
6821	100
6840	375
6843	00
6845	750
6846	625
6847	650
6850	110
6852	250
6854	599
68B54	780
6875	500
68000 New msk	£70
8035	600
8080A	250
8085A	350
8088	£18
81LS95/96	120
81LS97/98	120
8118-10	250
8123	125
8154	£9
8155	350
8156	350

8202	£25
8212	150
8214	425
8216	100
8224	150
8226	250
8228	220
8243	270
8250	850
8251A	250
8253	400
8255	225
8256A	£35
8257A	400
8259	395
8271	£36
8272	£17
8279	385
8282	450
8283	450
8284	350
8T26A	99
8T27	150
8T28A	120
8T31	350
8T95N	90
8T97N	90
9364AP	550
9602	220
AM26LS31C	125
AM26LS32	100
AM26LS32A	125
AM26LS33	150
AM26LS33A	125
AY-3-1015	300
AY-5-1013	300
AY-5-1350	388
AY-5-2376	600
AY-5-3600	750
COM8017	275
COM8116	700
DM8131	275
DP8304BN	250
DS3647	00
DS3691N	320
DS8820	110
DS8830	110
DS8831	125
DS8832	250
DS88LS120N	275
E9364	00
E9365	£38
E9366	£38
FD1691	£15
FD1771	£15
FD1791	£22
FD1793	£23
FD1795	£28
FD1797	£28
HA11235	200
HA17080	200
HA17083	200
HA80391	200
HD26501	75
IM6402	380
INS8060N	1050
MC1488	55
MC1489	55
MC14411	675
MC14412	725
MC3446	250
MC3447P	316
MC3486	175
MC3487	175
MK3886-2M	£7
MM5280D	695
MM5303	635
MM5307	1275
MM5387A	475
MM58174	700
RO-3-2513L	550
RO-3-2513U	650
SFF96364E	800
SP0256AL2	850
TMS2716-3	725
TMS4047	100
TMS4164-15	395
TMS4416-2	475
TMS4500	£14
TMS4532-3	350

TMS5100	600
TMS6011	500
TMS9927	£14
TMS9928	£20
TMS9929	£16
TMS9980	£20
TMS9995	£12
ULN2003	75
UPD7002	425
WD1691	£14
WD1943	700
Z80CPU 2·5	299
Z80ACPU4M	300
Z80ACTC	260
Z80B	875
Z80DART	495
Z80ADART	550
Z80ADMA	895
Z80DMA	695
Z80P10	280
Z80AP10	275
Z80S10-1	850
Z80AS10	900

74S

74S00	24
74S02	24
74S03	30
74S04	30
74S05	60
74S08	60
74S10	40
74S11	50
74S20	40
74S22	50
74S30	40
74S32	70
74S37	60
74S74	75
74S85	295
74S86	70
74S112	90
74S113	90
74S114	80
74S124	300
74S132	110
74S133	60
74S138	100
74S139	115
74S140	60
74S151	180
74S153	182
74S157	250
74S158	195
74S163	300
74S174	250
74S175	320
74S188	140
74S189	140
74S194	295
74S195	275
74S197	400
74S201	350
74S225	500
74S240	300
74S241	300
74S244	290
74S251	225
74S257	225
74S258	250
74S260	70
74S262	850
74S287	225
74S288	210
74S289	200
74S299	540
74S301	350
74S365	250
74S373	400
74S374	365
74S412	380
74S470	325
74S471	820
74S472	1150
74S474	400
74S475	800
74S571	620
74S573	950

75

75107/8/9	95
75110	90
75150	125
75154	195
75159	125
75182/3	99
75188/9	55
75322	140
75450	86
75451/2	52
75454	70
75491/2	65

TTL 74

7400	18
7401	18
7402	18
7403	18
7404	20
74L04	00
7405	20
7406	50
7407	50
7408	20
7409	20
7410	20
7411	20
7412	20
7413	35
7414	45
7416	35
7417	35
7420	20
7421	20
7422	30
7423	30
7425	30
7426	45
7427	30
7428	30
7430	25
7432	25
7433	25
7437	30
7438	50
7440	25
7441	55
7442	40
7443	70
7444	65
7445	75
7446	55
7447	55
7448	60
7450	25
7451	25
7453	25
7454	25
7460	25
7470	35
7472	35
7473	35
7474	30
7475	60
7476	35
7480	50
7481	140
7482	80
7483	50
7484	90
7485	110
7486	35
7489	175
7490	30
7491	48
7492	30
7493	30
7494	60
7495	35
7496	50
7497	120
74100	90
74104	50
74105	50
74107	35
74109	40
74110	35

74111	60
74112	170
74116	80
74118	75
74119	85
74120	80
74121	32
74122	40
74123	55
74125	35
74126	40
74128	45
74132	40
74136	35
74141	60
74142	175
74143	190
74144	190
74145	60
74147	85
74148	70
74150	85
74151	40
74153	40
74154	85
74155	40
74156	40
74157	40
74159	100
74160	50
74161	50
74162	50
74163	55
74164	55
74165	50
74166	55
74167	200
74170	150
74172	280
74173	60
74174	100
74175	70
74176	50
74177	45
74178	80
74179	90
74180	50
74181	140
74182	55
74184	100
74185	100
74186	70
74188	75
74190	70
74191	75
74192	75
74193	60
74194	60
74195	50
74196	60
74197	50
74198	100
74199	100
74221	80
74246	100
74247	100
74248	130
74249	120
74251	60
74259	150
74265	75
74273	175
74276	135
74278	130
74279	45
74283	70
74284	200
74285	210
74290	85
74293	65
74297	900
74298	70
74351	120
74365	60
74366	60
74367	60
74368	60
74390	80
74393	100
74490	110

74C

C244	195
C245	195
C373	240
C374	245
C922	420
C923	500
C925	400

74LS

LS00	18
LS01	18
LS02	18
LS03	18
LS04	18
LS05	18
LS08	18
LS09	18
LS10	20
LS11	18
LS12	20
LS13	22
LS14	36
LS15	20
LS20	18
LS21	20
LS22	18
LS24	00
LS26	22
LS27	18
LS28	20
LS30	18
LS32	18
LS33	20
LS37	20
LS38	20
LS40	20
LS42	32
LS47	50
LS48	50
LS49	50
LS51	20
LS52	20
LS54	20
LS55	20
LS63	55
LS73	22
LS74	22
LS75	38
LS76	22
LS78	40
LS83	40
LS85	55
LS86	28
LS90	30
LS91	55
LS92	35
LS93	35
LS95	45
LS96	75
LS107	36
LS109	36
LS112	36
LS113	30
LS114	30
LS122	55
LS123	60
LS124	150
LS125	32
LS126	32
LS132	40
LS133	26
LS135	24
LS136	24
LS138	38
LS139	38
LS145	60
LS147	110
LS148	100
LS151	45
LS153	45
LS154	150
LS155	35
LS156	35
LS157	35
LS158	30
LS160	45
LS161	45

LS162	40
LS163	40
LS164	45
LS165	50
LS166	75
LS168	140
LS169	00
LS170	85
LS173	75
LS174	00
LS175	40
LS181	100
LS183	100
LS190	55
LS191	00
LS192	55
LS193	50
LS194	45
LS195	50
LS196	55
LS197	50
LS221	75
LS240	60
LS241	60
LS242	68
LS243	68
LS244	70
LS245	120
LS247	60
LS248	60
LS249	60
LS251	40
LS253	40
LS257	40
LS258	40
LS259	70
LS260	30
LS261	30
LS266	70
LS273	150
LS275	165
LS279	40
LS280	150
LS283	40
LS290	40
LS292	900
LS293	40
LS294	000
LS295	70
LS298	70
LS299	115
LS320	160
LS323	175
LS324	150
LS325	150
LS326	000
LS327	000
LS347	65
LS348	125
LS352	60
LS353	60
LS356	180
LS362	000
LS363	000
LS364	000
LS365	45
LS366	45
LS367	40
LS368	40
LS373	60
LS374	70
LS375	40
LS377	75
LS378	85
LS379	80
LS384	475
LS385	185
LS386	50
LS390	60
LS393	60
LS395	85
LS396	00
LS398	80
LS399	80
LS445	000
LS447	50
LS465	120
LS467	120
LS471	000
LS490	80

LS540	90
LS541	90
LS624	00
LS640	000
LS641	200
LS645	000
LS668	000
LS669	000
LS670	120
LS673	950
LS674	900

CMOS

4000	14
4001	14
4002	14
4006	50
4007	15
4008	32
4009	24
4010	24
4011	15
4012	18
4013	20
4014	46
4015	40
4016	20
4017	32
4018	45
4019	25
4020	42
4021	40
4022	40
4023	15
4024	32
4025	16
4026	80
4027	20
4028	39
4029	45
4030	15
4031	125
4032	80
4033	125
4034	140
4035	45
4036	275
4037	115
4038	110
4039	280
4040	40
4041	40
4042	40
4043	40
4044	40
4045	105
4046	46
4047	40
4048	40
4049	25
4050	25
4051	45
4052	60
4053	50
4054	85
4055	85
4056	85
4057	£10
4059	435
4060	45
4061	1195
4062	995
4063	85
4066	24
4067	245
4068	18
4069	16
4070	18
4071	20
4072	18
4073	20
4075	18
4076	50
4077	18
4078	18
4081	18
4082	18
4085	50

4086	60
4089	125
4093	20
4094	70
4095	95
4096	70
4097	275
4098	75
4099	75
4160	95
4161	99
4162	99
4163	99
4174	99
4175	105
4194	105
4408	790
4409	790
4410	725
4411	675
4412	790
4415	480
4419	280
4422	770
4433	770
4435	850
4440	999
4450	350
4451	350
4490	350
4500	675
4501	28
4502	60
4503	40
4504	75
4505	185
4506	35
4507	35
4508	130
4510	46
4511	46
4512	45
4513	199
4514	115
4515	125
4516	65
4517	275
4518	40
4519	30
4520	50
4521	90
4522	125
4526	60
4527	65
4528	50
4529	150
4530	90
4531	130
4532	50
4534	400
4536	275
4538	80
4539	90
4541	140
4543	70
4544	150
4548	40
4549	375
4553	245
4554	180
4555	35
4556	35
4557	320
4558	120
4559	395
4560	160
4561	104
4562	495
4566	165
4568	250
4569	175
4572	36
4580	460
4581	250
4582	99
4583	90
4584	48
4585	70
4597	330
4599	290

40097	45
40098	42
40100	215
40101	130
40102	140
40103	175
40104	95
40105	105
40106	35
40107	60
40108	198
40109	100
40110	300
40114	240
40161	194
40163	50
40174	45
40175	50
40181	220
40192	75
40193	95
40194	90
40195	80
40244	195
40245	195
40257	198
40373	240
40374	245

HOME LIGHTING KITS

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

TDR300K	Remote Control Dimmer	£14.30
MK6	Transmitter for above	£ 4.20
TD300K	Touchdimmer	£ 7.00
TS300K	Touchswitch	£7.00
TDE/K	Extension kit for 2-way switching for TD300K	£ 2.50

CHRISTMAS PRESENTS GALORE

3-NOTE DOOR CHIME

Based on the SAB0600 IC the kit is supplied with all components, including loudspeaker, printed circuit board, a pre-drilled box (95 x 71 x 35mm) and full instructions. Requires only a PP3 9V battery and push-switch to complete. AN IDEAL PROJECT FOR BEGINNERS Order as XK102. £5.00

MW RADIO KIT

Based on ZN414 IC, kit includes PCB, wound aerial and crystal earpiece and all components to make a sensitive miniature radio. Size: 5.5 x 2.7 x 2 cms. Requires PP3 9V battery. IDEAL FOR BEGINNERS. £5.00

LIGHT DIMMER KIT

Contains all components, including front panel and knob, to make a dimmer for lights up to 300W. £3.50

LCD 3½ DIGIT MULTIMETER

16 ranges including DC voltage (200 mv-1000 v) and AC voltage, DC current (200 mA-10 A) and resistance (0-2 M) + NPN & PNP transistor gain and diode check. Input impedance 10M. Size 155x88x31 mm. Requires PP3 9v battery. Test leads included. ONLY £29.00

BEGINNERS STARTER PACKS

Containing selection of electronic components including transistors, LEDs, diodes, capacitors, ICs etc. together with a descriptive booklet with 10 easy-to-build projects plus a solderless circuit board enabling the components to be re-used. Requires 9V battery.
Discreet component pack (no ICs) £5.00 Integrated circuit pack £6.00

STOCKING FILLERS All full spec. branded devices.

PACK (1)	650 Resistors 47 ohm to 10Mohm — 10 per value £4.00
PACK (2)	40 x 16V Electrolytic Capacitors 10µF to 1000µF — 5 per value £3.25
PACK (3)	60 Polyester Capacitors 0.01 to 1µF/250V — 5 per value £5.55
PACK (4)	45 Sub-miniature Presets 100 ohm to 1 Mohm — 5 per value £2.90
PACK (5)	30 Low Profile IC Sockets 8, 14, and 16 pin — 10 of each £2.40
PACK (6)	25 Red LEDs (5mm dia.) £1.25

DISCO LIGHTING KITS

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

DLZ1000K
A lower cost version of the above, featuring undirectional channel sequence with speed variable by means of a pre-set pot. Outputs switched only at mains zero crossing points to reduce radio interference to a minimum. £8.00

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

DL3000K
This 3 channel sound to light kit features zero voltage switching, automatic level control and built in mic. No connections to speaker or amp required. No knobs to adjust — simply connect to mains supply and lamps (1Kw channel) Only £11.95

ELECTRONIC LOCK KIT XK101

This KIT contains a purpose designed lock IC, 10-way keyboard, PCBs and all components to construct a Digital Lock, requiring a 4-key sequence to open and providing over 5000 different combinations. The open sequence may be easily changed by means of a pre-wired plug. Size: 7 x 6 x 3 cms. Supply: 5V to 15 V d.c. at 40uA. Ouput: 750mA max. Hundreds of uses for doors and garages, car anti-theft device, electronic equipment, etc. Will drive most relays direct. Full instructions supplied. ONLY £10.50

Electric lock mechanism for use with latch locks and above kit £13.50

HOME CONTROL CENTRE

This kit enables you to control up to 16 different appliances anywhere in the house from the comfort of your armchair. The transmitter injects coded pulses into the mains which are decoded by receiver modules connected to the same mains supply and used to switch on the appliance addressed. The transmitter also includes a COMPUTER interface so you can programme your favourite micro (eg. ZX81) to switch lights, heating, electric blanket, make your morning coffee, etc. automatically without rewiring your house. **JUST THINK OF THE POSSIBILITIES.** The kit includes all PCBs and components for one transmitter and two receivers, plus a pre-drilled box for the transmitter.

Order as XK112. £42.00

Additional Receivers XK111 £10.00

"OPEN-SESAME"

The XK103 is a general purpose infra-red transmitter/receiver with one momentary (normally open) relay contact and two latched transistor outputs. Designed primarily for controlling motorised garage doors and two auxiliary outputs for drive/garage lights at a range of up to 40 ft. The unit also has numerous applications in the home for switching lights, TV, closing curtains, etc. Ideal for aged or disabled persons.
The Kit comprises a mains powered receiver, a four button transmitter, complete with pre-drilled box, requiring a 9V battery and one opto-isolated solid state switch kit for inter-facing the receiver to mains appliances. As with all our kits, full instructions are supplied.

ONLY £23.75

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We also stock peripherals and accessories disc drives, printers, joy sticks etc. together with a wide range of books and the latest software for all the above computers including ZX81.
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Have you got our
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NO?! Send S.A.E. 6" x 9" TODAY!!
It's packed with details of all our KITS plus large range of SEMICONDUCTORS including CMOS, LS TTL, linear, microprocessors and memories, full range of LEDs, capacitors, resistors, hardware, relays, switches etc. We also stock VERO and Antex products as well as books from Texas Instruments, Babani and Elektor.
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Answering service evngs & wnds

REMOTE CONTROL KITS

FOR A DETAILED BOOKLET ON REMOTE CONTROL — send 30p + 6" x 9" S.A.E.

MK6 SIMPLE INFRA RED TRANSMITTER
Supplied with hand held plastic box. Requires 9V (PP3) battery £4.20

MK7 INFRA RED RECEIVER
Mains powered with triac output to switch up to 500W at 240V ac. Range approx. 20 ft. on/off or momentary control £9.00
IRC 500K — special price for MK6 MK7 (£12.50)

MK9 4 WAY KEYBOARD
For use with MK 18/MK 12 transmitter receiver where only 4 channels are required £1.90

MK10 16 WAY KEYBOARD £5.40

MK11 10 channel + 3 analogue o/p receiver
A mains powered I.R. receiver providing control signals to 10 on/off and 3 analogue circuits. May be used for controlling the volume of an amplifier, brightness of a lamp, etc £12.00

MK12 16 CHANNEL I.R RECEIVER
A mains powered I.R. Receiver providing up to 16 outputs for switching £11.95

MK18 based on the SL490. This kit includes all components to make a coded transmitter. Requires a PP3 battery and keyboard (MK9, MK10 or MK13) size 8 x 2 x 1.3cm. Range approx. 60 ft. £6.20

MK13 11 way keyboard for use with MK18 and MK11 kits £4.35

ALL PRICES EXCLUDE VAT

MICROPROCESSOR CONTROLLED MULTI-PURPOSE TIMER

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

FEATURES INCLUDE:

- 7mm LED 12 hour display
- Day of week, am pm and output status indicators
- 4 open collector outputs for driving relays, triacs, etc
- 50 60Hz mains operation
- Battery backup saves stored programmes and continues time keeping during power failures. (Battery not supplied)
- Display blanking during power failure to conserve battery power
- 18 programme time sets
- Powerful 'Everyday' function enabling output to switch every day but use only one time set
- Useful 'sleep' function — turns on output for one hour
- Direct switch control enabling output to be turned on immediately or after a specified time interval
- 20 function keypad for programme entry
- Programme verification at the touch of a button
- Plastic box with attractive screen printed front panel 15 x 10 x 5.5cm

Now only £39.00
(Kit includes all components, PCB, box, assembly and programming instructions)
Order as CT6000

XK114 OPTIONAL RELAY KIT
Kit includes one relay, PCB to accommodate up to four relays, terminal blocks, etc to fit inside CT6000 box. Provides up to four 3amp 240V AC changeover contacts
£3.90
Additional relays £1.65 each

PE LOGIC TUTOR

A complete kit of top quality components including PCB, connectors, sockets and switches and transformer. £21.00
PCB only £4.95

24 HOUR CLOCK/ APPLIANCE TIMER KIT

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

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

DVM/ULTRA SENSITIVE THERMOMETER KIT

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

Price £15.50

Add 65p postage & packing + 15% VAT to total Overseas Customers:
Add £2.50 (Europe), £6.00 (elsewhere) for p&p
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Goods by return subject to availability.

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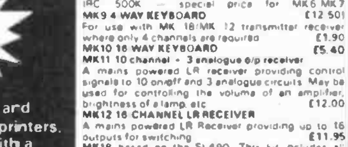

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TRIACS – PLASTIC

4 AMP – 400v – T0202 – TAG 136G

1 OFF	10 OFF	50 OFF	100 OFF
40p	£3.75	£17.50	£30.00

8 AMP – 400v – T0220 – TAG 425

60p	£5.75	£27.50	£50.00

MINIATURE FM TRANSMITTER

Freq: 95-106MHz. Range: ¼ mile
Size: 45 × 20mm Add: 9v batt. **ONLY £5.50**
Not licenced in U.K.
ideal for: 007–M15–FBI–CIA–KGB etc.

PROGRAMMABLE UNIJUNCTION TRANSISTOR

PUT case T0106 plastic MEU22 Similar to 2N6027/6028 PNPN Silicon

Price:	1–9	10–49	50–99	100+
Each	20p	18p	15p	13p

Normal Retail Price £0.35 each.

VALUE PACKS

Pak No.	Qty	Description	Price
VP1	300	Assorted Resistors Mixed Types	£1.00
VP2	300	Carbon Resistors ⅛-¼ Watt Pre-Formed	£1.00
VP3	200	⅛ Watt Min Carbon Resistors Mixed	£1.00
VP4	150	½ Watt Resistors 100 ohm – 1M Mixed	£1.00
VP5	200	Assorted Capacitors All Types	£1.00
VP6	200	Ceramic Caps Miniature – Mixed	£1.00
VP7	100	Mixed Ceramics Disc. 1pf – 56pf	£1.00
VP8	100	Mixed Ceramic Disc. 68pf – .015pf	£1.00
VP9	100	Assorted Polyester/Polystyrene Caps	£1.00
VP10	60	C280 Type Caps Metal Foil Mixed	£1.00
VP11	100	Electrolytics – All Sorts	£1.00
VP12	60	Bead Type Polystyrene Min Caps	£1.00
VP13	50	Silver Mica Caps Ass. 5.6pf – 150pf	£1.00
VP14	50	Silver Mica Caps Ass. 180pf – 4700pf	£1.00
VP15	50	High Voltage Disc. Ceramic 750v – 8Kv Mixed	£1.00

VALUE PACKS

Pak No.	Qty	Description	Price
VP16	50	Wirewound Res. 9W (avg) Ass. 1 ohm – 12K	£1.00
VP17	50	Metres PVC Covered Sinlge Strand Wire Mixed Colours	£1.00
VP18	30	Metres PVC Covered Multi Strand Wire Mixed Colours	£1.00
VP19	40	Metres PVC Single/Multi Strand Hook-Up Wire Mixed	£1.00
VP20	6	Rocker Switches 5 Amp 240v	£1.00
VP21	20	Pcs. 1 – 2 & 4 mm Plugs & Sockets Matching Sizes	£1.00
VP22	200	Sq. Inches Total. Copper Clad Board Mixed Sizes	£1.00

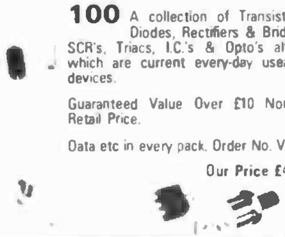
VALUE PACKS

Pak No.	Qty	Description	Price
VP23	20	Assorted Slider Pots. Mixed Values	£1.00
VP24	10	Slider Pots. 40 mm 22K 5 × Log 5 × Lin	£1.00
VP25	10	Slider Pots. 40 mm 47K 5 × Log 5 × Lin	£1.00
VP26	20	Small .125" Red LED'S	£1.00
VP27	20	Large .2" Red LED'S	£1.00

TRANSISTOR CLEARANCE

100 All Sorts Transistors. A mixed Bag NPN–PNP Silicon & Germ. Mainly Uncoded You To Sort Pack Includes Instructions For Making Simple Transistor Tester. Super Value. Order No VP60 **£1.00**

SEMICONDUCTORS FROM AROUND THE WORLD



100 A collection of Transistors, Diodes, Rectifiers & Bridges SCR's, Triacs, I.C.'s & Opto's all of which are current every-day useable devices.

Guaranteed Value Over £10 Normal Retail Price.

Data etc in every pack. Order No. VP56

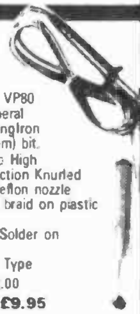
Our Price £4.00

VALUE PACKS

Pak No.	Qty	description	Price
VP28	10	Rectangular .2" Green LED'S	£1.00
VP29	30	Ass. Zener Diodes 250mW – 2W Mixed Vlts. Coded	£1.00
VP30	10	Ass. 10W Zener Diodes Mixed Vlts. Coded	£1.00
VP31	10	5 Amp SCR's TO-66 50-400v Coded	£1.00
VP32	20	3 Amp SCR's TO-66 Up To 400v Uncoded	£1.00
VP33	200	Sil. Diodes Switching Like IN4148 DO-35	£1.00
VP34	200	Sil. Diodes Gen. Purpose Like OA200/BAX13/16	£1.00
VP35	50	1 Amp IN4000 Series Sil Diodes Uncoded All Good	£1.00
VP36	8	Bridge Rects. 4 × 1 Amp 4 × 2 Amp Mixed Vlts. Coded	£1.00
VP37	8	Black Instrument Type Knobs With Pointer ¼" Std	£1.00
VP42	10	Black Heatsinks To Fit TO-3, TO-220 Ready Drilled	£1.00
VP43	4	Power-Fin Heatsinks 2 × TO-3 2 × TO-66 Size	£1.00
VP44	1	Large Power Heatsink 90 × 80 × 35 mm Drilled For Up To 4 TO-3 Devices	£1.00
VP45	50	BC107/8 Type NPN Transistors Good Gen. Purpose Uncoded	£1.00
VP46	50	BC177/8 Type PNP Transistors Good Gen. Purpose Uncoded	£1.00
VP47	10	Silicon Power Trans. Similar 2N3055 Uncoded	£1.50

TEACHIN 84
Complete kit of component parts.
Price £21.50

BI-PAK SOLDER – DESOLDER KIT



Kit comprises: ORDER 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 (1.83m) Resin Cored Solder on Card
1 Heat Shunt tool tweezer Type
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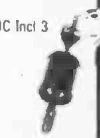

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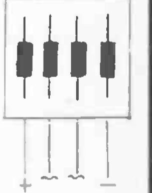

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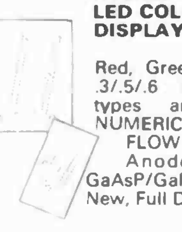

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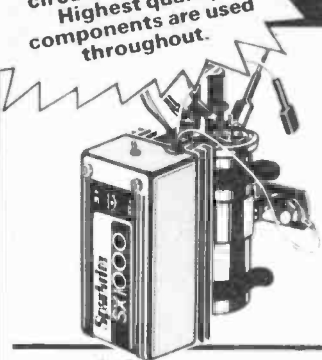

SX 1000 Electronic Ignition

● Inductive Discharge ● Extended dwell circuit stores greater energy in coil ● Three position changeover switch ● Patented clip-to-coil fitting ● Easy to assemble, easy to fit ● Contact breaker triggered – includes bounce suppression circuit.

SUPER SAVE

SX 2000 Electronic Ignition

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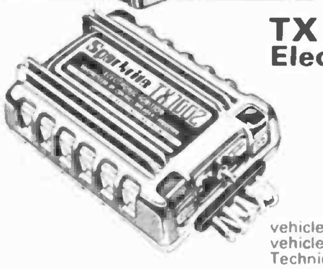

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TX2002 Electronic Ignition

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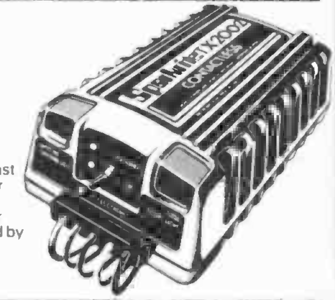
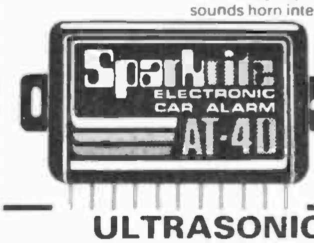


AT-40 Electronic Car Alarm

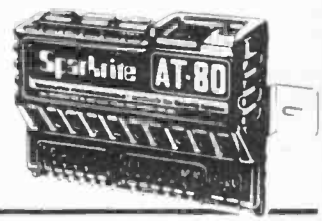
● Guards doors, boot, bonnet from unauthorised entry ● Armed/disarmed using concealed switch ● 30 second delay-to-arm: 7 second entry delay ● Can alternatively be wired to exterior key switch ● Flashes headlights & sounds horn intermittently for 60 seconds when activated ● Security loop protects accessories ● Low consumption C-MOS circuitry.



NEW

AT-80 Electronic Car Security System

● Guards doors, boot, bonnet from unauthorised entry ● Armed/disarmed from outside vehicle by magnetic key fob passed across sensor pad adhered to inside of windscreen ● Individually programmable code ● 30 second delay-to-arm ● Flashes headlights and sounds horn intermittently for 60 seconds when activated ● Security loop protects accessories ● Function lights to assist setting-up ● Low consumption C-MOS circuitry.



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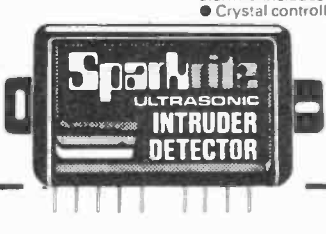
● Supplementary to AT-40 & AT-80 ● Will work in conjunction with any door switch input or voltage sensing alarm ● Detects attempted break-in and movement within passenger compartment & triggers alarm ● Includes high efficiency ultrasonic transducers ● Crystal controlled for low drift ● Ingenious sensitivity control allows freedom from false alarms ● Low current consumption



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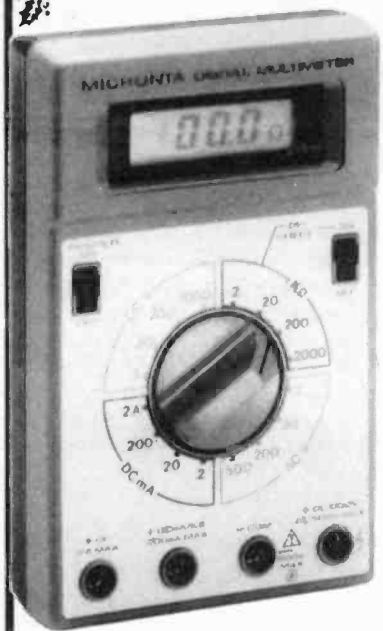

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PE

VOLUME 19 No. 12 DECEMBER 1983

POP SOFTWARE

THE personal computer has now been with us for five years and in that time has moved from a strictly specialist hobby item to a mass interest consumer product. The problem is that the real reasons for the development of the microprocessor and ultimately the personal microcomputer, for problem solving, accounting, design and development, filing and similar tasks, have been overshadowed—in the eyes of most consumers—by the ability of the micro to play exotic klingon-zapping games.

The sales of software cassettes for games are rivalling pop records and record companies are being forced into software sales to assure their futures. Don't get us wrong, we enjoy frog hopping and flying war planes (fictional ones of course) as much as the next person. We also believe the fun side of computing, which has led to the massive sale in the UK of home computers, can ultimately be blamed for providing the basis of an exciting new development in home computing: the use of micros for "serious" applications.

As regular readers will know, PE has shown the way in both microcomputer development, with publication of a number of basic designs in the early days, and in developing systems for control purposes. Our *Into The Real World* series proved very popular with those wishing to interface their computers to the outside world. With electrical control systems for Aquarius and Electron being announced recently the manufacturers are also moving in this direction. It is noticeable that much of the new software is for applications like word processing, education, data bases and personal accounting; no doubt the software houses realise that game playing will eventually wane.

Where does PE come in? We will continue to provide designs to stretch microcomputers, to interface them with other items and to develop other uses. We will also provide designs using dedicated micros in control situations.

HOW THEY WORK

With so many children learning programming it is unlikely that there will be many jobs available in that area in years to come, but those with an additional understanding of electronics will no doubt be better placed to secure employment. Not so many months ago parents encouraged their children to learn electronics—the technology of the future—now they seem to feel computing is more important, let's not forget we need to know how the damn things work. For those that are interested our *Introduction to Digital Electronics* course is essential reading.

Incidentally we find it frustrating to buy some software in a microcomputer shop and have to wait while the assistant laboriously writes out a sales docket with full name and address and then separates the copies before taking the money. With all that high technology around surely just one micro could be switched from games to perform a sensible task of stock control and mailing list recording. Or is that just too much to expect?

We would be interested to hear of other areas where mundane tasks are still performed "by hand" while the staff are surrounded by high technology.

Mike Kenward

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

ELAN'S ENTERPRISE

The home-micro market is without doubt an expensive and difficult place in which to compete for business. By the spring Elan Computers will add their machine to the list, which by that time is likely to exceed 30 options under £250. Elan feel they will not be missing out on the Christmas sales bonanza by launching the Enterprise 64K in the spring. 'It's a product of the future' they say, and are confident that it will remain when its contemporaries bite the dust.

The Enterprise has 69 contoured full travel keys with an extra 8 being user-definable. On the right of the keyboard is an integral joystick that can be used for games or text manipulation. Two memory options are available, the 64K and the 128K, both are ultimately expandable to 4Megabytes with add-on units.

The machine has a built-in word processor and can handle 56 lines of text at any one time, each with 84 columns. Two cassette recorder connections enable the user to read text or data from one tape machine while writing on the other, an indicator ensuring correct volume level setting when loading programs.

Another unique feature is stereo sound, via connection to a hi-fi or to headphones.

The graphics and sound are both controlled from customised chips. The colour of each pixel is controllable and therefore high-resolution graphics are a reality rather than a claim. Four sound sources are available each with full volume control on stereo output. Tone generation is from 30Hz to 125kHz giving a musical range of a full 8 octaves. Multiple combinations of white noise generation, low/high pass filtering and ring modulation are possible.

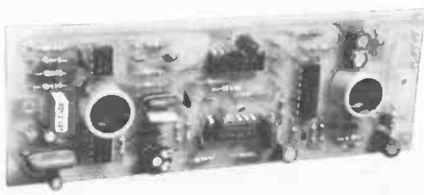
The peripherals are modular and designed to stack together in an effort to make interconnecting spaghetti-junctions redundant. The machine is connected to the stack 'base unit' via a flexible ducting which contains all the necessary wiring. The base unit has an adaptor which supplies all the peripherals in the stack with their needs.

Separate 64K ROM cartridges can be plugged into the machine, with games and education dominating this aspect. Languages include FORTH and LISP with BASIC as the norm.

ULTRASONIC MOVEMENT DETECTOR

Riscomp Limited have just launched the US 5063 which is an ultrasonic movement detection module employing digital techniques for processing the received signal. Such an approach not only provides a superior performance when compared to the conventional analogue circuitry, but also allows a choice of three levels of discrimination against false alarms. An exit delay and fixed alarm time have been incorporated, together with a selectable entrance delay. The transmitter section of the module is crystal controlled which allows several units to be used without inter-action problems where large areas are to be covered. A 'hold' facility, together with a built-in l.e.d. indicator, is provided for setting-up purposes. Priced at £13·95, the module is supplied with a comprehensive data sheet.

Riscomp Ltd., 21 Duke Street, Princes Risborough, Bucks HP17 0AT (084 44 6326).

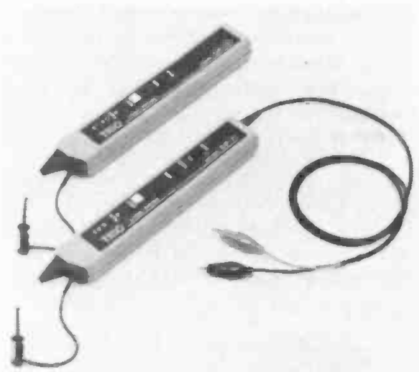


LOGIC PROBES

Two brand new logic probes from Trio are now available from House of Instruments, DP-71 for TTL and CMOS up to 50MHz and the DP-70 for TTL up to 30MHz.

Logic probes enable the quick determination of the operational state of logic circuits, providing the user with a powerful trouble-shooting and development tool.

