Australia 85c South Africa 80c New Zealand 85c Malaysia $2.25

PRACTICAL ELECTRONICS

NOVEMBER 1978

50p

MOON LANDING GAME

SPECIAL!

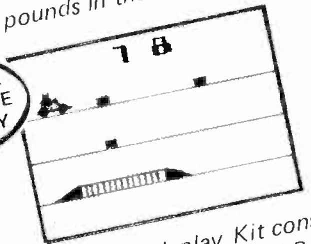
CAR DEVICES
8 PAGE SUPPLEMENT

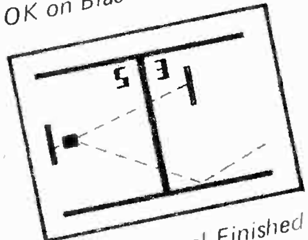
2 Soldering Iron Offers

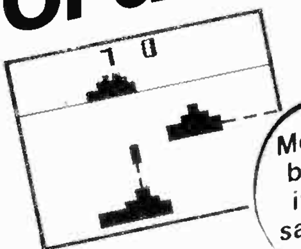
Teleplay presents the PROGRAMAGAME of all time!

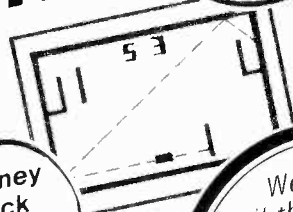
TELEPLAY have produced a new product of easy to assemble cartridge games, for you and all your family, that will not go out of date. Just ADD each new cartridge, as it becomes available, and your colour video centre will be up to date the Teleplay way. You will save pounds in the long run. Works OK on Black and White TV.

EX-STOCK IMMEDIATE DELIVERY







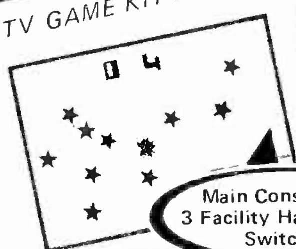


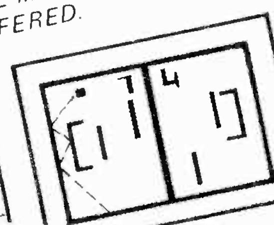
Money back if not satisfied

We offer all this to you for ONLY **£28·90** + £2.31 VAT

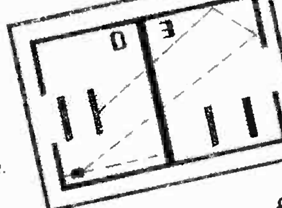
Fully Assembled £35.90

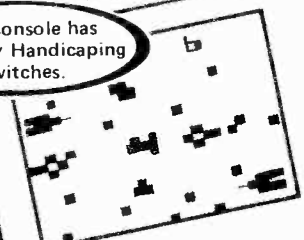
The Teleplay Kit consists of a Professional Finished Inject Moulded Box – Joystick Hand Controls – one cartridge which consists of 10 games – Football, Tennis, Solo Squash (1 & 2 players), Hockey, Basketball (1 & 2 players), Shoot etc. Mains Adaptor. All holes are pre-drilled – No Special equipment required. You'll be surprised how easy it is to assemble this professional kit! Instruction Manual supplied separately at 0.45p. TELEPLAY GIVES YOU TWICE THE FUN BUILDING AND PLAYING THE MOST PROFESSIONAL TV GAME KIT EVER OFFERED.



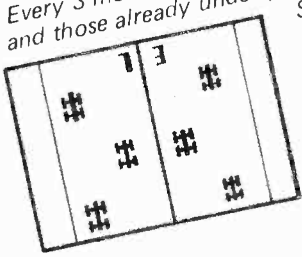


Main Console has 3 Facility Handicaping Switches.





Every 3 months a NEW game will become available to you and those already under production include Submarines, Space War, Wipe Out and many more. The price of these will vary from £12 to £19 depending upon the complexity of the game.



Additional cartridges NOW available include:

Stunt Cycle – 4 games – Cartridges and Hand Controls – **£14.90** + £1.14 VAT.
Tank Battle – Cartridge and Hand Controls – **£18.90** + £1.51 VAT.
Road Race – 2 games – Cartridge – Controls already with basic kit – **£12.90** + £1.03 VAT.

Fully assembled add £3.00

Cartridges come complete with printed case and easy to follow assembly instructions.

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All parts fully guaranteed.

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Watch this page each month for new cartridges, as they become available.

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teleplay

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PRACTICAL
ELECTRONICS

VOLUME 14 No.15 NOVEMBER 1978

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

SPECIAL 8-PAGE SUPPLEMENT

Our December issue will be on sale Friday, 10 November 1978
(for details of contents see page 1145)

WATFORD ELECTRONICS

35 CARDIFF ROAD, WATFORD, HERTS., ENGLAND
MAIL ORDER, CALLERS WELCOME. Tel. Watford 40588/9

ALL DEVICES BRAND NEW, FULL SPEC. AND FULLY GUARANTEED. ORDERS DESPATCHED BY RETURN OF POST. TERMS OF BUSINESS: CASH/CHEQUE/P.O.s OR BANKERS DRAFT WITH ORDER. GOVERNMENT AND EDUCATIONAL INSTITUTIONS' OFFICIAL ORDERS ACCEPTED. TRADE AND EXPORT INQUIRY WELCOME. P&P ADD 30p* TO ALL ORDERS UNDER £10.00. OVERSEAS ORDERS POSTAGE AT COST. AIR/SURFACE.

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VAT Export orders no VAT. Applicable to U.K. Customers only. Unless stated otherwise, all prices are exclusive of VAT. Please add 8% to devices marked ★. To the rest add 12½%.

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POLYESTER CAPACITORS: Axial lead type. (Values are in µF) **400V**: 0.001, 0.0015, 0.0022, 0.0033 **7p**; 0.0047, 0.0068, 0.01, 0.015, 0.018 **9p**; 0.022, 0.033, **10p**; 0.047, 0.068 **14p**; 0.10 **15p**; 0.15, 0.22 **22p**; 0.33, 0.47 **39p**; 0.68 **45p**. **160V**: 0.039, 0.15, 0.22 **11p**; 0.33, 0.47 **19p**; 0.68, 1.0 **29p**; 1.5 **29p**; 2.2 **32p**; 4.7 **36p**. **DUBILIER**: **1000V**: 0.01, 0.015 **20p**; 0.022 **22p**; 0.047 **26p**; 0.1 **38p**; 0.47 **48p**.

POLYESTER RADIAL LEAD (Values are in µF) **250V**: 0.01, 0.015, 0.022, 0.027 **5p**; 0.033, 0.047, 0.068, 0.1 **7p**; 0.15 **12p**; 0.22, 0.33 **13p**; 0.47 **15p**; 0.68 **18p**; 1.0 **24p**; 1.5 **27p**; 2.2 **31p**.

FEED THROUGH CAPACITORS 100µF 350V **8p**

ELECTROLYTIC CAPACITORS: Axial lead type (Values are in µF) **500V**: 10 **40p**; 47 **68p**; **250V**: 100 **65p**; **63V**: 0.47, 1.0, 1.5, 2.2, 2.5, 3.3, 4.7, 6.8, 8, 10, 15, 22 **8p**; 47, 32, 50 **11p**; 63, 100 **27p**; **50V**: 1.0 **7p**; 50, 100, 220 **25p**; 470 **50p**; 1000, 2200 **68p**; **40V**: 22, 33 **7p**; 100 **11p**; 3300 **62p**; 4700 **64p**; **35V**: 10, 33 **7p**; 330, 470 **32p**; 1000 **49p**; **25V**: 10, 22, 47 **6p**; 80, 100, 160 **8p**; 220, 250 **13p**; 470, 640 **25p**; 1000 **27p**; 1500 **30p**; 2200 **41p**; 3300 **52p**; 4700 **54p**; **16V**: 10, 40, 47, 68 **7p**; 100, 125 **8p**; 330, 470 **16p**; 1000, 1500 **20p**; 2200 **34p**; **10V**: 4, 100 **6p**; 640 **10p**; 1000 **14p**.

TAG-END TYPE: **70V**: 2000 **98p**; 4700 **121p**; **50V**: 3000 **75p**; **40V**: 4000 **70p**; 2500 **65p**; **25V**: 4700 **48p**; 2000 **37p**; **40V**: 2000 + 2000 **95p**; **325V**: 200 + 100+ 50 + 100 **190p**.

TANTALUM BEAD CAPACITORS 35V: 0.1µF, 0.22, 0.33, 0.47, 0.68, 1.0, 2.2µF, 3.3, 4.7, 6.8 **25V**, 1.5, 10, **20V**: 1.5, **16V**: 10µF **13p** each. 47, 100 **40p**, **10V**: 22µF, 33, 47 **6V**: 47, 68, 100, **3V**: 68, 100µF **20p** each.

MYLAR FILM CAPACITORS
100V: 0.001, 0.002, 0.005, 0.01µF **6p**
0.015, 0.02, 0.04, 0.05, 0.056µF **7p**
0.1µF, 0.15, 0.2 **9p** 50V: 0.47µF **11p**

CERAMIC CAPACITORS 50V
0.5pF to 10nF **3p** each
15nF, 22nF, 33nF, 47nF **4p** each
0.1µ **6p**

POLYSTYRENE CAPACITORS
10pF to 1nF **6p**; 1.5nF to 47nF **10p**.

SILVER MICA (Values in pF) 3.3, 4.7, 6.8, 10, 12, 18, 22, 33, 47, 50, 68, 75, 82, 85, 100, 120, 150, 220 **9p** each
250, 300, 330, 360, 390, 600, 820 **18p** each
1000, 1800, 2000, 2200 **20p** each

CERAMIC TRIMMER CAPACITORS
2–7pF, 4–15pF, 6–25pF, 8–30pF **20p**

MINIATURE TYPE TRIMMERS
2.5–6pF, 3–10pF, 10–40pF **22p**
5.2pF, 5–45pF, 60pF, 88pF **30p**

COMPRESSION TRIMMERS
3–40pF, 10–80pF, 25–190pF **25p**
100-500pF 38; 1250pF **68p**

POTENTIOMETERS (AB or EGEN)
Carbon Track, ¼W Log & ¼W Linear values
500Ω, 1K & 2K (lin only) Single **27p**
5KΩ-2MΩ single gang **27p**
5KΩ 2MΩ single gang D/P switch **60p**
5KΩ 2MΩ dual gang stereo **70p**

SLIDER POTENTIOMETERS
0.25W log and linear values 60mm
5KΩ 500KΩ single gang **70p**
10KΩ 500KΩ dual gang **80p**
Self Stick Graduated Bezels **22p**

PRESET POTENTIOMETERS
Vertical & Horizontal
0.1W 50Ω – 5MΩ Miniature **8p**
0.25W 100Ω – 3.3MΩ Horiz **10p**
0.25W 200Ω – 4.7MΩ Vert **10p**

RESISTORS – Erie make 5% Carbon Miniature High Stability Low noise

RANGE	VAL	1–99	100+
¼W 2.2Ω-4.7M	E24	1.5p	1p
½W 2.2Ω-4.7M	E12	2p	1.5p
1W 2.2Ω 10M	E12	5p	4p
2% Metal Film 10Ω-1MΩ		6p	4p
1% Metal Film 51Ω-1M		10p	8p

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

PE DIGITAL THERMOMETER
All parts available.
Send SAE for list.

OPTO ELECTRONICS★
LEDs plus clip
TIL209 Red **13**
TIL211 Grn **18**
TIL212 Yellow **22**
.2" Red **15**
.2" Yellow Green **19**
Spare Clips **2**
LS400 **255**
TIL307 **695**
ORP12 **63**
2N5777 **45**
7 Seg Displays
TIL312 C An 3" **105**
TIL313 C Cth 3" **105**
TIL321 C An 5" **115**
TIL322 C Cth 5" **115**
DI704 C Cth .3" **99**
DL707 C.A. .3" **99**
FND357 **120**
MAN3640 **175**
LCD 3½ digit **975**

SWITCHES★
TOGGLE 2A 250V
SPST **28p**
DPDT **38p**
4 pole on/off **54p**
SUB-MIN TOGGLE
SP changeover **59p**
SPST on/off **54p**
DPDT 6 tags **70p**
DPDT Centre off **79p**
DPDT Biased **115p**
SLIDE 250V:
1A DPDT **14p**
1A DP c/over **15p**
½A DPDT **13p**
4 pole c/over **24p**
PUSH BUTTON
Spring loaded
SPST on/off **60p**
SPDT c/over **65p**
DPDT 6 Tag **85p**

	JACK PLUGS		SOCKETS		
	Screened chrome	Plastic body	open metal	moulded with break contacts	in line couplers
2.5mm	12p	8p	8p		11p
3.5mm	15p	10p	8p		12p
MONO	23p	15p	13p	20p	18p
STEREO	31p	18p	15p	24p	22p

	PLUGS	SOCKETS	In Line
DIN 2 PIN Loudspeaker	11p	7p	18p
3, 4, 5 Pin Audio	13p	8p	20p
CO-AXIAL (TV)	14p	14p	14p
PHONO assorted colours	9p	5p single	15p
Metal Screened	12p	8p double 10p 3-way	—
BANANA 4mm	11p	12p	—
2mm	10p	10p	—
1mm	7p	7p	—
WANDER 3mm	9p	9p	—

SWITCHES ★ Miniature Non-Locking
Push to Make **15p** Push to Break **25p**
ROCKER (white) 10A 250V
SP changeover centre off **30p**
ROCKER: (black) on/off 10A 250V **23p**
ROCKER: Illuminated (white)
Lights when on: 3A 240V **52p**
ROTARY: (ADJUSTABLE STOP) 1 pole/2-12 way 2p/2-6W 3p/2-4W 4p/2-3W **41p**
ROTARY: Mains 250V AC, 4 Amp **45p**

DIL SOCKETS ★ (Low Profile – Texas)
8 pin **10p**; 14 pin **12p**; 16 pin **13p**; 18 pin **20p**; 20 pin **27p**; 24 pin **30p**; 28 pin **42p**; 40 pin **55p**.

DIGITAL MULTIMETER

Announcing DM900 – The Digital Multimeter with a difference – It measures Capacitance too. *(as published in E.T.I. August 1978)*

Throw away your analogue meters, here's digital accuracy at only half the price of an equivalent commercial Multimeter.

The DM900 is a 3½ digit multimeter with an 0.5in L.C.D. display incorporating:

5 AC & DC Voltage ranges; 6 Resistance ranges.
5 AC & DC Current ranges; 4 Capacitance ranges.

The prototype accuracy is better than 1%.

This is a unique design using the latest MOS ICs and due to the minimal current drain, is powered by only one PP3 battery. There is also a battery check facility.

DM900 is an attractive hand-held lightweight device, built into a high impact case with carrying handle and has been ingeniously designed to simplify assembly.

Never before have all these features been offered to the electronics enthusiast in a single unit.

Price: **£54.50*** only (p&p insured add 75p)

Ready Built units available on order
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(Demonstration on at our shop)

PE VDU SYSTEMS

parts now available
(send SAE for list)

Convert your TV into a VDU by using the new Thomson-CSF TV-CRT controller chip SF.F 96364. 16 lines by 64 characters, text refreshment, cursor management on TV screen, line erasing, line end erasing. Compatible with any computing system.

SFF 96364E	**£11.50***
AY-5-1013 UART	**£4.50***
71301 ROM	**£8.20***
SFS80102 RAM 1K	**£2.05***
74LS163 RAM	**£0.95***
SN75450	120p*
SN75451	70p*
SN75452	70p*
SN75454	225p*
2102 LF	160p*
2513	595p*
74LS132	95p*
81LS97	109p*
1 MHz crystal	323p*

TTL 74★

7400	13	7494	78	74194	105
7401	13	7495	65	74195	95
7402	14	7496	57	74196	99
7403	14	7497	189	74197	85
7404	14	74100	119	74198	150
7405	18	74105	62	75150	110
7406	38	74107	29	75491	75
7407	38	74109	64	75492	80
7408	17	74110	54		
7409	17	74111	68		
7410	15	74112	88		
7411	20	74116	198		
7412	17	74118	83		
7413	30	74119	119		
7414	51	74120	115		
7416	30	74121	25		
7417	30	74122	46		
7420	16	74123	48		
7421	29	74125	38		
7422	24	74126	57		
7423	27	74128	74		
7425	27	74132	73		
7426	36	74136	73		
7427	27	74141	56		
7428	35	74142	269		
7430	17	74143	314		
7432	25	74144	314		
7433	40	74145	65		
7437	30	74147	175		
7438	33	74148	109		
7440	17	74150	99		
7441	74	74151	64		
7442	68	74153	64		
7443	115	74154	96		
7444	112	74155	53		
7445	94	74156	80		
7446	94	74157	67		
7447	82	74159	210		
7448	56	74160	82		
7450	17	74161	92		
7451	17	74162	92		
7453	17	74163	92		
7454	17	74164	105		
7460	17	74165	105		
7470	28	74166	161		
7472	25	74167	20		
7473	32	74170	230		
7474	27	74172	625		
7475	38	74173	170		
7476	36	74174	87		
7480	48	74175	87		
7481	86	74176	75		
7482	69	74177	78		
7483	72	74178	102		
7484	95	74180	85		
7485	106	74181	165		
7486	31	74182	160		
7489	210	74184	135		
7490	33	74185	135		
7491	75	74188	275		
7492	38	74190	115		
7493	32	74191	105		
		74192	105		
		74193	105		

CMOS★

4000	15	4056	134
4001	17	4057	2570
4002	17	4059	480
4006	105	4060	99
4007	18	4061	2380
4008	87	4062	999
4009	50	4063	110
4010	50	4066	58
4011	18	4067	380
4012	18	4068	22
4013	42	4069BE	20
4014	86	4070	32
4015	89	4071	21
4016	45	4072	21
4017	89	4073	21
4018	89	4075	23
4019	48	4076	85
4020	99	4077	40
4021	91	4078	21
4022	88	4081	20
4023	20	4082	21
4024	66	4085	74
4025	19	4086	73
4026	180	4089	150
4027	45	4093	85
4028	81	4094	190
4029	99	4095	105
4030	50	4096	105
4031	205	4097	372
4032	100	4098	110
4033	145	4099	145
4034	196	4160	109
4035	111	4161	109
4036	325	4162	109
4037	100	4163	109
4038	108	4174	110
4039	320	4175	99
4040	105	4194	108
4041	80	4408	720
4042	75	4409	720
4043	94	4410	720
4044	88	4411	995
4045	145	4412F	1650
4046	128	4412F	1380
4047	87	4415F	795
4048	58	4415V	795
4049	48	4419	280
4050	48	4422	545
4051	72	4433	1180
4052	72	4435	825
4053	72	4440	1275
4054	110	4450	295
4055	128	4451	295
		4490F	695
		4490V	525
		4501	17
		4502	120
		4503	69
		4506	51
		4507	55
		4508	298
		4510	99
		4511	150
		4512	98

LINEAR IC'S

702	75	MC1303	88
709C 14 pin	35	MC1304P	260
710★	48	MC1310	149
723★	45	MC1312P	195
733★	99	MC1488★	99
741C★ 8 pin	22	MC1489★	99
747C★	70	MC1495★	395
748C★	36	MC1496	92
753	150	MC1710★	79
810	159	MC3401	69
8038CC★	335	MC3340P★	150
AY-1-0212	580	MC3360P	89
AY-1-1313	660	MFC4000B	85
AY-1-1320	305	MFC6040★	97
AY-1-5050	208	MK50398★	635
AY-1-5051	145	MK50362★	650
AY-1-6721/6	195	MM2102-2★	190
AY-3-8500★	385	MM2112★	100
AY-3-8710★	750	MM2112-2★	295
AY-5-1224A★	260	MM57160★	620
AY-5-1230★	450	NE518A★	210
AY-5-1315	560	NE555★	29
AY-5-1317A	630	NE556D8★	60
CA3011★	82	NE560★	325
CA3020	170	NE561★	410
CA3023	170	NE562★	410
CA3028A★	80	NE565A★	185
CA3035	223	NE566★	180
CA3043	190	NE567★	157
CA3046	71	NE571★	450
CA3048	200	RAM2102-2★	210
CA3075	175	RC4136D★	120
CA3080E★	70	ROM2513★	700
CA3081	190	SG3402	295
CA3089E	210	SN76003N	175
CA3090AQ	375	SN76013N	140
CA3123E	200	SN76023N	140
CA3130★	85	SN76033N	175
CA3140★	70	SN76115N	215
ICL7106E★	950	SN76477★	225
ICM7205★	1150	SN76227	115
LD130★	452	TAA621AX1	228
LM301H	170	TAA960	300
LM301A	30	TBA120S	70
LM304	240	TBA540Q	220
LM308	110	TBA550Q	330
LM318	195	TBA641BX11	250
LM324★	79	TBA651	180
LM339★	80	TBA800	90
LM348★	95	TBA810S	99
LM379★	375	TBA820	70
LM380	95	TBA920Q	260
LM381	145	TDA1022★	595
LM381AN	241	TDA2020	320
LM382	125	TLO71CP★	60
LM1458★	50	TL081CP★	52
LM3900★	60	TL082CP★	96
LM3909N★	70	TL084CP★	130
LM3911★	125	UAA170	198
M252AA★	750	ZN414	90
M253AA★	795	ZN424	130
MC724★	175	ZN425E★	375

TRANSISTORS

AC117★	35	BC170	17	BF184★	30	OC41★	48	ZTX311	17	2N3563	20
AC125★	20	BC171	11	BF194	10	OC42★	32	ZTX314	24	2N3614★	169
AC126★	20	BC172	10	BF195	10	OC43★	55	ZTX326	40	2N3615★	135
AC127★	20	BC177★	17	BF196	10	OC44★	31	ZTX341	20	2N3663	24
AC128★	20	BC178★	17	BF197	10	OC45★	20	ZTX500	13	2N3702	10
AC141★	24	BC179★	17	BF198	18	OC46★	28	ZTX501	14	2N3703	11
AC141K★	38	BC182	9	BF200★	28	OC70★	19	ZTX502	19	2N3704	10
AC142★	24	BC182L	10	BF224A	18	OC71★	25	ZTX503	15	2N3705	11
AC142K★	38	BC183	9	BF244	24	OC72★	30	ZTX504	25	2N3706	10
AC176★	18	BC183L	10	BF256★	50	OC76★	36	ZTX531	25	2N3707	10
AC187★	20	BC184	9	BF257★	26	OC77★	76	ZTX550	25	2N3708	10
AC188★	20	BC184L	10	BF258★	26	OC79★	76	2N526★	58	2N3709	10
ACY17	35	BC186	21	BF259★	30	OC81★	28	2N696★	35	2N3710	16
ACY18★	40	BC187★	28	BF394	22	OC82★	45	2N697★	21	2N3711	10
ACY19★	40	BC212	9	BF594	40	OC83★	48	2N698★	39	2N3715★	250
ACY20★	40	BC212L	10	BF595	38	OC84★	44	2N699★	39	2N3772★	170
ACY21	35	BC213	9	BFR39	25	OC122★	48	2N706A★	19	2N3773★	288
ACY22★	40	BC213L	11	BFR40	25	OC123★	48	2N707★	50	2N3819	22
ACY28★	40	BC214	9	BFR79	28	OC139★	85	2N708★	19	2N3820	32
ACY39	78	BC214L	10	BFR80	28	OC140★	85	2N914★	32	2N3823★	65
ACY40★	48	BC307B	14	BFX29★	26	OC141★	85	2N916★	27	2N3824★	70
ACY44	39	BC308	13	BFX81★	130	OC170★	40	2N918★	30	2N3866★	90
AD140★	69	BC328	13	BFX84★	24	OC171★	40	2N920★	51	2N3903	18
AD149★	70	BC338	12	BFX85★	24	OC201★	75	2N930★	18	2N3904	18
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AF115★	25	BC547	11	BFY18★	30	TIP29	43	2N1302★	35	2N4058	17
AF116★	25	BC548	11	BFY50★	20	TIP29A	44	2N1303★	50	2N4061	17
AF117★	25	BC549	11	BFY51★	20	TIP29C	60	2N1304★	50	2N4064★	120
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AF125★	35	BCY34★	75	BSY65★	30	TIP30C	65	2N1308★	46	2N5135	42
AF126★	35	BCY39★	80	BSY95★	25	TIP31★	40	2N1613★	23	2N5136	42
AF139★	35	BCY40★	78	BSY95A★	25	TIP31A★	40	2N1671★	190	2N5138	20
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AF180★	70	BCY58★	22	BU205★	190	TIP31C★	66	2N1893★	28	2N5180★	60
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AF239★	42	BCY70★	15	E5567	65	TIP32A★	49	2N2160★	105	2N5305★	24
ASY26★	40	BCY71★	17	MD8001★	158	TIP32B★	70	2N2217★	48	2N5457	32
ASY27★	45	BCY72★	17	ME4102	10	TIP32C★	70	2N2218A★	31	2N5458	32
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BC108C★	12	BD124★	115	MJE340★	45	TIP34★	85	2N2297	45	40311★	50
BC109★	9	BD131★	38	MJE370★	55	TIP34A★	85	2N2303★	45	40313★	125
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BC113	17	BD135★	36	MJE521★	65	TIP35★	219	2N2476★	125	40324	85
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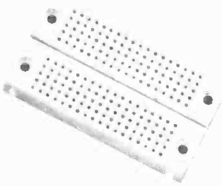
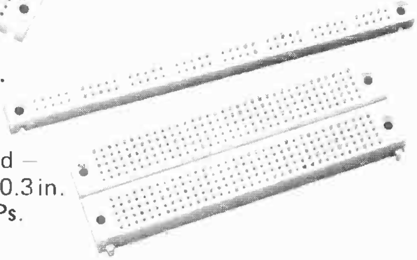
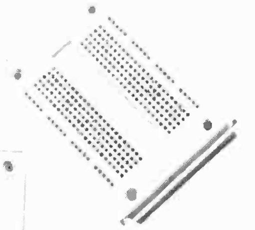
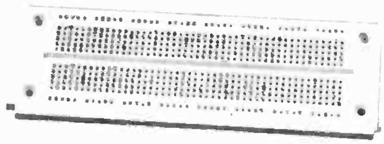
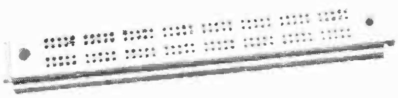
BC115	19	BD137★	36	MJE3055★	70	TIP35C★	270	2N2484★	30	40327★	62
BC116	19	BD138★	36	MPF102	30	TIP36A★	265	2N2646★	48	40347★	80
BC117	15	BD139★	36	MPF103	36	TIP36C★	325	2N2784★	55	40348★	101
BC118	19	BD140★	36	MPF104	36	TIP41A★	63	2N2846★	140	40360★	43
BC119★	26	BD142★	59	MPF105	36	TIP41B★	73	2N2894★	30	40361★	45
BC134	19	BD145★	198	MPF106	50	TIP42A★	64	2N2904A★	22	40362★	48
BC135	20	BD222★	60	MPF107	50	TIP42B★	82	2N2905A★	20	40407★	50
BC136	18	BD695A★	75	MPSA05★	24	TIP2955★	63	2N2906★	18	40411★	289
BC137	20	BD696A★	75	MPSA06★	24	TIP3055★	60	2N2907★	20	40412★	63
BC140★	28	BDY17★	195	MPSA12	40	TIS43	36	2N2907A★	22	40467	95
BC142★	25	BDY60★	110	MPSA55	24	TIS44	45	2N2926G	10	40576★	190
BC143★	25	BDY61★	165	MPSA56	24	TIS46	45	2N2926O	8	40594★	80
BC147	7	BF115★	22	MPSA70	34	TIS50	47	2N2926R	8	40595★	90
BC148	7	BF154★	25	MPSU02★	58	TIS60	45	2N2926Y	8	40603★	65
BC149	8	BF156★	29	MPSU05	48	TIS62	45	2N3011★	24	40636★	125
BC153	14	BF167	25	MPSU06	54	TIS74	47	2N3053★	20	40673★	68
BC154	14	BF173★	25	MPSU52★	65	TIS90	18	2N3054★	49		
BC157	10	BF177★	24	MPSU55★	53	TIS91	22	2N3055★	55		
BC158	11	BF178★	25	MPSU56★	56	ZTX107	11	2N3108	39		
BC159	11	BF179★	30	MPU131★	39	ZTX108	11	2N3121	40		
BC160	27	BF180★	20	OC25★	120	ZTX109	11	2N3133	43		
BC167A	11	BF181★	30	OC26★	150	ZTX300	13	2N3135	33		
BC168C	12	BF182★	30	OC28★	99	ZTX301	16	2N3250	33		
BC169C	10	BF183★	30	OC29★	160	ZTX302	18	2N3252	36		
				OC35★	80	ZTX303	21	2N3302	35		
				OC36★	99	ZTX304	24	2N3442★	131		

