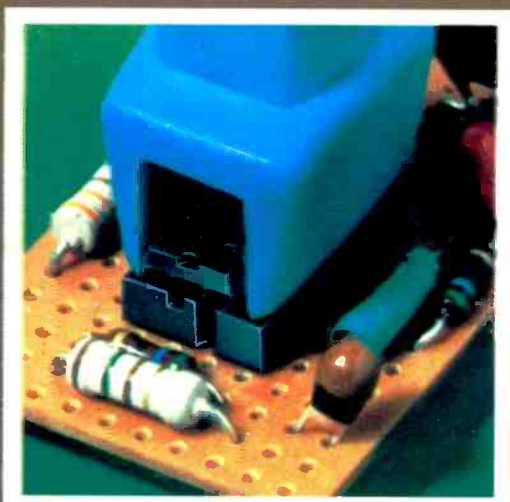
Austrelia $1.50 Malaysia $4.95 IR £1.26 (inc. VAT)

PRACTICAL ELECTRONICS

MAY 1983

85p



New Feature SEMICONDUCTOR CIRCUITS ... USING CHIPS

PROJECTS • AUTOMOBILE TEST SET • PERSONAL STEREO AMPLIFIER • MAINS WATCHDOG • COMPUTING ZEAKER MICRO-ROBOT • ULTIMUM MICROPROMPT • NEWS & FEATURES • SPACEWATCH MICROFILE • PATENTS REVIEW • INDUSTRY NOTEBOOK

EXTRA! – EDITORIAL PAGES – EXTRA!

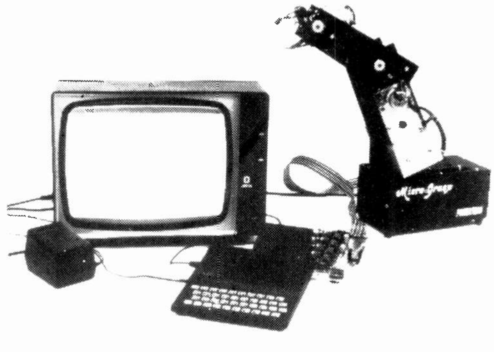
Get moving with these new developments in UK Robotics

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

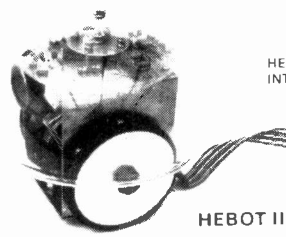
[illegible]

Robotic experience ... MICROGRASP provides the lowest cost means of acquiring that experience but despite its ultra low price the robot has considerable versatility. There are ... axes ... Control is by any computer with ... the ZX81 being particularly suitable ... operates under BASIC ... [illegible]

MICROGRASP [illegible]	£145.00
[illegible]	£48.50
[illegible]	£2.50
ZX81 [illegible] RAM [illegible]	£3.00

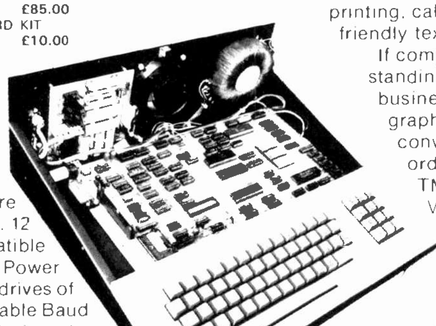


MICROGRASP, INTERFACE BOARD AND ZX81



HEBOT KIT £85.00
INTERFACE BOARD KIT £10.00

HEBOT II



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

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

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

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

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

[illegible] READY BUILT	£1950.00
[illegible] CORTEX [illegible] KIT £295.00 READY BUILT	£395.00

[illegible] CORTEX

Example prices and specifications

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

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

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

6 axis model in kit form	£675

Complete Systems as shown in Photograph on right

Genesis S101

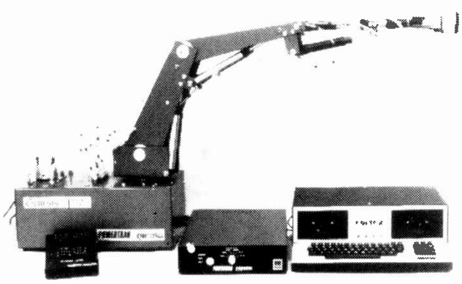
4 axis system in kit form	£681.50
5 axis system in kit form	£737.50
5 axis system Ready Built	£1450

Genesis P101

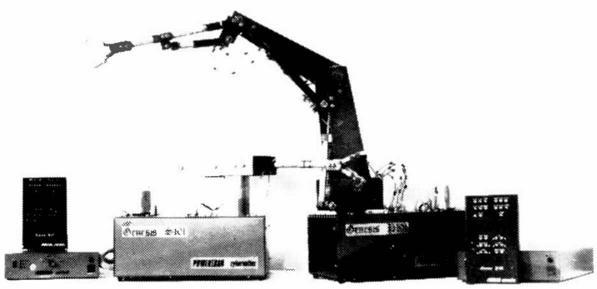
6 axis system in kit form	£945.00
6 axis system Ready Built	£1650

All prices exclusive of VAT

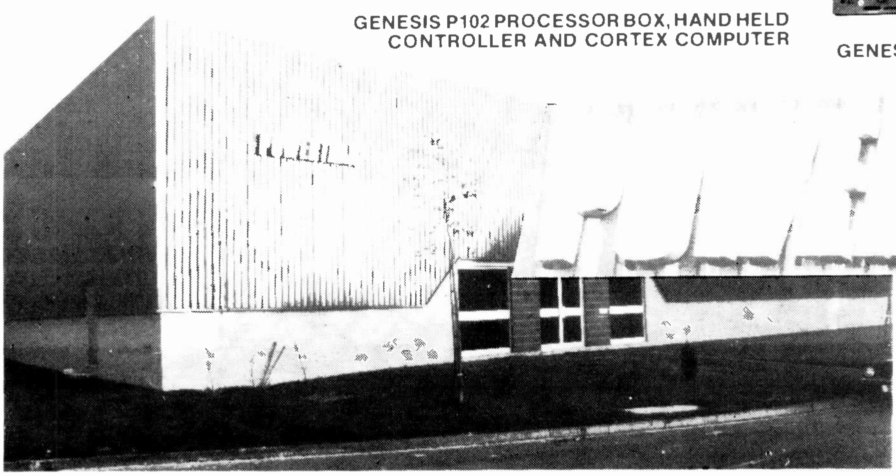
With prices starting below £1000 the Genesis range of general purpose robots provide a first rate introduction to robotics for both education and industry. Each has a self-contained hydraulic power source which enables loads of several pounds to be smoothly handled. The system operated from a single phase 240 or 120V AC supply or a 12V DC supply. The machine can be supplied with up to 6 axes each of which is fully independent but capable of simultaneous operation. Position control is achieved by means of a closed loop feedback system based around a dedicated microprocessor. Movement sequences can be entered, stored and replayed by use of a hand held controller, alternatively the systems can also be interfaced to an external computer via a standard RS232C link.



GENESIS P102 PROCESSOR BOX, HAND HELD CONTROLLER AND CORTEX COMPUTER



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



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PORTWAY INDUSTRIAL ESTATE
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WILTS SP5 1BP (0264) 781545
TELEX: 477407 ZENMON

PRACTICAL
ELECTRONICS
VOLUME 19 No. 5 MAY 1983

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

We regret that due to circumstances beyond our control we are unable to publish Micro-file this month

OUR JUNE ISSUE WILL BE ON SALE FRIDAY, MAY 6th, 1983
(for details of contents see page 31)

WATFORD ELECTRONICS

33, CARDIFF ROAD, WATFORD, HERTS WD1 8ED, ENGLAND
Tel. Watford (0923) 40588. Telex: 8956095 WAELEC

ALL DEVICES BRAND NEW. FULL SPEC. AND FULLY GUARANTEED. ORDERS DESPATCHED BY RETURN OF POST. TERMS OF BUSINESS: CASH/CHEQUE/P.O.s OR BANKERS DRAFT WITH ORDER. GOVERNMENT AND EDUCATIONAL INSTITUTIONS OFFICIAL ORDERS ACCEPTED (ACCESS ORDERS BY TEL. PHONE 0923-50234). TRADE AND EXPORT INQUIRY WELCOME. P & P ADD 50p TO ALL CASH ORDERS. OVERSEAS POSTAGE AT COST.

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

POLYESTER CAPACITORS: (Axial Lead) 400V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8 **11p**; 10n, 15n, 18n, 22n **12p**; 33n, 47n, 68n **16p**; 100n, 150n **20p**; 220n **30p**; 330n **42p**; 470n **52p**; 680n **60p**; 1µF **68p**; 2µ2, 4µ7 **85p**. **1000V**: 1nF **17p**; 10nF **30p**; 15n **40p**; 22n **36p**; 33n **42p**; 47n, 100n **50p**.

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 **48p**; 2200 **90p**; **25V**: **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 **30p**; 33, 47 **40p**; 100 **75p**; 220 **88p**; **10V**: 15, 22 **26p**; 33, 47 **35p**; 100 **55p**.

POTENTIOMETERS: Carbon Track, 0.25W Log & Linear Values.

500Ω, 1K & 2K (LIN ONLY) Single	30p
5KΩ-2MΩ single gang	30p
5KΩ-2MΩ single gang D/P switch	78p
5KΩ-2MΩ dual gang stereo	88p

SLIDER POTENTIOMETERS
0.25W log and linear values 60mm track

5KΩ-500KΩ Single gang	70p
10KΩ-500KΩ Dual gang	110p

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 each**
220, 250, 270, 330, 360, 390, 470, 600, 800 & 820pF **21p each**
1000, 1200, 1800 **30p each**
3300, 4700 **60p each**

SIEMENS mulitlayer miniature capacitors
250V: 1nF, 1n5, 2n2, 3n3, 4n7, 6n8, 8n2, 10n, 15n, 22n **7p**; 18n, 27n, 33n, 47n **8p**; 39n, 56n, 68n **9p**.
100V: 100n, 120n, **10p**; 150n **11p**; 220n **13p**; 330n **18p**; 470n **23p**; 680n **30p**; 1µF **34p**; 2µ2 **50p**.

PRESET POTENTIOMETERS

0.1W 50Ω-2.2M Mini Vert. & Horiz.	7p
0.25W 100Ω-3.3MΩ Horiz. larger	10p
0.25W 250Ω-4.7MΩ Vert.	10p

RESISTORS
Hi-stab, Miniature, 5%, Carbon.

	RANGE	Val.	1-99	100+
0.25W	2Ω2-4.M7	E24	2p	1p
0.5W	2Ω2-4.M7	E12	2p	1p
1W	2Ω2-10M	E12	6p	4p
2% Metal Film 10Ω-1M			6p	4p
1% Metal Film 51Ω-1M			8p	6p

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

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

AC125/6	35	BC214L	10	BFY64	35	TIP34C	88	2N1613	30	2SC1061	250
AC127/8	35	BC237/8	14	BFY81	120	TIP35A	110	2N1671B	160	2SC1096	85
AC141/2	30	BC307B	14	BFY90	80	TIP35C	128	2N2160	295	2SC1162	30
AC176	28	BC308B	16	BRY39	40	TIP36A	130	2N2219A/20A/		2SC1172	125
AC187/8	32	BC327/8	15	BSX20	20	TIP36C	140	21A/22A	25	2SC1173	125
ACY17/18	70	BC337/8	15	BSX29	34	TIP41A	50	2N2369A	18	2SC1306	100
ACY19/20	75	BC441	34	BU105	170	TIP41B	52	2N2646	45	2SC1307	150
ACY21/22	75	BC461	34	BU205	190	TIP42A	55	2N2846	80	2SC1449	85
AD142	120	BC477/8	40	BU206	200	TIP42B	58	2N2904A/05A/		2SC1679	190
AD149	79	BC516/7	40	BU208	200	TIP120	70	06A/07A	26	2SC1678	140
AD161/2	42	BC547/8	12	MD8001	250	TIP121	73	2N2926G	10	2SC1923	50
AF118	95	BC549C	14	MJ2955	70	TIP141	105	2N3053	26	2SC1945	225
AF139	40	BC556/7	15	MJE340	54	TIP142	105	2N3054	58	2SC1953	90
AF239	55	BC558/9	15	MJE370	100	TIP147	120	2N3055	48	2SC1957	90
BC107/8	10	BCY70	16	MJE371	100	TIP2955	60	2N3442	140	2SC1969	140
BC107B	12	BCY71/2	20	MJE520	95	TIP3055	60	2N3614	199	2SC2028	85
BC108B	12	BD124	115	MJE2955	99	TIS43	32	2N3615	199	2SC2029	200
BC108C	12	BD131/2	48	MJE3055	70	TIS44	45	2N3702/3	10	2SC2078	170
BC109	10	BD133	60	MPF102	40	TIS88A	50	2N3704/5	10	2SC2091	85
BC109B	12	BD135	45	MPF103/4	30	TIS90	30	2N3706/7	10	2SC2166	165
BC109C	12	BD136/7	40	MPF105	30	TIS91/93	32	2N3708/9	10	2SC2314	85
BC117/8	20	BD138/9	40	MPF106	40	VK1010	80	2N3710	10	2SC2465	125
BC140/42	30	BD140	40	MPSA05	25	VN10KM	55	2N3771	179	2SC2547	30
BC147/8	9	BD245	45	MPSA06	25	VN46AF	78	2N3772	195	2SD234	75
BC147B	10	BD378	70	MPSA12	32	VN66AF	80	2N3773	210	2SK45	90
BC148C	10	BD695A	125	MPSA55	30	VN88AF	94	2N3819	22	2SK288	225
BC149	9	BD696A	125	MPSA56	30	VN89AF	96	2N3820	38	2SJ83	225
BC149C	12	BF180	38	MPSA70	30	ZTX107/8	11	2N3822/3	45	2SJ85	225
BC153/4	27	BF194/5	12	MPSU02	58	ZTX109	12	2N3866	90	3N128	112
BC157/8	10	BF198/9	18	MPSU05	55	ZTX212	28	2N3903/4	15	3N140	112
BC159	11	BF200	30	MPSU06	55	ZTX300	13	2N3906/5	15	40097	120
BC167A	10	BF224	25	MPSU52	65	ZTX301/2	16	2N4069	45	40100	215
BC168C	10	BF244A	28	MPSU55	60	ZTX303	25	2N4427	80	40101	130
BC169C	10	BF244B	29	MPSU56	60	ZTX304	17	2N4859	78	40250	95
BC170	16	BF256B	35	OC23	170	ZTX320/26	30	2N4871	55	40251	150
BC171/2	11	BF257/8	32	OC28/36	220	ZTX451	23	2N5135/6	20	40311	60
BC173	11	BF259	35	OC41/42	75	ZTX500/1	14	2N5172	18	40313	130
BC177/8	16	BF336	40	OC44	75	ZTX502/3	18	2N5179	45	40315	90
BC179/81	20	BF594/5	30	OC70	40	ZTX504	25	2N5180	45	40316	95
BC182/3	10	BFR39/40	23	OC76	50	ZTX531	25	2N5191	75	40317/20	80
BC184	10	BFR41/79	23	OC81/82	50	ZTX550	25	2N5194	80	40360	60
BC182L	10	BFR80/81	25	OC83/84	40	2N696	30	2N5305	24	40361/62	70
BC183L	10	BFR98	105	TIP29A	32	2N697	23	2N5457	30	40406/7	75
BC184L	10	BFX29/84	28	TIP29C	38	2N698	40	2N5458/9	30	40408	75
BC186/7	26	BFX85/86	28	TIP30A	35	2N699	48	2N5485	36	40411	285
BC212/3	10	BFX87/88	28	TIP30C	37	2N706A	19	2N5777	45	40412	90
BC212L	10	BFY50/51	23	TIP31A	38	2N708	19	2N6027	32	40467	130
BC213L	10	BFY52	23	TIP31C	37	2N914/5	32	2N6109	60	40468	85
BC214	10	BFY56	32	TIP32A	38	2N918	35	2N6290	70	40594	105
				TIP32C	42	2N930	20	2SA636	250	40595	110
				TIP33A	65	2N1131/2	24	2SA671	250	40603	110
				TIP33C	78	2N1303/4/5		2SA715	60	40673	70
				TIP34A	74	2N1307/8	65	2SC495/6	70	40871/2	90

LINEAR IC's

555 CMOS	80	LM311	55	SAB3271	485
702	75	LM318	150	SAB4209	595
709C 8 pin	35	LM319	195	SG3402	295
710	48	LM324	65	SL490	350
741	14	LM334Z	90	SL6270	150
747C 14 pin	65	LM335	128	SN76013N	350
748C 8 pin	36	LM339	47	SN76023N	350
753 8 pin	185	LM348	64	SN76033	350
810	159	LM349	115	SN76477	420
8037CJ	850	LM358	60	SN76488	480
9400CJ	350	LM377	175	SP8629	299
AY-1-1320	225	LM379	480	TA7120	125
AY-1-5050	99	LM380	75	TA7130	125
AY-1-5051	160	LM381N	145	TA7204	195
AY-1-6720	210	LM382	115	TA7205	175
AY-3-1270	675	LM384	160	TA7222	150
AY-3-8910	420	LM386	90	TAA900	395
AY-3-8912	450	LM387	120	TAB1042	110
AY-5-1230	450	LM389	95	TAD100	159
AY-5-1317A	630	LM392	60	TBA120S	70
CA3011	130	LM393	45	TBA540	275
CA3012	175	LM394CH	290	TBA550Q	330
CA3014	275	LM725CN	325	TBA641	290
CA3018	86	LM733	70	TBA651	190
CA3019	80	LM2917	195	TBA800	80
CA3020	210	LM3302	75	TBA810S	95
CA3023	210	LM3900	50	TBA820	80
CA3028A	95	LM3909	85	TBA920Q	200
CA3035	255	LM3911	125	TBA990	350
CA3036	270	LM3914	200	TCA270	350
CA3043	275	LM3915	200	TCA280A	220
CA3045	365	LM3916	250	TCA940	175
CA3046	70	LM13600	110	TCA965	145
CA3048	225	LS7220	280	TDA1004	290
CA3059	285	M51513L	230	TDA1008	310
CA3075	213	M51515L	320	TDA1010	198
CA3080E	70	M706B1	125	TDA1022	499
CA3081	190	MB3712	220	TDA1024	115
CA3086	48	MB3756	440	TDA1034	350
CA3089E	200	MC1303	98	TDA1490	350
CA3090AQ	375	MC1304P	260	TDA2002	325
CA3123	165	MC1310P	150	TDA2003	198
CA3130	90	MC1445	250	TDA2004	495
CA3140	40	MC1455	50	TDA2006	330
CA3160	95	MC1458	35	TDA2020	320
CA3161E	160	MC1469	300	TDA2030	295
CA3162E	450	MC1494	694	TDB0791	420
CA3189	200	MC1495	350	TL061CP	40
CA3240	110	MC1496L	70	TL062CP	60
HA1366	175	MC1596	225	TL064CN	98
HA1388	255	MC1648	290	TL071CP	24
ICL7106	690	MC1709G	90	TL072CP	45
ICL7107	975	MC3302	90	TL074CN	100
ICL7204	550	MC3340P	120	TL081CP	24
ICL7611	99	MC3360P	120	TL082CP	45
ICL7660	248	MC3401	65	TL083CP	75
ICL8038CC	300	MC3403	75	TL084CP	90
ICL8211	350	MC3405	150	TL091CP	55
ICM7204	550	MC3423P	80	TL170	50
ICM7205	1150	MF10	350	TL430C	90
ICM7207	475	MFC6040	75	TL507	110
ICM7215	1050	MK50398	635	UA2240	100
ICM7216A	£22	ML924	275	UA78540	230
ICM7217A	750	MSM5526	820	UAA170	180
ICM7224	785	NE515	275	UAA180	180
ICM7240	300	NE529	225	UAA1003-3	935
ICM7555	80	NE531	140	UGN3020T	160
ICM7556	150	NE543	225	ULN2001	80
LA3350	220	NE544	210	ULN2003	75
LA4031P	240	NE555	16	ULN2004	75
LA4032	295	NE556DB	45	ULN2068	290
LA4400	295	NE558	140	ULN2802	200
LA4422	275	NE560	325	ULN2804	150
LC7120	350	NE561	395	ULN2283	100
LC7130	340	NE562B	410	UPC575	165
LC7137	395	NE564	420	UPC1025H	265
LF347	150	NE565A	120	UPC1032	95
LF351	48	NE566	155	UPC1182	270
LF353	95	NE567	140	UPC1156H	225
LF355	85	NE570	410	UPC1366	195
LF356	95	NE571	400	XR2206	300
LF357	110	NE5532	145	XR2207	375
LF398	475	NE5534	105	XR2211	575
LM10	325	OM335	750	XR2216	675
LM301A	24	RC4136D	60	XR2266	360
LM307	45	RC4558	45	ZN414	80
LM308	95	S566B	225	ZN419CE	180
		SAB3209	425	ZN423E	130
		SAB3210	325	ZN424E	130

ZN425E-8	345	8251A	250
ZN426E-8	300	8253	400
ZN427E-8	590	8255	225
ZN428E	410	8256A	£35
ZN429E-8	210	8257A	400
ZN459	325	8259	395
ZN1034E	200	8271	£28
ZN1040E	665	8279	385
ZNA234E	850	8282	450

COMPUTER IC's

		8283	450
		8284	350
		8285	365
		8287	£17
		8288	£10
1702	350	8T26A	99
1802CP	650	8T27	150
2114L-200n	95	8T28A	120
2147-3	425	8T31	350
2532-3	300	8T95N	90
2564	£6	8T97N	90
2708	225	9364AP	550
2716 5V	225	9602	220
2732	350	AM26LS31C	125
2764	575	AM26LS32A	125
3242	590	AM26LS33A	125
4116-150	85	AY-3-1015	300
4116-200	80	AY-5-1013	300
4118-250	325	AY-5-1350	388
4164-200	425	AY-5-2376	600
4532-3	350	AY-5-3600	750
4816-100ns	215	COM8017	275
5101	220	COM8116	700
6116-150ns	350	DM8131	275
6116L-120ns	550	DP8304BN	250
6117-100n	490	DS3691N	320
6167-6	795	DS8820	110
6502 CPU	325	DS8830	110
6503	600	DS8831	125
6504-250	550	DS8832	250
6520	100	DS88LS120N	275
6522 VIA	295	E9365	£38
6530 RRIOT	£11	E9366	£35
6532 RIOT	570	FD1761	£15
6545 CRTC	899	FD1771	£15
6551 ACIA	650	FD1791	£22
6592 PC	£20	FD1793	£23
68B54	780	FD1795	£28
6800	220	FD1797	£28
6802	250	HD26501	75
6803	850	HMG167-6	795
6804	160	IM6402	380
6805	670	INS8060N	1050
6808	520	INS8154N	£9
6809	630	MC1488	55
6810	115	MC1489	55
6820	100	MC14411	675
68821	220	MC14412	725
6821	100	MC3446	250
6840	375	MC3447P	315
6843	00	MC3486	175
6845	650	MC3487	175
6847	650	MK3886-2M	£7
6850	110	MM5280D	695
6852	250	MM5303	635
6854	599	MM5307	1275
6875	500	MM5387A	475
68000	£78	MM58174	700
74922 New msk	400	RO-3-2513L	650
8080A	250	RO-3-2513U	600
8085A	350	SFF96364E	800
8088	£18	SP0256AL2	£18
81LS95	80	TMS2716-3	725
81LS96	80	TMS6011	365
81LS97	80	TMS4164-15	475
81LS98	85	TMS4416-2	475
8118-10	225	TMS4532-3	350
8123	125	TMS9927	£14
8155	350	TMS9928	£20
8156	350	TMS9929	£16
8202	£25	TMS5100	£10
8205	225	TMS6011	365
8212	110	TMS4164-15	475
8214	425	ULN2003	75
8216	100	UPD7002	425
8224	110	Z80CPU 2.5	299
8226	250	Z80ACPU4M	300
8228	220	Z80CTC	250
8243	270	Z80ACTC	260
8250	850	Z80B	875

Z80DART	495
Z80ADART	550
Z80ADMA	895
Z80DMA	675
Z80P10	260
Z80AP10	275
Z80S10-1	850
Z80AS10	900

74S Series

74S00	24
74S02	24
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	90
74S124	300
74S132	110
74S133	60
74S138	115
74S139	115
74S140	60
74S151	180
74S153	182
74S157	250
74S158	195
74S163	300
74S174	250
74S175	320
74S188	140
74S189	140
74S194	320
74S195	480
74S197	400
74S201	350
74S225	500
74S240	300
74S241	300
74S244	290
74S251	250
745257	250
745258	250
74S260	70
74S262	850
74S287	225
74S288	150
74S289	290
74S299	540
74S301	000
74S365	000
74S373	400
74S374	365
74S470	325
74S471	620
74S472	1150
74S474	400
74S475	800
74S571	620
74S573	950

75 Series

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

TTL 74

7400	11	74142	175
7401	11	74143	210
7402	11	74144	210
7403	12	74145	50
7404	13	74147	75
74L04	85	74148	60
7405	15	74150	50
7406	20	74151	40
7407	20	74153	40
7408	14	74154	55
7409	14	74155	40
7410	14	74156	40
7411	16	74157	30
7412	18	74159	80
7413	18	74160	60
7414	20	74161	48
7416	20	74162	40
7417	20	74163	40
7420	15	74164	40
7421	20	74165	48
7422	20	74166	48
7423	20	74167	150
7425	18	74170	125
7426	18	74172	250
7427	18	74173	60
7428	25	74174	54
7430	14	74175	19
7432	20	74176	40
7433	22	74177	45
7437	25	74178	80
7438	22	74179	80
7440	15	74180	40
7441	55	74181	115
7442	32	74182	60
7443	90	74184	90
7444	90	74185	95
7445	55	74186	470
7446	60	74188	250
7447	35	74190	48
7448	40	74191	46
7450	16	74192	46
7451	16	74193	45
7453	16	74194	40
7454	16	74195	40
7460	16	74196	46
7470	30	74197	40
7472	24	74198	80
7473	24	74199	84
7474	20	74221	54
7475	25	74246	120
7476	25	74247	120
7480	40	74248	120
7481	120	74249	120
7482	65	74251	65
7483	38	74259	150
7484	70	74265	55
7485	60	74273	150
7486	20	74276	120
7489	170	74278	100
7490	20	74279	50
7491	35	74283	50
7492	25	74284	155
7493	25	74285	155
7494	35	74290	105
7495	35	74293	80
7496	35	74297	236
7497	90	74298	100
74100	80	74351	195
74104	50	74365	30
74105	55	74366	30
74107	20	74367	30
74109	25	74368	30
74110	35	74390	75
74111	55	74393	90
74112	170	74490	95
74116	50		
74118	55		
74119	60		
74120	60		
74121	25		
74122	35		
74123	35		
74125	35		
74126	35		
74128	35		
74132	28		
74136	28		
74141	55		

74C

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

74LS

LS00	11	LS191	36
LS01	11	LS192	36
LS02	11	LS193	37
LS03	12	LS194	33
LS04	12	LS195	33
LS05	12	LS196	45
LS08	12	LS197	45
LS09	12	LS221	55
LS10	12	LS240	55
LS11	12	LS241	55
LS12	12	LS242	55
LS13	15	LS243	55
LS14	26	LS244	50
LS15	12	LS245	70
LS20	12	LS247	50
LS21	12	LS248	55
LS22	12	LS249	55
LS26	12	LS251	32
LS27	12	LS253	32
LS28	14	LS257	30
LS30	12	LS258	35
LS32	13	LS259	55
LS33	14	LS260	22
LS37	14	LS261	100
LS38	15	LS266	18
LS40	13	LS273	54
LS42	28	LS275	125
LS47	35	LS279	30
LS48	45	LS280	90
LS49	50	LS283	40
LS51	14	LS290	53
LS54	14	LS293	40
LS55	14	LS295	75
LS63	120	LS298	80
LS73	18	LS299	150
LS74	18	LS320	200
LS75	20	LS323	160
LS76	18	LS324	168
LS78	18	LS325	295
LS83	36	LS326	240
LS85	42	LS327	240
LS86	16	LS347	95
LS90	24	LS348	90
LS91	60	LS352	62
LS92	32	LS353	62
LS93	23	LS362	750
LS95	40	LS363	140
LS96	95	LS364	140
LS107	40	LS365	28
LS109	23	LS366	32
LS112	22	LS367	28
LS113	16	LS368	35
LS114	22	LS373	60
LS122	36	LS374	55
LS123	38	LS375	50
LS124	90	LS377	85
LS125	24	LS378	80
LS126	25	LS379	110
LS132	35	LS384	395
LS133	30	LS385	250
LS136	24	LS390	46
LS138	25	LS393	42
LS139	28	LS395	95
LS145	70	LS399	150
LS147	100	LS445	100
LS148	70	LS471	620
LS151	40	LS490	200
LS153	40	LS540	100
LS154	80	LS541	80
LS155	30	LS640	180
LS156	36	LS641	180
LS157	27	LS645	180
LS158	30	LS668	125
LS160	32	LS669	120
LS161	37	LS670	100
LS162	37	LS673	550
LS163	37		
LS164	43		
LS165	50		
LS166	52		
LS168	85		
LS170	70		
LS173	55		
LS174	50		
LS175	40		
LS181	90		
LS183	180		
LS190	36		

CMOS

		4013	20	4440	999
		4014	46	4450	350
		4015	40	4451	350
		4016	20	4490	350
		4017	32	4500	675
		4018	45	4501	28
		4019	25	4502	60
		4020	42	4503	35
		4021	40	4504	75
		4022	40	4505	185
		4023	13	4506	35
		4024	32	4507	35
		4025	13	4508	130
		4026	80	4510	46
		4027	20	4511	48
		4028	39	4512	42
		4029	45	4513	199
		4030	15	4514	125
		4031	125	4515	125
		4032	80	4516	65
		4033	125	4517	275
		4034	140	4518	40
		4035	45	4519	30
		4036	275	4520	70
		4037	115	4521	130
		4038	110	4522	125
		4039	290	4526	60
		4040	40	4527	50
		4041	40	4528	50
		4042	40	4529	150
		4043	40	4530	90
		4044	40	4531	130
		4045	105	4532	50
		4046	46	4534	455
		4047	40	4536	275
		4048	40	4538	70
		4049	25	4539	90
		4050	25	4541	140
		4051	45	4543	70
		4052	60	4544	150
		4053	50	4548	40
		4054	85	4549	375
		4055	85	4553	245
		4056	85	4555	35
		4059	435	4556	35
		4060	45	4557	320
		4061	1195	4558	120
		4062	995	4559	395
		4063	85	4560	160
		4066	24	4561	104
		4067	245	4562	495
		4068	14	4566	165
		4069	13	4568	250
		4070	13	4569	175
		4071	13	4572	36
		4072	13	4580	460
		4073	15	4581	250
		4075	13	4582	99
		4076	50	4583	99
		4077	13	4584	48
		4078	15	4585	99
		4081	13	4597	330
		4082	13	4599	290
		4085	50	40097	45
		4086	60	40098	42
		4089	125	40100	215
		4093	20	40101	130
		4094	70	40102	140
		4095	95	40103	175
		4096	70	40104	95
		4097	190	40105	115
		4098	75	40106	75
		4099	75	40107	60
		4160	95	40108	450
		4161	99	40109	100
		4162	99	40110	300
		4163	99	40114	240
		4174	99	40163	50
		4175	105	40174	45
		4194	105	40175	50
4000	10	4408	790	40192	95
4001	10	4409	790	40193	95
4002	12	4410	725	40194	90
4006	50	4411	690	40195	80
4007	14	4412	790	40244	195
4008	32	4415	480	40245	195
4009	24	4419	280	40373	240
4010	24	4422	770	40374	245
4011	10	4433	770	45106	595
4012	16	4435	850		

SPEAKERS
8Ω, 0.3W, 2"; 2.25", 2.5", 3" — 80p
0.3W, 2.5" 40Ω; 64Ω or 80Ω — 80p

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

Noise Diode
Z5J — 195

SCR's Thyristors	
0.8A-100V	32
5A/300V	38
5A/400V	40
5A/600V	48
8A/300V	60
8A/600V	95
12A/100V	78
12A/400V	95
12A/800V	188
BT106	150
BT116	180
C106D	38
TIC44	24
TIC45	29
TIC47	35
2N5062	32
2N5064	38
2N4444	130

DIAC
ST2 — 25

BRIDGE RECTIFIERS (plastic case)	
1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	46
2A/600V	65
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	298
25A/200V	240
25A/600V	395
BY164	56
VM18	50

ZENERS
Range 2V7 to 39V 400mW — 8p each
Range 3V3 to 33V 1.3W — 15p each

VARICAPS	
MVAM2	165
BA102	30
BB105B	40
BB106	40

TRIACS	
3A/100V	48
3A/400V	56
3A/800V	85
8A/100V	60
8A/400V	69
8A/800V	115
12A/100V	78
12A/400V	82
12A/800V	135
16A/100V	103
16A/400V	105
16A/800V	220
25A/400V	185
25A/800V	295
25A/1000V	480
30A/400V	525
T2800D	120

SOLDERCON PINS
100 — 75p
500 — 370p

OPTO ELECTRONICS

LEDS including Clips	
TIL209 Red 3mm	10
TIL211 Green 3mm	14
TIL212 Yellow	14
TIL220 2" Red	12
0.2" Yel, Grn, Amber	14
Rectangular LEDs with two part clip R, G & Y	29
Rectangl. Stackable LEDS	18
Triangular LEDs R&G	18
0.2" Flashing LED Red	56
0.2" Bi colour LEDs Red/Green	65
Green/Yellow	80
0.2" Tri colour LEDs Red/Green/Yellow	85
0.2" Red High Bright	59
LD271 Infra Red (emit)	46
TIL32 Infra Red (emit)	52
SFH205 (detector)	118
TIL78 (detector)	54
TIL38	45
TIL81	82
TIL100	90

7 Segment Displays

TIL321 .5" C.An	115
TIL322 .5" C.th	115
DL704 .3" C.Cth	99
DL707 .3" C.Anod	99
FND357 or 500	120
.3" Green C.A.	140
±1 .3" Red or Green	150
Bargraph 10 seg. Red	225
Bargraph NSM3914	500

0.5" LIQUID CRYSTAL DISPLAYS

3½ digit	495
4 digit	530
6 digit	625

BPX25	195
BPW21	295
BPX65	270
IL74	45
ILD74	99
ILQ74	185
TIL111	75
OCP71	120
ORP12	78
2N5777	45
4N33	135
Pin diode	510

OPTO SWITCH
Reflective TIL139 — 170
Slotted similar to RS — 186

ALUM. BOXES

4×2¼×2"	85
4×2¾×2¾"	103
4×4×2½"	120
5×4×2	105
5×2¼×1½"	90
5×2¼×2½"	130
5×4×1½"	99
5×4×2½"	120
6×4×2"	120
6×4×3"	150
7×5×3"	180
8×6×3"	210
10×4¼×3"	240
10×7×3"	275
12×5×3"	260
12×8×3"	295

FERRIC CHLORIDE
Crystals 1lb
195p + 50p p&p

DALO ETCH RESIST
Pen plus spare tip — 90p

COPPER CLAD BOARDS

	Single sided	Double sided	SRBP 9.5"×8.5"
Fibre Glass 6"×6"	90p	110p	95p
6"×12"	150p	195p	

VEROBOARDS 0.1"

	Clad	Plain
2½×3¾"	85p	—
2½×5"	100p	—
3¾×3¾"	100p	—
3¾×5"	115p	85p
3¾×17"	390p	275p
4¾×18"	495p	—
Pkt. of 100 pins	55p	
Spot Face Cutter	150p	
Pin Insertion Tool	185p	

'VQ' Board	180
'DIP' Board	374
Vero Strip	144
S100 Board	£14

PROTO-DECs

Veroblock	405
S-Dec	350
Eurobreadboard	520
Bimboard 1	695
Superstrip SS2	£13

VERO WIRING PEN and Spool — 350p
Spare Wire (Spool) 75p; Combs 6p ea.
Wire Wrapping Stakes 100 — 250p

VOLTAGE REGULATORS

1A T0220 Plastic Casing

	+ve		-ve	
5V	7805	40p	7905	45p
12V	7812	40p	7912	45p
15V	7815	40p	7915	45p
18V	7818	40p	7918	45p
24V	7824	40p		

100mA T092 Plastic Casing

5V	78L05	30p	79L05	60p
6V	78L62	30p	—	
8V	78L82	30p	—	
12V	78L12	30p	79L12	60p
15V	78L15	30p	79L15	60p

ICL7660	248	LM317K	320
78H05 5V/5A	550	LM317P	99
78H12 12V/5A	580	LM323K	500
78HG+5 to +24V 5A	599	LM337T	175
		LM723	35
79HG -2.25V to -24V 5A	685	TBA625B	75
		RC4194	375
LM309K	135	RC4195	160

SWITCHES

SLIDE 250V

1A DPDT	14
1A DPDT C/OFF	15
½A DP on/on/on	40

PUSH BUTTON Spring loaded

Latching or Momentary 6A SPDT c/over	99
DPDT c/over	145

MINIATURE Non Locking

Push to make	15p
Push break	25p

TOGGLE 2A 250V

SPST	33
DPDT	44
4 pole on off	54

SUB-MIN TOGGLE 2 amp

SP changeover	60
SPST on off	54
SPDT c/off	85
SPDT Biased	105
DPDT 6 tags	75
DPDT C/OFF	88
DPDT on/on/on	185
DPDT Biased	145
3 pole c/over	205

★ SPECIAL OFFER ★

1 MEGABYTE DRIVES

Mitsubishi Slim Line, Uncased, Double track, Double density, 5¼". Track Density 96TPI, track to track. Access time: 3mSec. **Only £255.**

ROTARY: (Adjustable Stop Type) 1 pole/2 to 12 way, 2p/2 to 6 way, 3 pole/2 to 4 way, 4 pole/2 to 3 way — 45p

ROTARY: Mains 250V AC, 4 Amp — 64p

DIL SWITCHES: (SPST) 4 way 65p; 6 way 80p; 8 way 87p; 10 way 135p; (SPDT) 4 way 190p.

THUMBWHEEL Mini front mounting
Decade Switch Module — 220p
B.C.D. Switch Module — 275p
Mounting Cheeks (pair) — 75p

PROXIMITY Switch with magnet — 125p

DIL SOCKETS

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

ZIF DIL SOCKET

16 way	475p
24 way	575p
28 way	850p
40 way	975p

DIL PLUGS (Headers)

Pins	Solder	IDC
14	38p	95p
16	42p	100p
24	88p	138p
40	195p	218p

RIBBON CABLE (price per foot)

Ways	Grey	Colour
10	15p	28p
16	25p	40p
20	30p	50p
26	40p	65p
34	60p	85p
40	70p	90p
64	100p	135p

ULTIMUM

WATFORD'S most versatile MICRO EXPANSION SYSTEM. Interfaces with: APPLE, ATOM, DRAGON, PET, RESEARCH MACHINE, SPECTRUM, SUPERBOARD, VIDEO GENIE, ZX81, etc. As published in P.E. starting from Nov., 1982.
Send SAE for details.

IDC CONNECTORS (Speed block type)

2 rows	PCB Male with latch Strt. Pins	Angle Pins	Female Header Socket	Female Card-Edge Connector
10 way	90p	99p	85p	120p
16 way	130p	150p	110p	195p
20 way	145p	166p	125p	240p
26 way	175p	200p	150p	320p
34 way	205p	236p	169p	340p
40 way	220p	250p	190p	420p
50 way	235p	270p	200p	470p

EURO CONNECTORS

	FEMALE SOCKETS Strt.	Angle	MALE PLUGS Strt.	Angle
DIN 41617 31 way	170p	—	—	175p
DIN 41612 2×32 way	275p	320p	220p	285p
DIN 41612 2-3×32 way	295p	340p	240p	300p
DIN 41612 3×32 way	360p	385p	260p	395p

'D' CONNECTORS:

Pins	9 way	15 way	25 way	37 way
MALE				
Solder	80p	110p	160p	240p
Angle	150p	210p	250p	355p
Strait	170p	160p	220p	310p
FEMALE				
Solder	105p	160p	200p	338p
Angle	165p	215p	290p	440p
Strait	175p	200p	300p	420p
COVERS	90p	80p	80p	90p

IDC 25 way Plg. 385p, Skt. 450p

TRANSFORMERS (mains Prim. 220-240V)
3-0-3V, 6-0-6V 100mA, 9-0-9V 75mA; 12-0-12V 75mA, 15-0-15V 75mA — 98p
6VA: 2x6V-5A, 2x9V-4A, 2x12V-0.3A; 2x15V-.25A — 220p
12VA: 2x4V5-1.3A; 2x6V-1.2A, 2x12V-.5A; 2x15V-.4A — 295p (35p p&p)
24VA: 6V-1.5A 6V-1.5A; 9V-1.2A 9V-1.2A, 12V-1A 12V-1A; 15-.8A 15-.8A; 20V-.6A 20V-.6A — 330p (60p p&p)
50VA: 2×6V-4A; 2×9V-2.5A; 2×12V-2A, 2×15V-1.5A; 2×20V-1.2A; 2×25V-2A; 2×30V-0.8A — 465p (60p p&p)
100VA: 2×12V-4A; 2×15V-3A; 2×20V-2.5A, 2×30V-1.5A, 2×40V-1.25A; 2×50V-1A — 920p (60p p&p)

EDGE CONNECTORS

SIL Sockets 0.1"		
20 way	65p	
32 way	95p	

	1"	.156"
2×10 way	—	135p
2×15 way	—	140p
2×18 way	180p	145p
2×22 way	199p	200p
2×23 way	170p	190p
2×25 way	225p	220p
2×28 way	210p	—
2×30 way	245p	—
2×36 way	295p	—
2×40 way	315p	—
2×43 way	395p	—
2×75 way	550p	—

JUMPER LEADS Ribbon Cable Assembly DIL Plug (Headers)

Single Ended Lead, 24" long Length	14pin	16pin	24 pin	40 pin
24"	145p	165p	240p	325p
Double Ended Leads				
6"	185p	205p	300p	465p
12"	198p	215p	315p	490p
24"	210p	235p	345p	540p
36"	230p	250p	375p	595p

IDC FEMALE RECEPTACLE Jumper Leads 24"

	20pin	26pin	34pin	40pin
1 end	160p	200p	260p	300p
2 ends	290p	370p	480p	525p

COMPUTER CORNER

- **SEIKOSHA GP100A** – Unihammer Printer, normal & double width characters, dot resolution graphics 10" Tractor feed, parallel interface standard. **FREE 500 Sheets** — **£175**
- **SEIKOSHA GP 250X** Printer — **£230**
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A highly sophisticated Acorn Atom Utility ROM. Plugs straight into floating point Atom's Utility socket. Gives many unique BASIC Extensions: Hi-speed tape Interface; 2 key rollover keyboard; full disassembler, Memory dump modify; Machine code breakpoints; BASIC error trapping; READ, Data £ restore; Full BASIC keyboard scanner (BBC like); Find line & delete; Auto line numbering; Plus: Chain, Cursor movement, Loop aborting Easily extendible further. Manual Supplied.