These new probes feature response to input frequencies up to 50MHz and pulse widths down to 20ns, achieved by an extremely short ground lead, inherent in the clever design. A light compact plastic case that can be held neatly in one hand, houses the probe and l.e.d.s, while switches have been grouped for easy viewing and use on one side only.



The operational status of logic circuits is clearly indicated by three l.e.d.s, one for logic high (1), one for logic low (0) and one to indicate the existence of a continuous pulse. By placing the probe to memory mode, single pulses down to 20ns in width, leading or trailing edges, can be detected with a reset switch to return to normal pulse mode.

Inputs are protected up to ±100V d.c. continuous and ±250V d.c. or 175V r.m.s. up to 15 seconds. DP-70 with a 50kohm input impedance, operates from internal batteries, while DP-71 has a 1Mohm impedance and may be powered from a 4·5 to 18V d.c. source.

The DP-70 is priced at £24·00 plus p&p and VAT and the DP-71 is priced at £49·00 plus p&p and VAT.

Quiswood Ltd. 30 Lancaster Road, St. Albans, Herts AL1 4ET (0799 24922).

POINTS ARISING...

INGENUITY UNLIMITED
Pseudo Telephone Ringer Sept. 83
IC2 should be a 7490 decade counter—not a 555 timer as printed.

MARKET PLACE

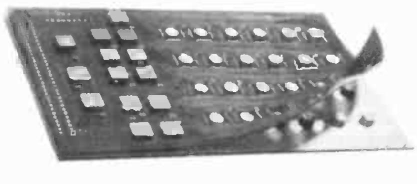
Thermionic Integrated Circuits

A valve renaissance? Thermionic valve versions of integrated circuits, for real! No need to check, this is not the April issue, nor are integrated thermionic circuits (i.t.c.s) the work of Ireland's Ballygobackwards. They are, according to a report in Electronic Times, the joint creation of Arizona University and Los Alamos Scientific Laboratory. Circuits are delineated using conventional i.c. photolithographic techniques. Everything one would expect is sputtered onto an insulating sapphire substrate—grids, cathodes, anodes and heaters (the latter in the form of metalisation films).

But why? Because the i.t.c. will run at 600 deg. C compared with silicon's ceiling of 150 deg. C. And i.t.c.s, with as many as 1000 switches per square inch, are radiation resistant. Los Alamos, which had to develop a high temperature ceramic package for the device, has produced i.t.c.s which could be used commercially right now, although, as yet, there are no takers.

Cool Chips

An ingenious and cost-effective system for keeping i.c.s cool is being marketed by Welwyn Electric after experimental work in conjunction with British Telecom's engineers at Martlesham. The chip carriers are mounted on a flexible p.c.b. which has holes punched through it. Each i.c. is sited over one of these holes, holes which accommodate steps, or pillars, in an alloy backplate type heatsink. The flexible p.c.b. ensures that each i.c. is tensioned against its metal pillar to give good thermal contact, and to evenly distribute mechanical stress. Thermally conductive grease is used to improve heat transfer from the chip carriers to the heat sink.



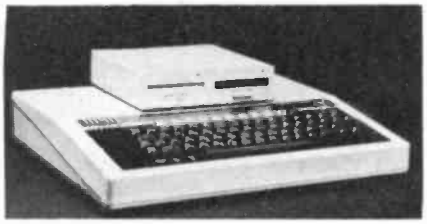
During production of an assembly, the fact that the flexible polyimide circuit has holes in it makes it easier to clean off flux. Once assembled, another plate is clipped to the top of the module to create a sandwich of only a few centimetres thick, which may be stacked one upon another.

DISC SYSTEM FOR MICRO-B

Advanced Memory Systems have produced the smallest possible disc system for the BBC Microcomputer using the new Hitachi 3" drives.

The drives are cased in rigid steel and cost £225 and £399 for the single and double versions. The system comes complete with cables, manuals, utilities on disc and EPROM as well as free discs.

The Hitachi drive has a brushless direct motor and when cased fits neatly on top of the BBC Micro. The casing has been textured and painted to match the computer.



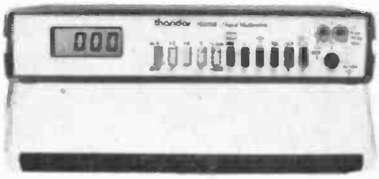
Each side holds 100K of storage. The small light on the drive casing reminds you which side you are using.

At present the product is only available by mail order from Advanced Memory Services Ltd., Woodside Technology Centre, Green Lane, Appleton, Warrington. (0925 62682).

BATTERY DMM

The TM356 is a battery-operated 3½ digit multimeter with a large 0·5" liquid crystal display.

It has a full measurement capability of d.c. and a.c. volts, d.c. and a.c. current, resistance and diode check in 29 ranges permitting measurement of voltages from 100µV to 1000V (750V a.c.), current from 100nA to 10A, and resistance from 100mΩ to 20MΩ.



Battery life from alkaline 'C' cells is typically in excess of 3000 hours and a low battery indicator shows when approximately 10% of life remains.

The instrument is housed in a tough ABS moulded case with carrying handle/stand making it suitable for portable applications as well as bench work.

The TM356 is priced at £85.00 plus VAT. Thandor Electronics Limited, London Road, St. Ives, Huntingdon, Cambs. PE17 4HJ (0480 64646).

Silicon News Corner

Bulletins announcing new semiconductor devices arrive at PE daily, so it is possible only to describe them briefly. Details of how to obtain further information are included, however.

Motorola ▶ Darlingtons added to 25kVA line are complements to MJ10042/45/47. The MJ10041 handles 25A @ 850V. MJ10047 handles 100A @ 250V. MJ10044 handles 50A @ 450V.

▶ Formerly available 350-600V (150W) n-channel TMOS power MOSFETs now available in TO-218AC package.

▶ 48 complementary transistors added to bipolar line (TO-220 package) are direct replacements for GE devices, available as D44C, D45C, D44H & D45VH series.

▶ MOSFET "Energy Management" series raises power by 250%. Typical device: 100A/60V @ 20mΩ on-resistance.

▶ MC10HO16 high speed binary counter joins MECL 10KH line. Has improved propagation delay over Fairchild F10016.

▶ TL431 is a 3-terminal adjustable shunt regulator 2·5–36V with low temp. coef. 1–100mA range, & dynamic impedance of 220mΩ.

▶ MC3424 is a dual channel supervisory chip for power supply protection. Every function on board to sense overvoltage transients, regulator failures, input line loss etc.

▶ Slotted opto-couplers/interrupters are replacements for GE H21 & H22 series. Infra-red diode faces silicon n.p.n. photo-transistor in plastic housing. Slot allows beam to be interrupted. Called MOC7811–23. Motorola European Literature Centre, Motorola Semiconductors, 88 Tanners Drive, Blakelands, Milton Keynes.

Litronix/Siemens ▶ Intelligent alpha-numeric displays called DL1814. 8 × 17 seg. 0·112" chars incorporating CMOS memory, decode & drive etc.

▶ 35 dot intelligent display is DLO 7135 series. In red, yellow or green, produces full ASCII range chars. On board memory, decode & drive simplifies row/address signalling from µP.

▶ "World's smallest" production reflective switch is the SFH900 (match head size). Up to 5mm position sensing and has ambient light filtering, and excellent light/dark ratio.

▶ 10kV r.m.s. opto-isolator HIL10. Synchro Services, High St., Harrold, Bedford.

INDUSTRY NOTEBOOK

By Nexus

NEW LOOK

The most heartening event for industry and the general economic climate this year was the Trades Union Congress. It followed, of course, the general election which revealed that fewer than 40 per cent of union members supported the Labour Party while the majority voted either Conservative or Liberal/SDP Alliance.

Congress had few doubts on the survival of trade unions but many on the credibility of their traditional ally—the Labour Party, which they had themselves created and supported financially.

Thus, at the 115th Annual Congress, questions which would have been unthinkable only a few years ago were now being openly asked. Should Congress now consider distancing itself from Labour if not actually parting company completely? Would not the membership benefit more by co-operation with the Government in union reform rather than resisting? Is it not time for union leaders to recognise that they are servants of their members rather than their bosses? Was it not just conceivable that the union leadership had got it all wrong, in policies, in union management, in leadership itself?

Of course there were cries of betrayal, invocation of memories of the Tolpuddle Martyrs, the tradition of working class solidarity. But all this sounded hollow in 1983 when the majority of members are property-owning consumer-oriented men and women inclined to consider themselves middle rather than working class.

The truth is that the membership has changed while the leadership has been left behind. The cloth cap and choker, traditional badge of the union member, is in decline, the business suit and briefcase in the ascendancy. Service industry membership now exceeds that of the industrial shop floor.

Yes, Congress would re-consider general policy, would talk to the Conservatives, would participate in the 'little Neddy' working parties. The old hard-liners still had their way through block votes on withdrawal from the Common Market, on anti-nuclear policy but not convincingly.

The new-look unions which could emerge in the year ahead might well conclude that the interests of their members are best served through generating new wealth by co-operation rather than by obstruction and old-fashioned confrontation. Much of the old rhetoric was still mouthed at Congress but one detects a positive shift to moderation.

ACORNS INTO OAKS

Those who complain of the power of the big corporations and multi-nationals often conveniently forget that they all started as virtually one-man bands and this includes even mighty IBM. And the opportunities of the small business to grow are as great today as ever they were. Anyone can join at any time in getting a start. Success, however, is dependent on entrepreneurial flair, the right product or service offered, hard work, sound financial management and a modicum of luck.

The Racal Group started off with two partners and £100 capital. In the last six years of general economic recession Racal's peripheral small companies, the odds and ends making accessories and components, are now recording over £120 million in sales, equal to the whole Group turnover as recently as 1977. So growth is possible even in recessionary periods.

The Racal founders worked at Plessey before deciding to break out on their own. History repeats itself with two Racal employees breaking out in 1978 to form their own company, Telemetrix. Roy Cole and John Westover offered their expertise first as consultants, later becoming manufacturers as well, mainly through a subsidiary company, Westward Micro Systems, building graphic terminals. Telemetrix, after five years, are turning over £5 million a year with profits of £1·5 million and have made their debut on the Stock Exchange.

So the list of new-generation electronics millionaires and potential millionaires grows. Cole and Westover had good jobs in Racal. Now they have better jobs and a fortune in prospect. Any hard feelings? Not at all. Racal is a valued customer of Telemetrix, as are GEC, Plessey and Ferranti.

Another newcomer to the Stock Exchange is Oxford Instruments. When I first came across this company it was a tiny outfit working closely with the Clarendon Laboratory, Oxford University, on their programme of cryomagnetic research which involved the use of powerful magnets operating at cryogenic temperatures. The company's founder and deputy chairman, Martin F. Wood, is a mechanical and mining engineer who joined the Clarendon in 1955 and designed all their giant magnets, later leaving to start Oxford Instruments but with the Clarendon still a major customer.

Today Oxford Instruments is still in magnets which are used in nuclear magnetic resonance body scanners, the latest wonder in medical diagnosis. Martin Wood has a 30 per cent stake in a company which is now putting up a new £5 million factory and is expected to improve profits to over £8 million next year from increased capacity. His present success owes much to the Clarendon Laboratory, to Sir Nicholas Kurti who headed the cryomagnetic research programme and, incidentally, to Mullard Ltd who generously endowed the Laboratory with a sum which covered most of the costs of a new building to house the experiments and was formally inaugurated on 30th June, 1965.

PRICE WAR

Meantime, the violence characteristic of so many computer games is now matched, if not exceeded, by the violence of price competition between personal computer manufacturers. Some have already been forced out of business, others are subject to panic 'rescue' measures.

The long hot summer carries some of the blame as demand slumped when millions took to the beaches and forgot about shopping for electronic novelties. But the autumn is the build-up period for stocks in preparation for the Christmas rush and many companies hadn't the cash-flow nor the financial backing in support. Such are the hazards of the consumer market.

Viewing the current scene and recalling what happened to the pocket calculator and the digital watch it is understandable that investors are jittery. As prices tumble so margins are squeezed. This must mean that more of the hardware will be made in low-cost areas in the Far East, leaving most of the profit, if any, in software.

If the expected Christmas boom turns out to be a bust, look out for real give-away prices in the New Year.

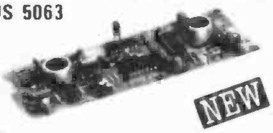
OUTLOOK

Economists remain in stubborn disagreement on the general economic outlook although the optimists still appear to outnumber the pessimists. The August unemployment figures were down for the first time in four years but still depressingly high and forecast to rise again. But three million unemployed needs to be set against 23·5 million who are employed and record car sales, video recorders and other consumer durables don't exactly give a picture of a nation on its knees. Nor do the record crowds at Test matches and other sporting events, not to mention the level of overseas holidays and simultaneous record personal savings.

Of course the distribution of wealth is unequal both geographically and financially in the UK, it always has been. Attempts by governments over the past 30 years at levelling have been universally unsuccessful. But with information technology and light industry (e.g. electronics), the distance from the centre is becoming less critical and herein lies the hope that manufacturing and prosperity can be more equally spread.

SECURITY Build your own system and SAVE POUNDS!

DIGITAL ULTRASONIC DETECTOR US 5063



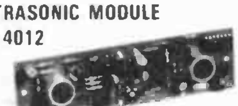
NEW

- 3 levels of discrimination against false alarms
- Crystal control for greater stability
- Adjustable range up to 25ft.
- Built-in delays
- 12V operation

This advanced new module uses digital signal processing to provide the highest level of sensitivity whilst discriminating against potential false alarm conditions. The module has a built-in exit delay and timed alarm period, together with a selectable entrance delay, plus many more outstanding features. This advanced new module is available at

only £13.95 + V.A.T.

ULTRASONIC MODULE US 4012

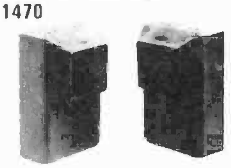


- Adjustable range from 5-25ft.

This popular low cost ultrasonic detector is already used in a wide range of applications from intruder detectors to automatic light switches and door opening equipment, featuring 2 LED indicators for ease of setting up, the unit represents outstanding value at

£10.95 + V.A.T.

INFRA-RED SYSTEM IR 1470



Consisting of separate transmitter and receiver both of which are housed in attractive moulded cases, the system provides an invisible modulated beam over distances of up to 50ft, operating a relay when the beam is broken. Intended for use in security systems, but also ideal for photographic and measurement applications, the system is available at

only £25.61 + V.A.T. Size: 80 × 50 × 35mm.

POWER SUPPLY & RELAY UNIT PS 4012

Provides stabilised 12V output at 85mA and contains a relay with 3 amp contacts. The unit is designed to operate with up to 2 ultrasonic units or 1 infra-red unit IR 1470. Price £4.25 + V.A.T.

SIREN MODULE SL 157

Produces a loud penetrating sliding tone which, when coupled to a suitable horn speaker, produces S.P.L.'s of 110dbs at 2 metres. Operating from 9-15V, the module contains an inhibit facility for use in 'break to activate' circuits. Price £2.95 + V.A.T.

5½" HORN SPEAKER HS 588

This weather-proof horn speaker provides extremely high sound pressure levels (110dbs at 2 metres) when used with the CA 1250, PS 1865 or SL 157 Price £4.95 + V.A.T.

3-POS. KEY SWITCH 3901

Single pole, 3-pos. key switch intended for use with the CA 1250. Price £3.43 + V.A.T.

All modules are supplied with comprehensive instructions.
Units on demonstration.
Shop hours 9.00-5.30 p.m.
Wed. 9.00-1.00 p.m.
SAE with all enquiries.

ALARM CONTROL UNIT CA 1250

The heart of any alarm system is the control unit. The CA 1250 offers every possible feature that is likely to be required when constructing a system whether a highly sophisticated installation, or simply controlling a single magnetic switch on the front door.

- Built-in electronic siren drives 2 loud speakers
- Provides exit and entrance delays together with fixed alarm time
- Battery back-up with trickle charging facility
- Operates with magnetic switches, pressure pads, ultrasonic or I.R. units
- Anti-tamper and panic facility
- Stabilised output voltage
- 2 operating modes – full alarm/anti-tamper and panic facility
- Screw connections for ease of installation
- Separate relay contacts for switching external loads
- Test loop facility

Price £19.95 + V.A.T.

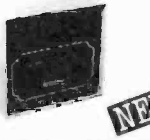
SIREN & POWER SUPPLY MODULE PSL 1865

NEW

A complete siren and power supply module which is capable of providing sound levels of 110dbs at 2 metres when used with a horn speaker. In addition, the unit provides a stabilised 12V output up to 100mA. A switching relay is also included so that the unit may be used in conjunction with the US 5063 or US 4012 to form a complete alarm.

Price £9.95 + V.A.T.

HARDWARE KIT HW 1250



only £9.50 + V.A.T.

NEW

This attractive case is designed to house the control unit CA 1250, together with the appropriate LED indicators and key switch. Supplied with necessary mounting pillars and punched front panel, the unit is given a professional appearance by an adhesive silk screened label. Size: 200 × 180 × 70mm.

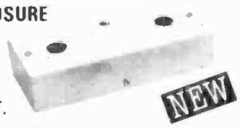
HARDWARE KIT HW 5063

only £9.95 + V.A.T.

NEW

This hardware kit provides the necessary enclosure for a complete self-contained alarm system which comprises the US 5063, PS 1865, loud speaker type 3515 and key switch 3901. Attractively styled, the unit when completed, provides an effective warning system without installation problems. Size: 200 × 180 × 70mm.

ULTRASONIC MODULE ENCLOSURE



only £2.95 + V.A.T.

NEW

Suitable metal enclosure for housing an individual ultrasonic module type US 5063 or US 4012. Supplied with the necessary mounting pillars and screws etc. For US 5063 order SC 5063; for US 4012 order SC 4012.

Add VAT to all prices.
Add 50p post & packing to all orders. Please allow 7 days for delivery.
Order by telephone or post using your credit card.

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including Keyboard

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STAGE MODEL
inc. Cabinet & Stand

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PROGRAMMABLE DRUMS
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73 NOTE	£50	30 NOTE	£19

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Easy-to-assemble kit of parts	**£78.50**

Send SAE for list of separately avaiable parts.

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(PE March '83)

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Patents Review

Copies of British Patents can be obtained from: The Patent Office, Sales, St. Mary Cray, Orpington, Kent (£1.75); and copies of Foreign Patents can be obtained from The Science Reference Library, 25 Southampton Buildings, London, WC2A 1AJ. (Prices on application.)

BROADCAST BATTLE IN USA

In the USA, there's currently a pitched battle on the open market over AM stereo broadcasting. There are five different systems of transmitting mono-compatible stereo on AM and the Federal Communications Commission originally intended to choose a single system as the US standard. But now the FCC has adopted the free market approach. Record radio stations across America can use any system they like. In theory, the broadcasters, press, electronics trade and public are supposed to choose the best system. But of course in practice it isn't working that way. Receiver manufacturers won't invest in any one system until it is a standard. Nor will the public. So almost no-one receives the broacast transmissions in stereo.

In an effort to break the deadlock Leonard Kahn, inventor of one of the five systems, is patenting a multi system receiver. His British patent application 2105558 gives a useful run down on the five systems proposed. One uses a mixture of amplitude and frequency modulation; another uses phase modulation instead of frequency modulation; a third uses compatible quadrature amplitude modulation; the fourth is a modification of the third, compatible phase multiplex; and the fifth is an independent side band system which modulates the carrier so that the left channel is on the lower side band and the right channel is on the upper side band. Although they are different, all five systems have one feature in common. They all rely on a pilot tone to switch the receiver into stereo mode. Kahn observes that the pilot frequencies are different for each system. For AM/FM it's 20Hz, for AM/PM it's 5Hz, for CQUAM it's 25Hz, for CPM it's 55–96Hz and for ISB it's 15Hz. What Kahn proposes is a multi-system AM stereo receiver which has tone sensing circuitry and can decode two or more of the five systems.

The circuit in Fig. 1 can cope with ISB, AM/PM and CQUAM signals.

Logic circuit 96 determines which system is being received from the frequency of the pilot tone. It then switches gates 46, 48 and 50 for appropriate decoding; gates 102, 110 are used where the decoder can handle other systems. Of course, some of the circuitry for one system can be used for another system, but it is still an inelegant approach which underlines the dangers of a free market choice, philosophy.

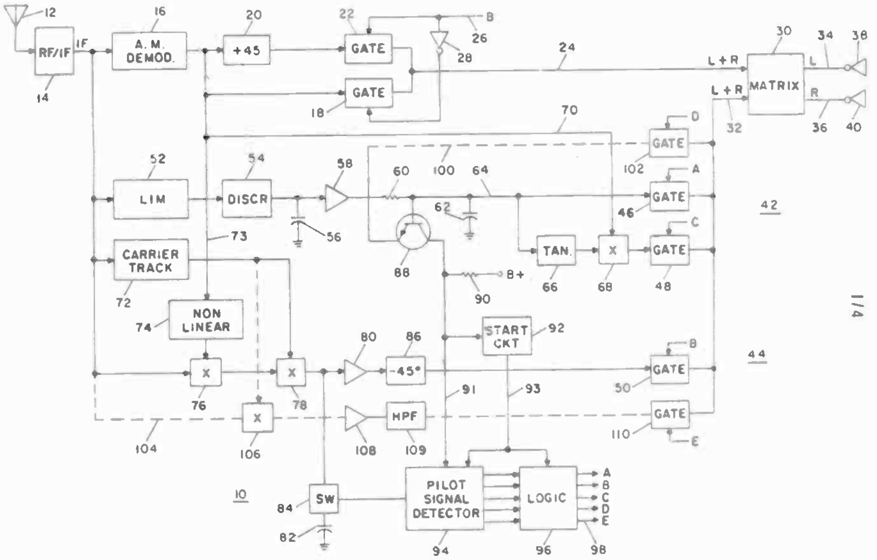


FIG. 1

INSTANT DIGITAL DISC

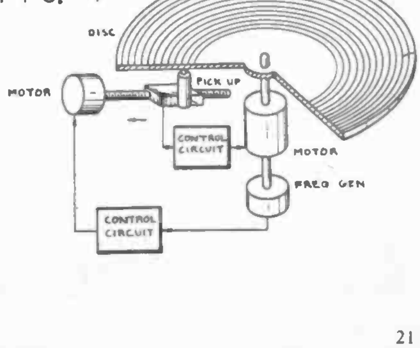
Although it was Philips who invented the Compact Disc system, Sony contributed valuable improvements to the digital coding and error correction. The company is now pushing ahead with further improvements. One is described in British patent application 2106698. The aim is to offer broadcasters a Compact Disc player with instant start.

When a Compact Disc player is in the stand-by mode, the disc is spinning and the laser is trading one turn of the pit spiral over and over again. The time taken to scan one full turn varies from 0·126 seconds, at the inside of the disc, to 0·292 seconds at the outside of the disc. So when the player is switched from standby to play mode (like lowering the stylus of a conventional gramophone), there will be a delay of up to 0·292 seconds before the laser can read from the beginning of the turn and start to reproduce sound. Although inconsequential for domestic use, this brief delay can be a problem for broadcasters. The Sony broadcast player will have a RAM which can store sufficient bits from the disc to buffer the delay and make a genuinely instant start possible. In standby mode the player stores the buffer bits and reads out these bits from its RAM before changing over to direct readout from the disc. The RAM needs to store over 0·5 megabits of information to cope with the delay of up to 0·292 seconds, because the data stream coming off the disc is running at over 4 megabits a second.

Fig. 1 is a cut-away view of a typical disc player to which this system may be applied.

The broadcast player also incorporates forward and reverse and slow playback modes. These allow a broadcaster to "spot" a chosen passage of a recording down to the split second for instant start. In these modes the laser keeps skipping back and forth over the same tracks to expand the music in time.

FIG. 1



GAS SAVER

Mike Abbott

Dynamite will prevent one type of gas wastage, but if you want to save unnecessary gas in your central heating system, you'll need some electronics. Read on . . .

WITH "white goods" manufacturers at last coming to terms with microelectronics control, we are fast moving away from the world of springs and contacts towards an era in which flexibility, convenience and efficient energy management will be taken for granted. The latter is of particular importance now that fuel is no longer cheap—*domestic gas consumers are still smarting from swingeing increases*—and yet the average gas central heating system wastes this precious fuel in two ways.

As for those springs and contacts, they will not disappear overnight, and many of us (author included) still depend upon them in equipments of an earlier generation. In a typical gas central heating system, the boiler is fired when the gas valve is opened, this valve being energised by a simple thermo-mechanical switch. This presettable thermo-mechanical switch, known to the user as the "Water Temperature" thermostat, is linked to the nearby boiler jacket. Heat from the jacket travels slowly along a heat-conducting copper wire to the thermostat, causing it to cut off the gas valve again when the required temperature is reached. Alas, this is a sluggish process in which the termostat is expensively out of step with the boiler. Also, an ideal gas controller would sense the temperature of the hot water storage tank in addition to the boiler, but presumably the *average-priced* system could not be stretched to include this feature—certainly a heat-conductive copper wire could not be *stretched* as far as the tank, usually a "cool" distance away from the boiler/control unit. Even were this extra sensor at the tank to be included, what would the thermostat do with *two* inputs? If, on a cost basis, the manufacturer of the day had ruled out electronics, whilst electronics was the only technology capable of the logic necessary in a two-input thermostat, then we may hazard a guess at why gas central heating storage tanks are generally minus a temperature sensor.

CONVENTIONAL GAS SYSTEMS

Gas central heating systems vary in detail, Gas Saver being designed to improve the efficiency of the author's particular system, this being an "Ideal Standard Concord". Gas Saver will almost certainly make any comparable system run much more economically. The type this applies to is described in Fig. 1, in which the circulation pump is energised only whilst radiator heating is required. It can also be seen that only the boiler temperature is sensed, and that the thermostat is at the opposite end of a heat-conducting copper wire—a linkage that is painfully slow to respond, and which takes no account of the temperature of the hot water storage tank. Both of these shortcomings cost the consumer money. Fig. 2 shows the gas ignition pattern and temperature curves of the conventional CH system outlined.

GAS SAVER

If nothing else, Gas Saver senses the boiler water temperature electronically, and therefore responds *instantaneously* to changes in heat level. But more importantly than this "secondary" economising mode, it senses the temperature of the hot water tank, in order to compute more logically the control signal to the gas burner. What this means, in short, is that with the radiators off, once the hot water tank has reached its preset temperature the system will shut down until hot water is next drawn off. And with

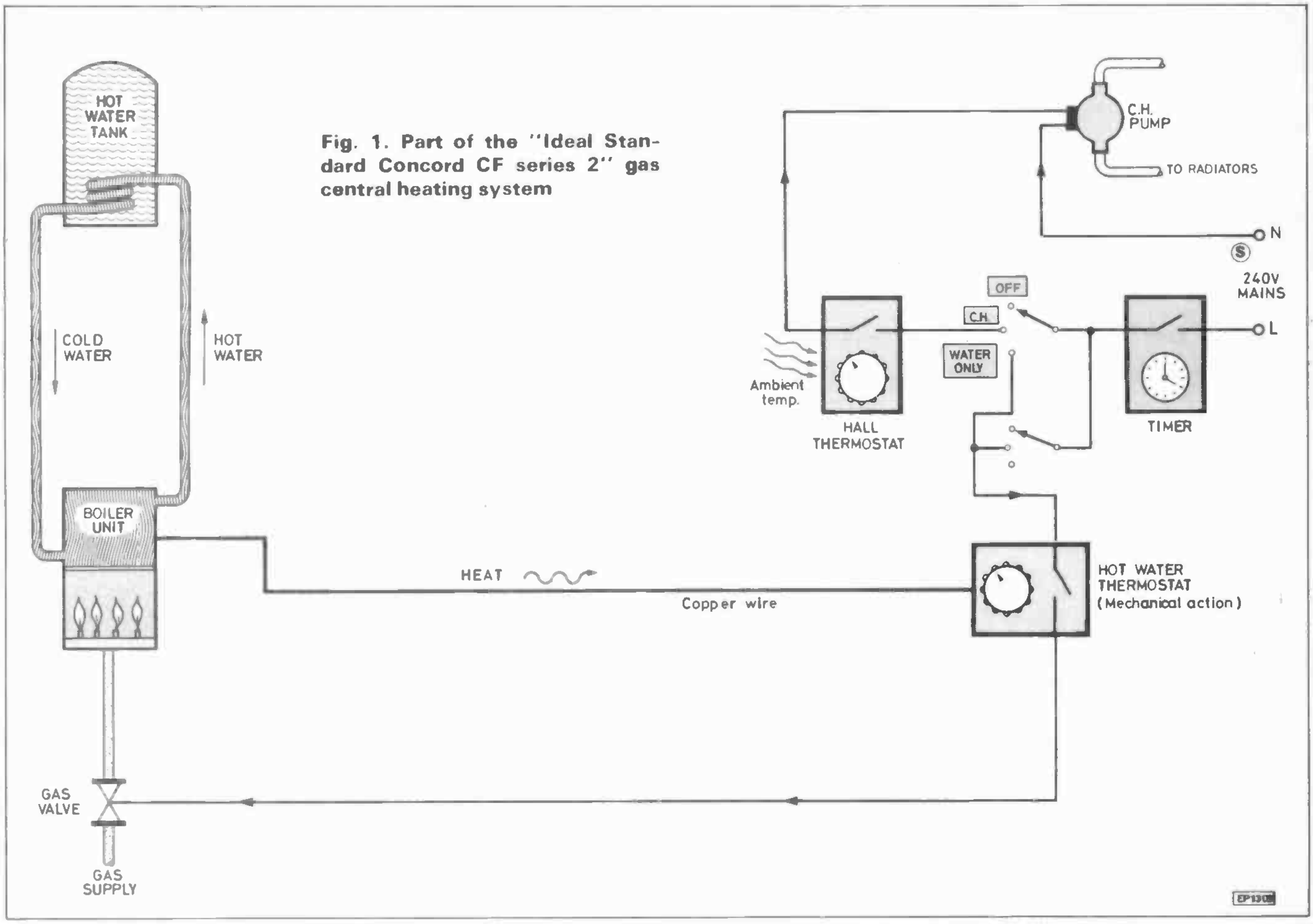


Fig. 1. Part of the "Ideal Standard Concord CF series 2" gas central heating system

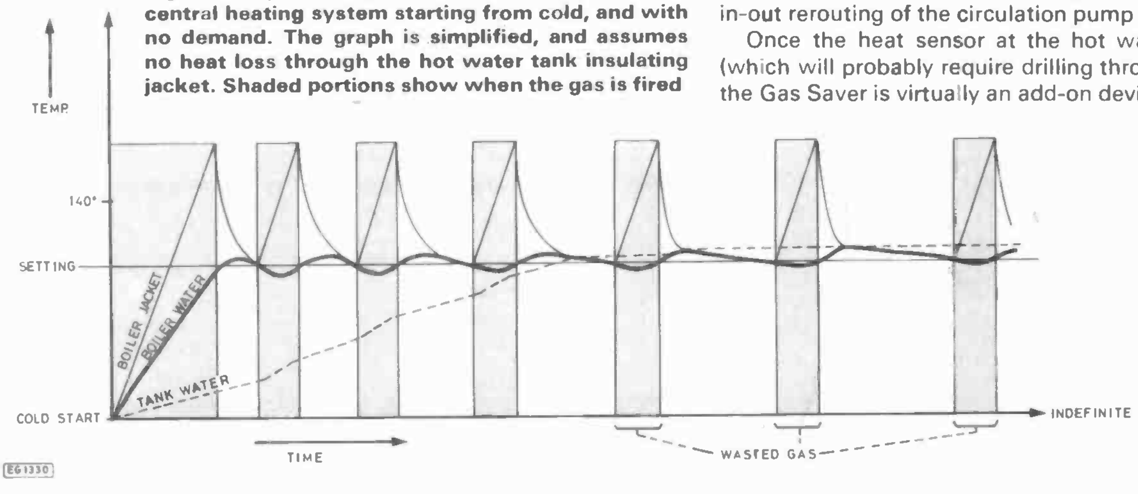
the radiators on, Gas Saver will ignore the tank water temperature but at least regulate the gas burner duty cycle more precisely than the conventional system. Fig. 4 shows how Gas Saver behaves with the radiators turned off—its "primary" economising mode.

The entire project was designed to be as cheap as possible to construct, without compromising reliability and safety—essential requirements in such a utility.

Gas Saver, when installed, renders the original water thermostat redundant, water temperature from then on being set by potentiometer VR1, and controlled via a triac mains switch that replaces the electrical contacts of the old thermostat (see Fig. 3). The original thermostat may be left in place, so that should a fault develop in Gas Saver, it is possible to convert quite quickly back to the original system. The plans given in this article adhere to a policy of plug-and-socket interconnection compatibility with the central heating's own distribution panel. If this policy is complied with, the original system, albeit less efficient, is always only a few seconds away from standby operation. Gas Saver can take its mains supply from the timer switch, and its only other claim on the central heating unit's wiring is the direct in-out rerouting of the circulation pump wires.

Once the heat sensor at the hot water tank is installed (which will probably require drilling through an internal wall) the Gas Saver is virtually an add-on device.