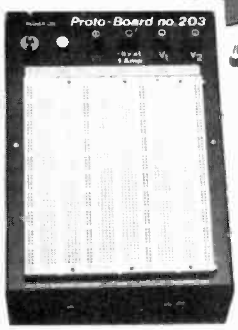
Diodes

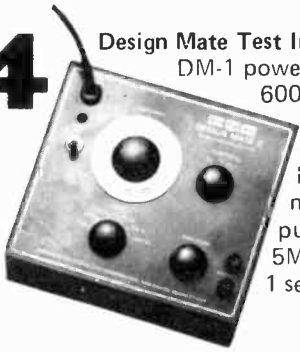
IN4148	4
CRO33★	148
Zeners 400mw 2.7-33v	9

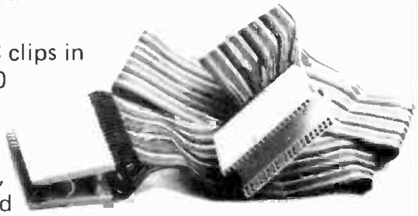




PROTO BOARD 6
INSTRUCTION MANUAL
Proto Board 6
Proto-Board no. 203





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Hours, minutes, seconds, day, OR Hours, minutes, date, day, ten seconds, seconds by flash. Day, date, month, year. Selectable 12 hour (with am/pm) or 24 hour clock.
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COMPLETE STEREO ROADSHOWS – BUILT IN SOUND TO LIGHT/SEQUENCER & DISPLAY

TWO YEAR GUARANTEE

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These systems feature full mixing for two decks tape & mic with monitoring facilities – override and are supplied complete with sound to light + sequencer, display, speaker leads etc.

JUST PLUG IN AND GO!

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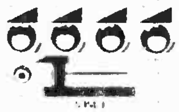

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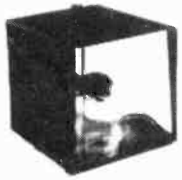

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(Pro-Strobe has external trigger facility).

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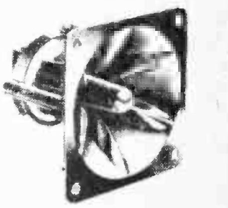

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BP39	50 (FET) Field Effect Transistor Projects	£1·25†
BP43	How to make Walkie-Talkies	£1·25†
BP44	I.C.555 Timer Projects	£1·45†
BP47	Mobile Discoteque Handbook	£1·35†
BP129	Universal Gram-motor Speed Indicator	10p†
BP160	Coil Design and Construction Manual	75p†
BP196	AF-RF Reactance Frequency Chart for Constructors	15p†
BP202	Handbook of integrated Circuits (ICs) Equivalents and Substitutes	75p†
BP205	First Book of Hi-Fi Loudspeaker Enclosures	75p†
BP213	Electronic Circuits for Model Railways	85p†
BP214	Audio Enthusiasts Handbook	85p†
BP216	Electronic Gadgets and Games	85p†
BP217	Solid State Power Supply Handbook	85p†
BP219	Solid State Novelty Projects	85p†
BP220	Build Your Own Solid State Hi-Fi and Audio Accessories	85p†
BP222	Solid State Short Wave Receivers for Beginners	95p†
BP223	50 Projects Using IC CA3130	95p
BP224	50 CMOS IC Projects	95p
BP225	A Practical Introduction to Digital IC's	95p†
BP226	How to Build Advanced Short Wave Receivers	£1·20†
RCC	Resistor Colour Code Disc Calculator	10p

BOOKS BY NEWNES

No. 229 Beginners Guide to Electronics	Price £2·25†
No. 230 Beginners Guide to Television	Price £2·25†
No. 231 Beginners Guide to Transistors	Price £2·25†
No. 233 Beginners Guide to Radio	Price £2·75†
No. 234 Beginners Guide to Colour Television	Price £2·25†
No. 235 Electronic Diagrams	Price £1·80†
No. 236 Electronic Components	Price £1·08†
No. 237 Printed Circuit Assembly	Price £1·08†
No. 238 Transistor Pocket Book	Price £3·90†
No. 225 110 Thyristor Projects Using SCRs & Triacs	Price £2·50†
No. 227 110 COS/MOS Digital IC Projects For the Home Constructor	Price £2·25†
No. 226 110 Operational Amplifier Projects for the Home Constructor	Price £2·50†
No. 242 Electronics Pocket Book	Price £3.90†
No. 239 30 Photoelectric Circuits & Systems	Price £1·80†

NUTS AND BOLTS

BA BOLTS packs of BA threaded cadmium plated screws slotted cheese head.

Supplied in multiples of 50.

Type	No.	Price	Type	No.	Price
1in 0BA	839	£1·20	½in 4BA	846	£0·32
½in 0BA	840	£0·75	¼in 4BA	847	£0·25
1in 2BA	842	£0·65	1in 6BA	848	£0·40
½in 2BA	843	£0·45	½in 6BA	849	£0·21
¼in 2BA	844	£0·52	¼in 6BA	850	£0·25
1in 4BA	845	£0·44			

BA NUTS packs of cadmium plated full nuts in multiples of 50

Type	No	Price	Type	No	Price
0BA	855	£0·72	4BA	857	£0·30
2BA	856	£0·48	6BA	858	£0·24

BA WASHERS – flat cadmium plated plain stamped washers supplied in multiples of 50.

Type	No.	Price	Type	No.	Price
0BA	859	£0·14	4BA	861	£0·12
2BA	860	£0·12	6BA	862	£0·12

SOLDER TAGS – hot tinned supplied in multiples of 50.

Type	No.	Price	Type	No.	Price
0BA	851	£0·40	4BA	853	£0·22
2BA	852	£0·28	6BA	854	£0·22

SWITCHES

Description	No.	Price
DPDT miniature slide	1973	£0·11*
DPDT standard slide	1974	£0·14*
Toggle switch SPST 1½ amp 250V a.c.	1975	£0·33*
Toggle switch DPDT 1 amp 250V a.c.	1976	£0·42*
Rotary on-off mains switch	1977	£0·50*
Push switch – Push to make	1978	£0·13*
Push switch – Push to break	1979	£0·18*

ROCKER SWITCH A range of rocker switches SPST – moulded in high insulation. Material available in a choice of colours ideal for small apparatus.

Colour	No.	Price
RED	1980	£0·26*
BLACK	1981	£0·26*
WHITE	1982	£0·26*
BLUE	1983	£0·26*
YELLOW	1984	£0·26*
LUMINOUS	1985	£0·26*

Description	No.	Price
Miniature SPST toggle, 2 amp 250V a.c.	1958	£0·50*
Miniature SPDT toggle, 2 amp 250V a.c.	1959	£0·55*
Miniature DPDT toggle, 2 amp 250V a.c.	1960	£0·70*
Miniature DPDT toggle, centre off, 2 amp 250V a.c.	1961	£0·85*
Push button SPST, 2 amp 250V a.c.	1962	£0·78*
Push button SPDT, 2 amp 250V a.c.	1963	£0·83*
Push button DPDT, 2 amp 250V a.c.	1964	£0·98*

MIDGET WAFER SWITCHES

Single-bank wafer type – suitable for switching at 250V a.c. 100mA or 150V d.c. in non-reactiver loads make-before-break contacts. These switches have a spindle 0·25in dia. and 30° indexing.

Description	Order No.	Price
1 pole 12 way	1965	£0·48*
2 pole 6 way	1966	£0·48*
3 pole 4 way	1967	£0·48*
4 pole 3 way	1968	£0·48*

MICRO SWITCHES

	Order No.	Price
Plastic button gives simple on-off action Rating 10 amp 250V a.c.	1969	£0·20
Button gives 1 pole change over action Rating 10 amp 250V a.c.	1970	£0·25

FUSE HOLDERS AND FUSES

Description	Order No.	Price
20mm x 5mm chassis mounting	506	£0·07*
1¼in x ¼in chassis mounting	507	£0·12*
1¼in car inline type	508	£0·15*
Panel mounting 20mm	509	£0·20
Panel mounting 1¼in	510	£0·30

QUICK BLOW 20mm

Type	No	Type	No.	Type	No.
150mA	611	1A	615	3A	619
250mA	612	1·5A	616	4A	620
500mA	613	2A	617	5A	621
800mA	614	2·5A	618		

All **5p** each excepting 616 which is **7p**.

ANTI-SURGE 20mm

Type	No.	Type	No.	Type	No.
100mA	622	1A	625	2·5A	628
250mA	623	2A	626	3·15A	629
500mA	624	1·6A	627	5A	630

All 7p each

QUICK BLOW 1¼in

Type	No.	Type	No.	Type	No.
250mA	631	500mA	632	800mA	634

All 7p each

Type	No	Type	No.	Type	No.
1A	635	2·5A	638	4A	641
1·6A	636	3A	639	5A	642
2A	637				

All 6p each

CASES AND BOXES

INSTRUMENT CASES. In two sections vinyl covered top and sides, aluminium bottom, front and back.

No.	Length	Width	Height	Price
155	8in	5½in	2in	£1·52*
156	11in	6in	3in	£2·12*
157	6in	4¾in	1¾in	£1·30*
158	9in	5¼in	2½in	£1·76*

ALUMINIUM BOXES. Made from bright ali., folded construction each box complete with half inch deep lid and screws.

No.	Length	Width	Height	Price
159	5¼in	2¼in	1½in	62p*
160	4in	4in	1½in	62p*
161	4in	2¼in	1½in	62p*
162	5¼in	4in	1½in	74p*
163	4in	2½in	2in	64p*
164	3in	2in	1in	44p*
165	7in	5in	2½in	£1·04*
166	8in	6in	3in	£1·32*
167	6in	4in	2in	86p*

METAL FOIL CAPACITOR PAK

Containing 50 metal foil Capacitor—like Mullard C280 series. Mixed values ranging from ·01uf—2·2uf. Complete with identification sheet O/N 16204 **£1·20***

TRANSFORMERS

MINIATURE MAINS Primary 240V

No.	Secondary	Price
2021	6V-0-6V 100mA	90p*
2022	9V-0-9V 100mA	90p*
2023	12V-0-12V 100mA	95p*

MINIATURE MAINS Primary 240V with two independent secondary windings

No.	Type	Price
2024	MT280-0-6V, 0-6V RMS	£1·50*
2025	MT150-0-12V, 0-12V RMS	£1·50*

1 AMP MAINS Primary 240V

No.	Secondary	Price	
2026	6V-0-6V 1 amp	£2·50*	P. & P. 45p
2027	9V-0-9V 1 amp	£2·00*	P. & P. 45p
2028	12V-0-12V 1 amp	£2·60*	P. & P. 55p
2029	15V-0-15V 1 amp	£2·75*	P. & P. 66p
2030	30V-0-30V 1 amp	£3·45*	P. & P. 86p

STANDARD MAINS Primary 240V

Multi-tapped secondary mains transformers available in ½ amp, 1 amp and 2 amp current rating. Secondary taps are 0-19-25-33-40-50V

Voltages available by use of taps: 4, 7, 8, 10, 14, 15, 17, 19, 25, 31, 33, 40, 25-0-25V.

No.	Rating	Price	
2031	½ amp	£5·50*	P. & P. 86p
2032	1 amp	£6·60*	P. & P. 86p
2033	2 amp	£8.40*	P. & P. £1·10

AUDIO LEADS

107	FM Indoor Ribbon Aerial	£0·60*
113	3.5mm Jack plug to 3.5mm jack plug. Length 1.5m	£0·75*
114	5 pin DIN plug to 3.5mm. Jack connected to pins 3&5. Length 1.5m	£0·85*
115	5 pin DIN plug to 3.5mm. Jack connected to pins 1&4. Length 1.5m	£0·85*
116	Car aerial extension. Screened insulated lead. Fitted plug & skt.	£1·10*
117	AC mains connecting lead for cassette recorders & radios. 2 metres	£0·68*
118	5 pin DIN phono plug to stereo headphone jack socket	£1·05*
119	2 + 2 pin DIN plugs to stereo jack socket with attenuation network for stereo headphones. Length 0.2m	£0·90*
120	Car stereo connector. Variable geometry plug to fit most car cassette, 8 track cartridge & combination units. Supplied with inline fused power lead and instructions.	£0·60*
123	6.6m Coiled Guitar Lead Mono Jack Plug to Mono Jack Plug BLACK	£1·50*
124	3 pin DIN plug to 3 pin DIN plug. Length 1.5m	£0·75*
125	5 pin DIN plug to 5 pin DIN plug. Length 1.5m	£0·75*
126	5 pin DIN plug to Tinned open end. Length 1.5m	£0·75*
127	5 pin Din plug to 4 Phono Plugs. All colour coded. Length 1.5m	£1·30*
128	5 pin DIN plug to 5 pin DIN socket. Length 1.5m	£0·80*
129	5 pin DIN plug to 5 pin DIN plug mirror image. Length 1.5m	£1·05*
130	2 pin DIN plug to 2 pin DIN inline socket. Length 5m	£0·68*
131	5 pin DIN plug to 3 pin DIN plug. 1&4 and 3&5. Length 1.5m	£0·83*
132	2 pin DIN plug to 2 pin DIN socket. Length 10m	£0·98*
133	5 pin DIN plug to 2 phono plugs. Connected pins 3&5. Length 1.5m	£0·75*
134	5 pin DIN plug to 2 phono sockets. Connected pins 3&5. Length 23cm	£0·68*
135	5 pin DIN socket to 2 phono plugs. Connected pins 3&5. Length 23cm	£0·68*
136	Coiled stereo headphone extension lead. Black. Length 6m	£1·75*
178	AC mains lead for calculators etc.	£0·68*

ELECTROLYTIC PAKS

A range of paks each containing 18 first quality, mixed value miniature electrolytics.

16201—values from ·47mFD—10mFD	60p*
16202—values from 10mFD—100mFD	60p*
16203—values from 100mFD—680mFD	60p*

VISIT US AT BREADBOARD SEYMOUR HALL, LONDON W1.
NOV 21st-25th
10 am to 7 pm

STANDS E2, E3, F2, F3, E10, E11

ORDERING Do not forget to state order number and your name and address.

V.A.T. Add 12½% to prices marked*. 8% to those unmarked. Items marked are zero rated.

P&P. 35p unless otherwise shown.

BI-PAK

DEPT. PE11, P.O. Box 6, Ware, Herts

COMPONENTS SHOP: 18 BALDOCK STREET, WARE, HERTS.

High quality audio modules for Stereo and mono

S450

STEREO FM TUNER Fitted with phase lock-loop

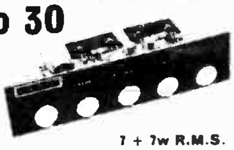
£22·30
+ 40p p&p
+ 12½% VAT

FREQUENCY RANGE	88–108 Mhz
SENSITIVITY	3·0 μV
BANDWIDTH	250 kHz
SPURIOUS REJECTION	50 dB
SELECTIVITY ± 400 kHz	55 dB
AUDIO OUTPUT ([illegible] kHz deviation)	100 mV
STEREO SEPARATION	30 dB
SUPPLY REQUIREMENTS	20 to 30V (90mA max)
AERIAL IMPEDANCE	75 ohms
DIMENSIONS	240mm × 110mm × 32mm

The 450 Tuner provides instant programme selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, simply by changing the settings of the pre-set controls. Features include FET input stage. Vari-Cap diode tuning. Switched AFC LED Stereo Indicator.

Stereo 30

COMPLETE AUDIO CHASSIS



£18·95
+ 40 p&p
+ 12½% VAT

7 + 7w R.M.S.

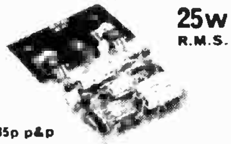
OUTPUT POWER	7 Watts RMS
LOAD IMPEDANCE	8 ohms
TOTAL HARMONIC DISTORTION	Less than 5% (Typically 3%)
FREQUENCY RESPONSE	50 Hz to 20 kHz ± 3dBs
TONE CONTROL RANGE	± 12 dBs at 100Hz and 10kHz
SENSITIVITY	190 mV for full output
INPUT IMPEDANCE	1 M ohms
TRANSFORMER REQUIREMENTS	22 V.A.C. rated at 1A
DIMENSIONS (Less controls and panel)	200mm × 130mm × 33mm

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind will produce a high quality audio unit suitable for use with a wide range of inputs i.e. high quality ceramic pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel, knobs, main switch, fuse and fuse holder and universal mounting brackets.

AL60

25w R.M.S.

AUDIO AMPLIFIER MODULE 25 Watts RMS



£4·55 + 35p p&p
+ 12½% VAT

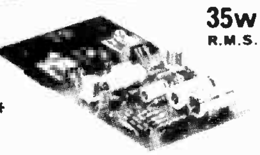
OUTPUT POWER	25 Watts RMS
SUPPLY	30–50 V
LOAD IMPEDANCE	8–16 ohms
TOTAL HARMONIC DISTORTION	Less than 1% (Typically ·06%)
FREQUENCY RESPONSE	20 Hz to 30 kHz ± 2 dBs
SENSITIVITY	280 mV for full output
MAX. HEAT SINK TEMPERATURE	90°C
DIMENSIONS	103mm × 64mm × 15mm

This high quality audio amplifier module is for use in audio equipment and stereo amplifiers and provides output powers up to 25 RMS with distortion levels below 0·1%.

AL80

35w R.M.S.

AUDIO AMPLIFIER MODULE



£7·15*
+ 35p p&p
+ 8% VAT

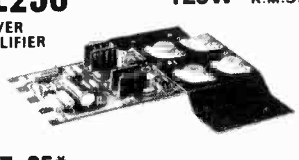
OUTPUT POWER	35 Watts RMS
SUPPLY	40–60 V
LOAD IMPEDANCE	8–16 ohms
TOTAL HARMONIC DISTORTION	Less than 1% (Typically ·06%)
FREQUENCY RESPONSE	20 Hz to 30 kHz ± 2 dBs
SENSITIVITY	280 mV for full output
MAX. HEAT SINK TEMPERATURE	90°C
DIMENSIONS	103mm × 64mm × 15mm

The AL80 is similar in design to the AL60 above and is of the same high quality but provides output powers up to 35W with distortion levels below 0·1%.

AL250

125w R.M.S.

POWER AMPLIFIER



£17·25* + 40p p&p + 8% VAT

OUTPUT POWER	125 Watts RMS continuous
OPERATING VOLTAGE	50–80 V
LOADS	4–16 ohms
FREQUENCY RESPONSE	25 Hz 20 kHz measured at 100 Watts
SENSITIVITY FOR 100 WATTS O/P AT 1 kHz	450 mV
INPUT IMPEDANCE	33 K ohms
TOTAL HARMONIC DISTORTION	
50 WATTS into 4 ohms	0·1%
50 WATTS into 8 ohms	0·06%

This unit, designated AL250, is a power amplifier providing an output of up to 125W RMS, into a 4 ohm load.

AL30A

10w R.M.S.

AUDIO AMPLIFIER MODULES

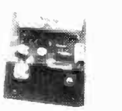
£3·75 + 35p p&p
+ 12½% VAT

MAXIMUM SUPPLY VOLTAGE	30 V
POWER OUTPUT for 2% THD	10 Watts RMS
TOTAL HARMONIC DISTORTION	Less than 25%
LOAD IMPEDANCE	8–16 ohms
INPUT IMPEDANCE	100 K ohms
FREQUENCY RESPONSE	50 Hz–25 kHz ± 3 dBs
SENSITIVITY	75 mV for full output
DIMENSIONS	74mm × 63mm × 28mm

These low cost 5 and 10 watt modules offer the utmost in reliability and performance, whilst being compact in size.

SPM80

STABILISED POWER SUPPLY



£4·25 + 35p p&p
+ 12½% VAT

INPUT A.C. VOLTAGE	33–40V
OUTPUT D.C. VOLTAGE	33 V nominal
OUTPUT CURRENT	10 mA–1·5 amps
OVERLOAD CURRENT	1·7 amps approx.
DIMENSIONS	105mm × 63mm × 30mm

Designed to power two AL60s at 15 Watts per channel simultaneously. Circuit Techniques include full short circuit protection.

PA100

STEREO PRE-AMPLIFIER

£15·80
+ 40p p&p
+12½% VAT

FREQUENCY RESPONSE	20 Hz to 20 kHz ± 1 dB	
TOTAL HARMONIC DISTORTION	Less than 1% (Typically ·07%)	
SENSITIVITY INPUTS 1. TAPE	100 mV/100 K ohms	For an output 250 mV
2. RADIO TUNER	100 mV/100 K ohms	
3. MAGNETIC P.U.	3·5 mV/50 K ohms	
EQUALISATION	Within ± 1 dB from 20 Hz to 20 kHz	
BASS CONTROL RANGE	± 15 dBs at 75 Hz	
TREBLE CONTROL RANGE	+ 10–20 dBs at 15 kHz	
SIGNAL/NOISE RATIO	Better than 65 dBs (All inputs)	
INPUT OVERLOAD	Better than 26 dBs (All inputs)	
SUPPLY	20 to 40 V	
DIMENSIONS	300 × 90 × 33mm (less controls)	

A top quality stereo pre-amplifier and tone control unit, the PA100 provides a comprehensive solution to the front end requirements of stereo amplifiers or audio units. The six push button selector switch gives a choice of inputs together with two filters for high and low frequencies.

MPA30

MAGNETIC CARTRIDGE PRE-AMPLIFIER

£2·95
+35p p&p
+ 12½% VAT

Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the MPA 30 which is a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.

SENSITIVITY	3·5 mV for 100 mV output
EQUALISATION	Within ± 1 dB from 20 Hz to 20 kHz
INPUT IMPEDANCE	50 K ohms
SUPPLY	18 to 30 V—re earth
DIMENSIONS	110 × 50 × 25mm (inc DIN socket)

PA12

STEREO PRE-AMPLIFIER

£7·10
+ 30p p&p
+ 12½% VAT

The PA12 Stereo Pre-Amplifier chassis is designed and recommended for use with the AL 20/30 Audio Amplifier Modules, the PS12 power supply and the T538 Transformer. Features include on/off volume, Balance, Bass and Treble controls. Complete with tape output.

FREQUENCY RESPONSE	20 Hz–20 kHz (—3dB)
BASS CONTROL	± 12 dB at 60 Hz
TREBLE CONTROL	± 14 dB at 10 kHz
INPUT IMPEDANCE	1 Meg. ohm
INPUT SENSITIVITY	300 mV
CROSSTALK	—60 dB
SIGNAL/NOISE RATIO	—65 dB
OVERLOAD FACTOR	± 20 dB
TAPE OUTPUT IMPEDANCE	25 K ohms
DIMENSIONS	152mm × 84mm × 25mm

PS12 POWER SUPPLY

Designed for use with the AL30A S.450 and MPA30 in conjunction with transformer T538.