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C15W	450
CX17W	475
CCN15W	490
X25W	500
Spare bits	65
Elements	210
Iron stands	165
Heat Shunt	30

Just phone your order through, we do the rest. 0923-50234

CRYSTALS

32.768KHz	100
100KHz	235
200KHz	268
455KHz	370
1MHz	275
1.008M	275
1.28MHz	392
1.5MHz	420
1.6MHz	395
1.8MHz	395
1.8432M	200
2.0MHz	225
2.4576M	200
2.5MHz	225
2.56250M	220
3.2768M	150
3.57954M	98
3.6864M	300
4.0MHz	150
4.032MHz	290
4.194304M	200
4.433619M	100
4.608MHz	200
4.80MHz	200
5.0MHz	160
5.185MHz	300
5.24288M	390
6.0MHz	140
6.144MHz	150
6.5536MHz	200
7.0MHz	150
7.168MHz	250
7.68MHz	200
8.0MHz	150
8.08333M	395
8.867237M	175
9.00MHz	200
9.375MHz	350
10.0MHz	175
10.5MHz	250
10.7MHz	150
10.24MHz	200
12.0MHz	175
12.528MHz	300
14.31818M	170
14.7456M	175
14.765MHz	250
15.0MHz	200
16.0MHz	200
18.0MHz	180
18.432M	150
19.968MHz	150
20.0MHz	200
24.0MHz	170
24.930MHz	325
29.695MHz	150
26.670MHz	325
27.125MHz	295
27.145M	190
27.648MHz	300
38.66667M	175
48.0MHz	175
55.5MHz	400
100MHz	350
116.0MHz	300
145.8MHz	225

AMPHENOL PLUGS

	IDC	Solder
24 way IEE	475p	450p
36 way Centronix	525p	485p

ASTEC UHF MODULATORS
6MHz — 325p
8MHz Wideband — 450p

BBC MICRO & UPGRADE KITS

- BBC Micro Model A **£299;** Model B (incl.) **£399**
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(12 months warranty on Drives)

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- CS50E – Single Cased with PSU 80 track 5¼" Single sided 200K — £250
- CD50E – Twin Cased with PSU 80 track 5¼" Single sided 400K — £475
- CS50F – Single Cased with PSU 80 track 5¼" Double sided 400K — £330
- CD50F – Twin Cased with PSU 80 track 5¼" Double sided 800K — £599
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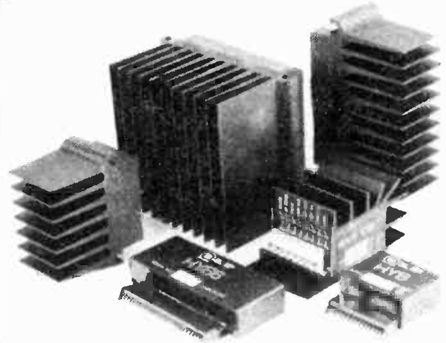
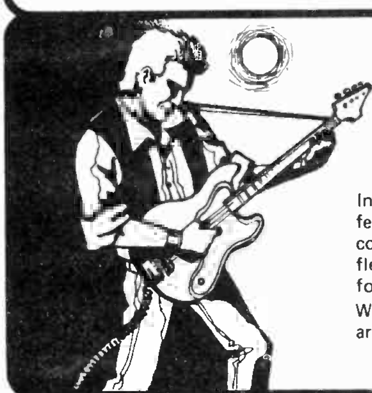


ILP Modular Amplifiers

the third generation

Due to continous improvements in components and design ILP now launch the largest and most advanced generation of modules ever.



WE'RE INSTRUMENTAL IN MAKING A LOT OF POWER

In keeping with ILP's tradition of entirely self-contained modules featuring, integral heatsinks, no external components and only 5 connections required, the range has been optimized for efficiency, flexibility, reliability, easy usage, outstanding performance, value for money.

With over 10 years experience in audio amplifier technology ILP are recognised as world leaders.

BIPOLAR MODULES

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

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

PRE-AMP SYSTEMS

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

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

Mounting Boards

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

POWER SUPPLY UNITS (Incorporating our own toroidal transformers)

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

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

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

Please note: X in part no. indicates primary voltage. Please insert "0" in place of X for 110V, "1" in place of X for 220V, and "2" in place of X for 240V.

MOSFET MODULES

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

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

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C15

Mono Power Booster Amplifier to increase the output of your existing car radio or cassette player to a nominal 15 watts rms.

Very easy to use.

Robust construction.

Mounts anywhere in car.

Automatic switch on.

£9.14 (inc. VAT)

Output power maximum 22w peak into 4Ω
Frequency response (−3dB) 15Hz to 30KHz, T.H.D. 0.1% at 10w 1KHz
S/N ratio (DIN AUDIO) 80dB, Load Impedance 3Ω
Input Sensitivity and impedance (selectable) 700mV rms into 15KΩ 3V rms into 8Ω
Size 95 x 48 x 50mm. Weight 256 gms.

C1515

Stereo version of C15.

Size 95 x 40 x 80. Weight 410 gms.

£17.19 (inc. VAT)

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CARBON FILM 5% HI-STAR LOW NOISE 10Ω to 10MΩ
¼W E24 2p
½W E24 2½p
1W E12 6p
2W E12 12p

METAL FILM ULTRA STABLE 0.4 EXTRA LOW NOISE 10Ω to 1MΩ
2% E24 5p
1% E24 6p

LOW OHMIC GLAZE ½W 0.22Ω to 8.2Ω E24 11p

WIREWOUND ON CERAMIC E12 SERIES
2 to 3 WATT 0.22Ω to 330Ω 28p
4 to 7 WATT 0.47Ω to 6k8 33p
10 to 11 WATT 1Ω to 33K 37p

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ROTARY POTS LOW NOISE ¼" SPINDLES E3 SERIES
4K7 to 2M LIN 32p
4K7 to 2M LOG 32p
As above with DP mains switch 79p
As above stereo (no switch) 89p

PRE-SETS PIHER (DUSTPROOF) E3 100Ω to 10MΩ
Mini Vertical 15p
Mini Hzontal 15p
Standard Vert 18p
Standard Horiz 18p

CERMET 20 TURN PRECISION PRE SETS ¾" E3 Series 50Ω to 500K 89p

CAPACITORS

CERAMIC 100V DISC (PLATE) E12 MICRO MINI typically -5% 1pF to 10nF 7p

POLYCARB 5% SIEMENS 7.5mm MINI-BLOC E12 250V
1nF to 6n8 7p
8n2 to 47nF 8p
56nF to 150nF 10p
100V 100nF to 150nF 11p
180nF to 270nF 14p
330nF to 390nF 20p
470nF to 560nF 26p
680nF 30p
1μF (10mm) 35p

POLYESTER 250V RADIAL (C280)
1nF 15nF 22nF 33nF 47nF 68nF 100nF 7p
150nF 220nF 10p
330nF 470nF 13p
680nF 18p
1μF 22p
1μ5 2μ2 39p

FEEDTHROUGH 1nF 500V 7p

HIGH VOLTAGE Capacitors please enquire many types in stock

TANT BEADS
1 35V 14p
22 35V 14p
33 35V 14p
47 35V 14p
68 35V 14p
1.0 35V 14p
2.2 35V 14p
3.3 35V 18p
4.7 16V 18p
4.7 35V 20p
6.8 25V 20p
6.8 35V 21p
10 16V 18p
10 35V 27p
15 10V 22p
15 16V 30p
15 25V 32p
22 6.3V 26p
22 16V 29p
33 10V 30p
47 3V 14p
47 6.3V 34p
47 16V 39p
100 13V 32p
100 10V 55p

ELECTROLYTICS Mainly Matsushita (Panasonic) & Siemens
AXIALS (Wires each end)
μFd V
47 63 8p
47 100 9p
47 350 30p
1 63 8p
1 100 9p
1 500 40p
2.2 75 8p
2.2 63 9p
2.2 100 11p
2.2 350 30p
3.3 25 10p
3.3 40 11p
3.3 63 12p
4.7 16 8p
4.7 25 9p
4.7 40 11p
4.7 63 12p
4.7 100 13p
10 25 8p
10 40 12p
10 63 14p
10 100 16p
μFd V
22 25 11p
22 40 14p
22 63 16p
22 100 21p
47 25 14p
47 40 17p
47 63 26p
47 100 28p
100 16 14p
100 25 16p
100 40 22p
100 63 25p
100 100 30p
220 10 16p
220 16 17p
220 25 22p
220 40 25p
220 63 30p
220 100 40p
470 16 22p
470 25 28p
470 40 33p
470 63 43p
470 100 60p
1000 16 30p
1000 25 38p
1000 40 46p
1000 63 65p
2200 16 40p
2200 25 63p
2200 40 70p
2200 63 134p
4700 16 75p
4700 25 89p

RADIALS (PCB wires one end) Matsushita only
μFd V
10 16 6p
22 10 6p
22 16 7p
47 10 7p
47 16 8p
100 10 9p
100 16 10p
220 10 11p
220 16 12p
470 10 17p
470 16 18p
1000 10 20p
1000 16 24p
2200 10 34p
2200 16 44p

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All 240V Primary
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12.0 12V
15.0 15V 100mA 95p
1A 2.90
20.0 20V
1.25A £2.90
12.0 12.0
50VA 4.35
12.0 12.0
100VA 8.95
0-6-6-9-9
1.25A 4.25
These goods are heavy send extra p&p. We will credit any difference

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0.1" COPPER TRACKS
2.5 3.75 80p
2.5 5 90p
3.75 3.75 90p
3.75 5 103p
2.5 17 280p
3.75 17 355p
4.79 17 466p
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Vero Wiring Pen + Spool 3.35
Spare Spool 75p
Combs 6p

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FERRIC CHLORIDE Quick dissolving pellets (mix with 1 litre water) 1.69

ETCH RESIST TRANSFERS
1 Thin lines
2 Thick lines
3 Thin bends
4 Thick bends
5 DIL pads
6 Transistor pads
7 Dots + holes
8 0.1" edge cons
9 Mixture
Any sheet of above 35p

GRADE ONE GLASS PCB
Single Sided
178 × 240mm 95p
420 × 195mm 130p
420 × 245mm 195p

DALO ETCH RESIST PEN + spare nib 90p

PHOTO SENSITIVE PCB 1st Class Epoxy Glass For better results than spray ing Expose to UV
Single sided
100 × 160 1.55
100 × 220 1.90
203 × 114 1.85
233 × 220 3.99
Double sided
100 × 160 1.65
100 × 220 2.15
203 × 114 2.21
233 × 220 4.55
Developer for above (do not use Sodium Hydroxide) 500ml 2.50

WIRE & CABLE

Prices per Metre
Solid connecting wire 5p

Mains/Speaker Cable
Twin 1 amp 14p
Twin 2½ amp 16p
3 Core 2½ amp 18p
3 Core 6 amp 31p
3 Core 13 amp 56p

Screened Cable
Single 14p
Stereo 27p
Mini Single 12p
Mini Stereo 15p
4 Core 4 Screens 44p
4 Core 1 Screen 54p
8 Core 61p
12 Core 80p

Aerial Cable
50Ω RG58A 36p
75Ω UHF 36p
75Ω VHF 28p
300Ω Flat 14p

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8 Way 19p
10 Way 21p
16 Way 30p
20 Way 38p
24 Way 47p
30 Way 55p
32 Way 57p
40 Way 72p

RECHARGEABLE BATTERIES

Top quality. Don't throw these but series way they charge up to 1000 times!
HP2 (1.2AH) 2.10
HP2 (4AH) 4.75
HP7 (.5AH) 99p
HP11 (1.2AH) 2.29
PP3 4.95

Chargers
TYPE H Adjustable to 6 of any HP type above £15.59
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TYPE P PP3 £5.50
TYPE A HP7 (Up to 4 at a time) £5.85

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ANTEX SOLDERING IRONS
C240 (15W) 4.59
X25 (25W) 4.99
Iron stand 1.65
C240 Element 1.99
X25 Element 2.05
Bits C240
No 2 (Small) 65p
No 3 (Med) 65p
No 6 (Micro) 65p
Bits X25
No 50 (Small) 65p
No 51 (Med) 65p
No 52 (Lge) 65p
SOLDER 125gms
18 swg 2.95
22 swg 3.10

PLUGS & SOCKETS

'D' Connectors
25 Way Solder
Male 1.60
Female 2.09
PCB Wire Wrap
Male 1.60
Female 2.09
Covers £1.00
Phono Plugs Blk Red Grn Wht or Yellow 15p
Line Skts 15p
Chas Skt 1 20p
Dual 30p
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2N930 20p
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2N2102 39p
2N2217 39p
2N2218 33p
2N2218A 25p
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2N2219A 28p
2N2220 22p
2N2221 23p
2N2221A 23p
2N2222 24p
2N2222A 25p
2N2223 2.60
2N2223A 4.15
2N2368 25p
2N2369 19p
2N2369A 18p
2N2904A 27p
2N2905 28p
2N2905A 29p
2N2906 25p
2N2906A 30p
2N2907 25p
2N2907A 26p
2N2920 3.47
2N2923 25p
2N2924 15p
2N2925 15p
2N2926 10p
2N3053 27p
2N3054 56p
2N3055 60p
2N3055H 120p
2N3250 36p
2N3251 36p
2N3439 98p
2N3440 80p
2N3441 1.25
2N3442 1.35
2N3442RCA 1.85
2N3445 4.80
2N3446 6.09
2N3447 5.72
2N3448 6.56
2N3468 1.00
2N3512 1.06
2N3553 2.30
2N3638 55p
2N3638A 67p
2N3702 10p
2N3703 10p
2N3704 10p
2N3705 10p
2N3706 10p
2N3707 10p
2N3708 10p
2N3709 10p
2N3710 10p
2N3711 10p
2N3712 2.00
2N3713 1.38
2N3714 2.98
2N3715 3.31
2N3716 3.60
2N3773 1.99
2N3819 25p
2N3820 38p
2N3821 1.84
2N3822 90p
2N3823 45p
2N3824 1.70
2N3866 90p
2N3903 15p
2N3904 15p
2N3905 15p
2N3906 15p
2N4030 66p
2N4031 55p
2N4032 65p
2N4036 58p
2N4037 43p
2N4240 3.00
2N4347 2.26
2N4400 15p
2N4401 27p
2N4402 30p
2N4403 30p
2N4409 36p
2N4410 42p
2N4427 79p
2N4870 80p
2N4871 55p
2N4888 92p
2N4901 1.69
2N4902 3.52
2N4903 3.24
2N4904 2.75
2N4905 3.25
2N4906 3.42
2N4907 3.20
2N4908 3.70
2N4909 2.90
2N4918 95p
2N4919 1.28
2N4920 1.34
2N4921 56p
2N4922 69p
2N4923 99p
2N5086 36p
2N5087 39p
2N5088 37p
2N5089 37p
2N5190 68p
2N5191 70p
2N5193 90p
2N5194 79p
2N5245 37p
2N5246 40p
2N5247 45p
2N5248 46p
2N5249 48p
2N5266 2.88
2N5293 98p
2N5294 1.28
2N5295 1.37
2N5401 35p
2N5415 1.10
2N5416 1.54
2N5447 16p
2N5448 19p
2N5449 21p
2N5450 23p
2N5451 25p
2N5457 29p
2N5458 29p
2N5459 29p
2N5460 72p
2N5551 37p
2N5884 5.95
2N5884 5.95
2N6121 54p
2N6122 56p
2N6123 59p
2N6124 56p
2N6125 59p
2N6126 71p
2N6129 79p
2N6130 93p
2N6131 98p
2N6132 83p
2N6133 1.14
2N6134 1.36
2N6253 1.45
2N6254 1.55
2SC1306 95p
2SC2078 1.70
2SJ49 3.50
2SJ50 3.75
2SJ82 4.29
2SK134 3.50
2SK135 3.75
2SK226 4.29
3N128 1.12
3N140 2.37
3N200 6.93
3N201 2.98
40360 60p
40361 67p
40362 67p
40363 2.22
40406 1.39
40407 75p
40408 1.58
40410 1.80
40411 2.85
40412 90p
40673 83p
40822 1.80
40871 89p
40872 89p
AC125 35p
AC126 25p
AC127 25p
AC128 25p
AC132 39p
AC141K 28p
AC142K 28p
AC151 51p
AC152 45p
AC153 55p
AC153L 64p
AC176 27p
AC176K 37p
AC187 25p
AC187K 28p
AC188 25p
AC188K 40p
AF239 55p
AF240 1.00
AL102 3.49
AU110 2.20
AU113 3.67
BC107 10p
BC107A 12p
BC107B 12p
BC108 10p
BC108A 12p
BC108B 12p
BC108C 14p
BC109 10p
BC109B 12p
BC109C 12p
BC140 29p
BC141 37p
BC142 29p
BC143 34p
BC147 10p
BC147A 10p
BC147B 10p
BC147C 20p
BC148 10p
BC148A 12p
BC148B 13p
BC148C 13p
BC149 10p
BC149B 12p
BC149C 13p
BC152 35p
BC153 23p
BC154 27p
BC157 11p
BC157A 12p
BC157B 13p
BC158 10p
BC158A 12p
BC158B 13p
BC159 11p
BC159A 12p
BC159B 13p
BC159C 18p
BC160 42p
BC161 48p
BC167 10p
BC167A 10p
BC167B 13p
BC168 10p
BC168B 10p
BC168C 10p
BC169 10p
BC169B 12p
BC169C 10p
BC177 16p
BC177A 25p
BC177B 26p
BC178 16p
BC178A 24p
BC178B 25p
BC179 20p
BC179A 25p
BC179B 28p
BC179C 27p
BC182 10p
BC182A 12p
BC182B 13p
BC182L 10p
BC182LA 13p
BC182LB 14p
BC183 10p
BC183A 11p
BC183B 12p
BC183C 13p
BC183L 10p
BC183LA 13p
BC183LB 13p
BC183LC 14p
BC184 10p
BC184B 12p
BC184C 13p
BC184L 10p
BC184LB 13p
BC184LC 14p
BC186 24p
BC187 26p
BC212 10p
BC212A 12p
BC212B 13p
BC212L 10p
BC212LA 13p
BC212LB 14p
BC213 10p
BC213A 11p
BC213B 12p
BC213C 13p
BC213L 10p
BC213LA 13p
BC213LB 13p
BC213LC 14p
BC214 10p
BC214B 12p
BC214C 13p
BC214L 10p
BC214LB 13p
BC214LC 14p
BC237 10p
BC237A 16p
BC237B 17p
BC237C 18p
BC238 14p
BC238A 15p
BC238B 16p
BC238C 17p
BC239 15p
BC239A 16p
BC239B 17p
BC239C 18p
BC300 45p
BC301 40p
BC302 43p
BC303 47p
BC327 14p
BC328 14p
BC337 15p
BC338 15p
BC440 32p
BC441 33p
BC461 33p
BC516 40p
BC517 40p
BC547 13p
BC547A 14p
BC547B 14p
BC548 12p
BC548A 13p
BC548B 14p
BC548C 15p
BC549 13p
BC549B 14p
BC549C 15p
BC550 30p
BC550C 33p
BC557 15p
BC557A 16p
BC557B 16p
BC558 14p
BC558A 15p
BC558B 16p
BC558C 17p
BC559 15p
BC559B 16p
BC559C 17p
BC560 32p
BC560C 34p
BC650 45p
BC651 46p
BCY70 16p
BCY71 16p
BCY72 19p
BD131 44p
BD132 44p
BD135 40p
BD136 40p
BD137 42p
BD138 39p
BD139 39p
BD140 39p
BD237 98p
BD238 96p
BD239A 57p
BD240A 59p
BD240C 73p
BD241A 61p
BD241C 67p
BD242A 65p
BD242C 70p
BD243A 72p
BD243C 85p
BD244A 82p
BD244C 1.00
BD245A 1.14
BD245C 1.30
BD246A 1.20
BD246C 1.50
BD249A 2.00
BD249C 2.31
BD250A 2.11
BD250C 2.46
BD437 88p
BD438 88p
BD439 90p
BD440 91p
BD441 91p
BD442 93p
BD529 1.20
BD530 1.30
BD535 75p
BD536 75p
BD537 80p
BD538 80p
BD539 80p
BD539C 1.10
BD540 85p
BD540C 1.20
BD675 72p
BD677 77p
BD677 78p
BD678 83p
BD711 1.32
BD712 1.32
BDX14 1.30
BDX18 1.59
BDX32 3.47
BDY54 1.70
BDY55 1.75
BDY56 1.80
BDY57 5.25
BDY58 6.15
BF194 12p
BF195 12p
BF196 12p
BF197 12p
BF198 15p
BF199 15p
BF200 1.49
BF224J 32p
BF225J 35p
BF240 38p
BF241 38p
BF244A 35p
BF244B 39p
BF245A 30p
BF245B 51p
BF246 52p
BF246A 39p
BF246B 53p
BF247A 54p
BF247B 55p
BF254 39p
BF255 42p
BF256A 35p
BF256B 48p
BF256C 62p
BF257 30p
BF258 32p
BF259 35p
BF457 46p
BF458 58p
BF459 62p
BF469 85p
BF470 85p
BFR39 25p
BFR40 25p
BFR41 25p
BFR79 25p
BFR80 25p
BFR81 25p
BFR90 2.11
BFS28 2.95
BFS61 1.50
BFS98 1.70
BFX29 26p
BFX30 27p
BFY50 23p
BFY51 23p
BFY52 23p
BFY53 31p
BSX19 24p
BSX20 24p
BSX21 40p
BU104 2.25
BU105 1.70
BU108 2.95
BU109 3.29
BU126 1.47
BU204 2.25
BU205 1.75
BU206 1.89
BU208 1.98
BU226 3.25
BU326S 2.35
BU406 1.45
BU407 1.45
BU408 1.35
BU500 2.95
BUY18S 3.95
E430 5.95
J300 48p
J310 53p
MJ802 3.99
MJ900 2.90
MJ901 3.10
MJ1000 2.50
MJ1001 3.00
MJ1800 3.60
MJ2500 2.19
MJ2501 2.25
MJ2955 1.00
MJ3000 2.19
MJ3001 2.25
MJ4502 3.99
MJ15003 4.85
MJ15004 5.55
MJ15015 2.45
MJ15016 3.34
MJE340 53p
MJE350 1.50
MJE2955 99p
MJE3055 69p
MPSA05 23p
MPSA06 25p
MPSA10 28p
MPSA12 29p
MPSA13 48p
MPSA14 46p
MPSA16 30p
MPSA18 65p
MPSA20 48p
MPSA42 49p
MPSA43 49p
MPSA55 28p
MPSA56 30p
MPSA65 40p
MPSA66 47p
MPSA70 45p
MPSA92 39p
MPSA93 39p
MPSL01 42p
MPSL51 48p
MPSU01 84p
MPSU04 1.32
MPSU05 55p
MPSU06 56p
MPSU07 75p
MPSU51 88p
MPSU55 58p
MPSU56 59p
MPSU57 1.20
OC20 2.30
OC25 2.50
OC28 1.70
OC29 2.35
OC35 2.35
OC43 70p
OC44 82p
OC70 50p
OC71 50p
OC72 50p
OC82 50p
OC83 75p
TIP29A 32p
TIP29C 38p
TIP30A 35p
TIP30C 38p
TIP31A 38p
TIP31C 39p
TIP32A 38p
TIP32C 42p
TIP33A 65p
TIP33C 78p
TIP34A 74p
TIP34C 88p
TIP35A 1.09
TIP35C 1.28
TIP36A 1.29
TIP36C 1.39
TIP41A 49p
TIP41C 55p
TIP42A 55p
TIP42C 65p
TIP49 1.20
TIP50 1.40
TIP53 1.57
TIP54 1.58
TIP110 74p
TIP112 90p
TIP115 81p
TIP117 96p
TIP120 69p
TIP122 73p
TIP125 84p
TIP127 84p
TIP130 93p
TIP132 93p
TIP135 99p
TIP137 99p
TIP140 1.04
TIP142 1.04
TIP145 1.15
TIP147 1.15
TIP162 4.95
TIP2955 77p
TIP3055 70p
TIS43 40p
TIS88A 62p
VN10KM 60p
VN46AF 84p
VN66AF 85p
ZTX107 10p
ZTX108 10p
ZTX109 10p
ZTX300 13p
ZTX301 15p
ZTX302 15p
ZTX303 23p
ZTX304 15p
ZTX310 35p
ZTX311 32p
ZTX312 35p
ZTX313 36p
ZTX314 24p
ZTX320 35p
ZTX330 35p
ZTX341 28p
ZTX450 39p
ZTX500 14p
ZTX501 14p
ZTX502 14p
ZTX503 17p
ZTX504 24p
ZTX510 34p
ZTX530 24p
ZTX531 25p
ZTX650 45p

DIODES

1N34A 30p
1N821 70p
1N823 92p
1N914 8p
1N916 10p
1N4001 4p
1N4002 4½p
1N4003 5½p
1N4004 5½p
1N4005 6p
1N4006 6½p
1N4007 7p
1N4009 20p
1N4148 6p
1N4150 18p
1N4448 22p
1N5400 12p
1N5401 13p
1N5402 14p
1N5403 15p
1N5404 18p
1N5406 18p
1N5407 19p
1N5408 20p
1N5024 52p
1S44 10p
BA102 25p
BA115 25p
BA133 40p
BA138 30p
BA142 20p
BA155 15p
BA156 38p
BA157 25p
BA158 30p
BA159 32p
BA182 40p
BA201 18p
BA202 26p
BA316 25p
BA317 25p
BA318 30p
BAV10 16p
BAV19 15p
BAV20 15p
BAX13 10p
BAX16 11p
BY126 20p
BY127 22p
BY134 52p
BY182 1.26
BY206 36p
BY207 36p
BY223 1.56
BY297 48p
BY299 55p
MZ2361 1.80
OA47 20p
OA90 10p
OA91 10p
OA95 20p
OA200 20p
OA202 20p

SCRs, TRIACS, DIACS

THYRISTORS 4, 8 & 12 Amps Texas TO220
Suffice A 100V
B 200V
C 300V
D 400V
M 600V
TIC106A 46p
TIC106B 47p
TIC106C 48p
4A TIC106D 49p
TIC106M 68p
TIC116A 66p
TIC116B 68p
8A TIC116C 71p
TIC116D 73p
TIC116M 80p
TIC126A 72p
TIC126B 72p
12A TIC126C 73p
TIC126D 77p
TIC126M 95p

TRIACS Texas 400V TO220 Case
TIC206D(4A) 66p
TIC225D(6A) 74p
TIC226D(8A) 88p
TIC236D(12A) 1.16
TIC246D(16A) 1.22
TIC253D(20A) 1.90
TIC263D(25A) 2.11

DIACS
BR100 40p
ST2 25p

ZENER DIODES

400 500mW E24 Series
2.4 47V 7p
1.3 Watt E24 Series 3.3 82V 14p

BRIDGE RECTIFIERS

(PIV shown in brackets)
1½ amp type
W01 (100) 20p
W02 (200) 26p
W04 (400) 28p
W08 (800) 40p
2 amp type Square with hole
S01 (100) 37p
S02 (200) 40p
S04 (400) 40p
S08 (800) 55p
6 amp type Square with hole
PW01 (100) 50p
PW02 (200) 78p
PW04 (400) 85p
PW06 (600) 90p
25 amp type Metal clad with hole
K01 (100) 2.20
K02 (200) 2.30
K04 (400) 2.80
K06 (600) 3.40

LEDs

R Red
G Green
Y Yellow
Large diffused 1 - 50 +
R5D 9p 7p
G5D 15p 12p
Y5D 15p 12p
Small diffused
R2D 8p 6p
G2D 12p 10p
Y2D 12p 10p
Micro 0.1"
R1D 25p 22p
G1D 27p 25p
Y1D 27p 25p
Large clear
R5C 12p 10p
G5C 17p 13p
Y5C 17p 13p
Super bright high efficiency Large (100 times brighter)
R5U 38p 29p
G5U 42p 34p
Y5U 42p 34p
Rectangular Stackables LEDs
R6L 17p
G6L 18p
Y6L 19p

LINEAR ICs

AY1 5050 95p
AY3 8910 5.39
AY3 8912 5.59
CA3048 2.99
CA3059 2.80
CA3090AQ 3.70
CA3130E 87p
CA3130T 1.80
CA3140E 39p
CA3140T 95p
HA1366W 2.40
HA1388 7.54
ICL7106 7.50
ICL7107 9.75
ICL7611 97p
ICL7660 1.95
ICL8038 2.95
ICL7555 80p
ICL7556 1.50
LC7120 3.20
LC7130 3.20
LC7137 3.85
LF347 1.40
LF351 47p
LF353 92p
LF355 85p
LF356 92p
LF357 1.09
LF398 4.59
LM335Z 1.19
LM348N 62p
LM349N 1.16
LM350K 4.60
LM379S 4.50
LM380N14 75p
LM380N8 1.50
LM381AN 2.26
LM381N 1.40
LM382N 1.12
LM3831 3.40
LM384N 1.40
LM386 88p
LM388N 2.43
LM391N60 1.70
LM391N80 1.93
LM723CH 1.21
LM723CN 40p
LM725CH 3.40
LM725CN 3.19
LM733 69p
LM741CH 96p
LM741CN 15p
LM747CN 69p
LM748CH 1.00
LM748CN 35p
LM1871 4.39
LM1872 4.38
LM1886 7.44
LM1889 3.77
LM2907N 2.75
LM2907N8 2.60
LM2917N 1.89
LM2917N 1.89
LM3900 49p
LM3911 1.20
LM3914 2.00
LM3915 2.00
LM3916 2.50
LM13600 1.10
OM335 7.20
NE531N 1.36
NE543N 2.50
NE544N 1.80
NE555 16p
NE556 45p
NE558 1.89
NE560 3.25
NE565 1.18
NE566 1.49
NE567 1.37
NE570 3.75
NE571 3.75
NE5534A 95p
PLL02A 4.95
PLL03A 12.75
RC4136 59p
TBA500 2.97
TBA500Q 3.11
TBA510 2.95
TBA510Q 3.05
TBA520 2.57
TBA520Q 2.75
TBA530 2.55
TBA530Q 2.76
TBA540 2.72
TBA540Q 2.74
TBA550 3.25
TBA550Q 3.27
TBA560C 2.87
TBA570 2.37
TBA570Q 2.48
TCA910 2.19
TCA940 1.99
TDA1002 3.39
TDA1003 3.94
TDA1004 2.87
TDA1005 3.94
TDA1010A 2.25
TDA1022 4.95
TDA1024 1.19
TDA2610 3.90
TDA2611A 2.50
UAA170 1.59
UAA180 1.69
ULN2003 85p
UPC575C2 2.50
UPC1156 2.75
XR2206 2.92
ZN414 79p
ZN419 1.90
ZN1034 1.90
ZN1040 6.75

TTL

7400 11p
7401 11p
7402 11p
7403 12p
7404 12p
7405 15p
7406 16p
7407 16p
7408 14p
7409 14p
7410 15p
7411 16p
7412 14p
7413 16p
7414 17p
7416 17p
7417 17p
7420 15p
7421 20p
7422 20p
7423 20p
7425 18p
7426 18p
7427 18p
7428 18p
7430 14p
7432 17p
7433 21p
7437 19p
7438 19p
7440 15p
7441 65p
7442 27p
7443 65p
7444 65p
7445 46p
7446 50p
7447 35p
7448 40p
7450 15p
7451 15p
7453 15p
7454 14p
7460 15p
7470 30p
7472 25p
7473 23p
7474 18p
7475 22p
7476 24p
7480 40p
7481 1.19
7482 63p
7483 38p
7484 63p
7485 60p
7486 18p
7489 1.70
7490 20p
7491 35p
7492 25p
7493 24p
7494 24p
7495 34p
7496 34p
7497 85p
74100 80p
74104 50p
74105 55p
74107 20p
74109 25p
74110 29p
74116 50p
74118 53p
74119 57p
74120 59p
74121 25p
74122 30p
74123 34p
74125 30p
74126 29p
74128 35p
74132 29p
74136 27p
74141 55p
74142 1.75
74143 1.95
74144 1.95
74145 38p
74147 89p
74148 55p
74150 49p
74151 35p
74153 35p
74154 49p
74155 40p
74156 40p
74157 30p
74159 75p
74160 40p
74161 40p
74162 40p
74163 40p
74164 40p
74165 40p
74166 48p
74170 1.17
74172 2.50
74173 48p
74174 54p
74175 49p
74176 39p
74177 45p
74178 68p
74180 40p
74181 1.15
74182 55p
74184 90p
74185 90p
74186 4.69
74188 2.50
74190 45p
74191 45p
74192 45p
74193 45p
74194 40p
74195 40p
74196 40p
74197 48p
74198 77p
74199 77p
74221 53p

74LS00 11p
74LS01 11p
74LS02 11p
74LS03 12p
74LS04 12p
74LS05 12p
74LS08 12p
74LS10 12p
74LS11 12p
74LS12 12p
74LS13 19p
74LS14 22p
74LS15 14p
74LS20 12p
74LS21 12p
74LS22 12p
74LS27 12p
74LS28 14p
74LS30 12p
74LS32 13p
74LS33 14p
74LS37 14p
74LS38 14p
74LS40 12p
74LS42 28p
74LS47 35p
74LS51 14p
74LS54 14p
74LS55 14p
74LS73 18p
74LS74 18p
74LS75 18p
74LS76 18p
74LS78 18p
74LS80 1.20
74LS83 33p
74LS85 39p
74LS86 16p
74LS90 22p
74LS92 25p
74LS93 24p
74LS95 36p
74LS96 50p
74LS107 20p
74LS109 23p
74LS112 20p
74LS113 22p
74LS114 22p
74LS122 25p
74LS123 34p
74LS124 89p
74LS125 24p
74LS126 25p
74LS132 33p
74LS136 24p
74LS138 24p
74LS139 23p
74LS145 70p
74LS147 99p
74LS148 69p
74LS151 30p
74LS153 39p
74LS154 79p
74LS155 29p
74LS156 36p
74LS157 27p
74LS158 28p
74LS160 32p
74LS161 35p
74LS162 35p
74LS163 35p
74LS164 40p
74LS165 50p
74LS168 84p
74LS169 85p
74LS170 70p
74LS173 55p
74LS174 39p
74LS175 39p
74LS181 88p
74LS183 1.20
74LS190 36p
74LS191 36p
74LS192 36p
74LS193 37p
74LS194 32p
74LS195 32p
74LS196 45p
74LS197 48p
74LS221 50p
74LS240 55p
74LS241 56p
74LS242 55p
74LS243 55p
74LS244 55p
74LS245 70p
74LS247 55p
74LS248 55p
74LS249 55p
74LS251 30p
74LS253 32p
74LS257 29p
74LS258 33p
74LS259 55p
74LS261 99p
74LS266 18p
74LS273 53p
74LS275 1.25
74LS279 30p
74LS280 95p
74LS283 40p
74LS289 4.70
74LS290 45p
74LS293 40p
74LS295 75p
74LS298 79p
74LS299 1.40
74LS323 1.55
74LS324 1.45
74LS325 2.96
74LS326 2.30
74LS327 2.30
74LS347 95p
74LS348 88p
74LS352 79p
74LS353 79p
74LS362 7.25
74LS365 29p
74LS366 29p
74LS367 29p
74LS368 29p
74LS373 59p
74LS378 58p
74LS386 1.14
74LS390 46p
74LS393 42p
74LS395 89p
74LS396 1.90
74LS398 2.70
74LS399 1.55
74LS445 99p
74LS490 2.20
74LS540 1.60
74LS541 99p
74LS640 1.69
74LS641 1.69

4000 10p
4001 10p
4002 11p
4006 49p
4007 15p
4008 32p
4009 24p
4010 24p
4011 10p
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4543 65p
4553 2.25
4555 35p
4556 35p
4560 1.40
4566 1.40
4569 1.59
4584 39p
4585 79p

LOGIC

CPU's
1802 7.00
2650A 11.99
6502 3.47
6800 2.25
6802 2.45
6809 6.24
8035 3.49
8060 10.90
8080A 2.30
8085A 3.49
SCMP1 17.06
Z80A 2.95

MEMORIES
2114 (200ns) 93p
2532 3.60
2564 11.95
2764 7.75
2708 2.25
2716 (5V) 2.10
4116 (200ns) 77p
4118 3.25
4164 3.95
5101 (450ns) 1.89
5204 7.50
6116 3.85
6514 3.30
6810 1.15
7489 4.20
74189 4.00
74LS289 3.25
74LS188 2.25
74LS287 3.05
74LS288 2.25

MISC LOGIC ICs
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ADC0816 14.90
ADC0817 10.06
AY5 2376 5.90
INS1671 20.90
INS1771 20.00
RO2513 C 6.99
RO2513UC 7.50
SAA5000 3.00
SAA5010 7.10
SAA5012 7.10
SAA5020 5.50
SAA5030 9.00
SAA5040 15.00
SAA5041 15.00
SAA5050 8.50
SAA5052 8.50
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8T26 95p
8T28 1.20
8T95 85p
8T97 85p
81LS95 90p
81LS96 1.20
81LS97 90p
81LS98 1.20
6522 3.19
6532 6.95
8154 9.42
8155 3.50
8212 1.10
8216 99p
8224 1.05
8226 2.47
8228 2.20
Z80ACTC 2.60
Z80ADART 5.60
Z80ADMA 6.70
Z80APIO 2.69
ZN425E8 3.39

VOLTAGE REGS

Positive 100mA
78L05A 26p
78L12A 26p
78L15A 26p
78L24A 30p
1 Amp TO220
7805T 39p
7812T 39p
7815T 39p
7824T 39p
Negative 100mA TO92
79L05 59p
79L12 59p
79L15 59p
1 Amp TO220
7905T 44p
7912T 44p
7915T 44p
7924T 44p

ZIF SOCKET

24 Pin 4.35

SWITCHES

Toggles (Mini)
SPST 49p
SPDT 55p
DPDT 69p
DPDT C off 85p
4PDT 2.75

PE VOLUME 19 No. 5 MAY 1983

PE EDUCATION

THE DoI recognises the value of PE projects in the educational environment! Well that might be a bit strong, but it is a fact that the Department of Industry is proposing a scheme to give robots to schools. In this country there are three companies making suitable small robots and now two of them, Powertran Cybernetics and Colne Robotics, have been involved with publication of robot designs in this magazine. In fact we have now published four designs for robots available from Powertran.

PE's commitment to education goes without saying and just as we were at the forefront of microprocessor learning and the development of personal computing, with publication of the UK101, we are also keeping up the pressure with a continuing involvement in robotics. This issue carries the first part of the highly educational project Zeaker, designed by David Buckley and for which Colne Robotics will be marketing kits.

BASIC PRINCIPLES

The schemes to give school children hands on experience, first of computers and now possibly of robots, are to be applauded but we begin to wonder if in its haste to help youngsters the Government is not failing to teach the technology behind these developments—electronics. It's all very grand to educate our youngsters to be aware of developments, to be able to use them and to appreciate the benefits they bring, but much of the wealth of industrial countries is based on the development and production of these very items that can assist the industrial world. We must never become so reliant on developments that we forget the basic principles of electronics on which they are built.

It is perhaps time to encourage the teaching of electronics in the way we now do computing lest this fundamental is trodden underfoot in the rush to keep up with the new developments it spawns. Computing and robotics are interesting and exciting but many PE readers can vouch that the experience is heightened by construction and understanding of the equipment in use. Such deep involvement in the tool being used also leads to new ideas and to the ability to fully understand limitations and develop ways to overcome them by basic design.

INNOVATION

We must make sure our country continues in the field at which it is best—innovative design in every area. Our software engineers are achieving a worldwide reputation for excellence, Clive Sinclair's achievements need no underlining and we are up with the rest in development of robots. We must not throw all this away by simply teaching our children how to use these tools and not providing them with sufficient basic knowledge of electronics and engineering to make them want to invent and develop the next generations of hardware.

Computers are not blessed with innovative thinking, they can only help achieve an end product from the basic ideas. One thing you can be sure of, PE will continue to thrive on ideas of a fundamental nature—even if these fundamentals do get overlooked elsewhere from time to time. We will also continue to employ these ideas in the design of equipment which is applicable to modern systems, be they computers, robots or whatever else comes along.

Mike Kenward

Technical *and* **Editorial** *queries and letters (see note below) to:*
Practical Electronics Editorial,
Westover House,
West Quay Road, Poole,
Dorset BH15 1JG
Phone: *Editorial* Poole 671191

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

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

Letters and Queries

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

Components and p.c.b.s are usually available from advertisers; where we anticipate difficulties a source will be suggested.

Back Numbers

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

Binders

Binders for PE are available from the same address as back numbers at £4·60 each to UK or overseas addresses, including postage and packing, and VAT where appropriate. Orders should state the year and volume required.

Subscriptions

Copies of PE are available by post, inland or overseas, for £13·00 per 12 issues, from: Practical Electronics, Subscription Department, Oakfield House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH. Cheques and postal orders should be made payable to IPC Magazines Limited.

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

...NEWS &

Clef Products...

Kits-Update Information

It is not always clear from the advertising that when specialist Kit Suppliers make a long term commitment to PE projects they are able to capitalise on constructor feedback to make modifications in specification or ease of construction. Some of these changes can be very minor but add considerably to the value of the final unit. This is particularly true of Clef Products who have recently provided the following update information on three of their popular musical projects.

MASTER RHYTHM: The facility to vary both tone colour and level of the instruments in this fully programmable Drum-Machine is one of the factors which continue to make the PE Master Rhythm very competitive with any of the commercial units available today. This feature has been extended by incorporating access holes, with identification, into the bottom of the case to give rapid E.Q. for varying situations and musical requirements. Following publication of the PE Bandbox a 7 pin DIN socket was fitted to the front of the Master Rhythm to link the two units and to provide external connection of start, stop, clock, programmed pulse etc., to give sequencer drive and footswitch operation. The complete Master Rhythm Kit incorporates both these changes and costs £79.

BANDBOX: The heart of this unique *"Backing Band"* is a 6502 based Microcontroller, which has allowed specification improvements to be developed purely in software, i.e. by relatively cheap replacement of the Monitor EPROM integrated circuit. Existing customers are notified when a new facility becomes available and around 80% take advantage of the offer to part exchange the old EPROM, at a cost of around ten pounds.