Fig. 2. Temperature patterns of a conventional gas central heating system starting from cold, and with no demand. The graph is simplified, and assumes no heat loss through the hot water tank insulating jacket. Shaded portions show when the gas is fired



ENERGY CONSERVATION DEVICE

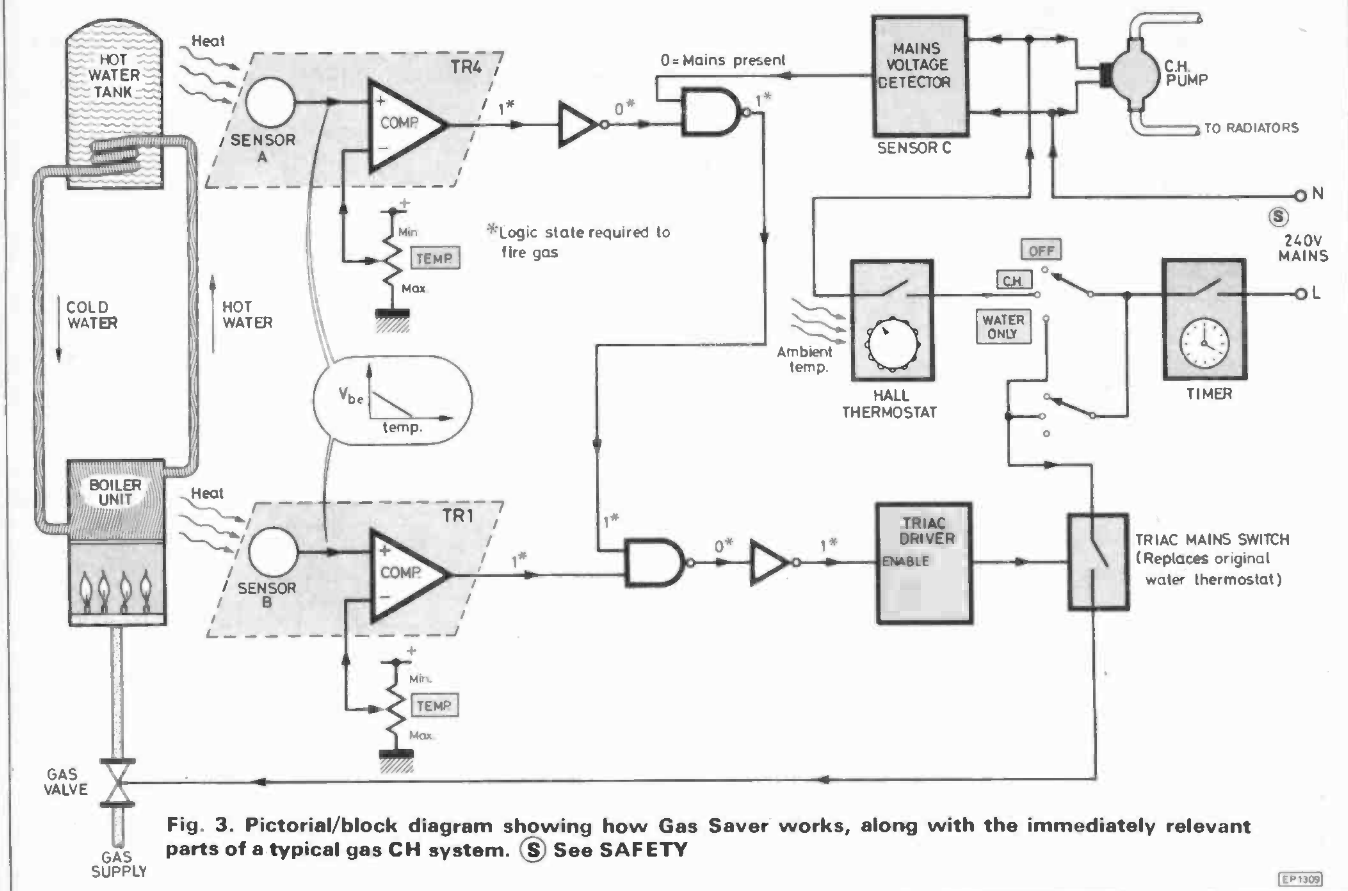


Fig. 3. Pictorial/block diagram showing how Gas Saver works, along with the immediately relevant parts of a typical gas CH system. (S) See SAFETY

CIRCUIT DESCRIPTION

The circuit (Fig. 5) is easier to understand once the three criteria of the design are appreciated. The three functions are:

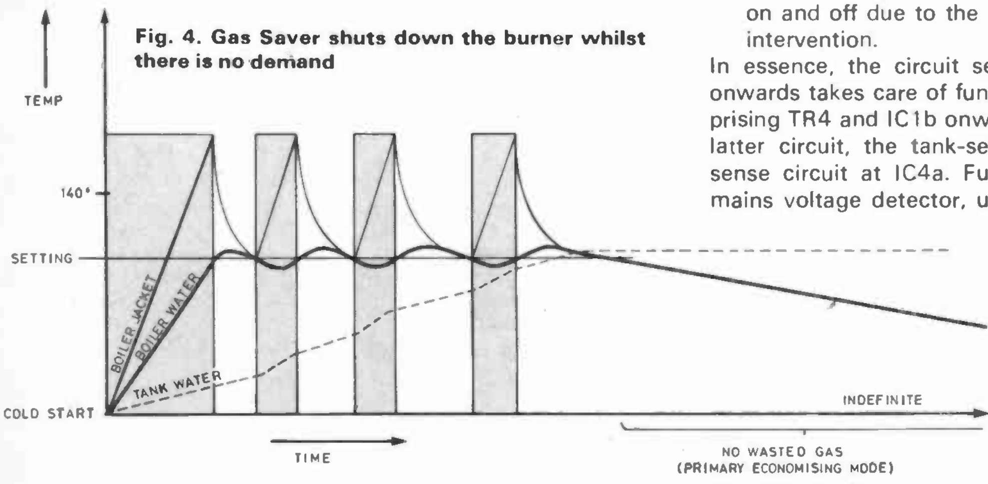
1) To take an instruction from the user to establish the water temperature required, this being achieved via the "Temperature" control VR1, and then regulate the gas burner duty cycle to average that temperature. The *boiler* temperature sensor, TR1, is the controlling agent for this function. As with a conventional controller, the temperature selected applies to both the radiators *and*/or the hot water storage tank.

2) To temperature-sense the hot water storage tank (TR4), and shut down the system when the water in the tank has reached the preselected temperature (this is the primary economising mode) and is achieved by inhibiting function 1.

3) To sense whether or not the radiator circulation pump is energised, and if so, *release* function 1 from the override capability of function 2. In other words, if the system is shut down because the water tank is up to the required temperature, switching on the radiator heating will again allow the gas to ignite, irrespective of the hot water tank condition. By sensing the pump itself, the system will respond, whether the radiators are turning on and off due to the hall thermostat, or due to manual intervention.

In essence, the circuit section comprising TR1 and IC1a onwards takes care of function 1. The identical circuit comprising TR4 and IC1b onwards takes care of function 2. This latter circuit, the tank-sense circuit, overrides the boiler-sense circuit at IC4a. Function 3 is realised by a simple mains voltage detector, using T3 for step-down and isolation. This is followed by a PSU style circuit which drives TR7 into conduction whenever the pump is energised. Therefore, whilst the radiator heating is on, the tank circuit's ability to inhibit the boiler control section is removed (at IC4c). There is, in effect, a cascaded override function.

Fig. 4. Gas Saver shuts down the burner whilst there is no demand



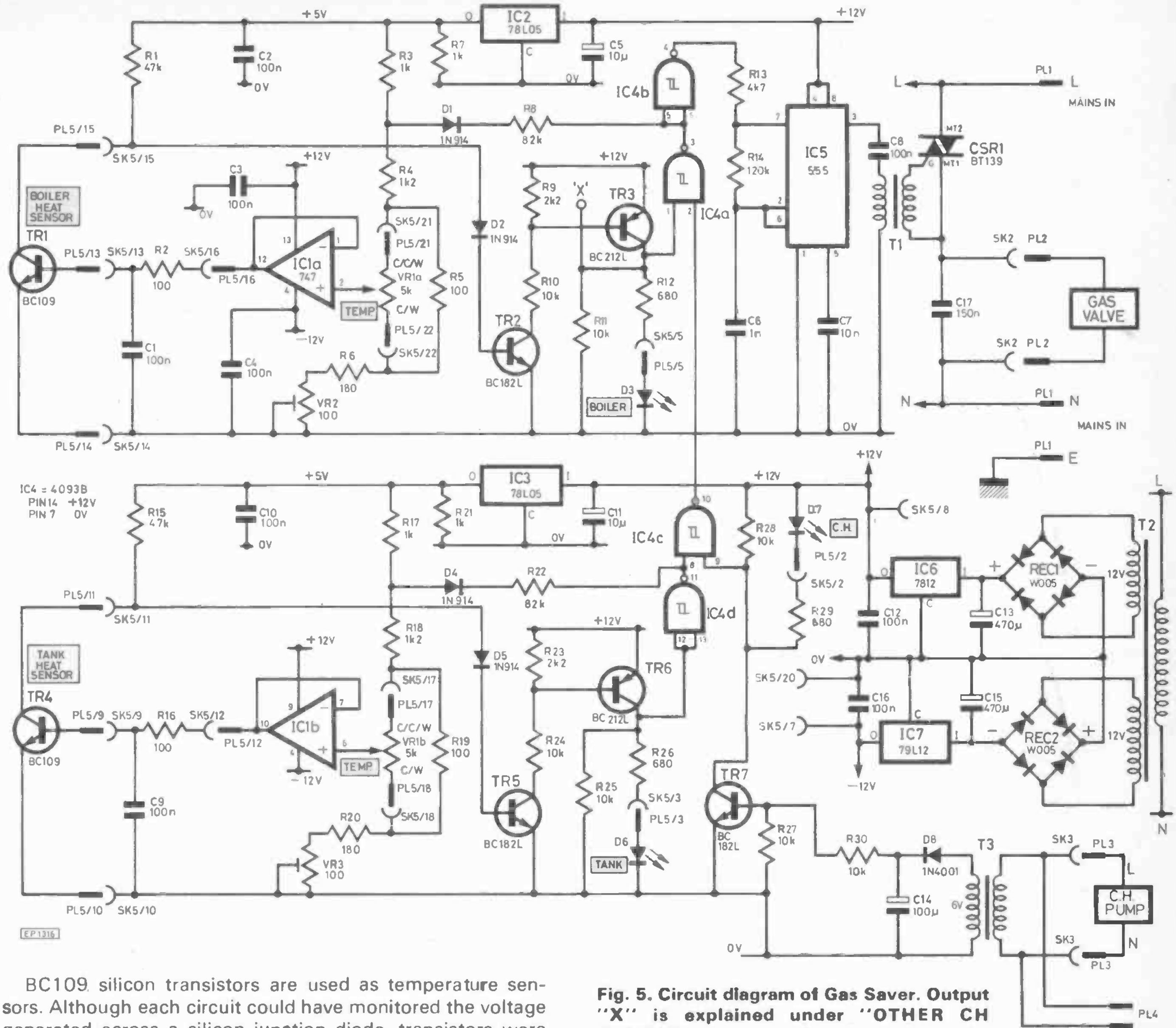


Fig. 5. Circuit diagram of Gas Saver. Output "X" is explained under "OTHER CH SYSTEMS", but can otherwise be ignored

BC109 silicon transistors are used as temperature sensors. Although each circuit could have monitored the voltage generated across a silicon junction diode, transistors were chosen because in a three-terminal mode they offer gain at the sensors themselves.

Taking the boiler half of the circuit as an example, what happens is this: the chosen temperature setting manifests itself as a voltage on the wiper of VR1a, and ignoring the voltage follower IC1a for a moment, this voltage is delivered to the base of the sensing transistor TR1. When this transistor is cold, the threshold, or "knee" voltage between its base and emitter is higher than the potentiometer voltage, and so the transistor is switched off. It follows then, that TR2 will be switched fully on, and likewise TR3. When illuminated, D3 shows that the boiler is below the preset temperature. To IC4a, the conduction of TR3 represents a logic 1 and so, unless overridden by the second sense circuit, IC4a outputs a 0. This output is tapped via R8 to provide positive feedback, modifying the original VR1 potentiometer voltage by something equivalent to a few degrees C. Thus the conditions which hold TR1 off are enhanced. This hysteresis is necessary for stable operation.

With the circuit in this state IC4b output is at logic 1, which enables the 555 oscillator, IC5. The pulse transformer is pulsed, the triac driven into conduction, and the gas valve opened. With the gas fired, the temperature of the boiler begins to rise, and with it the temperature of TR1.

At the preset temperature, TR1 will begin to conduct. This is because its base-emitter "knee" voltage will have fallen to, or below, the voltage generated by VR1. As TR1 moves into conduction, TR2 and TR3 are forced out of conduction, producing a logic 0 at pin 1 of IC4a.

Any temptation for the circuit to "hover" in a half-switched state is eliminated by the positive feedback via R8 and D1. Because now R8 is no longer stealing current from VR1's potentiometer network, the voltage to the base of TR1 will rise, tipping that transistor further into conduction. IC4 is a *Schmitt trigger* NAND, adding to the "snap" action of this bistable circuit.

The presets VR2 and VR3 are included in the potentiometer network because, like human beings, no two transistors are identical. It is necessary to be able to modify VR1's voltage swing by an amount capable of offsetting the Vbe production spread of BC109s. TR1 and TR4 should at least switch at the *same* temperature even though VR1 is not calibrated in deg. C at its dial, and the procedure for setting up presets for this is described later.

Returning to IC1; this is merely an impedance converter, or voltage follower, necessary because the silicon junction is a current device and will switch more rapidly if driven from a low impedance source. Impedance conversion would not be needed if dual-ganged 100 Ohm potentiometers were readily available to the hobbyist. Such potentiometers as appear "off the shelf" begin at 4k7 or 5k, and so one of these was selected, and its characteristics modified by a cheap op. amp. Resistor R2 protects the transistor from overdrive, whilst C1 acts as a short-circuit to r.f. interference picked up along the cable to the sensor. Ideally, this capacitor should be positioned at the sensing transistor end of the cable, but this may be mechanically inconvenient. It works perfectly well *within the main unit* on the prototype system, even though this effectively puts it in series with the lead inductance as far as the transistor is concerned.

Independent regulation for the two identical circuit sections is provided (by IC2 and IC3) so that neither is affected by the other's switching transients.

The circulation pump-sense override is now described. Obviously, if the central heating radiators are turned on, then the fact that the hot water tank has reached its required temperature should no longer be allowed to inhibit the gas burner. It is therefore necessary to detect whether or not the radiator circulation pump is running, and if so, to lock out the hot-tank signal. The pump detector is a simple PSU type circuit, taking its mains input when the pump does. This PSU simply inhibits the hot-tank signal by driving TR7 into conduction.

The illumination of D7 indicates that the radiators are being driven by the circulation pump, and it will thus light up and go out again repeatedly, in step with the hall thermostat (air temp.). Actually, although D7 lights up immediately as the pump energises, there is a delay of about four seconds before going out, due to the time constant of C14 and R30. This is of no consequence. The transformer, T3, may seem a clumsy way of detecting the state of the pump, but it is quite the cheapest, and the idea of this project is, after all, to avoid wasting money.

DRIVING THE GAS VALVE

The gas valve in the author's central heating system was found to be highly inductive. As a result, the pulse frequency from IC5 needed to be quite high; and more importantly, capacitor C17 had to be included for power factor correction. In plain English, this last point means that because current builds up slowly in an inductor, and because a triac is a current avalanche device it will fail to fire early enough for a full 360 degree conduction angle. Capacitor C17 provides some "lead" current for the triac to latch on to. If the gas valve makes an audible buzz, C17 may not be large enough (assuming nothing else is wrong). **If the gas valve makes any kind of noise, switch off the system until the fault is rectified.** Do not try to achieve a smooth triac action by connecting a capacitor/resistor snubber network across the triac itself, as this will probably leak enough current to prevent the gas valve dropping out again, once energised.

HEAT SENSORS

Transistors make economic, and conveniently linear temperature sensors—as long as the operating parameters are within certain limits. Silicon devices, including specifically designed silicon temperature sensors, will work up to 150 deg. C, a figure which gives a 50% safety margin in the application of sensing water temperature to boiling point at atmospheric pressure. So, unless an explosion is imminent, the two metal cannistered BC109s are not likely to run away thermally. If they were to, they would shut down the gas burner anyway!

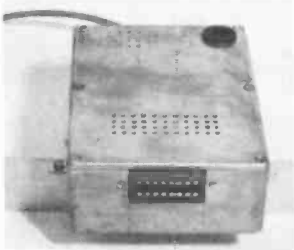
A transistor used in its natural three-terminal mode of operation can integrally perform the dual function of being both temperature sensor and comparator. A potentiometer provides the reference voltage, whilst the transistor's base-to-emitter threshold provides the temperature related voltage. This technique is not original though; it is seen in P. J. McFarlane's "Ice Warning & Lights Reminder" of *P.E. March '83.*

On a more practical note, the boiler sensor TR1 should be situated so as to detect the *water* temperature near the *top* of the boiler jacket, *not the hot gases rising from the burner.* The transistor should, therefore, be positioned with this in mind. Some CH boilers, probably most, have a receptacle at the top-centre of the boiler jacket to accommodate the conventional heat sensor, and this, in the case of the prototype installation, was eminently suitable. It was possible to push the transistor sensor well inside, without removing the original.

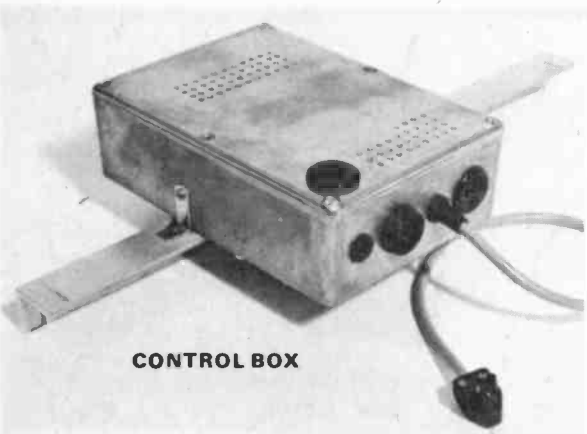
Both heat sensor transistors, TR1 and TR4, should be mounted and sleeved as shown in Fig. 6.

CONSTRUCTION

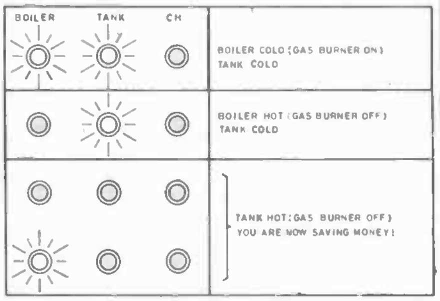
As can be seen in the photographs, Gas Saver is built using stripboards. The main control electronics board is housed



POTENTIOMETER BOX



CONTROL BOX



in a diecast alloy box, which is situated *inside* the CH boiler unit. The Potentiometer box (plastic), also containing the l.e.d.s and impedance converter op. amps, is mounted against the outside of the CH boiler housing in such a way that the temperature control knob (VR1) is readily accessed. The two boxes are linked by a multicore cable. This umbilical link should ideally be a 14-way screened cable, although 15 instrument wires bound by "spiral wrap" will probably suffice, or even ribbon cable. The stripboard and box layouts are shown in Figs. 7–9.

This dual box approach was dictated by the geometry of the author's CH system, and the fact that the boiler unit is fitted tightly in a corner with little external space. An alternative approach, if there is space around the boiler housing, would be to put *all* the electronics, including the potentiometer, in the alloy box, and mount it externally. This could make use of a p.c.b., or a large stripboard (although in the latter case the mains transformers should *still be mounted on a separate non-clad board*). The "single box" approach would have a number of advantages, one being the avoidance of the multiway connector and cable (and metalwork to fit it). Another is that of finding sufficient space within the boiler unit (space which is not subject to too much heat from the boiler itself) to take the main control box. It also involves one less mounting bracket, for those who do not enjoy metal bashing.

There are no special points concerning construction. Any hobbyist experienced enough to undertake this project will find the illustrations adequate, and will know that the CMOS 4093 requires careful handling and should be mounted in an i.c. socket.

Insulation should be placed beneath each of the component boards in the alloy box. PVC tape can be used, but in the prototype, plastic sheeting cut to the same dimensions as the boards themselves are used. These were cut from a jumbo bleach bottle, drilled with the same fixing holes as the stripboards, and dropped over the stand-offs first.

The main unit board is mounted on p.c.b. stand-off clips, and the high voltage (mains) board is mounted on 4BA screws with locking nuts—this providing greater security for the heavy transformers. The easiest and most accurate way of ensuring that the holes in the boxes line up with the mounting holes in the component boards, is to use the component boards as templates for marking out. The stripboards make ideal templates once they have been cut and drilled, but before any components have been mounted on them.

All mains earths must be observed when wiring the main control box, and these earths must be affixed to the metal box itself, using a nut and screw and solder tag for reliable connection.

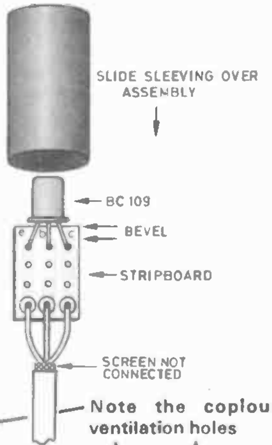
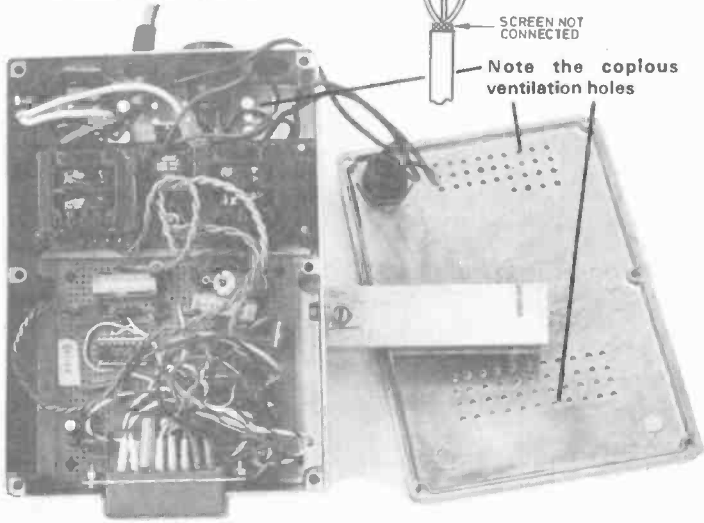


Fig. 6 (right). Transistor heat sensor assembly (two are required). The top board edge, against which the transistor should be closely mounted, is bevelled to truncate the copper tracks. Heatproof sleeving is required to electrically insulate the assembly from its surroundings, and this should be of a material that is rated to 150 deg. C minimum. Silicone rubber (180°C) will do, or expandable woven polyester (150°C)



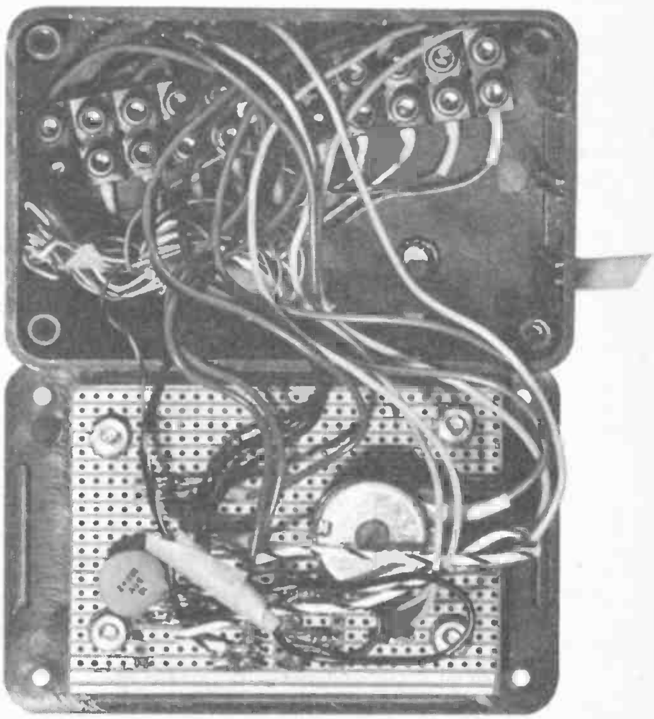
INSTALLATION

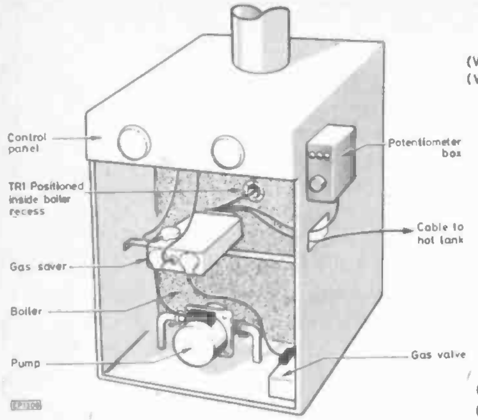
Apart from making brackets appropriate to the particular installation layout, it is necessary to hack out a fairly large hole (about 60mm square) through the side of the boiler housing. This can be done with an Abrafile or nibbler, after which the edges are filed smooth and covered with polythene grommet strip. This hole is required to pass the interconnecting cable between the two boxes (prototype layout), or to carry the pump, valve and other CH unit cables through to the electronics control box (in the case of the "single box" alternative layout).

An extended masonry drill will undoubtedly be necessary to drill a hole through an internal wall separating the boiler unit from the hot water tank (airing cupboard). This is to carry the hot water tank temperature sensor lead. If this lead is more than four feet long it will be wise to consider the use of screened three-core cable, this to be wired as shown in Fig. 6.

SETTING UP

The only setting up required is that of VR2 and VR3. The simplest way to do this is to power up Gas Saver with the gas valve socket disconnected, and place both sensors in some recently boiled water. VR2 and VR3 are then adjusted





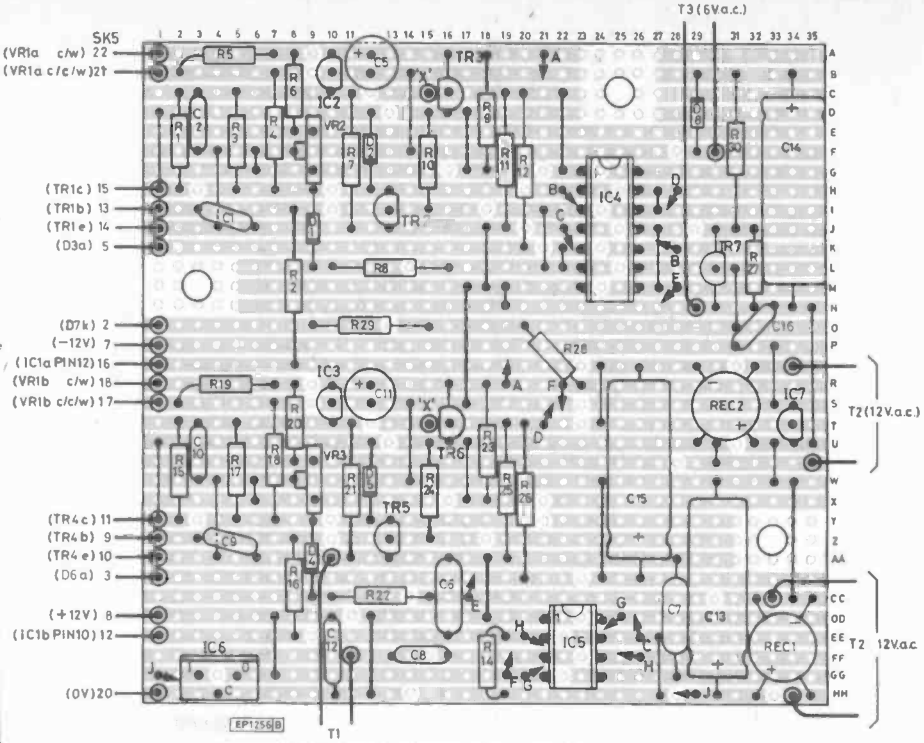


Fig. 7. Main electronics stripboard layout

COMPONENTS . . .

Resistors

R1, R13, R15	47k (3 off)
R2, R5, R16, R19	100 (4 off)
R3, R7, R17, R21	1k (4 off)
R4, R18	1k2 (2 off)
R6, R20	180 (2 off)
R8, R22	82k (2 off)
R9, R23	2k2 (2 off)
R10, R11, R24, R25, R27, R28, R30	10k (7 off)
R12, R26, R29	680 (3 off)
R14	120k

All resistors 0·25W high-stab carbon film

Potentiometers

VR1	5k dual rotary, lin law (may be 4k7)
VR2, VR3	100 vert preset (2 off)

Capacitors

C1–4, C8–10, C12, C16	100n disc cer (9 off)
C5, C11	10µ/16V elect. radial (2 off)
C6	1n ceramic
C7	10n ceramic
C13, C15	470µ/25V elect. axial (2 off)
C14	100µ/15V elect. axial
C17*	150n/400V (may be 100n)*

*See text

Integrated circuits

IC1	747
IC2, IC3	78L05 (2 off)
IC4	4093BE
IC5	555
IC6	7812
IC7	79L12

Semiconductors

TR1, TR4	BC109 (2 off)
TR2, TR5, TR7	BC182L (3 off)
TR3, TR6	BC212L (2 off)
D1, D2, D4, D5	1N914 or 1N4148 (4 off)
D3, D6	0·2" yellow l.e.d. (2 off)
D7	0·2" red l.e.d.
D8	1N4001
REC1, REC2	W005 (2 off)
CSR1	BT139 triac

Plugs & Sockets

SK1	P430SE (line socket)
SK2	P650
SK3	SA2404
PL1	P429 (chassis plug)
PL2	P649
PL3, PL4	SA2403 (2 off)

Note: These were the plugs and sockets required to install Gas Saver into the author's "Ideal Standard Concord" central heating system, in which PL2 and PL3 already exist. In other systems it will be necessary to inspect the interconnecting arrangements before ordering parts.

PL5	Any 24-way plug (Maplin YX37S + male pins)
SK5	Any 24-way socket (Maplin YX43W + female pins)

Note: If the suggested Maplin "Multicon" 4 x 6 contact connectors are used the "receptacle" type socket will require a 28 x 18mm cut-out.

Transformers

T1	Pulse transformer (RS 196–369 or Maplin HX81C)
T2	12V+12V, 3VA mains (p.c.b. mounting)
T3	6V+6V, 3VA mains (p.c.b. mounting)

Miscellaneous

Plastic case* (65 x 100 x 52mm) type TEKP2P (West Hyde)
Diecast alloy case (171 x 121 x 5mm)
Brackets for mounting the above case/cases
Stripboards: Main = 35 holes x 34 tracks
High voltage = 45 holes x 16 holes (no copper tracks)
Potentiometer= 30 holes x 20 tracks
6mm stand-offs, or nylon nuts and bolts

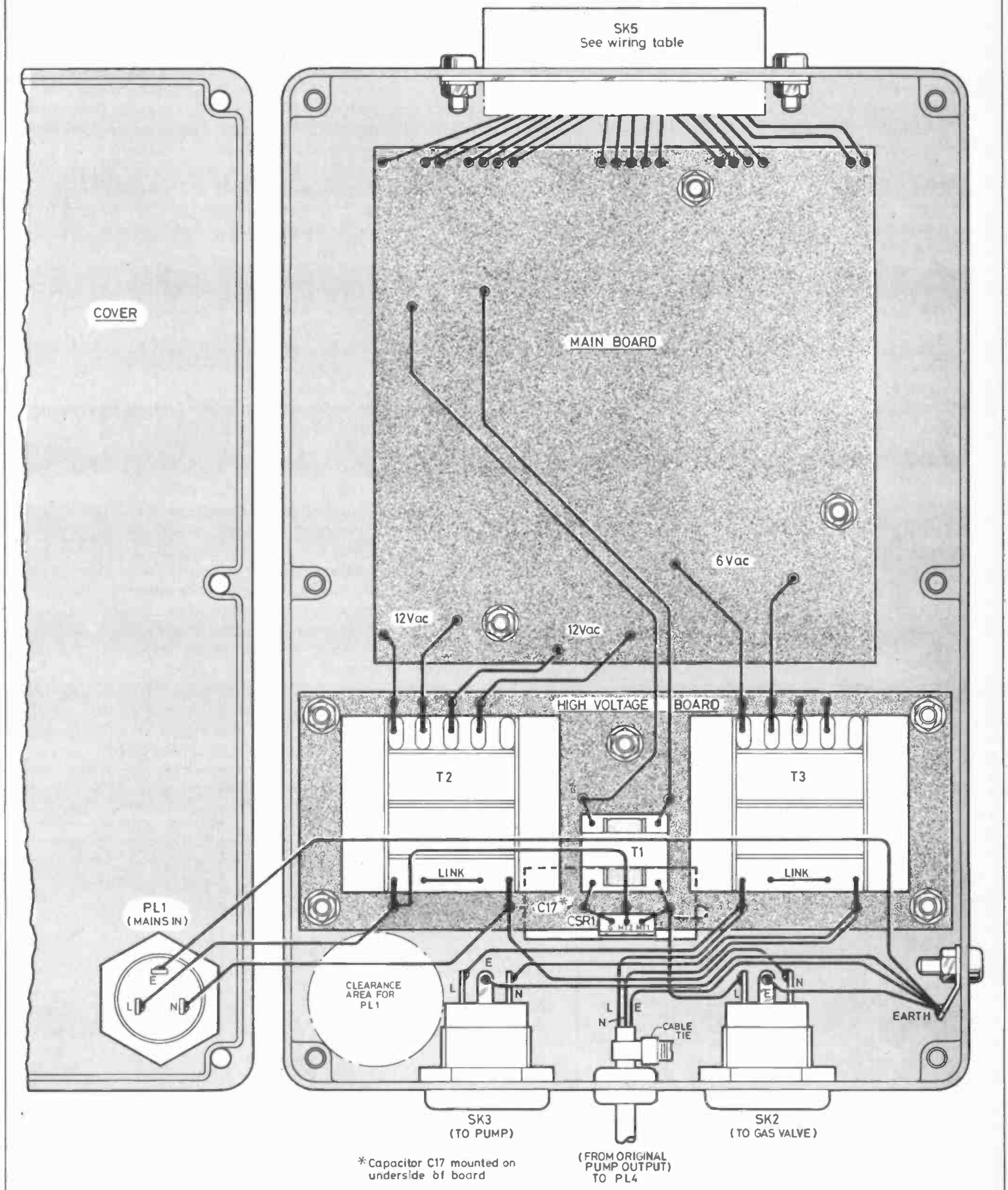


Fig. 8. High Voltage (mains) board layout, and overall wiring of main box. The High Voltage board is unclad

EP1311

until both sensing transistors can be made to switch at exactly the same point on VR1's scale. The front panel l.e.d.s will indicate the switching points. In fact, it is most probable that Gas Saver will function correctly with VR2 and VR3 both set to midway position, without conducting this test.

The dial on VR1 can be numbered, or simply lettered subjectively *warm, hot, very hot,* with intermediate temperatures being interpolated by the user. The point on VR1's dial that switches the l.e.d.s on and off whilst setting up VR2 and VR3 will, if using recently boiled water, serve as a marker for *very hot*.

SAFETY

Naturally, safety is all important in any equipment using gas and electricity simultaneously, particularly when running continuously without supervision. No short cuts should be taken during construction, and any part of the electronics housed within the boiler unit should be cased in a well ventilated metal (fireproof) box.

The possibility of a lost connection during service has to be considered. For example, it would not be desirable to lose a connection to *any one* of the wires to a heat sensor, and come home to a loft swirling with steam, or worse! A completely independent "over-temperature" cut-out must be considered, that will cut off power to the control box should the boiler water temperature rise above 100 deg. C.

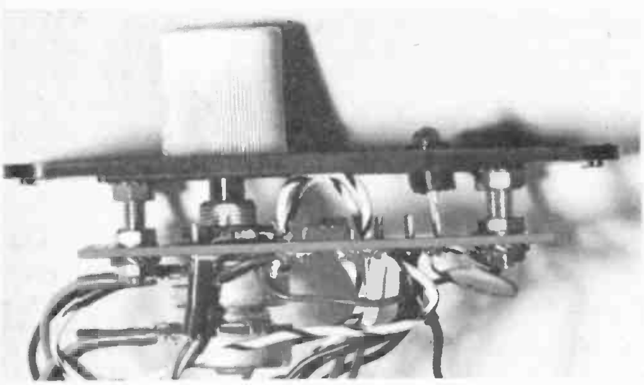
An obvious solution exists; the original thermostat! Other than ignoring its electrical contacts in the new system, it is left fully functional, so why not wire *its* contacts in series with the mains supply to the electronics controller? Then, if this original thermostat is turned up to a temperature setting way above those being selected for everyday use, it will limit the gas duty cycle should boiler overheating occur due to an electronic "latch-up". With this safety feature, the plug-and-socket compatibility for quick reversion to conventional operation *might* need to be partially sacrificed.