INPUT VOLTAGE	17–20v AC
OUTPUT VOLTAGE	27–30v DC
OUTPUT CURRENT	800mA
SIZE	60mm × 43mm × 26mm

£1·30
+ 35p p&p
+ 12½% VAT

GE 100 NINE CHANNEL MONO-GRAPHIC EQUALIZER

The GE100 has nine 1 octave adjustments using integrated circuit active filters. Boost and Cut limits are ± 12dB. Max. Voltage handling 2 V RMS, T.H.D., 0·05%, input impedence 100K. Output impedence less than 10 K. Frequency response 20 Hz -20 KHz (3dB). The nine gain controls are centred at 50, 100, 200, 400, 800, 1,600, 3,200, 6,400 and 12,800 Hz. The suggested gain controls are 10 K LIN sliders (not supplied with the module) See Paks S31 and 16192.

£22·00
+ 35p p&p
+ 12½% VAT

SG30 POWER SUPPLY BOARD for GE100 15-0-15 VOLT **£5·50 + 12½% VAT + 35p p&p**

SIREN ALARM MODULE

American Police screamer powered from any 12 volt supply into 4 or 8 ohm speaker. Ideal for car burglar alarm, freezer breakdown and other security purposes. Order No. S15. No. BP124.
Only £3·50 + 8% VAT + 35p p&p

MA60 HI-FI AMPLIFIER KIT

Build you own top quality amplifier, save yourself pounds. The MA60 kit comprises the following BI-kits modules, 2 × AL60 amps, 1 × PA100 pre-amp, 1 × SPM80 stab. power supply, 1 × BMT80 transf. giving 17 watts RMS per channel STEREO. All modules covered by the BI-PAK satisfaction or money back guarantee. Details of the above modules are in this ad.
Price £32·00 + 12½% VAT + 62p p&p.

TC60 KIT

A beautifully designed genuine TEAK WOOD veneered cabinet to put the professional touches to your home built amplifier. Full set of parts incl. Front & Back Panels, Knobs, Chassis, Fuses, Sockets, Noen, etc. Ideal for the MA60. Size: 425mm × 290mm × 95mm.
Price £19·95 + 12½% VAT + 86p p&p

TRANSFORMERS

T538 For use with S.450 AL30A MPA30
Order No. **2036** Price: **£3·20** + 55p p&p + 12½% VAT
T2050 For use with Stereo 30
Order No. **2050** Price: **£3·25** + 55p p&p + 12½% VAT
BMT80 For use with AL60 SPM80
Order No. **2034** Price: **£5·40** + 86p p&p + 12½% VAT
BMT250 For use with AL250
Order No. **2035** Price: **£6·35** + £1·10 p&p + 12½% VAT

BI-PAK

DEPT. PE11, P.O. Box6, Ware, Herts

AND OTHER PROJECTS

PHOTOGRAPHS in this advertisement show two of our units containing some of the P.E. projects built from our kits and PCBs. The cases were built by ourselves and are not for sale, though a small selection of other cases is available

LIST—Send stamped addressed envelope with all U.K. requests for free list giving fuller details of PCBs, kits and other components

OVERSEAS enquiries for list Europe—send 20p; other countries—send 50p.

KIMBER-ALLEN KEYBOARDS AND CONTACTS

Kimber-Allen Keyboards as required for many published circuits. The manufacturers claim that these are the finest moulded plastic keyboards available. All octaves are C to C, the keys are plastic, spring-loaded, fitted with actuators, and mounted on a robust aluminium frame.

3 Octave (37 notes)	£25·50
4 Octave (49 notes)	£32·25
5 Octave (61 notes)	£39·75

Contact Assemblies (gold-clad wire) for use with the above keyboards (1 required for each note):

Type GJ: Single-pole change-over	each 25½p
Type GB: 2 pairs of contacts, each pair normally open	each 28½p
Type GC: 3 pairs of contacts, each pair normally open	each 37½p
Type GE: 4 pairs of contacts, each pair normally open	each 46½p
Type GH: 5 pairs of contacts, each pair normally open	each 58½p
Type 4PS: 3 pairs of contacts plus single-pole changeover	each 57p

Printed Circuit Boards for use with GJ, GB and 4PS contacts (thus eliminating much interwiring) are available. Details in our lists.

RHYTHM GENERATOR

15-Rhythm Tempo, Timing and Logic control unit (excl. sw's but incl. PCB)	£9·75
10-Instrument Effects circuits	£14·23
PCB for Effects circuits	£4·25
Power Supply incl. PCB	£8·75

128-NOTE TUNE-PROGRAMMABLE SEQUENCER

(P.E. Nov/Dec 77)

Enables a voltage controlled synthesiser to automatically play pre-programmed tunes of up to 32 pitches and 128 notes long. Programs are keyboard initiated and note length and rhythmic pattern are externally variable. (Please use order codes quoted in brackets.)

Main Circuit (Nov) excl. sw s (KIT 76-1)	£18·03
Power Supply (KIT 76-3)	£4·72
Trigger Inverter and Alt. Output (KIT 76-2)	£1·15
LED Counter (KIT 76-4)	£2·10
PCB (as published) for KITS 76-1 & 3 (PCB 76A)	£2·61
PCB for KITS 76-2 & 4 (PCB 76B)	£2·54

P.E. STRING ENSEMBLE (PE Mar-July 78)

The new keyboard string-instrument synthesiser.

Basic component sets:

Power Supply (KIT 77-1)	£8·77
Tone Generator (KIT 77-2)	£14·66
Diode Gates (KIT 77-3)	£18·81
Chorus Generator (KIT 77-4)	£19·08
Voicing System (KIT 77-5)	£7·38

Printed Circuit Boards:

Double-sided PCB for Power Supply, Tone Generator & Diode Gates with most of the Matrix wiring as printed tracking (PCB 77L/R)	£18.40
PCB for Chorus Generator (PCB 77C)	£2.65
PCB for Voicing System (PCB 77D)	£2.62

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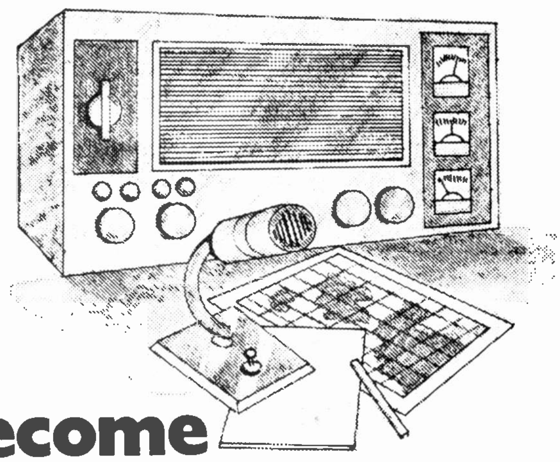

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PE VOLUME 14 No. 15 NOVEMBER 1978

MORE RAM

WE HAVE heard plenty about the 64K RAM over the last few months—so much that we hesitate to mention it again—however, it was only a couple of months ago that everyone was contemplating the government proposals and wondering if a sponsored company would be competitive. We have today received news of a Texas TMS 4164 which is—you've guessed it—a 64K RAM. This new device comes in a standard 16 pin d.i.l. package and is expected to be available in sample quantities towards the end of the year; volume production early 1979—where were we?

It is interesting to note that the photomasks for volume production will be made using electron-beam equipment. It has been stated that the 64K RAM is probably as far as we can go using the present production methods, this does not however mean that we are about to come to the end of further miniaturisation.

THE BUBBLE BURSTS!

New technologies are always coming along. One that we heard much of a few years ago was the discovery of magnetic bubbles and how they would effect the whole electronics industry. Well they haven't, have they? But wait, development of such things takes time and the bubble is just about to burst.

It seems that far from being contented with a probable first in the 64K RAM area, Texas have also been playing with a few bubbles. A few did we say, the TIB0303 92k bit bubble memory will soon be available. This device contains 252 minor loops each with 1137 bubble positions! Of course this takes up more room than the regular 64K semiconductor device and is therefore mounted in a 20 pin d.i.l. package! Can we go on believing it's all possible? (More details on this bubble memory can be found on page 1170.)

We find it harder to accept the fact that the quarter million bit bubble chip is with us than that 100,000 active elements can be put on a silicon chip. This is probably because we tend to think of bubbles as having a relatively large minimum size, whereas we hardly had time to accept the transistor before it became integrated. We must look at bubbles again.

COMPONENT COUNT

Dr. Robert R. Heikes, Vice President of Motorola Inc. and Assistant General Manager Semiconductors Group, speaking at a recent press conference made the following statement:

"By the early 1980's, we will no doubt see the routine production of integrated circuits containing at least 100,000 active elements per chip, and by the mid-80's, that device count will reach an incredible one million components on a chip no larger than one-quarter of an inch square; or several billionths (*American billionths that is—Ed.*) of a square inch per device.

With this degree of chip density, it is perfectly logical to assume that we will see the development, for example, of a product no larger than a hand-held calculator that will contain the computing power of today's largest main-frame computer. That's obviously a tremendous amount of computing capability."

It has been calculated that theoretically 10,000,000 components per chip might be achievable and, at the rate things are progressing (generally speaking the chip count has been doubling every year since the sixties), this will only take to the end of the eighties. What then? Many will say we will have gone far enough by then, but history tells us that we will continue to progress.

Mike Kenward

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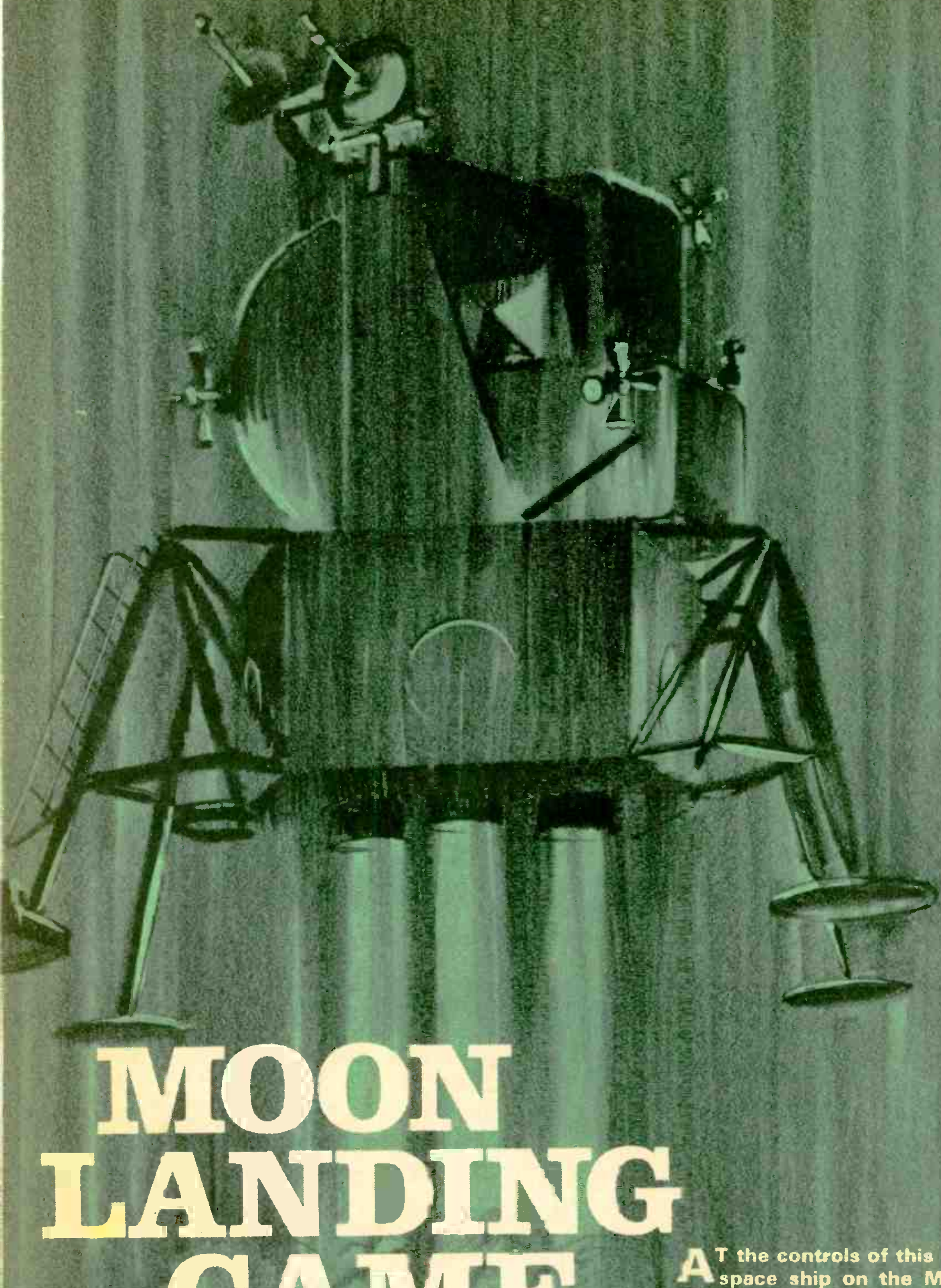
MOON LANDING GAME

A. RUSSELL



AT the controls of this game you can land your own space ship on the Moon and test your skill and timing by guiding the rocket to a safe landing before the fuel runs out.

Moon Landing is essentially a hard wired analogue computer which simulates approximately the dynamics of a space craft landing on the Moon. Additional circuitry monitors the computer and switches off the rocket motor when the fuel runs out, indicates when the craft has landed, and shows when a safe landing velocity is achieved.

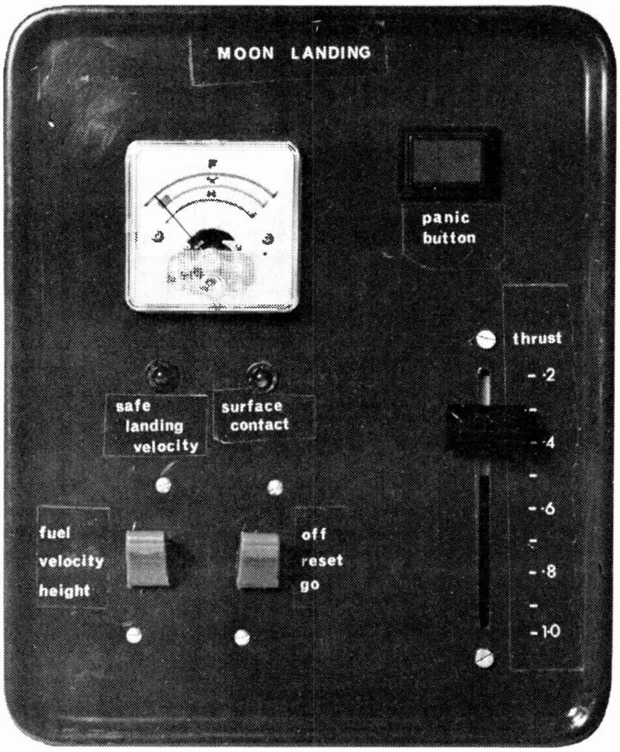
Playing the *Moon Landing* game gives children a feel for the concepts of distance, velocity and acceleration and the relationships between them. Thus as well as being fun to play it also has an educational value.

CONTROLLED DESCENT

You are pilot of the first British expedition to the Moon. At one minute before touchdown the flight control computer blows a fuse, leaving you to land under manual control. There is a lever to control rocket motor thrust and a meter which can be switched to read velocity, height or fuel reserves. Your object is to achieve touchdown at a safe landing speed.

Two lights are provided; one tells you that you have landed and the other indicates whether or not the touchdown was at a safe velocity. Therefore when both lights are on together you have completed a successful landing.

A "Panic" button is provided. In the event of fuel running out before landing (because of a bit of ham fisted driving on the part of the pilot) it will divert the contents of the medicinal whisky tank into the rocket fuel tanks, giving an extra 15 per cent fuel.



Control panel layout

SCHEMATIC

The analogue computer in *Moon Landing* represents a simplified view of a space craft landing on the Moon. No account is taken of the changing mass of the rocket as it burns fuel or changing gravitational attraction, etcetera.

A schematic diagram of the game is shown in Fig. 1. It is not intended to explain in detail the theoretical background of integral calculus and analogue computers. Those interested in finding out more could start by reading the "Analogue Computer" series currently running.

In Fig. 1, the value of thrust selected by the pilot is fed into Integrator 1 which calculates the total quantity of fuel used. When fuel runs out a level detector switches off the thrust. A "Panic" switch feeds more fuel into the fuel tank when it is pressed. Thrust from the rocket engines is added to Moon gravity to give total acceleration acting on the ship. Integrator 2 calculates the resulting velocity and a level switch lights the "Safe Landing Velocity" light when the downward velocity of the space craft falls below a certain value. Velocity is integrated by Integrator 3 to give space craft height and another level switch detects when this is zero to light the "Surface Contact" light.

CIRCUIT

The circuit diagram is shown in Fig. 2. Switch S2 has three positions. In the "Off" position power is disconnected from the circuit. In the "Reset" position capacitors in each integrator are charged to +5·1V to fill the fuel tanks (Integrator 1), give the rocket a large downward velocity (Integrator 2) and set the initial height above the Moon (Integrator 3).

When S2 is moved into the "Go" position the analogue computer starts its calculation. Slider pot VR1 ("Thrust") controls the voltage across R4. This voltage is fed into Integrator 1 (IC1) through R3. Output voltage of IC1 falls at a rate determined by the voltage across R4 (the "Thrust" setting) until point A goes sufficiently negative to forward

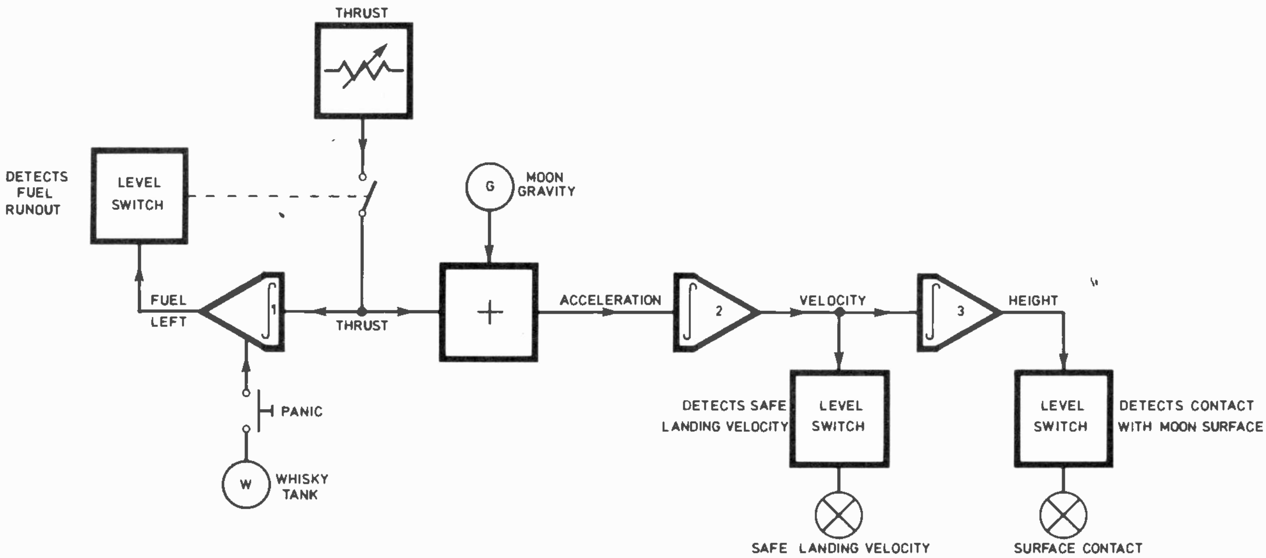


Fig. 1. Schematic diagram

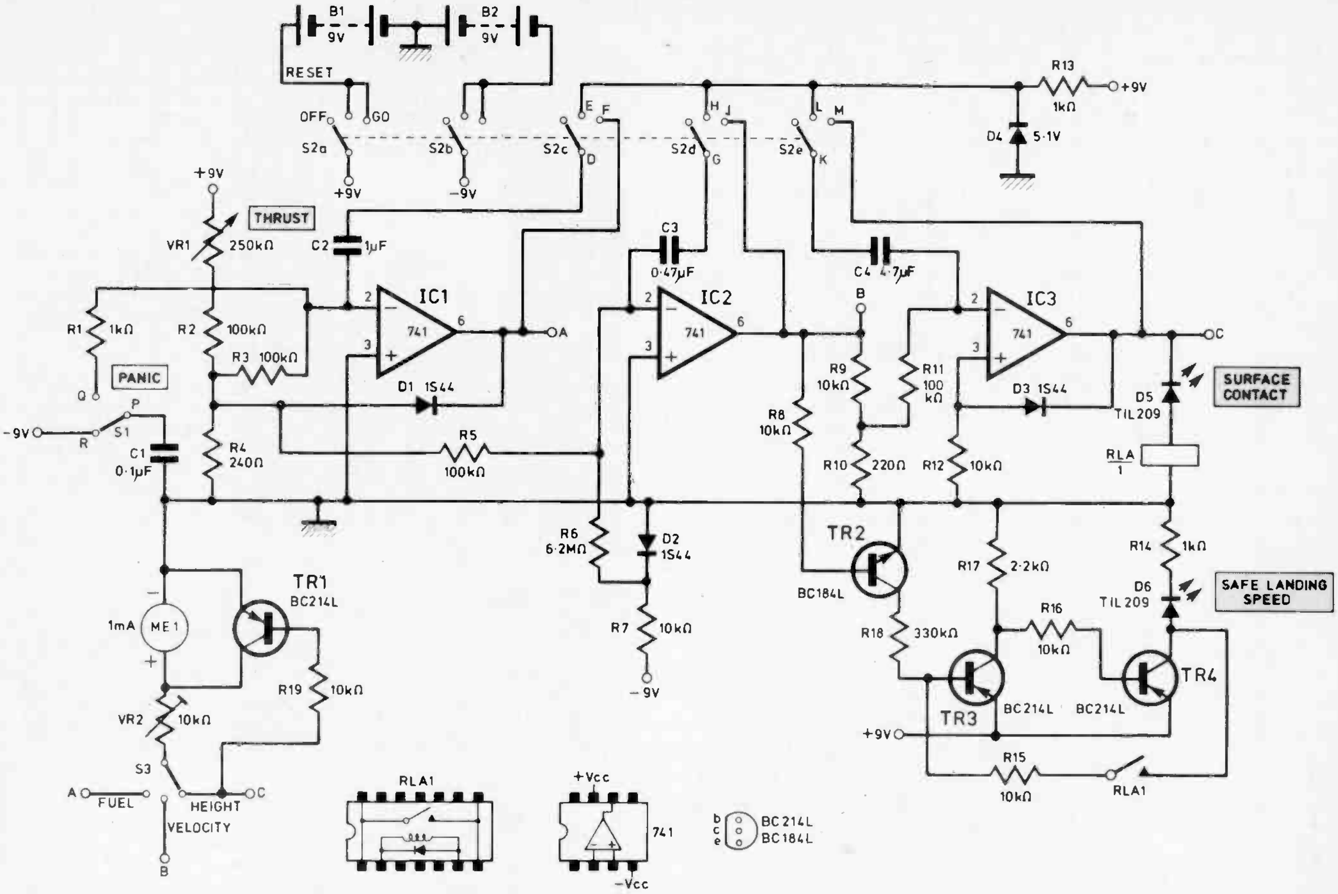


Fig. 2. ***Moon Landing* circuit**

COMPONENTS . . .

Resistors

R1	1kΩ	R11	100kΩ
R2	100kΩ	R12	10kΩ
R3	100kΩ	R13	1kΩ
R4	240Ω	R14	1kΩ
R5	100kΩ	R15	10kΩ
R6	6·2MΩ	R16	10kΩ
R7	10kΩ	R17	2·2kΩ
R8	10kΩ	R18	330kΩ
R9	10kΩ	R19	10kΩ
R10	220Ω		

All resistors $\frac{1}{8}$ watt 5% carbon

Capacitors

C1 0·1µF
C2 1µF
C3 0·47µF
C4 4·7µF
All capacitors polyester

Diodes

D1 1S44
D2 1S44
D3 1S44
D4 5·1V Zener
D5–D6 TIL209 (2 off)

Transistors

TR1 BC214L
TR2 BC184L
TR3 BC214L
TR4 BC214L
IC1 741
IC2 741
IC3 741

Potentiometers

VR1 250kΩ slider pot
VR2 10kΩ trimmer pot

Switches

S1 s.p.d.t. push-button
S2 PO type 1000 lever switch
S3 PO type 1000 lever switch

Miscellaneous

ME1 1mA meter. B1 and B2 PP3 batteries and suitable connectors. RLA d.i.l. reed relay 500Ω coil 3·7–10V operation. Veroboard, suitable plastic case, nuts and bolts, etc.