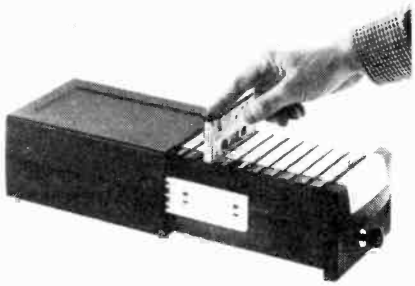
MICROSYNTH: Allan Bradford, the designer of the Microsynth, had made various models of his basic concept, up to four octave compass, and in conjunction with Clef it was decided to adopt a 30 note format as the standard for the Kit. Apart from the musical advantage, this allowed the p.c.b. to be extended in length to include the power supply giving a single board construction. At the same time the front panel layout was then able to accommodate the overall level control and preset adjustments for Line and Headphone outputs. Finally a Keyswitch similar to the principle used in the Clef Electronic Piano range was included giving a further simplification of construction.

Full details on the above can be obtained from Clef Products (Electronics) Ltd., 44A Bramhall Lane South, Bramhall, Stockport, Cheshire SK7 1AH. 061-439 3297.

CASSETTE FILING SYSTEM

For those of us who like things neat and tidy here's a drawer system for storage of cassettes. The Fischer C Box Drawer Unit is an easily accessible storage facility for data tapes containing long term information or games etc.

The cassette rests in a spring loaded box that opens at the touch of a button and incorporates splined hubs to prevent slackening of the tapes. There are ten individual boxes with easy change labels housed in each drawer unit, which can be stacked at the user's convenience.



Two designs are available: standard and deluxe (lockable) at £17·50 and £19·50 respectively inc VAT and p&p. Artur Fischer (UK) Ltd, 25 Newtown Road, Marlow, Bucks, SL7 1JY (06284 72882).

LITESOLD Soldering Systems

Litesold have modified their LE40 24 volt in-handle electronically controlled iron, to incorporate proportional band temperature control. Power to the heating element is only fully on or off outside a narrow temperature band centred on the set value. Within this proportional control band, power is supplied in regular pulses of equal interval, but of a length which varies according to the difference between the 'actual' and 'set' temperatures. At the set temperature, 'on' and 'off' periods are equal. Below this temperature the 'on' periods become progressively longer, and above it, progressively shorter, until the limits of the proportional band are reached, when power is continuously on or off. This feature provides much improved control, without temperature swing or overshoot.

External access is provided to the temperature adjustment, which can be set to any value between approximately 280–420°C. Temperature stability around the set point is typically within ±2°C.

The iron is available complete with a power unit for £58·50 inc. VAT.

Litesold have also recently introduced a complete soldering/de-soldering kit for the electronics hobbyist. The kit is centred around a high efficiency 18 watt mains iron, constructed to latest electrical standards, and fitted with a 3·2mm copper bit. There are also two alternative bits included, of 1·6 and 2·4mm. The kit also includes a 3 metre reel of 18 s.w.g. flux-cored solder, stainless steel tweezers, three double-ended soldering aids and a reel of de-soldering braid. This provides all that is required for soldering and de-soldering on almost any electronics project, and is ideal for beginner or expert. The kit comes in a clear PVC wallet, and is available direct from Litesold at a very special mail order price of £14·55 inclusive of postage and VAT. Light Soldering Developments Limited, 97/99 Gloucester Road, Croydon, Surrey, CR0 2DN. (01-689 0574.)

MARKET PLACE

'SCAMP'

A flexible, automatic manufacturing facility which can machine batches of work in three days where conventional manufacture takes eight weeks, has been built using joint government and industry finance. The facility is flexible in that it can be reprogrammed to carry out virtually any batch turning operation.

The parts (along with their blanks) shown in the photograph, were machined by the FMS (Flexible Manufacturing System) called Scamp. This completely automated production line utilises computer controlled turning, grinding and milling machinery, serviced by 600 Fanuc robots which remove the job pieces from a conveyor belt. The factory is manned by three engineers.

The plant is not in Germany, nor Japan, but here in the UK, and it is claimed to be a first. Scamp was developed and installed by Scamp Systems of Colchester, Essex, the home of Colchester Lathes, whose machines form much of the production line. A complex perpetual conveyor system, based on rollers, incorporates gates for controlling the queueing of work pieces. These pieces are conveyed on, and identified by binary coded pallets. Automatic Vision Orientation fixtures optically observe and

orientate the metal blanks correctly for insertion into cutting machinery. The whole process is under the control of a pair of Systime Series 5000E computers.

Scamp has overcome the majority of machine queueing problems associated with automated production. Department of Industry sponsorship was necessary because of the extremely high capital cost of the installation, which would not amortise itself on purely commercial grounds. However, the cost of robotics and electronics continues to fall, whilst the cost of labour continues to rise. It is the DoI's intention that their support scheme will spawn expertise in readiness for the crossover point.

£1000 REWARD

Yes £1000 has been offered as a reward for the recovery of goods, and apprehension of thieves who stole sound equipment from Aura Sounds Ltd in February. The company based in Purley, Surrey, lost several expensive items, the most important of which was a computer controlled rhythm unit known in the trade as the Wersimatic CX 1. The company who are the sole importers of Wersi Organs in the UK say the thieves could not have stolen a more easily traceable item.

The CX 1 pictured is the only one of its kind in the UK at the moment, and it is virtually a prototype, being one of only ten in the world.

MICRO-PROFESSOR COMPETITION

In our Micro-Professor Competition, readers were invited to place eight features of a microcomputer teaching aid in the order, they considered, warranted the greatest consideration.

Having considered all entries, the judges chose a number of identical attempts listing the following selection as being the best received. 1—C; 2—E; 3—K; 4—A; 5—B; 6—D; 7—L; 8—J.

All tying competitors took part in a postal eliminating contest from which the first prizewinner emerged as Mr. K. Lambert, of Halesowen. Mr. Lambert wins a full Micro-Professor system comprising microcomputer, EPROM programming board, and Speech Synthesiser board.

There were also four second prizewinners who each receive a Micro-Professor MPF-1B microcomputer. These winners are: Mr. D. Brown, Bristol; Mr. E. Radley, Liverpool; Mr. S. Rubie-Todd, Bristol; and Mr. D. Thursby, Sutton.

Our thanks to all who took part, and to Flight Electronics for supplying the prizes.

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.

Intersil ▶ The ICL 7137 is designed to interface to a l.e.d. display, and consumes only 200μA internally. It gives auto-zero to less than 10μV, zero drift less than 1μV/°C, input bias of 10pA max., and rollover error of less than one count. Ideal for economic load-cell, strain gauge and other bridge sensor measurements. A panel meter may be built using only seven passive components and a display. No overrange hangover or hysteresis effects.

▶ The ICL 7115 is a fast CMOS monolithic 14-bit A/D converter which uses successive approximation. Interfacing to a μP is aided by the use of standard Write and Read cycle timing and control. Interface to 8, 12 or 16 bit systems is possible through byte organised, three-state outputs. Resolution is 0·003%, there are no missing codes, conversion takes 40μs, linearity and gain tempco is 1ppm/°C, 4ppm/°C, power consumption is 60W, and no gain or offset adjustment is necessary (0·006% FS). Intersil Datel (UK) Ltd., Belgrave House, Basing View, Basingstoke, Hants.

RCA ▶ A low consumption BiMOS op amp featuring bandwidth/slew rate programmability, the CA3440 has two stages; a high gain (100dB) front end and a low impedance f.e.t./bipolar output stage. Input circuit features gate-protected PMOS transistors. A phase compensation technique allows stable operation in unity-gain follower configuration.

▶ Ultra high speed, high current rectifier family. Reverse recovery time of the RUR-810 is less then 35ns. Available in TO-220AB packages, they are rated at 8A forward current, with PIV of 200V. RCA Ltd., Lincoln Way, Windmill Road, Sunbury-on-Thames, Middx.

Burr Brown ▶ A new f.e.t. input TO99 op amp, the OPA 105 requires an input bias of less than 1pA. Guaranteed initial offset of 250μV, with a drift of 2μV/°C.

▶ Two high linearity voltage-to-frequency converters called the VFC62 and VFC320. Output pulse train repetition rate is proportional to Vin. They can also be used to convert a pulse train frequency back into a proportional voltage output! Linearity is ±0·005%. Full scale drift is 50 ppm of FSR/°C. Low noise, precision voltage reference, called the REF101, provides +10V ±5mV at 10mA, adjustable over ±2%. Noise is 100μV pp. Burr Brown, Cassiobury House, Station Road, Watford WD1 1EA.

DMM TEMPERATURE SENSOR

Anyone who has access to a digital multimeter can now use it as a versatile wide range temperature measuring instrument using standard type K thermo-couples, by adding the DVM/TC Interface Unit.

This new device has a temperature range of −50°C to +1100°C and incorporates automatic cold junction compensation. Thermocouples are attached through a miniature compensated socket. A basic thermocouple, mating plug and battery are supplied as standard with this instrument. The output of 1mV per degree centigrade is via a 0·75 metre coiled lead fitted with 4mm plugs. Long term stability is excellent and the low battery drain allows it to be used for continuous monitoring if necessary. Since the accuracy is not affected by the output loading (the DMM), it may be alternatively used to interface a low output impedance instrument such as a chart recorder. Priced at £42 including VAT and p&p, this interface unit is available from, Graham Bell Instrumentation, PO Box 230, 39 Derbyshire Lane, Sheffield S8 0TH (0742 582370).

INFRA-RED CONTROLLER

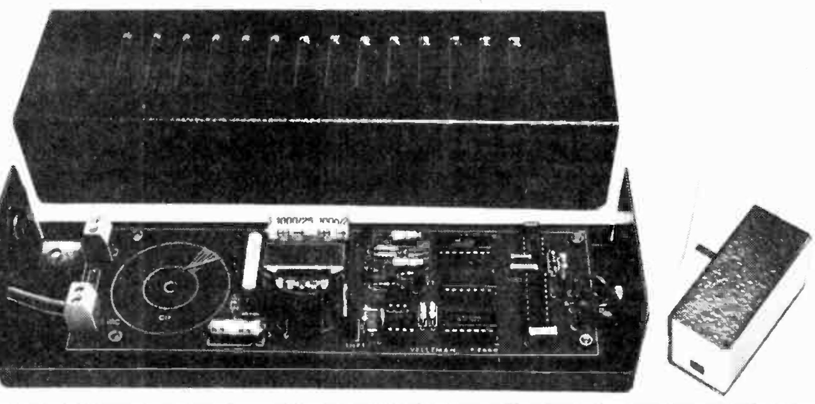
A two channel infra-red (IR) remote controlled light dimmer is now available in kit form, with separate transmitter and receiver units.

The receiver, designed to be controlled by its matching transmitter, gives independent remote on/off and variable control functions. Applications are extremely varied and include the automatic adjustment of both room temperature and lighting. In use, either of the two channels may be assigned to any one receiver, or two identical kits may be assigned to different channels and controlled individually by only one transmitter.

The receiver kit, supplied complete with housing, has a 240Va.c., 50Hz power supply and current consumption is 25mA maximum in the standby mode with a maximum control output of 300 watts. Reaction times from zero to maximum and maximum to zero are 7 seconds, with noise immunity ensured.

The transmitter, designed to operate an IR light dimmer, will control two receivers, with ON/OFF and dim commands. Specifications include bi-phase coded modulation, CMOS technology and power l.e.d. outputs, giving 15 mw/cm² maximum beamed power. Beam deflection is 30° with a reflector and 60° without.

The transmitter is priced at £15 plus VAT and the receiver at £33·60 plus VAT, both items require £1 p&p and are available from, Electronic & Computer Workshop Ltd, 171 Broomfield Rd, Chelmsford, Essex. (0245 62149).



The Open School

Many otherwise mature and competent people are nervous of trying a course in computing. The 'Open Computing School' at South Bank Polytechnic near Waterloo and Elephant and Castle, have developed courses designed to take complete novices to a position where they can design their own useful computer programs. Nor do they have to take a week off or spend a fortune. The Poly believes it is a unique type of service, allowing people who cannot commit themselves to a fixed timetable to work at their own pace, during the day or in the evening. The price is kept low to attract those who are paying their own fees, but the emphasis is on use in administrative work.

A number of managers and employers join in order to get an appreciation of what a microcomputer might do for their organisation, and clerical workers join with the object of improving their career prospects. Other students include engineers, teachers, translators and social service workers. However quite a number of students have no vocational interest but come just because they feel that they ought to keep up with the technological revolution. Some think it will help with the children's homework.

The Open School runs continuously through the college year. Special one-day appreciation courses can be provided for organisations on request. The introductory course costs £45. Write to Polytechnic of the South Bank at Borough Road, London SE1 0AA or Tel. Jack Flatau or Iris Mason on (01-928 8989) ext 2410.

Mobile Satellite

The advantages of having a portable satellite ground station for television are numerous, and the 'Beeb' are paving the way in seeking them out. Their 3M diameter, trailer mounted disc has been on many UK locations since its introduction in 1981. Its first overseas adventure was coverage of the UK team matches in the world cup in Spain last year.

More recently however it was borrowed by the Italian State Television Service for use at the International Slalom Ski event at Bormio, Italy. The ground station was used, from this difficult outside broadcast site, because a terrestrial network would have required five microwave radio links. Pictures of excellent technical quality were transmitted via satellite to the fixed ground station at Milan for local and European distribution. The mobile satellite ground station was built by BBC research engineers at Kingswood Warren in Surrey.

MARKET PLACE

Briefly...

Alone, all alone on the bridge of the Kinokawa Maru, a Japanese 177,000 tonne ore/coal carrier, stands the commander. The ship appears deserted, like the Marie Celeste. The commander talks to himself, seemingly; but the ship answers back with a metallic, synthesised human voice:

"Full Ahead!" resounds the instruction.

"Full Ahead!" echoes the vessel in confirmation.

The engine builds up to full power with no further human involvement.

A handful of years ago this *could* have been the stuff of science fiction, but now it cannot. For fiction it is no longer. The tide of events in technology has lead Sumitomo Heavy Industries to build what they claim to be the first ship in the world which is capable of being manoeuvred at sea by one man.

The Kinokawa Maru is no ordinary ship, for not only is its main engine speed controlled by electronics with voice recognition and synthesis, but it is designed to consume 45% less energy per cargo tonnage. The overall design significantly reduces its owner's fuel costs, whilst sparing its crew a number of chores.

The control system's speech recogniser has a capacity of 40 words, which match the voice pattern of an authorised user. It will ignore all other voices. Its phoneme type synthesiser has a fixed vocabulary of 480 words, and a programmable vocabulary of 1000 words.

With rising transport costs truncating shipping activities worldwide the Japanese look set to stay *full ahead* as a major shipbuilding nation. Each time the Kinokawa Maru puts to sea it leaves in its wake a message for the next generation of ship. To survive the swell of competition, this will need a level of automation that includes remotely controlled auxiliary machinery too, reducing still further the crew's workload—*and the crew!*

● ● ● ●

The Isle of Wight is to be the recipient of Britain's first undersea optical-fibre link. Manufactured by STC at a cost to British Telecom of £600,000, the cable will link Portsmouth with Ryde on the Wight. Due to go into service in 1985, the 23km cable will comprise two 140M bit "bothway" optical systems based on STC's monomode technique, which means that no repeaters will be necessary. The bit rate is equivalent to 1,920 two-way telephone conversations, although the Island's link-up will have the capability to transfer raw data, text and graphics too.

In contrast to the more common 850nm wavelength light source, the Wight connection will use 1300nm lasers. The monomode fibres give rise to less loss and signal scattering than multimode, allowing combined landline and underwater repeaterless transmission.

It is expected that in 1988 an intercontinental optical-fibre link will go into service, a contract for which is to be awarded in November this year.

● ● ● ●

The first Motorola 68000 microprocessor to be made in Europe was produced at East Kilbride, Scotland, in February. The device was produced on their pilot production line at their existing plant; production will be transferred to the new facility (module III) when its construction is complete.

As a 32:16 bit microprocessor it is gaining popularity and is apparently a favourite with software writers, making it the most written for device of its kind. The design team had only one prerequisite in common say Motorola and that was, none of them had been involved in the design of previous older processors.

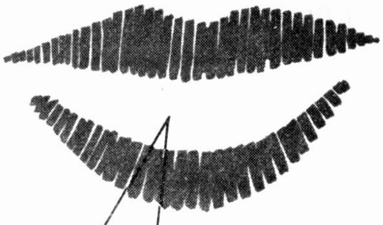
Aimed at European and Japanese markets (yes Japanese) the 68000 will find its home in systems such as personal computers, business machines, robotics and telecommunications as well as energy and medical fields. Motorola has been producing silicon chips at East Kilbride since 1972.

Countdown...

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

Circuit Technology April 18–20. Kensington Ex. Cntr., London. **J2**
All Electronics Show April 19–21. Barbican Cntr., London. **E**
Numerical Control (Ex. & Conf.) April 19–21. Wemb. Conf. Cntr., London **D3**
Fibre Optics April 19–21. Porter Tun Rooms, The Brewery (!) Chiswell St., London EC1. **E**
International Materials Handling April 19–26. Earls Court. **I**
International Packaging Exhibition April 25–29. NEC B/ham. **I**
HEVAC (Heating, Ventilation & Air Cond.) Apr. 26–28. Barbican. **I**
Scottish Personal Computer World Show April 16–18. MacRobert Pavilion, Ingliston, Edinburgh. **M**
Midland Computer Fair April 28–30. Bingley Hall, B/ham. **Z1**
Biotech May 4–6. Wembley. **O**
Micro City May 10–12. Bristol Exhibition Complex. **F3**
The Business Computer Show May 10–12. Wembley. **O**
Cable (Conf. & Ex.) May 10–12. Wembley Conf. Centr., London. **O**
Defence Components Expo May 10–12. Metropole, Brighton. **I**
Compec Scotland May 17–19. Kelvin Hall, Glasgow. **Z1**
Welsh Amateur Radio, TV & Electronics Rally May 22. Barry Memorial Hall, S. Glam. **C**
Computers In The City (conf. & ex.) May 24–26. Barbican. **O**
Business Telecom May 24–26. Barbican. **O**
International Word Processing May 24–27. Wembley Conf. Cntr. **Z**
Motradex May 25–27. Sandown Exhibition Centre, Surrey. **Z1**
East Suffolk Wireless Revival May 29. Ipswich Civil Service Sportsground. **V1**
Russian Holography June–Sept. Inc. Light Fantastic Gallery. **A8**
Semlab June. Olympia. **I**
IBM Productivity (conf. & ex.) June 14–16. Tara Hotel. London. **O**
Tectronica June 14–17. Earls Court. **I**
The Computer Fair June 16–19. Earls Court. **Z1**
Compec North June 21–23. Belle Vue, Manchester. **Z1**
Transducer/Tempcon June 28–30. Wembley Conf. Cntr. **T**
Leeds Electronics Show July 5–7. University. **E**
Electronic Hobbies Fair. The best event ever for the UK electronics hobbyists comes round for the second time from October 27th to 30th at Alexandra Pavilion. Make a date now and watch these pages for EHF news each month. **Z1**

A8	Holographic Exhibitions ✆ 01-826 6423
C	Reg. Rowles ✆ Cardiff 565656
D3	British Numerical Control Soc., London
E	Evan Steadman ✆ 0799 22612
E2	BARTG 89 Linden Gdns., Enfield, Middx.
F	Tomorrow's World Exhibitions, Bristol
I	Industrial Trade Fairs ✆ 021 705 6707
M	Montbuild Exhibitions ✆ 01-486 1951
O	Online ✆ 09274 28211
T	Trident ✆ 0822 4671
Z	BETA Exhibitions ✆ 01-405 6233
Z1	IPC Exhibitions ✆ 01-643 8040



PART 2 READOUT INTERFACE BOARD

Digit Talker

A. Wiggin

LAST month the voice synthesis board was described. The board holds a vocabulary of 204 words each of which could be selected by means of a microcomputer or manually operated switches. When used with a computer the vocabulary could be built into sentences, thereby producing an interesting personality for the machine.

There are, however, many applications in which speech is a valuable asset but the expense and sophistication of a microcomputer is not warranted. Such applications are found in the car, home and factory and include speaking the digits on a panel meter or clock, delivering short messages such as INTRUDER AREA ONE, DANGER HIGH PRESSURE etc. or even providing a robust, lightweight alternative to a B.T. teleprinter or VDU.

Until recently, speech could only be reproduced by electro-mechanical systems using magnetic tape or plastic discs. But since the introduction of cheap, reliable large-scale integrated circuits it has become possible to model the human voice using a Linear Predictive Coding algorithm. This algorithm is made up of a random signal generator which forms the basic fricative and plosive sounds, a variable frequency signal generator which is used to produce different pitch sounds and a digital filter which, when configured by a computer in any number of high and low pass, band pass and band stop configurations, moulds the words themselves. The use of the algorithm reduces the minimum amount of memory needed to produce one second of speech from 96,000 bits to 1,100.

VOICE SYNTHESIS BOARD

The basic voice synthesis board consists of a 128K, VM61001 Voice ROM connected to a TMS 5100 Voice Synthesis Processor which in turn drives an audio output stage. A 640kHz clock is produced by RC network which is divided down to give a ROM clock of 160kHz. The 6 control lines which program the board consist of 4 data lines (CTL1-CTL4) and 2 clock lines. All the address data and instructions are loaded via these 6 lines.

Since 18 bits are needed to address one location in a 128K memory, and there are only 4 data lines, then 5 nibbles of 4 bits are loaded sequentially to form each address. Before each nibble is accepted by the processor it must be preceded by a Load Address instruction, thereby commanding the processor to forward the address to the memory over the 4 bit internal bus. The control signal M1 is brought high by the processor during a Load Address instruction which gates the CTL lines directly to the internal bus.

The memory has its own internal register, and can be accessed either in a direct or indirect mode. If, after loading an address, a direct instruction is used, followed by a Test Talk and Speak instruction, then data held in this memory address will be passed to the processor in a serial form via the ADD 8 line of the internal bus. The internal address register will automatically increment, and the processor will request another bit of data by toggling its M0 line. The sequence will repeat until the last series of data instructs the processor to stop.

If, however, a Read and Branch instruction is used, followed by a Speak instruction, then the address loaded via the CTL lines will be taken as the address of the Look-Up table in which is held the address of the start of the data string. The memory then loads the latter address into its register and repeats the above sequence.

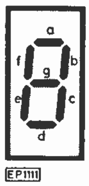
The TMS 5100 receives the speech data from the memory and immediately decodes it. The on-board 10 bit A-to-D converter produces an analogue speech signal from this which is then filtered and amplified by the audio output stage.

INTERFACE CIRCUIT

Fig. 2.3 shows a circuit which will produce speech from the voice synthesis board without the use of a microcomputer. The circuit has been designed to be as flexible as possible. Hence it can be operated with or without an EPROM. When the EPROM is inserted into the circuit it will convert coded data, such as that from a 3 digit, 7 segment display (Fig. 2.1), ASC II terminal or even BCD output, to that needed by the voice board. It can be used to multiply the words in a phrase by sequentially switching the inputs of

No	a	b	c	d	e	f	g	Hex	VSB Code
0	1	1	1	1	1	1	0	7E	02
1	0	1	1	0	0	0	0	30	04
2	1	1	0	1	1	0	1	6D	06
3	1	1	1	1	0	0	1	79	08
4	0	1	1	0	0	1	1	33	0A
5	1	0	1	1	0	1	1	5B	0C
6	1	0	1	1	1	1	1	5F	0E
7	1	1	1	0	0	1	0	72	10
8	1	1	1	1	1	1	1	7E	12
9	1	1	1	1	0	1	1	7B	14

Fig. 2.1. Seven-segment digit to VSB code conversion table for EPROM



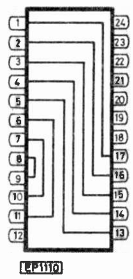


Fig. 2.2. Jumper strip for 2716 EPROM

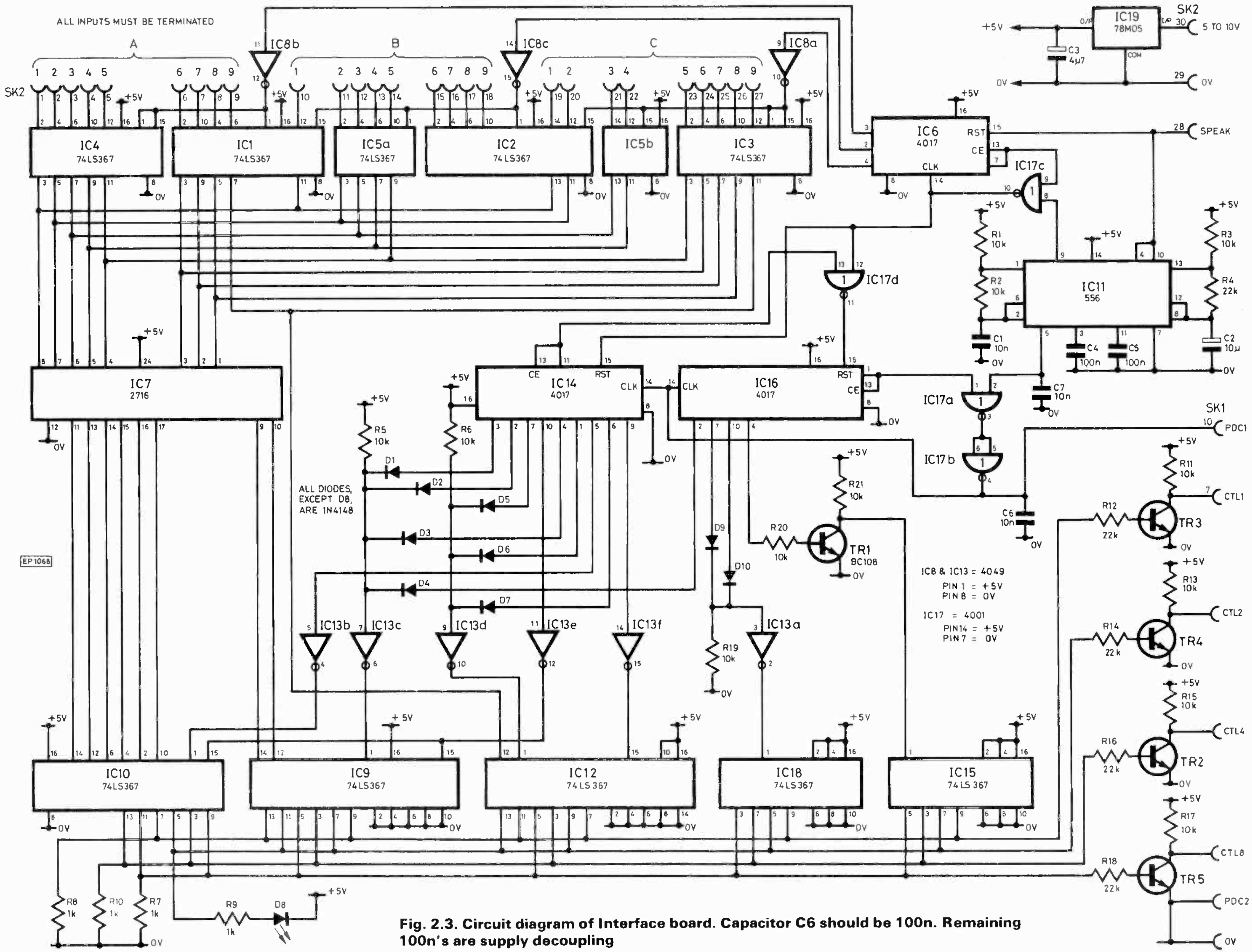


Fig. 2.3. Circuit diagram of Interface board. Capacitor C6 should be 100n. Remaining 100n's are supply decoupling

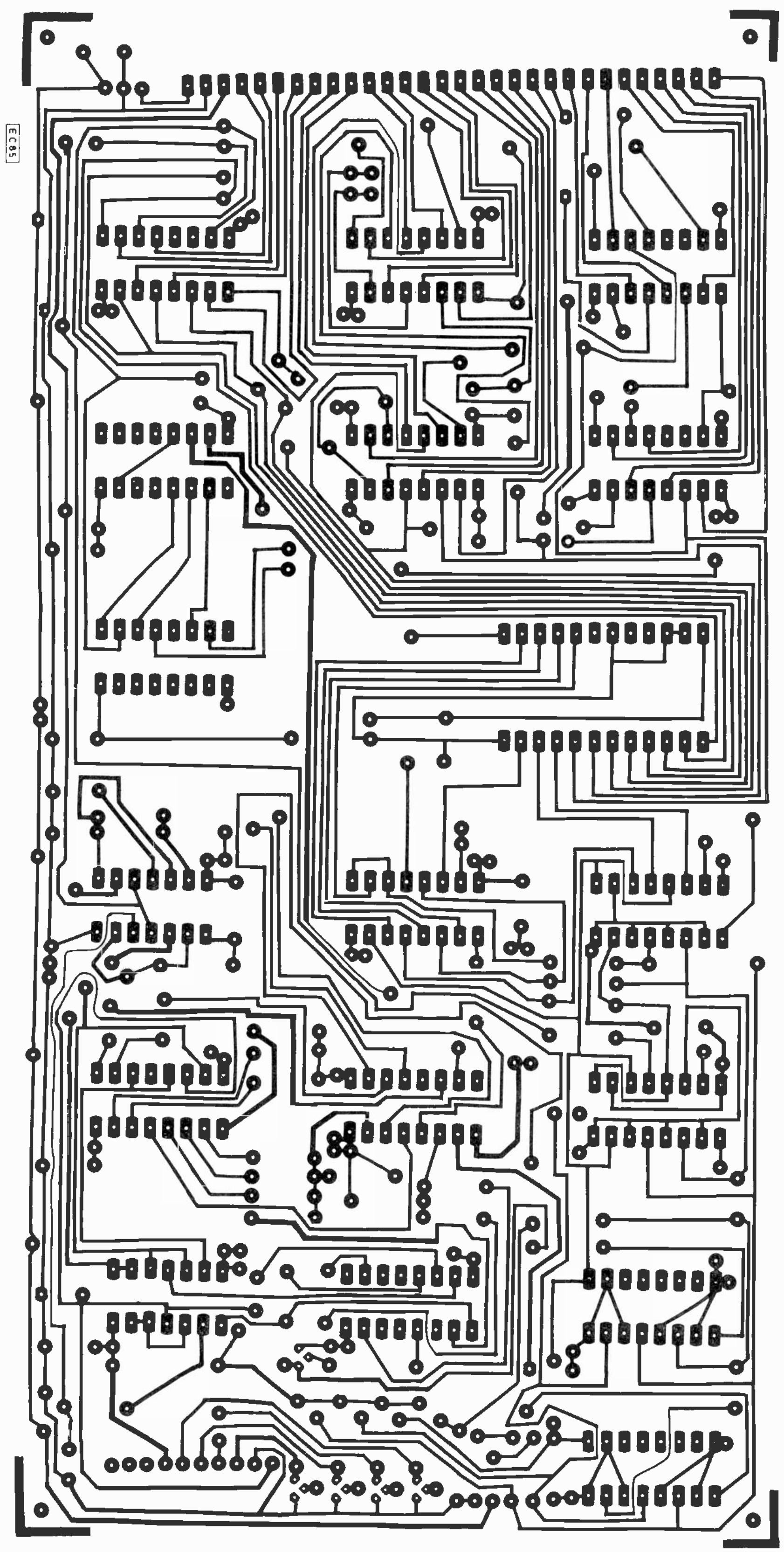


Fig. 2.4. Printed circuit board (actual size)

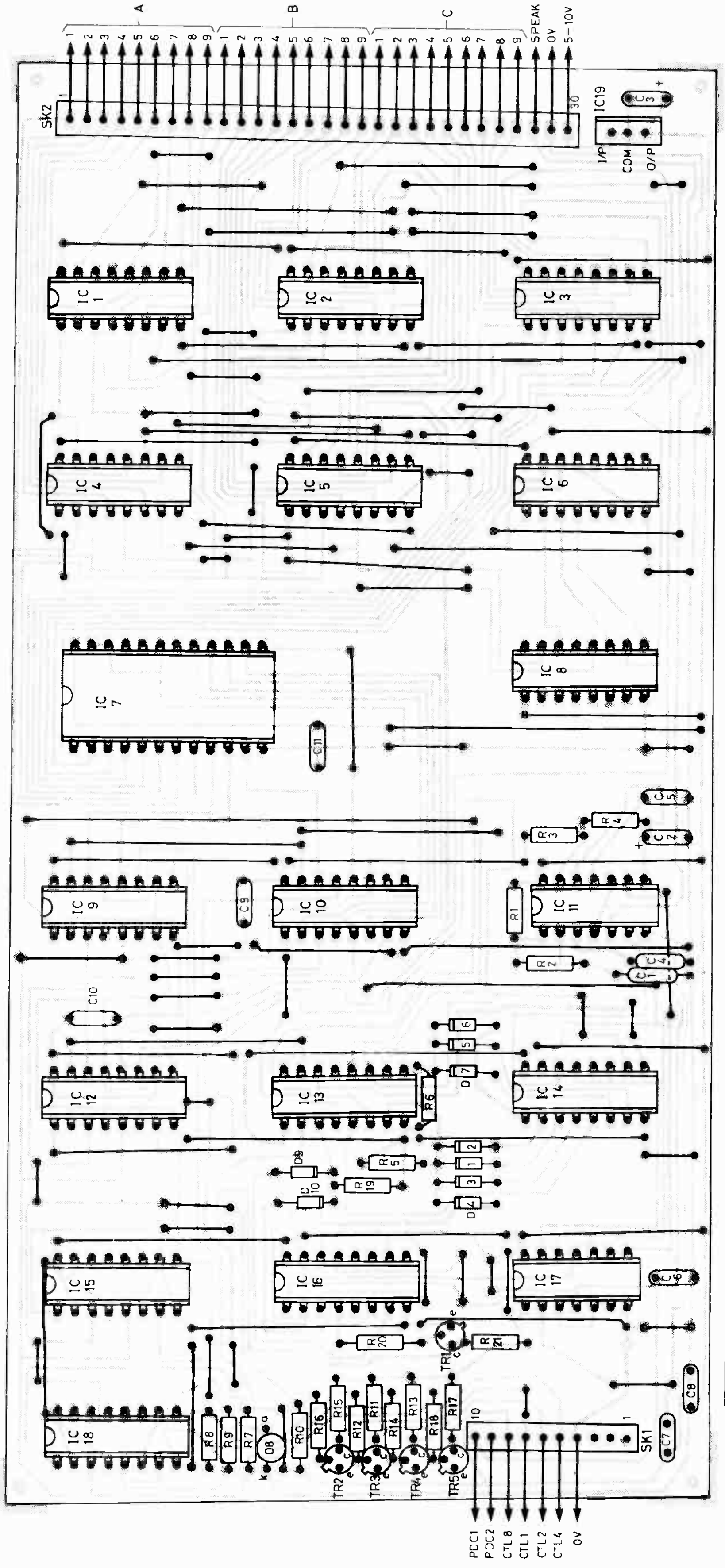


Fig. 2.5. Component layout

FROM READ-OUT TO SPEAK-OUT

a single port to a maximum of 64 words. In addition, three word messages can be formed by linking the EPROM out and switching each input port to give the address data of the respective word. A circuit for the EPROM substitute is shown in Fig. 2.2.

The interface circuit consists of 7 four bit high impedance buffers connected to a 4 bit CTL bus. Each one of the buffers can be latched in turn to the CTL bus by means of two decade dividers which are wired in series. A further 9 bit bus is formed on the input to the board. Data which is present on any one of the three, 9 input ports, can be selected sequentially to form either an address for the code conversion EPROM or, if a jumper strip is inserted in the EPROM socket, the address of the look-up table of the word required. Each one of the 9 bits in all three inputs must be terminated to 0 volts or + 5 volts for the board to operate successfully.

The output from the EPROM is connected to two 4-bit CTL buffers. The remaining four 4-bit buffers on the CTL Bus are wired in such a way that, when they are enabled, they produce the four following instructions:

0000 RESET
0010 LOAD ADDRESS
1100 READ & BRANCH
1010 SPEAK

CIRCUIT DESCRIPTION

When the speak input is brought high, both 555 timers start to run. Timer A runs at a frequency of 10kHz. Timer B can be set to give the rate at which the words are spoken. The first three clock pulses from 555 timer A step the decade counter and enable the 0000 buffer. Hence, three reset instructions are given to the processor. The next clock pulse enables the 0010 buffer which instructs the processor that the following nibble will be an address. The lower nibble from the EPROM is then latched to the CTL bus via its respective buffer. Once it receives a further clock pulse the decade counter is stepped and the 0010 buffer enabled. This is followed in turn by the upper nibble of the EPROM output being loaded onto the CTL bus. The decade counter then enables the 0010 buffer once more followed by the third 2-bit data buffer. The 0010 buffer is again enabled and followed on the next clock pulse by loading the 0000 buffer as data.

The decade counter then enables the 1100 buffer thereby instructing the processor to READ & BRANCH. The next clock pulse latches the 1010 and the processor begins to speak the first word. During this time the l.e.d. is switched on.

The decade counter is then held until the second 555 timer B times out. This steps the input counter IC10 which in turn enables the second 9-bit data port. In addition, the decade counter is reset and the above sequence repeated, thereby producing the second word.

The third word is produced when 555 timer B times out for the second time. This again resets the decade counter and steps the input counter which in turn latches the data present on the third input port onto the input bus.

The input counter is stepped once more, thereby causing it to latch, which in turn inhibits 555 timer B and hence the sequence is halted.

CONCLUSIONS

The voice synthesis board can be used in most applications where speech is needed. It has the capacity to speak phrases of between 3 to 64 words; it can cope with coded input such as seven-segment or BCD, and it can be operated by a microcomputer or simply as a stand alone unit for application in the house, car or factory. ★

COMPONENTS . . .

Resistors

R1, R2, R3, R5, R6, R11, R13, R15, R17, R19, R21	10k (11 off)
R7, R8, R9, R10	1k (4 off)
R4, R12, R14, R16, R18	22k (5 off)

Capacitors

C1, C7	10n (2 off)
C2	10µ
C3	4µ7 elect
C4, C5, C6, C8, C9 C10, C11	100n (7 off)

Integrated Circuits

IC1-IC5, IC9, IC10, IC12, IC15, IC18	74LS367 (10 off)
IC11	556
IC6, IC14, IC16	4017 (3 off)
IC7	2716
IC17	4001
IC8, IC13	4049 (2 off)
IC19	78M05 Regulator

Transistors

TR1-TR5	BC108 (5 off)

Diodes

D1–D7	1N4148 (7 off)
D8	L.e.d.

Constructor's note

Full kits of parts are available from the **Warwick Design Group,** 12 St. Georges Rd., Leamington Spa. (0926 34311) at £24 each. Kits to build the Voice Synthesis Boards are offered at £37.

NEW SERIES

SEMICONDUCTOR CIRCUITS

TOM GASKELL B.A.(Hons)

IN the early days of semiconductor design the variety of components available for general use were fairly limited. Transistors, diodes, and passive devices were predominantly used, and most circuits contained various combinations of these devices. The design emphasis was very much based on the methods and arrangements of interconnecting these devices, and on the passive component values used. Nowadays, the integrated circuit is the dominant type of component, with many circuit designs having no discrete transistors in them at all. Unlike diodes and transistors, however, the performance and operational parameters of an i.c. are often very difficult to specify. The electrical limits of performance must be detailed, of course, but the precise functioning and operation of the device must also be explained. For many i.c.s this explanation requires a number of tables, timing diagrams, and waveform diagrams. As a result, data sheets become very complex and contain a large amount of information which must be thoroughly assimilated before design can begin.

Many readers would like to use new semiconductor devices in their own projects but are daunted by the research necessary to enable them to do so. Initially, a suitable device has to be found, and then the relevant data has to be obtained; if it can't be found in a supplier's catalogue, then from whom? Many people don't have access to professional data services or distributors' information. Even if data has been satisfactorily obtained, it's often written in such a way that it proves difficult to put into practice. This is where we come to your help! This series of "application reports" features different semiconductor devices (mostly integrated circuits) with their pin connections and essential data clearly given. In many cases all the data that's available won't be given since much of it is of little value in the majority of design work and it would take up many pages every month! All the essential data will be given which as a result will be much easier to read and understand. Included will be a comprehensive description of how the device works, how it can be used, hints and suggestions for circuit arrangements, circuit diagrams, and finally a Veroboard layout for a typical circuit. This will give all the information needed to enable you to use the i.c. with confidence in designs of your own, often as a base for a larger project.

RANGE COVERED

The semiconductor devices looked at will cover the whole range of electronics with the exception of very specialised devices such as microprocessors (covered recently by "Microfile"), r.f., microwave, etc. These will range over op amps, audio amps, consumer i.c.s, display devices, encoders, decoders, power supply i.c.s; all these and many more will be covered. Some devices will be very new indeed, giving you access to the very latest technology. Others will be recently introduced or more familiar devices; the aim is to provide a comprehensive and wide ranging service.

Each month just one device or a small family of similar devices will be presented. However, to get the series off to a flying start, we feature two chips this month: an electronic combination lock, the **LS 7225**, and the **SAB 0600** door chime.

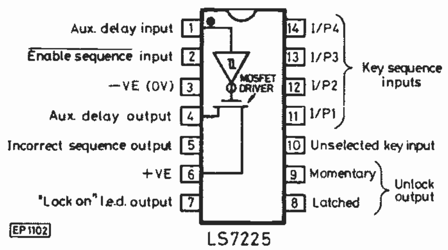
COMBINATION LOCK (LS 7225)

The LS 7225 is a relatively new and very interesting 14 pin i.c. which takes a lot of the effort out of designing an electronic combination lock. It's a monolithic PMOS device, rated at up to 18 volts supply, and has a low quiescent supply current which allows it to run for a very long time on a small battery if required.

It has sequential logic to detect a valid sequence of four key depressions. There are three main outputs of the i.c.; one directly drives a l.e.d. to indicate when the device is in the locked state, a second latches to the on condition (logic 1) when the correct code has been entered, and the third provides a momentary on signal (again a logic 1) when the correct code has been entered. If any "unused" keys are pressed, or if any of the correct keys are pressed out of sequence, an "Incorrect sequence output" of the i.c. is pulsed to logic 1 (i.e. a high level), and no changes occur to the main outputs of the device.

Various enable and delay facilities are also provided to ensure that a delay of several seconds or more is necessary between entering one code and being allowed to enter another one. This helps to prevent a light fingered person from typing in all possible combinations in a very short time! All the inputs have built in pull down resistors to help minimise the external component count. Power on reset is provided to set the i.c. into the "locked" state when power is first applied. Following such an application of power, the first correct sequence entered turns the lock off, then the next correct sequence turns it on again. The two main "unlock" outputs can drive many relays directly, providing that coil resistances of 1k or more are used.