The safety option described here will not shut down the system indefinitely in the event of the type of failure that keeps the gas on, but will limit the gas duty cycle to a "ceiling" temperature. At least a hot bath may be taken whilst the fault is considered.

QUANTITY, AND THE TANK SENSOR

The hot water tank sensor need only be tucked in between the side of the tank and the insulation jacket. The position of this sensor will be about halfway down.

Since hot water builds up from the top of the tank downwards (it is possible to have cool water at the bottom and piping hot water at the top) the vertical position of TR4 needs to be considered with this in mind.

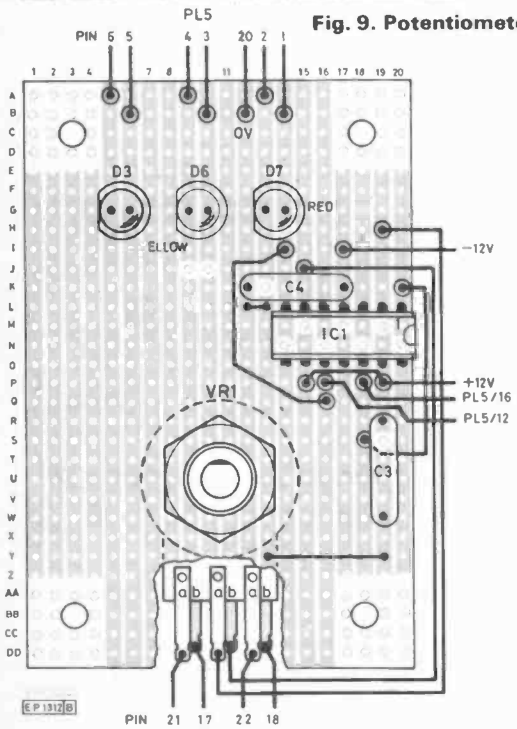


SAVINGS

The important question is: How much money does a Gas Saver save? Just a short summertime test has so far been possible (hot water only), during which Gas Saver reduced fuel consumption by 21%. One manufacturer of a similar energy conservation device guarantees a *minimum* saving of 16%. Savings also depend upon how efficiently the old "pot luck" mechanical system happened to be working, and the operating regime in any particular household.

Throughout 1981/82, gas prices increased four times, each time between 10–15%. It seems that the consumer is to be financially coerced into more efficient use of this "precious" fuel, whilst at the same time being sold equipment that wastes it! After-sale conservation devices will often provide the consumer's only escape route.

Fig. 9. Potentiometer board layout



SK5 WIRING TABLE

FROM (main unit)	PIN	WIRE COLOUR	TO (potentiometer box)
+12V	1		D7 (CH l.e.d.) anode
R29	2		D7 cathode
R26	3		D6 (TANK l.e.d.) anode
OV	4		D6 cathode
R12	5		D3 (BOILER l.e.d.) anode
OV	6		D3 cathode
–12V	7		–12V
+12V	8		+12V
R16	12		IC1b pin 10
R2	16		IC1a pin 12
R18	17		VR1b c.c.w.
R20	18		VR1b c.w.
OV	20	Screen*	OV
R4	21		VR1a c.c.w.
R6	22		VR1a c.w.
			TO (sensor)
R16	9		TR4 (TANK) base
OV	10		TR4 emitter
R15	11		TR4 collector
R2	13		TR1 (BOILER) base
OV	14		TR1 emitter
R1	15		TR1 collector

NOTE: c.w./c.c.w. = clockwise/counter-clockwise viewed from rear of pot.

OTHER CH SYSTEMS

Alas, the author is no expert on central heating systems in general, and therefore not in a position to suggest modifications to Gas Saver to adapt it to all other systems.

However, one common departure from the type of central heating Gas Saver was designed to work with, is one in which the circulation pump runs continuously. In this type, it is believed that for geometric reasons thermal currents cannot be relied upon to transfer hot water from the boiler to the storage tank—perhaps because the airing cupboard is no higher than the boiler. Consequently, a permanently energised pump is needed to circulate hot water from the boiler to the tank, and a motorised valve is used to bring in the radiators when required.

At first, it might seem that the obvious modification to Gas Saver is merely to sense the state of the motorised valve instead of the pump (sensor C of Fig. 3). The problem with this, is that whilst the gas burner is off for prolonged periods (as in the "primary" economising mode shown in Fig. 4) the pump will *remove* hot water from the tank and circulate it through a *cold* boiler jacket—the exact opposite to heating! It is not certain that Gas Saver will deserve its name in this situation.

A further modification is therefore necessary if Gas Saver is to be put to work fruitfully in such a CH system, and a suggested way to do it is illustrated in Fig. 10. It is emphasised that this modification has not been built and tested. The additional circuit is intended to shut down the circulation pump as soon as the boiler jacket becomes cold (having no more useful heat to impart), and re-energise the pump again as soon as the boiler is at least as hot as the storage tank. Any constructor embarking on this version of Gas Saver will need to run the system under observation, and arrive at his/her own conclusions as to its merits. ★

Gas Saver is an electronic thermostat that eliminates unnecessary firing in gas central heating, and can cut bills by up to 20%. Gas Saver can be built for around £30, and do the job of economisers costing four times as much.

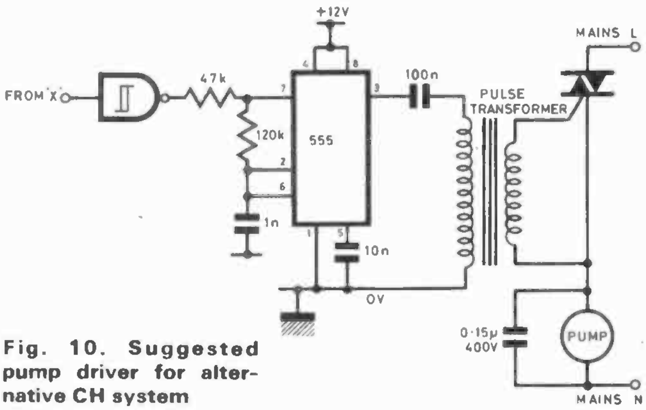


Fig. 10. Suggested pump driver for alternative CH system

THIS project has its origins in a production meeting of an amateur stage review, when the author was foolish enough to suggest a sci-fi sketch.

The main requirement was for a number of lightweight hand guns, capable of producing a flash of 'death rays' when fired, having a rapid recharge rate and a negligible standby power drain. Directed energy weapon technology being what it is, the source of 'death rays' reduced to a Xenon photographic flash tube. Most commercial flash gun circuits will not fulfil the last two criteria however, and so a suitable circuit was developed.

The other requirement was for the sound which every 'death ray' is presumed to produce, i.e. the 'zap'. Flash tubes themselves are embarrassingly quiet, and so a tone generator was developed, to be triggered by the flash. Such a circuit can be made to work in normal light, even fluorescent, because of the very rapid rise time of the flash tube output. In practice, reflection from dull surroundings at distances of up to 50 ft or so is sufficient to trigger the circuit.

TONE CIRCUIT

The tone generator circuit is shown in Fig. 1. Here IC1 operates as a current to voltage converter, the output of which is high pass filtered by C1 and R1, to produce a spike on receipt of a sudden increase in the light level by way of the phototransistor TR1.

VR1 sets the gain, and VR2 sets the trigger threshold of the comparator IC2.

IC3 is a retriggerable monostable, and VR3 sets the period, and hence the 'sustain' of the tone generated. The output at pin 6 charges C5 via D1, holding the voltage high until IC3 turns off, when C5 discharges at a rate set by VR4. The voltage on C5 is used to control IC4, a PLL chip used only as a voltage controlled oscillator. This has a square wave output which is not really ideal, but it was used because it conveniently switches off when the control voltage drops to zero.

VR5 sets the frequency range of the sweep. The amplitude of the output is reduced by R4 and R5. Control of the tone may be achieved in the power amplifier used.

The tone generator is constructed on Veroboard as in Fig. 2. On completion first set VR1 and VR4 to maximum, VR2

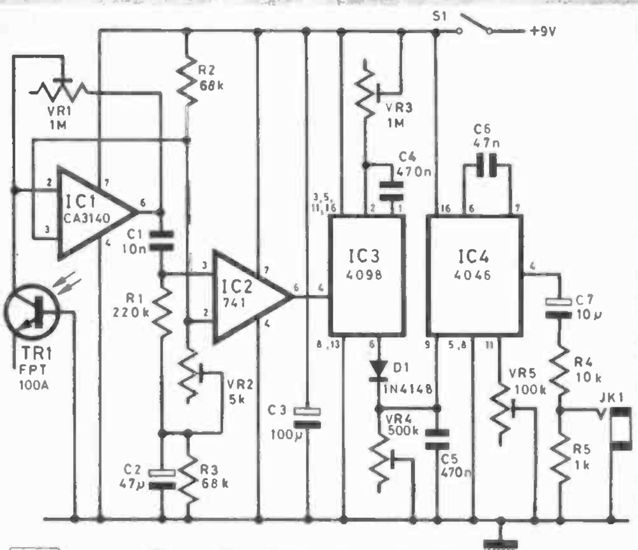


Fig. 1. Tone generator circuit

to minimum and VR3 and VR5 to mid position. A jack plug should be connected to a suitable power amplifier and loudspeaker and inserted at JK1.

Increase VR2 until triggering due to circuit noise and residual hum ceases. Obtain a photographic flash gun and charge it up then switch on the

COMPONENTS . . .

TONE GENERATOR

Resistors

R1	220k
R2	68k
R3	68k
R4	10k
R5	1k

All resistors ¼W 5% carbon

Capacitors

C1	10n
C2	47µ 16V
C3	100µ 16V
C4	470n
C5	470n
C6	47n
C7	10µ 16V

Semiconductors

IC1	CA3140
IC2	741
IC3	4098
IC4	4046
D1	1N4148
TR1	FPT100A

Potentiometers

VR1	1M
VR2	5k
VR3	1M
VR4	500k
VR5	100k

Miscellaneous

S1 — Single pole switch, Veroboard, pins

ZAP GUN

tone generator and fire the flash. If o.k. the circuit will 'sound off' with a briefly sustained tone and then die.

GUN CIRCUIT

The heart of the gun circuit is a push-pull inverter (Fig. 4) each half being driven by non-overlapping square wave inputs. The drive waveforms from the gates (Fig. 3) are inverted and buffered by TR1 and TR3, and the emitter followers TR2 and TR4 drive the output pair, TR5 and TR6. It is important that the output transistors are of the metal can variety, as the plastic versions have a lower minimum current gain, and may not completely saturate. Under normal operating conditions little heat is dissipated and large heatsinks are not needed. D4 and D5 protect the output transistors against reverse biasing voltages, and D6 and D7 with R11 and C5 limit positive going spikes to approximately $2V_{cc}$.

The high voltage output from T2 is rectified by D8–D11 and charges the main storage capacitor C6. The voltage on C6 is sensed by the potential divider R15/16 and R2, and compared with the reference voltage of D15 through IC1.

When the voltage on C6 is less than about 230V, the output of IC1 is high, enabling the CMOS astable oscillator, IC2(a) and providing an inhibit signal to the trigger circuit to prevent the gun being fired before it is fully charged. The output of the oscillator has an unequal mark-space ratio, which is gated by IC2(c) and (d) and IC3, a dual 'D' type flip-flop. This produces the non-overlapping drive waveform.

As the voltage on C6 rises to about 240V, IC1 output goes low, inhibiting the inverter, and arming the trigger circuit, TR7 etc. Two possible trigger circuits are given: a single shot circuit (for the bad guys); and a continuous repeat 'automatic fire' trigger (for the good guys). The single shot

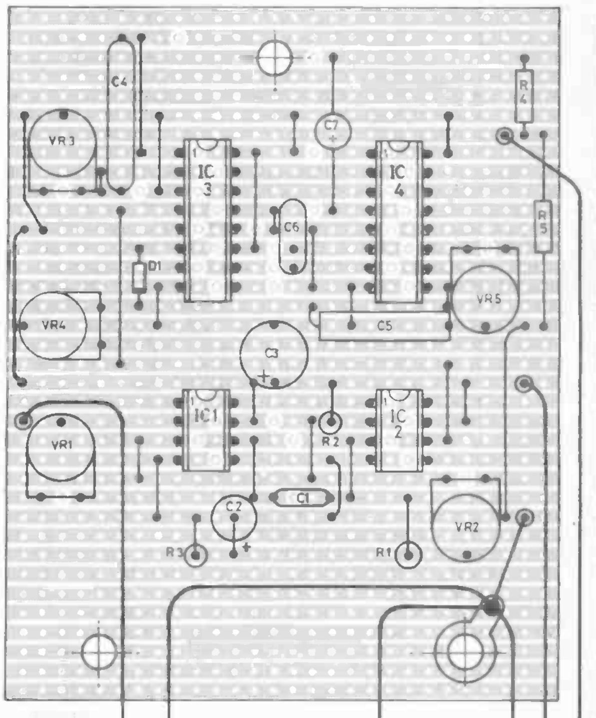


Fig. 2. Veroboard assembly of tone generator

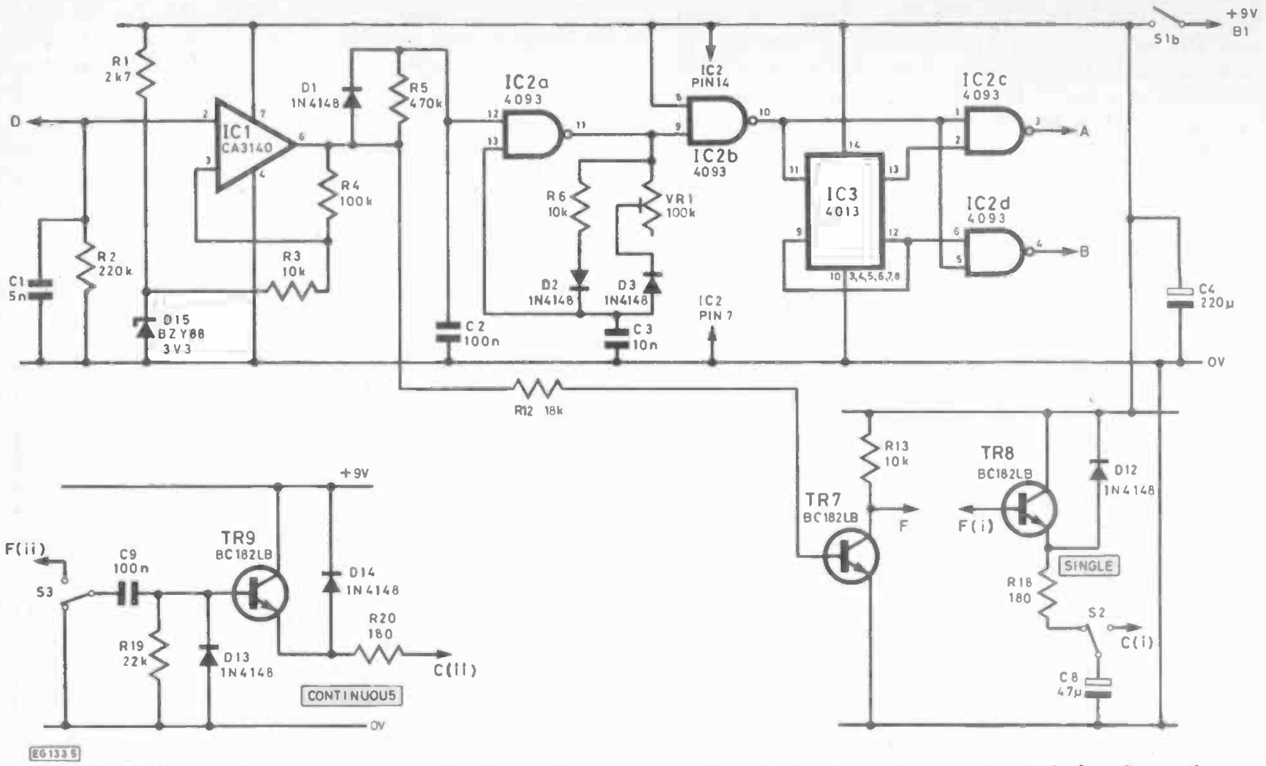


Fig. 3. Low voltage part of gun circuit. In the prototype the single shot trigger was used. An alternative continuous trigger is shown lower left

COMPONENTS . . .

GUN CIRCUIT

Resistors

R1	2k7
R2	220k
R3	10k
R4	100k
R5	470k
R6	10k
R7	22k
R8	1k
R9	22k
R10	1k
R11	680R
R12	18k
R13	10k
R14	100R
R15	10M
R16	10M
R17	1M
R18	180R
R19	22k
R20	180R

All resistors ¼W 5% carbon

Capacitors

C1	5n
C2,9	100n (2 off)
C3	10n
C4	220µ 16V
C5	47µ 40V
C6	32µ 450V
C7	47n 450V
C8	47µ 16V

Transformers and tube

Pri — 12 + 12 turns of 24 s.w.g. enamelled wire
Sec — 800 turns of 42 s.w.g enamelled wire
Xenon trigger transformer (Maplin YQ63T)
Xenon tube (Maplin YQ62S)

Miscellaneous

S1 D.P.S.T. toggle switch, S2–S3 S.P.D.T. toggle with single bias to one position, 20in length of 3 x 3in plastic trunking, VR1—100K, B1—PP3, B2—PP9

Semiconductors

TR1,3,7,8,9	BC182LB (5 off)
TR2,4	BD137 (2 off)
TR5,6	2N3055 metal can (TO3) (2 off)
D1,2,3,12,13,14	1N4148 (6 off)
D4–11	1N4007 (8 off)
D15	BZY88 3V3
CSR1	2N4443
IC1	CA3140
IC2	4093
IC3	4013

circuit used charges C8 via TR8 when TR7 is turned on by IC1; this charge is transferred to the gate of CSR1 when the trigger S2 is operated. CSR1 discharges C7 through the pulse transformer T2, providing 3 or 4kV to the trigger electrode of the flash tube, causing the tube to strike.

The falling voltage on C6 causes the cycle to repeat, with a delay due to C2 and R5 to prevent the inverter starting before the discharge is complete.

The continuous firing trigger circuit uses C9, R19 and D13 to differentiate the positive going edge generated when S3 wiper connects with TR7 collector, and IC1 output is

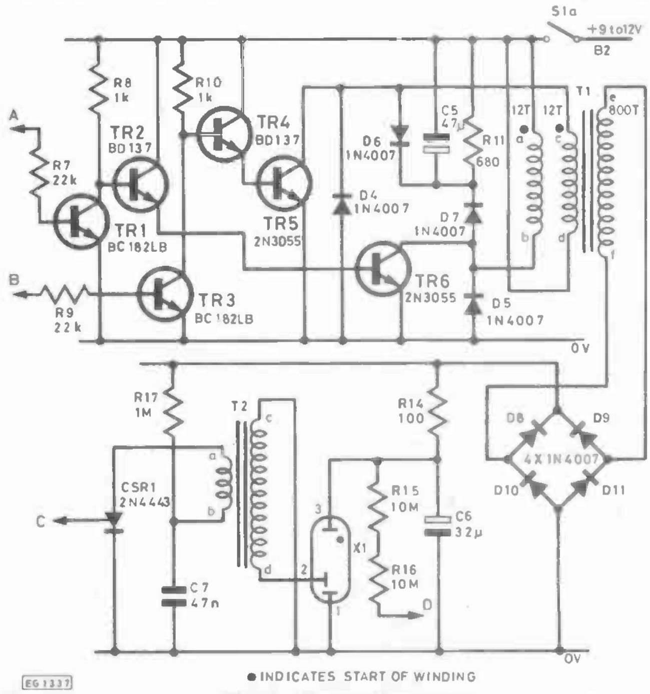


Fig. 4. High voltage part

low. This pulse briefly turns on TR9, firing CSR1 and hence the tube. The recharge cycle begins, with IC1 output going high, and when C6 is fully charged, going low again. TR7 collector goes from low to high, and if S3 wiper is still connected, this transition initiates the triggering, and so the cycle repeats until S3 is opened.

TRANSFORMERS

The construction of T1 deserves some comment. The primary winding consists of 12 plus 12 turns of 24 s.w.g. enamelled wire, bifilar wound on the core bobbin, and then insulated with a layer of tape. The secondary is made up of 800 turns of 42 s.w.g. enamelled wire, wound in four layers, each insulated from each other by a layer of tape. Sleeving should be placed over the free ends of the windings before covering with insulation to avoid chafing. The core used was a 36mm diameter item, of Siemens T26 material (available from Electrovalue).

T2 may be obtained from Tandy, Maplin, or may be recovered from a complete flash gun. Physical construction may vary so modify layout accordingly. Tubes for the prototype models were obtained complete with reflectors by purchasing a quantity of used photographic flash guns from a dealer (four for £6). Most Japanese items are suitable; tubes from German made units seem to require a higher supply voltage.

TESTING

The circuit may seem rather complex, but it has the virtue

GUN BOARDS

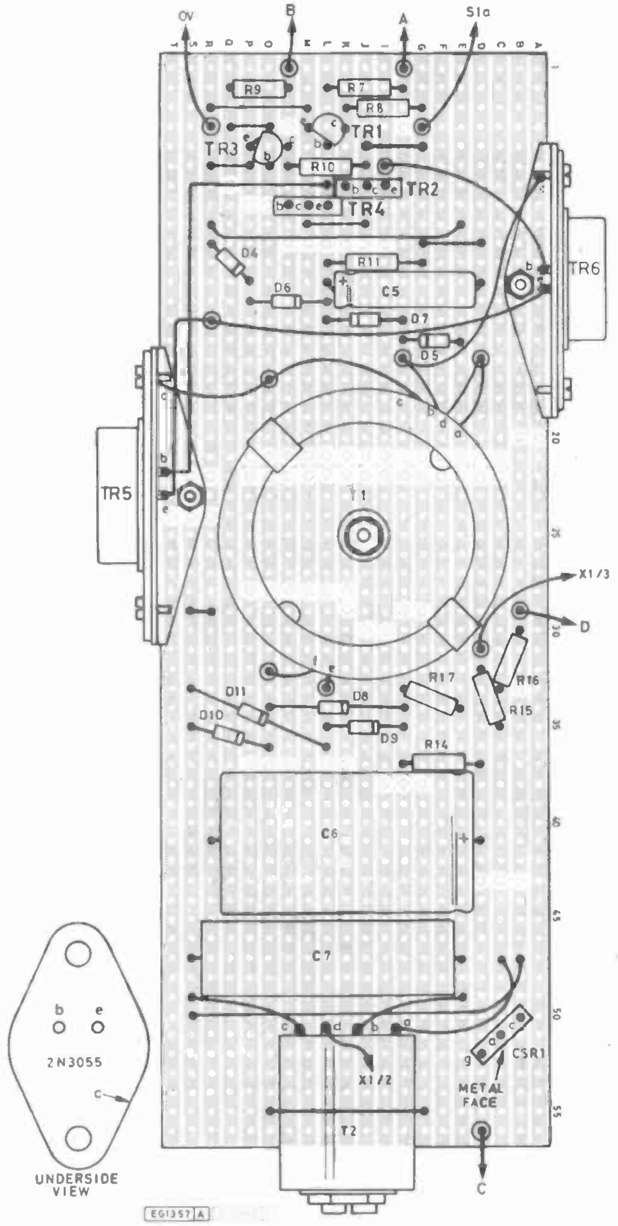


Fig. 5. High voltage gun board

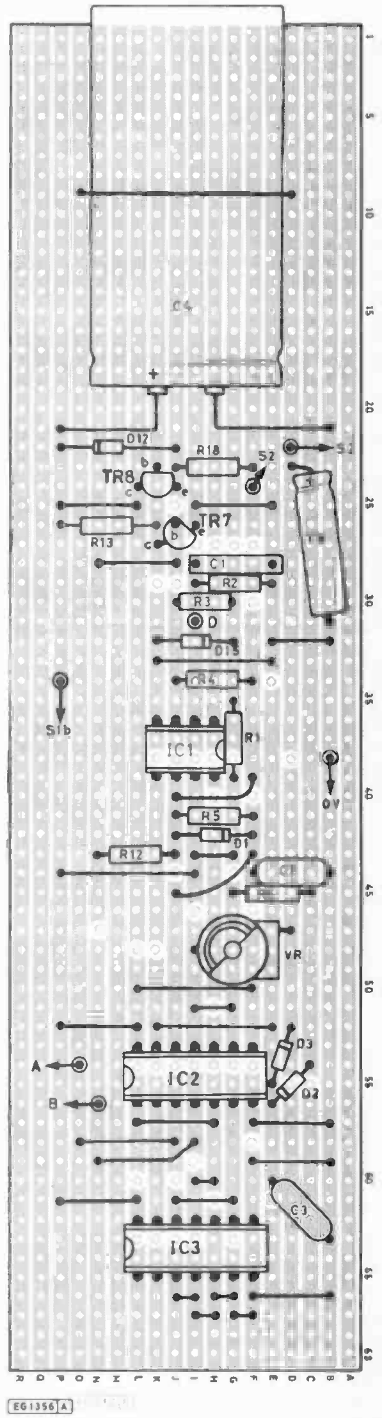
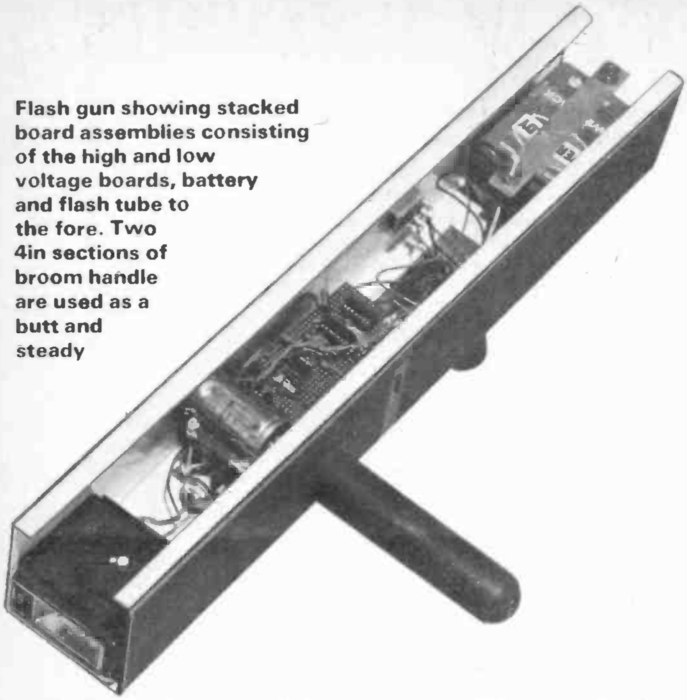
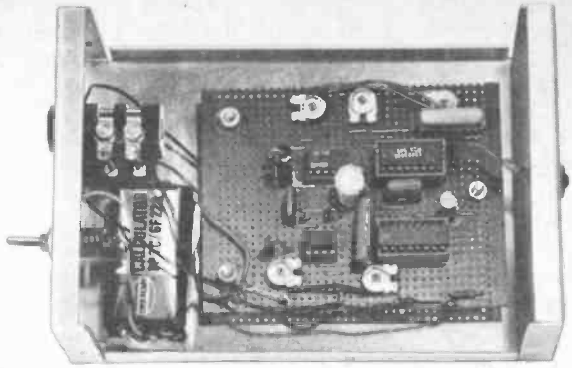


Fig. 6. Low voltage board



Flash gun showing stacked board assemblies consisting of the high and low voltage boards, battery and flash tube to the fore. Two 4in sections of broom handle are used as a butt and steady



The separate tone generator with phototransistor on right panel

that the standby current is only a few milliamps and only fires when fully charged. Recycle time depends on the value of C6 and the internal resistance of the power source. With the value shown, and a PP9 supplying power to the output stages, recycling takes about 0·5S. The prototype automatic version used two 6V lantern batteries in series to give a very satisfying flash rate.

Test the low voltage section of the circuit first. Connect TR1 and TR3 bases to V_{cc} via R7 and R9 to inhibit the output stages. Ground IC1 pin 2, and check that the oscillator is operating. Next, connect a high wattage resistor of about 15–20k in place of C6, and connect the inverter output stages to IC2, still keeping IC1 pin 2 at 0V. About 300V should appear across this resistor. Tune VR1 for a voltage maximum before restoring the circuit to its original form.

Note that if the circuit is tested with a bench power supply, the current trip will almost certainly operate, as the current demand is large.

HOUSING

The prototype units were built into 20in lengths of 3 x 3in plastic electrical trunking, with the flash tube secured in the gutted body of a defunct flash gun. Chamfered lengths of broom handle were screwed and glued to the trunking to act as butt and steady, and a biased toggle switch made a very effective trigger.

Six prototypes were built to this circuit and the only problems encountered were due to mechanical considerations, inasmuch as the finished products were thrown about with gay abandon by a troupe of scantily uniformed imperial stormtrooperettes.

Readout...

Off The Rails

Sir—With reference to Tom Gaskell's article in the August edition *Semiconductor Circuits*—ICL 7660, the stated absolute maximum voltage of +10·5V applies for the chip when it is used in its negative voltage generating mode only. If the chip is used as a positive to positive voltage converter then this maximum can be increased. An example of this is to provide a +7·5V supply from a +15V rail when using the ICL 7650 chopper stabilized operational amplifier. The 7660 can also be used as a negative to negative voltage converter in a similar manner. The circuit configuration is shown in Fig. 1:

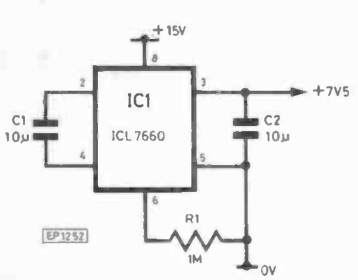


Fig. 1

L. N. Owen BSc.,
Blackfield,
Hants.

Tom Gaskell comments:

My thanks to Mr. Owen for providing us with an ingenious application for the ICL 7660. He is quite right in stating that this circuit allows operation from a +15V rail, rather than the specified +10·5 volts. In practice, though, the +10·5 volt limit still stands; it is the maximum permitted voltage between pin 3 and pin 8 (the '0V' pin and the +ve supply pin).

In Mr. Owen's circuit, the i.c. is 'floated' up to a nominal +7·5 volts; the 'negative' output of the i.c., pin 5, is connected to 0 volts, which (in combination with a +15 volt supply) forces pin 3 to +7·5 volts; this is our new supply rail. Reference was made in the original article to a diode in series with pin 5; this should ideally be included (between pin 5 of the i.c. and everything else) for supply voltages in excess of 13 volts (ie. twice 6·5 volts). Allowance should be made for its forward voltage drop. The maximum permitted supply voltage with this circuit arrangement is +21 volts.

Altogether, a most useful and interesting application of the device, showing that even fairly simple i.c.s such as this can often be extraordinarily versatile!

Finally, please note that there is a small but important error in Fig. 3 of August's Semiconductor Circuits, *on the ICL 7660: The caption should read D1 is not necessary for supplies <6·5V. Not >6·5V as printed.*

Help Sought

Sir— I have just purchased a BBC model 'B' micro and the high resolution graphics, on a large colour TV are good.

I do not normally use a large colour TV, however, for my computing, having instead a 14" monochrome portable. A problem which your readers may be able to help me with is that the characters tend to flicker at the edges when this monochrome TV is used. My previous computer, a UK101, exhibited the same effect until I changed the value of capacitor C60 as advised in the manual, when the display became rock steady and clear.

Is there a corresponding cure for the BBC?

I would also be interested to hear of a good user group for this micro.

Seamus McKenna
Co. Donegal
Ireland.

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- 8K BASIC interpreter (Extra)
- 8K FORTH (Extra)

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RAM: 4K CMOS (2 x 6116)
Input/Ouput: 48 system I/O lines
Speaker: 2.25" coned linear
Display: 20 character 14 segment green phosphorescent
Expansion:
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   7. Assembler and Disassembler.
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- **SSB-MPF-1P:** Speech Synthesizer. Inc. 20 words and clock program. 1200 words available.
- **SGB-MPF-1P:** Sound Synthesizer Board.
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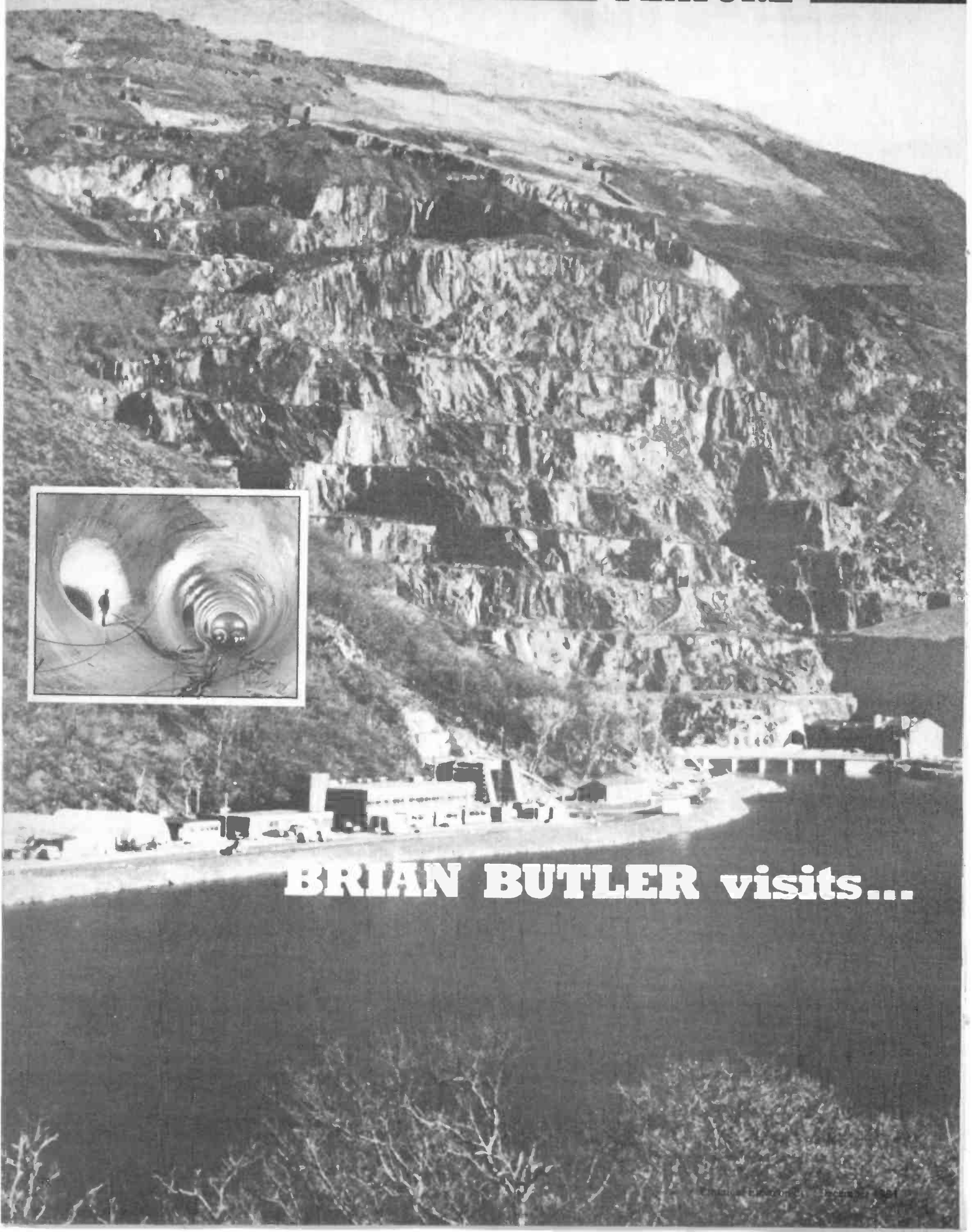


BRIAN BUTLER visits...