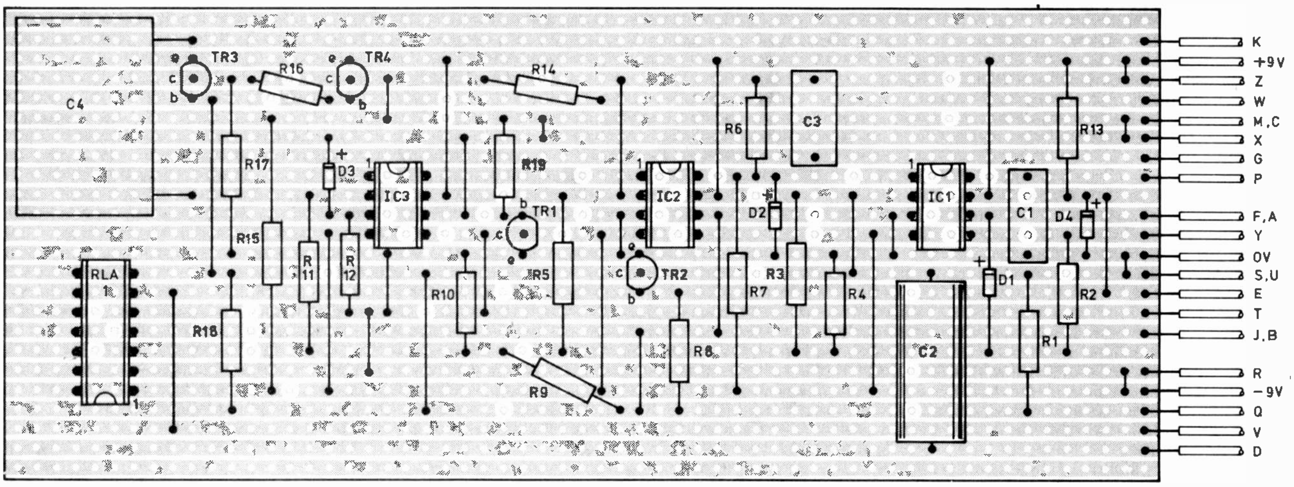


Fig. 3. Veroboard component layout

bias D1. Current drawn through D1 reduces the voltage across R4 to zero and effectively switches off the thrust.

If the "Panic" button is pressed, charge on capacitor C1 is fed into Integrator 1 which increases the voltage at A by about +0·9V thus adding to the fuel reserves.

The voltage across R4 is also fed into Integrator 2 (IC2) along with the effect of gravity (voltage across D2). These two inputs represent the accelerations acting upon the space craft and the output of Integrator 2 is the resulting velocity.

This output is monitored by TR2 which forms the "Safe Landing Velocity" level switch. When the voltage at B is above +0·5V, TR2 is biased on and feeds current into the base of TR3, via R18, which also switches on.

TR3 collector voltage is about +9V when it is switched on and so no current can flow through R16 to switch on TR4. D6 is therefore off. As the voltage at point B falls below +0·5V TR2 switches off and so TR3 also switches off. TR3 collector voltage becomes more negative, current flows into TR4 base, switching it on and lighting D6. When the relay pulls in upon landing, TR3 and TR4 are connected into a bistable circuit, by feedback through R15, which remembers the condition of D6 at the instant of landing.

The voltage at B ("Velocity") is fed through a potential divider R9 and R10 and then into Integrator 3 (IC3) which calculates the space craft height. When the voltage at C ("Height") falls to about −0·4V ("Surface Contact") diode D3 becomes forward biased and current flows through R12. The resulting voltage across R12 appears on the non inverting input of IC3 and is amplified in a positive feedback loop which forces the output of IC3 to −9V. D5 becomes forward biased and lights ("Surface Contact") and the relay is energised which latches D6 into the state it was in when the rocket landed.

METERING

The meter ME1 may be switched by S3 to read "Fuel", "Velocity" or "Height". When the voltage at C switches to −9V on landing, TR1 is switched on and shorts out the meter so that all readings fall to near zero on landing.

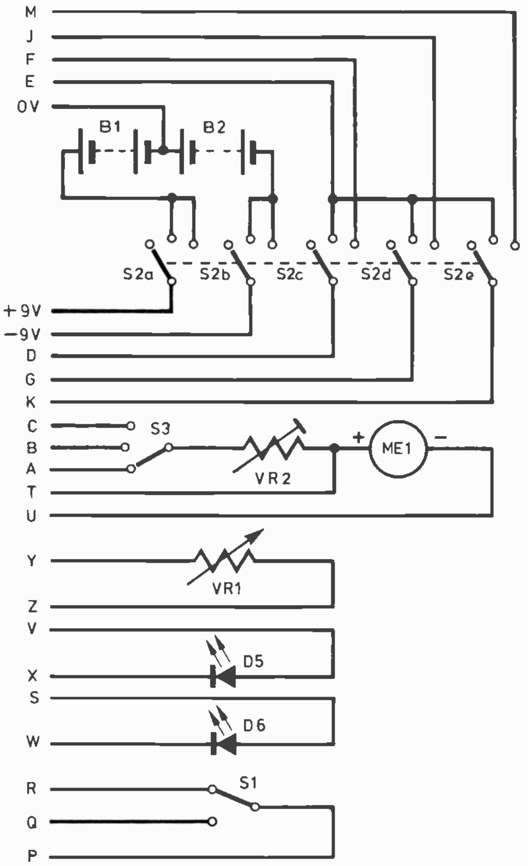
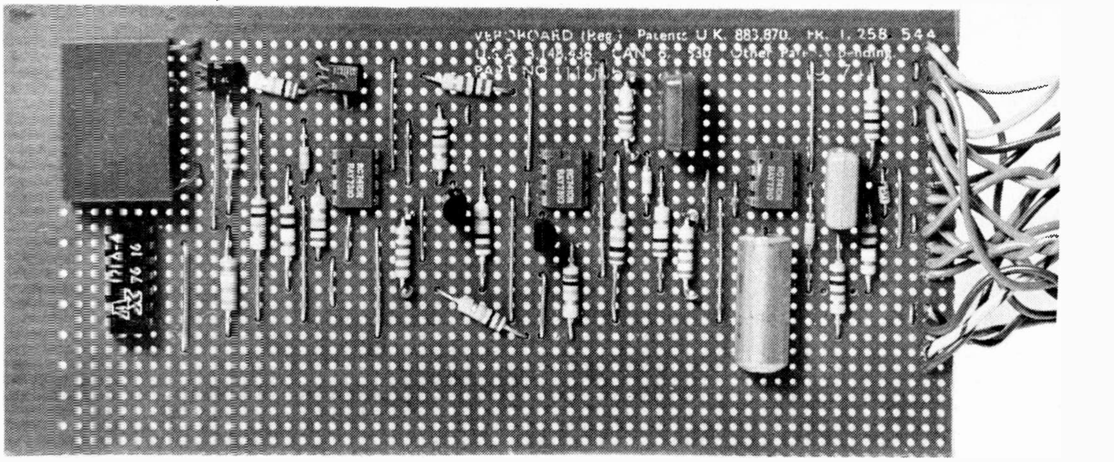
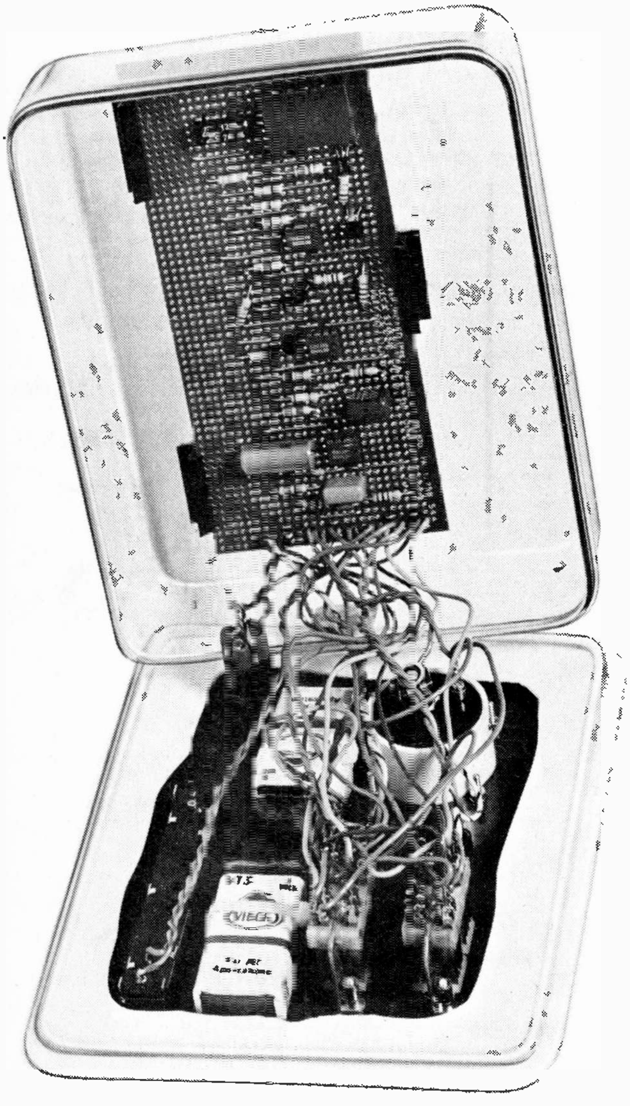


Fig. 4. Control panel wiring to Veroboard





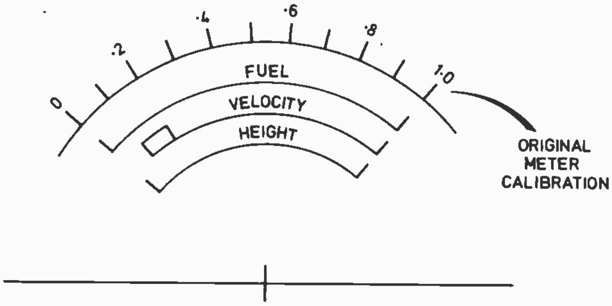


Fig. 5. Rescaling an existing milliammeter

CONSTRUCTION

The Veroboard layout of the *Moon Landing* circuit is shown in Fig. 3 and should present no constructional difficulties. Connections between the Veroboard circuit and the switches, l.e.d.s, etc. are shown in Fig. 4. These components are all mounted on the front panel. A plastic sandwich box was used to house the complete game and the layout chosen for the front panel controls is shown in the photograph.

CALIBRATION

The 1mA meter ME1 requires a new scale. Fig. 5 shows the relationship between the original 0–1mA calibration and the new one for fuel, velocity and height. The new scale may be drawn on plain white paper, cut to shape and glued into position. Take great care not to damage the meter movement while taking it apart.

Use the zero adjusting screw on the meter to set the pointer at zero on the velocity scale with the power off. Adjust VR2 to make the initial values (immediately after "Reset") of fuel, velocity and height agree with the new scale. The meter is now calibrated and landing is for "go". ★

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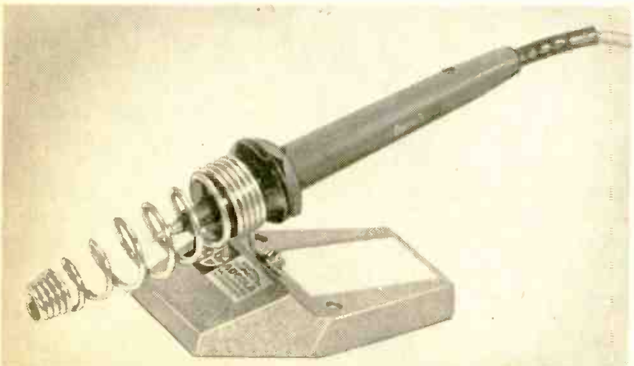

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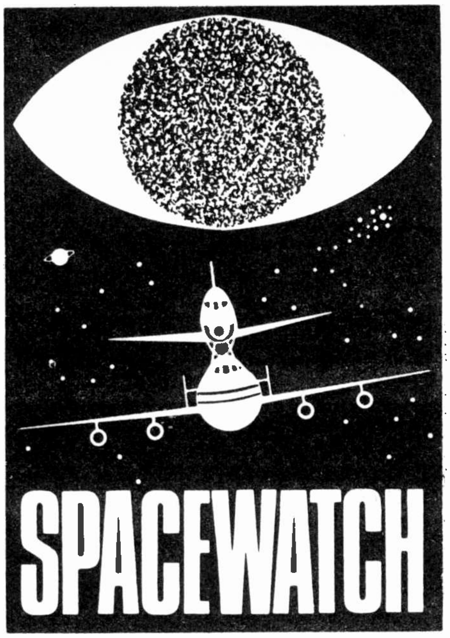

FRANK W. HYDE

SPECIAL GERMAN SATELLITE

A satellite is being built at the Max Planck Institute for Extraterrestrial Physics near Munich. It will contain sub-satellites made in Britain, Germany, USA and, it is hoped, the Soviet Union. The main portion is the Firewheel Satellite. It will perform like a firecracker when it begins its special mission.

The satellite will be launched from Kourou in French Guinea. The sub-satellites will eject ionised barium and lithium which will become clouds of plasma. Instruments on the ground, in aircraft and in the satellites will monitor the way in which the plasma is affected by the Earth's magnetic field. This will create similar circumstances that exist in the fusion experiments where a plasma is confined by a magnetic field in a Torus. The great advantage in doing this in space compared with the Earth based laboratory is that in space the plasma will continue to exist for 30 minutes or more, whereas in the laboratory it lasts for only a few seconds.

The satellite will be launched using the Ariane 200 ton vehicle from the new site in Guyana. It is a relatively cheap launch since its work load will last only a few hours. This means a very large saving in equipment and back up facilities. It is an important launch under the auspices of the European Space Agency.

MILITARY WEATHER SATELLITE

A third satellite has been launched by the US Air Force from the Vandenberg base. The satellite which weighs 513kg was put into a circular orbit at 833km by a Thor launcher. This satellite is part of what is known as Block D Integrated Spacecraft System and is part of the Defence Meteorological Satellite programme. These rather special satellites have been designed to operate in the higher radion levels which are expected during the increase of radiation as the sunspot cycle nears maximum. It is heavier than its predecessors.

A particular technological note in respect of these satellites is that the on-board computers eliminate the need for a separate booster guidance system. The computers can also keep the pointing of the vehicle to Earth with an accuracy of 0·1°. Block D can take pictures of the whole of the Earth's surface twice a day. It has a high resolution, both in the visible and infra-red bands, of up to 0·5km. Other facilities carried are an auroral detector, a line scanning radiometer, temperature-moisture sounder and pressure measuring equipment. The weather information is distributed to civilian users as well as the armed services.

TRACKING AND DATA RELAY SATELLITE SYSTEM, TDRSS

An expensive re-design of the TDRSS has been set in motion after a report of the preliminary design review. The report showed that there was a hazard from Soviet interference. Several of the present ground stations will be replaced by two geosynchronous satellites capable of handling television, voice telemetry and scientific data to and from Earth orbiting spacecraft in the next decade.

The new programme was conceived when the fact was realised that the shuttle would demand extensive expansion because of the increase in traffic. NASA decided that the answer was to orbit spacecraft that could collect information and then pass it to selected stations. The report showed that the present designs were vulnerable and could be disabled by Soviet radar.

Western Union is providing $796 million for the design of six of the satellites. NASA will lease two of the satellites for its own communications purposes in late 1980, at the time of the first shuttle launch. The two satellites will operate at 41°W over the Atlantic and 171°W over the central Pacific basin. Engineers were particularly concerned about the vulnerability, and have begun the complete redesign of the integrated circuits and ground facilities to make for immunity.

The present time allowed for data entry is 0·01 sec. As the time to be used in order to avoid interference is of the order of 0·00001 sec, NASA finds itself in dispute with the contractors who claim that this item was not stipulated in the original requirement.

PIONEER VENUS 2

Pioneer Venus 2 made a flawless start on its journey with four special probes to achieve a controlled landing through the atmosphere of Venus and make special observations. These were described in detail in a previous Spacewatch. Pioneer Venus 1 is due to encounter Venus on December 4th. It is the orbiter spacecraft of the mission and will observe Venus 2 as it approaches on December 9th. The probes will be released ahead of the main craft.

The important thing about the Venus 2 is that it is the last of the spacecraft to be launched by an expendable rocket. The next missions will be flown by shuttle techniques, in 1982. That will be the Galileo flight to the planet Jupiter.

Under monitor now there are no less than eight missions. In addition to the Venus encounters on the 4th and 9th of December, there is continuous coverage of Voyager 1 which will fly past Jupiter in March 1979, Voyager 2 will follow in July. Pioneer 11 is due to reach Saturn by September 1979. The Viking orbiter and the landers will continue to report from Mars at least to the end of this year.

TELEOPERATOR RETRIEVAL SYSTEM

NASA have contracted to Martin Marietta the development project for the service work on satellites in orbit. Teleoperator Retrieval System, TRS, is a reusable TV equipped spacecraft which will be used by the crew of the shuttle to deliver and stabilise satellites and when necessary recover them from orbit.

The TRS is a low thrust type of spacecraft which is to be operated by remote control from the shuttle. It is possible to carry it from, and return it to, Earth in the cargo bay. It can, if required, be left in orbit, parked, until it is collected at a later date. From time to time it would be returned to Earth for service.

The shuttle will take the TRS into a low orbit, and an astronaut will operate it by remote control from the Orbiter. A camera mounted on the bow of the vehicle will be the eye for the operating astronaut, enabling him or her to carry out the necessary manoeuvres required for docking with satellites and carrying out any task required.

The TRS has its own guidance control system. It will be able to take itself to higher orbits in order to deliver payloads or deliver them to the shuttle. It is a very exciting step for the new shuttle age.

The TRS chassis, or core as it were, will measure 1·2m by 1·5m. There will be 24 attitude thrusters on its eight corners, three to each corner. With the thrusters, three axis controls will be available, also forward and reverse movements. Up to four 680kg Hydrazine propulsion kits (90cm in diameter and 1·5m long) will each have eight rocket engines.

On the after flight deck of the Orbiter will be the hand controls for the TRS together with the communications and data management equipment, also a television monitor and displays which will allow control of the TRS through all its operations. From here it will be possible to transmit, receive and process telemetry, receive television pictures and to issue commands. A flight unit is scheduled to be delivered by September 1979.

INTELSAT TERMINAL

At Goudji in Chad, the Central African Republic, an Earth satellite station has been installed by Thomson-CSF and CIT-Alcatel. The station is equipped with a 14·5m antenna and can handle telegraph, telex and telephone communications via the Intelsat satellites. After 14 years of operation Intelsat is still expanding.

SPACELAB 2

It is announced that there will not be a British astronaut on the Spacelab 2 mission. Two Britons were short listed but lost place to two Americans. The British pair were Bruce Patchett of the Appleton Laboratory and Keith Strong of the Mullard Space Science Laboratory.

NEXT MONTH

GUITAR SOUND MULTIPROCESSOR

Until now there has been no device which fills the space between foot pedal effects and the incredibly expensive guitar synthesisers. This "bucket brigade" design will fill that gap.

2 RADIO CONTROL PROJECTS

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CHROMOSONICS

24 Page

CATALOGUE

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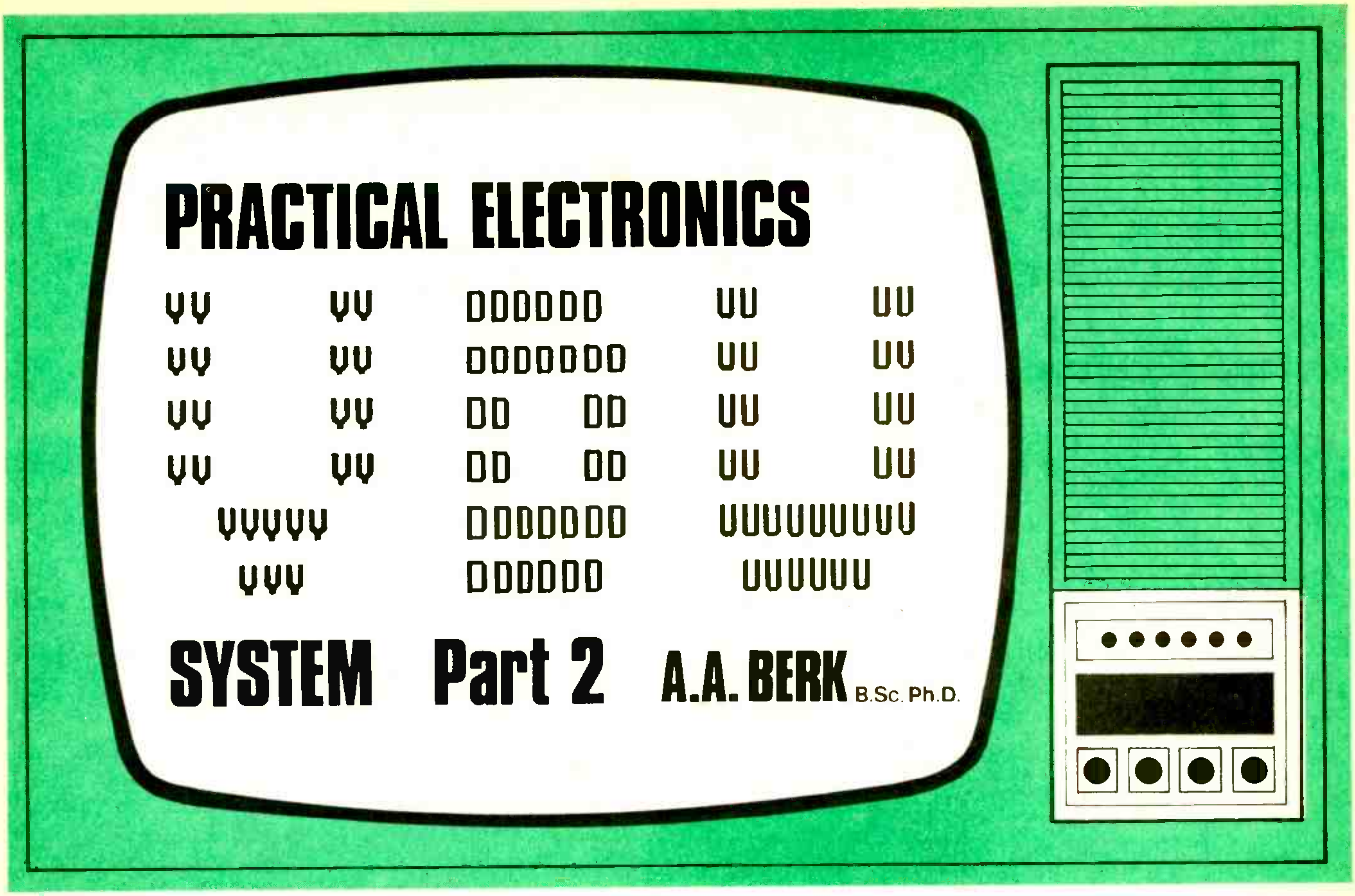
PRACTICAL ELECTRONICS

OUR DECEMBER ISSUE WILL BE ON SALE FRIDAY, 10 NOVEMBER, 1978.



PRACTICAL ELECTRONICS VDU SYSTEM Part 2

A.A. BERK B.Sc. Ph.D.

IN PART 1 of this article, the theory and circuit description of the VDU and its operational characteristics were presented along with a block diagram. In this part, construction, testing and setting up are dealt with. Construction falls readily into two component units: the RAM module and the main p.c.b.

RAM MODULE

The 1K block of RAM is constructed from eight 2102 i.c.s. Each of their ten RAM Address lines (RA1-10) must be connected together from chip to chip (80 interconnections). Similar common lines are required for their power supplies, chip select and R/W lines (a further 32 interconnections). The RAM unit Data-In (DI . . .) and Data-Out (DO . . .) lines are all separate. Conventionally these i.c.s would be placed on an area of p.c.b., with all interconnections being made by fragile narrow copper tracks of minimal spacing (easy to solder–bridge or break) and consuming a considerable area of the board. The RAM module featured in this design drastically reduces the area of p.c.b. required, and the number of interconnections.

Two pieces of 0·1in matrix stripboard are cut to include 8 tracks by 17 holes each, and on one of these boards, 14 cuts are required as shown in Fig. 3(e). The leads of the eight RAM i.c.s must be fully and carefully straightened using a pair of long-nosed pliers (preferably non-serrated). These packages, even in plastic, are very robust and no harm will come to them as long as the pins are bent just once and with the minimum of stress. The pins may then be inserted through the Veroboards into alternate rows of holes *leaving the copper tracks outwards*. One complete row of holes is left free at each end of these boards to use as solder pads for connection to the main p.c.b. Check that the orientation of the chips is such that pins 11 and 12 are fitted into the isolated portions of tracks of Fig. 3(e).

As soon as the i.c.s are in place, a couple of pins on each board should be soldered down to prevent the boards from slipping apart. The soldering should be done as fast as possible with a clean narrow bit, working along one *track* at a time so that successive solder joints are made to different i.c.s. This exposes each element to the minimum build-up of heat. Finally, the bottom two tracks (holding pins 8 and 9 of the i.c.s) are soldered to the copper strips on the main p.c.b. via stiff copper wire "legs", ensuring that the Vero track containing the pin 9s of the i.c.s is soldered to the 0V rail, refer to Fig. 3(a). Two legs should be used for each strip—again using the minimum heat necessary.

This technique, of course, is not restricted to 1K blocks of memory, and the reader will appreciate how easy it is to extend this method to large blocks of RAM for the MPU main memory.

An excellent investment of effort is to carefully and fully clean away the solder flux from the work with cellulose thinners using a paint brush. This facilitates a check with a watchmaker's glass or magnifying lens, for solder bridges and dry joints, thus preventing flux laying across the joints, picking up moisture, and causing noise and cross-talk.