Fig. 1. LS7225 pin out with the aux delay circuitry shown internally. The specification is shown below



Characteristic	Notes	Min	Typical	Max	Units
Supply voltage	No input should exceed supply voltage	4		18	V
Quiescent current (I/P's & O/P's open circuit)	Supply = 5V			20	µA
	Supply = 12V			40	µA
Temperature range		–25		70	°C
"Lock on" l.e.d. output current	Supply = 5V	0·6	1·0	1·3	mA
(Voltage limited to +1·7V)	Supply = 12V	6·5	8·7	11·0	mA
Unlock outputs (Logic 1)	Supply = 5V, O/P = 3V	2·2	3·0	4·1	mA
	Supply = 12V, O/P = 10V	9·0	11·6	14·4	mA
Incorrect sequence output (Logic 1)	Supply = 5V, O/P = 3V	0·5	0·7	0·9	mA
	Supply = 12V, O/P = 10V	2·0	2·6	3·2	mA
Aux. delay output	Supply = 5V, O/P = 3V	0·4	0·6	0·8	mA
	Supply = 12V, O/P = 10V	1·8	2·4	3·0	mA
Load current, all inputs	Supply = 12V, I/P = 0V		6		µA
Key sequence Input 1	Logic 0, Supply = 5V	0		2·0	V
	Logic 1, Supply = 5V	3·5		5·0	V
All other inputs	Logic 0, Supply = 5V	0		2·0	V
	Logic 1, Supply = 5V	4·0		5·0	V

KEY SEQUENCE INPUTS

These inputs are taken to logic 1 (i.e. a high level) by the relevant switches of the switch bank or keypad. Input 1 should be held at logic 1, while 2 is taken to logic 1 momentarily, followed by 3, then by 4. Only after Input 4 has been operated should Input 1 be allowed to go open circuit (or to logic 0); see the timing diagrams, Figs. 4 and 5, for clarification of this. Alternatively, by taking a capacitor from Input 1 to ground, the logic 1 level will be maintained for a short period after the first switch is released, giving a "time window" in which the other switches may be pressed. A 1µ tantalum capacitor will typically give a 4 second delay, which is quite long enough to allow the pressing of the other three switches. Note that this will also result in a delay before any further sequences can be entered; once the capacitor has been charged, it must be allowed to discharge before another sequence is started.

UNSELECTED KEY INPUT

All the unused switches or keys are connected in parallel and taken to this pin. Hence, if any incorrect key is pressed, this pin is taken to logic 1, the sequential logic is reset, and a pulse is fed to the "Incorrect sequence output" pin.

UNLOCK OUTPUTS

The momentary unlock output goes to logic 1 as soon as the correct sequence of switch or key inputs has occurred. It returns to logic 0 as soon as "Key sequence" Input 1 returns to logic 0, either when the first key in the sequence is released, or (if one is fitted) when the capacitor discharges a few seconds later. The latched "Unlock output" also goes to logic 1 as soon as the correct sequence of key inputs has occurred. To reset this to logic 0 (the "system locked" condition), the whole correct sequence must be entered again.

"LOCK ON" OUTPUT

This directly drives an l.e.d. with no need for any external resistor. This is lit when the lock is on, i.e. when the latched "Unlock output" is at logic 0.

Pin 3 is normally at 0V. Pin 6 is the +ve supply, which can be anything from +4V to +18V. As a rule of thumb, try not to go above +15V generally, to guard against any supply voltage fluctuations or noise pushing the voltage above the maximum rating for the i.c. Some capacitors across the supply rails should also be provided for decoupling; in Fig. 2 these are C5 and C6, with R1 and C1 providing further supply decoupling.

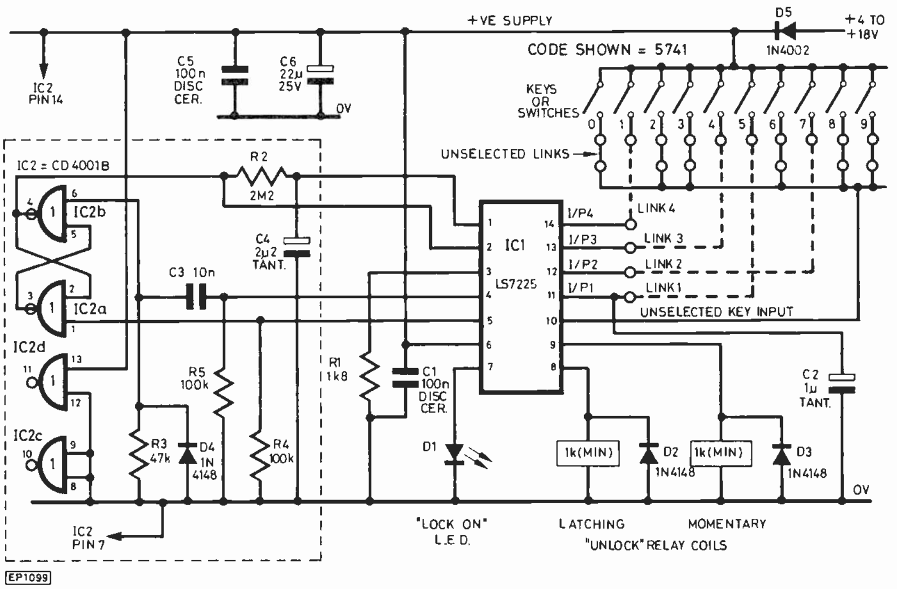
INCORRECT SEQUENCE OUTPUT

This gives a positive going pulse out (to logic 1) when any form of incorrect code sequence is entered. This pulse is extremely short in duration, only 15µs approximately, so be careful how you use it.

ENABLE SEQUENCE INPUT

This input, in common with all the others of the i.c., has a pull down resistor fitted internally, and is normally kept at logic 0 (or open circuit) to allow the system to operate. If it is taken to logic 1, then the sequence detection circuitry is disabled. This can be used in conjunction with the "Aux. delay" facility and the "Incorrect sequence output", to provide a fixed delay (following an incorrect sequence entry) before another attempt at entering the correct sequence is allowed.

Fig. 2. Combination lock circuit. The dotted box gives optional 12s delay between successive codes. If not required connect IC1/2 to 0V. The links should be connected for the required key sequence with the unselected links in parallel



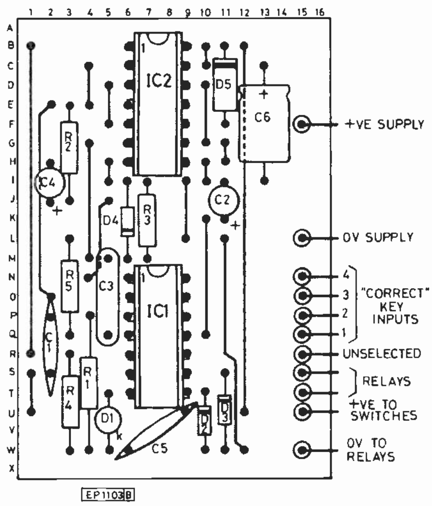


Fig. 3. Veroboard assembly

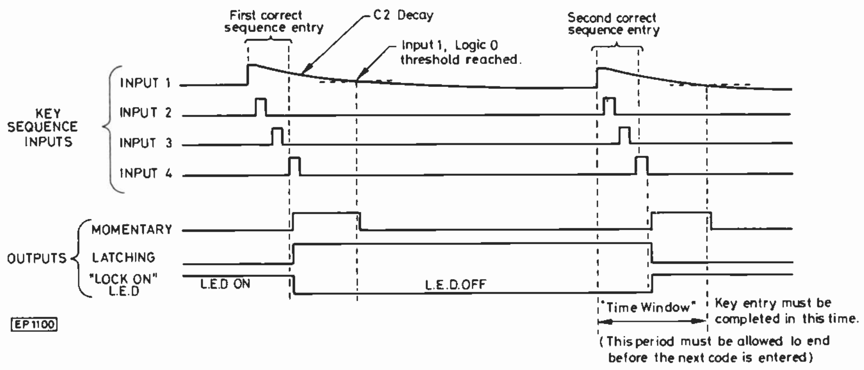
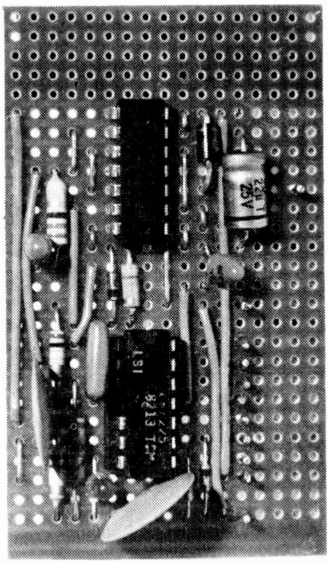


Fig. 4. Timing diagram, correct sequence



AUX DELAY INPUT/OUTPUT

The internal circuitry for this is shown in Fig. 1. When pin 1 is taken high (towards logic 1), the Schmitt trigger inverter's output goes to logic 0, turning on the MOSFET output stage and feeding a logic 1 level to pin 4. An RC timing network can be used to delay any signal fed to pin 1, which is "cleaned up" into a sharp edged logic change by the Schmitt trigger input of the inverter, and fed to pin 4 as just described. See Figs. 2 and 5 for further clarification of how this works in practice.

POINTS TO NOTE

Because of the internal pull down resistors, no external ones are needed except for the "Aux. delay input". However, beware of taking any input up to the positive supply with a resistor, since the internal and external resistors will combine to form a voltage divider, making the input voltage to the i.c. poorly defined. If you must use a pull up resistor, try to keep it down to just 1 or 2 kilohms if possible. The outputs at pins 4, 5, 7, 8 and 9 are all unloaded MOSFET driver stages; when "on" their output voltage is nearly at the positive supply rail, but when "off" their outputs do not go to 0V of their own accord; they merely become open circuit. If these outputs are being used to drive into any other logic circuitry, add a suitable load resistor to 0V; the 100k resistor R4 in Fig. 2 is being used for just this purpose.

The Veroboard layout for the circuit is shown in Fig. 3. As usual, take care with the handling of both i.c.s, and avoid touching the pins with your fingers. D5 protects the circuit against the supply being connected the wrong way round; since this may be a battery, it is a worthwhile precaution. Don't forget to add D2 and D3 to protect the i.c. against back-e.m.f. spikes from any relays that you might connect to the circuit. The more switches that are provided, then the more difficult it is to crack the code; you could consider having, say, 26 cheap switches on a panel, with the correct four switches spelling out an appropriate word! For high security applications, the "Incorrect sequence output" could be used to trigger an alarm circuit, so that the user would only ever get one attempt at entering the correct code. Alternatively, consider cascading two i.c.s in series, so that you have to enter eight keys in sequence to operate the circuit. Use the first i.c., when sequenced correctly, to enable the second one.

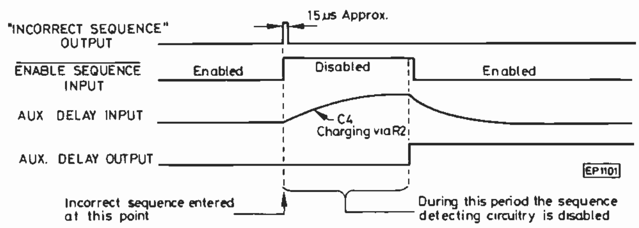
Finally, remember that it isn't restricted to only working with switches as inputs; the i.c. would make an excellent detector for logic sequences too. A set of four consecutive logic pulses, in the correct order only, would trigger the device.

Altogether, it's a very versatile and interesting device!

A similar i.c. to the LS 7225 is also available: The LS 7220 does not have any "Incorrect sequence" facility, but can instead be made to temporarily over-ride the sequence decoding logic, so that anyone can operate the lock, even if they do not know the correct sequence. (Naturally, the i.c. can then be switched back to operate in the "normal" mode.)

Both i.c.s can be obtained from **TK Electronics.**

Fig. 5. Timing diagram, incorrect sequence



THREE TONE CHIME (SAB 0600)

The all-electronic doorbell has been a popular concept for many years now, being originally based on simple analogue techniques, then later involving digital control, culminating in today's microprocessor based designs. Just about every tune that you could think of can be played whenever the milkman calls. The only thing that the majority of these doorbells seem unable to play is a good, simple, traditional, "ding-dong"!

The SAB 0600 is an 8 pin i.c. from Siemens which is designed specifically to provide such a chime. In fact, it's more a case of "ding-dang-dong", since three tones of descending order of frequency are provided, not just two. The tones are harmonically related so that the chime is always in tune, and sophisticated logic control provides for a realistic and pleasing decay of sound level. There is even a power amplifier provided in the device, so that only half-a-dozen passive components plus a switch and loudspeaker need to be added to make a complete door chime.

The block diagram of the i.c. is shown in Fig. 7. When the device is triggered (by taking pin 1 to the positive supply) an internal regulator is turned on to supply regulated power to the rest of the internal circuitry. A high frequency master clock oscillator is provided, with its frequency determined by an external RC network connected to pins 6 and 7; varying either the R or the C will cause a change in the oscillator frequency. The output of the clock oscillator feeds into a digital tone generation circuit. The master clock is divided down to provide the three chime frequencies, ensuring that the musical relationship between the tones is kept constant, and hence the chime will remain in tune. The master clock is then divided down still further, and this very low frequency square wave is used to control the timing of changes in relative amplitude of the three tones. The amplitudes are controlled independently, so that the first tone is decaying away when the second one starts, and both the first and second tones are decaying away when the third one starts. The result is a very natural and melodic sequence; in fact, if you listen very carefully to the chime you can actually hear the amplitude decreasing step by step at the end of the sequence as the final decay progresses.

The three separate outputs of the digital tone generator are mixed together at the summing input of the power amplifier. The latter is designed to drive a load of 8 ohms or more, which must be capacitively coupled via a 100μ capacitor. Under these circumstances the i.c. will deliver 100mW without the need for any heatsinking.

Finally, an external capacitor between pin 8 and ground (0 volts) will act as a filter, rolling off some of the high frequency content of the square waves. The more filtering that 'is applied, then the subjectively quieter the chime seems to be, although of "smoother" tone, so the adjustment of this is a matter of personal preference. The chip's internal power supply shuts down when the tones have ceased. This reduces the current consumption to less than 1μA, which in combination with the supply voltage requirements of 6 to 11 volts makes the device ideal for powering by a small 9 volt battery.

BASIC CIRCUIT

The basic chime circuit is shown in Fig. 8. Varying R2 or C4 adjusts the frequency of the chime tones, and (because the timing of the digital tone generator is also derived from the master clock) the duration of the chime sequence; the higher the tones in frequency, then the shorter the sequence will last. The value of C5 can be adjusted to give the most suitable tone to the chime.

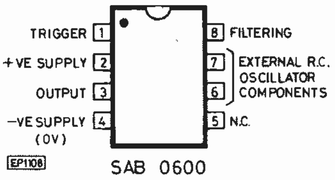
If the chime is too loud for your liking, add a resistor in series with C2; anything up to 20 ohms should do the trick. C1 and C6 must be in place and as close to the i.c. as possible, since they ensure the stability of the whole circuit. Normally the three tones come in the order of descending frequency. If instability is present, the tones may seem to increase in frequency, or even change frequency as they are decaying away. The cure for this is simply to add more capacitance; increase the value of C1, or add more 100n disc ceramic capacitors across the supply rails close to the i.c. If the switch is very far away from the i.c. then add an 82k resistor between it and pin 1 of the i.c. (close to the chip itself) to limit any spurious induced currents to an acceptable level.

ELABORATING IT

The basic circuit of Fig. 8 works very well, but for the adventurous there is a more sophisticated circuit shown in Fig. 9, with its Veroboard layout given in Fig. 11. Two switches are provided, "Doorbell 1" and "Doorbell 2", so that both front and back doors of your house can be connected to the circuit. Doorbell 1 will give a short duration high frequency chime, and Doorbell 2 a longer, low frequency chime.

IC2c and IC2d form a simple flip-flop or latch circuit. If the Doorbell 1 switch is pressed, IC2d pin 11 goes to logic 0 and IC2c pin 10 goes to logic 1. This situation remains constant (even after the switch has been released) until Doorbell 2 is pressed, when IC2d pin 11 goes to logic 1 and IC2c pin 10 goes to logic 0, etc. IC3 is a quad CMOS analogue switch. This acts in a similar way to a relay, but in solid state form; if pin 13 (a "control" pin) is taken to logic 1, then pins 1 and 2 become "connected together" via a 300 ohm resistor internal to the i.c., and can pass analogue signals bidirectionally. Hence, if pin 13 goes to logic 1 and pin 12 is at logic 0, R3 is effectively connected between pins 6 and 7 of IC1, with R2 remaining unconnected. Similarly, if pin 12 is taken to logic 1 with pin 13 at logic 0, R2 is connected between IC1 pins 6 and 7, and R3 remains unconnected. By this means, the two doorbell switches will connect different resistors to IC1, which in turn will cause different frequencies of chime to be heard. IC2a and IC2b are merely connected to make an OR gate; if either one switch OR the other is pressed, then the chime i.c. is triggered.

Fig. 6. SAB 0600 pin out with specifications set out below



Characteristic	Notes	Min	Typical	Max	Units
Supply voltage		+7	+9	+11	V
Quiescent current	I.c. in idling condition (Not chiming)			1·0	μA
Temperature range		0		70	°C
Power dissipation	Driving 8 ohm load		100		mW
Max output voltage	Driving 8 ohm load	2·1	2·5	2·9	Vpk/pk
Min trigger voltage needed at pin 1		0·5		1·5	V
Input resistance at pin 1		5	7·5	10	Kilohms
Max current into pin 1		–2		+2	mA
Load impedance (at output)			8		Ohms

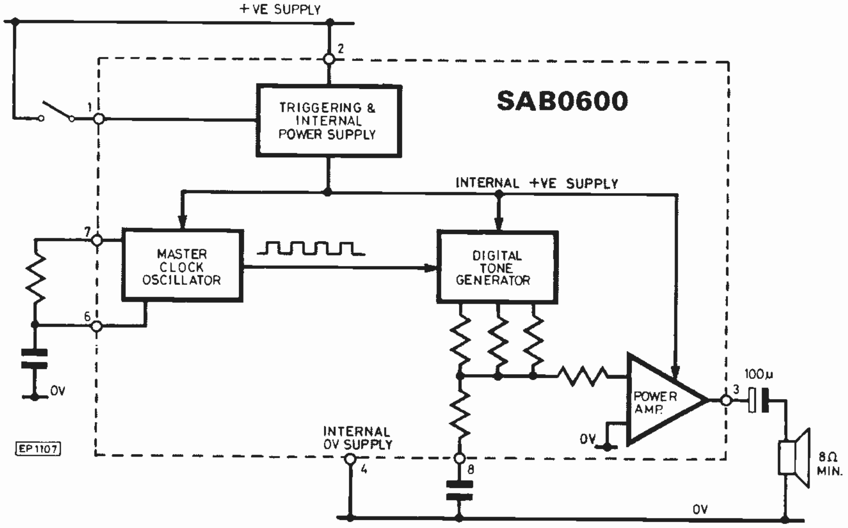


Fig. 7. Block diagram of SAB 0600

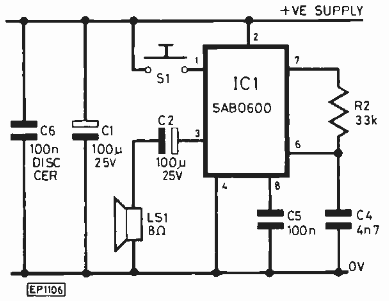


Fig. 8. Basic circuit

CIRCUIT NOTES

R1 and C3 provide some simple filtering to help prevent the triggering of IC1 by spurious pulses. R6 and R7, together with D1, D2, D3 and D4, protect the circuitry against short duration high voltage pulses induced into the lengthy wiring between the doorbell switches and the actual circuitry itself. R4 and R5 provide biasing for the flip-flop when the switches are released. Changing the value of R3 will vary the low frequency chime, and changing R2 will similarly affect the high frequency chime. As with the simple circuit of Fig. 8, don't forget that R10 can be added to reduce the loudspeaker volume if required. Make R10 a wire link for full volume. C5 can be varied to alter the tonal quality of the chime. Again, be careful with decoupling capacitors C1, C6 and C7; add to these if instability is a problem. Finally, note that D5 is used to protect the circuit against incorrect connection of the battery — always a good

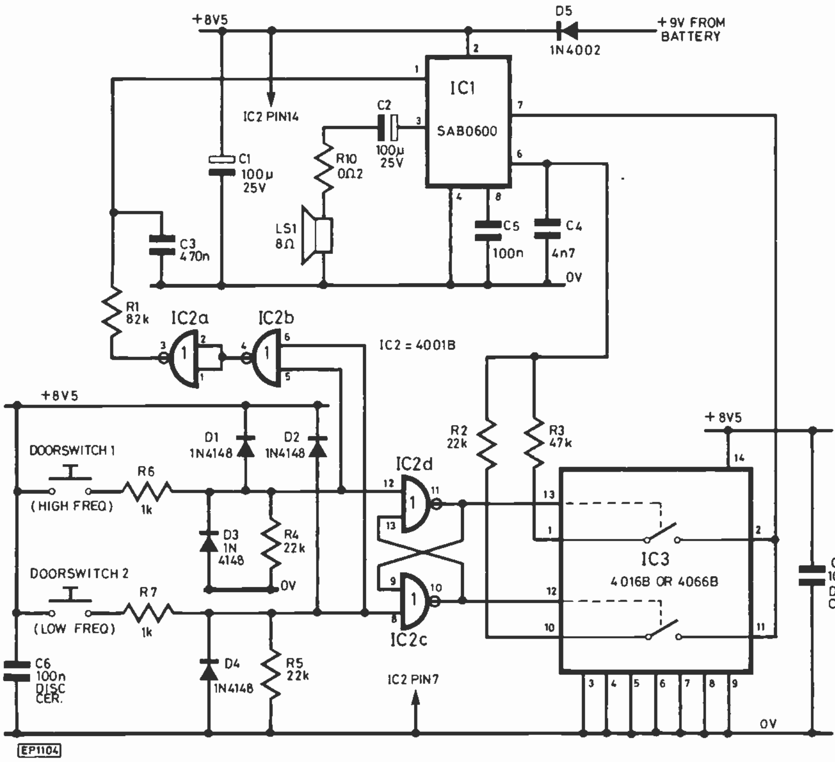
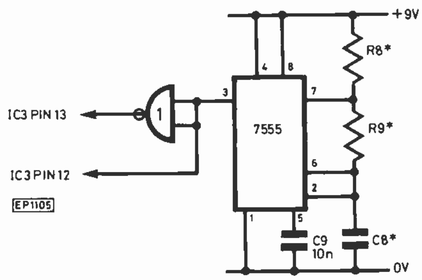
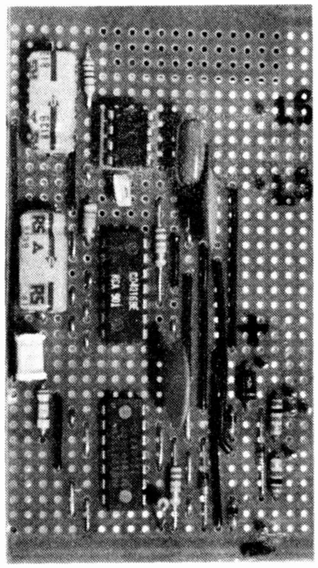


Fig. 9. Sophisticated chime circuit





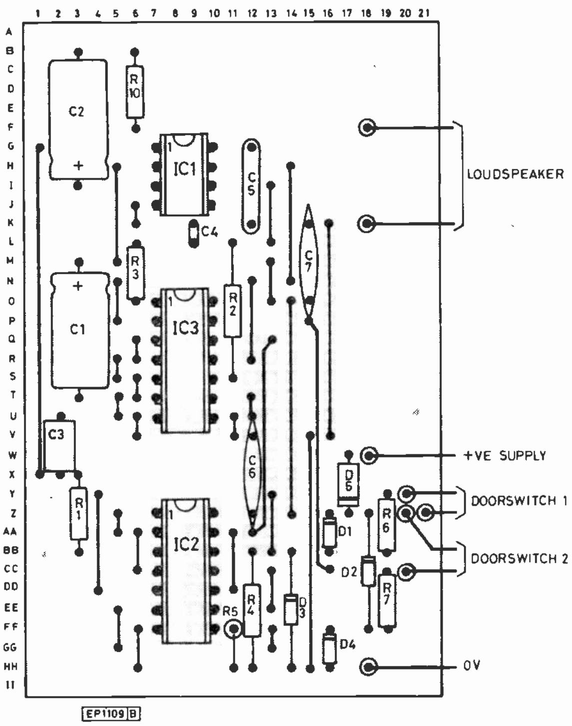


Fig. 10. (Top right) circuit for varying pitch during chime. The gate is ¼ of a 4001B and R8, R9 and C8 are 33k, 470k and 100n to 2µ2 respectively

Fig. 11. (Left) Veroboard assembly of three tone chime circuit

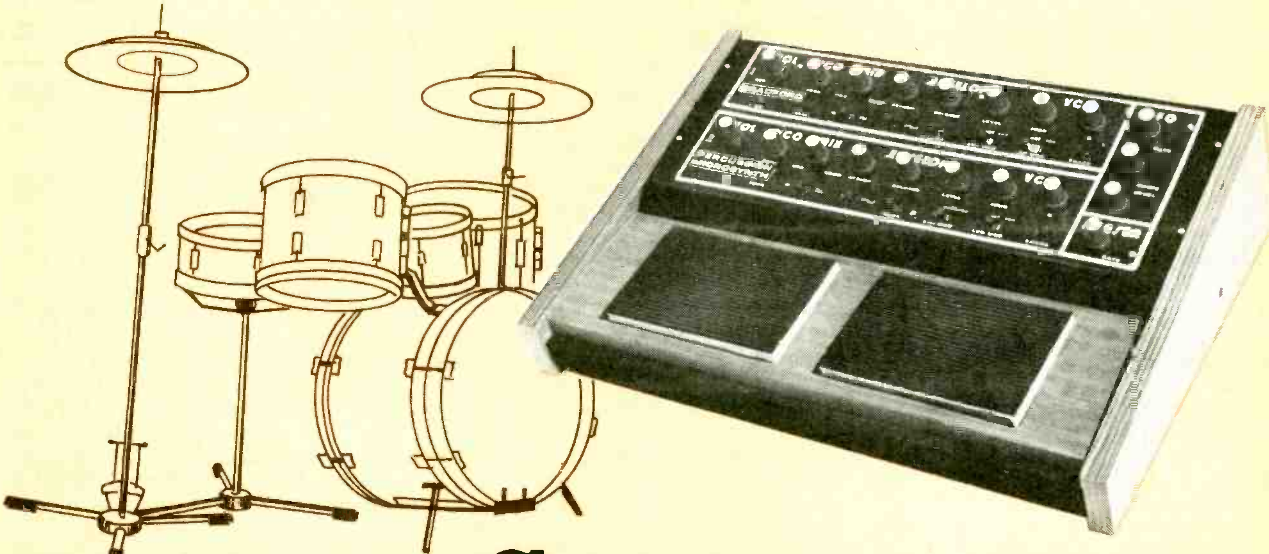
idea! Battery life will be many months in normal use, because the SAB 0600 turns itself off when not in use, and the CMOS i.c.s draw negligible current.

If more loudspeaker power is needed than can be provided by the i.c.'s own amplifier, then replace C2 by a 100n capacitor, and the loudspeaker by a 100k resistor (almost any values will do here), then feed the connection between this capacitor and resistor out to an external power amplifier. The signal level may need attenuating, though!

Why not experiment more with the circuit; running two SAB 0600 i.c.s together simultaneously could prove interesting, giving the effect of musical chords being played. Alternatively, try connecting the circuit of Fig. 10 to IC3 pins 12 and 13 in place of the circuitry shown in Fig. 9; this will cause a continual changing of frequency actually during the chime, which is a very strange sound indeed. Perhaps in the end, though, the most pleasant effect is the original one: a simple, melodious, three tone chime, which is a welcome change from so many modern electronic doorbells!

The SAB 0600 is available from **TK Electronics,** who also sell complete doorchime kits based on this i.c.

all in your **JUNE** issue!



PERCUSSION MICROSYNTH

This is an instrument provided with variable sensitivity trigger pads that may be played with hands or drum sticks. It is capable of tailoring a vast range of sounds that include drums, cymbals, bells, explosions, triangles, gongs, rockets, marching feet, steam trains, wind and surf etc., as well as an equal range of abstract sounds.

PROGRAM CONDITIONER

A circuit that is useful as a signal conditioner to rescue poor recordings and enable them to be successfully loaded into a computer. If two recorders are available it permits programs to be copied directly without tying up a computer.

FUSION:- TOWARDS REALITY

Nuclear power without radio-active waste is the target of a group of European scientists who built the little known giant of Oxfordshire—*the JET Tokamak*. This article will reveal their amazing toroidal machine, and its significance.

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PRACTICAL
ELECTRONICS

JUNE ISSUE ON SALE FRIDAY, MAY 6, 1983

Space Watch...

THE IRAS SATELLITE

After three years of working and planning the International Infrared Astronomical Satellite (IRAS) was launched successfully in January. The allocation of responsibility for this international project was distributed between the United States, the Netherlands and the United Kingdom. The act of launching was celebrated by an all night watch of the pre-launch procedures at the Rutherford Appleton laboratory, to which not only active participants in the project were invited but also their families, the press and other visitors. The personnel on duty were fully occupied with their particular tasks and routines, but all this activity was made available to the guests by the monitor screens set up in the lecture theatre. Continuous monitoring was available and all the countdown procedures could be observed.

Between events the visitors were given tabloid information from various members of the staff. Since each stage of the proceedings from the launch site at the Vandenberg Air Force Base in California was via live voice relay, the frequent "Mission completed" indicated in a loud voice as each procedure was finished often broke in over the local speakers voices. This seemed to increase the level appreciation to those assembled. It was clearly a stroke of admirable planning to bring together those most concerned while problems were being solved, often involving long hours of waiting for the families at home. The very intense excitement of the last period, before the actual final count, was filled with thoughts of other launches, yet each time the anticipation is still felt as though it was the first time.

Visitors from America, the Netherlands and other countries together with the press were restless during the final seconds and none could resist audibly counting with the rest. At the moment of lift-off the tension was released and everyone turned to his and her neighbour applauding. The excitement continued through the stages to the time of the satellite being inserted into the correct orbit and the signals returned to say that the Satellite was fully operational. Finally for those more technically concerned a quick rush to the refreshments and into groups to discuss the programme and to get ready for the first pass of the satellite over the control station at the SERC Laboratory at Chilton.

The official programme began at 1.00a.m. on the 26th January with a welcome to the Rutherford Appleton Laboratory at Chilton by Dr. G. Manning the director of the laboratory followed by a brief introduction to the purpose of the project by the United Kingdom project manager Dr. Eric Dunford. This was followed by a talk from Professor Richard Jennings of University College, London on the place of the infrared telescope in astronomy. He was interrupted by the announcement from the launch site that it was "GO". At 1.30a.m. The technical schedule of events was given by Eric Dunford. The science analysis manager Dr. G. Thomas, then took over with a description of the operations involved at the control centre. Mr. Peter Doms of the Telescope Support Team gave information of the early operations and an explanation of the monitor screens placed in the lecture theatre so each step of the operations could be observed at all the centres. This part of the "show" was constantly interrupted as the launch preparations continued.

Then followed the launch itself. At 2.21a.m. the command signal was sent from Chilton to the Goldston tracking station, at 2.25a.m. the LOS (loss of signal) indicated that the pass over the Goldston sector had been successful and that the satellite was on its way over the Indian Ocean. At 3.11a.m. the AOS (acquisition of signal) and at 3.24 the LOS, followed by the Chilton pass at 3.29a.m. Throughout the Chilton acquisition of signal the movement of the controlled dish at Chilton, fully floodlit, was observed. In its turn the LOS for Chilton was signalled and at 3.44 first results of the passes were recorded. There was a final pass over Chilton at 5.19a.m. which was watched by the enthusiasts and the Press from the windows of the control room.

INFRARED ASTRONOMY

Recently a new dimension was brought into being using the UKIRT (United Kingdom Infrared Radio Telescope) high up on the mountain at Haiwai. This new dimension was the operation of the control centre at Edinburgh Observatory where sitting at a console the astronomer could operate the telescope and carry out normal duties. This was reported in detail in a recent issue of *Spacewatch*. It might therefore be thought that this new telescope operating in space is duplicating facilities. There is a very important reason for the new telescope which will in the course of the next 6 to 9 months complete the most comprehensive view of the infrared spectrum of the Universe. This reason lies in the fact that though a great deal of data has been collected there are gaps in the actual spectrum which cannot be "seen" from Earth. The reasons for this situation are concerned with the "forbidden" wavelengths which cannot be seen through the Earth's atmosphere for a number of reasons. It becomes necessary then to go outside the Earth where the whole spectrum can be observed.

There is another very important matter to be considered. This arises from the fact that the level of the radiation may be very low. To take this into account the sensitivity of the new telescope is such that it can detect levels down to one million, trillionth of a watt per square centimetre. Special design and cryogenic operation becomes necessary to accomplish this. Yet though the signal at the receiver may only be minute the actual source and origin may be extremely great and energetic. This is the tremendous importance of the satellite telescope.

The heart of the satellite is the telescope. It is an f/9.6 Ritchey-Chretien type design with a 22·4 inch effective aperture of primary mirror. The mirror itself is of light weight Berryllium. The effective field of view is 30 arc minutes. It has a focal length of 5,500mm. There are 62 rectanglular detectors which vary in size from 7·2 × 1·2mm to 7·5 × 5mm. These detectors form the focal plane array at the base of the telescope. The detectors observe in four wavebands

Band 1. 8·5–15 microns
Detectors 15 silicon–arsenide.
Band 2. 19–30 microns
Detectors 16 silicon–antimonide.
Band 3. 40–80 microns
Detectors 16 germanium–gallium.
Band 4. 83–119 microns
Detectors 15 germanium–gallium.

The detectors are so arranged that each source encounters two detectors in each of the four wave bands which produce a 'signature' for a point source. By this method each area of observation is covered four times giving a possible source detection coverage of eight. Some of the special observations will involve the examination of well known asteroids and new ones that may be encountered. Thus this satellite will deal with almost any type or source of infrared that may be scanned by the telescope.

THE DUTCH EXPERIMENTS

There is an additional Dutch experiment called DAX which consists of three instruments. These are also located near the focal plane. One instrument is a low resolution spectrometer which will produce sectra between the wavelengths of 7·4 and 23 microns. This will aid in the identification of sources of infrared. A second instrument will operate between 4·1 and 8 microns. The third instrument is a "chopped" photometric channel and has two detectors in two bands between 41 to 62 microns and between 84 and 114 microns. The shutters are operated so that every fifteen seconds a shutter opens and each closes in such a way that all energy is shut out. During the period of closure the instrument is automatically calibrated.

ATTITUDE CONTROL

The attitude control of the IRAS is a digital subsystem with an accuracy of 30 arc seconds (1/20th of a degree). It is expected that the operation techniques will lead to a pointing ability of a few arc seconds over small areas but in any case the data accuracy of pointing will be better than 20 arc seconds. There are sun sensors around the satellite to ensure Sun acquisition during the initial operating period. It is important to keep the telescope aperture away from the Sun, the Moon, and the Earth. Part of this is assured by the use of a special cold mirror coated screen which reflects unwanted infrared away from the aperture of the telescope.

A primary computer and an identical backup is provided on board. Transfer of data from the satellite is stored on a recorder and, for the ordering of the daily programme each section of work programmed has various special memory facilities.

AUTOMOBILE TEST SET

MICHAEL TOOLEY B.A. **& DAVID WHITFIELD** M.A. M.Sc.

WORKING on auto electrical systems must rank among the greats in the league table of love-hate activities. The fascination is all but irresistible; the wiring schedule and the components seem so simple and straightforward. In practice, the success or otherwise of any job concerned with auto electrics is based on a sound understanding of the principles involved, and having the appropriate test instruments. The Auto Test Set brings together a range of instruments usually to be found separately, and combines them into a compact and robust unit. By this approach it minimises the number of units which must be brought to bear, and perched precariously under the bonnet or dashboard, thereby minimising many of the frustrations which otherwise lie in wait for the unwary.

GENERAL DESCRIPTION

The Auto Test Set is essentially a group of closely related instruments which have been collected together in such a way that all of the functions remain available, but many of the necessary facilities are shared. An overall block diagram for the test set is shown in Fig. 1, and a summary of the specifications appears in the table. The schematic, and the full circuit diagram shown in Fig. 2, shows that the instruments fall into two main sections; those which use the meter for display, and those which do not.

The first group consists of the voltmeter, the tachometer, and the dwell meter circuits. These all share a common test probe known as the volts/coil probe, and the input signal is simultaneously applied to all three circuits. The output from each circuit can be selected for display on a large moving coil meter, ME1, by means of S1. This switch also effects range switching in the tachometer circuit. A conventional moving coil meter is used because it may easily be read to whatever accuracy required, and with such a display it is very much easier to detect trends; important during tuning and performance testing. A moving coil meter will also have the effect of averaging a signal which exhibits rapid fluctuation which might affect a digital type of display. In order to protect the meter movement from damage when not in use, a carrying position is provided on S1 to short the terminals when not in use. Further protection of the movement is provided by D9 and D10.

The second group of instruments include the circuit tracer and the lamp/fuse tester. Each of these has separate inputs with respect to ground, the V-input and the Z-input, respectively. The circuit tracer uses a voltage comparator and displays the result on a single l.e.d., with an optional audible warning. The lamp/fuse tester uses an impedance comparator and provides a GO or NOGO indication on two l.e.d.s, again with the option of using the (same) audible warning.

The overall instrument derives its power independently from the vehicle under test via SK3 and SK4; D11 provides visual indication of the presence of the necessary supply. The overall instrument is housed in a rugged diecast box, with the majority of the components mounted on a single-sided printed circuit board. The circuit and uses are described below for each constituent instrument in turn, before proceeding to the constructional details next month.

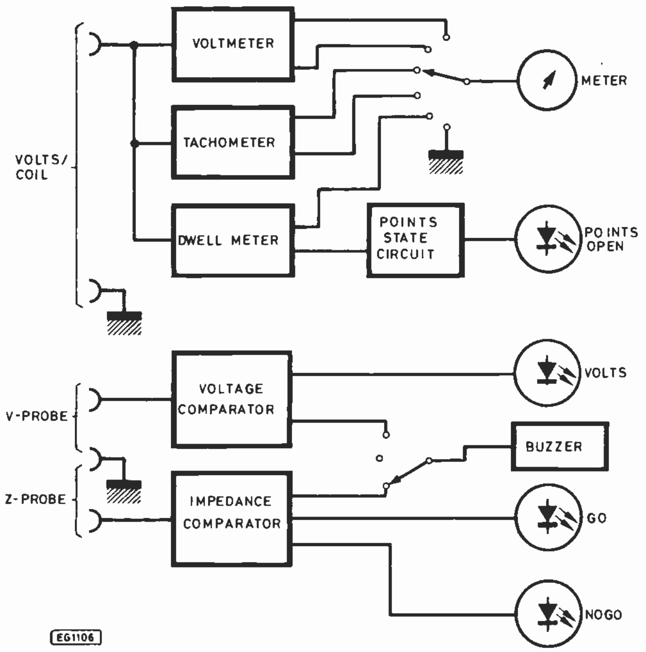


Fig. 1. Block diagram of Auto Test Set

VOLTAGE MEASUREMENT

The Auto Test Set provides two scales for measuring voltages; a simple 0 to 15V range, and a 10 to 15V offset zero range. The first range simply inserts the appropriate series resistance, R12, between the potential to be measured and the meter, ME1. This provides an extremely useful general purpose voltmeter.

In many situations, particularly when interested in the state of the battery, it is rather wasteful to have an instrument which is accurate over a wide range. The range of values to be measured in such situations will usually be at the end of the scale. The provision of an offset zero voltage scale, therefore, allows a much clearer indication of the performance of the battery under load to be obtained. The nominal open-circuit terminal voltage of a conventional six-cell lead/acid battery is 13·2 volts. This value falls under load, especially as the internal resistances of the cells rise due to physical deterioration; and the voltage rises during charging. With the exception of starting, the battery voltage will rarely fall below 11 volts, and the voltage regulator should ensure that the terminal voltage does not rise much above 15 volts. The behaviour of the battery when extra loads, such as headlamps, are applied can give a useful guide to the overall condition of the battery and/or regulator circuit.

The offset zero voltmeter range is provided by using D18 to 'remove' 10 volts from the input potential. The load for the Zener diode is provided by R32, which causes a Zener

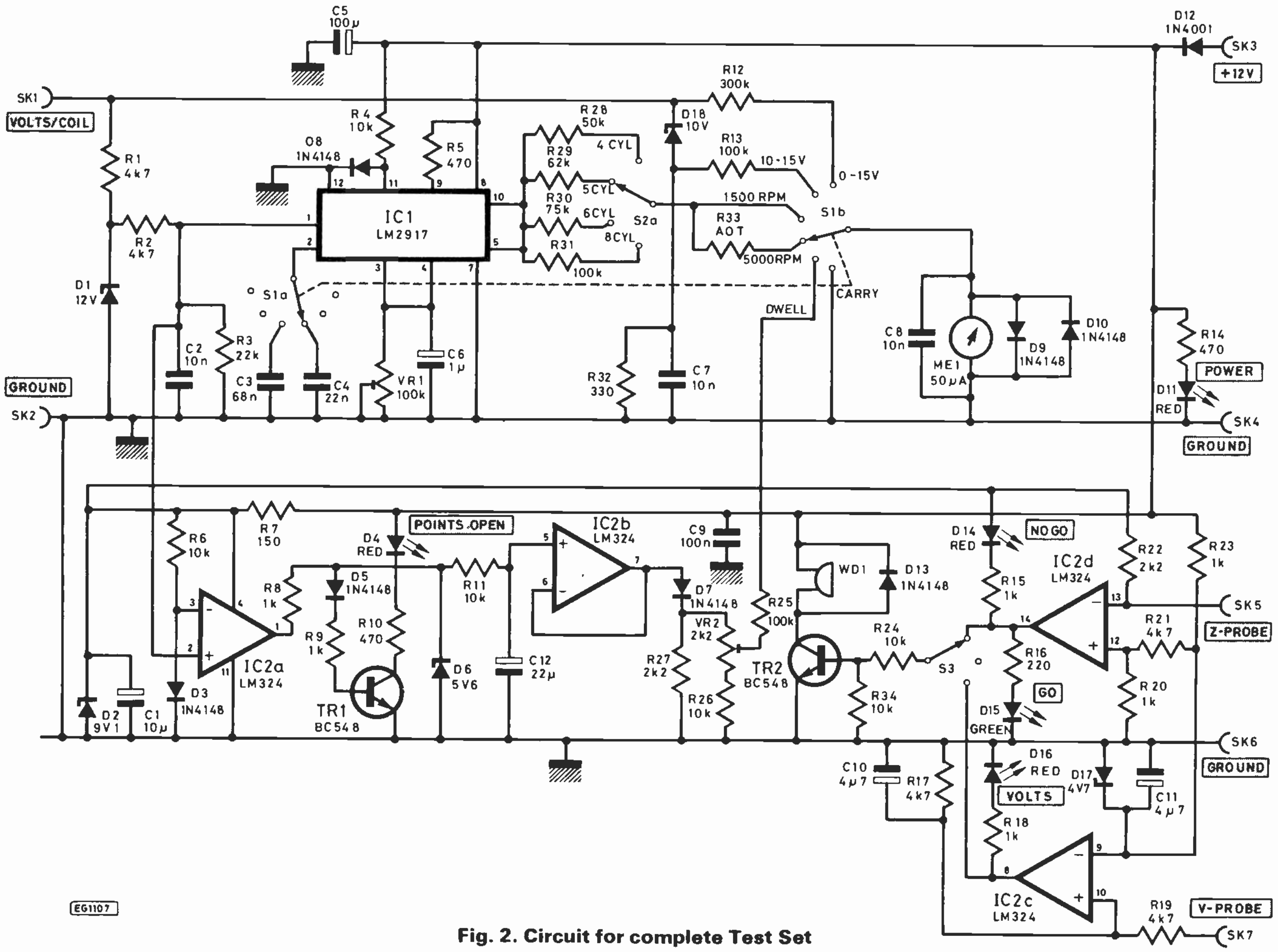


Fig. 2. Circuit for complete Test Set

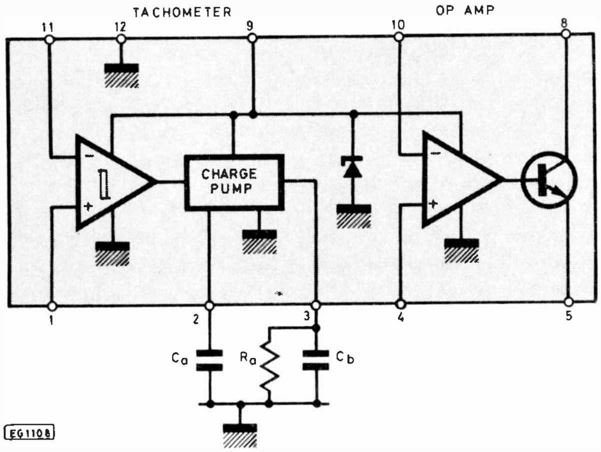


Fig. 3. The LM2917 frequency-to-voltage converter

current of approximately 10mA to flow at the expected operational mid-scale value. In practice, the calibration of the offset zero scale will not be perfectly linear, with the maximum errors at either ends of the scale, but this should not prove to be a great handicap since the greatest use of the scale is in the clear indication of variations.