ALTHOUGH hydro-electric power is a very efficient method of producing electricity—you simply collect a few million gallons of water, store it in a dam and then dispose of it through a turbine-generator placed somewhere well below the water level—an ingenious alternative to the traditional hydro-electric plant has been developed by the CEGB (Central Electricity Generating Board) at Dinorwig, North Wales. The massive underground plant is a pumped-storage system which can supply 1300MW of electricity to the national grid system in just 10 seconds, overcoming the costly business of stand-by stations.

With the introduction into our homes of infinite numbers of electrical appliances over the last couple of decades came the inevitable load on the national grid system. The coal- and oil-fired power stations of the fifties proving less and less capable of supplying large amounts of electricity to the grid system when a sudden demand occurs. To keep these stations in a stand-by mode, awaiting a peak demand, is a costly business.

At the same time as these significant changes were occurring in the daily pattern of electricity demand it was realised that there was an increasing need for reserve generating capacity to make up for the sudden loss of a large modern generator.

EARLY STUDIES

In the late sixties it was estimated that the stand-by capacity needed to cover the worst possible unplanned loss of large generators during the two following decades were calculated by the CEGB to be about 1300MW within some six seconds (a tall order indeed).

It was therefore decided to compare the engineering and economic merits of gas turbines with pumped-storage, for providing generating capacity able to respond rapidly to sudden demands for electricity in the long term. Pumped-storage generation offered a significant advantage for this duty because of its unique ability to spin without load, ready for generation within a few seconds. This technique allows the turbines to be spun on compressed air via hydraulically controlled valves when neither generating or pumping, thus allowing a quick-start time for either operation. The results of the economic studies in the late 1960s demonstrated that overall system costs were in favour of pumped-storage. The system costs represented the overall lifetime capital, fuel and other operational charges, but of course the fuel estimates did not anticipate the subsequent drastic change in oil costs. This provided an even more attractive case for pumped-storage, and also changed the balance in favour of nuclear energy compared with fossil-fired stations.

therefore cheaper, being provided by the most efficient base-load power stations. The scheme in effect uses the massive body of water in the upper reservoir to store potential electrical energy for almost instant use at peak demand periods.

ENGINEERING MARVEL

Construction began in 1975 and the station is now undergoing its final commissioning deep beneath the old Dinorwig slate quarry at Llanberis in North Wales. The site was chosen for its geological characteristics, hydrology and reservoir potential, construction requirements, power transmission line routes, environmental impact and, of course, pure economics.

Marchlyn Mawr, an existing lake, has been enlarged to provide Dinorwig's upper reservoir. Llyn Peris, a lake about 500 metres (1,640 feet) below, has also been enlarged to provide the lower reservoir. The high head of water (over 500 metres) available from the top reservoir gives the advantage of a smaller reservoir capacity for a given station output and it was possible to use Llyn Peris with very little extra capacity being required to form the lower reservoir. Indeed work was carried out on both reservoirs to optimise their usage for their precise roles in this project.

At all times during construction the CEGB placed paramount importance on the effect to the environment. Dinorwig is almost invisible from above ground which makes it all the more difficult to relate just how massive the underground workings really are.

This £425 million project is civil engineering on a vast scale. Around three million tonnes of slate has been excavated to create the station's network of huge tunnels and caverns, requiring the use of some 4,500 tonnes of gelignite. The main civil engineering contract was believed to be the largest ever let in the UK when it was placed in 1975. The underground chamber housing the main plant is one of the largest excavated caverns in the world—twice as long and half as wide as a football pitch and higher than a 16-storey building.

HYDROLOGY

Dinorwig uses more than 6·6 million cubic metres (1,462 million gallons) of water during a full generating cycle. The water is retained in Marchlyn Mawr by a 600-metre-long rock fill dam, landscaped on the downward face to blend with the scenery. The upstream side is faced with asphalt to provide the necessary water seal and the flexibility to meet the pressure changes caused by such a vast weight of water being continually moved in and out of the lake.

DINORWIG
Pumped Storage Power Station

A pumped-storage power station differs from a normal hydro-electric station because it has two reservoirs—one above and one below the generating plant—and it uses the same water again and again.

After flowing from the upper reservoir to drive the turbines, the water is then pumped back from the lower reservoir to be used again (see Fig. 1). The turbine generators at Dinorwig work in reverse as motor-pumps and use power from the national grid when in the pumping mode. The water is pumped back at night when demand for electricity is low and electricity for pumping is

As can be imagined when the generators are shut-down there is a tremendous back pressure created in the feed tunnel and for this reason a massive surge shaft was incorporated in the hydraulic system. Being open ended the 43 metres high, 10 metres diameter surge shaft allows the excess pressure to be dissipated; it surmounts the 439 metre deep, high-pressure shaft.

Maximum station water demand is 420 cubic metres per second, and the system velocities were selected by balancing the cost of various tunnel sizes and their energy losses within limits of previous experience to ensure a satisfactory tunnel lining and

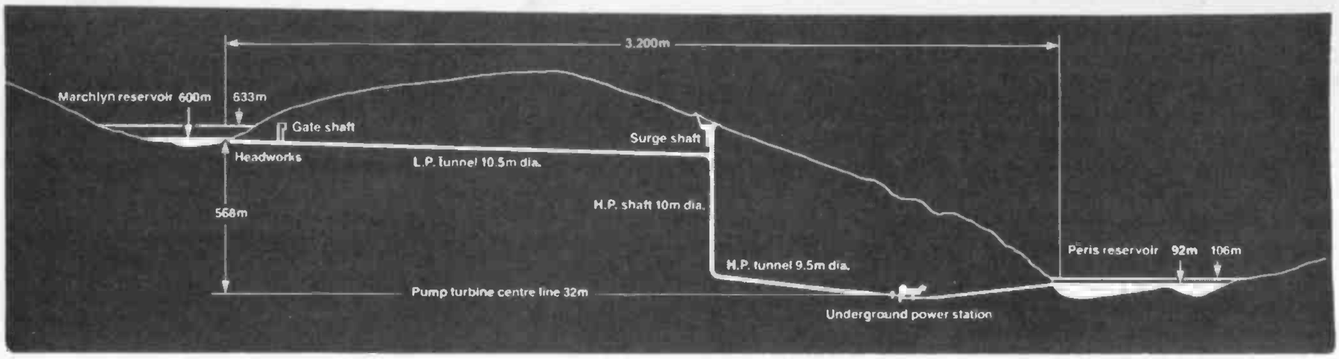
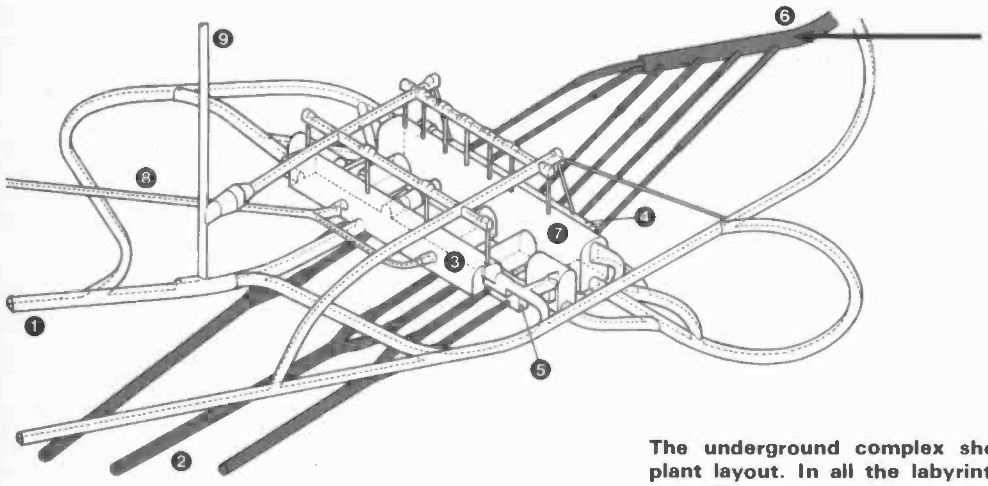


Fig. 1. Cross-sectional view showing the basic layout at Dinorwig. The overall distance between the upper and lower reservoirs is around 3·2 kilometres. The high-pressure and surge shafts together form a vertical shaft ½ kilometre deep—nine times the height of Nelson's Column

acceptable pressure surge levels. The power/time criterion was also an important factor in tunnel sizing because of the need to accelerate the 2km water column from standstill to full flow in just a few seconds.

THE STATION LAYOUT

The underground tunnels were integrated with caverns housing the mechanical and electrical plant and access tunnels for construction and operation. An important factor in settling the

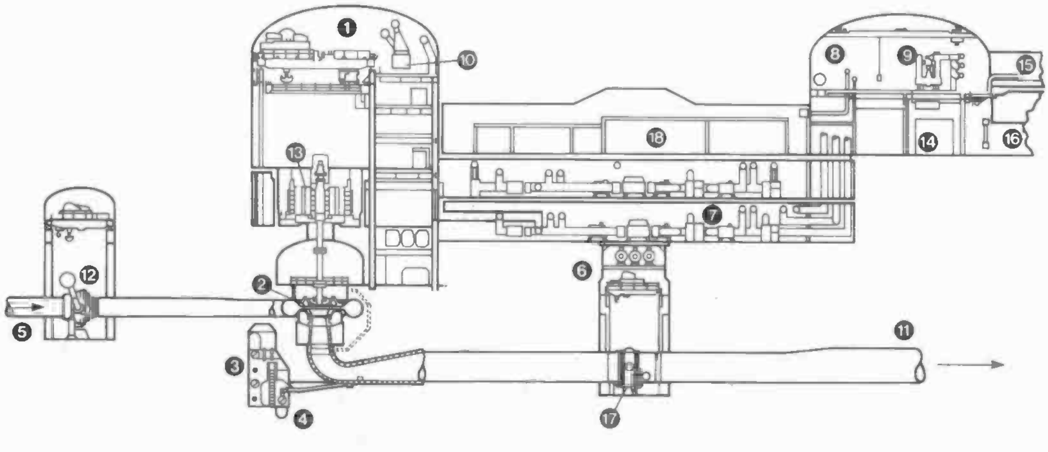


Inset photograph (1st page) taken here, showing high-pressure inlet tunnels under construction

1	Access tunnels
2	Tailrace tunnels
3	Transformer hall
4	Main inlet valve gallery
5	Draft tube valve gallery
6	High pressure tunnels
7	Machine hall
8	Cable tunnel
9	Ventilation shaft

The underground complex showing tunnel systems and plant layout. In all the labyrinth incorporates 10 miles of tunnelling

1	Machine hall
2	Pump turbine
3	Pipe gallery
4	Drainage sump
5	From top reservoir
6	Starting busbars
7	Busbar gallery
8	Transformer hall
9	400kV switchgear
10	Heating and ventilation plant
11	To tailworks and lower reservoir
12	Main inlet valve
13	Generator motor
14	Generator motor transformer
15	Cable tunnel
16	Plant access tunnel
17	Draft tube valve
18	Metal clad switchgear

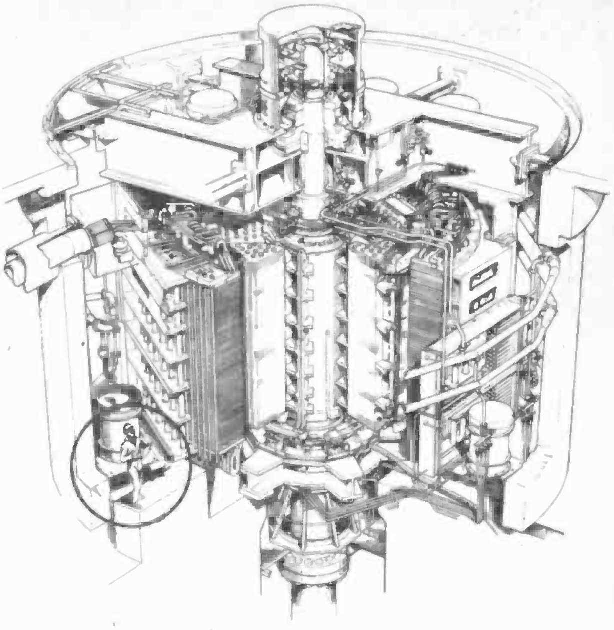


Section through station. Electricity generated in the machine hall at 18kV is conducted via aluminium bus-bars to the transformer hall, then at 400kV to the national grid system through a 6 mile underground tunnel

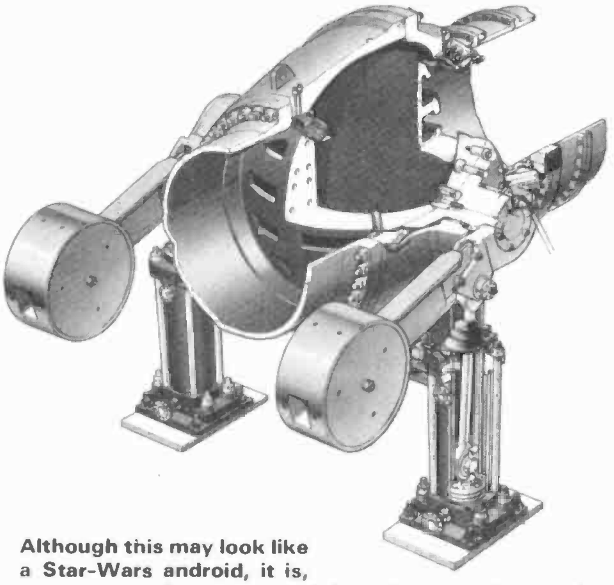
level of the main cavern was the submergence needed by the pump-turbines below the bottom reservoir to minimise air bubbles forming which could damage the pump-turbines. Other important features include: the cavern width, determined by the structural and water-bearing properties of the rock, provisions for maintenance, disposition of electrical busbars, the number of machines connected to transformers which supply the power to the high voltage grid system, equipment for starting the machines when they are operated as pumps, location of high voltage switchgear, control rooms and welfare facilities.

The 24 metre wide main cavern houses the six pump-turbines, and has adequate maintenace and plant provisions. In elevation, the cavern is a three-level arrangement dictated by access to the turbine/generators (Fig. 2.). The control room and equipment, low voltage switchgear and batteries utilise the space above the machine busbar routes. Workshops are arranged at one end of the main cavern with direct access to the plant. Three main busbar galleries, one per pair of machines, connect the machines and transformers. These galleries also house high voltage switchgear.

The six vertical pump-turbines are directly coupled through intermediate shafts to the generator motors mounted immediately above them. Each pump-turbine is reversible and has a single runner which rotates in one direction as a turbine when generating, and the other direction as a pump when being driven by the generator motor.



One of the six generator/motors, the rotating parts of which weigh 484 tonnes



Although this may look like a Star-Wars android, it is, in fact, one of the six main inlet valves. Its diameter is some 2·5 metres and each of the counterbalances weigh 16 tonnes

TURBINE/GENERATORS

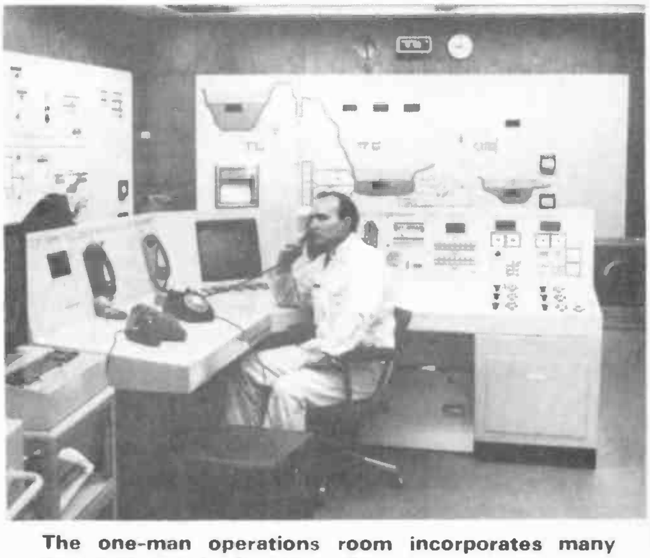
Each generator unit, operating in the turbine/generating condition, has a nominal water flow of 65 cubic metres per second, and delivers 300MW to the national grid. Flow regulation is achieved by 24 guide vanes which incorporates a restraint device to prevent extreme movement. The vanes, operating in conjunction with an electro-hydraulic governor, are powered by balanced double acting servo motors acting on a regulating ring.

The air-cooled generator motors, rated at 330MVA, are designed for direct coupling to the pump-turbine via intermediate shafts. The rotating parts are supported by a thrust bearing above the top joint of the generator-motor. Eight air coolers using circulating water from the lower reservoir are located on the stator frame which is totally enclosed within a concrete housing. Electrical and mechanical braking systems are included so that the operating mode of generating and pumping can be quickly changed.

Under normal working circumstances a generator unit may be required to perform 5,000 start/stops per year. The generator shaft is the largest mild steel forging ever produced by British Steel. The total weight of the rotating parts of each of the generator motors is 484 tonnes.

The construction of the generator assemblies was completed on site, as transportation limitations precluded shipment of the huge one-piece stators.

It is planned that under normal working conditions only four of the six generator units will be used, the remaining two will be reserved for emergency and sudden demand use. These two stand-by units have a slightly different winding in order that comparisons may be made between the two types with regard to circulating current losses, cost and installation considerations. The basic specification remains the same.



The one-man operations room incorporates many automatic monitoring systems

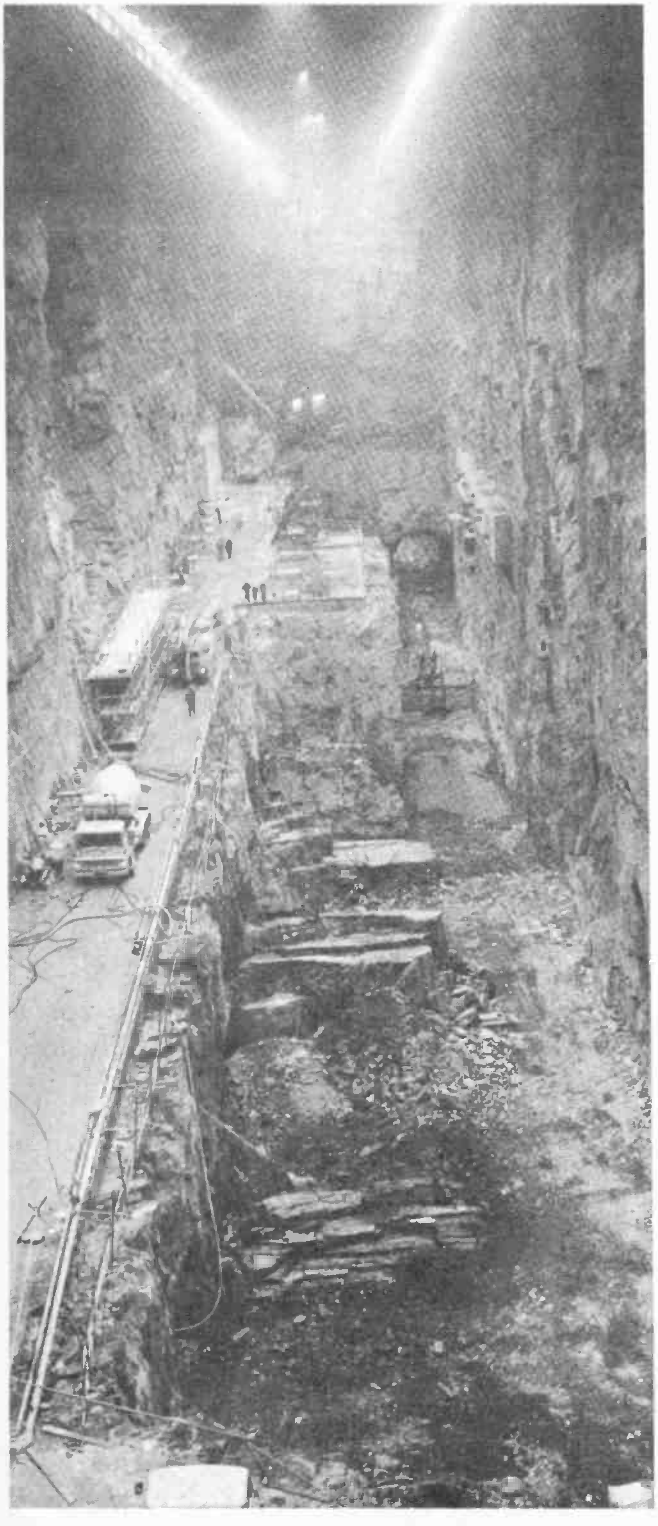
CONTROL SYSTEMS

The control room is situated in the main cavern overlooking the machine hall. Automatic operation is provided for all generating and pumping conditions, including changing from full load pumping to full load generation.

The control room was designed for use by a single operator but the layout allows for two operators if necessary.

The electronic analogue control system enables the equipment racks to be mounted remotely from the control panels and the system is built up from function modules which, in addition to basic control elements such as high/low alarms etc., include computing functions that enable complex signal manipulation to be carried out.

Other interesting control features include environmental equipment, turbine vibration monitoring and pressure resonance detection equipment used to monitor the underground hydraulic system and guard against damaging resonance phenomena. Level switches have been incorporated to guard against station flooding. An ingenious "radiating feeder" communication system has been incorporated throughout the underground network. A narrow co-axial cable can be found all through the labyrinth, this being a feeder cable that "leaks" radio signals which would otherwise be screened by the mass of solid rock; this system enables immediate radio contact to be maintained within the plant. Radio pagers are also incorporated for staff location.



In its excavated form the machine hall was 179 metres long, 24 metres wide and 60 metres high. It is believed to be the largest single man-made cavern in Europe

INDUSTRIAL RELATIONS

From the outset of this project the CEGB placed great importance on using local labour wherever possible. For this reason a multi-skill training centre was established at Dinorwig to train the 95% strong local labour force in the many skill requirements needed. Highly experienced representatives were drafted in from each of the contractors supplying equipment to Dinorwig, and it was they who passed on their skills to the new workforce. Of course, there already existed an important skill which only the Welsh could supply, namely their invaluable knowledge of local slate mining techniques.

ACKNOWLEDGEMENTS

The technical data in this article was supplied by the CEGB who also furnished the photographs and illustrations.

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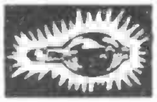

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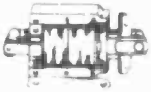

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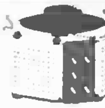

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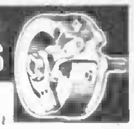

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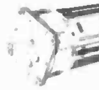

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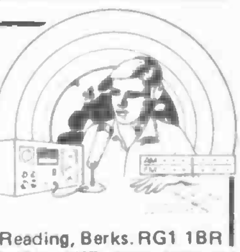

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INTRODUCTION TO DIGITAL ELECTRONICS

MICHAEL TOOLEY BA DAVID WHITFIELD MA MSc CEng MIEE

O & A Level Part Three

WE HAVE seen in the PE Logic Tutor how useful it is to be able to indicate logic states using l.e.d.s. This idea may be extended further to the point where the output of a logic network is actually intended to drive l.e.d.s as the primary function of the circuit. For example, with the advent of different coloured l.e.d.s, model engineers are now able to build replica traffic lights using l.e.d.s driven by logic. The problem, however, is how to interface the logic gates to the l.e.d.s?

In order to drive an l.e.d. to reasonable brightness, it is necessary to pass a current of around 10mA to 20mA through the diode. In general, a nominal 10mA will produce adequate brightness for red diodes, with the other colours often requiring somewhat more (due to their lower efficiencies). A typical red l.e.d. will have a voltage drop of approximately 2V across its terminals under these conditions, other colours slightly more (up to around 2·5V). This in effect is a description of the characteristics of the load which we want to drive from a logic circuit. We must now look again at the capabilities of TTL gate outputs to see if this is possible directly, or whether some intermediate circuitry is necessary.

We have already seen that a standard TTL gate output is capable of sinking a current of at least 16mA in the low state. In this condition we know, from the TTL level definitions, that the output voltage will not exceed 0·8 volts. This means that it is possible to connect a load between the gate output and the +5V supply, and draw 16mA through it, with a voltage of 4·2V (minimum) being dropped across the load.

A voltage drop of 4·2V is too great for an l.e.d. on its own. However, if we connect a resistor in series with the l.e.d., as shown in Fig. 3.1, the current then flows through both the resistor and diode. Selecting the value of resistor allows us to set the volt drop across the diode to an appropriate value. Assuming the worst case, we calculate the resistor value such that it will drop (5-l.e.d. drop) volts at the selected operating current, which must be less than 16mA. Thus, typical resistor values are around 220Ω to 270Ω, although 330Ω is also a common value. Using this method, we can still use the gate to drive normal logic loads, although the effective fan-out has been reduced by approximately six. The rule, as before, is that the total current which the gate can sink and still operate reliably is unchanged at 16mA. A disadvantage of this method is that the l.e.d. is illuminated when the output is in a 0 state, and this can be confusing if not properly considered. The second method offers an alternative which overcomes this minor problem.

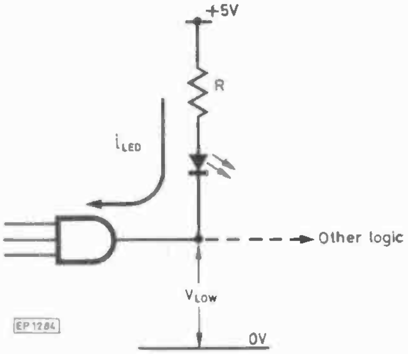

Fig. 3.1. Driving an l.e.d. from a TTL gate in the 0 state

Looking at the drive capabilities of a TTL gate in the 1 state, we might think that this could not be used directly to drive an l.e.d.; only 400µA of drive is available. The voltage in the 1 state is a minimum of 2·4V, and is typically 3·4V. So much for the theory. In practice, if we are willing to accept that using a gate output to drive an l.e.d. will make its output unavailable for other uses, then something can be done. In fact, the result is one of the simplest ways of driving an l.e.d., since it requires no additional components. Simply connect the diode between the gate output and 0V, as shown in Fig. 3.2, and all should be OK. The question now is "Why does it work at all?".

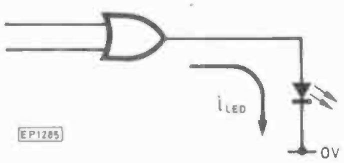

Fig. 3.2. Driving an l.e.d. from a TTL gate in the 1 state

The reasons once again relate to the detailed characteristics of the TTL gate output circuit. Suffice it to say that the load represented by the l.e.d. is such that the output voltage of the gate falls to approximately 2V at a current of around 5 to 10mA. This is exactly what is required to drive the l.e.d., even though it is *not* a legal TTL logic level. All-in-all a very simple (and safe) way of driving an l.e.d. from a TTL circuit. This is in fact a common way of using up 'spare' gates in i.c.s when the main circuit design has been completed without needing all of the gates in every i.c., and is a useful way of providing test indicators. The nice additional feature of this method is that the l.e.d. is illuminated when the gate output is at a 1 level.

LOGIC INTEGRATION

With the advent of integrated circuit technology, the electronic subassemblies which had previously been used in the construction of logic circuits disappeared. In their place came ranges of integrated circuits (i.c.s) which contained standard gates fabricated on silicon 'chips'. As the technology has advanced, it has become possible to include more numerous and more complex circuits inside such i.c.s. We have seen, from the TTL i.c.s described so far in the series, that one effect of this progress has been the inclusion of more than one of a particular gate within a single package. Indeed, the number of gates is now often limited solely by the number of pins available on the package. In the interests of standardisation, the number of pins is restricted to 14 or 16 wherever possible, although 18- and 24-pin devices are now becoming increasingly common.

To try and give some idea of the scale of integration involved, a typical TTL gate currently occupies a piece of semiconductor which measures less than 0·2mm square; smaller than the proverbial pin head! By comparison, the black package of a 14-pin i.c. is approximately 19mm by 6mm. With such a degree of integration available at low cost (e.g. a 7408 costs around 20p), it is not perhaps surprising, therefore, to find that ever more complex logic functions are being integrated into single i.c.s. It is interesting, therefore, to look at some of the reasons behind this move, and some of the advantages which result.

One of the first things that we notice when we look at complex logic circuits is that they can involve quite a number of i.c.s. This in turn means that there are many interconnections, and that the boards required for the circuit become quite large. Two consequences of this are that such circuits are expensive to make, and that they are less reliable due to the greater number of components. Ideally, the rule in this respect is the smaller the physical circuit, the better. If, therefore, we can identify arrangements of logic gates which occur frequently, it should be possible to make the complete arrangement *inside* an i.c., and so keep the number of i.c.s required to a minimum.

Much of the rest of this series is concerned exactly with these types of logic elements, i.e. standard arrangements of basic logic gates. Originally, many logical functions were performed by circuits made up from arrangements of discrete gates, but as the TTL family has developed, many of these arrangements have themselves become available as 'standard' components. In this part of the series we will begin by looking at some simple combinations of the basic gates covered so far. Future parts will then move on to look at some of the more complex logic elements which are available in the TTL family. We will also be looking at the ways in which even these familiar gates can be built up from only a single type.

THE NAND GATE

In many discussions of logic, the first gate discussed is the NAND gate. This is often for no other reason than that it is the gate which is fundamental to the TTL family. The internal circuit for a TTL gate shown in part one of the series was in fact that for a 2-input NAND gate. This, however, is incidental to any progressive introduction to logic, and we have therefore waited until this point to consider the NAND gate. We will look on the NAND gate at this point as a gate which represents a combination of two of the basic logical functions already described.

The NAND gate combines the action of an AND gate and an inverter (NOT gate). Fig. 3.3 shows the way in which these gates may be connected to make up a NAND gate. Table 3.1 shows the truth table for a 2-input NAND

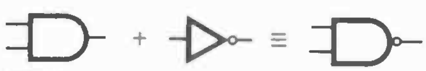

Fig. 3.3. The NAND gate as a combination of AND and NOT gates

INPUTS		OUTPUTS	
A	B	AND	NAND
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

EP1281

Table 3.1. Truth table for 2-input AND and 2-input NAND gates

gate, side-by-side with that for a 2-input AND gate for comparison. From the table it can be seen that the output of a NAND gate is a 1 unless both of its inputs are a 1, when the output changes to a 0.

Much of the usefulness of the NAND gate stems from the fact that it produces an inverting action, and Fig. 3.4 even shows how a 2-input NAND

Fig. 3.4. Connecting a 2-input NAND gate to behave as an inverter

gate may be connected to behave exactly like an inverter. We shall be returning to this point again later on, but for the moment we will take a look at a practical NAND gate in the TTL family.

7400 TTL NAND GATE

The 7400 is a quadruple 2-input NAND gate whose pin configuration is shown in Fig. 3.5. As before, each of

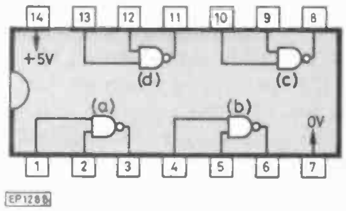

Fig. 3.5. Pin configuration for a 7400 quadruple 2-input NAND gate

the four gates is identical, and the power supply connections are quite standard. The 7400 is perhaps the most commonly used of all the TTL family. There are those, perhaps cynically inclined, who would claim that this is only because it is first in any list of TTL i.c.s! Whilst there may be some truth in this, it is nevertheless true that a 7400 will always 'do' to implement any logic function, and so it is probably deserving of at least some of its popularity.

In the previous section we introduced the NAND gate as a combination of an AND gate and a NOT gate (inverter). If we connect a further inverter to the output of the NAND gate, therefore, we would expect to get back to a simple AND gate, since two inverters connected in series behave as a buffer. Fig. 3.6 shows a circuit which allows us to investigate this AND and NAND gate action available from the

7400. Indicator D3 should respond as an AND, while D4 should respond as a NAND, in accordance with Table 3.1.

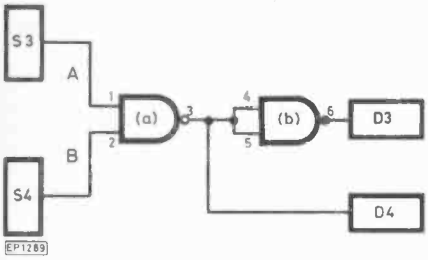

Fig. 3.6. Test circuit for NAND and AND operation from 7400

This circuit is set up by inserting a 7400 into the B socket, with pin 1 in position B1, and adding the following links.

S3	to	B1	(Input signal A)
S4	to	B2	(Input signal B)
B3	to	D4	(NAND o/p signal)
B3	to	B4	(Link)
B4	to	B5	(Tie i/p together)
B6	to	D3	(AND o/p signal)
B7	to	0V	(Supply)
B16	to	+5V	(Supply)

In this circuit we have used a NAND gate connected (as previously shown in Fig. 3.4) to behave as an inverter. The B socket has been used for the i.c. in preference to the usual A socket simply to spread the wear and tear on the breadboarding sockets!

As a final test of skill in constructing truth tables, the circuit in Fig. 3.7 is offered as a challenge. To which 2-input gate does the behaviour of this circuit correspond? The circuit is set up using

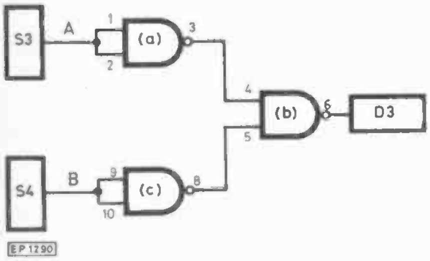

Fig. 3.7. A combination of NAND gates with an equivalent?

the same i.c. as above, but with the following (different) set of links.

S3	to	B1	(Input signal A)
B1	to	B2	(Tie i/p together)
S4	to	B11	(Input signal B)
B11	to	B12	(Tie i/p together)
B3	to	B4	(Inverted A i/p)
B10	to	B5	(Inverted B i/p)
B6	to	D3	(Output signal)
B7	to	0V	(Supply)
B16	to	+5V	(Supply)

We will now go on to look at another common combination of basic gates, the NOR gate.

THE NOR GATE

As with the NAND gate, the NOR gate combines the action of an already encountered gate with that of an inverter. Fig. 3.8 shows how a NOR gate can be considered to be made up of an OR gate and an inverter, and the truth table for the arrangement is shown in Table 3.2. The output from a NOR gate will be a 0 unless both of its inputs are a 0, in which case the output changes to a 1.