Having produced the RAM module, it is now necessary to connect buses of ribbon cable between the block and the main p.c.b. Three buses need to be connected to the RAM module: Data In (DI0 to DI7), Data Out (DO0 to DO7), and RAM Address RA0 to RA9). The p.c.b. component layout of Fig. 8 contains the above identifications (in brackets) marked against their respective vero-pin positions, and this should simplify interwiring of the RAM module and main p.c.b. Figs. 3(c) and (e) show the connections at the RAM end of the buses. Alternatively, Fig. 5 showing the RAM module circuit

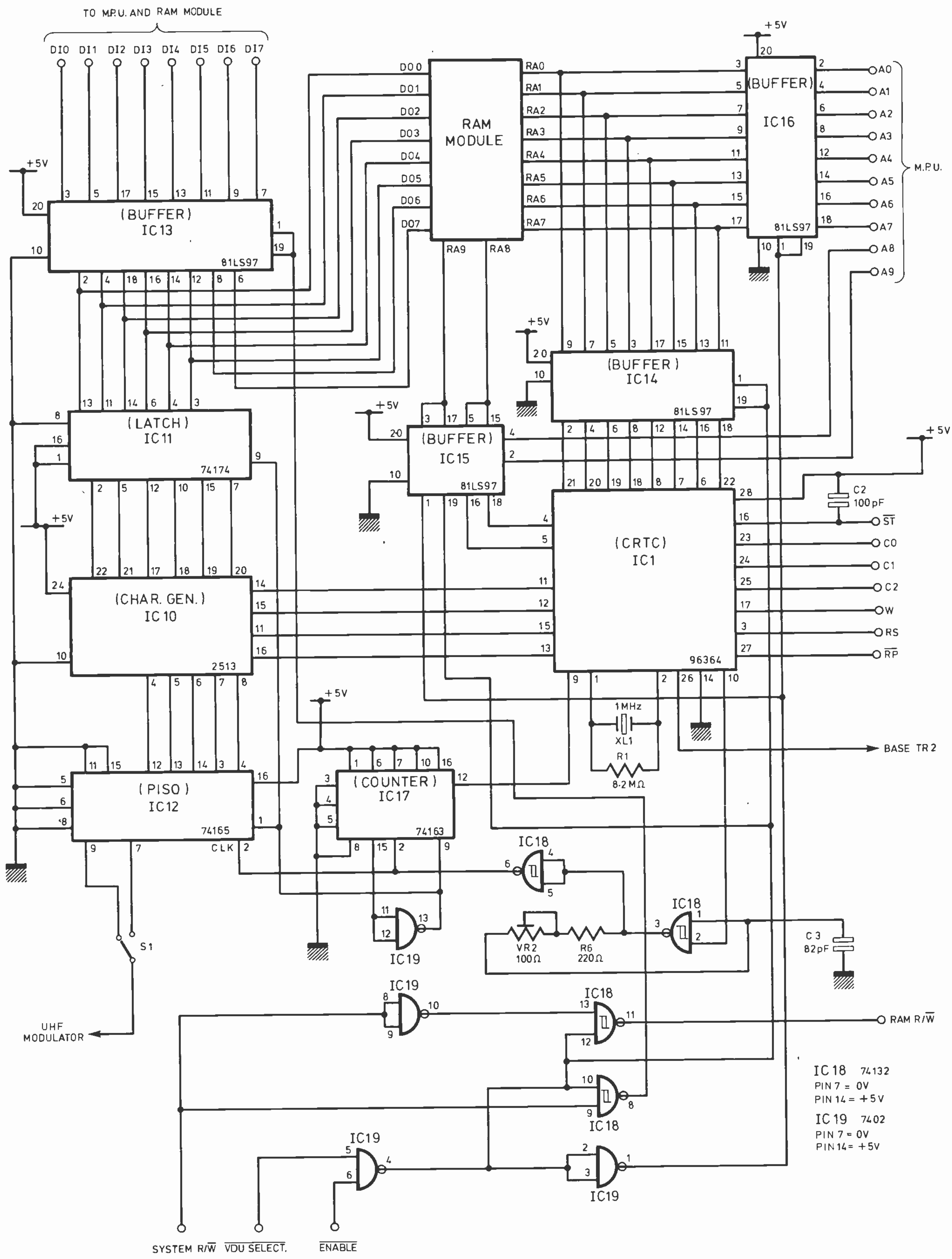


Fig. 1. Circuit diagram of VDU. (The video switching stage and stripline modulator are shown in Fig. 2)

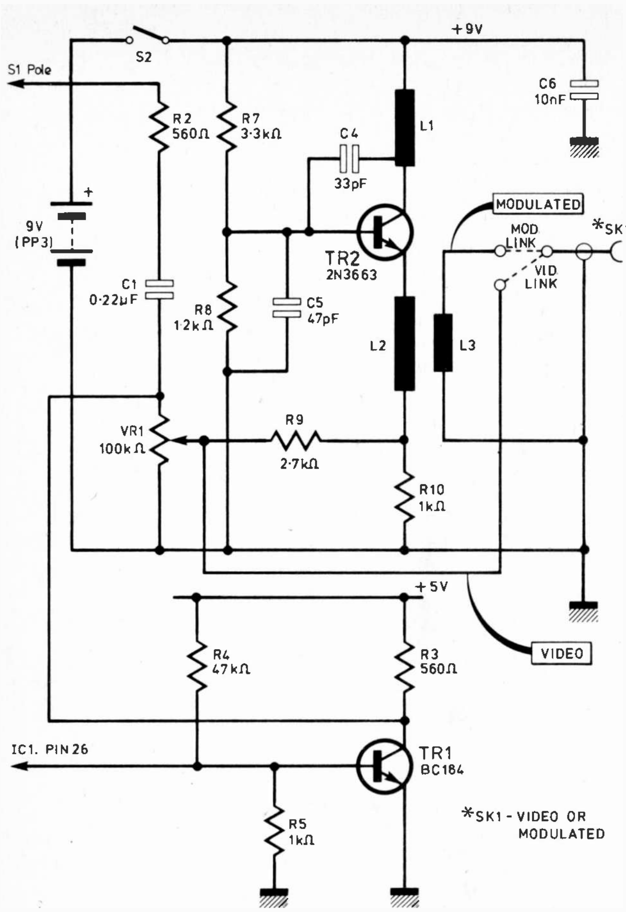


Fig. 2. UHF (stripline) modulator and video switching stage. See P.E. June 1977 for description of this modulator

diagram can be used for wiring up. It should be remembered that the RAM address lines are separate from the MPU address lines. but the Data In lines connect both to the MPU and the RAM module.

The order of connection of the data bits is irrelevent, except that data bit numbers IN must agree with bits OUT. Thus, if one of the i.c.s is chosen to accept data bit 4 IN (i.e. from the MPU bus) make sure that the same chip is chosen to supply data bit 4 OUT (to the buffer IC13).

The use of ribbon cable (preferably coloured) greatly facilitates checking faults. However, any type of thin wire is suitable, and p.t.f.e. covered wire is useful since the insulation is not prone to the usual effects of heat.

The RAM R/$\overline{W}$ line, and +5V line may now be added. Finally, connect $\overline{CS}$ (pins 13) to the OV rail. This completes the RAM module and its wiring.

MAIN BOARD ASSEMBLY

The construction of this section is conventional and straightforward. All pins for through-connections should be soldered in place first. Veropins will be found suitable. Next insert and solder all the i.c.s except for IC1 and IC10. Pay careful attention to i.c. orientation, positioning and minimum application of heat. It is better to make successive solder joints to different i.c.s, swopping back and forth between devices to expose each element to as small a temperature rise as possible. The i.c.s chosen are robust devices and, apart from IC1 and IC10, reasonably cheap, making sockets less important. However, ICs 1 and 10 should be provided with sockets. These should be soldered in next, taking care not to overheat them as the thermoplastic of which they are usually constructed melts easily at soldering temperatures.

The capacitors, resistors and transistors may now be soldered in, afterwards clipping all leads as close to the board as possible. Particular care should be taken to construct the modulator components neatly. It should be borne in mind that many of the copper foil sections on the modulator are deliberately employed as inductors. The precision of their geometry, for those who are producing their own boards, is therefore, of utmost importance.

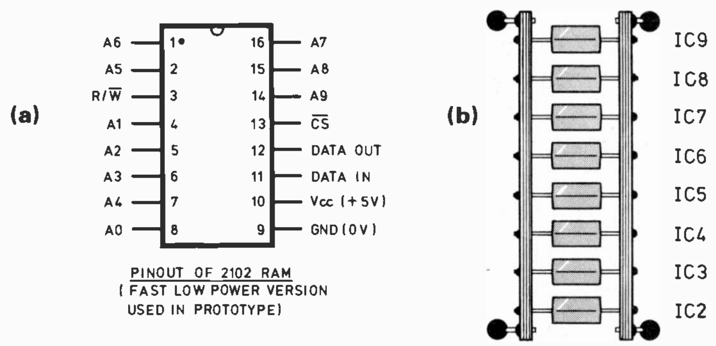
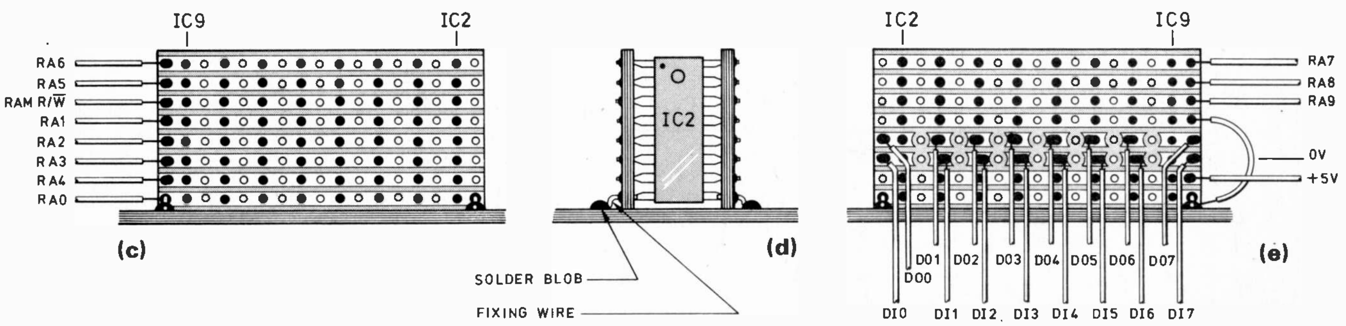


Fig. 3. RAM module construction. Four pieces of stiff wire can be soldered to each end of each bottom track, to produce mounting "legs" which can then be soldered to secure the module to the p.c.b.



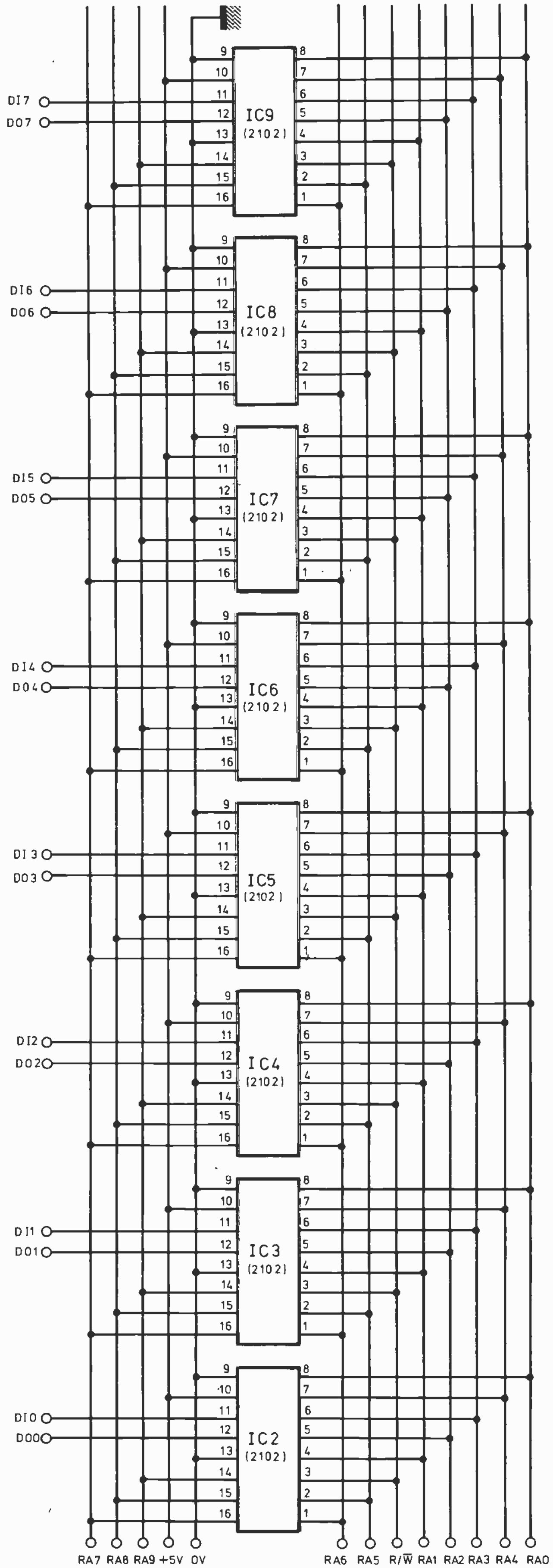


Fig. 5 (left). RAM module circuit diagram

The external wire links, sockets, variable resistors, PP3 battery connector (with appropriate lead length) may now all be soldered in place. The 1MHz crystal can then be inserted with a piece of insulating material between its case and the p.c.b. The crystal should be pressed up against the board and soldered, *very carefully.* A note of caution on this final component is necessary. Whether the crystal be of the wire or the pin type, excessive heat or vibrational shock will detach it from its connections within the metal case, *as the author has discovered to his cost.* Thus, once the crystal is in place, subject the board to as little physical impact as possible.

The final operation should be, as mentioned before, to fully clear the p.c.b. of flux. This is especially important around the pins of i.c.s 12, 17, 19 and associated components, and the whole of the UHF modulator section.

SETTING UP

Provision has been made on the p.c.b. for an inverting switch (S1). Initially, link $\overline{Q}$ (pin 7) output of IC12 to the centre wiper position of the switch (i.e. to R2). Q may be used later, and an external switch fitted.

IC1 and IC10 may now be inserted and, after a final check of the other i.c.s to ensure all are inserted correctly, the 5V and 0V lines may be connected to their appropriate pins on the p.c.b. A 'scope is quite useful at this point to check for the presence of a signal at the video output (collector of TR1). This should appear as in Fig. 4 when using a range of about 10µs per centimetre.

The portion A-B is a negative going TV line synchronisation pulse to ensure that the electron beam strobes across the TV screen at the right time to catch and display the video information from the VDU board. Portion B-C is at a high level to ensure that the part of the line before the character display is bright. C-D contains information controlling the line's brightness across the screen (depending upon which line of characters is being built up, and the height along these characters at which the electron beam is passing through). D-E produces the bright portion at the end of the line. Bright portions are also placed at the top and the bottom of the picture as well as between character rows. This displays the 16 lines of characters *as black upon a white background* and spaced away from the distorting edges of the screen. VR2 is used to set the length of the character rows and may be varied to suit the TV set being used.

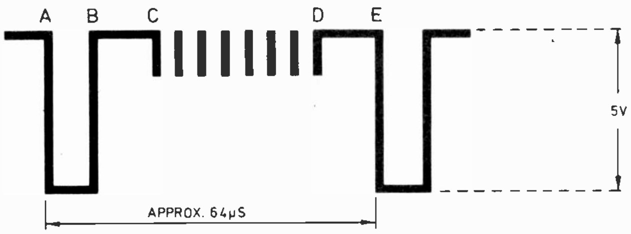


Fig. 4. Video output signal. Several of these sweeps are required to build up a line of characters on the screen, and the "light-dark" information is contained between C and D

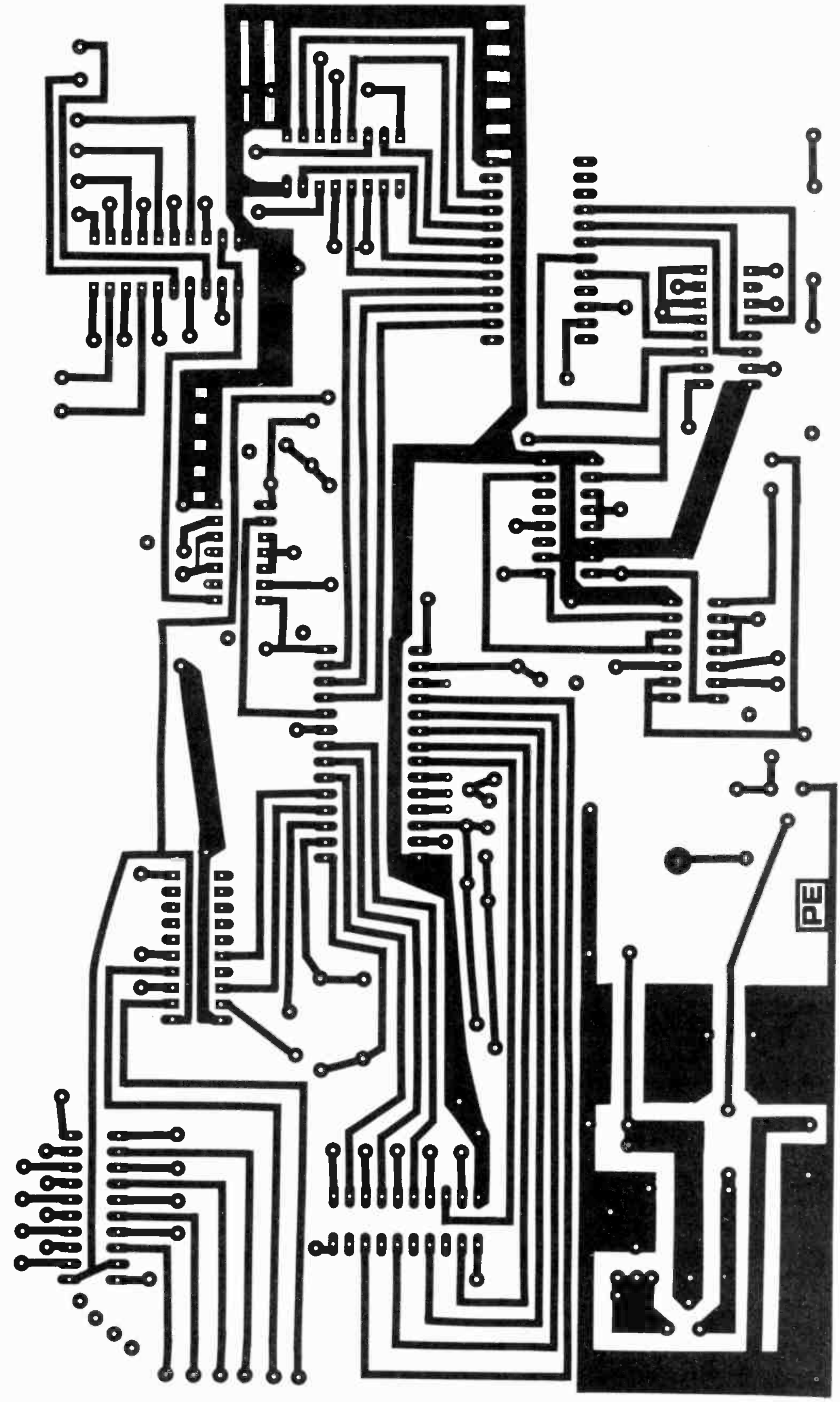


Fig. 6. Conductor side p.c.b. (Actual size). *Copyright Technomatic*

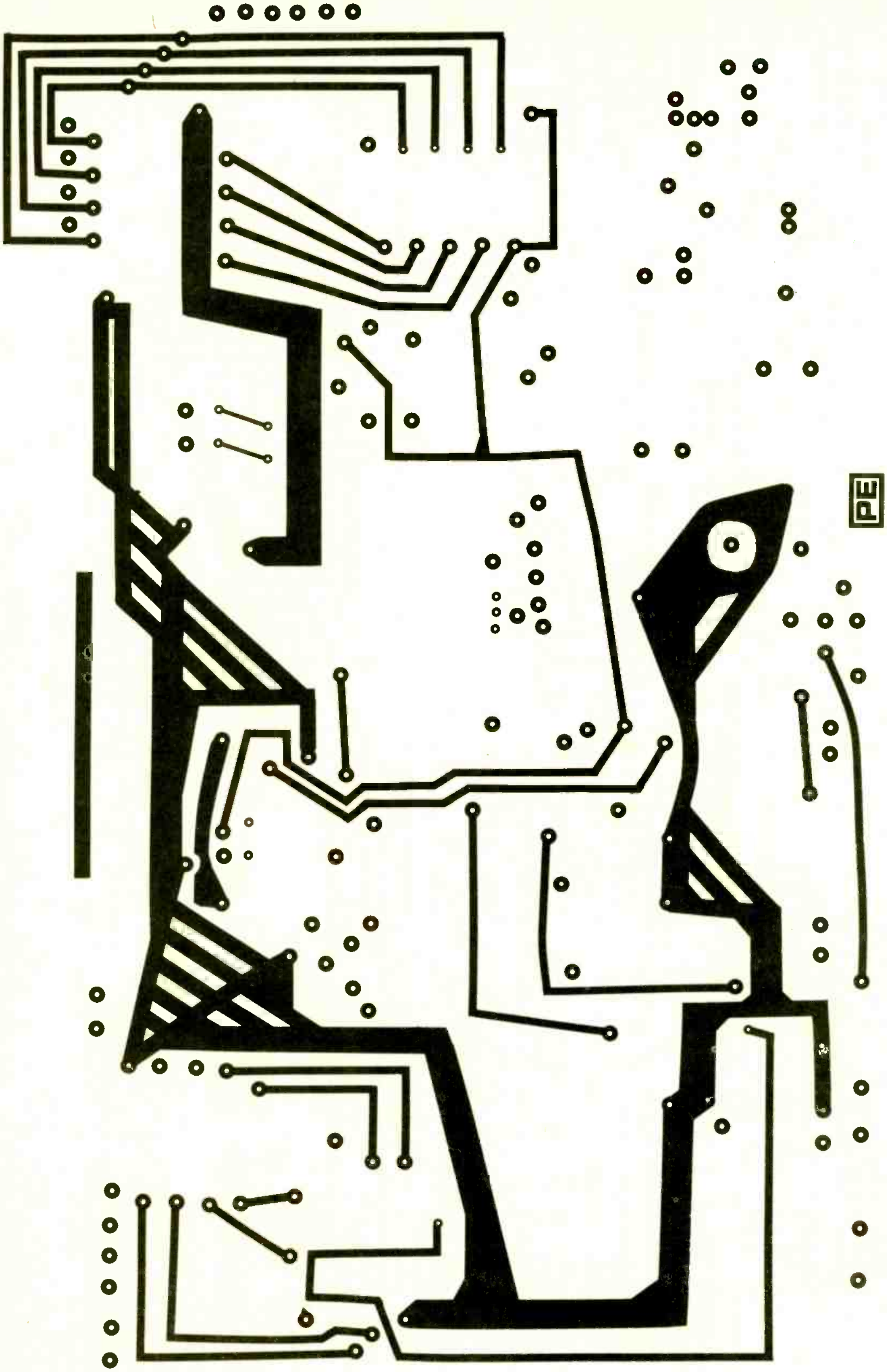


Fig. 7. Component side p.c.b. (Actual size). *Copyright Technomatic*

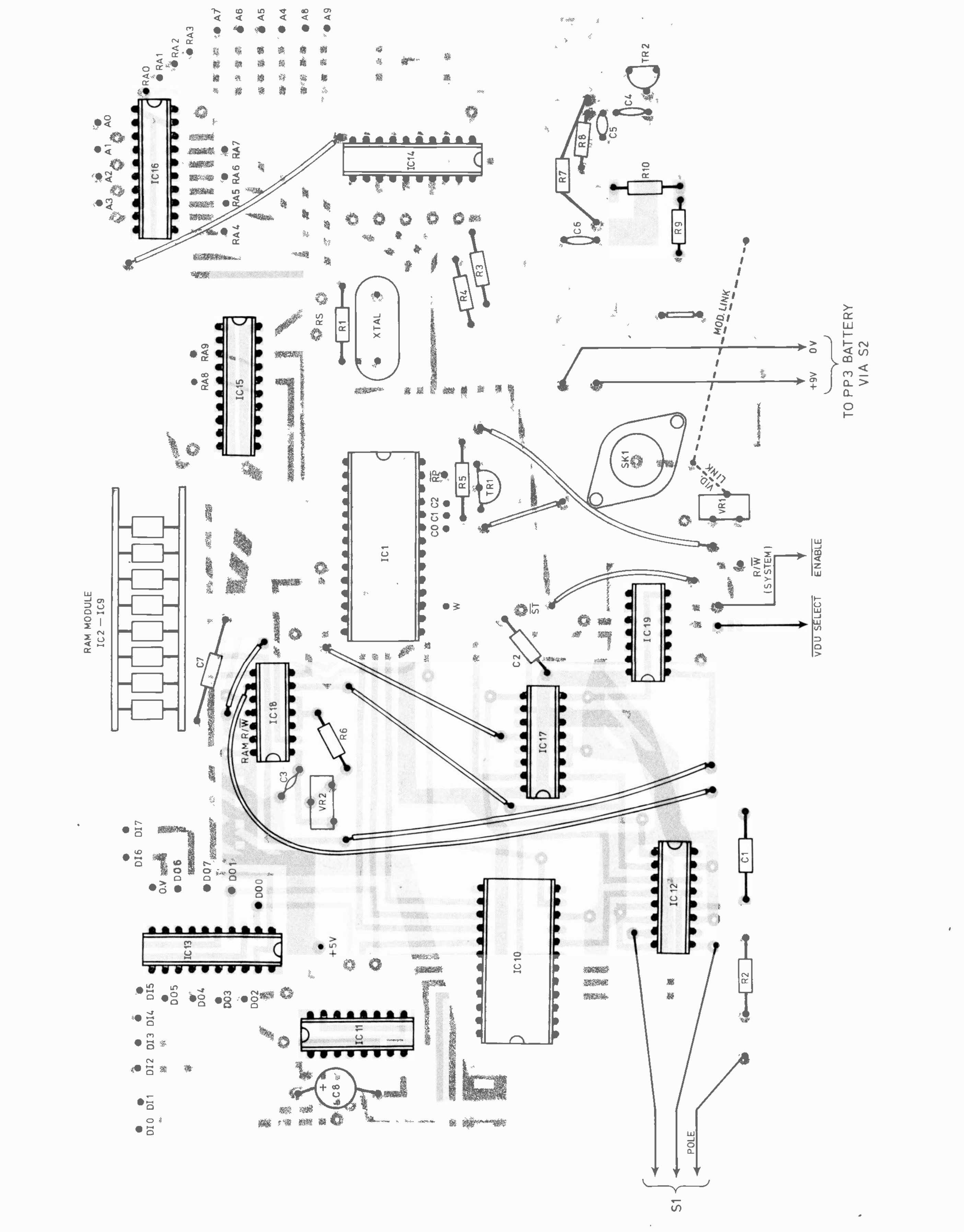


Fig. 8. Component layout for VDU board

If the correct waveform is *not* found at the collector of TR1, try looking at the $\emptyset_1$ input to the CRTC. If no oscillation is observed, suspect IC17, IC18, the crystal, R1, R6, VR2 or C3. If 1 to 2MHz oscillations are present at $\emptyset_1$ with a good amplitude, check that R_0, R_1, R_2, PT, address lines and sync are all oscillating. CRTC is suspect if not. If all are in working order, only IC10 and IC12 are left. R_0, R_1, R_2 and PT inputs in a state of oscillation will produce dynamic information on b_0 to b_5 outputs of IC10. LOAD and CLOCK oscillations to IC12 will produce outputs on Q and $\overline{Q}$ of IC12. By this process, the fault should be narrowed down easily.