TACHOMETER

During engine tuning, it is usually necessary to make certain measurements (e.g. ignition timing advance) at known engine speeds. The 'tickover speed' also needs to be carefully adjusted to the correct value; it should not be so high as to waste fuel at idle, but again it should not be so low that the car has difficulty in moving off smoothly when required.

The measurement of engine r.p.m. makes use, in the main, of the fact that the distributor shaft rotates at exactly half the speed of the crankshaft in a conventional engine. As a result, the ignition circuit produces a pulsed signal across the primary winding of the coil at a frequency of N pulses per minute, where N is given by the equation:

$$N = \frac{1}{2} \times \text{engine r.p.m.} \times \text{number of cylinders}$$

There are many ways in which the pulsed signal from the ignition coil may be sampled and converted to a voltage proportional to engine r.p.m., but the use of the National Semiconductor LM2917 i.c. produces one of the simplest circuits. The LM2917 is a linear monolithic device which contains a frequency-to-voltage converter, together with a high gain op amp/comparator designed to drive a relay or other external load up to 50mA. The tachometer section uses a charge pump technique and offers frequency doubling for low output ripple. Also provided in the i.c. is input protection, and an output which falls to ground level for a zero frequency input; in use the LM2917 has been designed to be easy to use.

The tachometer configuration of the LM2917 is shown in Fig. 3. A single RC network provides the frequency doubling, and the output voltage is simply related to the input frequency by the formula:

$$V_{out} = f_{in} \times V_{ref} \times R_a \times C_a$$

The integral voltage regulator sets the value of V_{ref} and this ensures accurate and stable conversion performance. The input stage is a differential amplifier in a positive feedback configuration. The flip-flop circuit allows the user to define the input switching level, while retaining the necessary hysteresis for good noise rejection. The charge pump then converts the input frequency, by now at a constant amplitude, to a d.c. voltage. The operation of the charge pump is determined by the timing capacitor, C_a, load resistor, R_a, and the filter capacitor. The filter capacitor determines the trade-off between output ripple voltage and the response time of the circuit.

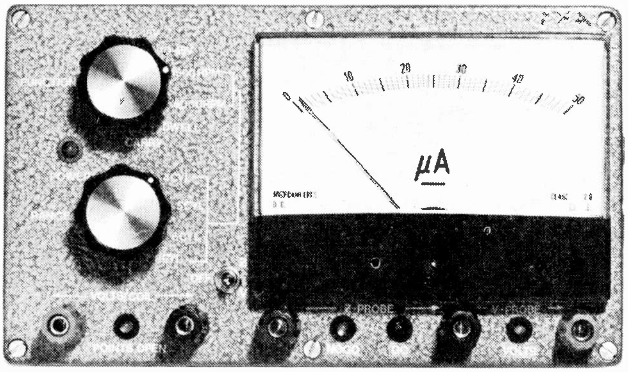
The circuit diagram for the complete tachometer is included in Fig. 2. The input from the ignition circuit is taken by connecting the volts/coil probes as shown in Fig. 4. The input signal at SK1 is then processed by R1, D1, R2, C2 and R3 to remove spikes and noise which may otherwise affect the operation of the LM2917. The input switching level of the voltage comparator within IC1 is set by the combination of R4 and D8; the level at pin 1 must exceed approximately 600mV before the comparator switches. The output at pin 5 of IC2 is determined by the signal frequency, the capacitor selected by S1a, and the setting of VR1. The response time of the circuit is set by C6; increasing the value will increase the response time, and vice-versa. The series resistor for the internal Zener regulator, R5, is chosen to minimise the reference voltage variation over a supply range of 9 to 15V. The calibration of the output for differing numbers of engine cylinders is achieved by S2, and the associated resistors, R26 to R31.

DWELL MEASUREMENT

The dwell angle of the contact breaker cam has a significant effect on the performance of an engine, particularly at higher speeds. Each vehicle has a specific dwell angle quoted for the distributor, and will have a value which depends on the design of the ignition circuit, and on the engine configuration. The distributor cam itself has a number of lobes, equal to the number of cylinders in the engine, symmetrically spaced on the shaft. The angular separation of these lobes will be 90°, 72°, 60° or 45° for engines with 4, 5, 6 or 8

SPECIFICATIONS

FUNCTION	RANGES	PROBE
Voltmeter	0 to 15 volts f.s.d. 10 to 15 volts offset zero	Volts/Points
Tachometer	0 to 1500 r.p.m. 0 to 5000 r.p.m. Both ranges may be used for 4, 5, 6 or 8 cylinder engines	Volts/Points
Dwell Meter	0 to 45°, 60°, 72° or 90° Calibration depends on the number of cylinders fitted	Volts/Points
Points State	An l.e.d. illuminates when the points are open	Volts/Points
Circuit Tracer	An l.e.d. illuminates when greater than 9·5 volts is present. Optional audible warning also available	V-probe
Lamp/Fuse Tester	GO/NO GO green/red l.e.d. indication of lamp/fuse state. Green shows resistance less than approx. 150 ohms. Optional audible warning.	Z-probe
Carry	The meter movement is shorted during carrying for safety	



cylinders, respectively. The actual dwell angle is defined as the angle through which the cam rotates whilst the contact breaker points are closed. The correct dwell angle for a particular vehicle will be found in the workshop manual, but is typically around two-thirds of the angle between the cam lobes.

The correct adjustment of dwell angle is often a matter which is left somewhat to chance; the more approximate measure of points gap is frequently used instead. To ensure correct combustion, however, it is the dwell angle which is actually the important factor in maintaining good performance and fuel economy. The angle must be large enough to allow the core of the ignition coil to become magnetically saturated, but not so large that the coil starts to overheat, eventually leading to breakdown. Too small a dwell angle, however, will result in a poor spark, and may cause overloading of the capacitor and burning of the points at low engine speeds.

Dwell angle is most easily measured by observing the duty cycle of the voltage waveform across the points. If the duty cycle is 100% (i.e. points open all of the time), then the dwell angle is 0°; conversely, if the duty cycle is 0% (i.e. points closed all of the time), then the dwell angle is equal to the angle between the cam lobes.

In general, duty cycle and dwell angle are related by the following formula:

$$\text{Dwell Angle} = \text{Cam Lobe Angle} \times \frac{100\% - \text{Duty Cycle}}{100\%}$$

The dwell measurement circuit, which is included in Fig. 2, makes use of two of the operational amplifiers in IC2. The contact breaker waveform is sampled by connecting the volts/coil probe as shown in Fig. 4. The waveform at SK1 is then filtered by R1/D1 to remove high voltage spikes, and by R2/C2 to remove high frequency noise. The filtered signal, which will have an amplitude of approximately two-thirds the input waveform, is then applied to the non-inverting input of IC1a. This amplifier is arranged as a voltage comparator, with the switching threshold set by R6 and D3. The overall effect is that the amplitude at SK1 must exceed approximately 1 volt to cause the output of the comparator to go high. The resulting comparator output is a rectangular waveform whose levels are limited only by the output saturation levels of the op amp itself; approximately 0·6V

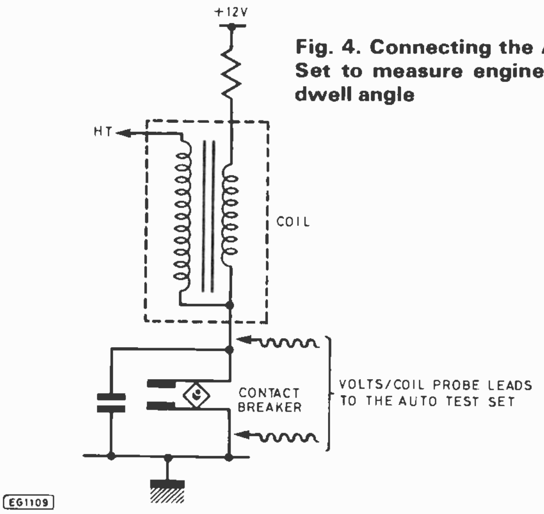


Fig. 4. Connecting the Auto Test Set to measure engine revs and dwell angle

COMPONENTS

Resistors

R1	4k7	R18	1k
R2	4k7	R19	4k7
R3	22k	R20	1k
R4	10k	R21	4k7
R5	470	R22	2k2
R6	10k	R23	1k
R7	150	R24	10k
R8	1k	R25	100k 2%
R9	1k	R26	10k
R10	470	R27	2k2
R11	10k	R28	50k 2% (2 x 100k)
R12	300k 2%	R29	62k 2%
R13	100k 2%	R30	75k 2%
R14	470	R31	100k 2%
R15	1k	R32	330
R16	220	R33	AOT (see text)
R17	4k7	R34	10k

VR1 100k horizontal preset
VR2 2k2 horizontal preset
All resistors 5% ¼W carbon types except where stated

Capacitors

C1	10μ 16V elect	C7	10n ceramic
C2	10n polyester	C8	10n ceramic
C3	68n polycarbonate	C9	100n ceramic
C4	22n polycarbonate	C10	4μ7 16V elect
C5	100μ 16V elect	C11	4μ7 16V elect
C6	1μ 35V elect	C12	22μ 16V elect

Semiconductors

D1	BZY88 C12V	D13	1N4148
D2	BZY88 C9V1	D14	Red l.e.d.
D3	1N4148	D15	Green l.e.d.
D4	Red l.e.d.	D16	Red l.e.d.
D5	1N4148	D17	BZY88 C4V7
D6	BZY88 C5V6	D18	BZY88 C10V
D7	1N4148		
D8	1N4148	TR1	BC548
D9	1N4148	TR2	BC548
D10	1N4148		
D11	Red l.e.d.	IC1	LM2917
D12	1N4001	IC2	LM324

Miscellaneous

SK1 to SK7 Panel mounting terminals to constructor's choice
Printed circuit board
Terminal pins
ME1–50μA large panel meter (Maplin RX54J)
Diecast box approx. 190 x 110 x 60mm
Ribbon cable
S1 2P 6W rotary switch
S2 3P 4W rotary switch
S3 SP on/off/on toggle switch—centre off
WD1 Piezoelectric or similar d.c. buzzer (RS 249–794)
Knobs (2 off)

(low) and V_{supply} − 1·2V (high). The dependence on supply voltage is eliminated by the clipper circuit made up of R8 and D6.

The average value of the processed waveform from IC1a is developed across C12, due to the integrating effect of R11/C12. A further op amp, IC1b, is arranged as a voltage follower to reduce the loading effects on the integrator circuit. The output low level saturation voltage from the buffer stage is removed by the action of D7, and the dwell circuit calibration is provided by VR2.

CONTACT POINTS STATE

The state of the contact breaker points is indicated by an l.e.d., D4, which is illuminated when the points are open. A switching transistor, TR1, is driven by the output of the voltage comparator stage in the dwell meter circuit.

CIRCUIT TRACER

Tracing wiring faults and broken connections in a vehicle wiring circuit must count as one of the more frustrating and tiring of diagnostic tasks. It is not so much that the job is difficult; it can, after all, be described as simply a matter of finding the point at which the voltage disappears.

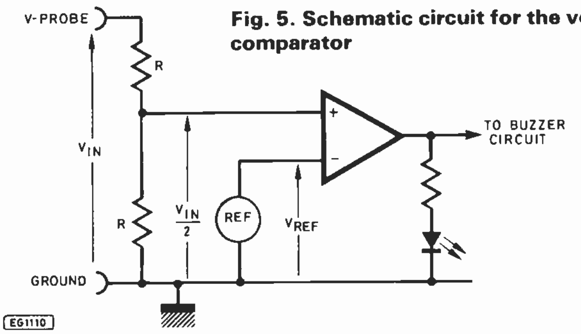


Fig. 5. Schematic circuit for the voltage comparator

A multimeter is understandably a natural first choice of diagnostic aid for the motorist with an interest in electronics. A few hours of crawling around under the dashboard, however, soon shows that it is no mean feat of skill to hold the two probe leads in position with one hand, while trying to operate the offending control with the other, and read the voltage on the meter.

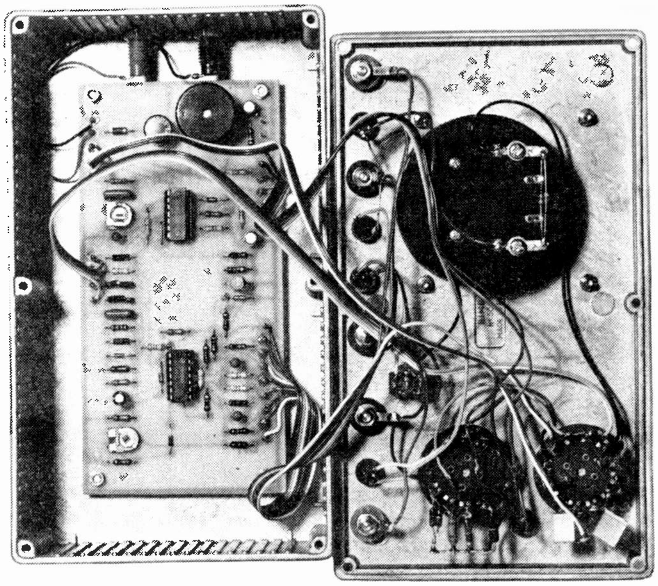
What is required is a test instrument which is more in tune with the requirements of the problem; simplicity is a prime consideration.

In circuit tracing applications the exact value of the voltage detected is of only secondary importance. The major point is to detect that the circuit is continuous up to the point being measured, since the usual cause of the problem is a dry joint, broken wire or faulty component. The significant effort in such fault diagnosis is to localise the fault as quickly as possible, and then more precise measurements may be made if required.

The circuit tracer in the Auto Test Set provides a simple indication of the presence of a voltage of greater than approximately 9½ volts. The indication is permanently provided by an l.e.d., but an additional buzzer indication may also be selected.

The circuit tracer basically consists of a voltage comparator circuit driving a load of an l.e.d. and an optional buzzer circuit.

The general principles of the circuit are shown in Fig. 5. The circuit tracing probe is the V-probe; the potential present at the V-probe tip is attenuated by 50% by the



resistive attenuator, and then applied to the non-inverting input of the differential amplifier. The input to the inverting input of the amplifier is from a voltage reference source. The output of the amplifier is a saturated high level when the input voltage exceeds twice the reference voltage, thus turning the l.e.d. on. The buzzer circuit is arranged so that the buzzer is also on (if selected) when the amplifier output is high.

The voltage comparator circuit is built around IC2c, as shown in Fig. 2. The input attenuator is formed by R17 and R19, and the voltage reference source is provided by R23 and D17. With the component values shown, the l.e.d. D16 will be illuminated whenever the potential at SK7 exceeds approximately 9½ volts; a buzzer will also sound if selected by S3.

LAMP/FUSE TESTER

Trouble-shooting in auto electrical circuits is a process which usually starts when some item of electrical equipment stops performing correctly. In many cases the symptoms are quite dramatic; one moment everything is running smoothly, and the next moment it has stopped. The most commonly encountered example of this abrupt change must surely be represented by the conventional filament lamp. The rectification of such a fault requires a realistic and methodical approach if an undue amount of time is not to be wasted; stories of changing the alternator to mend a fuse bear witness to the penalty which can be incurred by hasty diagnosis. The first step, and often the only one required, is to investigate the state of the non-functioning component, or at least the component which appears not to be working, before moving back to more remote ones.

The lamp/fuse tester is designed to provide a simple and easy-to-use "go/no go" indication of the state of simple electrical components. The tester can be used to examine the state of lamps, fuses, wiring, switches, relays, and indeed almost any passive electromechanical component. To assist in circuit tracing, particularly pin-pointing wiring breaks, a "go" result may also be used to activate the audible warning.

The lamp/fuse test circuit consists basically of an impedance comparator circuit which illuminates one of two l.e.d.s and an optional buzzer circuit. Which of the two l.e.d.s is illuminated is determined by whether the impedance

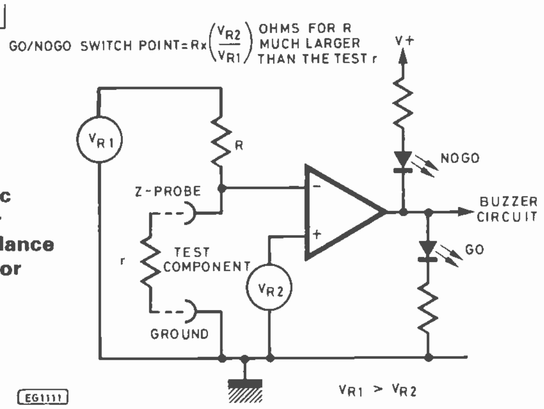


Fig. 6. Schematic circuit for the impedance comparator

between the Z-probe and ground is greater or less than the preset threshold. The general principles of the comparator are illustrated in Fig. 6. From this circuit, it can be seen that when there is no test load, the output level will be low, thereby illuminating the "no go" l.e.d.; conversely, when the test load is a short circuit, the output will be high and will cause a "go" indication. The switching point, i.e. the impedance for test load below which a "go" indication will be obtained, is determined by the two reference voltages and the value of R.

The lamp/fuse tester is built around IC2d, as shown in Fig. 2. The reference input to the non-inverting amplifier terminal is provided by an attenuator across the reference diode D17; this results in a reference of just under a volt. The other reference supply for the inverting input is provided by R7 and D2, and is at a level of 9·1 volts. The value of R22 sets the switching level of the comparator, in conjunction with the two reference levels as shown in Fig. 6, to approximately 150 ohms. This value has been chosen as it represents the on resistance of a 1 watt automotive bulb, and as such represents probably the highest correct resistance likely to be met in practice.

Next month: Constructional details, testing and calibration will be presented.

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SINCLAIR Spectrum 16K, perfect with "Horisons" tape. Also ZX81 and System 2000 amplifier. Must sell. Offers. A. Brown, 92 Queen Alexandra Mansions, Hastings Street, London WC1H 9DP. Tel: 01-278 4685.

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PE BAZAAR MAY '83

INDUSTRY NOTEBOOK

By Nexus

The Goonhilly Show

It seems incredible now that only a little over a decade ago few people had ever heard of Goonhilly. An unlikely, even comical, place invented perhaps by the Goons themselves or even earlier as a setting in a Wodehouse novel. Instead it turned out to be a very real piece of real-estate in Cornwall. In the summer of 1962 Goonhilly Downs emerged from obscurity to become world famous. But even then few of us glued to our tubes to watch the first ever live transatlantic TV transmission via communications satellite realised the speed at which the new technique would become established.

Goonhilly today is not the only satellite earth terminal site in the UK but it remains the largest and, commercially, the most important. The addition this year of Goonhilly 5, the fifth big steerable dish in the complex, marks yet a further stage of expansion.

The new terminal is dedicated to maritime communications. The concept is not new as the first shipborne terminals were fitted in 1976. But take-up of the maritime satellite service has been painfully slow so that after some seven years there are only a little over 1,500 installations in service. This is mainly due to the ingrained attitude of many shipowners who regard the ship's radio room and its operator(s), mandatory by international law for safety reasons, as an imposed overhead expense. Why go beyond the minimum requirement? Add to this the unhappy plight of world shipping in a trade recession and there is even greater reluctance to spend money on what could be senseless extravagance rather than prudent investment.

Goonhilly 5, like its predecessors, was built by Marconi and is owned and operated by British Telecom who, in their newly acquired competitive spirit, have put together a sales package which could break through the apathy of shipowners. What BT is offering is direct dialling ship-to-shore telephone links between most destinations in the world at a cost of up to 50 per cent less than the already established service from the United States. Goonhilly 5's global coverage embraces about 80 per cent of the world's shipping and offers total communications reliability round-the-clock, vastly superior to ordinary ship's h.f. radio with its diurnal variations and ionospheric disturbances.

At present the rate of new shipborne installations is running at about 40 a month. It is estimated that by the end of this decade some 12,000 ships will have been fitted. This has to be good for business and good for shipowners, too. Of course the shipowners are still counting their pennies, with most of them anxiously monitoring their overdrafts, but shipping economics today are more than ever dependent on productivity. A tide lost or a cargo missed is big money. Instant and reliable communication can tip the balance from loss to profit. So the sales pitch is not whether a shipowner can afford it but whether he can afford to do without it.

The Big Fight

As I write there is no firm date for the forthcoming big fight. Both the main contestants are, however, in training with broad strategies defined, tactics to be decided much nearer the day. The champions in the blue corner might be described as political realists, the challengers in the red corner as political dreamers. The realists are favourite in the polls but the odds could and often do shift unpredictably. How will the result affect industry?

On the industrial front the main issue of principle between the two major parties is nationalisation and private enterprise. If we take history as a guide there will be no clear cut victory. Whatever might be said on either side, even written into manifestos, there has always been a compromise. No Labour government has killed off private enterprise, no Conservative government butchered nationalised industry. The mixed economy is here to stay although the balance of mix may change. In the end all is compromise with Labour pouring money into private industry when in office and Conservatives pouring ever-growing amounts into failing State-run industries.

On the broad economic front Labour's biggest punch, a straight left, is unemployment, supplemented by body blows on defence and withdrawal from the European Common Market. Such a combined attack could floor the Conservatives if only because it has great emotional appeal. But if the knock-out takes place what will subsequently happen in practice is very unlikely to be that predicted in rhetoric. Labour cannot significantly reduce unemployment without distorting the economy. On defence, in particular on disarmament, semantic experts are working as I write on a form of words which will declare a unilateral stance on nuclear weapons within a multilateral context, which will commit nobody. On the Common Market the policy will be to withdraw in theory but remain in practice through a "re-negotiation".

The most effective punch from the defending champion is low inflation, the pound in your pocket being worth very nearly as much next year as it is today. This will be backed by a less than normally vicious budget (already announced) and the undeniable fact that people still in work, the silent majority who are not dramatically newsworthy, have never had it so good.

Paradoxically the blue policy, so objectionable to the red corner, is the very one they were advocating in October 1964 when they set up the new Ministry of Technology "to guide and stimulate a major national effort to bring advanced technology and new processes into British industry". Mintech was to be the vehicle for obtaining improved economic performance and improved competitive power. By 1969 Mintech had a staff of 36,000 dedicated to the ideal. In the event every innovation was bargained over, resisted as long as possible. A transition which could have been achieved smoothly over two decades has had to be compressed into the past four years at the worst possible time in world trade with consequent unnecessary pain.

No, I haven't forgotten the Liberal/SDP alliance. In the event of no decision the alliance will, in effect, become a biased referee favouring one side or the other. The alliance is itself a compromise but on withdrawal from the ECM and the nuclear question they are more blue than red.

So, unless the extremists of either persuasion come unexpectedly from behind, there won't be much change.

More Showbiz

It was perhaps inevitable after all the ballyhoo in 1982. Anyway, here it is folks, the first ever International Conference and Exhibition on Satellite and Cable TV in Europe. Or Cable '83 for short. It will be held at the Wembley Conference Centre with over 50 authoritative speakers from the UK, Europe and North America.

The organisers, Online Conferences Ltd already have a track record in other IT areas and have used every emotive word and phrase they can think of to promote the event. Thus we have a scene which is "explosive and complex" but nevertheless calls for "an adaptive sensitive approach" in what is clearly "a dynamic situation".

I was especially intrigued by some of the conference topics. Under the heading of Marketing the question is posed, "Broadband-moneyspinner or black hole?" Under Direction we are promised a discussion on "The franchising jungle". Under the heading of Issue Areas the no doubt vital issue is "Go-go or go-slow". Again under Marketing there are talks on "Entering and surviving" and another question, "What follows the movies?"

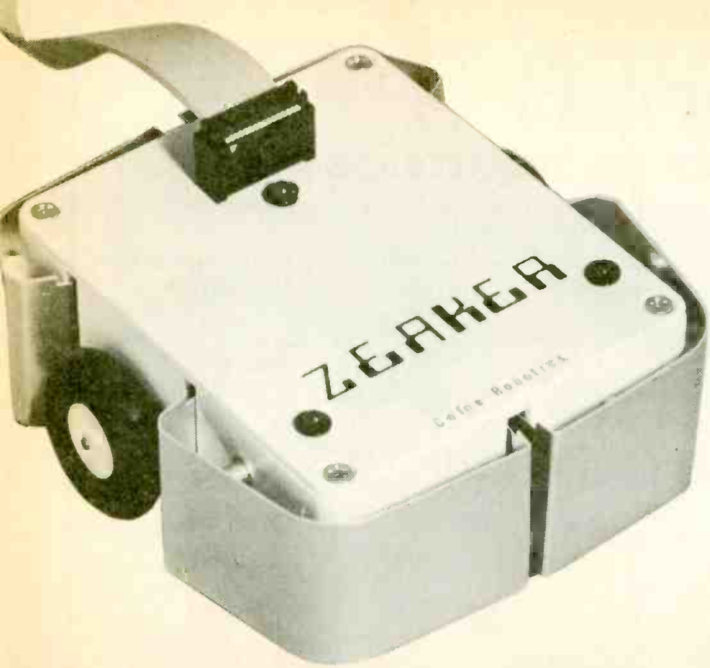
The organisers say with evident satisfaction that there are likely to be few restriction on Cable TV programme content, even fewer on imported material, and that cabling the UK alone will shift £2·5 billion into pockets of the participants. So roll up, roll up! How to win in this brand new game will all be explained from 10–12 May. A game? It must be. The advance billing says plainly "The major players are already jockeying for position". Ughh!

ZEAKER

MICRO-ROBOT

PART 1

DAVID BUCKLEY



ZEAKER is a small, low cost computer controlled robot vehicle designed to have all the normal functions of a "turtle" i.e. steering, lights, pen, horn and bump sensors but it is also capable of being expanded using photosensors for eyes to seek out or avoid light or to follow white lines etc; with a complex sound generator for special noises à la R2D2, and with computer speech.

It will easily interface to most popular microcomputers and can be programmed in a high level language like BASIC, although a modular language like FORTH or PASCAL would be better.

Under program control Zeaker can go forward, backwards or rotate right or left on the spot; it has two navigation lamps: port and starboard (or eyes if you prefer) which can be turned on or off; a speaker which can emit a high or low tone or a combination of both; 6 tactile sensors which can detect a collision with an object in Zeaker's path and finally but not least a pen which can be lowered or raised to enable Zeaker to draw Turtle Graphics. The up or down state of the pen is indicated by a lamp on the top of Zeaker.

Zeaker was designed to run on a table top, but will also run on smooth floors and because of this and to keep down the cost, the controlling electronics and power supply are contained in a separate box linked to Zeaker by a 2 metre umbilical cord (16 way ribbon cable). This separate box ('Zeaker Control Station') is linked to the microcomputer by two short ribbon cables.

DESCRIPTION OF ZEAKER (VEHICLE)

Zeaker's chassis is a modified ABS plastic box inside which are two electric motors complete with gearboxes, one driving each of the two wheels; a small speaker for the horn and a solenoid to lower the pen.

Mounted in the lid of the box are the navigation lamps, or eyes (red and green l.e.d.s), the socket (SK1) to connect the umbilical cord and the pen status l.e.d. (yellow) whilst on the outside are the four Aluminium Fenders which when touched compress foam plastic blocks and make contact with screw heads in the side of the box, thus forming 16 simple switches which are paralleled into 6 groups (Fig. 11). Underneath at the front is a plastic "toe" to give Zeaker stability.

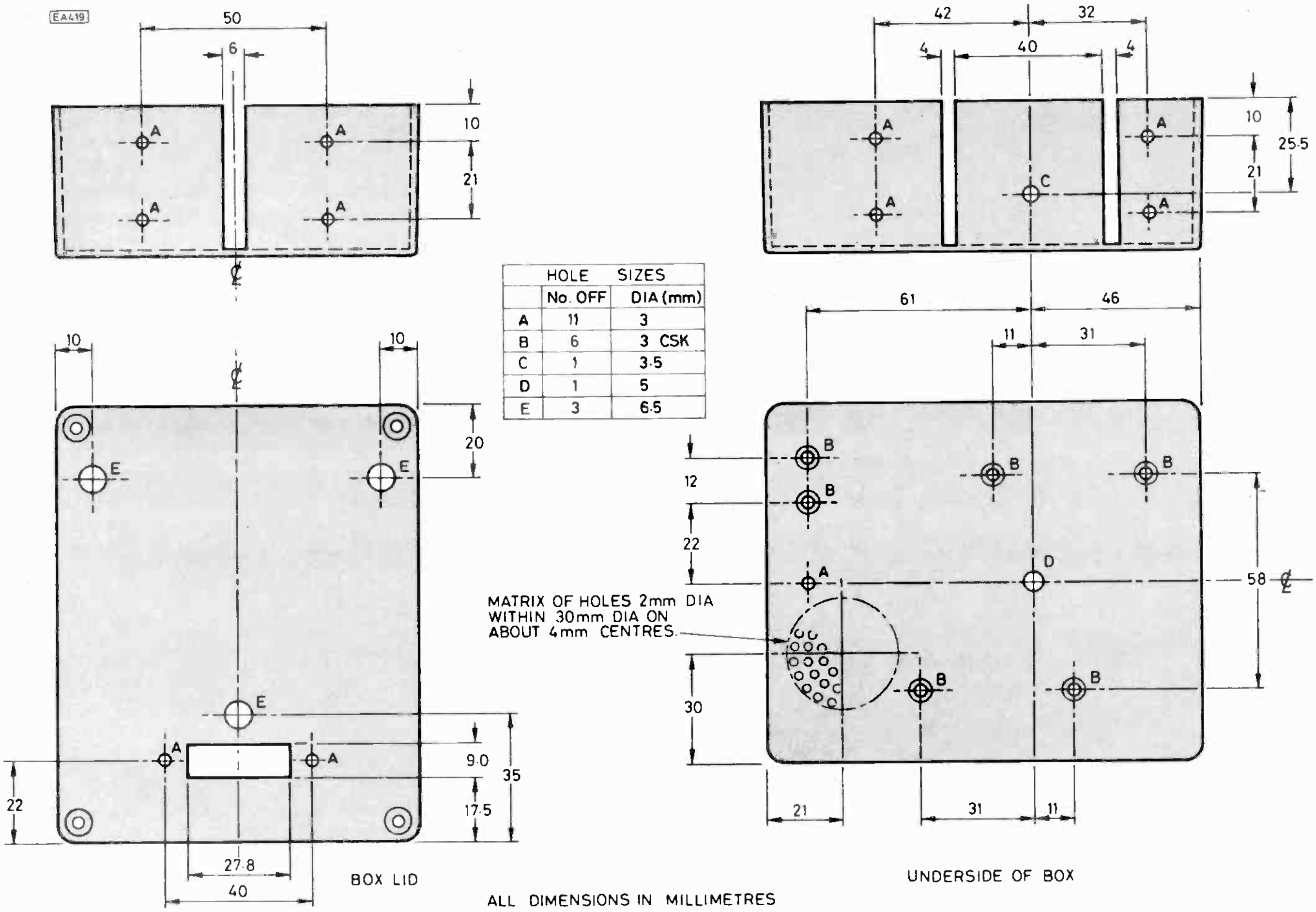
DESCRIPTION OF ZEAKER CONTROL STATION

The Control Station contains 4 Nicad C-cells to provide the power for Zeaker. This eliminates all the safety problems with mains powered equipment and thus it may be left without fear in the hands of the youngest child. Using Nicads also leads to a more compact power supply unit and a fully charged set will power Zeaker for at least 4 hours but including thinking time, human's and Zeaker's, this will easily stretch to 8 hours. To recharge the Nicads the computer's power supply can be used, in the version here, the ZX–81 power supply simply plugs in the back and trickle charges the Nicads through a lamp which also acts as a reminder that the supply is on. The ZX–81 power supply will recharge the Nicads overnight.

A printed circuit board holds the driver transistors which switch on the motors, lights and solenoid. A 556 dual oscillator is used to provide the tones for the horn whilst a 74LS00 Quad NAND i.c. wired as a set/reset latch prevents the motors being switched into reverse as well as forward. On the front panel is a switch which isolates the control electronics from the Nicads and acts as an "off" switch for Zeaker. No robot (leastways with present technology) should be without an "off" switch.

VEHICLE CONSTRUCTION

First, the box should be modified as shown in Fig. 1, then the metal Fenders should be made and bent to shape using the template drawings in Fig. 2. The solder tags should be attached as shown in Fig. 3 and the bends checked again. Make up the pen arm and bracket (Fig. 4), once again this drawing can be used as a template for bending the pen arm. A corner of one of the motor gearboxes (Fig. 5) should be removed. (This will be the starboard motor assembly.) The motors and gearboxes should be assembled using only 4 of the black plastic gears with the long end of the small motor shaft shortened so the shaft is 39mm in length. Next press on the white gear wheel and put on the spacers. Assemble the gearbox and secure the end cap with polystyrene cement (for plastic kits) (Fig. 6).



HOLE	SIZES	
	No. OFF	DIA (mm)
A	11	3
B	6	3 CSK
C	1	3.5
D	1	5
E	3	6.5

Fig. 1. Cutting and drilling details for Zeaker's chassis

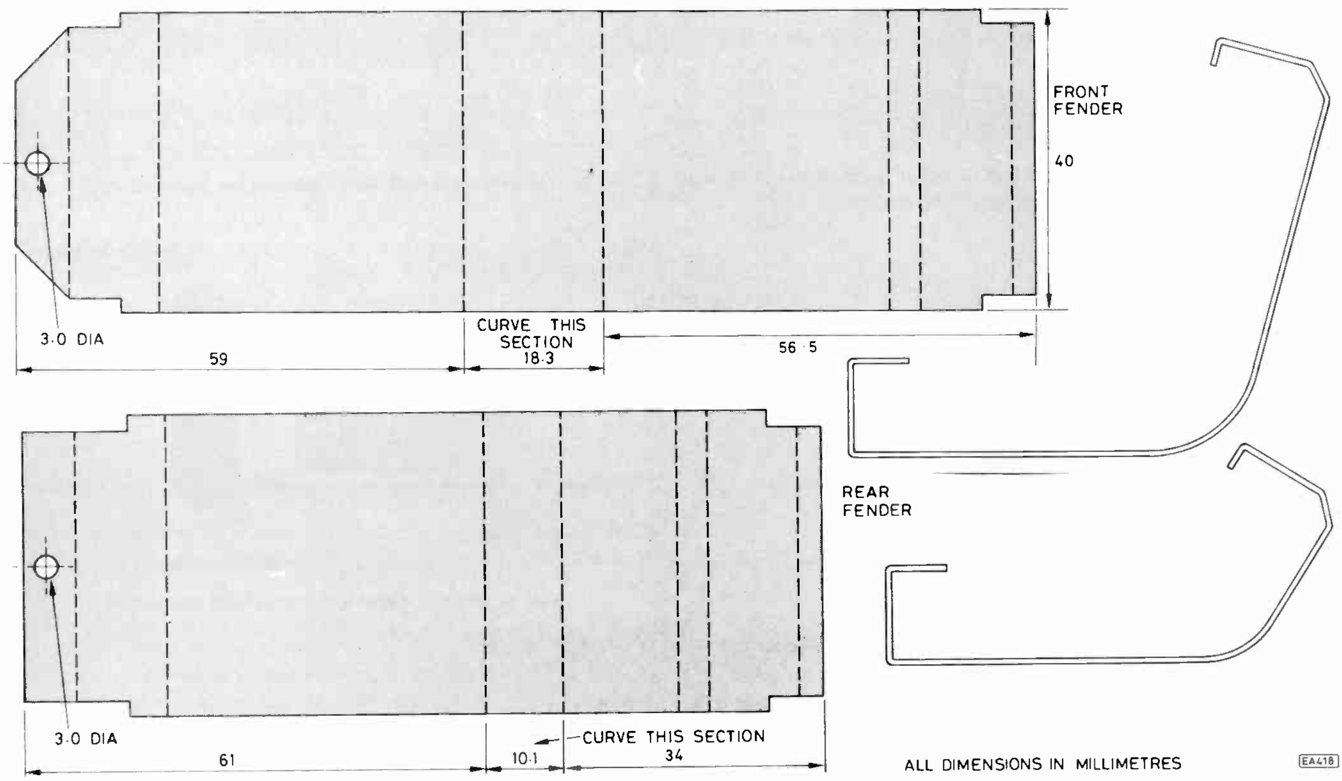


Fig. 2. Fender cutting and bending details. Note this drawing is full size and can be used as a template for cutting and bending the fenders

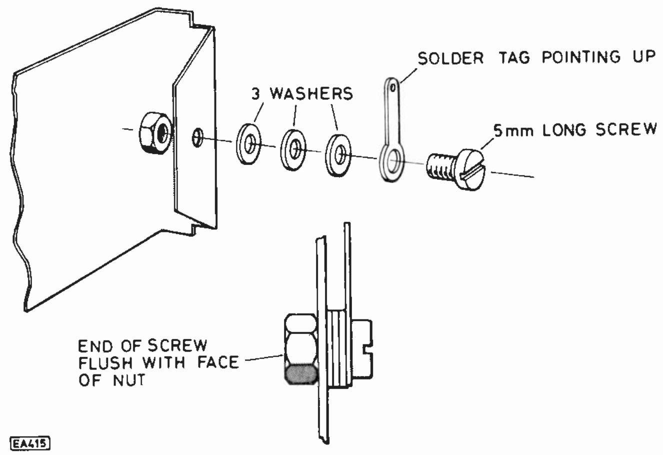


Fig. 3. Method for attaching solder tags to fenders

the solder tag and the toe components fitted to hold the speaker (Fig. 8).

The left motor assembly can now be positioned checking that it doesn't bind. Now assemble the solenoid in its bracket, fit the plunger extension and spring (Fig. 4) and bolt the bracket to the bottom of the box fixing the pen arm underneath. The pen arm should be loose enough to move freely under solenoid control. Fit the pen and make sure that it is centred in the hole at the bottom of the box, adjusting the bracket position accordingly.

A fibre washer should be placed on each wheel shaft and then the wheels can be fitted (Fig. 6). Adjust the pen in its holder so that in the down position it projects about 1 to $1\frac{1}{2}$mm below the bottom of the wheels. The pen can then be shortened so that its top is level with or just below the top of the pen arm.

The Fenders should just drop in the slots of the box, after being eased over the foam pads. They should push in and make contact with the pillars very easily and the foam pads should spring them out again.