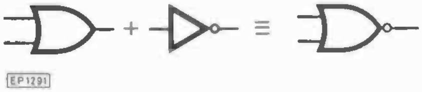

Fig. 3.8. The NOR gate as a combination of OR and NOT gates

INPUTS		OUTPUTS	
A	B	OR	NOR
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

EP1282

Table 3.2. Truth table for 2-input OR and 2-input NOR gates

If both of the inputs of a NOR gate are connected together, as shown in Fig. 3.9, it behaves in the same way as a similarly arranged NAND gate, and produces an inverting action. The

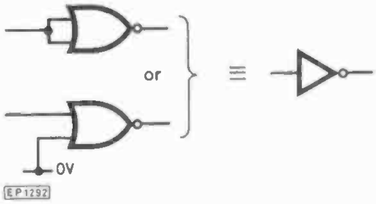

Fig. 3.9. Connecting a 2-input NOR gate to behave as an inverter

figure also shows an alternative method of constructing an inverter, using the second input tied to the 0 volt supply rail.

The NOR gate can equally well be used to construct any of the logic gates in the TTL family. The NAND gate is usually used in preference, however, since its internal gate circuit involves significantly fewer components and also dissipates less power. Either gate type will nevertheless produce an equally valid solution, and in different applications one type may require fewer physical gates than the other.

7402 TTL NOR GATE

The 7402 is a quadruple 2-input NOR gate whose pin configuration and internal layout is shown in Fig. 3.10.

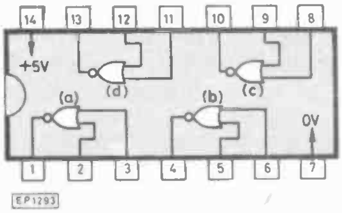

Fig. 3.10. Pin configuration for the 7402 quadruple 2-input NOR gate

Each of the four gates is electrically identical, but it should be noted that the layout of inputs and outputs does *not* follow the pattern of the previous 2-input gates. The power supply connections are, however, quite standard.

The 7402 essentially completes the basic set of 2-input gates for the present. We are now able to select the most appropriate i.c. for the task in hand, knowing that many of the gates may also be adapted to perform the functions of other i.c.s, thereby allowing us to keep the total number of i.c.s in a circuit to a minimum. As a final demonstration for the present, Fig. 3.11 shows two NOR gates connected as a NOR-NOT pair. The circuit is set

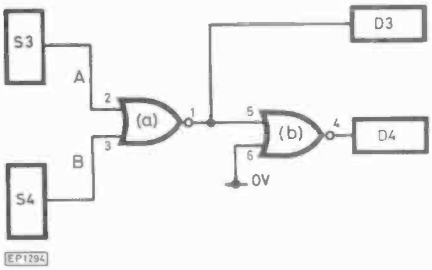

Fig. 3.11. Combination of NOR gates

up by inserting a 7402 in the C socket (for another change!), with pin 1 in position C1, and adding the following links.

S3	to	C2	(Input signal A)
S4	to	C3	(Input signal B)
C1	to	D3	(NOR o/p signal)
C1	to	C5	(Link)
C6	to	0V	(Tie i/p to ground)
C4	to	D4	(OR o/p signal)

C7 to 0V (Supply)
C16 to +5V (Supply)

It is interesting to check the overall operation of the circuit against the truth table. In addition, however, certain similarities may be noticed between the behaviour of this circuit and that shown in Fig. 3.7, and we shall return to this point later. Another point to note is the effect of disconnecting the link from C6, and observing that the result is the same as setting the input to a logic 1.

BOOLEAN ALGEBRA

In Part Two we discovered that the actions of gates can be described in the form of truth tables. A truth table indicates the output that will be obtained from a gate for any given combination of inputs. The technique can be applied equally well to individual gates, and to gate combinations. When more than two inputs are involved, however, the truth tables very quickly become quite large and cumbersome. Each additional input to be considered doubles the number of lines in the table. There is then a very real danger that the overall function of the circuit will become obscured by the sheer quantity of information presented in the table.

What we need then is a more compact way of representing the logical functions involved in logic circuits. It is also useful if any such representation can subsequently be expanded into a truth table should it prove necessary. What we are effectively grasping for here is a form of logical shorthand; something whose meaning we can readily understand, but which can expand at will to provide the same detail as the truth table. To be useful, therefore, we must choose a shorthand which has a very close relationship to the gates whose workings are being represented, and one which is widely understood. The most common shorthand in use today is known as Boolean Algebra.

Boolean Algebra is a logical shorthand which was developed by an English mathematician, George Boole, long before the introduction of digital electronics. Its purpose was to provide a simple way of writing the complicated logical statements encountered in the study of logic. The idea was to be able to determine rapidly whether a particular statement was true or false, depending on the outcome of other related statements. If we now relate logical statements to digital logic gates, and the result true/false to gate outputs of 1/0, we can see how easily Boolean Algebra can be applied to the analysis of logic circuits. It also helps to explain why we so often see digital gates referred to as logic gates.

BOOLEAN EXPRESSIONS

In order to be useful, a shorthand must have an established set of symbols. Algebra in turn must have a set of rules in order to be able to determine the outcome of a particular problem. We will start by looking at the way in which Boolean Algebra allows logic situations to be expressed in what are known as Boolean Expressions. Later on we will return to look at some of the basic rules of Boolean Algebra itself, which will allow us to manipulate such Boolean expressions.

The fundamental gate actions of digital logic are, as we have already seen in this series, those of AND, OR and NOT. Boolean Algebra uses special symbols to represent each of these gate actions, and these are shown in Table 3.3. As with any shorthand, alternative symbols are sometimes used, but the symbols shown in the table are those in common use, and they will therefore be adopted for this series.

Now that we have a set of shorthand symbols, it is appropriate to see how they are used in practice. We will stay, for the moment, with the three basic gate actions of AND, OR and NOT. Fig. 3.12 shows three examples of the use of the shorthand notation introduced

LOGICAL FUNCTION	EXAMPLE
AND	$A \cdot B$
OR	$A + B$
NOT	$\overline{A}$

EP1283

Table 3.3. Boolean symbols for fundamental gate actions

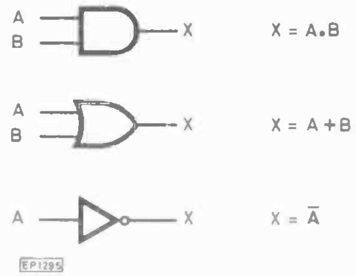

Fig. 3.12. Boolean expressions for basic gate functions

above. In the first example, concerning the AND function, the expression shown as $X = A.B$ indicates that the X output signal is the result of passing signals A and B through an AND gate. Put another way, X equals **A and B**; X is 1 if, and only if, both the A and B inputs are at a logic 1.

The second example treats the OR gate in a similar way. The output from

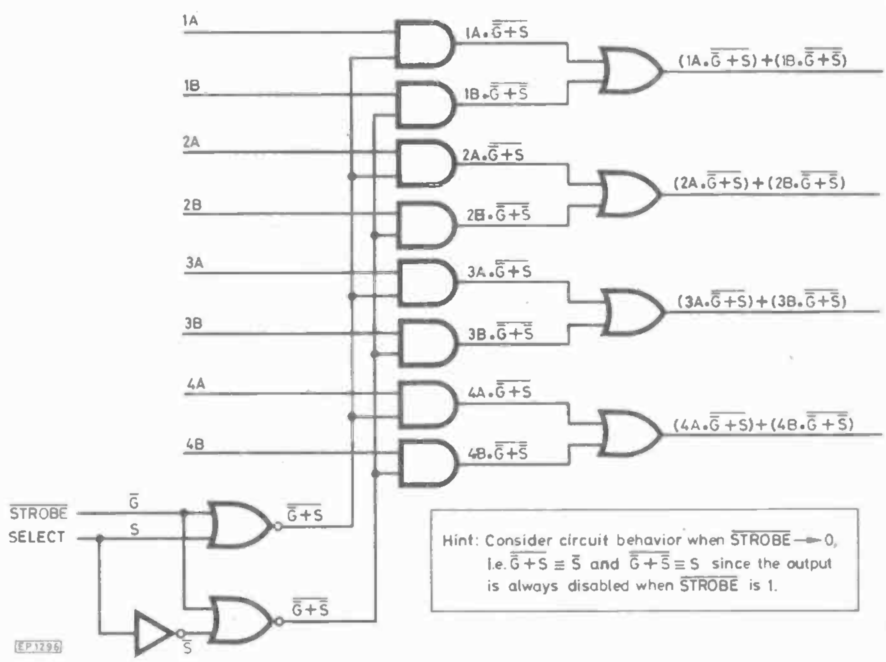

Fig. 3.13. Circuit labelled with Boolean expressions

the gate, X, is shown as $X = A + B$, indicating that X is the result of passing signals A and B through an OR gate. The action of the gate is **A or B**, and X is 1 if either A or B is a logic 1. The action of the inverter, shown in the third example, is to cause the output X to become equal to $\overline{A}$, read as A-bar or NOT-A.

Now that we have a shorthand for writing down Boolean expressions, let us pause for a moment to look at the circuit shown in Fig. 3.13. In this circuit the signals still have simple names (A, B, C, etc.), even though these would be replaced in a real circuit by the names of actual signals. The circuit has outputs labelled with their appropriate Boolean expressions, but can you think of a use for this type of circuit? Hint: this is actually available as a standard function in the TTL family. (74LS157)

NEGATIVE LOGIC

At this point it is perhaps timely to stand back for a moment and ask ourselves about the way in which we describe and use logic signals. For example, when we call a signal Motor On or Light Off, what do we actually mean? The answer is hopefully self-evident; we assume that the motor will be turned on, or the light turned off, respectively, whenever the signal is at a logic 1. So far, so good, but is this the only way to use logic signals?

If we always have logic signals of the type described above, there can be unexpected, but predictable, problems with TTL circuits. Consider, for example, part of the motor control circuitry for a milk float, shown in Fig. 3.14. As we can see, the control unit is situated in the driver's cab and only requests motor movement when the ignition key is on, when the driver has pressed the foot pedal, and has also selected either 1st or 2nd gear. Unless all of these conditions are satisfied (i.e. all necessary inputs are 1), the Motor On signal will be a 0, and the milk float will therefore not move. When all of the necessary conditions are satisfied, the Motor On signal will change from 0 to 1. The signal will then pass to the motor compartment, and the motor will be activated via a suitable buffer. In reality there is likely to be further stages between the buffer and the motor, but the principle is unchanged. The circuit seems to work ideally, so what is the problem?

As with many situations in the real world, the danger in this circuit is when something goes wrong. The most common problem in this type of situation, where different parts of the circuit are physically separated, is that the interconnecting wiring may become broken. This is an unexpectedly common occurrence, and may be caused by vibration, traffic damage, or even the printed circuit board containing the control unit being removed from its socket for testing. In any event, the situation we then have is that the link between points X and Y on the circuit is broken, at least in electrical terms. This is where the trouble really starts! Although the control unit output may be a 0 (say the driver has turned the ignition key to off), because the X-Y link is now broken, the input to the buffer in the motor compartment will float high, turning the motor on. What we have then is a runaway milk float.

The example above is obviously rather contrived, and hopefully non-representitive of milk floats, but it does show the type of situation which we must avoid at all costs. The simplest solution to this type of problem is to use what are known as Negative Logic control signals. What we have explained so far in this series is known as Positive Logic; the signal condition is true (e.g. the motor is to be turned on) when the signal (Motor On) is at a logic 1. In negative logic, we use the opposite convention, and the signal condition is true when the signal level is a logic 0. In order to distinguish between the two types of signal, we use the bar notation introduced earlier. In this way, Motor On should turn the motor on when at a logic 1, whereas Motor On will turn the motor on when at a logic 0.

To illustrate this idea in practice, the motor control circuit described earlier has been re-designed in Fig. 3.15 to make use of negative logic. Should there be any doubt about the correct operation of the circuit, a truth table will demonstrate that the motor is only turned on when the appropriate combination of negative logic signals are input.

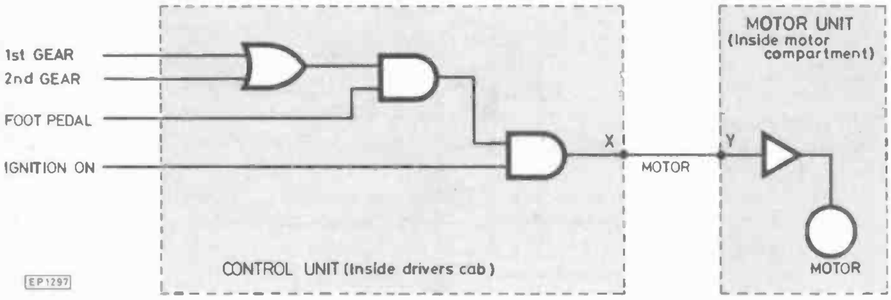

Fig. 3.14. Milk float motor control circuit

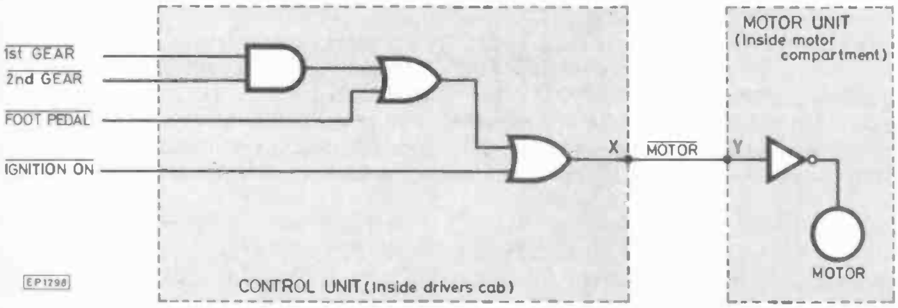

Fig. 3.15. Motor control circuit using negative logic

MORE ON BOOLEAN ALGEBRA

In the discussion above we have seen that there are many situations where it is useful to use inverted logical signals. Boolean Algebra has, as we have seen in Fig. 3.12, a shorthand way to indicate the operation of logical NOT, using the over-rule notation. This is readily extended to cover all types of negative logic signals, as shown by the Boolean representations for NAND and NOR in Fig. 3.16.

The general rule for logical inversion, therefore, is that an over-rule is added to the output signal whenever the gate performs an inversion. Thus the output from a NOR gate whose inputs are $\overline{A}$

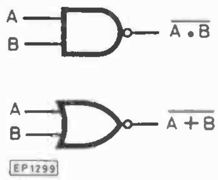

Fig. 3.16. Boolean shorthand for NAND and NOR gates

and B will be $\overline{A + B}$. If the output from this gate is now fed through an inverter, as shown in Fig. 3.17, the output will then have two over-rules, $\overline{\overline{A + B}}$. If we draw the truth table for this circuit, we can probably deduce that a double over-rule of this type has a very simple equivalent, but what is it?

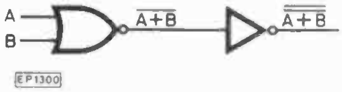

Fig. 3.17. Boolean double-inversion

SLOW SIGNALS

In Part One we saw the way in which the output of a TTL buffer changes as a steadily increasing voltage is applied to its input. We saw that the output will be below 0·8V until the input has risen to over 0·8V. Similarly, we saw that the ouput will be at least 2·4V whenever the input voltage exceeds 2·0V. In the middle range, however, where the input is between 0·8V and 2·0V, the behaviour of the gate is somewhat unpredictable. The output could be either above 2·4V or below 0·8V, or anywhere in between, without any real guarantee of where it might be. These features are summarised in Fig. 3.18, in what is known as the Transfer Characteristic of

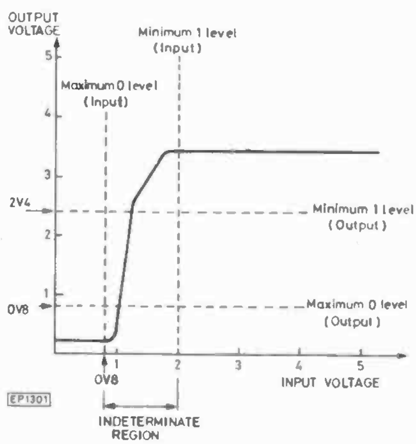

Fig. 3.18. TTL buffer transfer characteristics

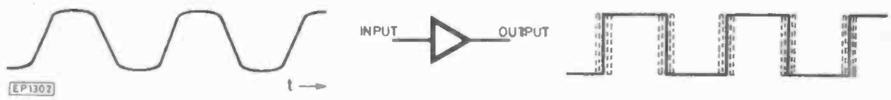

Fig. 3.19. Variation of switching point

a TTL gate. From this graph we are able to predict the behaviour of a TTL gate which has an input signal level that is *not* within the indeterminate region. There are, however, problems which can arise when a signal crosses this indeterminate region.

If we look at a signal which has a slowly changing level (in TTL terms at least), we see that, as it varies between 0 and 1, it crosses and re-crosses the indeterminate region. Fig. 3.19 shows a typical such input waveform, together with a corresponding output signal. This seems at first sight to be quite straightforward, but in fact there are a number of hidden problems. The first is that the point at which the output changes from 0 to 1 can be quite variable, being particularly sensitive to changes in temperature and supply voltage. The results of this effect are shown by the dotted lines in Fig. 3.19, and a degree of uncertainty therefore exists in predicting the instant at which the output will change.

The next problem, however, can have a much more dramatic effect on the overall behaviour of a logic circuit. The difficulty arises from the fact that, in any real circuit, the laws of physics dictate that there will always be *some* electrical noise present. This will usually be small by comparison with the standard TTL levels and, even when it becomes superimposed on the logic signals, it is not usually enough to upset the 0 and 1 levels. The effect of the noise, however, is to cause the signals to vary slightly above and below their ideal levels. The amounts, and the intervals between these variations are random, but they are usually fairly small, and it is only usually when we have a slowly varying signal that this noise can become troublesome.

As before, the problems arise near the point at which the gate output switches between 0 and 1. Near the switching point, the noise on the input signal can be sufficient to take the input above and below the switching point a number of times, before it finally settles down. At all times, the general trend of the signal (which is equivalent to a perfect, noise-free signal), remains steadily upwards or downwards through the indeterminate region. It is while the signal is near the switching point, however, that noise can upset the expected smooth transition of the output level.

The overall effect of noise on the output of a gate being used to process a slowly varying input signal can be as shown in Fig. 3.20. The output here can be seen to 'chatter' quite a number of times, before finally settling down. If the circuit following the input gate is counting pulses, or is affected in any way by the *number* of transitions, the result of this chattering can be quite dramatic; errors of up to 500% can easily occur for slowly varying input signals. It should be remembered here that TTL gates switch in a very small fraction of a micro-second, so many signals unexpectedly fall into the category of 'slow'.

So much for the problem, but what about a solution? What we ideally require here is a gate which has a 'snap-action' transfer characteristic. By this we mean that, once the input signal has passed a defined level, a *significant* change in the *opposite* direction is required in order for it to have any effect. This characteristic would result in a circuit which is immune from small changes in level around the switching point, and would obviate the possibility of the chatter effect. As might have been guessed, special TTL gates exist which have such a snap-action property, and they are known as Schmitt Gates.

SCHMITT GATES

The most important feature of a Schmitt-input TTL gate is its behaviour in the so-called indeterminate region. In almost every other respect a Schmitt gate behaves just like any other TTL gate, but it is more versatile since

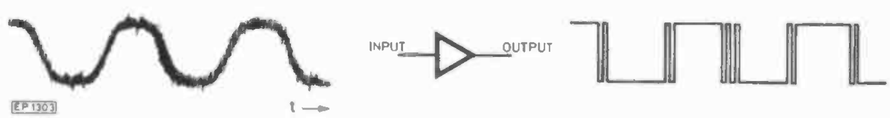

Fig. 3.20. Effect of noise on switching

Schmitt gates can be used in place of ordinary gates, but not necessarily vice versa.

The transfer characteristic for a Schmitt buffer is shown in Fig. 3.21. When looking at this characteristic, it is important to note the directions of the arrows, otherwise the figure can make no sense at all. If we consider, by way of illustration, an input signal which

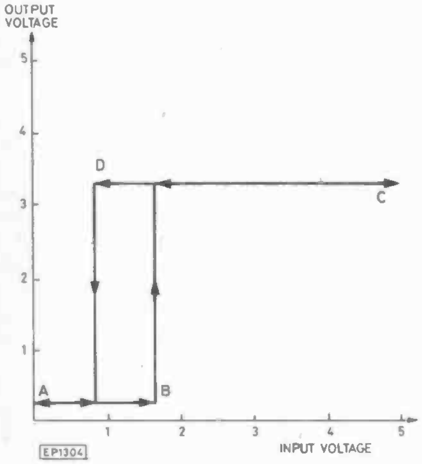

Fig. 3.21. Schmitt gate transfer characteristic

varies smoothly from 0V to +5V, and then back again, this will help us explain the shape of the graph.

The input signal starts at point A with a level of 0V, and the corresponding output here is less than 0·8V, as for any other type of TTL gate. As the input voltage increases from zero towards point B, the output stays at or around this level. At point B, the first switching threshold is reached, and the output jumps (snap-action), from below 0·8V, to above 2·4V. Further increasing the input voltage, towards the maximum allowed input at point C, has little or no effect. Thus, with a steadily increasing input voltage, the gate behaviour follows the path A-B-C.

Following the reverse path, the output level stays above 2·4V until the input level falls to the second switching threshold, at point D. The snap-action switching effect is then repeated, but in the reverse direction, and the output falls to below 0·8V. For the steadily falling input voltage, therefore, the gate behaviour follows path C-D-A.

The real points to note here are the snap-action switching behaviour and the difference that exists between the two switching thresholds known as the 'hysteresis'. Once the gate has switched, therefore, change of input level equal to *at least* the hysteresis of the gate and in the *opposite* direction, is required in order to make the gate output change state again. This combination of snap-action switching and the hysteresis of Schmitt gates combine to substantially remove the problems associated with slow signals. Other uses of Schmitt gates will be examined later in the series. For the present, however, we will look briefly at some practical details of Schmitt gates.

Typical circuit symbols or Schmitt gates are shown in Fig. 3.22, from

Fig. 3.22. Circuit symbols for Schmitt gates

which it can be seen that the standard outlines are used, but with an additional symbol inside. The extra symbol is, in fact, in the form of the transfer characteristic shown earlier in Fig. 3.21. One of the most common Schmitt gates in the 7400 TTL family is probably the 7414 the Schmitt equivalent of the 7404 hex inverter. The pin-out is shown in Fig. 3.23, and it can be seen that the 7404 and the 7414 are pin-compatible.

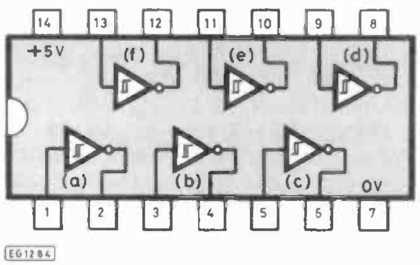

Fig. 3.23. Pin configuration for the 7414 hex Schmitt inverter

To conclude this brief look at Schmitt gates, the circuit of Fig. 3.24 allows us to compare the operation of the 7404 and the 7414. A variable resistor, or a variable power supply, is used here to provide the input signal which varies over the range 0 to +5V.

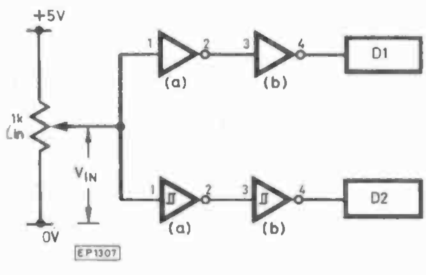

Fig. 3.24. Comparison of gate performance

This circuit is wired by placing a 7404 in socket A, and a 7414 in socket B, and adding the following wire links.

VAR	to	A1	(Variable supply i/p)
A1	to	B1	(Tie i/p together)
A2	to	A3	(Link)
B2	to	B3	(Link)
A4	to	D1	(Ordinary gate o/p)
B4	to	D2	(Schmitt gate o/p)
A7	to	0V	(Supply)
B7	to	0V	(Supply)
A16	to	+5V	(Supply)
B16	to	+5V	(Supply)

The variable supply (VAR) may be taken either from a 0 to +5V supply or, as shown, from a potentiometer connected between the two supply rails. As the input voltage is slowly increased, it should be noted that a point is reached where D1 will flicker on and off for small adjustments of input voltage. D2, on the other hand, will have a definite snap-action, with two quite distinct and separate switching points. It is an interesting exercise to try and plot the transfer characteristics for the two types of gate on the same axes for comparison; the differences are quite noticeable!

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Microstate Ltd., 5 Northfield Close, Fernhill Heath, Worcester WR3 7XB (0905 56322)

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PLEASE NOTE

The R19 shown on the Logic Tutor Board next to link 3 should be R15. Under the heading 'Initial Tests' diode D9 is referred to as diode D5; diodes D5 and D6 are referred to as D6 and D7 whilst diodes D7 and D8 are referred to as D8 and D9.

Space Watch...

NEW USSR RADAR

A new radar installation has appeared in central Siberia. Since it is near to the heavy missile fields of that region it is to be assumed that it is for the detection of ballistic missiles. If this is so, then it will be highly sensitive as an early warning device. The actual site is situated at approximately 58.08°N and 92.4°E.

The United States discovered this late last July. It was not detected earlier because for reasons of economy America had restricted activity for some months. The Americans used a Big Bird satellite and analysts have now verified this installation. A map has been released showing where the principal missile bases are together with the radar sites. According to this map there is every sign of readiness exhibited. There has been quite a large coverage of the subject recently. As has been pointed out on previous occasions it is not the policy to deal with these matters in *Spacewatch*. The excuse for bringing it forward now is that the event of the Korean jet airliner has brought the matter to serious proportions and many people in all parts of the world now seem more concerned with *accidents* precipitating events leading to a holocaust.

THE SHUTTLE

The success of the latest shuttle flight was a new venture, a night landing and the highly successful launch of another satellite, this time for India. The mission has considerably enhanced the prestige of NASA. Naturally officials are full of a very real pride in all concerned.

An aspect of night landings is the 'seeing' ability available to the crew. The last critical phases of the touch-down were very important in this respect. The portable lighting system was set up on the lake bed at runway 17. Lights were also available for the ground crew. The shuttle could not be seen by observers at Edwards until it entered the Xenon beams before touchdown, but a rumbling sound could be heard before the craft came into view.

A statement made by Lt. General J. A. Abrahamson, a NASA associate administrator, confirming the advantages of night landings, went on to say, "this opens up another 12 hour door for launching at Kennedy. It is vital because then we can take advantage of the best weather." Abrahamson also said that it was certain that night landings in future would exceed those made in daylight. The Orbitor turnround was delayed because of manifold drainage problems. Altogether there was a 16 hour delay, the reason for this lengthy procedure was the result of playing it safe. There were often minor faults which were referred to investigation.

The set manoeuvres carried out were done so successfully, much new information on the shuttle performance has been gained, hitherto there has been a radio blackout during the landing phase, and there is a suggestion that the aerials on the top of the vehicle should be used. The method of penetrating the ionized atmosphere was overcome some years ago in manned satellite investigation and was given some coverage in these columns. However if it can be done with existing equipment it will save weight. It is to be hoped that the American government will not inflict economies on space activity for scientific and commercial purposes, since there is much to be done if the full use is to be made of advances in these fields.

GERMANY

The German Infrared Laboratory has now completed its first tests and design review. It now remains for the German government to give assent to proceed with the project. The observatory was planned as a successor to IRAS. The plans are aimed at a launch date around September 1987. This is hoped to be attained, and launch is to be by shuttle. The Laboratory was approved by an independent review board in July. The further work required is for the manufacture of the qualification and flight models of the laboratory. Four scientific experiments are proposed and the estimated cost is some 1·9 million pounds. The experiments will be made by subcontractors.

The satellite is expected to provide more detailed observations than is possible with IRAS and is expected to be as much as ten times more sensitive. It will use the infrared survey being carried out by IRAS and help to select targets for more detailed study. The laboratory would be in space for several years before two other observatories are ready. These will be the infrared facility on the Shuttle and the Infrared Space Observatory put up by the European Space Agency. The time scale for these is 1990 for the American telescope and 1992 for ISO. The purpose of these vehicles will be complementary.

The immediate German programme will hope to gather information that could help to clarify whether the Universe is 'closed' or 'open'.—That is to discover if there is enough matter in the Universe to generate gravitational force to prevent expansion. Other questions to be settled include 'Is the Universe made of hydrogen and protostars like Jupiter'? More details of the equipment and programme will be available when the vital question of the funding is settled.

JAPANESE ACTIVITIES

The Japanese are planning a new launcher with a capacity of two tons of payload. They expect to launch 78 satellites between now and the year 2000. It is Japan's stated intention to compete with America. They are asking for an annual increase in funding of up to 10% per annum for 17 years.

The programme is for launching several satellites at the same time. This is necessary because of an agreement they have with local fishermen. The fishermen claim substantial losses at each launch. The agreement being—the authorities will only launch during February and August of each year. A detailed list of the launch plans will be available at a later date.

The long term plan would be to offer launch services to construct ground stations and to develop software.

SOYUZ RENDEZVOUS FAILURE

The Russian Soyuz crew failed to rendezvous with the Salyut 7 Space Station earlier this year. This was because the radar antenna would not deploy and an optically guided approach to the station had to be aborted in darkness when the cosmonauts feared a collision between the two vehicles. The Soyuz crew did not attempt to dock. Mission Commander Vladimir Titov said "I was unable to approach closer than some 525 feet."

The Soyuz problems began on the second orbit when the crew found that the dish antenna mounted on a large boom had only deployed partially. This antenna is a key element in the Soyuz automatic docking system. The crew received ground control permission to make several attitude control manoeuvres at rates high enough to swing the antenna into position. The attempt failed. Titov said that Soyuz mission rules dictate that after such a failure no attempts to try other methods are allowed. Nevertheless the crew sought and obtained permission to attempt a rendezvous with Salyut by optical means with the aid of ground radar signals. Such a situation was new and the crew had little hope of success.

Without ranging data to provide distance and closing information Titov had to tell the ground 'how large' the Salyut appeared compared with the reticle markings on the sight and then the ground team computed what type of manoeuvring to perform. On the 19th orbit Titov saw the Salyut in his alignment sight and reported the data. The ground control told him to fire the spacecraft's manoeuvring engine for 50 seconds. He then reported to the ground that the Salyut was closing.

At that point both vehicles flew out of the ground radar sight for 35 minutes. Titov was able to approach within 1000 feet of the Salyut and shine a searchlight from Soyuz onto the passing Salyut station until they went into darkness. Commander Titov tried braking and other methods without success. When they were again in radar sight they were found to be about 2·5 miles apart. Further attempts were abandoned. It was then decided to return to earth. Titov was naturally disappointed. Subsequently another vehicle made the rendezvous without any trouble at all.

When one looks back it is quite remarkable that beyond these limited scares, spaceflight seems safe enough.

Frank W. Hyde

VERNON TRENT *at Large!*

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

EVAN Steadman is 45 years old and well-built. He's tastefully tailored, except perhaps for the tie-of-the-day—the badge of your true extrovert. The abundance of greying hair is studiously ruffled and he keeps his loose change—which, in his case, could include a £50 note—in a little purse. A minus point this. Men of substance should at least appear to be less concerned about their petty cash. But I quibble.

Evan is a man who's unoffended, even tickled, to be labelled an exhibitionist. He knows that in the sense people use the description about him it has nothing to do with the dictionary definition of 'one who has a compulsive desire to attract attention by exaggerated behaviour or boasting'. Or, in another listed sense, 'by indecent exposure'.

He is one of the woefully few 'characters' who has survived the creeping standardisation of so much about the electronics industry and whose drive and personality is behind many of the best-known and most-successful high-technology exhibitions to which hundreds of thousands of hobbyists and professionals alike flock year after year.

A one-time schoolteacher, he entered the world of publicity via Fleet Street as a feature writer. "My only gift," he says, "was an ability to turn out 1,500 words to order on any subject my editor demanded. It was usually sheer bloody rubbish, of course. But no matter." This led to work with advertising agencies and publicists and eventually to the post of European advertising and publicity manager for Texas Instruments.

"But deep down," he said, "there was this congenital desire to go off and do my own thing—if only because this was the sole way I could make more money. I was based in the South of France at the time of the big decision. I was living in Christian Dior's villa, if that matters, and life was magnificent. My salary was on an American scale, but even so I managed to spend it. Very naughty of me. So I made tracks for the UK and set up a PR business in the bedroom of the house I'd kept on in Cambridge. My capital was £75."

Today he owns three advertising agencies and three PR companies. "I don't work much on them personally because it wouldn't be cost-effective. I devote the bulk of my time to exhibitions. The sums of money involved here are fantastic. Take the Antiques Fair at Grosvenor House, London—the only non-technical show I handle. There's a £5 entrance fee, the catalogue costs £4 and we get around 20,000 visitors. That, if your maths are right, adds up to £180,000 in cash taken at the door. Even so, mine's a chancy game. When an exhibition fails I lose a lot of money. When it works I make a lot. But when it fails it only fails once. When it works it works several times."

He pays tribute to the professionalism of the talented guys who run his companies. "But they find exhibition work too nauseating, too stressful, too tough. I thrive on stress and toughness. Don't ask me why. But if you find you like it you try it again."

The All-Electronics Show—an all-Steadman production—started nine years ago at Grosvenor House with 180 stands. The idea was born when some of his clients said that to stage the IEA and RECMF exhibitions at Birmingham when the electronics industry was based mainly in the South was absolute nonsense. "I agreed. And I told them that they didn't have to go to Birmingham. I'd put on a show right here. It worked, and it's been working ever since. Now I've become involved with two major annual exhibitions—all in the high-technology sector—plus six conferences. And the list is growing at a rate of four a year."

I asked Evan whether he ever found his lack of formal training in high-technology a drawback. He was visibly affronted. "You underestimate me, madam," he replied with some coolness, putting me by way of riposte into a sexual category to which I clearly do

"I thrive on stress and toughness"

not belong. "I've spent the last 13 years right in the thick of high-technology. And it hasn't been simply a matter of learning the buzzwords. It's been a matter of seizing on definitions and opportunities and employing lateral thinking . . . I won't go on. It would be too boring.

"But let me give you an instance. I claim to be the first to realise that the need for fibre optics had to be brought home to the world. That grandiose statement is justified by the fact that I put on the first-ever exhibition devoted to the subject. That show attracted 7,000 visitors, the next 12,000. Last year 70 companies took part. Next year it'll be 140.

"Of course, I'm no good at design and I couldn't wire up a p.c.b. But I reckon I know more about high-technology and all its implications than any of the guys working on the benches at Marconi or wherever. Certainly they know all about copper and wire and the rest of it. They understand circuit construction inside out. But they don't know where it all fits in, what it's all leading to. It's the understanding, the appreciation of significance and the breadth of experience that matters. And I've got it. That's not meant to be an arrogant statement—though I have been known to make them.