The TTL oscillator IC18, should produce between 10 and 15MHz, which will be difficult to resolve into a sine-wave on 'scopes with a lower band-width, but the waveform $\emptyset_1$,out of pin 12 of IC17 should be seen easily on most 'scopes.

If either a monitor or modified TV set (which can accept video directly) is available, link SK1 on the p.c.b. to the video output, and turn VR1 to minimum signal and connect up. Turn VR1 up and a display of random characters should be seen. If necessary, adjust the horizontal and frame holds. The line length can then be adjusted by VR2. VR1 should be set for the clearest display setting. The prototype gave the best picture on a modified TV by feeding the video through a very small capacitor, about 0·0001μF is adequate but some experimentation is worthwhile here.

If there is only an unmodified UHF (625 line) TV available, setting up is restricted to linking SK1 to the modulator output, plugging in the PP3 battery and tuning the set (with VR1 up full), until it receives the field and then adjusting VR1 for the best picture. Use coaxial cable with proper coaxial plugs for connections.

UHF MODULATOR

For those experiencing trouble with the modulator, the following information should be of use. The modulator has an isolated power supply which will last for some time with normal use. Check that its e.m.f. is 8 to 9 volts on load. The modulator section should not be resting on anything. Raise the whole board and support it an inch or two from the bench. The foil pattern or the value of the capacitor, C4, may be inaccurate—try replacing C4 by a trimmer and, with the TV tuned well away from any stations, tune the trimmer in to the TV.

If the TV tunes in, but the picture is unsatisfactory, even after adjustment, then the only recourse is to house the p.c.b., or at least the modulator and battery, in a properly earthed metal box (connected to the 0V line). This final construction gives very good results with the modulator if the p.c.b. is properly suspended away from the box sides (about 25mm being sufficient).

TV MODIFICATION

If you have decided to modify a TV to accept video, a few words of advice will be useful. As most sets do not have a mains isolating transformer, the first check must be to determine whether the *live side of the mains is connected to the TV's chassis.* Use an ohmmeter between mains plug and chassis. *If so reverse the live and neutral wires and use a polarised mains plug to ensure neutral remains connected to chassis.*

Somehow, the video line in the TV has to be found, broken and fed from the video output of the VDU. As mentioned before, video may be fed through a small capacitor to the TV set. The chassis of the set may also be connected through a capacitor to the 0V line of the VDU, though it was found that too small a capacitor caused an intolerable degree of mains "beating" on the display. Once again some experimentation is advantageous here.

Some sets cannot be modified as the video line is contained within an integrated circuit, and so it is as well to check this before beginning.

One final note: the constructor should appreciate that the neater the wiring, the better the display. Use coaxial cable and sockets wherever possible, especially if using UHF.

CONSTRUCTOR'S NOTE

A complete kit of parts including drilled p.c.b. is available from Technomatic Ltd. (01-452 1500) for £49 including VAT and P. & P. The p.c.b. is not plated-through as previously stated, and we apologise for this error. Constructors will find that minimal extra effort results from using the p.c.b. supplied.

A limited number of assembled and tested boards will also be available at £69 inclusive, from **Technomatic Ltd., 17 Burnley Road, London, NW10,** where a model is available for demonstration during normal hours.

Note: C9 in Part 1 components list, does not exist.

NEXT MONTH: Some ideas for interfacing to a system, some expansions of the basic VDU, and some hints on hardware for using the cursor control referred to last month.

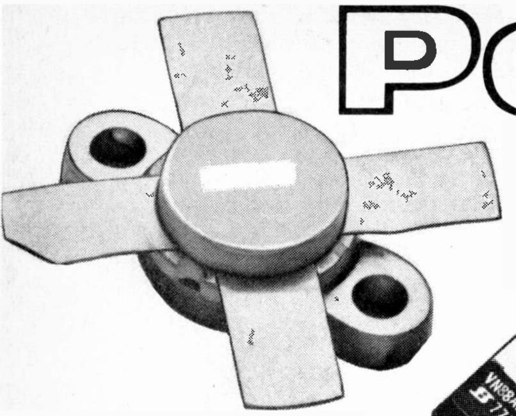
News Briefs

STARLIGHT VISION

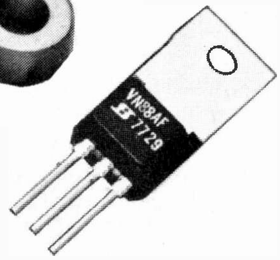
A HIGH sensitivity proximity image intensifier now available from Mullard weighs less than 100 grams, and measures only 30mm in length and 43mm diameter. It is therefore particularly suitable for use in night-vision goggles and other applications where low weight and small size are of prime importance. The intensifier, type XX1410, operates from a level of illumination below starlight (10^{-4}lux), has a luminance gain of between 7500 and 15000 and incorporates automatic gain control which maintains a constant level of 3cd/m^2 on the screen.

The XX1410 comprises a fibre-optic input window on the rear of which is deposited a low noise, high sensitivity, tri-alkali S25 photocathode (300 to 900nm). A micro-channel plate multiplies the electrons from the photocathode which are then focused onto the eye-adapted JEDEC P20 phosphor screen of a fibre-optic image inverter to form a bright image. Resolution is 25 line pairs/mm over the useful photocathode diameter of 18mm.

The intensifier is encapsulated in a white plastic body together with its own integral d.c./d.c. converter incorporating switched-mode power supply techniques. Nominal supply voltage is 2·7V d.c. and the current drain is typically 15mA.



Power FET's



A recent development in semiconductor technology

DAVID SHORTLAND

WHEN bipolar transistors are used in high power circuits, many limitations are imposed on the designer because of inherent problems within the structure of the device. These limitations, which include thermal runaway, secondary breakdown, non-linear distortion and a limited frequency response, restrict the use of the device and have resulted in the need for complex and expensive protection circuits.

With the introduction of the Junction Field Effect Transistor (J-FET) and the Metal Oxide Semiconductor Field Effect Transistor (MOSFET) many of these limitations were overcome but the FETs themselves were limited by their poor power handling capability. Now new fabrication processes are enabling FETs suitable for high power applications to be manufactured and these power FETs will directly challenge the supremacy of the bipolar transistor in many applications.

The new processes have resulted in the manufacture of three basic devices:

The VMOS power FET
The V-JFET
The power MOSFET

The first two devices utilise vertical current flow whilst the third retains the conventional horizontal current flow normally associated with low power field effect transistors.

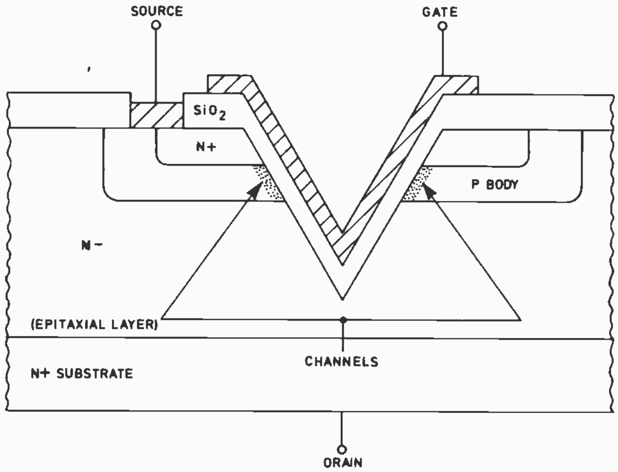


Fig. 1a. Cross section of a typical VMOS device

VMOS POWER FETs

VMOS, which is currently being developed by the Siliconix Corporation, enables a vertical channel MOSFET structure to be fabricated using a diffusion process similar to that used in the manufacture of double diffused bipolar transistors. After diffusion a "V" groove is cut into the silicon to create the vertical current channel which is a characteristic of VMOS FETs. A cross section of a typical device is shown in Fig. 1. (A double diffused bipolar transistor and a conventional MOSFET are also shown for comparison.)

The substrate of the device which is n+ material is used as the drain with the p− body separated from it by an epitaxial layer of n− material. This epitaxial layer increases the drain-source breakdown voltage by absorbing the depletion layer from the drain-body junction. Because the gate overlaps n− rather than n+ material the concentration of impurities is less, the feedback capacitance is reduced and the frequency response of the device increased. After the "V" groove has been etched through the

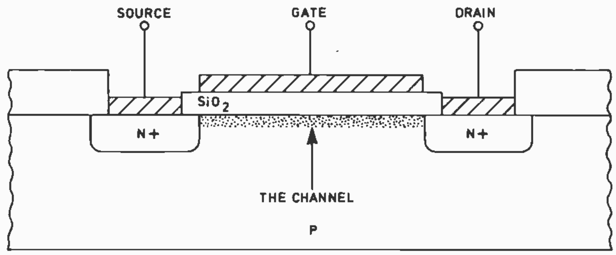


Fig. 1b. Cross section of a conventional MOS device

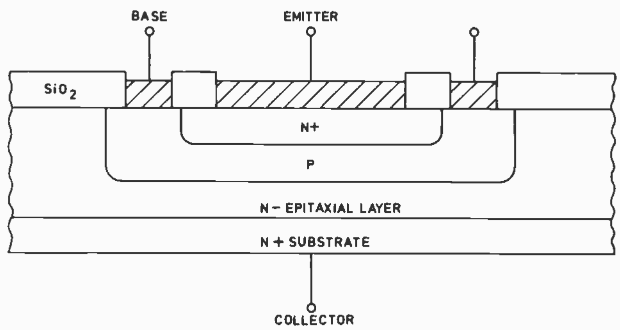


Fig. 1c. Cross section of a typical double diffused bipolar transistor

source and body into the epitaxial layer, oxide is then grown over the surface of the device and aluminium deposited to form the source and gate connections.

ADVANTAGES AND DISADVANTAGES

A comparison between VMOS and bipolar transistors includes many of the trade offs which are associated with their low signal counterparts. There are, however, several important differences which exist at higher power levels. These include:

(1) The very high input impedance of VMOS, which enables it to directly interface with other high impedance devices such as CMOS and opto-isolators. With a typical leakage current of less than 0·01mA a fanout of more than 100 can be obtained from a CMOS device which is far higher than is possible with any bipolar transistor.

(2) The absence of minority carrier storage time. This is the time taken for excess charge carriers stored in the base region of a bipolar transistor to be depleted before the junction can change from the forward to reverse bias state. This delay affects the efficiency of a circuit especially when transistors are used in switching applications, with the result that in some switching circuits faster switching transistors with a low power rating are sometimes preferred to the slower types with a high power rating. As a VMOS power FET is a majority carrier device, with its charge carriers being controlled by electric fields rather than the injection and recombination of minority carriers, the only delay is caused by parasitic elements such as series gate inductance. A typical switching delay for a VMOS device is about 4 nano seconds to turn a 1 amp current on or off which is about 10 to 200 times faster than for a bipolar device.

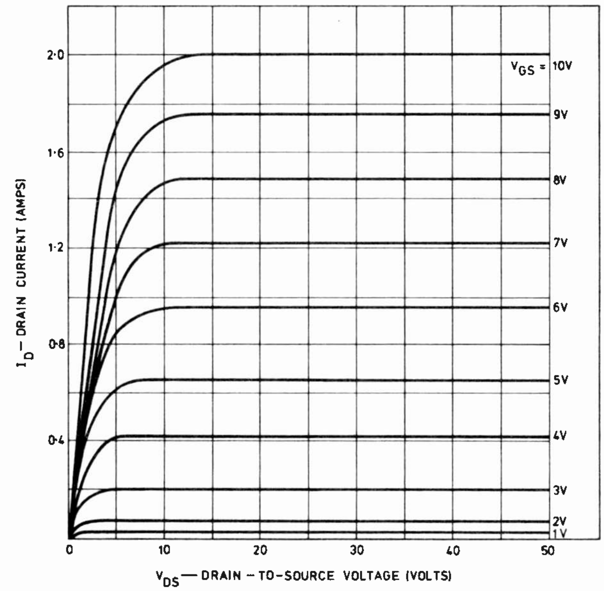


Fig. 2. Output characteristic curves of a VN66AJ VMOS device

(3) The absence of secondary breakdown. In power transistors this is caused by the very narrow base structures that are used to improve their high frequency response. The condition occurs because the distribution of current becomes non-uniform at certain high levels of current and voltage. With the current being focused on very small areas, localised thermal runaway or "hot spots" develop which melt the silicon, causing a short circuit between the collector and emitter. This problem cannot develop in a VMOS device because its temperature coefficient is negative (a bipolar's is positive). Therefore as its temperature increases it draws less current instead of more thus eliminating the device from both thermal runaway and secondary breakdown problems.

(4) The very high gain of these devices enables them to directly replace Darlington pairs with improved reliability.

The two major disadvantages of VMOS are:

(1) With VMOS technology still being relatively new there is no "p" channel device presently available for complementary circuits although one is planned for the near future. It is however possible to overcome this problem by using "n" channel devices in a quasi-complementary configuration which does not appear to impose many of the problems associated with similar bipolar designs.

(2) The saturation voltage of a VMOS device (up to 3V at 10A) is higher than for a comparable bipolar device (2V or less). This affects the efficiency of an amplifier using VMOS and as a result slightly higher power supply voltages must be used for a given power output or with the saturation region being resistive, two devices can be connected in parallel which halves saturation voltage of a single device. However, as the technology improves the saturation voltage should be substantially reduced.

There are also several advantages offered by VMOS over conventional MOS:

(1) The current density of a VMOS channel—which is determined by its width/length ratio—can be increased in a VMOS device by making the length shorter. This is because the channel length is determined by diffusion depths which can be more precisely controlled than the photolithographic techniques used to define the source-drain spacings of the horizontal MOSFET. The minimum channel length obtained in VMOS is 1·5μm while a conventional MOSFET is limited to about 5μm.

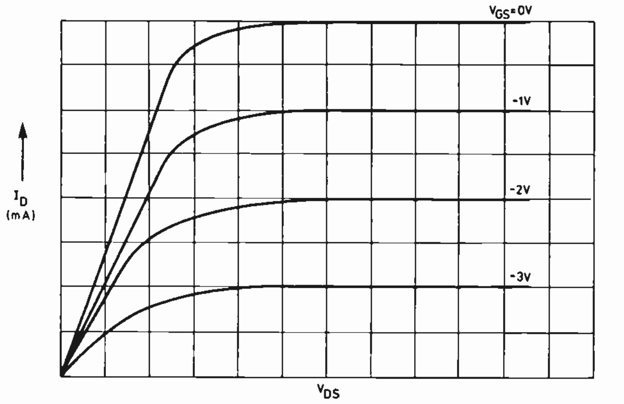


Fig. 3. Output characteristic curves of a conventional MOSFET device

(2) Because its characteristic "V" groove creates two drain channels (one on each face of the "V" groove) the current density of a VMOS device is inherently doubled.

(3) With the substrate of the device being used as the drain there is no need for drain metallisation runs on the surface of the chip. This allows the size of the chip to be further reduced and also keeps the saturation resistance low.

(4) In conventional MOS the amount by which the gate overlaps the source and drain must be large to allow for the tolerances in the photolithographic mask. This overlap increases the channel capacitance and limits the frequency response of the device, whereas the overlap in VMOS can be controlled more precisely by the diffusion techniques used.

CHARACTERISTIC CURVES

The output characteristic curves of a VN66AJ are shown in Fig. 2. If these curves are compared to those of a conventional MOSFET (shown in Fig. 3) the main difference is that the drain current is in amps rather than milliamps. The output curves are very flat because the output conductance is low, therefore any increase in the drain to source voltage, i.e. variations in the power supply voltage, will have little effect on the drain current above 1.0 volts due to the buffering effect of the epitaxial layer, allowing the current flow to be almost entirely controlled by the gate voltage.

HEAT DISSIPATION

Although VMOS has a negative temperature coefficient which inherently reduces the current flowing in the device as its

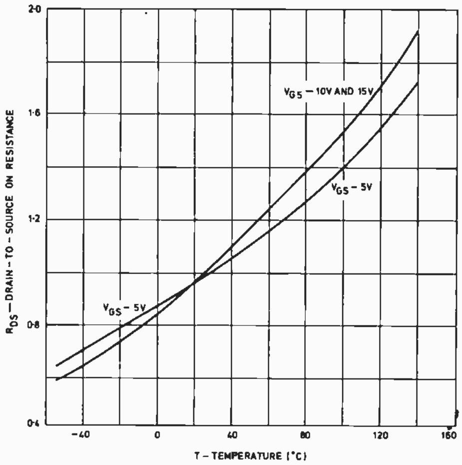


Fig. 4. Graph showing drain-source resistance against temperature (Siliconix)

temperature increases, it is not totally immune from thermal problems. From the graph in Fig. 4, which shows how the drain-source resistance (Rds) is affected by increases in temperature, it can be seen that as the temperature of the device rises its "on" resistance increases causing the current through the device to decrease. However, this rise in resistance causes an increase in the gate-source voltage which will increase the temperature of the device. If no action is taken to dissipate this increase in temperature the resistance of the device would not stabilise until after the safe operating temperature of the junction has been exceeded. So although the device is free from both thermal runaway and secondary breakdown problems it can still be permanently damaged by operating temperatures unless it is mounted on a suitably sized heatsink.

SERIES AND PARALLEL CIRCUITS

The negative temperature coefficient of VMOS enables several devices to be connected in parallel to increase the current handling capacity without the need for either power wasting ballast resistors or matching networks. If one of the devices shown in the parallel arrangement of Fig. 5 starts to draw more current, its temperature increases causing the current flow to be reduced and equalised throughout the devices. When two or more VFETs are connected in parallel their total "on" resistance is lowered. This effect results in low insertion losses when VMOS is used to switch low impedance systems. If parallel devices are used in the output stage of an amplifier the lower resistance enables the same amplification to be achieved with less current being drawn from the driver stage, whereas parallel bipolar devices require current to be supplied to both bases with the result that the driver must be uprated to handle this increase in current.

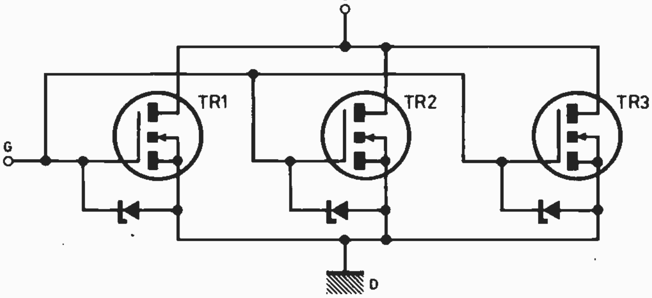


Fig. 5. Method of correcting VMOS devices in parallel (Siliconix)

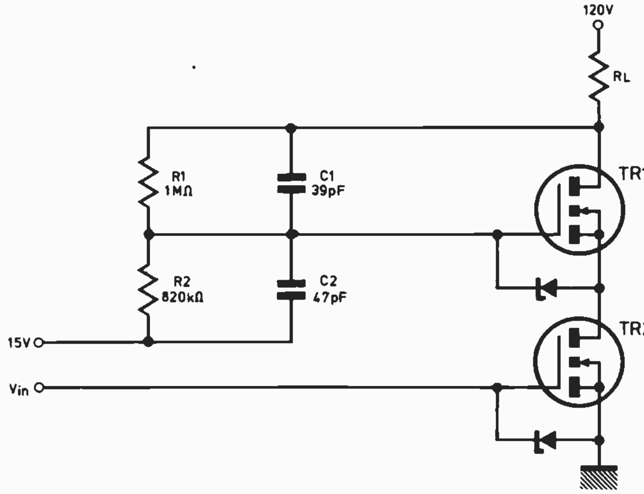


Fig. 6. Method of correcting VMOS devices in series (Siliconix)

When two or more devices are connected in series, as shown in Fig. 6, the breakdown voltage is increased. The resistors R1 and R2 have very high values because the gate drive current to TR1 is very small. To ensure a fast switching time the gate is dynamically balanced by the capacitance divider formed by C1 and C2. If the values of the resistors and capacitors are chosen correctly any number of VFETs can be connected in this way.

VMOS DEVICES

The complete range of VMOS devices available from Siliconix is shown in Table 1. They are split into three main categories: general purpose, RF and power peripheral drivers.

General Purpose N-Channel Enhancement Mode VMOS FETs

Type	Package	Power Dissipation Tc = 25° C (W)	ID (Max) (A)	VDSS (Min) ID = 10 μA (V)	VDS(ON)/ID VGS = 10 V (V/A)	VGS (th) ID = 1·0mA (V) (Min)	(Max)	tON (nsec)	tOFF (nsec)
2N6656	TO-3	25	2.0	35	1.8/1.0	0.8	2.0	10.0	10.0
2N6657	TO-3	25	2.0	60	3.0/1.0	0.8	2.0	10.0	10.0
2N6658	TO-3	25	2.0	90	4.0/1.0	0.8	2.0	10.0	10.0
2N6659	TO-39	6.25	2.0	35	1.8/1.0	0.8	2.0	10.0	10.0
2N6660	TO-39	6.25	2 0	60	3.0/1.0	0.8	2.0	10.0	10.0
2N6661	TO-39	6.25	2.0	90	4.0/1.0	0.8	2.0	10.0	10.0
VN46AF	TO-202	12.5	2.0	40	3.0/1.0	0.8	2.0	10.0	10.0
VN66AF	TO-202	12.5	2.0	60	3.0/1.0	0.8	2.0	10.0	10.0
VN88AF	TO-202	12.5	2.0	80	4.0/1.0	0.8	2.0	10.0	10.0
VN84GA	TO-3	80.0	12.5	80	—	—	—	50.0	50.0

F N-Channel Enhancement Mode VMOS

Type	Package	Power Dissipation Tc = 25°C (W)	ID (Max) (A)	VDSS (Min) ID = 10 μA (V)	VDS(on)/ID VGS = 10 V (V/A)	VGS (th) ID = 1·0 mA (V) (Min)	(Max)	tON (nsec)	tOFF (nsec)
VN33AJ	TO-3	25	2.0	35	1.8/1.0	0.8	2.0	8	8
VN66AJ	TO-3	25	2.0	60	3.0/1.0	0.8	2.0	8	8
VN96AJ	TO-3	25	2.0	90	4.0/1.0	0.8	2.0	8	8
VN33AK	TO-39	6.25	2.0	35	1.8/1.0	0.8	2.0	8	8
VN66AK	TO-39	6.25	2.0	60	3.0/1.0	0.8	2.0	8	8
VN98AK	TO-39	6.25	2.0	90	4.0/1.0	0.8	2.0	8	8
VMP4	380 SOE-F	25	2.0	60	—	—	—	—	—

ower Peripheral Drivers

Type	Output Voltage (V)	Output Current (A)	Propagation Delay—Typical nsec	Input Voltage Logical "0" (V)	Input Voltage Logical "1" 10 = .30 A (V)	Power Dissipation Tc 225° C (W)	Package
S75V01	60	2.0	8.0	0.8	5.0	25	TO-3
S75V11	35	2.0	8.0	0.8	5.0	25	TO-3
S75V12	90	2.0	8.0	0.8	5.0	25	TO-3
S75V02	60	2.0	8.0	0.8	5.0	6.25	TO-39
S75V21	35	2.0	8.0	0.8	5.0	6.25	TO-39
S75V22	90	2.0	8.0	0.8	5.0	6.25	TO-39

TABLE 1

The general purpose range has ten types of VFET available in three different packages according to the power dissipation required. This range was designed primarily for amplifier and switching circuits and can be obtained in the following voltage ratings: the 2N series 35V, 60V and 90V; the VN series 40V, 60V and 80V. All the general purpose VFETs except the VN84GA include a gate to source Zener diode to protect the gate oxide from rupture due to static charge build up.

The VN84GA is a second generation device capable of handling up to 12·5A with a breakdown voltage of 80V. At low frequencies it can deliver up to 80 watts whilst at 30MHz its power output is only reduced to 50 watts.