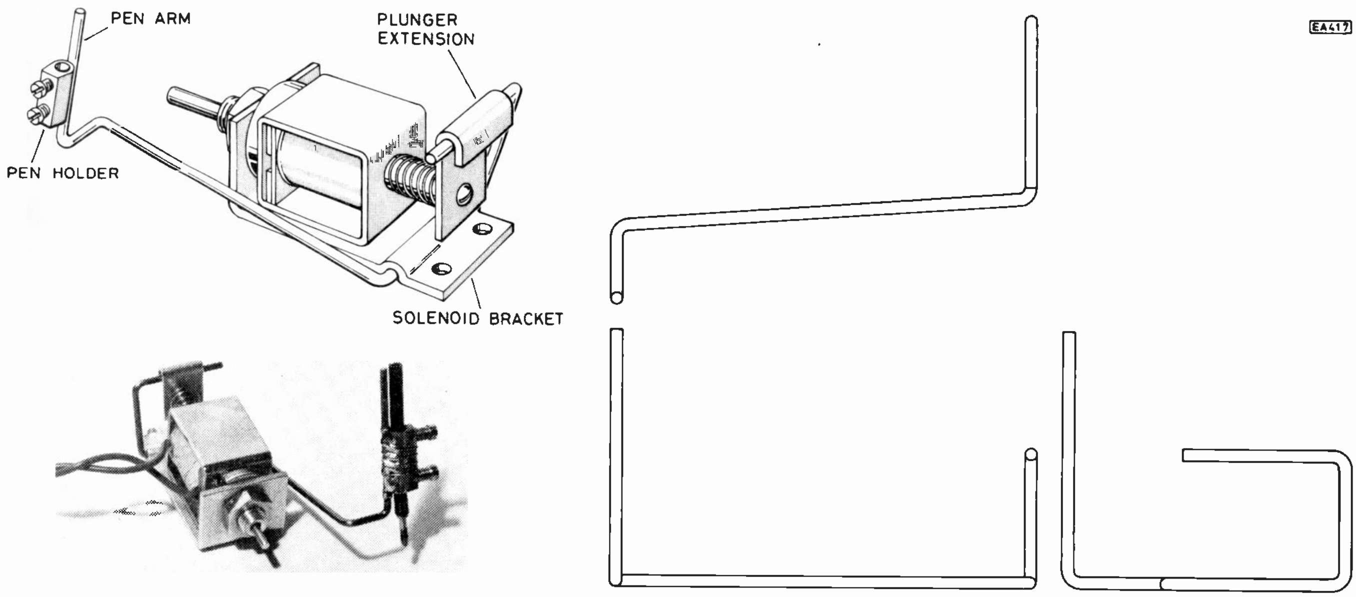


Fig. 4. Solenoid mounting bracket and pen arm. Note the pen arm drawing is full size and can be used as a template for cutting and bending the arm

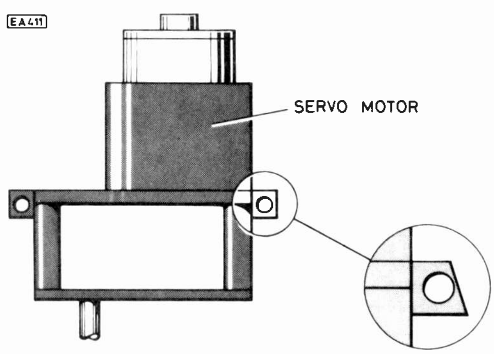


Fig. 5. Servo motor modification

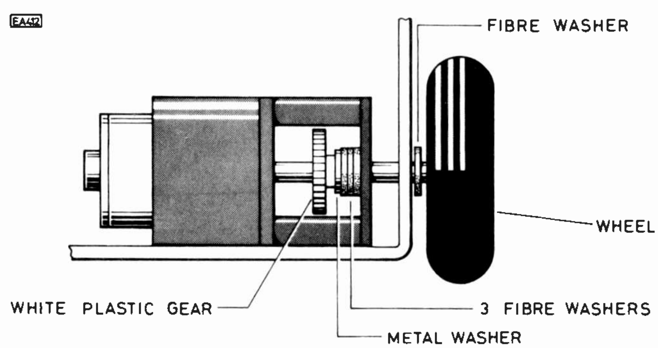


Fig. 6. Motor, gearbox and wheel assembly

The tactile sensor screws and pillars should be fitted next (Fig. 7 and Table 1) and then the foam pads can be mounted as shown in the photograph. The starboard motor assembly should be bolted into position and a solder tag fitted on top of the front mounting lug to hold the speaker in position. Check that the output shaft does not bind on the sides of the case hole. The speaker can now be fitted in position under

VEHICLE PCB

The vehicle p.c.b. is shown in Fig. 9 with the component layout shown in Fig. 10. The components are mounted on the solder side of the board with the exception of SK1. Before fitting the components, solder should be run onto each square pad to form solder bumps. The diode, resistors and RF chokes should then be soldered, blobbing the ends of

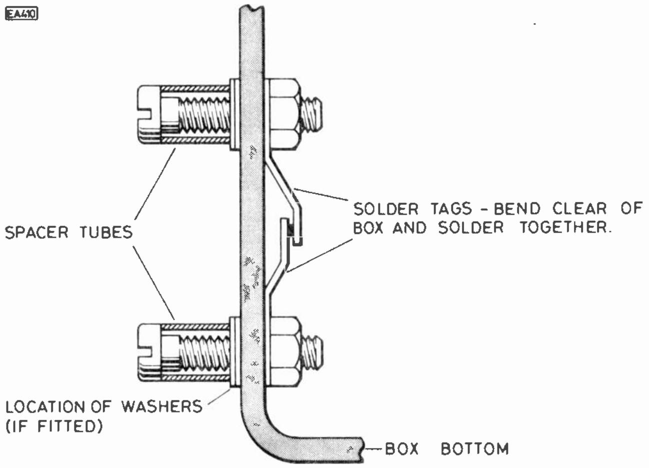


Fig. 7. Tactile sensor contact assembly

Top and bottom contact points are identical

LOCATION	SPACER LENGTH
Front	3mm
Side front	7mm (6mm spacer + 2 washers)
Side rear	6mm
Rear	3mm

Table 1

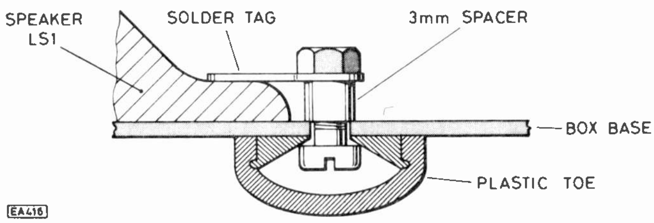


Fig. 8. Toe assembly

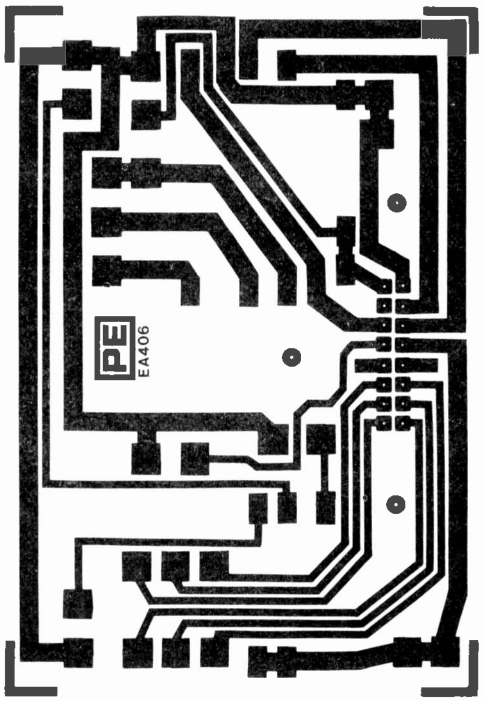
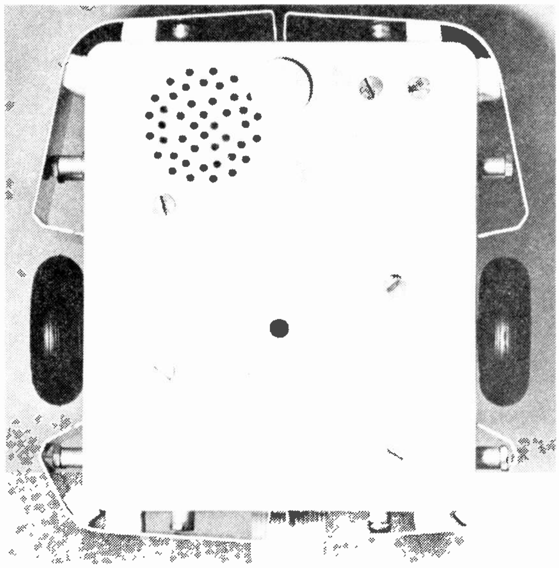


Fig. 9. P.c.b. for vehicle



Photograph showing the position of the foam pads

the leads into the solder bumps (Fig. 10). The 16-way Molex connector (SK1) should be fitted from the opposite of the board and soldered in place.

The p.c.b. should be bolted onto the lid of Zeaker using two fibre washers over the p.c.b. tracks. The l.e.d.s and link wires to the p.c.b. can be soldered next with the leads of the centre l.e.d. bent down and soldered to the two adjacent pads.

VEHICLE WIRING

All the top and bottom solder tags on the contact-points should be linked as should the side-rear and rear contact-

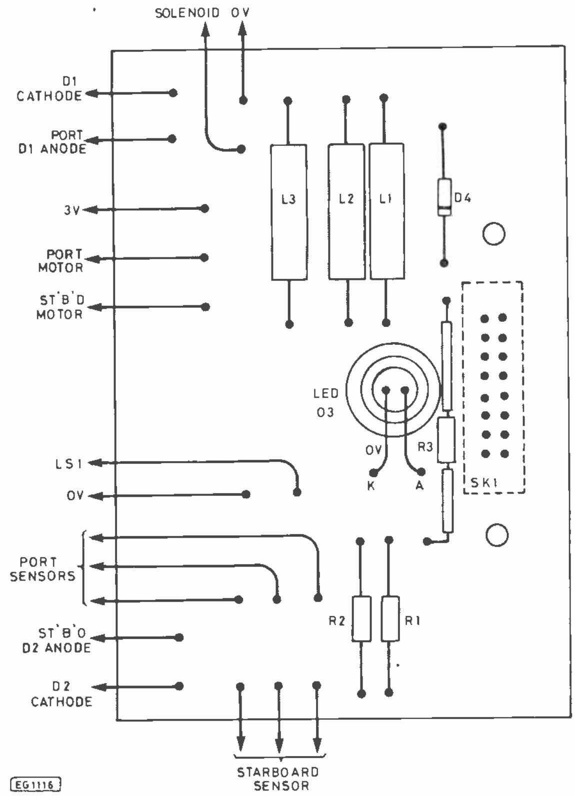


Fig. 10. Component layout

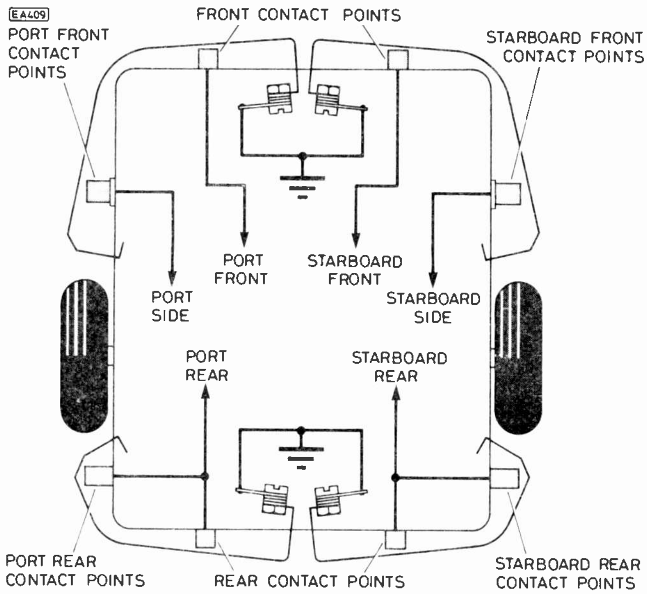


Fig. 11. Location of Zeaker's tactile sensors

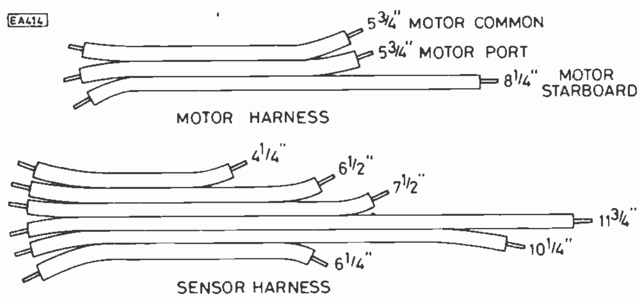


Fig. 12. Motor and Sensor harnesses

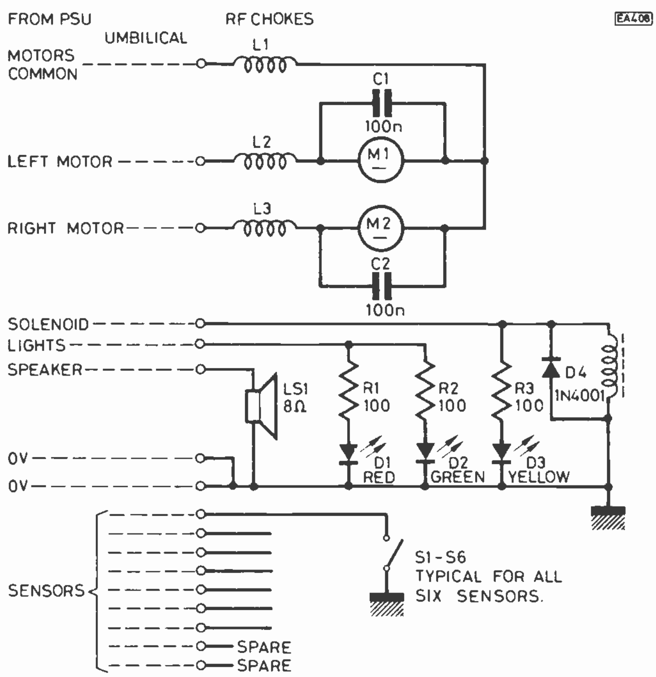


Fig. 13. Wiring diagram for the vehicle

COMPONENTS . . .

VEHICLE

Resistors
R1, R2, R3 100 (3 off)

Capacitors
C1, C2 100n (2 off)

Semiconductors

D1	0·2 in red l.e.d.
D2	0·2 in green l.e.d.
D3	0·2 in yellow l.e.d.
D4	IN4001

Inductors
L1, L2, L3 Lamp RF chokes (3 off)

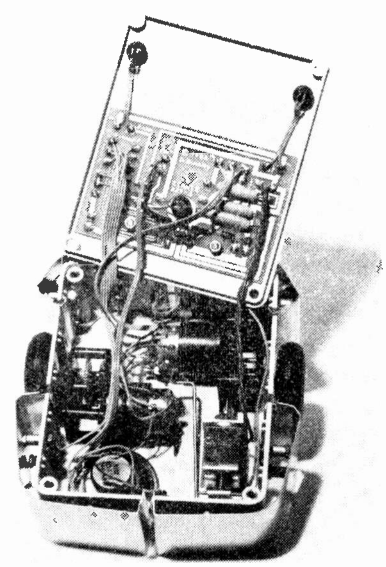
Miscellaneous
ABS plastic box (120 x 100 x 45mm)
Cover cap for toe
Micro Mold 38 x 13 wheel (2 off)
Como motors and gearboxes, small (2 off)
Keyswitch Varley 5V solenoid SM00
1½in. dia. 8 ohm speaker
Pen holder—centre from 5A connector block
Clips for l.e.d.'s (3 off)
Molex connector 5332 series 16 pin
Aluminium for fenders, plunger extension and solenoid mounting bracket
Rod for pen arm
Fender foam pads (self-adhesive draught excluder)

Constructor's Note

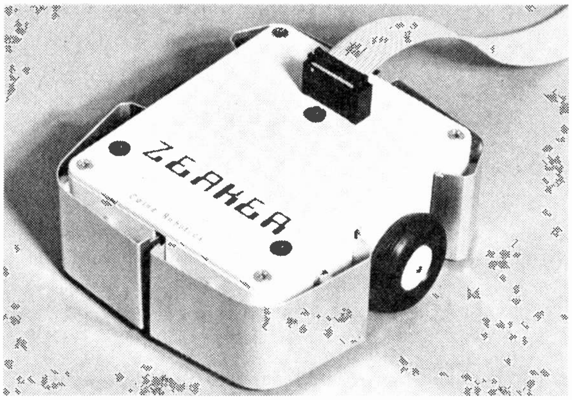
The toe cover cap is available from most hardware stores and the wheels and motor gearboxes assemblies are obtainable from hobby shops.

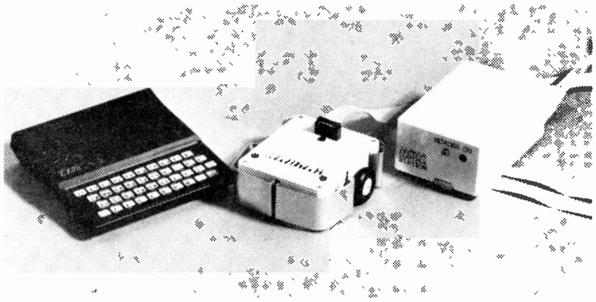
A complete kit of parts for the vehicle (including machined, cut and ready bent items) and control station with a manual and software is available from Colne Robotics Ltd., Beauford Road, off Richmond Road, Twickenham TW1 2PH (01-892 8197/8241). Price £59·95 inc. VAT.

Colne Robotics are also able to supply the separate parts, please write or phone for details.



Internal view of the vehicle





The Zeaker Vehicle together with its Control Station and a ZX-81

FORWARD

STARBOARD

SENSOR PORT FRONT 1	SENSOR PORT SIDE 3	SENSOR PORT REAR 5	SENSOR SPARE (a) 7	SPEAKER 9	MOTOR STARB'D 11	MOTOR COMMON (2·5V) 13	SOLE-NOID 15
SENSOR STARB'D FRONT 2	SENSOR STARB'D SIDE 4	SENSOR STARB'D REAR 6	SENSOR SPARE (b) 8	LIGHTS 10	MOTOR PORT 12	MOTOR COMMON (2·5V) 14	OV 16

PORT

CABLE CHANNEL

Fig. 14. Molex connector pin allocations (viewed from copper side (below) of p.c.b.)

points (Fig. 11). The 6-way harness can then be fitted to the contact-points starting with the longest lead at the Front Port contact-point and then fit the speaker harness, finish the interwiring and fit the motor harness. Then slot the fenders into position and solder the fender links. Finally solder the harnesses to the appropriate pads on the p.c.b. (Fig. 13). The solenoid leads should be cut to $5\frac{1}{4}$ inches, twisted together and soldered into place on the p.c.b. Check that when the lid is shut none of the wires foul the fenders and that they can be pushed in to make contact as before.

VEHICLE CHECKOUT

Using a signal/pin allocation diagram (Fig. 14) check with a multimeter that each of the sensor lines is shorted to 0V when the appropriate contact pillar meets the fender and that upon release there is an open circuit. Apply +5V to the solenoid pin and check that the solenoid clicks in and lowers the pen, similarly check the lights with +5V. Applying 2V ($1\frac{1}{2}$V will do) between motor common and the motor lines check that +ve voltage on the port motor line makes the motor go forward and −ve makes it go in reverse and check that a +ve voltage on the starboard motor line makes it go back and −ve makes it go forward i.e. to go forward port line is +ve and starboard line is −ve (to even out battery use).

NEXT MONTH: Control station construction.

MICRO-BUS

Compiled by DJD.

Appearing every two months, Micro-Bus presents ideas, applications, and programs for the most popular microprocessors; ones that you are unlikely to find in the manufacturers' data. The most original ideas often come from readers working on their own systems; payment will be made for any contribution featured.

MANY microcomputers now offer programming languages such as FORTH, PASCAL, and LISP as alternatives to the ubiquitous BASIC which has become established as the universal programming language of micros. This month's Micro-Bus takes a detailed look at one of these (LISP) and the advantages it offers over BASIC for certain applications.

LISP

The most apparent difference between LISP and BASIC is the way programs are written. In BASIC the program is written as a number of statements which can be listed, edited etc; this is then RUN to perform the desired actions. In LISP the programming consists of defining 'functions' which have exactly the same status as the functions which constitute the language itself. For example, PLUS is a function provided in LISP for performing addition; the programmer can define a function ADD which behaves in exactly the same way as PLUS, or indeed can re-define PLUS to do something different (as shown later in this article).

ATOMS AND LISTS

The nuts and bolts of LISP are very simple when compared to BASIC. Whereas in BASIC there are variables, arrays, functions, subroutines, and language statements, in LISP there are just two fundamental types of object: atoms and lists. The atoms are indestructible units, such as numbers like 23, or symbols like NAME, PROG1, etc. Lists are composed of atoms, and a simple list of three atoms might be:

(RED WHITE BLUE)

where the brackets are used to enclose the elements of the list. Lists may be composed of any number of atoms, or other lists; for example:

(16 (THIS))

is a list of two elements, the atom 16 and the list (THIS).

Symbols can have values, so they act like the variables of other languages. Normally anything typed at the keyboard of a LISP system is evaluated, and as a reminder of this LISP's prompt is:

Evaluate:

So if we type an atom, such as:

Evaluate: LINEWIDTH

we are given its value in return:

Value is: 40

The value could be a number, a symbol, or a list. Note that evaluating a number just gives the same number.

FUNCTIONS

A symbol can also be designated as the name of a function; we have already met PLUS, the LISP function for performing addition. How then do we call a function? The answer is that we first construct a list starting with the function name, and followed by the list of arguments that the function needs. Then we ask LISP to evaluate that list. Thus to add 2 and 3 we type:

Evaluate: (PLUS 2 3)

And the answer comes back:

Value is: 5

Arguments to functions are normally evaluated before being passed to the function, so we can write:

Evaluate: (PLUS (TIMES 1 2) (TIMES 4 6))

to find the answer to 1*2+4*6.

In addition to all the usual built-in functions, LISP contains functions for manipulating lists. The three most important ones are CAR and CDR (the names are historical) which break down lists, and CONS which constructs a list.

CAR returns the first element of a list, and CDR returns the list with the first element removed. Thus, suppose LIS had the value:

(ONE TWO THREE)

then (CAR LIS) would give ONE
(CDR LIS) would give (TWO THREE)
(CAR (CDR LIS)) would give TWO
(CDR (CDR LIS)) would give (THREE)

CONS takes two arguments, the second of which must be a list; it adds the first argument to the front of this list. Thus:

(CONS 4 LIS)

is (4 ONE TWO THREE).

Although arguments to functions are normally evaluated, one can prevent this by using the QUOTE function, which can be abbreviated . . . Thus:

(CAR '(ONE TWO THREE))

would give ONE as before. However:

(CAR (ONE TWO THREE))

would normally give an error because ONE is not a valid function.

So far we have not discussed how values are assigned to atoms. Again, this is by means of a function; the function, SETQ, takes two arguments, and the value of the second is assigned to the first. Thus:

(SETQ NO 4)

would give NO the value 4. (Note that this is one function that does not evaluate its first argument.)

We now need to look at the COND function which gives LISP conditional facilities. Consider the following example:

```
(COND
   ( (EQ VAL 1) (PRINT 'ONE) )
   ( (EQ VAL 2) (PRINT 'TWO) )
   (T (PRINT 'NOT 'ONE 'OR 'TWO) )
```

COND is followed by a series of lists. The first element of each list is a condition; if this condition evaluates to a non-NIL value it is taken as being true or (T), and the remaining elements of the list are evaluated. For example, (EQ VAL 1) will have the value T if VAL is 1, and NIL otherwise. If none of the conditions are true COND returns NIL; normally, however, the last condition is T, as in the above example, so it will always be true.

DEFINING FUNCTIONS

Finally, the most important LISP function is DEF because it allows you to define new functions in LISP. As an example of defining a new function, let us see how a verbal description can be translated into a LISP function. The example used should be well known to everyone who has studied electronics: the calculation of the power dissipated in a resistor. This is given (in watts) by the equation: P = I ↑ 2 * R, where I is the current in Amps, and R is the resistance. The function will be given the name POWER; after the name comes a list of the parameters that will be supplied to the function (in this case, I and R), followed by the actual definition of the function:

```
(DEFUN POWER (I R)
   (TIMES (TIMES I I) R) )
```

Trying it out for a 3 ohm resistor carrying 2 amps:

Evaluate: (POWER 2 3)

Value is: 12

WHY LISP

What are the advantages of LISP over BASIC? Two advantages will be illustrated in this article. The first is that LISP's list structures provide a very convenient way of representing certain types of data. For example, the resistor network shown in Fig. 1 can be represented by the following list where (PAR X Y) denotes that X and Y are in parallel, and (SER X Y) denotes that X and Y are in series:

(PAR (SER (PAR 1 (SER 2 3)) 4) 5)

We can write LISP functions to operate on this list; for example, to find the total resistance of the network.

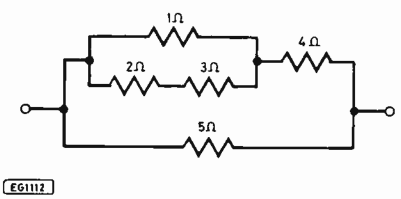


Fig. 1. Resistor network used by the LISP program described in the text.

A second advantage of LISP over BASIC is its extensibility; the programmer can add new facilities to the language itself to increase its power. For example, it might be useful to be able to define new types of data, such as complex numbers, vectors, and physical quantities, to cope with some particular application. Most languages, BASIC included, would require the programmer to set up a sub-language to handle the new datatypes. LISP, however, has the very attractive feature that the programmer can extend the definitions of the built-in functions to cope with new datatypes. This is illustrated for the following simple example which adds rational arithmetic to LISP.

RATIONAL-ARITHMETIC PACKAGE

Most implementations of LISP, at least on microcomputers, only include integer arithmetic. The rational-arithmetic package provides a way of expressing numbers which are not exact integers by extending LISP's integer arithmetic to include a new datatype, a rational number or ratio of two integers. In LISP this is represented as a list of two integers: for example, (12 23) represents the rational number: 12/23. The package can then be used to perform calculations on integers and rational numbers. Note that, unlike floating-point calculations, all calculations involving rationals using this package are exact.

To illustrate the package in use, we calculate 3+4/5:

Evaluate: (PLUS 3 '(4 5))

Value is: (19 5)

Thus the answer is 19/5.

The first step in writing the package is to provide a way of converting integers into rational form; thus the integer 6 should be converted into the rational number 6/1. We therefore define a function RAT that takes either a rational or an integer and always returns a rational; see Fig. 2.

Fig. 2. RAT converts an integer to a list representing a rational number.

```
(DEFUN RAT (A)
  (COND ( (NUMBERP A) (LIST A 1) )(T A) ) )
```

It uses the built-in function LIST which makes a list out of its arguments. Thus:

Evaluate: (RAT 6)

Value is: (6 1)

Next we redefine LISP's built-in arithmetic functions with new names, so that we can refer to them in the definitions of the functions that are to replace them:

```
(SETQ PLUS£ PLUS)
(SETQ MINUS£ MINUS)
(SETQ DIFFERENCE£ DIFFERENCE)
(SETQ TIMES£ TIMES)
(SETQ QUOTIENT£ QUOTIENT)
```

The two rational numbers 6/4 and 3/2 both represent the same number; to avoid this ambiguity we keep all rational numbers in lowest terms by cancelling out any common factor between numerator and denominator. The function NORM shown in Fig. 3 takes two integer parameters A and B, and returns a list (A B) representing the rational number A/B with any common factor between A and B cancelled out. It uses Euclid's method to find the Greatest Common Divisor between A and B, and returns an integer if possible; otherwise it returns a list of two integers.

```
(DEFUN NORM (A B (AA) (BB) )
  (SETQ AA A)
  (SETQ BB B)
  (LOOP
    (UNTIL
      (EQ
        (SETQ A (REMAINDER B (SETQ B A) ) )
        0)
      (COND
        ( (EQ BB B) (QUOTIENT£ AA B) )
        (T (LIST
          (QUOTIENT£ AA B)
          (QUOTIENT£ BB B) ) ) ) ) ) )
```

Fig. 3. NORM returns a list representing A/B as a rational in lowest terms.

Finally, we redefine the arithmetic functions to behave as normal on integers, and to deal correctly with rationals. Here only the definitions for PLUS and QUOTIENT are given; the other functions are left as an exercise!

For PLUS, shown in Fig. 4, we use the identity:

a/b + c/d = (a.d + b.c)/b.d

Each argument is first converted to a rational number, and the final result is normalised before being returned.

QUOTIENT, shown in Fig. 5, is simpler than PLUS since it must always perform the calculation in rationals, even if the arguments are both integers.

```
(DEFUN PLUS (A B)
  (COND
    ( (AND (NUMBERP A) (NUMBERP B) )
      (PLUS£ A B) )
    (T (SETQ A (RAT A) )
      (SETQ B (RAT B) )
      (NORM
        (PLUS£
          (TIMES£ (CAR A) (CADR B) )
          (TIMES£ (CAR B) (CADR A) ) )
        (TIMES£ (CADR A) (CADR B) ) ) ) ) ) )
```

Fig. 4. New definition for PLUS works with rationals as well as integers.

```
(DEFUN QUOTIENT (A B)
  (SETQ A (RAT A) )
  (SETQ B (RAT B) )
  (NORM
    (TIMES£ (CAR A) (CADR B) )
    (TIMES£ (CADR A) (CAR B) ) ) )
```

Fig. 5. QUOTIENT works with rationals.

RESISTORS NETWORK

Finally, as an example of how the rational versions of PLUS and QUOTIENT can be used, consider the practical problem of calculating the resistance of the resistor network shown in Fig. 1, represented by the list:

(PAR (SER (PAR 1 (SER 2 3)) 4) 5)

From the laws governing resistors in series and parallel, namely:

s = a + b for resistors a and b in series, and 1/p = 1/a + 1/b for resistors a and b in parallel, we obtain:

```
(DEFUN SER (A B) PLUS A B) )
(DEFUN PAR (A B)
(QUOTIENT 1 (PLUS (QUOTIENT 1A)
(QUOTIENT 1 B) ) ) )
```

Finally, to calculate the resistance of the above network:

Evaluate: (PAR (SER (PAR 1 (SER 2 3)) 4) 5)

Value is: (145 59)

Thus the resistance is 145/59 ohms, (2·46Ω).

Mains Watchdog

Chris Lare

EVEN though most homes rely heavily on electrical power, a mains supply failure for a short period of time is generally little more than an inconvenience provided that it is noticed and any necessary action taken. During the night, however, it is unlikely that such a break will be observed with the result that all electro-mechanical clocks will stop for the duration of the break, and many digital clocks will simply reset. The result of oversleeping the following morning and eventually rising to find that the central heating has also stopped leaves little to the imagination.

More seriously, there are those who rely on mains electrical power for medical reasons and for whom the supply failure can be a worrying experience even though most medical equipment is fitted with battery back-up. It will always be a comfort to such people to have company during this time and it seems desirable to have a unit which will warn others of a mains failure.

The design presented here is for a small and cheap mains powered circuit which will light an l.e.d. and sound a tone if the mains fails. The circuit will detect quite short breaks (60ms) and thus should be more sensitive to mains failures than other items. It is intended that the completed unit be left switched on at all times and be used as a 'wake up' alarm in event of supply failure.

THE CIRCUIT

It was decided from the outset that the complete unit should be small and cheap to make. It is obvious that some form of battery supply to power the circuit, once the mains has failed, is needed and it was decided that a small nickel cadmium re-chargeable battery would be ideal. The cell is trickle charged during the time the mains is on by means of a small transformer mounted directly onto the circuit board.

The circuit is centred around a dual CMOS version of the well known 555 timer. One of the timers is used as a conventional astable oscillator to produce a 1kHz tone, the other as an edge triggered latch to detect and remember the supply failing. It is worth examining the action of the 555 used as a latch because it often provides a simpler and more compact solution than conventional logic designs.

In normal astable operation (Fig. 1) the capacitor charges up until the 'threshold' voltage is reached. At this time the output changes state and the discharge output pulls low, discharging the capacitor. This state continues until the 'trigger' voltage is reached when the output changes state again, the discharge output starts to float and the capacitor recharges.

It is obvious from this that the trigger is operated from a falling voltage and the threshold from a rising voltage. Both these inputs have the advantage that they are specifically designed to cope with slow edges, which would undoubtably require a Schmitt trigger interface to conventional logic latches. To use the 555 as a latch is a simple matter of omitting the timing capacitor and associated resistors. Fig. 2 shows the schematic and truth table that results from this. It is important to note two main points about the trigger and threshold inputs. Firstly, they should not be connected directly to the active supply rail which can cause lock-up in some manufacturers' parts which are not fitted with an internal bias generator and so a series resistor of some 220 ohms should always be inserted in series with the inputs, or the input should be a.c. coupled with a capacitor. The second point to note is that these inputs are level sensitive and not edge triggered, and should only be pulsed

AN AUDIO/VISUAL MAINS FAILURE WARNING SYSTEM

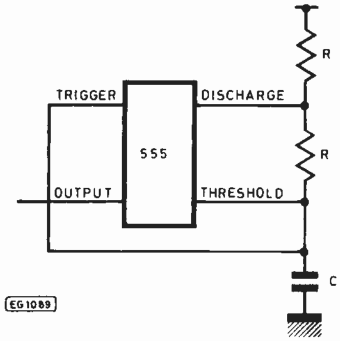


Fig. 1. Astable operation

to activate them since unstable conditions occur if they are both active at once.

In this application it is required to detect a falling edge and so the threshold input is connected to 0 volts. This is acceptable since 0 volts is not the 'active' supply rail for the threshold input. Obviously once the 555 is triggered by a falling edge on the trigger input it will remain so until manually reset, in this case by the reset button connected to the 555 reset line.

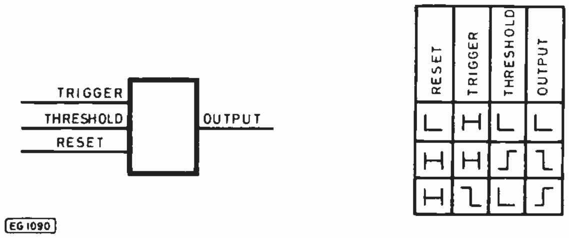


Fig. 2. Schematic and truth table for the latch including reset

A 3VA transformer was used to power the circuit (Fig. 3.). In view of the low standby power it would have been possible to derive the supply directly from the mains via dropping resistors but this was not done for reasons of safety. The transformer is connected to the mains via a 50mA fuse which will blow if the circuit fails in any way. This must not be omitted since it is intended that the final unit be left plugged in for long periods of time without any checks being made on it.

The output of the transformer is rectified by D1 and D2. This rectified power is used to trickle charge the 9 volt ni-cad battery via R1 (to limit the current) and D3 (to prevent the battery from interfering with the operation of the actual fail detection circuit). It should be noted that the regulating effect of the battery avoids the need for a smoothing capacitor.

The 15 volt Zener diode, D4, plays no part in the normal operation of the circuit and serves to limit the supply voltage to the i.c. should the battery ever become disconnected.

The actual fail detection circuit uses half a CMOS 556 as a latch with the threshold input grounded as previously described. When the mains voltage is present C2 will charge up to about 9 volts by virtue of R2 and clamp diode D5. This means that C3 is nearly discharged since R4 will hold pin 6 of the 7556 at about 9 volts as well. It is necessary to clamp the voltage on C2 to be about the same as the battery voltage or C2 would tend to discharge into the battery through R2 and the normal trickle charge path which would keep triggering the unit. When the mains input ceases C2 will discharge through R3 which in turn requires that C3 charges through R4, temporarily pulling the 7556 trigger input low as it does so.

The latch action of the timer is reset by S1, which simply grounds the reset input. Capacitor C4 is included to provide a battery power-up reset and prevent spurious noise causing erratic resets.

The output of the timer-latch is used to turn on an l.e.d. by means of a transistor buffer, required because the CMOS version of the timer cannot source sufficient current for this purpose. The output also enables a conventional astable oscillator, which, after suitable transistor buffering, is used to drive a small speaker. The volume level was limited in the prototype by a 47 ohm series resistor but this may be altered if required. The diode D8 acts as a clamp to prevent back e.m.f. from the speaker upsetting the operation of the astable circuit.

CONSTRUCTION

A small plastic box (120×40×65mm) was used to house the prototype, and the printed circuit board is designed to fit into this size of box. There is not much room in the box and it is suggested that the parts are roughly fitted and then any necessary holes drilled so that they do not foul the circuit board or the speaker. As a guide the prototype circuit board was mounted upside down in the box, the switch, l.e.d. and speaker fitting alongside the transformer below D1 and D2. The mains cable was fed through a hole in one end of the box. A 20mm hole was drilled in the bottom of the box 43mm from one end and covered with speaker cloth on the inside. The speaker was then glued in place above this hole so as to leave room for the battery plate (Fig. 4). The p.c.b. design for the circuit is shown in Fig. 5 with the component layout shown in Fig. 6.

A certain amount of care should be used when assembling the p.c.b. since parts of it carry mains voltages. Also note that if the board is to be manufactured using an etch resist pen at least 3mm should be left between those tracks carrying the mains supply and any others.

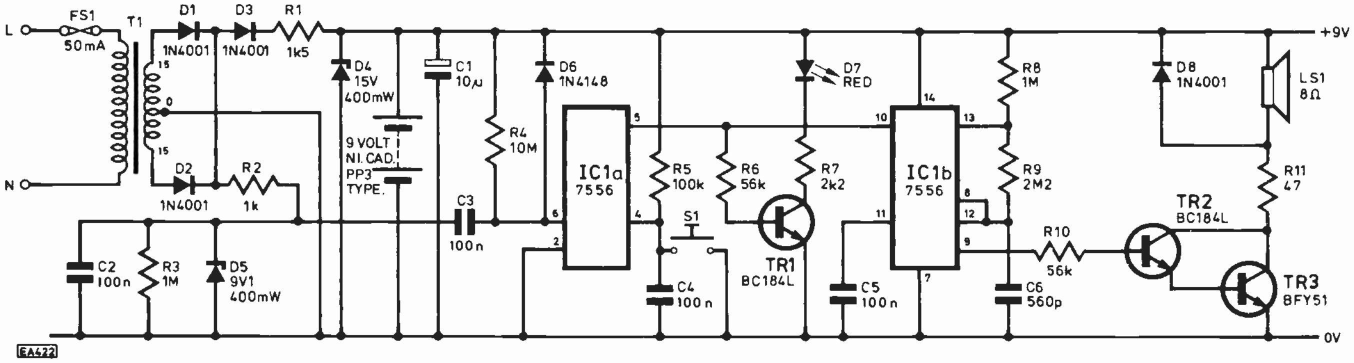


Fig. 3. Circuit diagram

COMPONENTS . . .

Resistors

R1	1k5
R2	1k
R3, R8	1M (2 off)
R4	10M
R5	100k
R6, R10	56k (2 off)
R7	2k2
R9	2M2
R11	47

Capacitors

C1	10μ 25 volt tant
C2, C3, C4, C5	100n C280 type polyester (4 off)
C6	560p polystyrene

Semiconductors

D1, D2, D3, D8	1N4001 (4 off)
D4	15V Zener 400mW
D5	9V1 Zener 400mW
D6	1N4148
D7	Red 0·2" l.e.d.
TR1, TR2	BC184L (2 off)
TR3	BFY51
IC1	ICM7556

Miscellaneous

50mA fuse and two p.c.b. fuse clips
35 ohm speaker (or 80 ohm) to fit box approx. 50mm diameter
Printed circuit board
Terminal pins
Push button switch
PP3 nickel cadmium battery
PP3 battery clip
Aluminium sheet to make battery plate
Plastic box 120 × 40 × 65mm with ribbed inner walls
Main 2 core cable and plug
Grommet and cable tie
Connecting wire

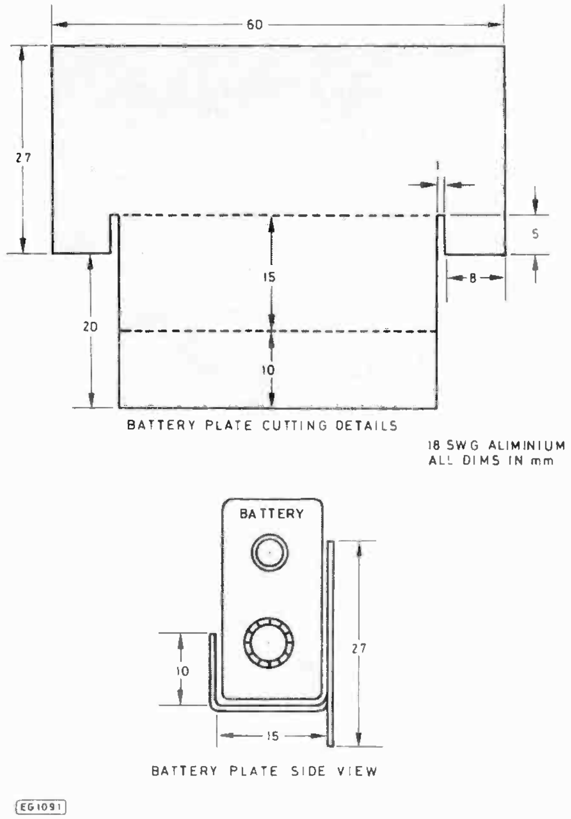


Fig. 4. Battery holder details

The prototype board was held in place in the box by the lid. Two plastic combs usually used to clip boards in were glued to the sides of the box to be flush with the top of the slots in the box wall. The complete circuit boards balanced on these and was clamped into place by the lid.

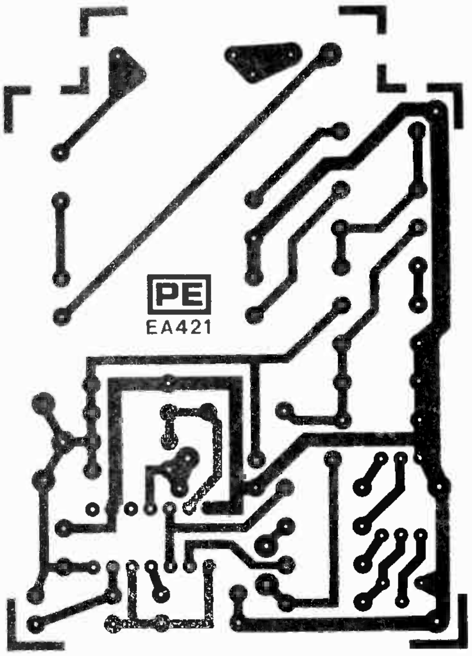


Fig. 5. P.c.b. design

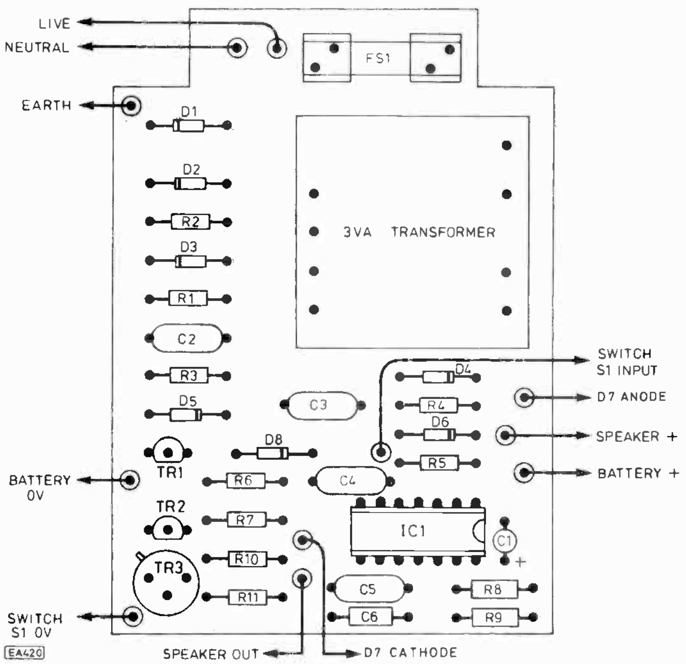


Fig. 6. Component layout

Internal view of the unit

A cable tie should be fixed around the mains cable on the inside of the box to prevent it being pulled out and a grommet must be used to stop the wire rubbing on a rough edge.

A plastic box should be used but if a metal box is required it is essential that it is earthed very well. In any case the circuit board itself should be earthed as indicated.

TESTING

Ensure that the nickel cadmium battery is disconnected before testing commences. All live parts of the circuit board must be well covered in insulating tape before the unit is plugged in. The usual precautions for handling mains powered systems must be observed.

Connect a multimeter across the battery clips and switch on. The voltage should be slightly less than 15 volts. Switch off and repeat with the meter connected across D5 when a reading of 9 volts should be seen. If the tone sounds during this time and sounds very rough do not worry since with the battery missing the circuit supply is largely unsmoothed and 50Hz hum will be superimposed on the tone. Connect in the battery and press the reset if the tone sounds.

Switch the unit on and off and the tone should now sound cleanly and the l.e.d. should light. It may happen that the tone will sound briefly and fade out; this is due to the battery being flat and so the unit should be left on for some 24 hours in order to charge the battery up.