"Let me give you another illustration. I recognised when the time was ripe for a p.c.b. exhibition. Internepcon used to cover the subject, but then gave it up and became simply a major general electronics exhibition held on the South Coast. The baby had been passed out with the bath water. So I knew it was time to act.

"So now you'll see why I marginally resent the suggestion that old Evan hasn't got the qualifications, because he bloody well has. Anyone with an IQ of 140 has all the qualifications he needs."

What material rewards has his energy, imagination, acumen and, in large measure, audacity brought? He's quite frank about that. "Oh I'm a millionaire (he might well have been telling me he was an expert on the banjo). I've a chauffeur-driven Bentley, three houses and a farm. I also own the building we work from."

I asked the stock question: had he yet reached the height of his ambition? "I've hardly started," he said. "A person who is really ambitious never really achieves the ultimate. He goes on. I don't mean that it's a sort of drug. It's like a way of life. But it's not just for money, power, sex with your secretary or the other things that people believe that ambitious men seek. It's the need to get into things where there is an aching void which you think you can fill. Nature abhors a vacuum. And I'm one of Nature's abhorrers. There are not millions of us like that, but there are lots who are prepared to grasp the nettle, given the chance.

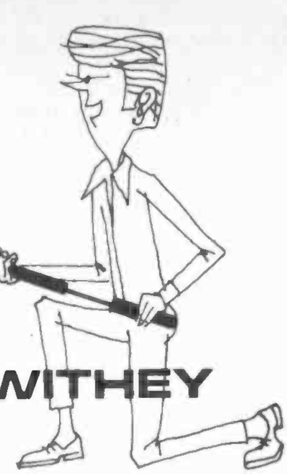
Evan Steadman does not rely for his remarkable stamina on such aids as specially prescribed diets, Swedish exercises or transcendental meditation. "I believe in excess in everything," he freely admits. "As a result I'm exhausted all the time. I'm fat. I've got spots before the eyes and spots on the skin and I'm all hyped-up. But, for me, sitting down relaxing in the sun for a couple of hours would be the kiss of death.

"Mind you, that doesn't mean that I haven't any relaxation at all. I've lots of children and I'm heavily into child culture. One son is a drummer and I have a daughter training to be an actress. Then there are my homes, the farm and so on. These need a lot of attention and in a way this adds up to a kind of hobby. Also, I've a private cinema in one of my homes. It's always there if I want it. And I'm a voracious reader. I get through two or three books a week. But the best type of relaxation is the business of living."

For all the success he has enjoyed and the excitement of his life, Evan Steadman is not a man I envy. Anymore than he envies me. As he says, his life style demands a hefty price. It can mean stress, ulcers, long hours, overindulgence in most of the things which should be taken in moderation. "But," he says. "If you're like me you'll know that it's all part of what your body's been telling you to do since the day you were born. Better to have been a has-been than a never-been.

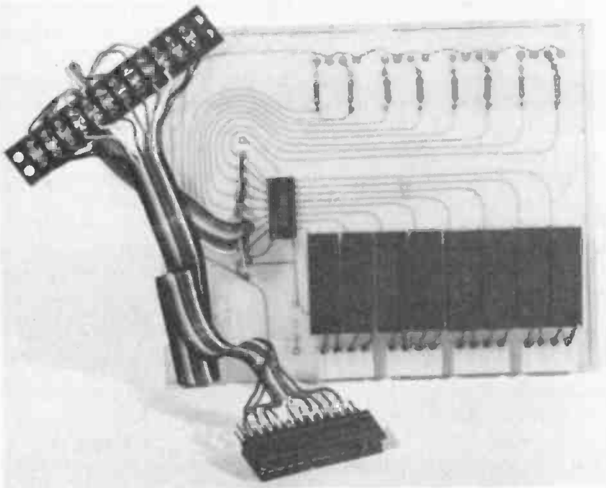
"Joy, you know, is never present. You always feel you've failed to get to the point you wanted to reach. That's why you go on. You'll find it hard to believe that sometimes when I climb into the Bentley and say: Take me home Bernie, I feel pain."

EXPANDING THE VIC 20



PART THREE SAM WITHEY

OUTPUT DRIVER BOARD . . .



FOR AROUND £12

THE next stage in interfacing the Vic 20 involves the dedication of lines as outputs and inputs. As these lines are now to connect the computer to external electrical devices, it becomes necessary to physically isolate the computer from such devices. We can carry this out by using opto-couplers and relays. This makes the interface rather more costly than the l.e.d.s and switches board, but it opens up exciting new fields for the serious computer enthusiast and hobbyist, and turns the home computer into a useful precision control instrument.

After much deliberation about the allocation of output and input lines, it was decided to give first consideration to dedicating all lines to output applications. This gives great potential to those who wish to control models and small motors, as well as those who wish to experiment with light displays.

This article deals with two output control boards and an input control board.

INPUT/OUTPUT CONTROL BOARDS

In the first interface, all 8 lines are set up as outputs. They are isolated by relays suitable for use with voltages up to 50V, and current handling capabilities up to 500mA.

The second interface uses opto-isolated triacs capable of controlling mains voltages and currents up to 1·2A. In both circuits, disabling of the outputs, when not under computer control is carried out by pulling the output lines down to ground potential. This must incorporate the use of insulated mechanical switches as with the l.e.d.s and switches board.

Whilst most control applications are likely to be in output mode, there are many instances when the computer has to be called upon to sense inputs. These can include counters and alarm sensors of many types.

The input board (to follow next month) uses opto-isolators.

All these options can be mixed by using a simple connector block suggested in this article.

LOW VOLTAGE OUTPUT BOARD

The principal devices used in the first control interface are the ULN2803A, octal driver integrated circuit and 700R, 500mA relays. See Fig. 3.3.

The ULN2803A is an 18 pin d.i.l. integrated circuit, which contains 8 open collector, darlington driver stages with a maximum operating voltage of 50V and each capable of sinking 500mA. Each stage incorporates a diode, which offers protection when switching inductive loads.

Applications include relay, lamp, solenoid and small motor switching, and individual stages may be paralleled to increase the output sink current.

The relays used incorporate a 6 to 9 Vd.c., 700ohm coil, and normally-open contacts rated at 500mA, 200Vd.c., 10 Watt maximum; whilst other similar relays have contacts rated at 200mA, 50Vd.c., 5 Watt maximum. No diode is included in the encapsulation, but the top of the moulded case of both types clearly illustrate the position of the coil and contacts.

See Figs. 3.4 and 3.5 for construction.

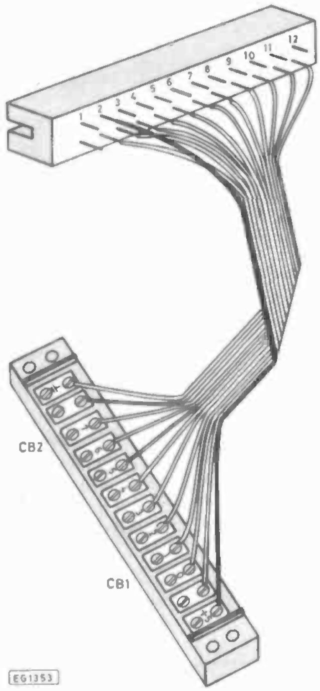
Provision has been made for 4 way, 0·2in. pitch terminals, but these are optional.

There are many options available from the ULN2803A, being capable of directly driving lamps, solenoids and small motors up to 50Vd.c. and the additional advantage of being able to parallel the stages to increase the output sink current. Here it must be remembered that the Vic 20 is only capable of providing 100mA @ 5V, making the external power supply necessary. Also, without relays, there is not complete electrical isolation between the computer and peripheral.

The cost of the i.c. and relays is in the region of £10, whilst the inclusion of terminal blocks would increase the cost by approximately £3. Of course, there is no need to completely build the board at first, as each line of the port can be used individually. Each board can be just partially furnished for initial experiments and extended as required.

The principle of operation is similar to that of the l.e.d.s and switches board. A logic "1" at the port is inverted by the driver. The logic "0" at the output of the driver, being low relative to the supply voltage induces current to flow through the coil, the electromagnetic field of which causes the contacts of the relay to close.

Again, provision is made for disabling the logic "1" at the port by pulling the output down to ground potential. This could be brought about by microswitches to limit the travel of a moving piece of apparatus, the level of liquids or the lapse of a preset period of time.



Making up this connector will allow flexible use of the expansion boards

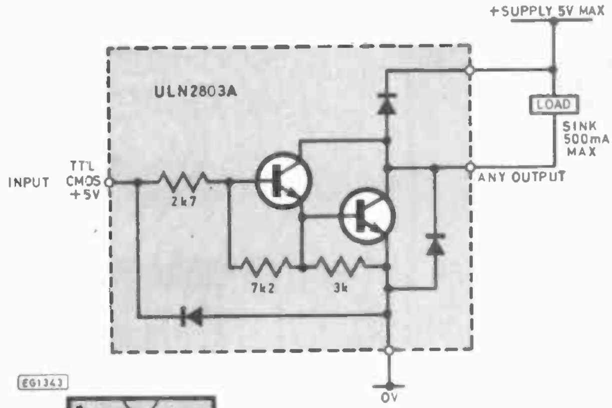


Fig. 3.1. Single stage schematic of ULN2803A

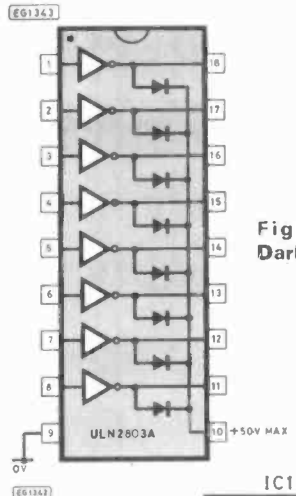
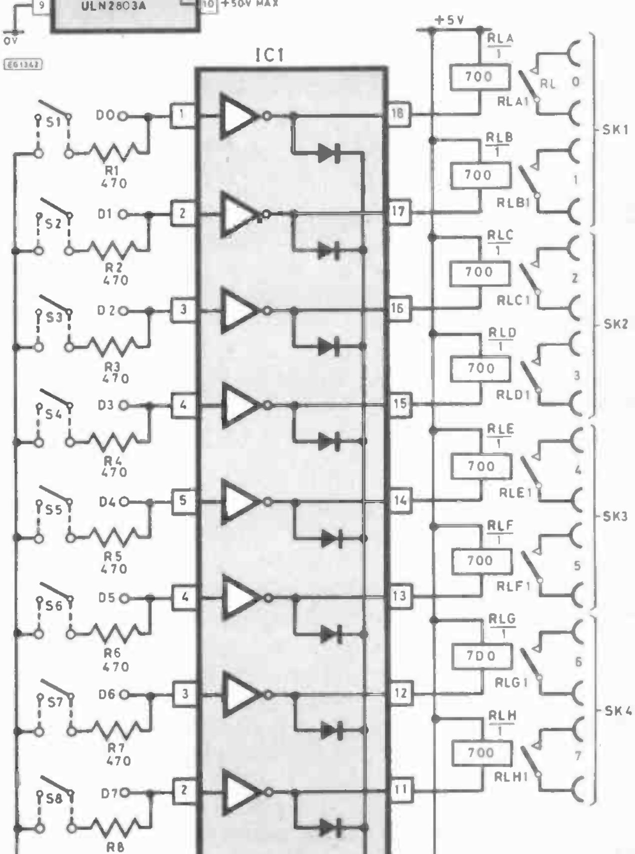


Fig. 3.2. ULN2803A octal Darlington driver i.c.

Fig. 3.3. Low voltage output control board circuit diagram



COMPONENTS . . .

OUTPUT CONTROL BOARD (low voltage)

Resistors

R1–R8	470 ¼W 5% (8 off)

Semiconductor

IC1	ULN2803A

Miscellaneous

RLA–H	6–9V 700 ohm 500mA reed relay (8 off)
S1–S8 (external)	S.p.s.t. toggle (8 off)
TB1–4	4-way 0·2in. pitch terminal block (optional) (8 off)
P.c.b.	

Constructors' Note

Project prices quoted are based on home etched p.c.b.s and "shop around" component prices, therefore some general purpose components are not specified to exact manufacturers or part numbers. If p.c.b.s are found to be unavailable from PE's usual suppliers, they may be obtained from Bradley P.c.b.s Ltd.

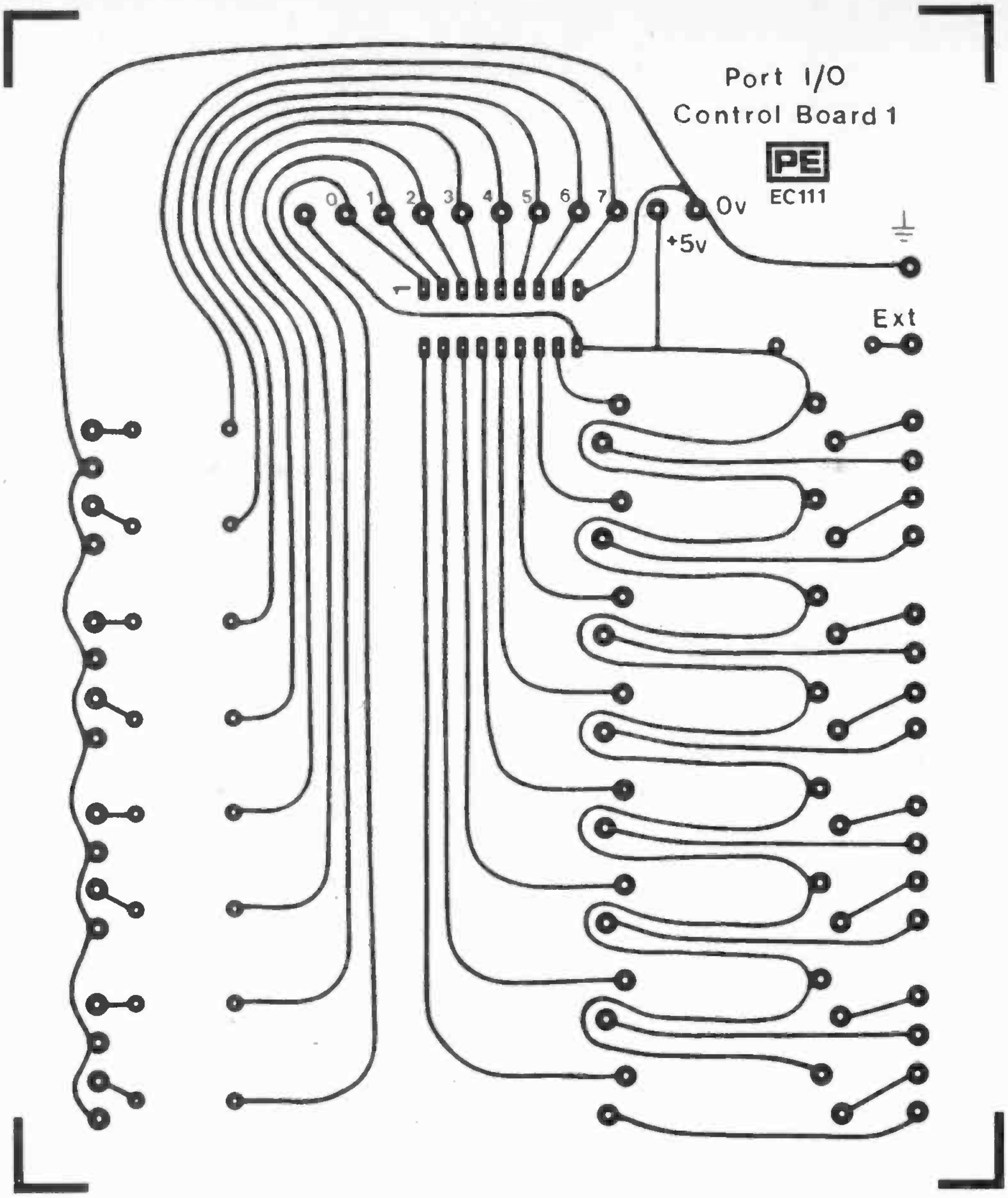


Fig. 3.4. Low voltage output control board printed circuit layout (actual size)

FEEDBACK

The current series on *Expanding the Vic 20* has brought a new and enthusiastic group of computer fans to the pages of *P.E.* A group which, having gained valuable experience at programming techniques, now wants to turn its machines to further use about the home. Some readers with little or no experience in construction have asked for some information on soldering and making p.c.b.'s, whilst others, having some difficulty in understanding the Vic 20 manual, have asked for a little more information on connections to the RAM/ROM Blocks. There is difficulty in choosing the most economical method of buying components. Some want more information about the Super Expander/Vicmon ROMs, and where to get them. Enquiries also concern the feasibility of getting even greater versatility from the RAM and ROM boards. Others ask for an extension of the series to include other computers.

The last request is the easiest to answer, because all the rest of the series, whilst aimed primarily at the Vic 20, is equally suitable for use on any home computer, having been developed some time ago for Nascom. All that is required is a suitable connector for your computer I/O port and some adaptation of the sample program routines.

NEXT MONTH: All the above points will be gone into, the topics being based on readers' letters during the series. A high voltage (mains) driver board will be featured, and an opto-isolated input board, along with details of construction and manufacturers' applications notes.

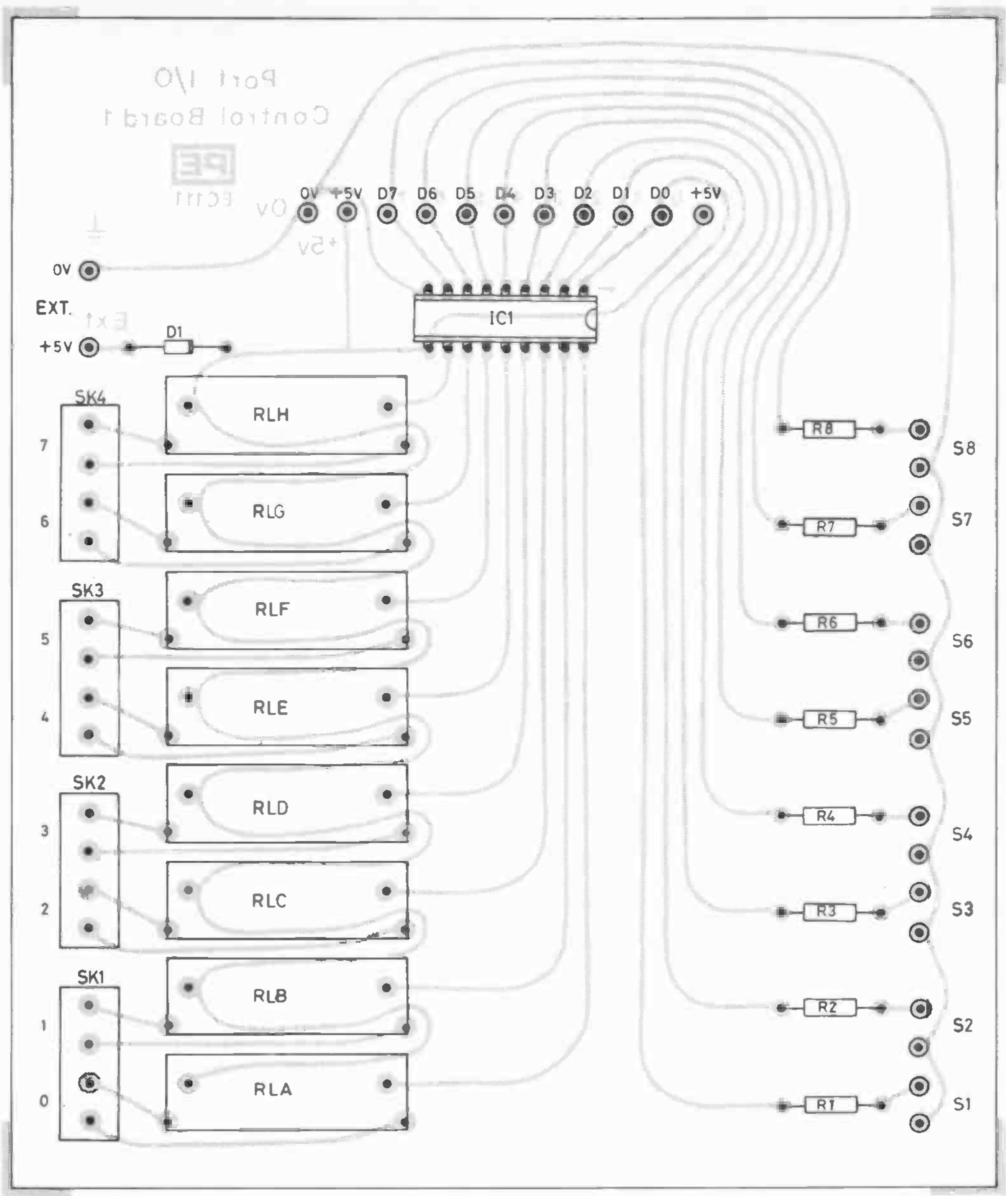


Fig. 3.5. Component layout of low voltage output control board

LOGIC ANALYSER

Part Five

D. MANDELZWEIG MSc Eng

PREVIOUS articles in this series have detailed the design and construction of a modular logic analyser. The basic unit as described has TTL compatible inputs. This final article in the series presents a fifth option, allowing the analyser to be adapted for use with CMOS circuitry.

REQUIREMENTS

Let us consider the requirements. Although today most computer systems run from a 5V supply rail, many other circuits use CMOS technology running from higher voltage levels. Thus the first requirement is to be able to level shift the CMOS power rails and logic levels to those compatible with TTL. The next requirement is of sufficient drive capability of the circuit under test. A LSTTL input represents on the average a tenth of the drive capability of a TTL output. Therefore using the analyser on TTL circuitry will not affect the operation of the circuitry (very seldom do good circuit designers allow TTL outputs to drive the maximum number of inputs). On the other hand, however, a common limit to the drive capability of CMOS outputs (as far as TTL is concerned) is two LSTTL inputs. If one, or two LSTTL gates have already been used in the design being tested, another LSTTL load may affect the operation of the circuitry. So the load applied to the circuit by any test probe should be as small as possible, and in the design presented here, is the equivalent of a single CMOS input. A third consideration, closely connected to drive capability, is of test lead length. Long leads, necessary to reach into the circuit being tested, represent capacitive loads to the drive circuitry as the frequency of the signals increase. Circuits with low drive capability may not be able to drive these capacitive loads, and the switching from one true logic level to another may be prevented. To overcome this problem, the input circuitry must be as close as possible to the test points of the circuit being tested.

SOLUTION

There are a few possibilities for the required solution. One would be to use comparators as input buffers, but many i.c.s would have to be used making the p.c.b. large and cumbersome. A better way is to use i.c.s specifically designed for the task. Two such i.c.s are available. The first is the RCA CD40116 high speed 8-bit bi-directional CMOS/TTL convertor, and is ideal for the application. Propagation delays through the i.c. are typically 15ns—of the order of those in the analyser itself. There are two disadvantages to this i.c. A minor one is that the CMOS side maximum level is 12V—some CMOS circuits work on 15V. The other one, somewhat larger, is the availability of the i.c., and especially its price, which does not make it (at present!) economical to use. The second i.c., a RCA CD40109B, is more readily available and is much cheaper. This device was designed to be a low-to-high voltage converter, but can be used in the opposite mode, as is done in the circuit to be described. There has to be a trade-off in performance to approximately 1MHz. If higher speeds are to be encountered (fast CMOS i.c.s are becoming available today) then it is recommended that a design using the first i.c. be considered. Although the i.c. is not pin-for-pin compatible with the one being used here, the three CD40109Bs can be replaced with two CD40116Bs with suitable modification to the p.c.b. layout. Remember, though, that the analysis maximum input frequency is 5MHz, and it is possible to test circuitry at lower speeds, as discussed in previous articles. Another problem arising out of slow propagation delays is that of data skew. (See part 1.) To avoid this problem, it is important that all the signals being observed (and being used for control, such as the clock modifiers etc) must be connected through the translator. This will ensure equal propagation delays, and all signals will arrive at the analyser simultaneously.

CIRCUIT DESCRIPTION AND CONSTRUCTION

Fig. 5.1 shows the logic diagram of a single translator. There are four translators per i.c., and using three i.c.s allows twelve lines to be translated. There are thirteen input lines to the analyser. It was decided that a fourth i.c. was not necessary for translating only one line, and the CQ3 input is therefore not used in this option. Referring to Fig. 5.2, the unused CQ3 input is held high by R513. (When using the analyser, the CQ3 input switch should be in the 'don't care' position.) In Fig. 5.2, all the Vcc inputs and the enable inputs are commoned, and taken to point A. All the translator inputs are also held 'high' to this common line via resistors R501–R512. These resistors present minimal loading, and prevent open inputs from floating (and possible damage). Linking A to B makes the option compatible with circuitry using 12V supplies. Linking A to C connects the option to the +Vin line, which must be connected to the supply line of the circuitry being tested. Input voltage range is +5V to +15V. A choice can be made at the construction stage as to which link to use. Alternatively, a small switch can be mounted on the case allowing easy change-over. VDD, the TTL level side of the i.c.s, is supplied by the 5V supply in the analyser. The supply line is decoupled by C501.

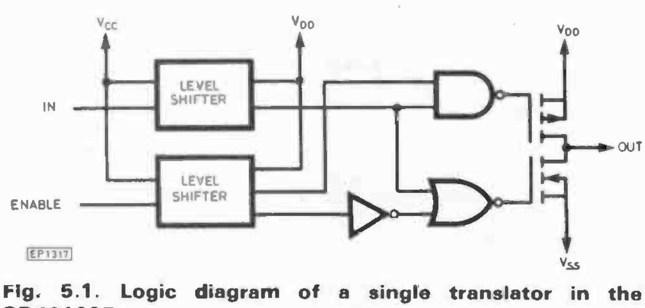


Fig. 5.1. Logic diagram of a single translator in the CD40109B

COMPONENTS . . .

Integrated Circuits

IC501–503	40109B	(3 off)

Resistors

R501–R512	1M $\frac{1}{4}$W 5%	(12 off)
R513	10k $\frac{1}{4}$W 5%	

Capacitors

C501	10μ 16V Tant

Miscellaneous

Ribbon cable, Eezy-hooks, plastic case, p.c.b. SPDT switch (optional)

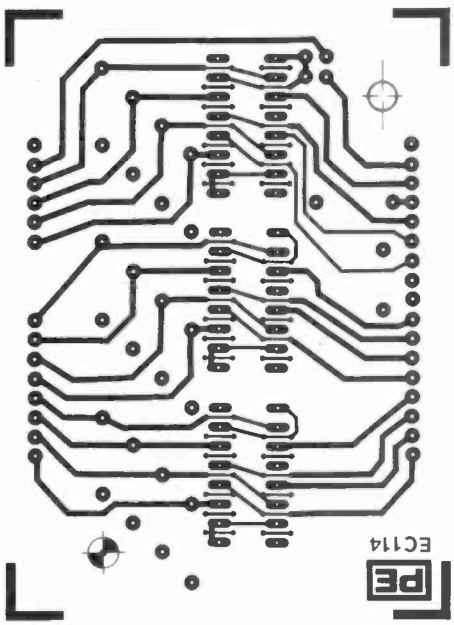


Fig. 5.3. Track side p.c.b. layout of CMOS input option board (actual size)

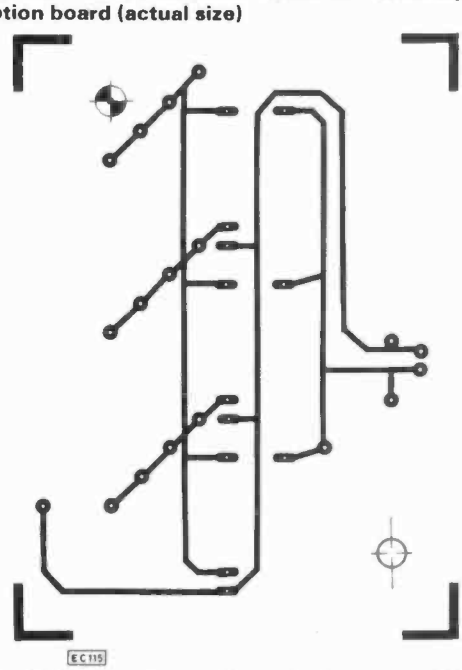


Fig. 5.4. Component-side p.c.b. layout of CMOS input option board (actual size)

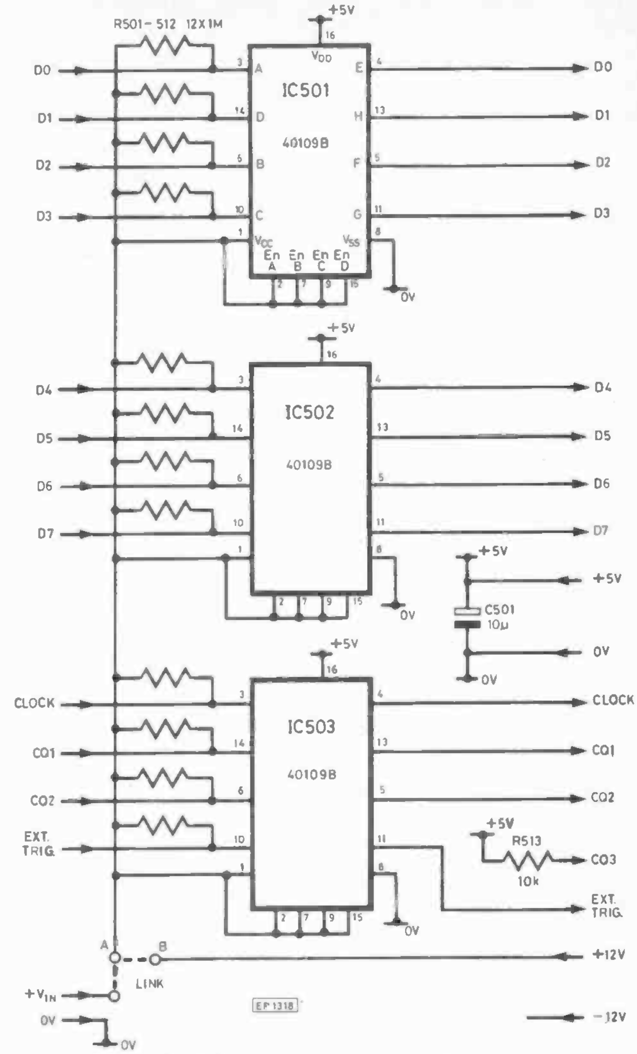


Fig. 5.2. CMOS input option circuit diagram

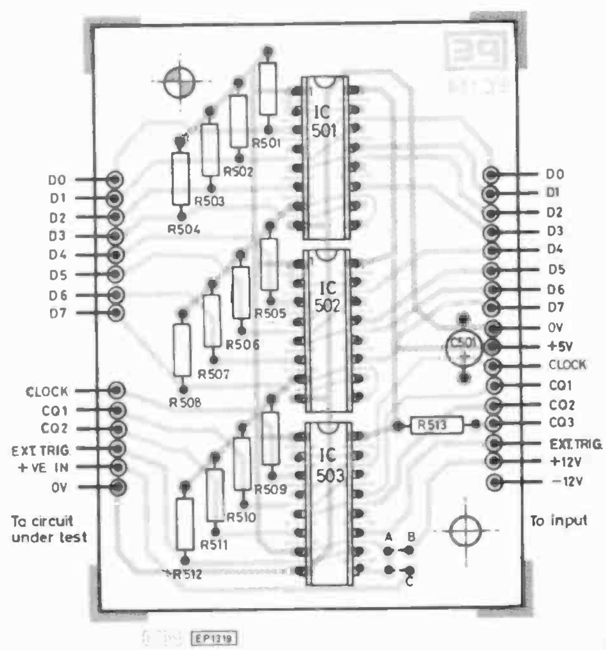


Fig. 5.5. Component layout

Construction of the unit is straightforward. Use soldercon i.c. socket strips for the i.c.s. Handle the i.c.s with care as they are CMOS devices. All necessary through-hole connections are made with component leads soldered to pads on both sides of the board. Extra pins are not necessary.

Link A to B or C, or if a switch is to be used, connect some lead wire to the p.c.b. 16-way ribbon cable is used to connect the p.c.b. to the analyser. This cable can be up to 0·5m long, and is connected to the analyser using the same method as the probe described in Part 2. The order of the connections from the p.c.b. match the order of the inputs to the analyser, so connections are made one-to-one. Part 2 shows these connection details. Note that the −12V supply is not used, and remember that CQ3 is not used. A piece of 14-way ribbon cable, no longer than 100mm, is used between the p.c.b. and the circuit under test. Coloured Eezy-hooks are again used as convenient probes on the circuit under test side. The p.c.b. can be mounted in a small plastic case, and the optional switch installed. The nearest sized, commercially available case is the Vero 202–21029J. This may be a little long, though. The author used a suitable plastic case found in the junk-box. Slots are cut on each side of the box to allow cable entry and exit.

TESTING

A circuit similar to that shown in Part 3 can be used for testing. Replace the 74LS90 with a 74C90, and use, say, 12V as a supply voltage. The clock input used must also be a signal switching from 0V to +12V. Use the +Vin line connected to the test circuit supply. (If A was linked to B, then use a supply voltage of 12V, but the +Vin line need not be connected.) A similar display to that seen during the original testing (Part 3) should be observed.

This concludes the series. It is hoped that those who have built the project have found the instrument useful, and those who have just followed the series have learnt something of interest. Finally, the author would like to thank *P. Duggan* for his assistance in checking the analyser timing diagrams. ★

NOTE: A hex dump of the contents of the IC10 and IC11 of the analyser's display board may be obtained from PE (Poole office) by sending a SAE.

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P.E. magazines, offers for sets from No. 1 to Dec. 81 Vol. 17 No. 12. Ring 0245 466251. A. C. Holvy, 14 Sussex Close, Boreham, Chelmsford, Essex CM3 3ED.

UK101 with case 8K £75 or offers. Sunbury 80300.

CHIPS: 8202A £10. 8253, 8275, 8259 £3 Each. 2716 (5V) £1.75. Z80AS/10/0 £7. 41/6 16 for £7. J. E. Walker, 7 Warwick Place, Peterlee, County Durham. Tel: Peterlee 868255 after 7pm.

UK101 8K Clegmon, cased, 300/600 baud. Lots of software and information offers. D. Callender, 17 Badger Way, Banbury, Oxon OX16 9UD. Tel: Banbury 53475.

VIDEO Computer, Interton VC4000 + Chess 2, Draughts, Solitaire, Super Space, Cartridges, New, Unused £125 o.n.o. Or "Spectrum" or "Ultimum interface" projects. Colm Merlehan, Doon, Rathronan, Clonmel, Co. Tipperary, Ireland. Tel: 052 22133.

YAMAHA PS-10 Automatic Bass Chord. Portable. Full size keyboard. 3½ octave. Auto rhythm £150. Call Chang. 041 332 7695 after 9pm. K. Y. Chang, 70 1-UP Ashley Street, Glasgow G3 6HW.

WANTED Acoustic Research Turntable type XB. Simon Jones, 1 Heather Cottages, Tilford Road, Hindhead, Surrey GU26 6RG. Tel: 042873 5726.