Of the seven RF types available six are in the VN range and are used in RF power amplifiers, high current analogue and bridge switching circuits. These are available in TO3 and TO39 packages with voltage ratings of 35V, 60V and 90V. The VMP4 device, designed for VHF broad band amplifiers, receiver front ends and power oscillators, is available in the flange mounted, opposing source, strip line 380-SOE-F package.

The third category covers power peripheral drivers designed to switch reactive loads such as solenoids, relays, lamps, displays and alarms. Because VMOS devices do not have secondary breakdown problems they are particularly well suited to handling the high voltages and currents which simultaneously occur in inductive loads.

PRACTICAL CIRCUITS

In order to drive a VMOS device the supply voltage must be applied to the source and drain with the drain being positive with respect to the source. Then because it is an "n" channel enhancement type device the gate voltage must be taken positive with respect to the source and body. The electric field set up by the gate voltage induces an "n" channel on both surfaces of the body facing the gate. This induced channel enables electrons to flow from the negative source through the epitaxial layer and into the drain via the substrate. This current flow is almost entirely controlled by the gate voltage.

The simple audio power amplifier shown in Fig. 7 has an output power of 4W over a frequency range of 100Hz to 15kHz. A

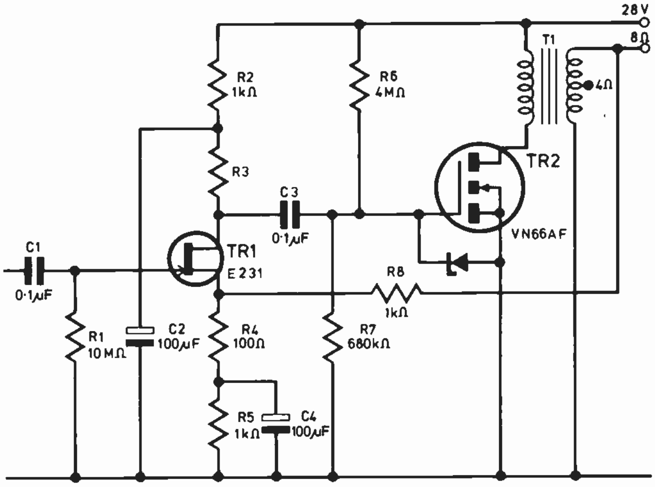


Fig. 7. Circuit diagram of a simple 4W audio power amplifier (Siliconix)

small signal JFET is used for the gate drive of TR2 and the design is greatly simplified by using an output transformer. The negative feedback applied via R8 keeps the overall distortion to 2 per cent at 3W.

The amplifier design shown in Fig. 8 is a basic configuration using the second generation VN84GA device which is capable of handling 12·5A. It will deliver 100W into 4Ω or using 120V VNGs and raising the supply voltages to 55V. 100W into 8Ω.

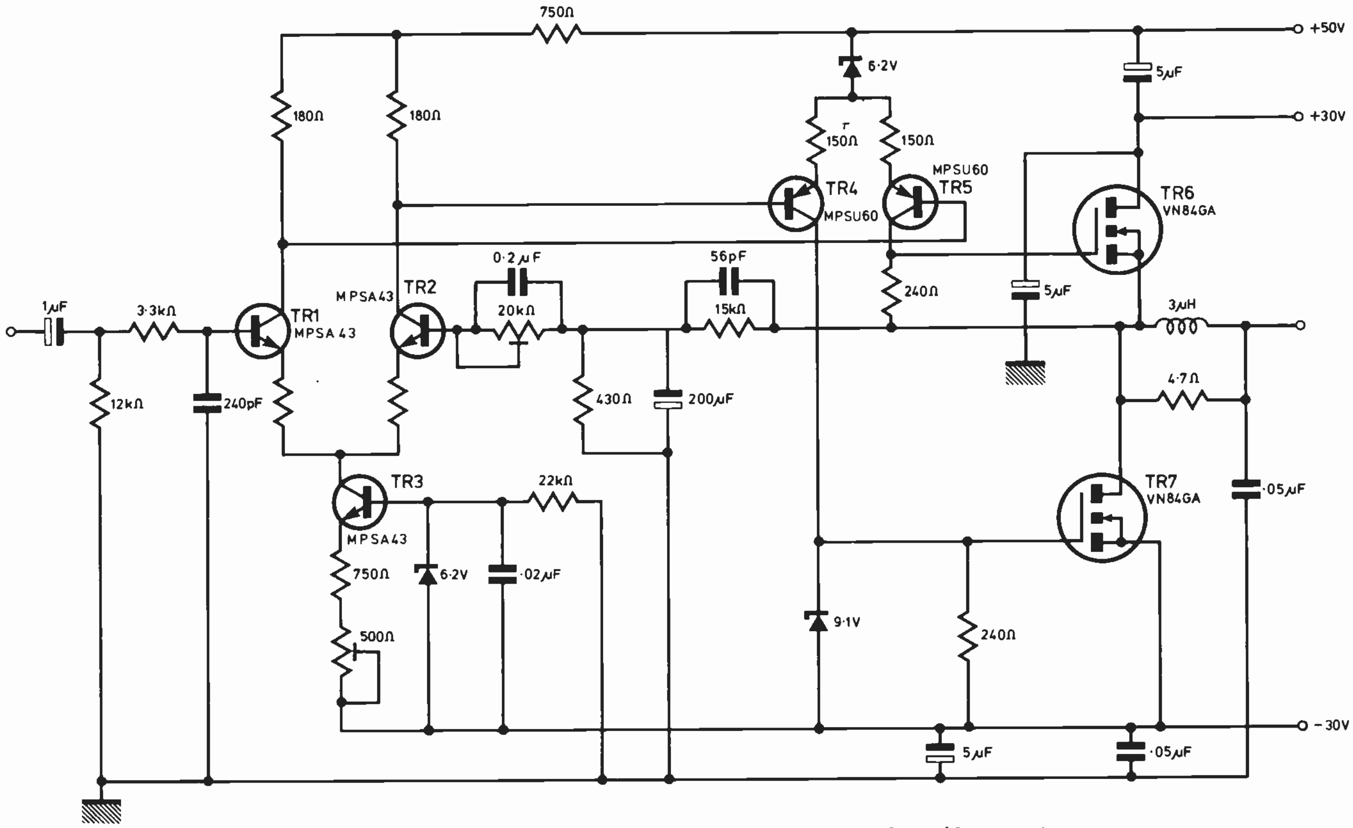


Fig. 8. Basic circuit configuration of a 100W audio amplifier (Siliconix)

THE VERTICAL JUNCTION FET (V-JFET)

The vertical junction FET, the first commercially manufactured power FET, was developed in Japan based on conventional JFET technology. Yamaha were commissioned by the Japan Development Foundation to develop a device using techniques invented by Professor Jun'ichi Nishizawa of the Electronic Telecommunications Laboratory, Tohuku University.

A cross section of a typical device is shown in Fig. 9. The body of the device which is n− material has a p+ type grid mesh diffused into it. This grid mesh structure has the effect of splitting the device into thousands of tiny FETs connected in parallel. Current flows through the channels between the gate grid and into the source. The depth of the depletion region around the gate is controlled by the gate voltage and if the depletion region is increased the current flowing through the device is reduced. Although the operation of a V-JFET is similar to that of a conventional JFET, it has many of the same advantages over the JFET that VMOS has over conventional MOS.

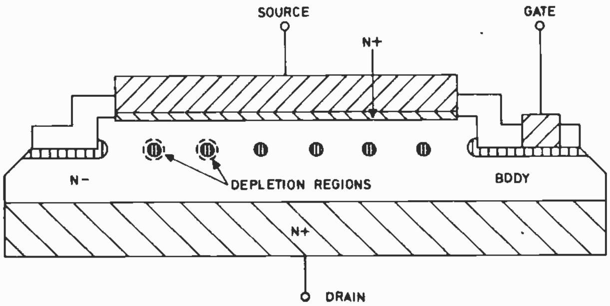


Fig. 9. Cross section of a typical V-JFET device

There are two main differences between the operation of a V-JFET and a VMOS power FET:

(1) The V-JFET is a normally on device with its maximum drain current being delivered when the gate voltage is zero. In order to bias a V-JFET off, a voltage must be applied to its gate. This effect does not cause problems at low power levels but if a V-JFET is to be used in high power applications the gate must be biased off before the supply is switched on, otherwise the drain current will rise rapidly and damage both the V-JFET and associated circuitry. On switch off the power must be removed from the output stage before the driver stage. This requirement results in a very complex power supply arrangement.

(2) Because the input capacitance of a V-JFET is higher than for a comparable VMOS device, its frequency response is lower.

V-JFET amplifiers are currently being manufactured by both Yamaha and Sony. For use in their B2 amplifier Yamaha have developed the 2SK-76 (n channel) and 2SJ-26 (p channel) power FETs which have complementary characteristics. Their respective performance figures are shown in Table 2, with their output characteristic curves shown in Fig. 10. The output power stage of the B2 is shown in Fig. 11. A higher supply voltage is used on the driver stage to ensure the FETs turn on to full conduction,

	2SK-76	2SJ-26
Drain-Gate Breakdown Voltage	200V	−150V
Gate-Source Breakdown Voltage	−40V	40V
Drain Current	10A	−10A
Gate Current	1A	−1A
Drain Dissipation	100W	100W
Max. Junction Temperature	150°C	150°C

TABLE 2

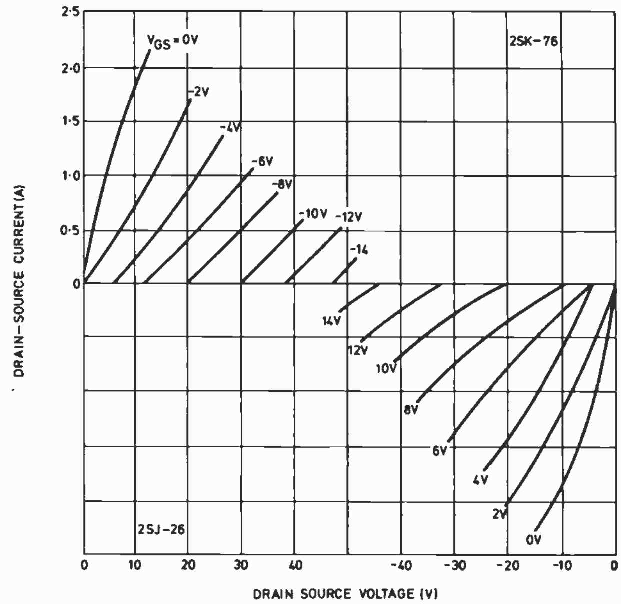


Fig. 10. Output characteristic curves of the 2SK-76 and 2SJ-26 devices

and to reduce the effect of the input capacitance a symmetrical push-pull drive circuit is used. This also reduces the time taken for the gate to source input capacitance to charge or discharge and gives the largest possible high frequency response

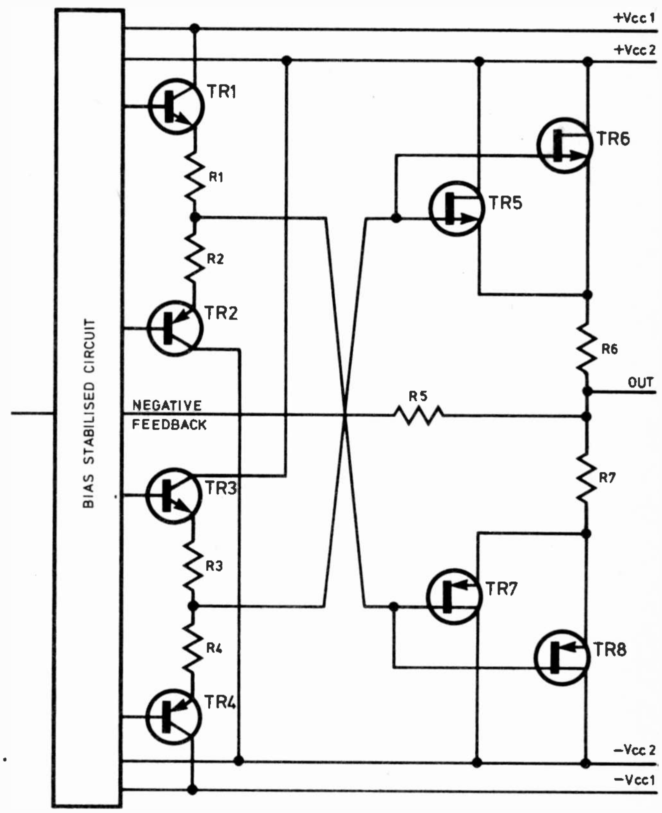


Fig. 11. Output power stage of the Yamaha B2 audio power amplifier

(0–100kHz). To ensure effective heat dissipation the power FETs, which are connected in parallel, are mounted on separate heatsinks by a special process which reduces the thermal resistance to less than half that achieved with conventional mica construction.

THE POWER MOSFET

The power MOSFET developed by Hitachi for use in their range of audio power FET amplifiers is a horizontal current device capable of handling 7 amps at 160 volts. This high current capability is achieved (as it is in all power FETs) by using a wide channel of short length which, in the case of the power MOSFET, is constructed under the gate electrode.

The power MOSFET has the same advantages over bipolar transistors that VMOS and V-JFETs have, but because it has both a high input capacitance and gate resistance, applications for the device are restricted to the audio power range.

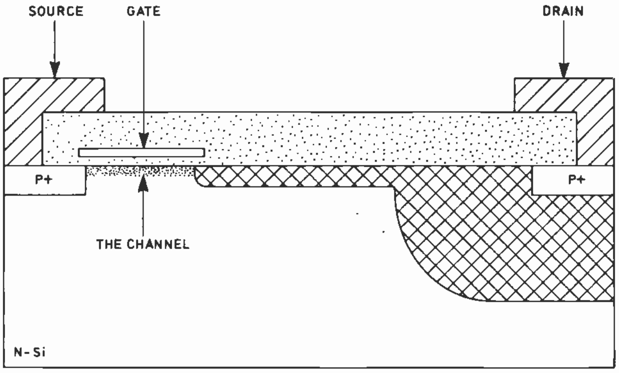


Fig. 12. Cross section of a typical power MOSFET device

A cross section of a typical MOSFET device is shown in Fig. 12. The high drain to source breakdown voltage is obtained by using an ion implanted offset gate structure. This technique, which is also used in small signal MOSFETs, reduces the electric field around the gate electrode and also helps prevent an excessive gate charge damaging the device.

	2SK135	2SJ50
Drain-Gate Breakdown Voltage	160V	−160V
Gate-Source Breakdown Voltage	14V	14V
Drain Current	7A	−7A
Gate Current	0·63A	−0·63A
Drain Dissipation	100W	100W
Max. Junction Temperature	150°C	150°C

TABLE 3

The performance figures of two complementary devices are shown in Table 3, and the graph in Fig. 13 compares the respective input powers required to drive bipolar and MOSFET devices, to achieve a 100W power output over a frequency range of 100Hz to 1MHz. With the MOSFET requiring a much smaller input power the driving circuit is greatly simplified.

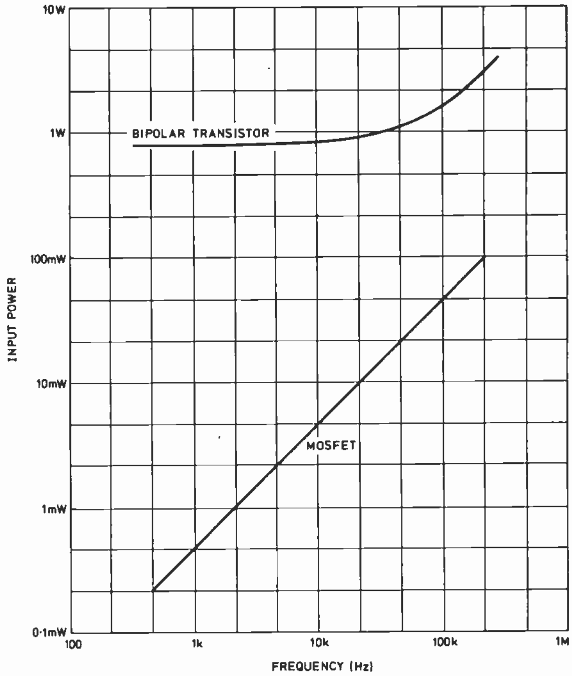


Fig. 13. Graph of the input power required to obtain 100W using MOSFET and bipolar devices (Hitachi)

The circuit diagram in Fig. 14 shows the basic design of a 100W MOSFET amplifier with parallel complementary devices in its output stage. The first two stages of the amplifier use differential pair configurations with an active collector load in the second stage to provide the push-pull action. The coil in the output line reduces the residual distortion which is induced by magnetic coupling between the output line and power supply wiring, from 0·01 per cent to 0·003 per cent. The total harmonic distortion at 100W is about 0·01 per cent, which is about ten times better than ordinary bipolar amplifiers. ★

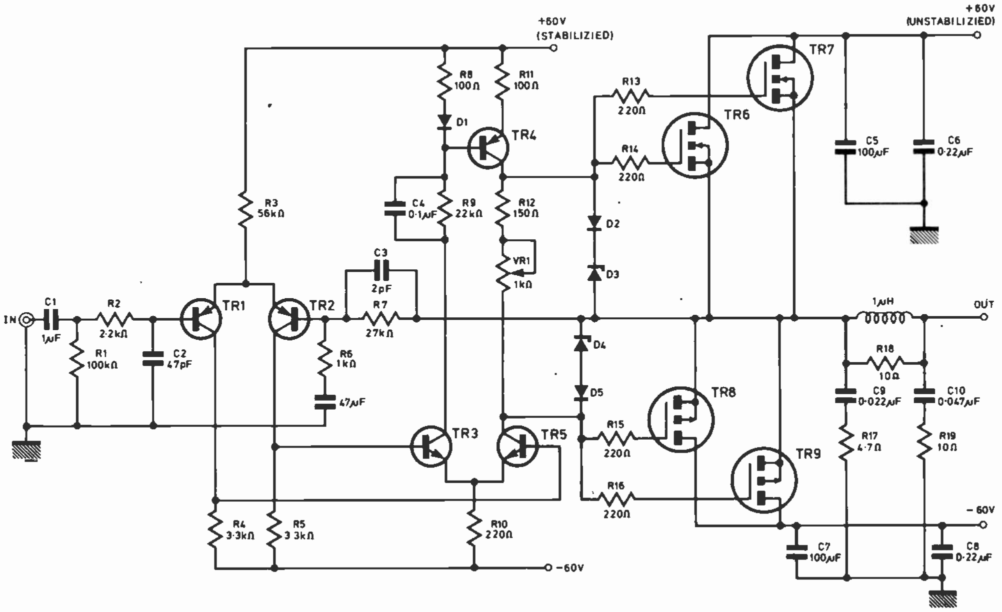
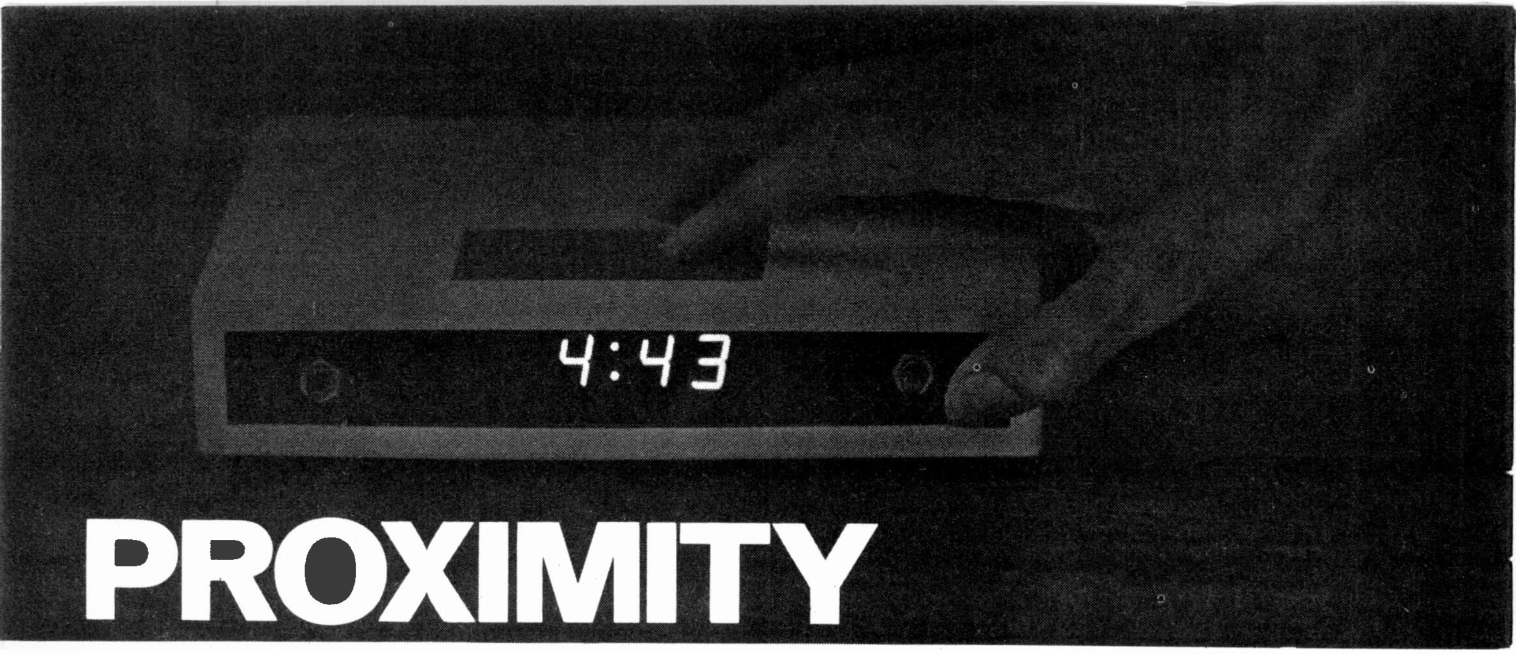


Fig. 14. Basic circuit configuration of a 100W MOSFET amplifier (Hitachi)



PROXIMITY SWITCH

A.K. LANGFORD

THE touch switch described here evolved from a need for a switching method that would activate the display of a digital clock for a short viewing period, the display being normally off.

To do this without modifying the fascia of the clock suggested the use of a proximity type sensing plate mounted inside the plastic top cover, so that touching the top cover would operate the time display. The system devised was found to be sensitive, and could be suitable for many similar applications.

CIRCUIT OPERATION

No originality can be claimed for this type of circuit, although systems of this type usually operate directly from the 240V mains. However, it was found that by incorporating a gain adjustment, adequate sensitivity was obtained from low voltages in the range 12–25V a.c. The principle of operation of the switch can be explained by considering the input to gate 1. This gate is biased into conduction by the 1MΩ resistor, and the voltage at the input settles to about midway between V_{DD} and V_{SS}; but by virtue of the single wave rectification of D4 from the secondary winding of the power transformer, the amplifier gate input is swept from approximately $V_{DD}/2$ to peak a.c. volts—$V_{DD}/2$ at 50Hz. Consequently when the plate is touched the input is referenced to zero volts by hand capacitance, and an a.c. voltage appears at the input to gate 1. Negative a.c. feedback via R1 and C1 reduces the sensitivity of the amplifier to stray high

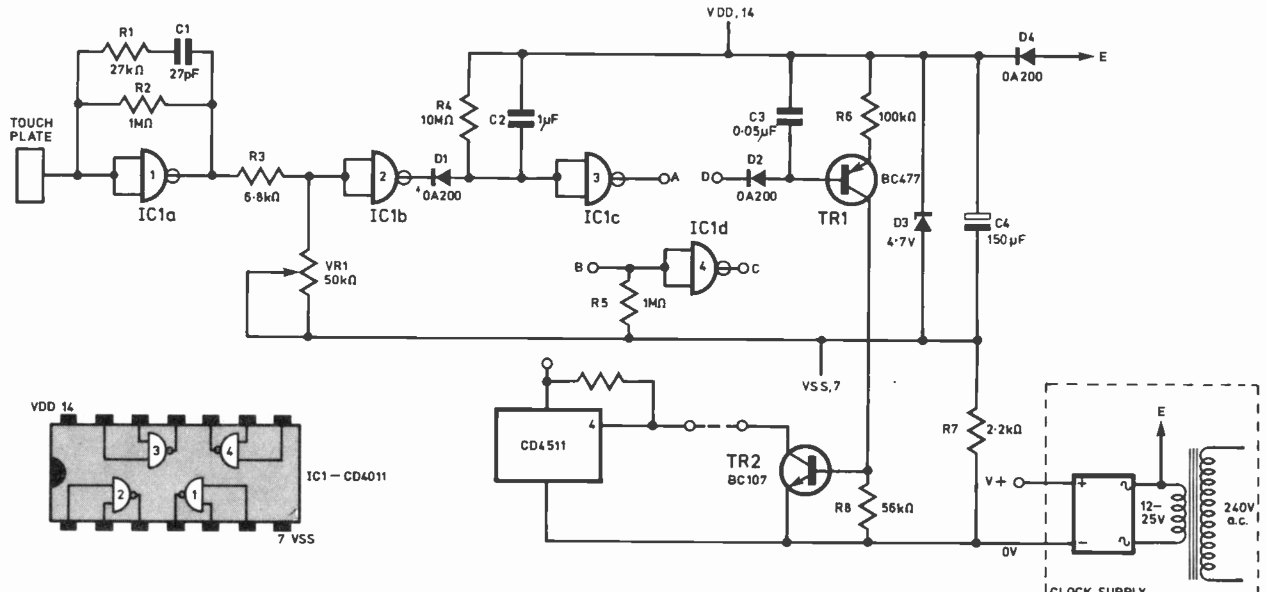


Fig. 1. Proximity switch circuit

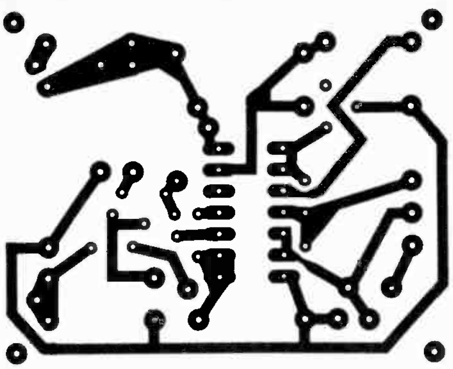
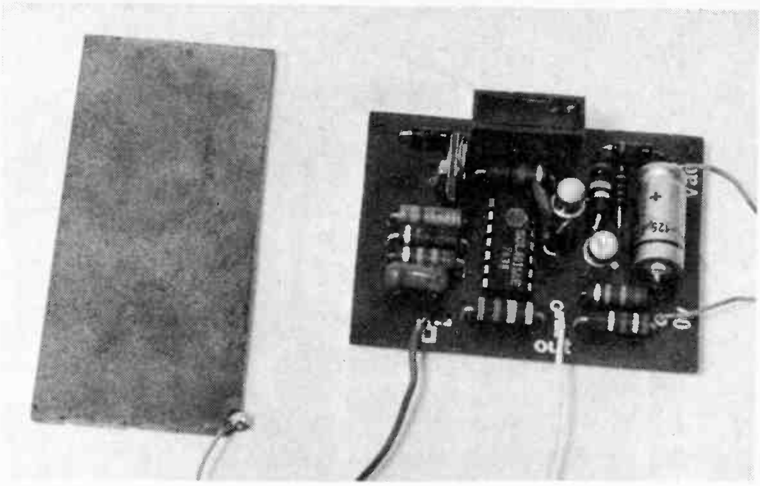


Fig. 2. P.c.b. layout



frequency pickup by the plate.