If problems are experienced and the l.e.d. does not come on when the power is removed unplug the unit and try connecting C2 to the +ve battery terminal and then removing it to simulate mains failure. It should be possible to see the voltage on pin 6 of the i.c. kick down but remember that the meter will alter the timing relationships.

There is little to say about the unit in use. The prototype was fitted behind a bedside table and simply left alone. Do remember to reset it if the power is turned off for any reason since it will run until the battery is dead. ★

Personal Stereo Amplifier

R.A. PENFOLD

PERSONAL stereo cassette and radio/cassette units provide a surprisingly high output quality despite their diminutive size and the fact that they are not fitted with Dolby B decoders (a fixed amount of treble cut normally being used when playing back cassettes). Perhaps an obvious add on for these units is a small amplifier plus a pair of compact loudspeakers. This would enable several people to listen to the unit simultaneously, would give better stereo imaging than using headphones, but would retain a degree of portability and the personal stereo unit could be used normally when maximum portability was required.

Amplifiers of this type do not appear to be available ready made, but a simple home constructor design for such an amplifier forms the subject of this article. The unit provides an output power of up to about 6 watts r.m.s. per channel with a total harmonic distortion level of only about 0·1% (typical) at most power levels. This is sufficient to give good volume from a pair of small, inexpensive loudspeakers, and many loudspeakers of this type are not able to handle higher power levels. The signal to noise ratio is better than 70dB and the noise level is negligible in comparison to that produced by the signal source. The amplifier has proper bass and treble tone controls which give the user far better control of the tone than the simple high/low tone switches.

While results are obviously not in the super-fi class, when used with a personal stereo unit and pair of compact loudspeakers of reasonable quality a very versatile portable hi-fi system having a worthwhile level of performance is produced.

THE CIRCUIT

The circuit diagram of the tone, volume, and balance controls is shown in Fig. 1, and in Fig. 2 the power amplifier.

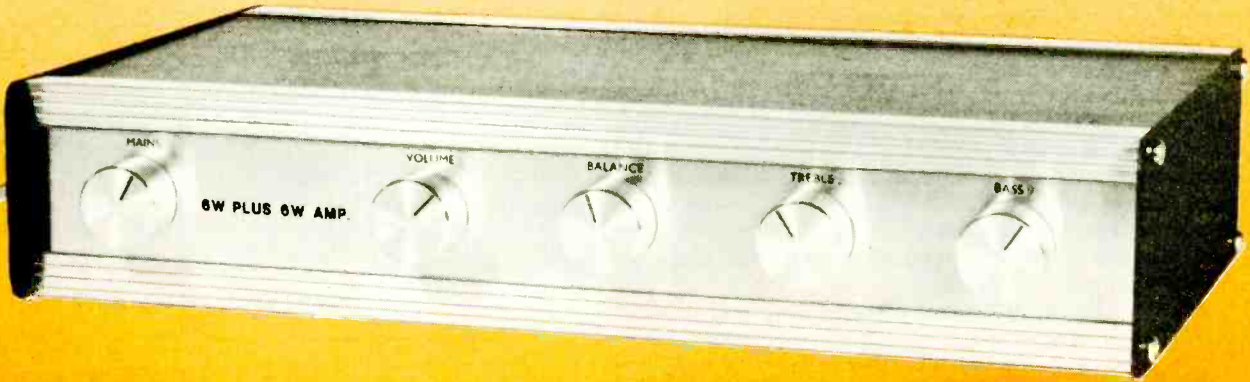
Taking the controls first, this is a straight forward passive circuit of conventional design. The bass control gives about 12dB of boost and cut at 100Hz and the treble control gives a similar degree of boost and cut at 10kHz.

It is not strictly necessary for the unit to have a volume control since all personal stereo units have a volume control which would still function with the amplifier in use. Most personal stereo units also have some means of permitting channel balancing (usually by simply having a separate volume control for each channel). Volume and balance controls were included in the unit merely because it was felt that this would be more convenient in use, and experience with the prototype supports this belief. However, the output of the tone controls can obviously be coupled straight through to the power amplifiers if preferred, with VR3, VR4–104, R5, R6, R105, and R106 all being omitted, if the volume and balance controls are considered to be superfluous.

There is a loss of about 20dB or so through the tone and balance control circuits, but this is not important since an input level of about 1 volt r.m.s. or more will be provided by the personal stereo unit. This gives an output level of about 100mV r.m.s. from the control circuits, which is sufficient to drive a small power amplifier.

The power amplifiers each use a TDA2006 integrated circuit which is a modern device capable of excellent performance. This device only had five leadout wires; the supply terminals, the output, plus inverting and non-inverting inputs. This device has no internal bias circuits, and it is used in very much the same way as an ordinary compensated operational amplifier such as the 741C, but it has a Class B output stage which is capable of delivering a maximim output current of 3 amps and can produce an output power of several watts into a load impedance of a few ohms.

In this circuit the TDA1006s are used in the inverting amplifier mode with R7 (R107) and R8 (R108) setting the input impedance and closed loop voltage gain of the amplifiers. R9 and R10 are used to bias the non-inverting inputs of both amplifiers to about half the supply voltage, and C8 prevents hum or other noise on the supply lines from being coupled into the amplifiers via the bias circuit. D1, D2, D101 and D102 are protection diodes, and C5 plus C105 are supply decoupling capacitors which are mounted physically close to IC1 and IC101 respectively to prevent instability.



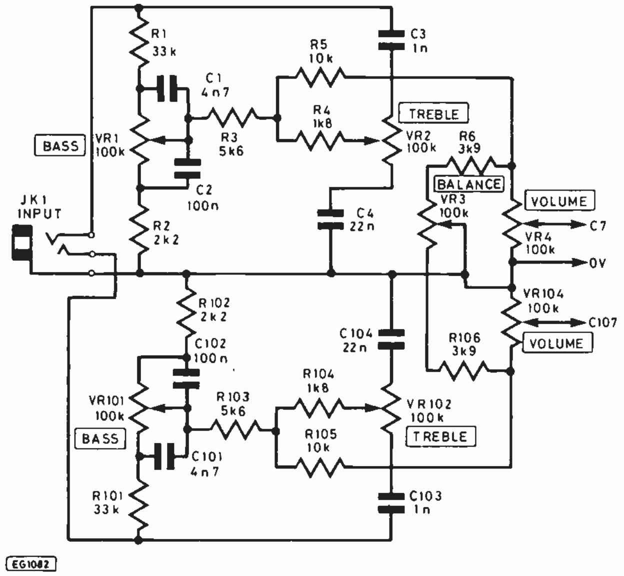


Fig. 1. Tone, volume and balance controls

MAINS POWER SUPPLY

Although battery operation of the amplifier would have the advantage of making the unit self contained, this is not really feasible since a supply potential of about 22 volts is required, and at high output powers the current consumption of the circuit exceeds 800 milliamps. The simple mains power supply circuit of Fig. 3 is therefore used to power the amplifier.

This is a straightforward non-regulated design using a bridge rectifier and smoothing capacitor C9. There is a significant amount of ripple on the output of the supply, but the TDA2006 devices used in the power amplifiers have 50dB of supply ripple rejection, and the filter used in the bias circuit of the power amplifiers also gives good immunity to hum on the supply lines. This results in no discernible mains hum from the loudspeakers despite the simplicity of the power supply circuit.

T1 is a toroidal transformer which has two 9 volt secondaries that are used in series in this circuit. This gives an unloaded supply voltage of just over 28 volts, but this falls slightly under quiescent loading, and reduces to about 22 volts with both channels fully driven.

Fuse FS1 should be an antisurge type rather than the more common quick-blow variety since the secondary windings of T1 provide a series of pulses of current to C9, not a reasonably constant current flow. There is also a large current flow at switch-on as C9 initially charges up, and there would be a danger of a quick-blow fuse "blowing" unnecessarily

CONSTRUCTION

A printed circuit board accommodates all the components apart form the mains transformer, on/off switch S1, and the sockets. Details of the printed circuit board and wiring of the unit are shown in Fig. 4.

Construction of the printed circuit board is easiest if the small components are soldered in place first, followed by the four controls, C6, C106, and finally C9. It would of course be possible to use ordinary potentiometers in the unit, but they would have to be mounted off-board and hard-wired to the component panel. Construction is far simpler using the correct printed circuit mounting potentiometers, and their use is strongly recommended.

Use pins in the printed circuit board at the points where it will be connected to T1 and the three sockets. Before soldering the integrated circuits into place carefully form the

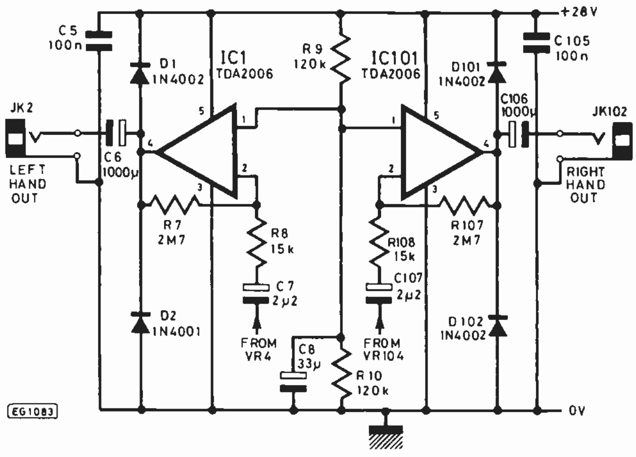


Fig. 2. Power amplifier

leadout wires of the devices and position them so that their mounting holes are aligned with the mounting holes in the board. It will be impossible to manoeuvre the integrated circuits into the correct position without risk of damage once they have been soldered into place. Make sure that the potentiometers are pushed right down into place before soldering them into position.

The recommended case is of aluminium and steel construction with approximate outside dimensions of 300 by 150 by 60mm, but any case having similar or larger dimensions should, with a little ingenuity, be just as suitable. Assuming the specified case is used the front panel is drilled as shown in Fig. 5, and this layout should be accurately copied or it will probably be impossible to fit all the components into the case.

When the four potentiometers are mounted on the front panel they provide the front mounting for the printed circuit board. An 18 s.w.g. aluminium mounting bracket is used to support the rear of the board and also provides a certain amount of heatsinking for the two integrated circuits. Details of the mounting bracket are provided in Fig. 6. One part of the bracket is placed between the printed circuit board and the heat tabs of the two integrated circuits, and then 6BA or M3 screws about 6mm long are used to bolt the bracket, board, and integrated circuits together. The lower part of the bracket is fixed to the base panel of the case, again using 6BA or M3 bolts about 6mm long. It is essential for the mounting holes in the base panel of the case to be accurately positioned, and it is probably best to fit the front panel, board, and bracket assembly in place in the case, check that the front panel is in the correct vertical position, and then use the bracket as a template to help mark the positions of the mounting holes on the base panel. A lack of accuracy here could make it impossible to fit the lid.

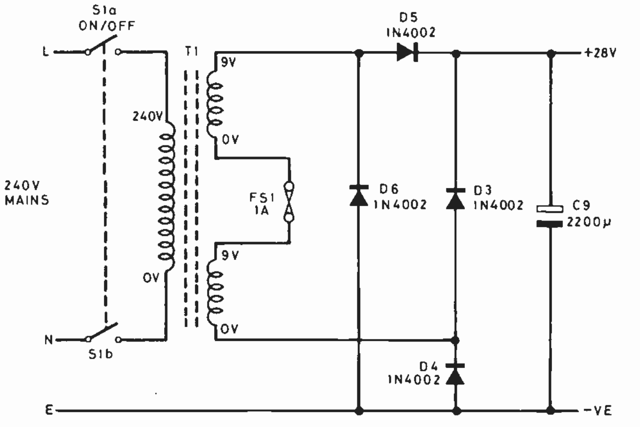
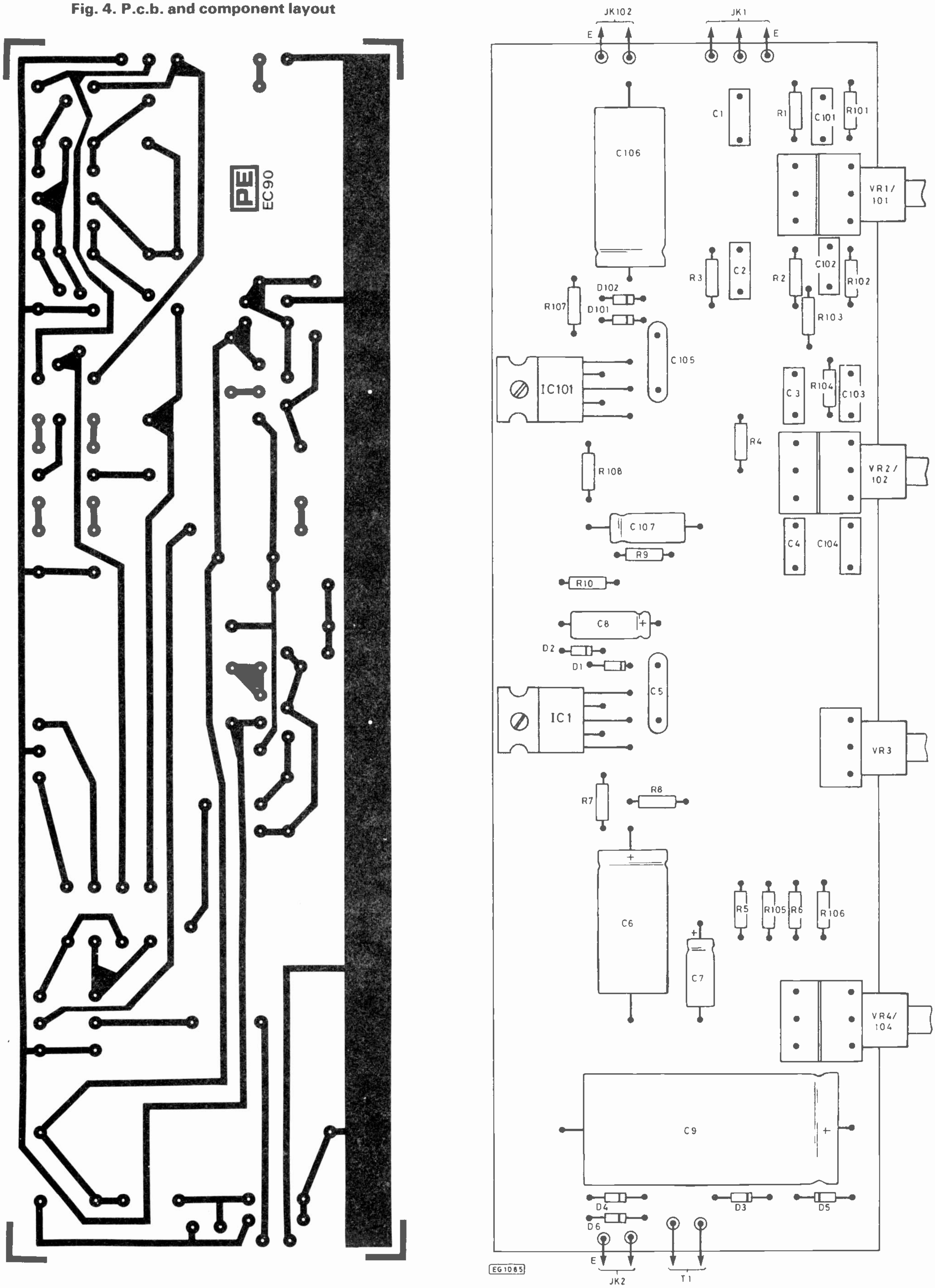


Fig. 3. Mains power supply

Fig. 4. P.c.b. and component layout



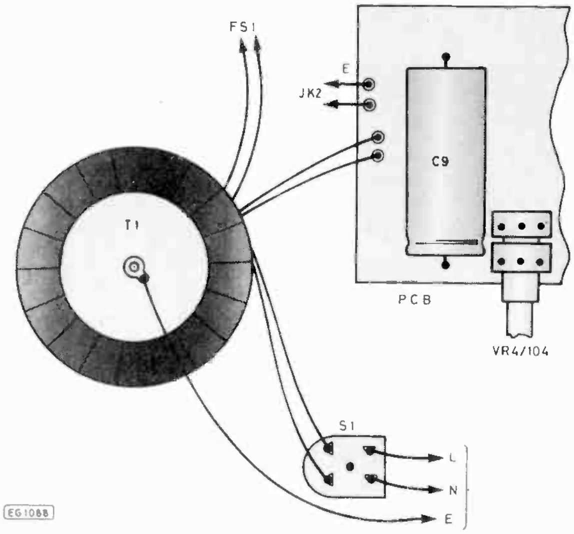
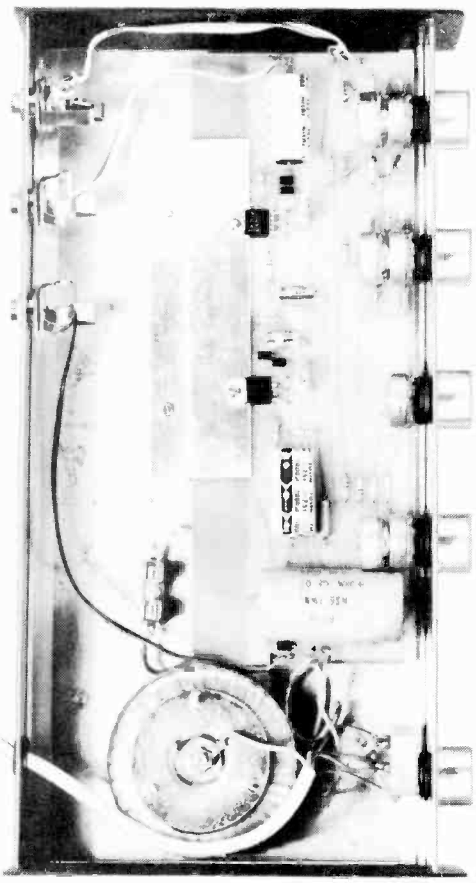


Fig. 5. Transformer connections

Mains transformer T1 is mounted on the base panel of the case to the left of the component board, and the toroidal component specified in the components list is supplied complete with a mounting kit. A single 6mm diameter mounting hole is required. A large solder tag fitted on T1's mounting bolt provides a chassis connection for the mains earth lead. The chassis mounting fuseholder for FS1 is mounted at any convenient place on the base of the case close to T1. An entrance hole for the mains lead is drilled in the rear panel near to T1 and this hole must be fitted with a grommet to protect the cable. The input and output sockets are mounted at the other end of the rear panel.



COMPONENTS . . .

Resistors

R1, 101	33k (2 off)
R2, 102	2k2 (2 off)
R3, 103	5k6 (2 off)
R4, 104	1k8 (2 off)
R5, 105	10k (2 off)
R6, 106	3k9 (2 off)
R7, 107	2M7 (2 off)
R8, 108	15k (2 off)
R9, 10	120k (2 off)

All 1/4 watt 5% carbon

Potentiometers

VR1–101, VR2–102	100k lin. dual gang printed circuit mounting (2 off)
VR3	100k lin. printed circuit mounting
VR4–104	100k log. dual gang printed circuit mounting

Capacitors

C1, 101	4n7 carbonate (2 off)
C2, 102	100n carbonate (2 off)
C3, 103	1n carbonate (2 off)
C4, 104	22n carbonate (2 off)
C5, 105	100n polyester (2 off)
C6, 106	1000u 25V axial electrolytic (2 off)
C7, 107	2u2 63V axial electrolytic (2 off)
C8	33u 16V axial electrolytic
C9	2200u 40V axial electrolytic

Semiconductors

IC1, 101	TDA2006 (2 off)
D1 to 6, 101, 102	1N4002 (8 off)

Switch

S1	Double pole rotary on/off mains type

Miscellaneous

JK1	Standard 6·35mm stereo jack socket
JK2, 102	Standard 6·35mm mono jack socket (2 off)
T1	30VA toroidal mains transformer with twin 9 volt secondary windings (ILP Transformers Ltd)
FS1	1A 20mm antisurge fuse

Chassis mounting holder for FS1
Printed circuit board
Five control knobs
Case type DX4 or similar (300 x 150 x 60mm)
Cabinet feet
Connecting lead with standard stereo and 3·5mm stereo jack plugs (Maplin)
Veropins
18 s.w.g. aluminium for heatsink
Mains lead, mains plug, connecting wire, etc.
Pair of compact 8 ohm impedance loudspeaker enclosures (e.g. Maplin 5W system)

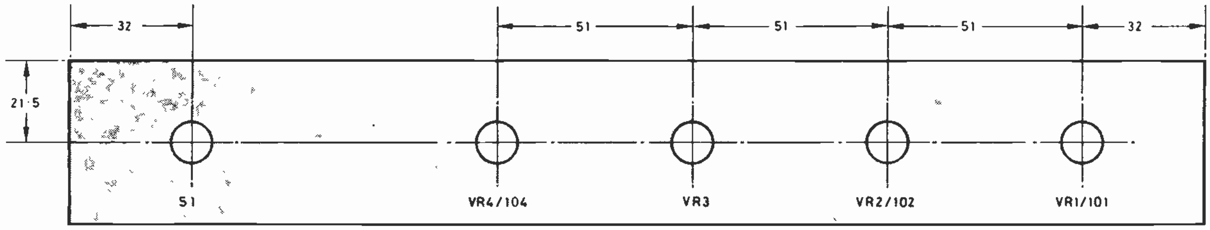


Fig. 6. Drilling details of the front panel

Once all the components have been fitted in place the final wiring can be completed. Due to the fairly low sensitivity of the amplifier and the very weak magnetic field of the toroidal transformer used for T1 there is no need to use screened cable to connect the printed circuit board to JK1. If output sockets JK2 and JK102 are not insulated types be careful to connect these correctly or the output will be short circuited. The TDA2006 integrated circuit has thermal and output short circuit protection built-in incidentally, and accidental overloads on the output would probably not result in the destruction of the output devices. Of course, JK2 and JK102 can be replaced with two way DIN sockets or some other type of connector if this would be more convenient in use.

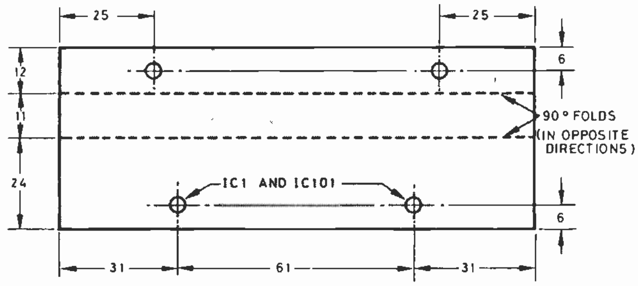


Fig. 7. Heatsink and board mounting bracket

IN USE

The output of the unit is coupled to the input socket of the amplifier using a three way lead fitted with a 3·5mm stereo jack (which connects to the personal stereo unit) and a standard 6·35mm stereo jack (which connects to the input of the amplifier). Due to the fairly low source impedance and high signal level it is not necessary to use a screened lead. Personal stereo units normally have the output socket wired so that the tip of the output jack carries the left hand channel, incidentally.

The volume controls on the personal stereo unit should be set at a position that would give a good high volume level if the unit was used with headphones, but should not be advanced so far that there is a danger of clipping occurring during periods of high volume. The tone switch should be set to the "high" position. Volume, balance, and tone are then adjusted using the controls on the amplifier.

Only 8 ohm impedance loudspeakers are recommended for use with the Personal Stereo Amplifier since higher impedance types would give a much lower maximum output power, and lower impedance speakers would almost certainly overload the power supply and cause FS1 to rupture. It is not difficult to build your own loudspeaker enclosures using modern materials, but there are a number of suitable commercially produced speakers which are suitable. In either case make sure that the speakers are rated at about 5 watts r.m.s. or more. Note that bookshelf monitor speakers are not suitable for use with this amplifier due to the low efficiency of speakers of this type, which consequently need quite a high input power in order to give high volume levels.

Patents Review

Copies of Patents can be obtained from:
the Patents Office Sales, St. Mary Cray, Orpington, Kent. Price £1·60 each.

TV WARNING

The unexciting title "Object Detecting Apparatus" for British patent application 2 090 411 from Tokyo Shibaura Denki of Japan, in fact covers a fascinating invention demonstrated by Toshiba at the London electronics trade shows in May 1981. Either by good planning or good fortune the patent claims priority dates of December 1980 and April 1981. It is of course a basic principle of British patent law (often overlooked by amateur inventors) that a patent application is invalid if it is filed after the invention has been shown off, other than under strict seal of confidence.

The Toshiba object detecting apparatus is a television set which senses the presence of a viewer and his or her distance from the screen. If a viewer comes too close and so risks getting eye strain, the set issues a warning in a synthesized voice. According to the patent the set says "You get too close to the TV set", and "stay away a little". In fact the Toshiba set, as demonstrated in Britain, spoke rather better English, "Watch from a distance for your eyes sake" it told anyone who got too close. The lengthy patent gives details of the clever circuits used to discriminate between furniture and viewers.

In Fig. 1 timing signal generator 26 is reset on the trailing edge of the output signals from oscillator 18. The output of monostable 20 controls oscillator 28, which produces an ultrasonic signal of between 40 and 60 kHz. This is radiated into the room by speaker 30.

Microphone 32 receives the wave reflected from furniture and viewers in the room and the received signal is amplified at 34, rectified at 36 and applied to sample and hold circuit 38. The sampled signal is compared at 40 with a reference signal from generator 42. Discrimination is achieved by storing the reflected signal during several periods of oscillator 18 and comparing the stored signal pattern with each subsequent received pattern. After counter 24 has clocked a given number of pulses e.g. 3, from oscillator 18 the flip-flop 52 is set. Data stored in memory 54 is then successively compared with reflected data in judging circuit 56. If the stored and received data match there is no change in the room. When they don't match the judging circuit 56 produces an output which triggers speech synthesizer 58.

The inventors claim that the invention is also usable as a security system for detecting burglars in the room. The output of judging circuit 56 then can be switched to sound an alarm.

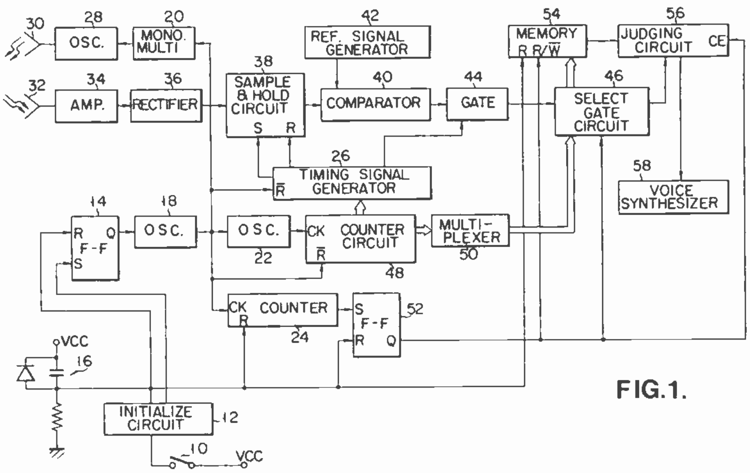


FIG.1.

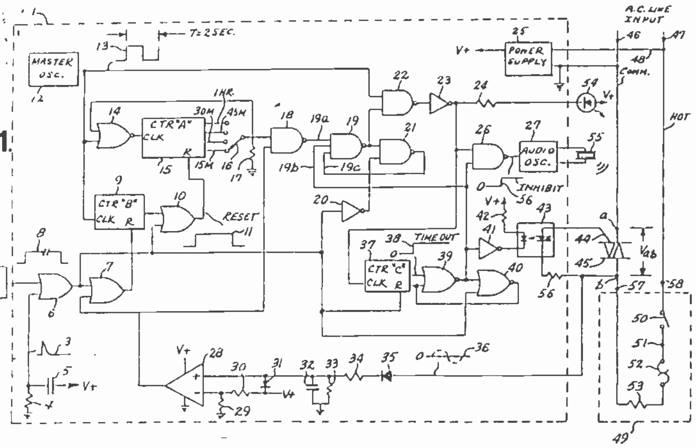
AUTOMATIC CUT-OUT

PCT application 82/03520 covers a device which could be useful for anyone who has a habit of leaving their soldering iron switched on and unattended. The application, which is filed in Germany, France, Britain, Japan and Holland, by Robert Franklin of California, is for an automatic power shut off system. It can be incorporated in any appliance which uses a heater element and is thus a fire hazard and expensive waste of energy. Or it can be connected as an add-on extra.

Fig. 1 shows the basic idea. Appliance 49, such as a soldering iron, receives a.c. power on line 46, 47. Triac 45 gates power to its heater element 53 via thermostat switch 52.

Use Detector and Timer (UDT) 1 has a master oscillator 12 which drives clock counter 15. This is pre-set to establish a period during which use of the appliance must be registered by a detector 2 to prevent a power shut down. Detector 2 can work by sensing motion of the appliance 49, or a grip on its handle, and can be either a touch sensitive switch, a piezo electric motion detector, a strain gauge, or a light or magnetic sensor. When detector 2 senses use, it re-sets UDT to zero. If no use is detected before the pre-set time, of say 15 minutes, runs out, then audible alarm 55 sounds and warning light 54 glows. This tells the user that the power is soon going to be turned off if the appliance isn't used. If it is used, the detector 2 resets the UDT to zero and it then starts counting again. If it isn't used then, 15 seconds after the warning, optic coupler 43 is switched off. This removes the gate drive for triac 45 which shuts off the power to appliance 49. Power is restored by touching the use detector 2 or momentarily unplugging UDT 1.

FIG1.



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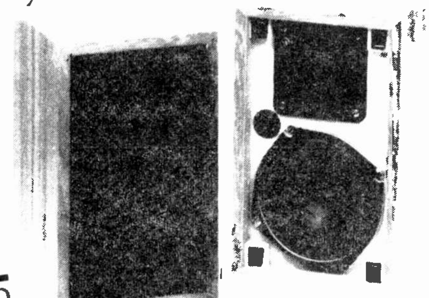

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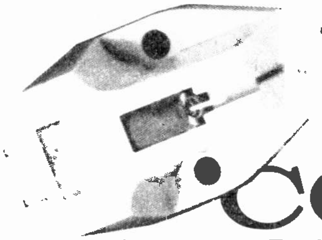

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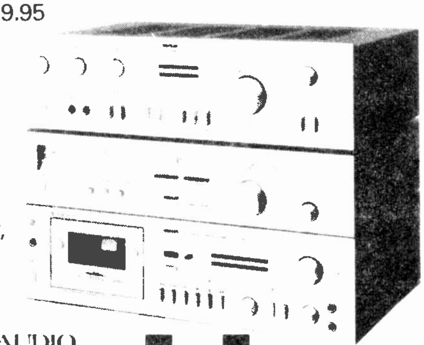

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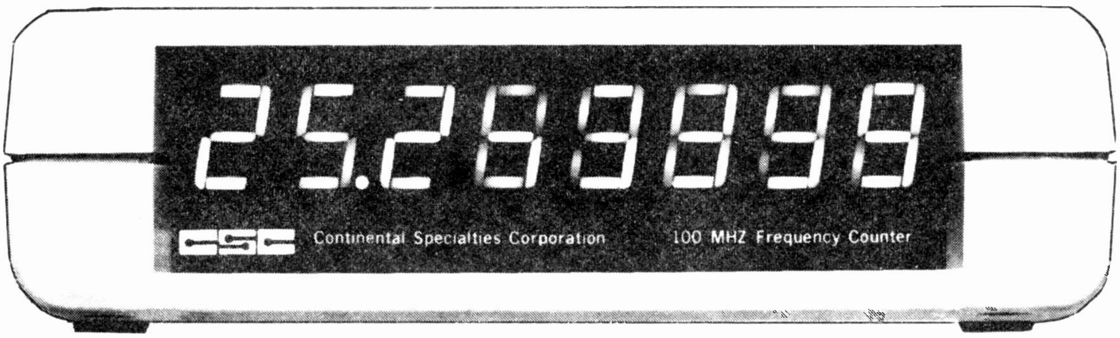

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into the REAL WORLD part 4

CONTROL CIRCUITS

Michael Tooley B.A.
David Whitfield M.A. M.Sc.

MICROPROCESSORS in control situations are concerned with the real world where the majority of situations involve the control of equipment which has not necessarily been designed with microprocessors in mind. This is particularly true of most mains-powered equipment, and in this part of the series we begin by examining some useful methods of power control. The essential theme of these techniques is to bring the power of the micro to bear in a control sense, while keeping the power source in the application safely at arms length.

A desirable aspect of any control system is that it should be able to talk to the operator. The series so far has made little mention of the topic of display driving, and this omission is covered by concluding the series with a description of some of the more commonly encountered numerical display techniques.

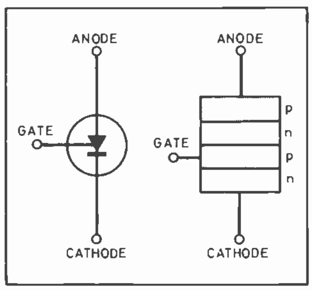
POWER CONTROL DEVICES

The traditional method of interfacing an electronic control circuit to a load which is connected to an a.c. supply has involved the use of an electromechanical relay. Such devices offer a simple, low cost, solution to the problem of maintaining adequate isolation between the control circuit and the potentially lethal voltages associated with the supply mains. Relays do in fact, offer many of the characteristics of an 'ideal' switch including very low 'on' resistance, very high 'off' resistance and a coil to contact breakdown voltage which is usually in excess of several kV. There are, however, several very serious disadvantages of the humble electromagnetic relay. These are principally associated with the transitory condition which occurs between the true 'on' and 'off' states. When current is applied to energise the coil of an electromagnetic relay, the relay contacts are relatively slow to react and, after this initial delay in response, several milliseconds of contact bounce can occur. This rapid fluctuation in the 'on' and 'off' state can cause rapid changes in load current which in turn may result in severe erosion of the relay contacts coupled with electromagnetic radiation over a wide range of frequencies.

When the energising current is removed from the relay coil, there is again some delay in the operation of the contacts and, whereas there is less likelihood of bounce on opening than closing, the air-gap between the relay contacts tends to ionise as the contacts open. Since the ionised air acts as a relatively good conductor, the arc only becomes extinguished when the line voltage approaches that required to sustain the arc. In this condition an excessive level of power can be dissipated in the space between the contacts. There is thus a safe working limit for every relay beyond which the contacts may suffer permanent damage and eventually burn-out! Readers should also note that, whereas a relay may be rated for operation at 240V a.c. its d.c. rating may be considerably less. This is by virtue of the fact that any arc produced between the contacts will become extinguished at the end of a half-cycle of the a.c. mains. With a d.c. supply of more than 50V, an arc may persist for some considerable time.

Modern semiconductor devices have fortunately provided the circuit designer with some elegant solutions to the problems of a.c. and d.c. power control. Silicon controlled rectifiers (also known as thyristors) and their derivatives have become commonplace in many power control applications, such as motor speed control and light dimming.

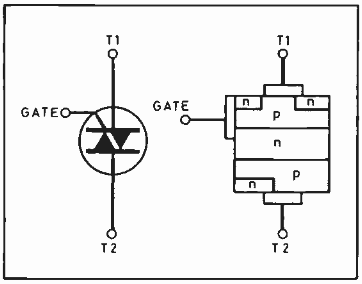
A silicon controlled rectifier (s.c.r.) is a four layer three terminal semiconductor device. Such a device will conduct a unidirectional load current whenever the rectifier has been triggered by the injection of a pulse of current into its gate. Provided that the latching value of current is exceeded, the device will remain in the 'on' conducting state until the anode current falls below a certain minimum value. This holding value is the minimum anode current that can flow through the s.c.r. and still maintain conduction. Such a condition can, of course, easily be achieved by momentarily interrupting the supply to the device. The symbol and internal arrangement of an s.c.r. is shown in Fig. 1.



EG1095

Fig. 1. Symbol and internal arrangement of a thyristor

An s.c.r. is, by virtue of its unidirectional property, ideally suited to d.c. power control applications. In a.c. circuits a single s.c.r. can only provide control over half-cycles of the supply. The triac is a development of the s.c.r. which can be used to pass or block current in either direction. The device essentially comprises two thyristor devices connected in anti-parallel but sharing a common gate electrode. The symbol and internal arrangement of such a device is shown in Fig. 2. The triac, like the s.c.r., has a minimum holding current below which conduction cannot be maintained. The device can, however, be triggered by both positive and negative gate current pulses. A complete discussion of the properties and characteristics of s.c.r. and triac devices is beyond the scope of this series and, where further information is required, readers are recommended to consult one of the currently available thyristor and s.c.r. manuals.

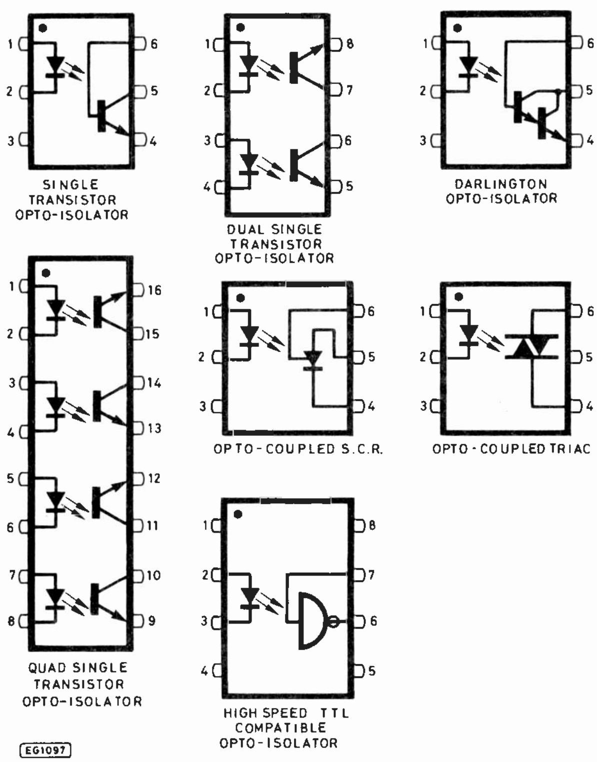


EG1096

Fig. 2. Symbol and internal arrangement of a triac

OPTO-ISOLATORS

Opto-isolators provide a means of coupling signals without the need for a direct electrical connection between devices. Signals are conveyed by means of a beam of infra-red radiation linking an emitting device to a detector housed in a common light-proof enclosure. The emitting device usually takes the form of a gallium arsenide diode whereas the detector may take one of several forms including phototransistor and photo-Darlington arrays. Photo-coupled s.c.r. and triac devices are also available. A variety of opto-coupled devices are shown, together with their conventional pin-outs, in Fig. 3.



EG1097

Fig. 3. A range of opto-coupled devices

The maximum voltage which can safely be applied between the input (emitter) and output (detector) terminals of an opto-isolator is usually in the range 1 to 7·5kV. This is comparable with the coil to contact breakdown voltage of most electromechanical relays. The insulation resistance of an opto-coupled device is generally around 10^{11} and 10^{12} ohm. This should be more than adequate for most applications including coupling to the 240V a.c. mains supply.

The efficiency of an opto-coupled diode, transistor or Darlington is usually expressed in terms of current transfer ratio (c.t.r.). This is simply the ratio of detector (output) to emitter (input) current. A typical c.t.r. for an opto-coupled transistor is 0·5 whilst that for an opto-coupled Darlington can be as much as 800. Since c.t.r. varies widely with emitter current, values must be specified for operation under particular conditions (i.e. emitter current, temperature etc).

The infra-red emitters of most opto-isolators have a maximum continuous current rating of between 20 and 60mA. The forward voltage drop of such a device is usually around 1·2V whilst the maximum reverse voltage maybe as low as 3 to 5V. A fixed current limiting resistor is often connected in series with the emitter in order to limit the current when driven from a conventional TTL logic gate. Values of between 180 and 270 ohm will limit the emitter current to between 17 and 10mA, respectively. Whereas the emitter is common to a range of opto-coupled devices, detectors tend to vary quite considerably. Desirable characteristics include not only a high value of c.t.r., but also a fast response. Devices which may be perfectly adequate for control applications in conjunction with the supply mains may be quite unsuitable for high speed data transmission. A range of fast opto-isolators have recently become available. Typical of these is the HCPL2601, the simplified internal block diagram of which is shown in Fig. 4. The detector is coupled

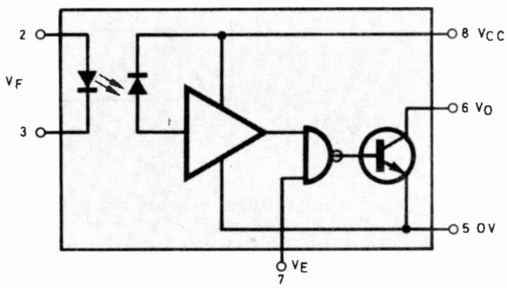


Fig. 4. Simplified internal block diagram of a high speed TTL compatible opto-isolator

INPUT V_F	ENABLE V_E	OUTPUT V_O
H	H	L
L	H	H
H	L	H
L	L	H

EG1098

Table 1. Truth table for the isolator shown in Fig. 4

to an integrated high gain amplifier which is followed by an AND gate. An enable input is provided to this gate and it, in turn, is followed by an open collector Schottky clamped transistor. An internal screen provides a common mode transient immunity of 1kV/µs. This is equivalent to rejecting a 1MHz sine wave of no less than 300V pk–pk!

PRACTICAL POWER CONTROL CIRCUITS

A practical arrangement for interfacing a microcontroller or microcomputer to a load driven from the a.c. mains supply is shown in Fig. 5. This simple circuit uses a Darlington opto-isolator coupled to a triac. When the input is held 'low', gate current flows and the triac conducts allowing current to flow through the load. Note that triggering only occurs on positive half-cycles of the supply and thus this circuit is limited to a maximum load of around 500W. Fig. 6 shows an arrangement which employs an opto-coupled thyristor in conjunction with a bridge rectifier and triac. The bridge rectifier allows triggering on both positive and negative half cycles of the supply. The series C–R network connected across the triac is known as a 'snubber' and is used to compensate for

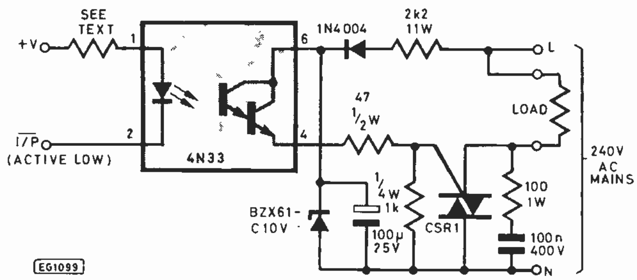


Fig. 5. A simple a.c. power control circuit using a Darlington opto-isolator

the effects of an inductive load. This network may be omitted when the load is purely resistive (such as an electric fire or light). An arrangement using an opto-coupled triac is shown in Fig. 7. Additional components have been included to cater for severely reactive loads. Where the power factor of the load is unknown, components should be fitted for a power factor of 0·9. This circuit is capable of controlling load powers in excess of 1kW.