TANGERINE Micron Keyboard with numeric pad £15. Also Hex keypad £4. Phone 01-732 4884 evenings. L. Wade, 16 Montpelier Road, London SE15 2HF.

PRACTICAL Electronics, Elector, Wireless World 1975 onwards for sale. Offers please (enc s.a.e.). D. Lawrence, 83 Main Road, Shavington, Crewe CW2 5DU.

UK101 Assembler/Editor and four graphic games, two original cassettes. Never used. Cost £14.00. Now £6.00 incl. Mr. P. Niem, 54 Park House, 314 Seven Sisters Road, London N4.

SERVICE Manual for Tektronix 475 £10 inc. post. Wanted cheaply, part-complete modular Z80 computer system. John Dykes, 2 Aire Place, Winsford, Cheshire CW7 3LW. Tel: (06065) 51303.

ACORN Atom. Fully Expanded. Colour circuit, extra ROM 5 volt power supply. Much software. Still boxed £120. A. G. Renwick, 86 Summerhouse Avenue, Heston, Middlesex. Tel: 01 570 4518.

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.

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PE BAZAAR DECEMBER '83

MICRO-BUS

and MICROPROMPT

Appearing every month, Micro-Bus now presents ideas, applications and programs for the most popular microcomputers and all micro-related projects so far published in PE. Ideas must be original, and payment will be made for any contribution featured.

ATARI VARIABLES

OWNERS of Atari 400/800 machines may be interested in this program, sent in by *C. Leech* of Leicester. It lists the names of all scalar and string variables referenced by BASIC, along with their current values. Once loaded, the BASIC program can be deleted and the m/c program called by an X = USR (ADR(VARILIST$)) command.

```
 1Ø DIM VARILIST$(283)
 2Ø FOR I=1 TO 283
 3Ø READ Z
 4Ø VARILIST$(I)=CHR$(Z)
 5Ø NEXT I
 6Ø DATA 1Ø4,165,13Ø,133,2Ø5,165,131,133,
    2Ø6,169,255,133
 7Ø DATA 2Ø9,165,2Ø6,197,133,2Ø8,7,165,2Ø5,
    197,132,48
 8Ø DATA 1,96,23Ø,2Ø9.16Ø,255.2ØØ,177,2Ø5,
    16,251,132
 9Ø DATA 224,23Ø,224,2Ø1,168,2Ø8,2,24Ø,6Ø,
    41,127,145
1ØØ DATA 2Ø5,152,72,162,Ø,169,11,141,66,3,
    165,2Ø5
11Ø DATA 141,68,3,165,2Ø6.141,69,3,165,224,
    141,72
12Ø DATA 3,169,Ø,141,73,3,32.86,228,169,Ø,
    141
13Ø DATA 72,3,169,61,32,86,228,1Ø4,168,177,
    2Ø5,9
14Ø DATA 128,145,2Ø5,56,176,6,56,176,164,56,
    176,43
15Ø DATA 165,2Ø9,133,2Ø3,169,Ø,133.2Ø4,6,
    2Ø3,38,2Ø4
16Ø DATA 6,2Ø3,38,2Ø4,6,2Ø3,38,2Ø4,24,165,
    2Ø3,1Ø1
17Ø DATA 134,133,2Ø7,165,2Ø4,1Ø1,135,133,
    2Ø8,16Ø,Ø,177
18Ø DATA 2Ø7,2Ø1,Ø,24Ø,8,2Ø8,74,56,176,115,
    56,176
19Ø DATA 2Ø1,162,Ø,16Ø,2,177,2Ø7,149,212,
    232,2ØØ,224
2ØØ DATA 6,2Ø8,246,32,23Ø,216,16Ø,255,2ØØ,
    177,243,16
21Ø DATA 251,41,127,145,243,2ØØ,169,155,145,
    243,162,Ø
22Ø DATA 169,9,141,66,3.165,243,141,68,3,165,
    244
23Ø DATA 141,69,3,169,4Ø,141,72,3,169,Ø,141,
    73
24Ø DATA 3,32,86,228,16,47,56,176,185,2Ø1,
    129,2Ø8
25Ø DATA 4Ø,16Ø,2,24,177,2Ø7,1Ø1,14Ø,141,68,
    3,2ØØ
26Ø DATA 177.2Ø7,1Ø1,141,141,69,3,162,Ø,169,
    9,141
27Ø DATA 66,3,2ØØ,177,2Ø7,141,72,3,2ØØ,177,
    2Ø7,141
28Ø DATA 73,3.32,86,228,24.165,2Ø5,1Ø1.224,
    133,2Ø5
29Ø DATA 144,2,23Ø,2Ø6,56,176,195
```

TRANSMISSION LINE CALCULATIONS

Sir—This program, for UK101, is derived from the standard transmission line equations, but assumes a loss-free line, sufficiently accurate for the lengths used by radio amateurs. It is more convenient to use than the Smith chart, and numerous cut-and-dry results can be obtained rapidly.

R. J. Newman,
Chesham.

```
30  PRINT"THE MEASURED IMPEDANCE AT LINE INPUT
    IS R+/-jX"
40  PRINT"OHMS. THE LOAD ON THE LINE IS A+/-jB OHMS"
50  PRINT" ENTER A OR B FOR REQUIRED TRANSFORM"
60  PRINT"A-LINE IMPEDANCE FOR GIVEN LOAD
    IMPEDANCE"
70  PRINT"B-LINE IMPEDANCE TO GIVE REQD. INPUT
    IMPEDANCE"
80  INPUT A$
90  IF A$="A"THEN310
100 IF A$="B"THEN110
110 INPUT"Give line characteristic
    impedance";ZØ
120 INPUT"Give line length
    (wavelengths)";LL
130 L=LL*2*3.14159
140 PRINT" !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
    !!!!!!!!!!!!!!!!"
150 INPUT"Give desired R";RR:R=
    RR/ZØ
160 INPUT"Give desired jX";XX:X=
    XX/ZØ
170 D1=((1+X*TAN(L))↑2+
    (R*TAN(L))↑2)
180 A=ZØ*R*(1+TAN(L)*TAN(L))
    /D1
190 B=ZØ*((X-TAN(L))*(1+X*
    TAN(L))+R*R*TAN(L))/D1
200 P=((B↑2)+(A↑2)-(ZØ↑2))/
    ((A+ZØ)↑2+B↑2)
210 Q=2*B*ZØ/((A+ZØ)↑2+B*B)
220 MRC=SQR(P*P+Q*Q)
230 SWR=(1+ABS(MRC))/(1-ABS
    (MRC))
240 SWR=(INT(SWR*100))/100
250 A=(INT(A*100))/100:B=(INT
    (B*100))/100
260 IFB<ØTHEN290
270 PRINT"A+/-jB=";A;"+j";B;
    "SWR=";SWR
280 GOTO140
290 PRINT"A+/-jB=";A;"-j";B;
    "SWR=";SWR
300 GOTO140
310 INPUT"Give line characteristic
    impedance";ZØ
320 INPUT"Give line length in
    wavelengths";L
330 L=L*2*3.14159
340 PRINT"......................
    ........."
350 INPUT"If the termination is
    A+jB, enter A";A
360 INPUT"Enter the series reactive
    component jB";B
370 D=((ZØ-B*TAN(L))↑2+
    (A*TAN(L))↑2)/ZØ
380 R=(A*ZØ)*(1+TAN(L)↑2)/D
390 X=((ZØ↑2-A↑2-B↑2)*
    TAN(L)+B*ZØ-B*ZØ*TAN(L)
    *TAN(L)*TAN(L)/D
400 R=(INT(R*100))/100:X=(INT
    (X*100))/100
410 REM: P=Real part of reflection
    coeff. Q=j part
420 P=((B↑2)+(A↑2)-(ZØ↑2))/
    ((A+ZØ)↑2+B↑2
430 Q=2*B*ZØ)/((A+ZØ)↑2+B↑2)
440 MRC=SQR(P*P+Q*Q)
450 SWR=(1+ABS(MRC))/(1-ABS
    (MRC))
460 SWR=(INT(SWR*100))/100
470 IFX/D<ØTHEN500
480 PRINT"R+/-jX=";R;"+j";X;
    "SWR=";SWR
490 GOTO340
500 PRINT"R+/-jX=";R;"-j";X;
    "SWR=";SWR
510 GOTO340
```

SEMICONDUCTOR CIRCUITS

TOM GASKELL B.A.(Hons)

LOGIC CONTROLLED DUAL REGULATOR (LT 1005CT)

THE voltage regulator i.c. has been with us for many years, and is an almost indispensable part of the design and construction of simple, compact, and low cost regulated power supplies. Although occasional variants do appear, most regulator i.c.s are the simple three terminal type: 7805, 7812, 7815, LM340, and similar series. This situation is about to change, however, because a new American company, Linear Technology, has produced a brand new and innovative design of 5V regulator: the LT 1005CT.

The i.c. contains two voltage regulators, one providing a 'main' output with supply currents of up to 1A, and the other providing an 'auxiliary' output for lighter loads of up to 50mA. Furthermore, an 'enable' control is provided which allows the main output to be turned on and off by suitable logic or voltage control. This enable facility has no effect on the auxiliary output which remains at +5V irrespective of the state of the main output.

Both outputs are short circuit protected, and the main output has thermal shutdown protection. Again, any such shutdown or fault condition on the main output has no effect on the auxiliary output.

POTENTIAL APPLICATIONS

For such an apparently simple device, the LT 1005CT has a vast array of potential applications in power control and voltage regulation. Because of its unique enable circuitry it can be used as a very effective control element for motors, lamps, and many other types of d.c. load. Several i.c.s can be connected together with suitable timing circuitry to ensure the correct sequencing of power supplies in systems which require the power to be turned on in a certain specific order. Finally, power to a system can be split, to provide some areas with power only occasionally, and others with power continuously. This would enable the bulk of a microprocessor system to be shut down while not in use, while certain areas of RAM could be kept powered up for the storage of important data, for example. Alternatively, any combination of ROM and RAM could be powered up or down, and data transferred between them as required.

The pin out and specifications of the LT 1005CT are shown in Fig. 1. The specifications show quite reasonable performance for both regulators; note that the 'aux' regulator can operate with input voltages down to 6·8V, half a volt less than the main regulator, making it even more suitable for battery use. Also note that the enable input to the i.c. (pin 2) can have up to 20V applied to it; even if the 'input voltage' is lower than this, no damage will be done.

USING IT

Fig. 2 shows a functional diagram of the i.c. As with most i.c. voltage regulators, it is good practice to bypass both the input and the outputs with capacitors, C1, C2, and C3. These should be as close to the i.c. as possible. C1 should be a 1µ tantalum bead, and the other two should be 220n or more; 1µ tantalums will be satisfactory here, too. The use of the enable input is very simple; a logic 1 level (high) turns the main output on, and a logic 0 level (low) turns it off. It should be connected directly to pin 4 or 5 when this facility is not being used. The input is compatible with both TTL and CMOS, although a pull up resistor will be needed if open collector TTL is used.

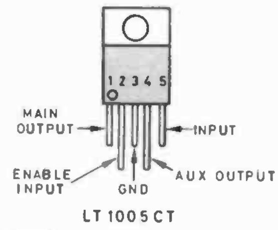

Fig. 1. Pin out with specification below

Characteristic		Notes	Min	Max	Units
Max supply voltage		All specs measured over full range of 7·5–20V d.c.		20	V
Quiescent current				5	mA
Temperature range		Measured at junction	0	125	°C
Main output	Output voltage	Enabled (Iout = 5mA–1A) Disabled (Load = 1k)	4·8	5·2 0·3	V V
	Load regulation	Iout = 5mA–1A		25	mV
	Line regulation			2	mV/V
	Ripple rejection	Vin = 8V, Freq = 50–500Hz	54		dB
	Thermal regulation			0·02	%/W
	Max output current		1·0		A
	Short circuit current			2·2	A
	Min input voltage	Iout = 5mA–1A	7·3		V
Aux output	Output voltage	Iout = 0–35mA	4·8	5·2	V
	Load regulation	Iout = 0–35mA		25	mV
	Line regulation			1·5	mV/V
	Ripple rejection	Vin = 8V, Freq = 50–500Hz	60		dB
	Max output current		50		mA
	Short circuit current			150	mA
	Min input voltage	Iout = 30mA	6·8		V
Enable input (pin 2)	Input voltage	For logic 1 (high) level For logic 0 (low) level	2	 1	V V
	Max input voltage			20	V
	Input current	For input of 0V For input of 2·4–20V		−150 1	µA µA

Fig. 3 shows a simple example of a circuit using the enable facility for optimising battery usage. A potential divider formed by VR1 and R2 controls the voltage fed to the enable pin. Once the battery discharges to below a certain voltage the main output regulator is disabled. Hence, most of the circuitry is turned off and the power consumption falls. The aux output can then feed warning circuitry, critical areas of the main circuit, etc. R3 adds hysteresis to the system, without which the increase in battery voltage when the load is suddenly turned off could cause the regulator to oscillate. The aux output will continue to supply power, of course, until the battery voltage drops to approximately 6·8V.

Many applications of the LT 1005CT will fall broadly into the category shown in Fig. 4. A small block of circuitry is powered from the aux output, and this circuitry is used to control the enable input to the i.c., amongst other

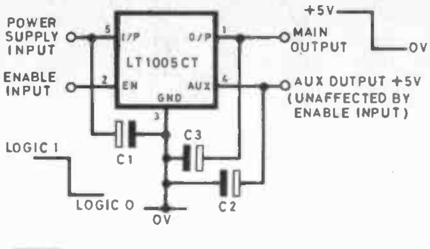

Fig. 2. Functional diagram of i.c.

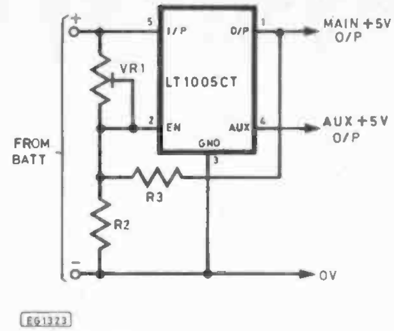

Fig. 3. 'Battery saver' circuit

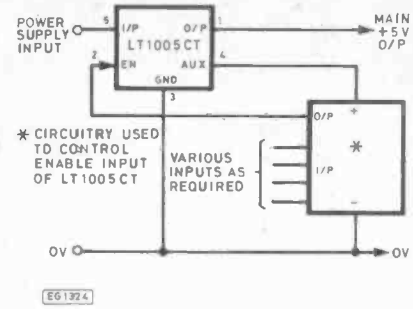

Fig. 4. Using both the 'Enable' and 'Aux' facilities

things. This is exactly the arrangement used in this month's applications circuit. (Note that bypass capacitors C1, C2, and C3 have been omitted for clarity in Figs. 3 and 4; in practice, they are still necessary).

APPLICATIONS CIRCUIT

Fig. 5 shows the circuit diagram of a power supply regulator with automatic shut-down and start-up facilities. The system responds to a short on its main output by shutting down that output, eliminating the large short circuit currents which would otherwise flow for the duration of the short. The circuit tries to turn the regulator on again for brief periods every few seconds. If it fails after seven attempts it then stops trying, and sounds a warning tone. All the circuitry is powered from the aux supply, making it independent of any shorts or other faults in the main system.

When a short occurs, IC4d pin 11 goes to logic 1, which causes IC5a pin 3 to go to logic 0. This then causes IC5b pin 4 to go to logic 1, starting IC2 oscillating at a very low frequency. When IC5a pin 3 goes to logic 0, it also turns off the enable input to IC1, via IC5c and IC5d. The oscillator, IC2, gives out a very short pulse every three seconds, the wide mark/space ratio being achieved by the use of D2 in an otherwise standard '555' circuit. The output pulses from IC2 enable IC1 (via IC5c and IC5d) for short periods, and also clock the decade counter IC3. If the short circuit across the main output of IC1 is removed, the next pulse from IC2 will cause the main output of IC1 to go to +5V. This will produce a pulse through C4 which in turn will reset IC3 via IC4c. IC2 will be disabled via IC5b, preventing further pulses from being generated. If, however, the short remains, IC3 will count up until pin 11 goes to logic 1, at which point it will turn on the audio frequency oscillator formed by IC4b, which drives a small piezo ceramic sounder in a simple bridge configuration with IC4a. This warning tone is turned off by removing the short circuit then connecting the 'reset' pins together with a suitable switch. The main output can be turned off permanently by connecting the two 'disable' pins together, again via a suitable switch. D3 is lit by TR1 whenever a pulse is put out by IC2, showing that the circuit is actually 'trying' to turn on the main supply again.

ASSEMBLY

The Veroboard layout for the circuit is shown in Fig. 6, and is largely self-explanatory. Allow plenty of space for a suitable heatsink for IC1, as large currents can be passed during perfectly normal operation of the main circuitry. Many small piezo ceramic sounders will suffice for producing the warning tone, although their mounting arrangements may vary; do ensure, though, that the sounder chosen only requires a current of a few milliamps at the most; i.e. it is compatible

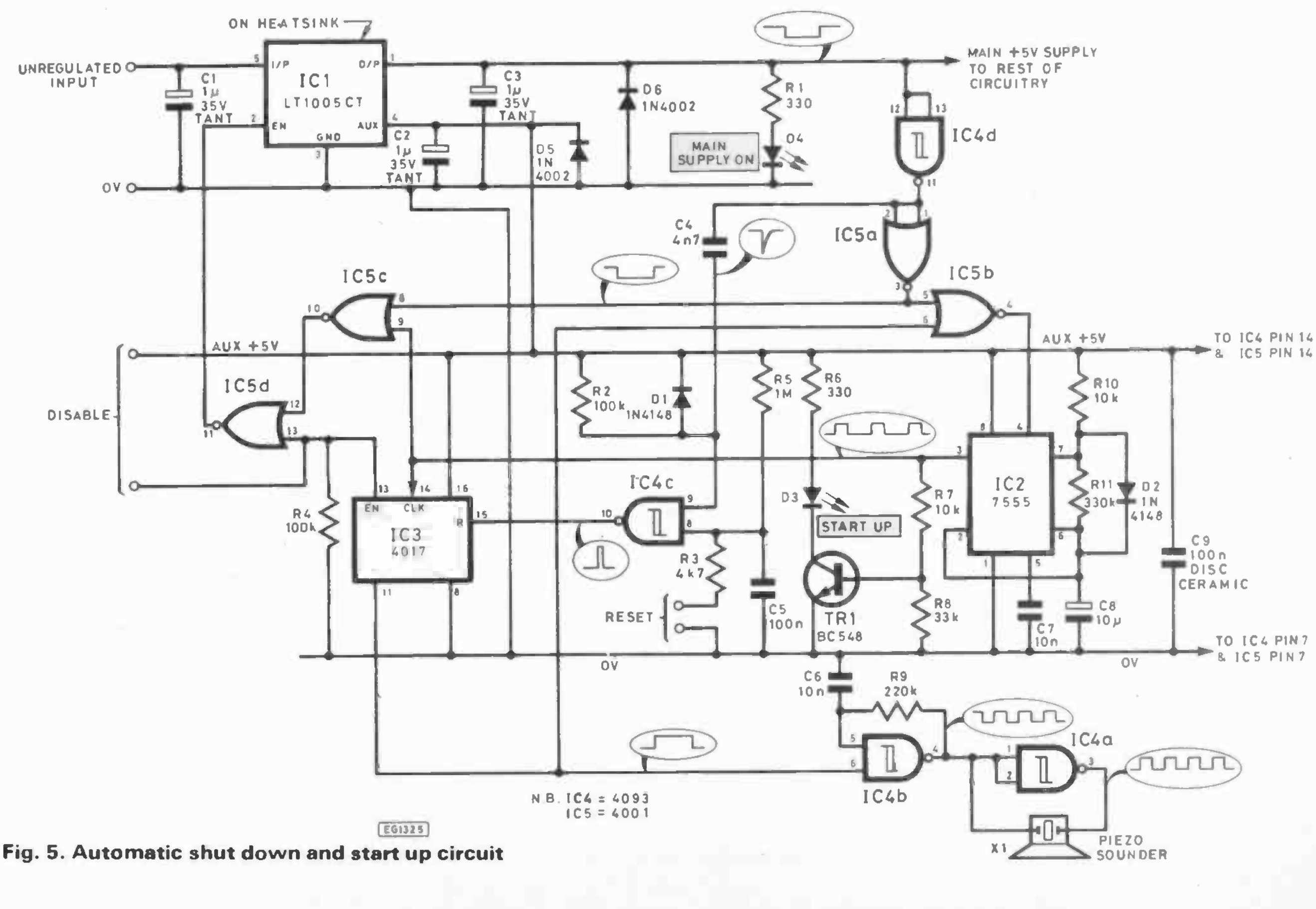

Fig. 5. Automatic shut down and start up circuit

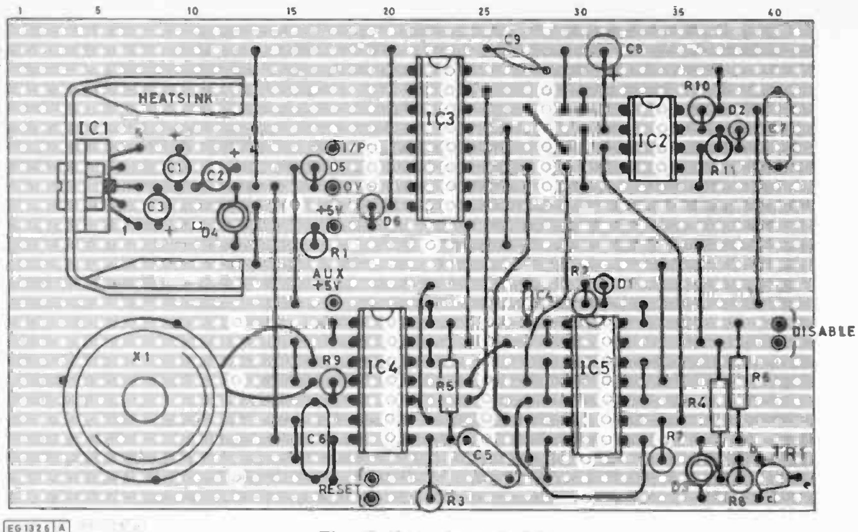

Fig. 6. Board assembly

with CMOS logic. C9 provides some supply decoupling, and D5 and D6 help to protect against short circuits to any negative voltages. The positive unregulated supply can be any voltage from approximately 7·5 to 20V, although it should be ensured that this range is not exceeded for either on-load or off-load conditions. Generally speaking, it is wisest to keep the unregulated supply down to 8 or 9V on load, to prevent excessive power dissipation. Change R11, and possibly C8, to vary the speed at which the circuit tries to 'start up' the main regulator, and take IC4 pin 6 and IC5 pin 6 to other output pins of IC3 to give different numbers of attempts before the alarm is sounded.

The LT 1005CT is a beautifully simple and effective i.c., the type of device that prompts one into wondering why nobody had thought of it before! It is available from **Ace Mailtronix Ltd, 3A, Commercial St., Batley,** West Yorkshire.

BAZAAR

VIC 20 16 Ram Pack. Brand new. £25. M. Johanson, 'Treetops', London Road, Kelvedon, Colchester, Essex CO5 9AR. Tel: Kelvedon 71296.

OPTISCAN SBE 125M 12/240V AM/FM Scanning Receiver, Dalwa Search 9 12V—YE E FM Manual Tune +10xtal switchable marine bands. I. M. Tasker, Colsterworth Road, Stainby, Nr Grantham. Tel: 0476 860421.

PRINTERS, Creed Envoy and ITT3320 excellent condition. £50 each. Powertran Lindsey-Hood 75+75W. Amplifier needs attention, offers. Mr. S. D. Holden, 1 Bacons Yard, Ashwell, Herts. SG7 5NH. Tel: 046274 2000.

WANTED any old computers for voluntary emergency service, also old oscilloscope to align our equipment. I. Bugden (Director MUM), 2 Morden Court, John Street, Rochester, Kent ME1 1YR.

UK101 40K Ram, 4/8000 baud cassette interface fitted but faulty, also slight video fault. £220 o.n.o. Mr. S. Nicholls, 18 Warwick Terrace, St. George's Road, Barnstaple, Devon EX32 7AR.

WALTERS "Datec" Dot matrix printer Centronics or serial interface £175. "Sharp" I/O box + serial I/O card £100. Painted alloy tins 54 x 44 x 7mm, 50 for £5 post free. Suitable res, caps or small transistor storage. Sample tin 25p, and s.a.e. Pearce, 8 Hollyoak Road, Southampton SO1 6GD. Tel: 788278.

TELETYPE including tape punch, reader, stand, dust cover 20mA. All manuals £40. Buyer collects. C. Marshall, 9 Mountfield Road, Witney, Oxon. Tel: 4867.

ELECTRONIC dwell angle (points) adapter for spot on ignition timing, new, with instructions, connectors, etc. £3.95. Duncan Head, 113 Raleigh Crescent, Stevenage, Herts. Tel: 0438 62179.

HITACHI de-55 Cassette Deck. Soft touch computer mechanism, Dolby, CRO2, metal facilities. 24 l.e.d. level indicator £65. Nicholas Brasier, Trilleck, Cliff Road, North Petherton, Bridgwater, Somerset TA6 6PA.

SINCLAIR ZX81 all complete. Unused (Sinclair built). Also 16K Ram. Offers. Mr. P. J. Green, Harbour Cottage, Whitehills, Banff. Tel: (02617) 566.

FOUR KT88 Five EL34 Two E.M.I. 10667M 1 inch Vidicon tubes. Unused. Offers. Early transistors s.a.e. details R. Atkinson, 7 St. Helen's Lane, Corbridge, Northumberland.

OSCILLOSCOPE Scopex. Dual trace 10MHz £165. Regulated p.s.u. 0–30V 0–1 amp £23. R.F. Generator 100kHz–500MHz £27. C. P. Dunlop, 11 Buckingham Gardens, Hurst Park, East Molesey, Surrey KT8 9TH. Tel: 01 979 9102.

MK14 and MK 14 p.c.b. INS8060 3 x 2708 EPROM x Nascom operating system. Offers. M. Gynane, 164 Stockbridge Lane, Liverpool L36 8EH. Tel: 051 449 2044.

CLEF Microsynth perfect £175. Pair OHM 100W Speakers new £150. Pair 2 x 12 180W suit disco £200. Allan Bradford, 76 Holly Lane, Erdington, Birmingham 824 GJR. Tel: 021 373 0461.

VINTAGE radios. McMichael 137, Murphy A8, Ekco AD65, Invicta A29 £15 each. You collect. John Dykes, 2 Aire Place, Winsford, Cheshire CW7 3LW. Tel: (06065) 51303.

CENTRONICS 737-2 printer. Parallel interface. Friction and pin feed. Plus box of paper. £175. Call Chang 041 332 7695 after 9pm. K. Y. Chang, 70, 1-UP Ashley Street, Glasgow G3 6HW.

200 transistors, equivalents to popular types—s.a.e. Accurate miniature multimeter, large ranges, leads, good condition £90. A. R. Cooper, Broomside, Loggerheads, M K T. Drayton, Salop IF9 4NZ. Tel: Ashley 2634.

FOR UK101 48 x 32CEGMON. Assembler 3 x 2716. Word Processor. New Basic 4 Toolkit. Medium res chip £10 each. Tel: 0642 484122.

BIG board Complete with twin 8 inch disk drives, power supplies, cased, runs CP/M wordstar etc. £600 o.n.o. Stuart Higgins, 138 Lower Farnham Road, Aldershot, Hants. Tel: Aldershot 28796.

WANTED circuit details or info. 220 a.c. razor to run off 12V d.c. will pay or what. G. T. Weston, "Lunar Hilladora", M.G. 39 Javea (Alicante), Spain.

WANTED PE Ranger CB transceiver. Any condition, unfinished kit or non-working etc. Tel: Nottingham 599250. J. Eite, 28 Windmill Lane, Snienton, Nottingham.

SCOPE Heathkit laboratory type working £15, AVO 8 MKV as new £80. Ring 01 594 4126.

CROTECH 3030 15MHz single trace triggered scope £85. Taylor, 34 Durban Road, Kettering, Northants NN16 0JA.

TV to oscilloscope converter, plugs into aerial socket, working £9. Dave, 0925 815970 (Warrington). D. Coleman, 137 Berkshire Drive, Woolston, Warrington WA1 4HB.

ATOM (expanded) £85. BBC board £30. Rack frame inc. sockets £30. Postage extra. Harris (0283) 42558. N. F. Harris, 4 Field Rise, Burton-on-Trent DE13 0HR.

ZX81 + 16K with 11 software tapes including ZX Chess II and set of quizzes. Tel: 01 361 0930. Mr. A. Dervish, 68 Friars Walk, Southgate, London N14 5LN.

7106 + 3½ l.c.d. £8.50. 7126 + 3½ l.c.d. £9.25. 47n/100V x 28 £7.40 or 30p each. BD131 x 12. £3.00. P. Whittle, 2 Ridley Road, London NW10 5UA. Tel: 01 961 6658.

SWR/ Power meter; 10 watt power amplifier; 100W antenna matcher; All 27MHz; All as new; All for £35. Flat 32, Evergreens, Butterwick, Boston, Lincs. PE22 0HF. A. Petrovic.

CASES, i.c.s, components, key locks, alarms books, displays, etc. List large s.a.e. No callers please. G. A. Noble, 50 Crofthill Road, Slough, Berks. SL2 1HF.

PAIR JBL L100 Stereo speakers. Walnut cabinets un-used. In storage 2 years. Cost £575. Accept £175. Write Raymond Fearnley, 29 Plane Court, Churchill Way, Salford M6, Lancs.

OLIVETTI PR 1350 dot matrix printer. Complete with service and reference manuals. £130 o.n.o. or swop. Twin beam oscilloscope.

VOLTAGE stabiliser for sale. Excellent condition. Never been used. £25 each (three to sell). Ring 061 736 5843 ext. 7256. G. R. Smart, 114 Pear Tree Court, Salford, Manchester M6 5AX.

HITACHI HMA 7500 stereo power amplifier. Excellent condition £140 o.v.n.o. Tel: 0404 3013. P. Lowman, 4 Glen View, Honiton, Devon EX14 8NT.

RELIABLE circuit diagram wanted for 78·1MHz Portable transceiver. Project for local A.T.C. cadets (amplitude modulated). R. K. Rees, 16 Eskdale Road, Telford Estate, Shrewsbury, Salop SY2 5UE. Tel: Shrewsbury 59340.

WANTED user instructions for Metrix 232 Wobuloscope also working rotactor for same unit. M. J. Parier, 18 Partridge Way, High Wycombe, Bucks HP13 5JX.

ZX81 wanted. Must be in good condition. Swap for 30 pounds of electronic components. Steven McNeil, 35 Sutors Avenue, Nairn IV12 5AZ.

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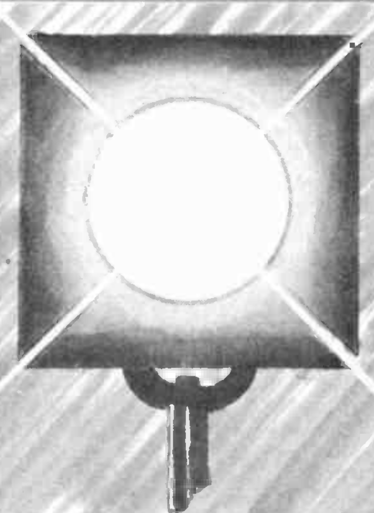

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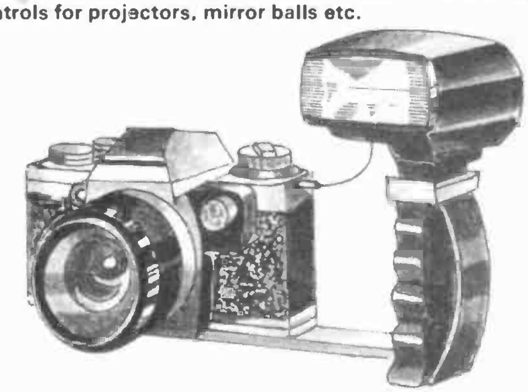

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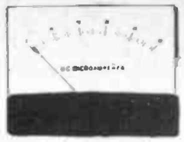

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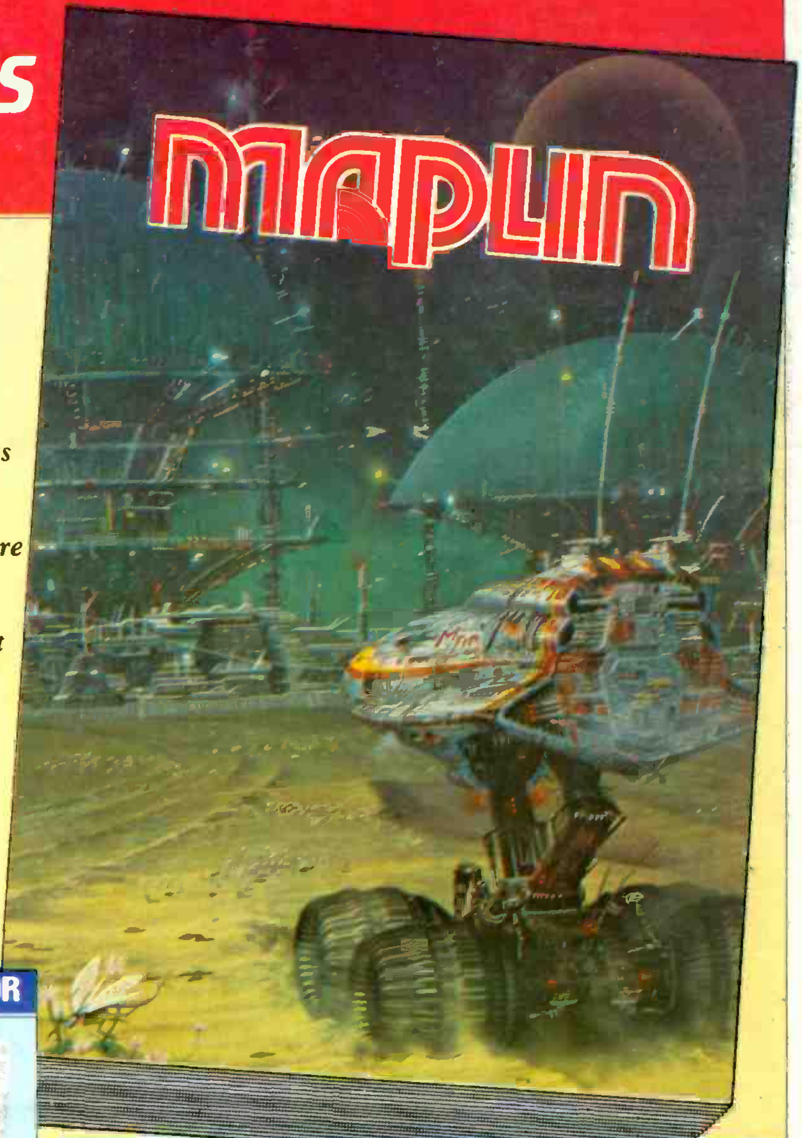

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