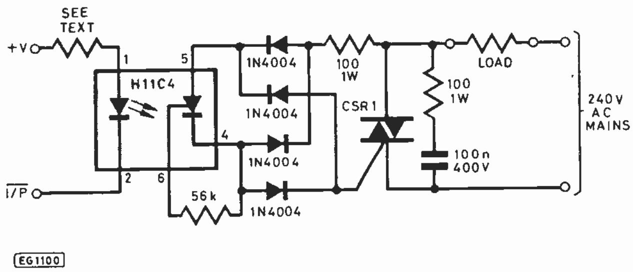


Fig. 6. An a.c. power control circuit using an opto-coupled thyristor

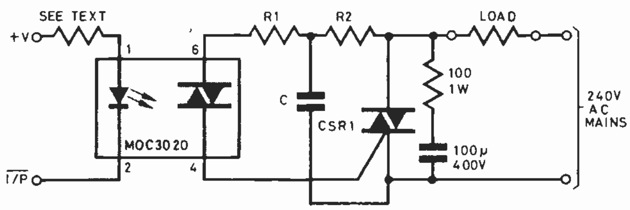


Fig. 7. Power control arrangement using an opto-coupled triac

LOAD POWER FACTOR	R1	R2	C
1	220	NIL	N.C.
0·9	180	560	100n
0·75	180	580	220n
0·5	180	680	330n

EG1101

Table 2. Component values for use with reactive loads

DISPLAY DRIVING

The control of displays is one of those areas of microprocessor system design, rather like keyboard handling, where the designer has the opportunity of making a number of hardware and software tradeoffs. The actual details of the tradeoffs which may be made, or even considered, will usually be determined by the characteristics of the particular application. In general, however, the factors to be considered will include: the amount of hardware involved, the complexity of the software required, the time available to perform the task, the memory space required, the speed of response, and any other tasks which must be performed concurrently.

Particular applications will have their own additional design constraints over and above those described above. Displays in hand-held applications, for example, will have tight space and power consumption constraints. The first step in all cases, however, will be to determine the extent to which hardware and software tradeoffs are practical, or even available; there is, after all, little point in deciding to use regular timer interrupts in a system where all of the user interrupt facilities have already been utilised.

Having defined the problem, and detailed the working limits for any solution, the designer is left with the task of producing a working design. There are few truly general guidelines which may be given, but careful consideration of flexibility, adaptability, future expansion possibilities, simplicity/modularity, and cost will usually help to narrow down the range of available choices. The discussion below covers some of the ways in which a typical seven-segment display may be controlled, and illustrates many of the practical considerations.

One straightforward way of driving a single common-anode seven-segment display is shown in Fig. 8. The A side

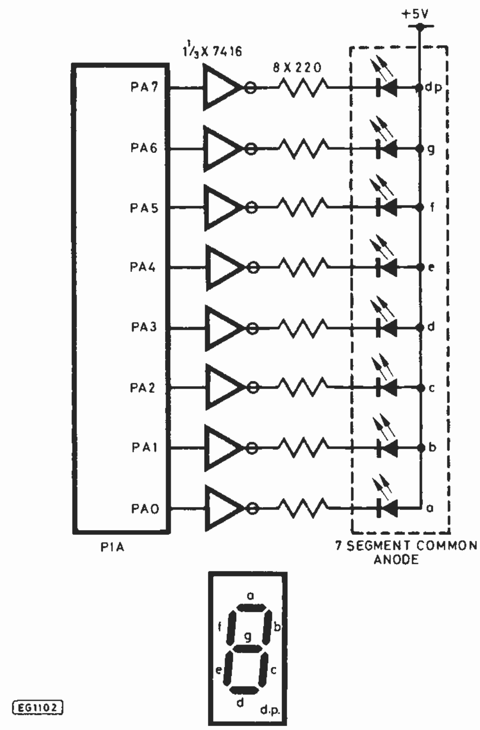


Fig. 8. Driving a single 7-segment display through a PIA

of the PIA is arranged so that one peripheral line is connected to each segment via a buffer stage, which is required to provide the necessary drive capability. Setting any of the PA0 to PA7 lines to a HIGH will cause the corresponding segment to be illuminated, as shown in Table 3 where all values are shown in hexadecimal format. Combinations of segments are selected by writing a value to the PIA register which is equal to the sum of the values for the individual segments. The values which must be written to the PIA to display the standard numerical digits are shown in Table 4.

There are two points which should be noted about this approach when considering its use in practice. The first is that, once a value has been written to the PIA, the display will remain constant until it is changed by the CPU writing a new value. No further CPU action, or by implication program in-

SEGMENT TO BE ILLUMINATED	VALUE WRITTEN TO PIA OUTPUT REGISTER
a	01
b	02
c	04
d	08
e	10
f	20
g	40
d.p.	80

Table 3. PIA output values to illuminate individual segments

NUMBER TO BE DISPLAYED	VALUE WRITTEN TO PIA OUTPUT REGISTER
0	3F
1	06
2	5B
3	4F
4	66
5	6D
6	7D
7	07
8	7F
9	67
A	77
b	7c
C	39
d	5E
E	79
F	71

Table 4. PIA output values for numerical displays

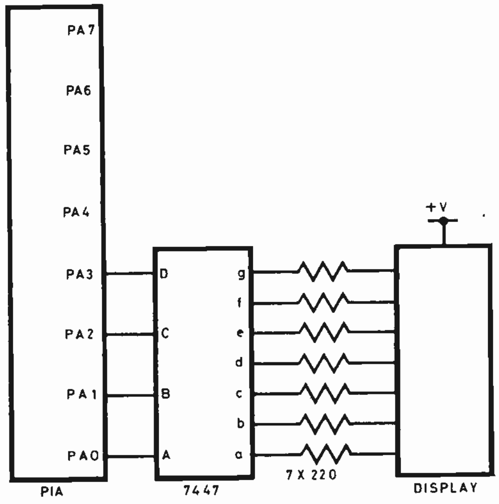


Fig. 10. Alternative scheme for driving a decimal display

added (this may require a loop and test approach in some processors) to the contents of the index register. The index register will now point to the value which must be output to the PIA to display the number required. The display value is then picked up using the index register, and output to the PIA register.

In contrast to the software look-up table, it is possible to use hardware to perform the output processing. Applications

DECIMAL OR FUNCTION	INPUTS							OUTPUTS						
	LT	RBI	D	C	B	A	BI/RBO	a	b	c	d	e	f	g
0	1	1	0	0	0	0	1	0	0	0	0	0	0	1
1	1	X	0	0	0	1	1	1	0	0	1	1	1	1
2	1	X	0	0	1	0	1	0	0	1	0	0	1	0
3	1	X	0	0	1	1	1	0	0	0	0	1	1	0
4	1	X	0	1	0	0	1	1	0	0	1	1	0	0
5	1	X	0	1	0	1	1	0	1	0	0	1	0	0
6	1	X	0	1	1	0	1	1	1	0	0	0	0	0
7	1	X	0	1	1	1	1	0	0	0	1	1	1	1
8	1	X	1	0	0	0	1	0	0	0	0	0	0	0
9	1	X	1	0	0	1	1	0	0	0	1	1	0	0
10	1	X	1	0	1	0	1	1	1	1	0	0	1	0
11	1	X	1	0	1	1	1	1	1	0	0	1	1	0
12	1	X	1	1	0	0	1	1	0	1	1	1	0	0
13	1	X	1	1	0	1	1	0	1	1	0	1	0	0
14	1	X	1	1	1	0	1	1	1	1	0	0	0	0
15	1	X	1	1	1	1	1	1	1	1	1	1	1	1
BI	X	X	X	X	X	X	0	1	1	1	1	1	1	1
RBI	1	0	0	0	0	0	0	1	1	1	1	1	1	1
LT	0	X	X	X	X	X	1	0	0	0	0	0	0	0

Table 5. Function table for the 7447 decoder/driver

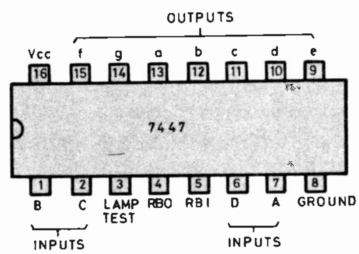


Fig. 9. Pin configuration for the 7447 7-segment decoder/driver

volvement, is required to sustain the display. The second point is that the program which drives the display will have to include, probably as a standard subroutine, a means of converting from a number in a register or memory, into the appropriate value to be output to the PIA. The most common approach to this problem is a look-up table, which is a way of including Table 4 in the control program. The look-up table approach must first ensure that the number to be displayed is within the allowed range; in this case it must be between 0 and F. The index register should then be set to point to the beginning of the table of values which correspond to digits 0 to F; these must be arranged in the order shown in Table 4, with 3F in the first memory location and 71 in the last. The number to be displayed should now be

which only require to display decimal values, for example, can use a 7447 decoder which will automatically convert decimal inputs into common-anode seven-segment code. Neither a table nor a conversion routine is necessary, and the 7447 will also offer additional features, as shown in Fig. 9 and Table 5. The LAMP TEST input allows all the segments to show if they are working, while the blanking input (BI) turns all the segments off. The ripple blanking input (RBI) and output (RBO) also allow leading and trailing zeroes to be suppressed if required. The simplest way to use the device, however, has the result that fewer PIA peripheral lines are required to drive the display, in addition to the reduction in software required. Fig. 10 shows how the original circuit is simplified for decimal displays; a more flexible display is obtained if the spare PIA lines are used to drive the control inputs for the 7447.

MULTI-DIGIT DISPLAYS

The single-digit display techniques described above may easily be extended to provide multi-digit displays; in the main it is simply a matter of increasing the number of PIAs used and providing the necessary additional driver hardware. Before very many digits have been added, however, it becomes noticeable that the number of peripheral components and connections required increases in direct proportion to the size of the display. This, in turn, decreases the overall reliability and increases the amount of board space required. A suggested policy is that simple techniques are applicable for displays which can be handled by a single PIA or similar peripheral interface. Beyond this limit, it is probably time to consider the use of intelligent or multiplexed display techniques. Intelligent displays are beyond the scope of this series, but multiplexed displays will usually offer realistic and cost-effective solutions to a wide range of controller display requirements.

Multiplexed displays rely on the fact that the display only needs to appear to be stable for it to be acceptable to the operator, and therefore it does not need to be driven with a 100% duty cycle. Rapid scanning of a display, coupled with the response characteristics of the display (i.e. the light output does not instantaneously fall to zero when the drive voltage is removed), and the afterglow in the operator's retina, means that it is possible to make the CPU scan AND perform other processing tasks apparently simultaneously.

A typical multiplexed seven-segment display configuration is shown in Fig. 11. The 8-digit display is connected between the A and the B sides of a single PIA: The A side determines which of the segments are selected, and the B side determines which of the digits (if any) are actually turned on. To illuminate a particular segment, it must be selected (PA0 to PA7) AND turned on (PB0 to PB7).

More than one segment may be selected at any one time, and more than one digit may be turned on. In normal practice, however, each digit is turned on in sequence, and the display scan routine selects the appropriate segments for that digit position. The single digit display can be thought of as a multiplexed display with one digit permanently turned on, i.e. omit the B side of the PIA and connect the common anode directly to the supply, as shown earlier in Fig. 8.

The display must be scanned often enough to avoid the display flickering, and this usually means that the scan rate is at least 50 to 100 times per second. This may be achieved by including the display scan routine in the main infinite control loop, or by arranging for a regular timer interrupt (every 10 to 20 msec) to initiate a display scan. In many applications the former method may be quite adequate, but the user must be aware that any operation in the main loop which uses a significant amount of time may result in display flicker whenever it is executed. The infinite loop approach does, however, mean that it is possible to trade display flicker against available processing time in applications where a task is not executed often, but when it is run it justifies degradation of display quality.

During each display scan it is normal practice for the scan routine to read from a display table to determine the output values for each digit position. In this way, the remainder of the control software only amends the contents of the display table once each time a change in display is required. This amendment is usually via a standard subroutine which converts the numerical value from the caller into the appropriate display code. The display routine is thus kept separate from the remainder of the control software, and they com-

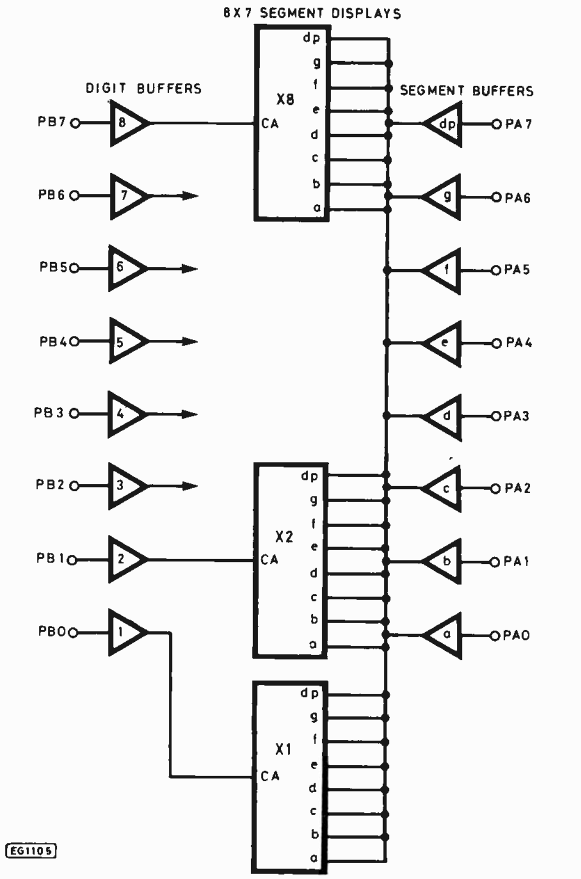


Fig. 11. An 8-digit, 7-segment multiplexed display scheme

municate via a well-defined interface, i.e. the subroutine.

For the display shown in Fig. 11, the display scan routine (when invoked) would output the values 01, 02, 04, 08, 10, 20, 40, 80 (hex) to the PIA B output register to select digits 1 to 8 in turn. The interval between changes is set by the time required for the display to achieve usable brightness (typically 1–2 msec), and is usually set by a software delay, although a hardware timer may be used instead if the facilities exist. As each digit is turned on, the corresponding value is read from the display table and output to the PIA A output register. At the end of the cycle it is advisable to turn off all digits, otherwise the last digit (8 in this case) will appear unequally bright.

The multiplexed display combined with the software display table technique has many advantages for the system designer. As far as much of the software is concerned the display appears as a fully latched and decoded unit; the decoding is actually done by the interface subroutine. The hardware, on the other hand, has been kept to a minimum and there is a wide range of multiplexed display hardware available at competitive prices. In all, a good example of a hardware/software tradeoff.

CONCLUSION

This concludes the series on the interfacing and use of microprocessors in real control situations. Of necessity, the subjects covered represent only a small proportion of possible applications. The intention, however, has been to encourage the use of microprocessors in the real world, and to this end the subjects covered should provide a good basis for the development of micro-based projects. ★

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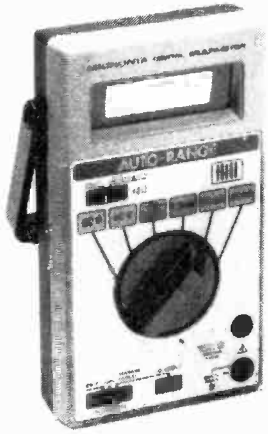

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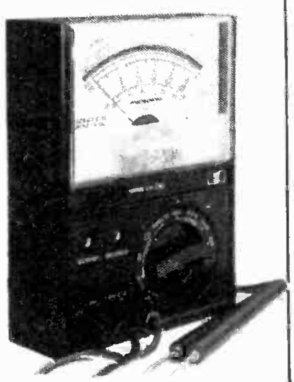

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PE MICROCONTROLLER: DATA SHEET 4

USER MONITOR ROUTINES

THERE will be many applications where peripheral hardware connected to the Microcontroller will require a regular opportunity to gain a share of the CPU processing time to perform some function, but without using interrupts. An example might be to maintain a continuous display of elapsed time on a 4-digit l.e.d. module connected to a user PIA, using the value of TICK which is held in DISBUG RAM. The majority of the processing required would be to refresh the l.e.d. digits in a similar fashion to that employed by DISBUG. Such a task could be performed by writing a user routine and using all of the available CPU time to perform it. This approach, although successful, would tie up the total CPU resources for what is essentially a 'background' task. The Microcontroller is capable of excuting more than 200,000 typical instructions every second, so it should be possible to perform some sort of background servicing at the same time as providing the normal DISBUG facilities.

The overall design of the infinite control loop in the top-level DISBUG routine was shown in Part 3 of the Microcontroller series. The code for this routine occupies twenty bytes, starting at the bottom of the EPROM at location F8ØØ, and is shown below. It can be seen that, just before jumping back to restart the loop, a user-defined monitor routine is called in the main loop. Once again this makes use of a software vector held in DISBUG RAM (UMRSA at location Ø3C4, 2 bytes long). At start-up the initialisation routine initialises this vector to point to a default service routine at F82B, which is simply an RTS instruction, and therefore the call has no effect other than a slight delay. Since the vector is held in RAM, however, this can easily be overwritten to define an alternative service routine; the technique is identical in concept to that used for the PF1 and PF2 keys, see Data Sheet 2.

User-defined monitor routines are written as subroutines, and must end with an RTS instruction. Once the start address in user RAM has been placed in Ø3C4/5 (UMRSA), the routine will be called every time round the monitor loop. No call will be made, however, when the keyboard scan produces an uncertain result; this is to avoid misleading results. On entry to the user routine, the state of all registers except SP will be undefined. The stack pointer will set to just below the top of the DISBUG stack area, with at least 1A bytes of unused stack space available. Users should allow for a further 7 bytes to be set aside for RTC and other interrupts, leaving 13 (hex) bytes of stack space for the user routine. This will allow the use of multi-level subroutines, which may include calls to previously described DISBUG routines, and also allows local temporary storage of variables on the stack.

```
DISBUG:  BSR   DISPLAY    ; Refresh the display
         BSR   KEYBOARD   ; Scan the keyboard keys
         CMPB  #FF        ; Uncertain scan result?
         BEQ   DISBUG     ; Yes—ignore this scan
         BSR   KEYCODE    ; No—convert to code
         JSR   COMPROC    ; Call command processor
         LDX   UMRSA      ; Call the user-defined
         JSR   ØØ,X       ; . . monitor routine
         BRA   DISBUG     ; Re-start the loop
```

DISBUG top level control routine

The addition of a user-defined routine to the existing monitor, in the form of either a single routine or a nested suite of routines, allows the facilities of the basic monitor to be extended to suit particular applications. By suitable programming, the user PIAs may even be configured to allow the use of extra keyboards and/or displays.

INTERRUPT SERVICE ROUTINES

Whenever a user interrupt is recognised by the 6800 (i.e. IRQ asserted and user interrupts not masked out), the CPU saves the registers on the stack, masks out further interrupts, and jumps to the address contained in locations FFF8 and FFF9. In DISBUG, these two locations point to a routine called IRQINT at location FF9Ø, and the code for this routine is shown below. IRQINT first of all checks to see if the interrupt was caused by an RTC 'tick', and if so it increments TICK in DISBUG RAM and resets the appropriate display PIA interrupt flag. The second action of IRQINT is to jump, using the software vector from IRQSRA (Ø3DC and Ø3DE in DISBUG RAM), to the user interrupt service routine for any further interrupt processing required. The IRQSRA vector is set up by the DISBUG initialisation routine to point to DEFISR (see below), which simply dismisses the interrupt and returns to the original program in the usual way.

Users may define their own additional interrupt processing by overwriting the vector in IRQSRA with the appropriate start address. The user-supplied routine should be written as a handler which terminates in an RTI instruction. On entry to such a user-defined routine, RTC interrupts will have been handled, but user interrupts will still be masked.

```
IRQINT:  LDA A DPIACRB    ; Read RTC int flag
         BGE NOTICK       ; Has clock ticked?
         LDX TICK         ; Yes . . .
         INX              ; . . . update the . . .
         STX TICK         ; . . . tick count
         LDA B DPIADRB    ; Reset int flag
NOTICK:  LSX IRQSRA       ; Call the user . . .
         JMP ØØ,X         ; . . . service routine
DEFISR:  RTI              ; Default routine
```

DISBUG interrupt service routine

DISBUG MEMORY MAP

The following brief memory map highlights some of the more significant routines within DISBUG for the benefit of the experimenter and enthusiastic disassembler. All except those marked with an asterisk are written as subroutines.

F8ØØ DISBUG
F814 DISPLAY
F82C KEYBOARD
F85D SCANKB
F86D IDKEY
F877 KEYCODE
F8BC DISDELAY
F8C6 KBDELAY
F8DØ DIGIT
F8F7 TWODIG

F918 COMPROC
F96B KEYLATCH
F984 PF1
F989 PF2
F98F RESTART
F9EE REGISTER
FACD MEMORY
FC91 PRESET
***FD3F SWINT**
FD9C PROCEED
FDF8 NMINT
FEØØ GO
FE76 BREAKPT
***FFØØ INIT**
FF77 WELCOME
***FF9Ø IRQINT**
***FFF8 Interrupt Vectors**

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Ultimum Computer Interface Part 7

WILLIAM EDWARDS   WATFORD ELECTRONICS

TO COMPLETE the series of sound generating peripherals, we describe a nine channel sound card complete with amplification. The card makes use of the General Instrument "sound chip" (three to be precise) which can be programmed to generate a wide range of sounds. The chip has been around for some time, which makes it a cheap and reliable way to convert bytes into musical (or totally non-musical) audio signals.

THE AY–3–8910

The sound chip is programmed via a set of internal registers. The 40-pin package leaves a lot of spare lines which have been allocated to parallel ports, so as a bonus, the card offers five, 8 bit ports which can be set up as inputs or outputs. These lines are TTL compatible.

In each chip there are three tone generators, which use programmable counters to determine the period of the tone. As these counters are 12 bits long, a reasonably accurate representation of the "well tempered" musical scale can be generated. The three generators can be used quite independently, or rather like the organ, they can be mixed to provide a complicated tone made up of synthesised harmonics, which gives added colour to the sound produced.

Each tone generator is fed into an envelope generator made out of a 4 bit D-to-A. The amplitude of each channel can be set, or provide some shaping by varying the amplitude with time. Some useful envelopes are pre-programmed into the chip, keeping the amount of external programming to a minimum.

In addition to the tones, a noise generator is provided. It is possible to colour the noise by setting a 5 bit time period in one of the internal registers, so that sounds from a low roar to a hiss are possible, very useful for games.

Two 8-bit ports are accessed by other registers in the chip. Each port can be set to all inputs or outputs.

THE CIRCUIT

Fig. 7.1 shows the circuit for the sound card. It is made up of an interface to the motherboard (decoding and a parallel port—the now familiar 8255), three AY–3–8910 sound chips and a low power amplifier to reproduce the sound through a small speaker. There is a pick-off for external amplification, but the highly "in-phase", square wave signals produced by most computer sound generators is not well suited to your best hi-fi as the signals impose a heavy load on the amplification and speakers. The port occupies four memory locations, the decoding allows one to map this area

COMPONENTS . . .

Resistors

R1	10M
R2	300
R3	10k
R4	470k
R5, R6	4k7 (2 off)
R7	10

All resistors ¼W 5%

Potentiometers

VR1	1k hor. 100mW preset

Capacitors

C1	20p ceramic
C2	10µ 16V tant.
C3, C7–19	100n ceramic (14 off)
C4–6	4µ7 16V tant. (3 off)

Integrated Circuits

IC1–4	74LS85 (4 off)
IC5	8255
IC6	74LS13
IC7–9	AY–3–8910
IC10	LM386
IC11	4013B
IC12	4011B
IC13, 14	8 x 4k7 s.i.l. resistor

Miscellaneous

S1 P.c.b. mounting low profile keyboard switch & cap
TB1 4-way p.c.b. mounting terminal block
2 x 32-way A + C male right-angle DIN41612
WE07 SBD printed circuit board
8-pin d.i.l. socket
14-pin d.i.l. socket (3 off)
16-pin d.i.l. socket (4 off)
40-pin d.i.l. socket (4 off)
3·579545MHz crystal

SAE to Watford Electronics (see Advertisers' Index) for price list of kits.

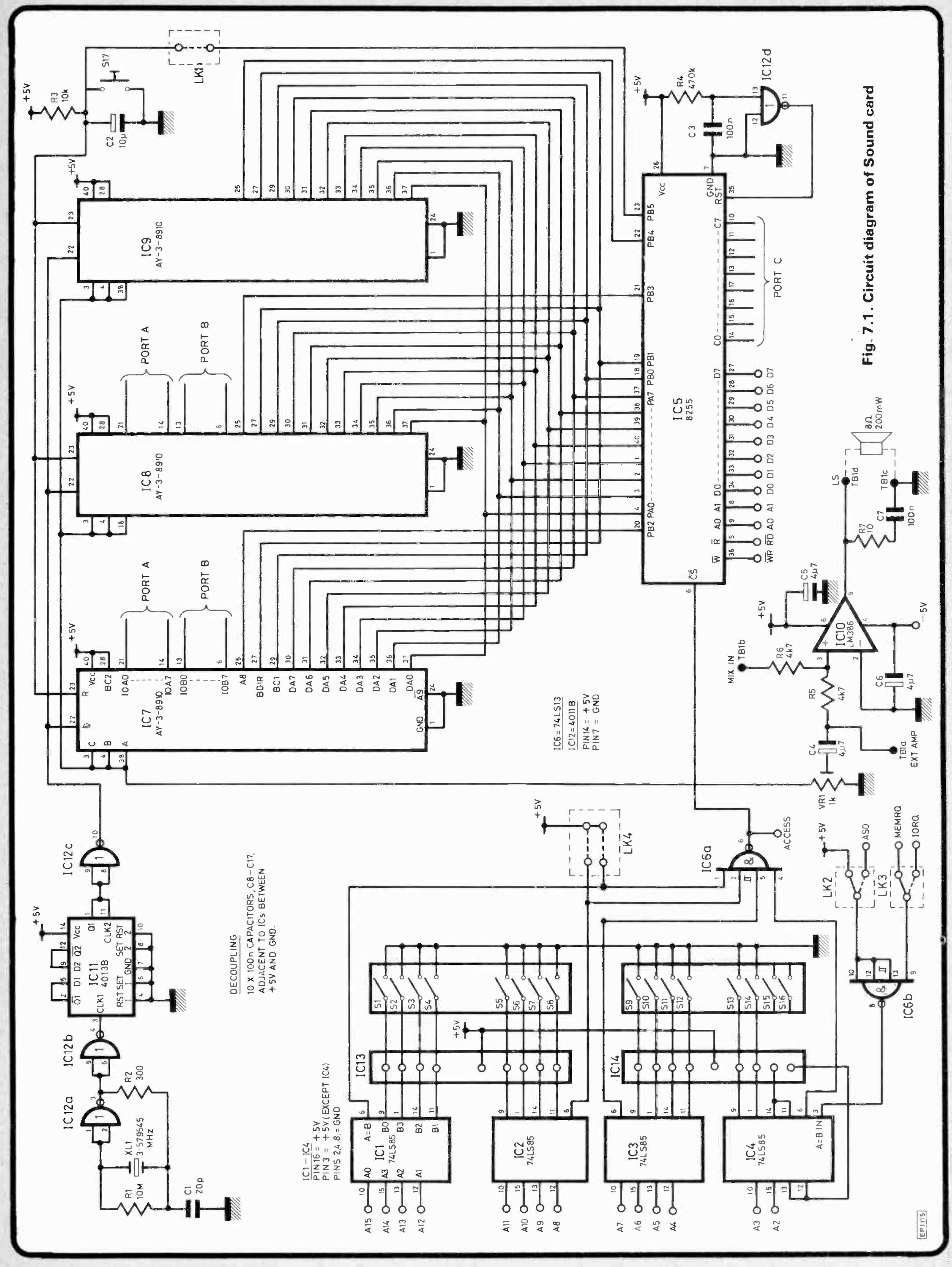

Fig. 7.1. Circuit diagram of Sound card

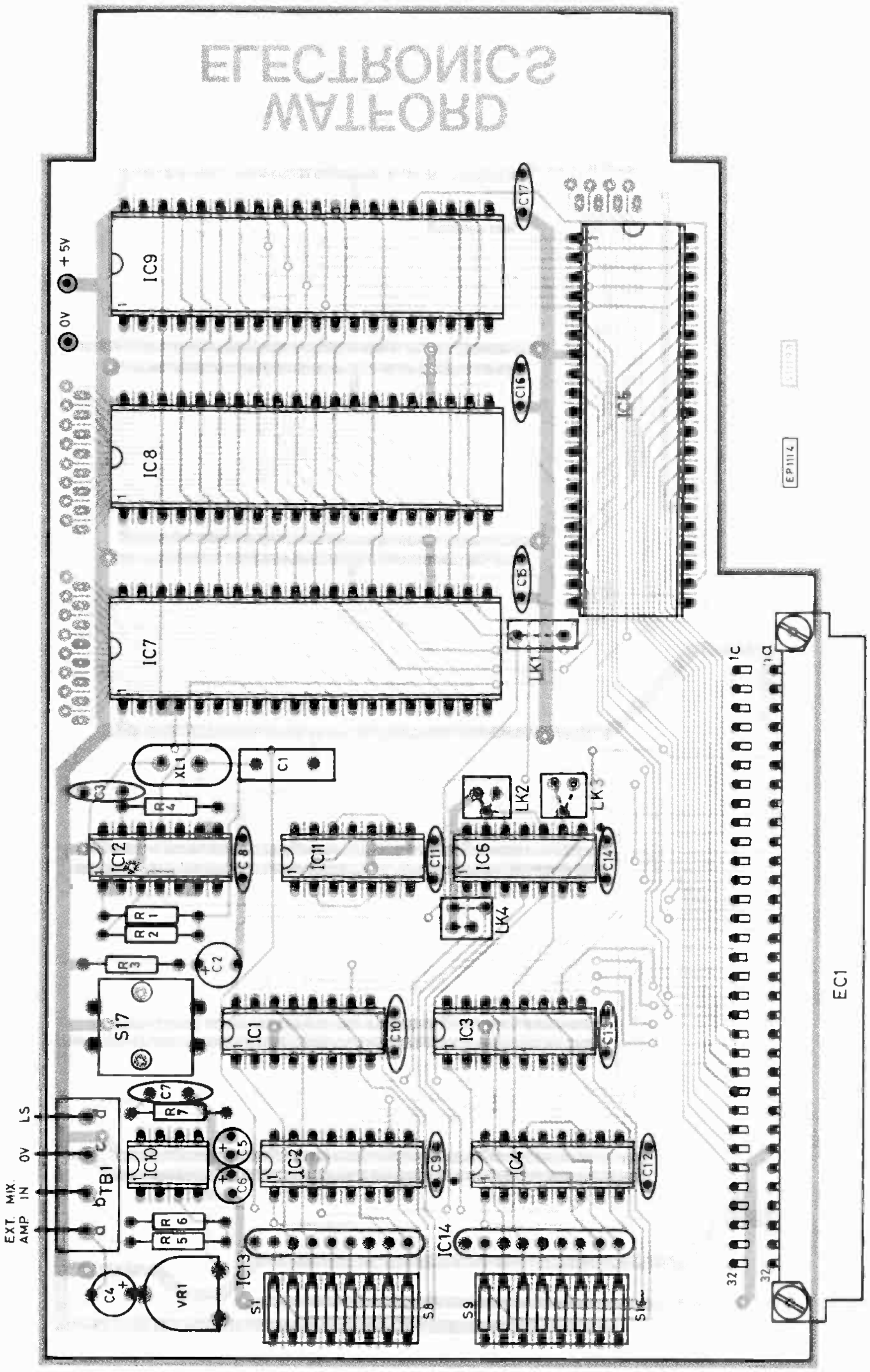

Fig. 7.2. Component layout

```
 10 P=....                    REM LOCATION OF 8255
 20 POKE P+3,128              REM SET UP ALL PORTS
                              FOR OUTPUT
 30 POKE P+1,32               REM RESET SOUND CHIPS
 40 C=1                       REM SET UP FOR FIRST
                              CHIP
 50 R=7                       REM REGISTER 7 —
                              ENABLE
 60 D=254                     REM SOUND ON
                              CHANNEL A
 70 GOSUB 200                 REM CALL THE REGISTER
                              DATA ENTRY ROUTINE
 80 R=8                       REM CHANNEL A
                              AMPLITUDE
 90 D=15                      REM FULL VOLUME
100 FOR L1=2 TO 0 STEP -1
110 R=1                       REM CHANNEL A COARSE
                              TUNE
120 D=L1
130 GOSUB200
140 R=0                       REM FINE TUNE
150 FOR D=255 TO 0 STEP -1
160 GOSUB 200
170 NEXT D
180 NEXT L1
190 END
200 POKE P,R                  REM STORE REGISTER
210 POKE P+1,2^(C+1)+3        REM SELECT CHIP TO
                              RECEIVE ADDRESS
220 POKE P+1,0                REM DESELECT CHIP
230 POKE P,D                  REM STORE DATA
240 POKE P+1,2^(C+1)+2        REM SELECT CHIP TO
                              RECEIVE DATA
250 POKE P+1,0                REM DESELECT
260 RETURN
300 REM VALID RANGES FOR C, R AND D
310 REM D BETWEEN 0 AND 255
320 REM R BETWEEN 0 AND 15
330 REM C BETWEEN 1 AND 3
```

Table 7.1. BASIC test program

```
 10 P=....                    REM ADDRESS OF 8255
 20 POKE P+3,128              REM ALL PORTS AS
                              OUTPUT
 30 POKE P+1,32               REM RESET SOUND CHIPS
 40 INPUT "CHIP"; C           REM COLLECT
 50 INPUT "REGISTER"; R       REM RELEVANT
 60 INPUT "DATA"; D           REM INFORMATION
 70 POKE P,R                  REM STORE REGISTER
 80 POKE P+1,2^(C+1)+3        REM STROBE ADDRESS
 90 POKE P,O                  REM CLEAR STROBE
100 POKE P,D                  REM STORE DATA
110 POKE P+1,2^(C+1)+2        REM STROBE DATA
120 POKE P+1,0                REM CLEAR STROBE
130 GOTO40
```

Table 7.2. Register access program

to anywhere in memory by setting switches (1–14). For ease of description we have continued to use the 8255 (there is one on most of the cards in this series, including the motherboard). Setting up the card is a matter of setting up this port and then writing to the AY–3–8910 registers via the control lines PAO–PA7 and PBO–PB4. A push button on the board allows you to reset the board. On power up, reset is automatic, but you can use PB5 to make reset possible from the host system, by setting link 1.

(a) $f_T = \frac{f_{CLOCK}}{16TP_{10}}$ (b) $TP_{10} = 256CT_{10} + FT_{10}$

Where: f_T = desired tone frequency
f_{CLOCK} = input clock frequency
TP_{10} = decimal equivalent of the Tone Period bits TP11–TP0
CT_{10} = decimal equivalent of the Coarse Tune register bits B3–B0 (TP11–TP8)
FT_{10} = decimal equivalent of the Fine Tune register bits B7–B0 (TP7–TP0)

From the above equations it can be seen that the tone frequency can range from a low of $\frac{f_{CLOCK}}{65{,}520}$ (wherein: $TP_{10} = 4{,}095_{10}$) to a high of $\frac{f_{CLOCK}}{16}$ (wherein: $TP_{10} = 1$). Using a 1·7MHz input clock, for example, would produce a range of tone frequencies from 27Hz to 111kHz.

To calculate the values for the contents of the Tone Period Coarse and Fine Tune registers, given the input clock and the desired output tone frequencies, we simply rearrange the above equations, yielding:

(a) $TP_{10} = \frac{f_{CLOCK}}{16f_T}$ (b) $CT_{10} + \frac{FT_{10}}{256} = \frac{TP_{10}}{256}$

Table 7.3. Tone frequency formulae

	position	
Link 1	open	power-up and manual reset
	made	software reset vice 8255—omit PB1, R3, C2
Link 2	default	board always in address space
	alternative	board may be mapped in and out by motherboard 8255
Link 3	default	board is memory mapped
	alternative	board is I/O mapped
Link 4 (pair)	open	memory mapped
	made	I/O mapped—omit IC1,2,13 and S1–8

Table 7.4. Link functions

CONSTRUCTION

Refer to the overlay (Fig. 7.2). This is a simple board to assemble. Use sockets for the i.c.s. These make repair etc. much easier. The crystal should not have its leads bent at the base as this might damage the housing.

Set the switches 1–14 by determining the area in memory to which the board is to be mapped (say 4120H), then translate this into binary (0100000100100000) discard the least significant two bits (01000001001000). For each zero in the pattern, turn on the corresponding switch (S0, in this case). Switches 14, 12, 11, 10, 9, 8, 6, 5, 3, 2, 1 are on.

If you want to reset the board via the 8255, short link 1, but leave out C2.

TESTING

The AY–3–8910 is a little more tricky to set up, because of its large number of registers. Obtain the data sheet for the internal register layout of this chip. The BASIC program of Table 7.1 is a commented test program which shows how the tone registers are set up. Table 7.2 gives details of how each individual register is accessed on each sound chip. Table 7.3 shows the simple formulae needed to calculate a particular tone, given the colour burst crystal supplied with the sound board. For more complicated applications, a full manufacturer's data sheet, complete with examples, is available with the kit, see Components List.

NEXT MONTH

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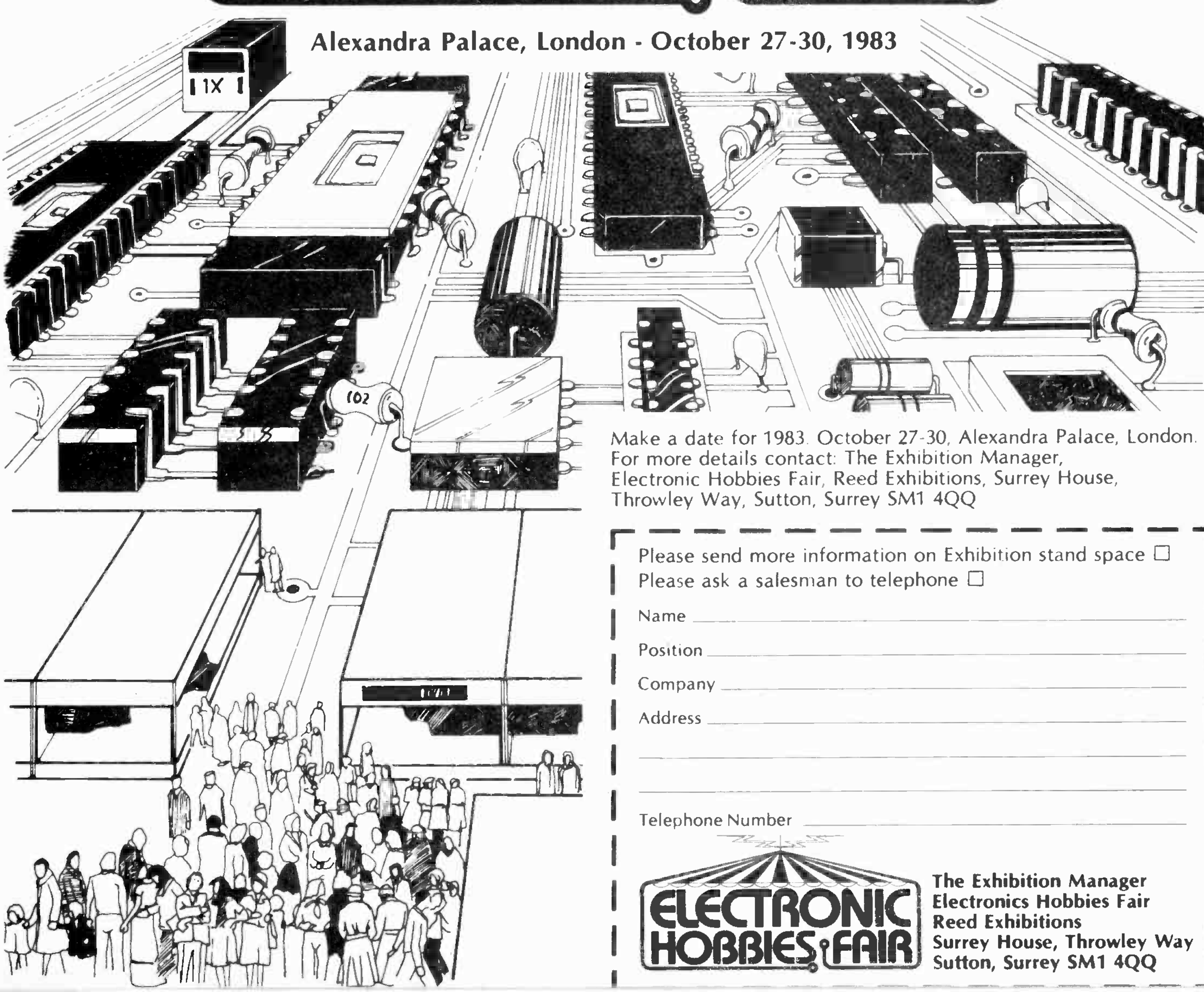

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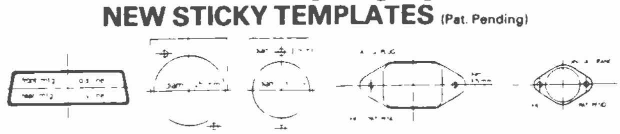

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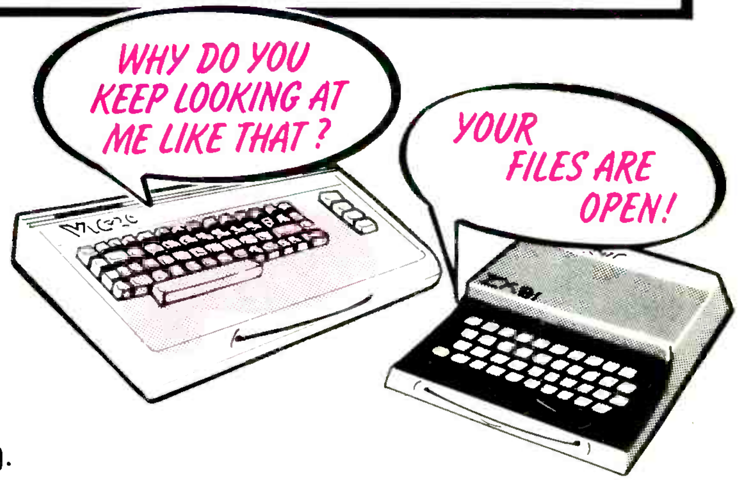

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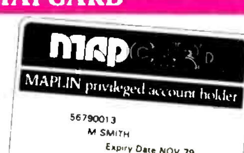

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