The amplified 50Hz signal is fed to the second gate which has its input switching threshold set by VR1, serving as a sensitivity control. The setting of this level is stabilised by the output voltage of gate 1 being used as the reference. By the action of R2, this is the characteristic switching voltage for the i.c.

Gate 2 shapes the signal and this charges C2 through D1, thus switching gate 3. The R4/C2 time constant determines the period for which the display is on. With the values shown this is about five seconds.

The output from gate 3 is not suitable for driving logic circuitry working from the zero volt supply. Therefore TR1, TR2 are used as level shifters, with TR1 acting as an inverting current switch driving TR2.

This was used to operate the blanking input to a CD4511 decoder/latch/driver. This input was held high to inhibit the display, with operation of the proximity switch causing TR2 to turn on and so allow the time to be seen.

For other applications it may be that reverse operation of TR2 is required (i.e. TR2 normally on, and is turned off by touching) and for this purpose gate 4 is available to invert the output from gate 3. If this is the case the connection A–D is removed and connections A–B, C–D substituted.

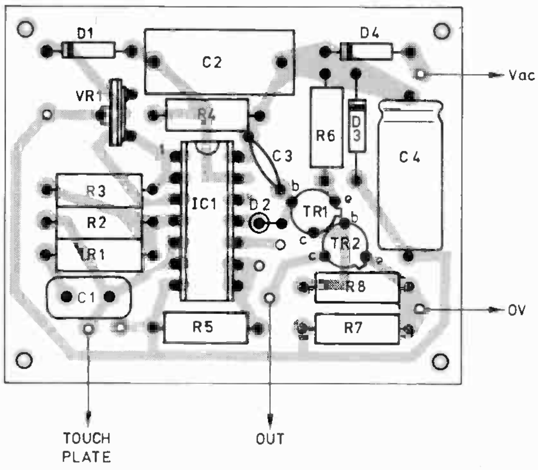


Fig. 3. Component layout

COMPONENTS . . .

Resistors
R1 27kΩ
R2 1MΩ
R3 6·8kΩ
R4 10MΩ
R5 1MΩ
R6 100k
R7 2·2kΩ
R8 56kΩ
All ½W carbon 10%

Potentiometer
VR1 50kΩ preset

Capacitors
C1 27pF
C2 1μF
C3 0·05μF
C4 150μF elect. 40V

Semiconductors
TR1 BC477
TR2 BC107
IC1 CD4011
D1–D2 OA200 (2 off)
D3 4·7V Zener 400mW (BZY88C)
D4 OA200

CONSTRUCTION

A printed circuit layout is shown in Fig. 2. Extra holes are not shown for optional mounting of a horizontal preset resistor for VR1. Here the choice will depend on the mounted position of the board so that there is easy access to adjust for sensitivity.

Further holes are present to allow for the addition of the inverting gate 4, if this is required. Alternatively the printed circuit could be modified to include this gate.

The sensing plate may be a piece of aluminium foil or copper laminate glued inside the plastic or wooden case of the switched equipment, and is connected by a short length of wire (less than 12in) to the component board.

ADJUSTMENT

The size of the sensing plate is not critical and a 5cm square worked well on both 12 and 25V a.c.

The sensitivity control should be finally adjusted when the plate and switch board are mounted in their permanent positions. If the zero volt line is "mains earthed" then there will be a change in sensitivity, but this is easily compensated for by adjustment of VR1. The sensitivity can be adjusted to trip at a distance of several inches, or by lightly touching the case—depending on individual preference. ★

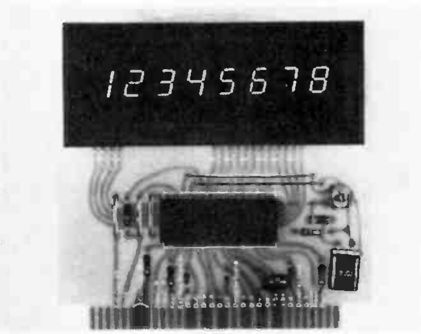
Market Place

Items mentioned are usually available from electronic equipment and component retailers. However, where a full address is given, general enquiries may be made direct to the firm concerned. All quoted prices are correct at time of going to press.

by Alan Turpin and David Shortland

8-DIGIT COUNTER-TIMER

The 8-digit counter/timer introduced by Lascar Electronics is claimed to perform all the major counting and timing functions. The module can measure frequency from 0–10MHz, period from 0·5 micro-seconds to 10 seconds, frequency ratio between two inputs, time intervals in increments of 0·1 micro-seconds, and can also function as a normal 8-digit totaliser. Mode selection is by a single external switch.



Four different ranges can be selected which determine the time or the number of cycles that the displayed data is accumulated over.

Fitted with 0·4in, high efficiency orange l.e.d.s, the modules operate from +5V d.c. Controls include store, hold and reset, while various outputs enable all functions to be monitored externally. The module is fitted with a 10MHz quartz crystal to give a highly accurate timebase, with a temperature stability of ±10ppm over a temp range −20°C to +70°C. Price is £54·95 plus VAT.

For further information contact **Lascar Electronics Limited, P.O. Box 12, Module House, Billericay, Essex.**

ALL THAT GLITTERS

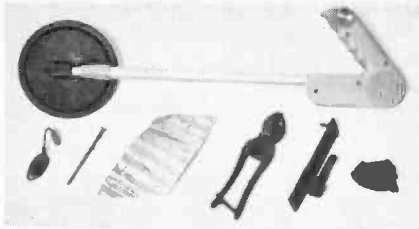
Autumn is here and the beauties on the beach are covering up, so take a last look at this delectable detector by courtesy of Dixons publicity department.

Dixons offer four versions; one for children and beginners at £29·95, two sophisticated models at £39·95 and £49·95, and an enthusiasts machine with meter, at £69·95, which Dixons claim can detect a single coin at one foot, or larger objects at four feet.

ANY OLD IRON/ALLOY/CARBON

Rumour has it that there is five hundred million pounds of lost or buried treasure in the country.

Market Place has been trying out an induction balance detector over lawns, paths, flower beds, etc. We didn't find any valuables



but did dig up one of Uri Geller's old spoons, a six inch nail, aluminium lawn edging, a pair of rusted secateurs, a large garage door hinge pin, and a piece of coke.

At only £13, inc. p&p, you might well uncover the cost of your investment.

Readers P.C.B. Services Limited, P.O. Box 11, Worksop, Notts.

HANDY DETECTOR

Pocket size detectors which can trace wiring or water pipes and show the presence of iron reinforcing are available from sole U.K. distributors HDP Electronics Ltd.

There are three models: a metal detector (403), a voltage indicator (405), and a combination unit (407).

The detectors run off one 9V battery and indication is by a signal lamp.

Volltronic is the name of the range which is manufactured in West Germany.

403 and 405 are £13·19 and the 407 is £28·64, including p&p and VAT. Trade enquiries invited.

HPD Electronics Limited, 34/38 Dock Street, Leeds LS10 1JF. Telephone 450222.

6800 PROGRAMS

JCN Electronics have four programs for 6800 based microprocessors. They have been written to run with MIKBUS firmware and are available as photocopy listings or all together on a Cuts Format Cassette at £2 inc.

Lunar Landing	75p
Mastermind	30p
Matchsticks	30p
Print Formatter	20p

Send large s.a.e. to **JCN Electronics, Hodsock Park, Langold, Worksop, Notts. S81 0TF. Telephone Worksop 730282.**

Note. October Market Place, Wonderboards. Orders should include 30p for p&p.

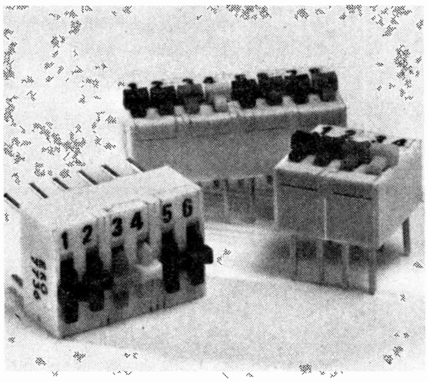
ON BOARD SWITCHING

If you are prone to housing small projects in tobacco tins these dual in line switches may help the aesthetics.

Fit them on the track side of 0·1 inch matrix board, then stand the board off the lid.

As well as smarten up a front panel they can be used, on board, as function/mode selectors, test switching, range changing, etc.

Contact ratings: 1μV to 100V a.c., 1μA to 1A—at up to 10VA.



They are colour coded as per the resistor colour code and are available in banks of 4, 6 and 8 at 84p, £1·24 and £1·52 each, including p & p but add VAT at eight per cent.

Verospeed, Barton Park Industrial Estate, Eastleigh, Hants SO5 5RR. Telephone: 0703 618525/6.

"I AM YOUR AUTOMATIC MUSIC CENTRE"

Sharp's SG500 has front located controls so that there is no need to lift the dust cover to operate. It has a LW/MW/SW/FM/FM MPX stereo tuner amplifier, a two motor drive cassette deck and a direct drive record player.

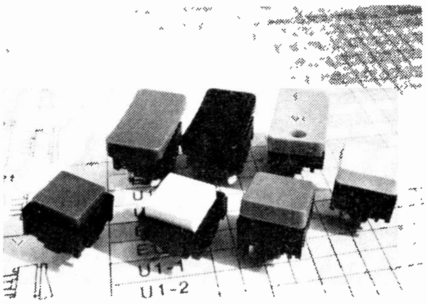
The amplifier has a 45W/channel (r.m.s.) output with 0·5 per cent THD at 4Ω and sensor touch tuning on FM with up to seven preset stations.

Sharp's Auto Programme Search System is included in the cassette section, which locates and plays back automatically the track required, as well as Dolby noise reduction and tape selectors and changeover facilities.

The sensor touch player has a 31cm turntable and a VM type cartridge. An auto disc detection system determines whether there is a record on the turntable and also its size, so that it automatically plays at the right speed and leads the arm to the correct position. Price is £644·95. Remote control accessory, £84·95.

MINIATURE PUSH BUTTON SWITCHES

A range of miniature snap-action push button switches, designed for 0·1in printed circuit board mounting is now available from Impectron Ltd.



They have a positive snap or rocker action. Single pole press-to-break and changeover configurations are all available as standard, and an l.e.d. indicator can be incorporated to provide visual warning of function selected.

The basic body size of all types is 12·4 × 12·4 × 7·5mm. The selected push button or rocker action will add a further 5mm to body depth.

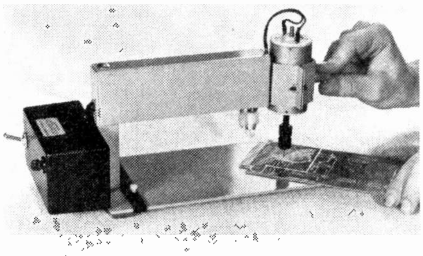
Switches may also be mounted in line or block format to form key sets with mechanical interlocking and release mechanisms.

Despite their small size the switches are capable of handling up to 25mA at 50V d.c. Contact resistance is less than 20mΩ and operational life is in the excess of 10^5 operations at full load. Operating temperature range is −25° to +75°C.

Impectron Limited, Impectron House, 23–31 King Street, London W3 9LH. Telephone 01-992 5388.

LARGE THROAT P.C.B. DRILL

A p.c.b. drill stand, specially designed for drilling small quantities of boards, prototypes, one-off production specials, missed production holes and modifications, is now available from Technomark, Maidstone, Kent.



The motor body is supported on a cantilever spring system which switches the motor on when depressed. If the motor body is adjusted so that the motor switches on with the drill just touching the board surface, drill wander can be eliminated to enable accurate drilling of plain copper surfaces.

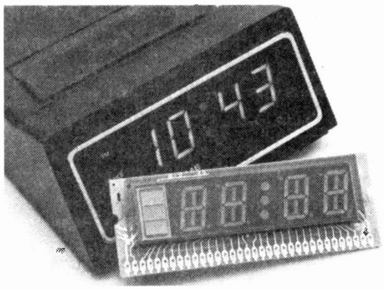
It has an integral 12V d.c. power supply, fused and switched, low voltage lighting and a reliable high speed motor. Throat depth is 168mm.

Each unit comes complete with chuck, collets, light and x-y locating jigs. Price is £61 plus VAT.

Technomark, Allnut Mill, Church Road, Lower Tovil, Maidstone, Kent.

CLOCK DISPLAY

A four-digit, seven-segment light-emitting-diode display designed for digital-clock applications has been introduced by Micro Electronics Ltd. The MCD 461 Series has a red numeric display which uses 0·6in (15mm) high gallium arsenide phosphide light-emitting diodes. Both 12 and 24 hour versions are available.



The display is designed to offer a wide viewing angle, and can be mounted with a 0·1 in-pitch edge connector or connection pins.

The static forward voltage per segment is 1·7V and the maximum ratings at 25°C are: reverse voltage 5V; peak forward current per segment 200mA; continuous forward current per segment 20mA; and power dissipation 300mW. Operating temperature range is −20°C to +75°C.

The price of the unit is £54·95 plus VAT and for further information contact **Micro Electronics Limited, York House, Empire Way, Wembley, Middlesex.**

Market Place

REVIEW OF INTRUDER ALARMS AND SECURITY SYSTEMS

Beat the burglar if you can. He'll be straight in through everyday doors and windows. Mortice locks will make him think twice, but until we have shuttered windows like our EEC neighbours then a piece of treacled paper is all he needs for a silent entry—unless you detect him and sound the alarm. Vandalism of private property is on the increase too. Big dogs are expensive to feed so how about this doppler fido.

ELECTRONIC WATCHDOG

The BD 100 is a security device which combines the function of electronic clock with an intruder alarm. Unobtrusively built into a digital clock, the burglar alarm is brought into readiness by removal of an electronic 'key'. This sets up transmission of an inaudible high-frequency signal which establishes a sensitive field completely filling the room in which the alarm is set. Disturbance of the field by an intruder or any movement in the room is registered by the unit, setting off a high intensity audible alarm similar to that of a motor car horn. The alarm signal may be silenced only by the insertion of a uniquely-matched electronic key.

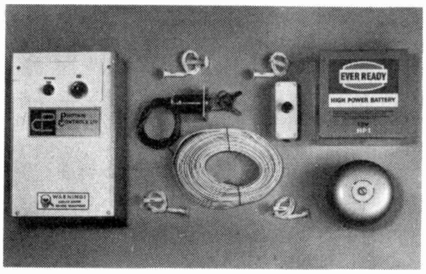
The device allows a 20-second delay between entry into the room and insertion of the key without setting off the alarm. A similar delay allows removal of the key on departure.

Unlike many burglar alarm systems designed for the home, the BD 100 requires no special wiring. The unit simply plugs into a standard 13-amp mains socket. If there is a power cut, or if the plug is removed from the socket, internal batteries take over the power supply. The batteries are recharged when mains power is resumed.

The price of the BD 100 is £62·00 plus VAT and further information can be obtained from **Fotherby, Willis Electronics Ltd, Gladstone Terrace, Stanningley, Leeds.**

ALARM KIT

The "Remick" burglar alarm kit, complete with instructions and wiring diagram enables a handyman to install the system to suit his own requirements. The kit—which includes a control unit, four sets of magnetic switches (for doors or windows), pressure pad (for front door mat), mini siren and cable—can be extended to suit any size premises by fitting additional sensors and alarms which can be obtained separately.

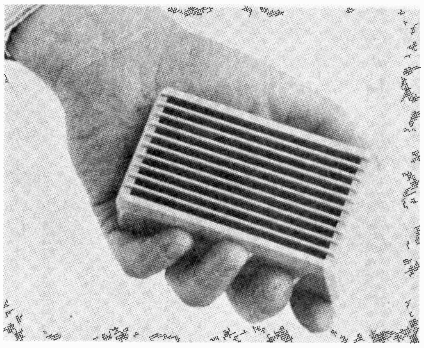


The system operates from mains supply with the loop circuits and alarm bell at 12V d.c. The double loop circuit is provided so that any attempt to cut or short the leads will result in the alarm operating. Whenever the alarm rings it continues until it is manually switched off by the keyholder. A 12V battery is supplied to maintain the operation of the system during a mains failure.

The price of the kit is £56 plus VAT. For further information contact **Photain Controls, Unit 18, Hangar No. 3, The Aerodrome, Ford, Sussex.**

MINI-MICRO

The ML-1500, which is also available from Photain Controls, is a miniature doppler microwave detector which has a linear range of 15 metres with a wide 140 degrees horizontal beam pattern. A special protection circuit prevents any interference from fluorescent lights affecting the circuit.



The unit should be mounted 2–3 metres above floor level and as microwaves can penetrate certain building materials such as glass and thin partitions, the unit should be pointed away from windows wherever possible. Price £80 plus VAT.

TOUCHLESS CONTROL

The door control system marketed by Inertial Systems is virtually vandalproof because the sensor and control equipment are concealed in the wall near the door and operated by presenting a "command key", rather like a credit card, a few inches away from the sensor. Once the validity of the card is established the control unit operates the electronic lock on the door.

The command keys are precision tuned passive circuits which when energised by the sensor return a specific frequency pattern. The keys can be programmed with individual private codes to enable the system to grant or deny individual access according to the time and day. If required, the system can maintain a printed record of individual entries and exits by the time and date.

For further information contact **Inertial Systems Limited, Elvaco House, High Street, Egham, Surrey.**

SELF TEST SYSTEM

The Mk III Harley alarm system has a self test facility which checks the unit when it is switched on. The complete system includes a 12V battery, key bypass switch, battery level indicator, a "bell test" circuit, five magnetic contacts for doors or windows and two anti-

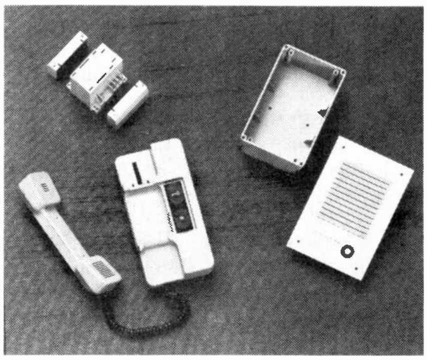
tamper micro switches, one of which will operate the alarm whether or not the unit is on or off if any attempt is made to interfere with the control unit.

For further information contact **Harley Security Systems, 94 Normandy Street, Alton, Hants.**

DOOR ANSWERING SYSTEM

The Siedle 2000 door communication system available from Baron Security is a D.I.Y. unit suitable for use in individual homes.

The system consists of a door loudspeaker/microphone, home telephone, bell transformer and door release mechanism. The front plate of the door loudspeaker unit is flush mounted and includes a call button in the name plate.



The entrance door latch can be released by pressing the button mounted on the telephone.

The recommended price of the Siedle 2000 is £76·15 plus VAT and it is available from **Baron Security, 52 Monmouth Street, London.**

Car Devices

Here is a collection of simple projects for use in vehicles with 12V systems

AUTO-LIGHT

P. Scargill

THE circuit to be described will be especially useful to those motorists who have been in the unfortunate situation of being left with a flat battery through leaving their lights on all day, or worse still, those who have been stopped at night by the police for having no lights on, as it will automatically switch both side and dipped lights on when the ambient light level warrants such action.

It is left unaffected by short tunnels, street lights, etc. so that before long the user will wonder why all cars don't have such a device.

Construction should present no problems, and as an added bonus, the front panel has a couple of indicators so that you can amaze non-technical friends with the wonders of modern science. These also function as lighting status indicators so that if you should ever have cause to use the car lighting on manual, they will act as a handy switch off reminder. By the use of moderately rated components, it is most likely that the life of the unit will outlast that of the vehicle.

CIRCUIT

The operation of the circuit is shown in block form in Fig. 1. The ambient light level present at any one time is sensed by a photocell and the output of this is compared to a fixed reference. When the light level falls, a timing circuit is started up. The instantaneous light level is hence averaged out over a period of time.

Fig. 1. Block diagram

The output from this section is again compared to a fixed reference and when a certain level is exceeded, the resulting output is fed to a relay which controls the car lighting.

Fig. 2 shows the basic diagram of a Schmitt of the type used in this circuit.

R_a and R_b hold the op amp + input at a level of around half the supply voltage.

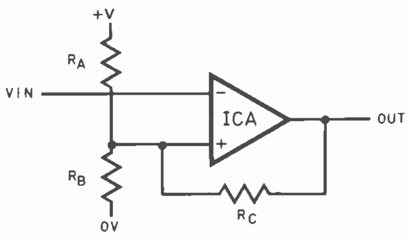


Fig. 2. Schmitt circuit

Hence if V_{in} exceeds +V/2, the output will swing low. R_c introduces positive feedback to the circuit which as well as ensuring sharp switching of the output, introduces a certain amount of hysteresis which is determined by the combination of the relative values of R_a, R_b and R_c.

The format used in Fig. 1 ensures that there is no loading of the input by the presence of R_c.

In referring to Fig. 3—R1, VR1, and R11 form a resistive voltage divider across the supply rails, the voltage at the junction of R11 and VR1 varying in accordance with changes in ambient light level.

This voltage is fed via R2 to IC1, a Schmitt as described previously, so that the output of IC1 changes state at two different light levels, an upper and lower level brought about by the hysteresis produced by the presence of R5.

So we have a simple light sensor, but one incapable of distinguishing between light-up time and, say, a short dark tunnel.

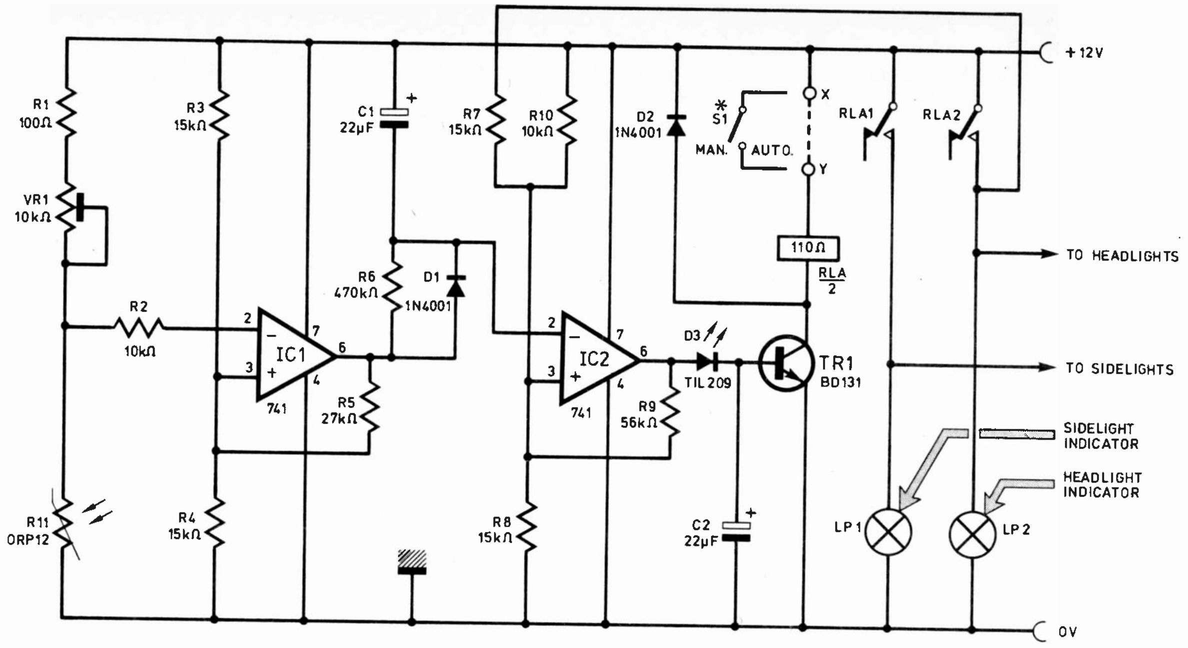
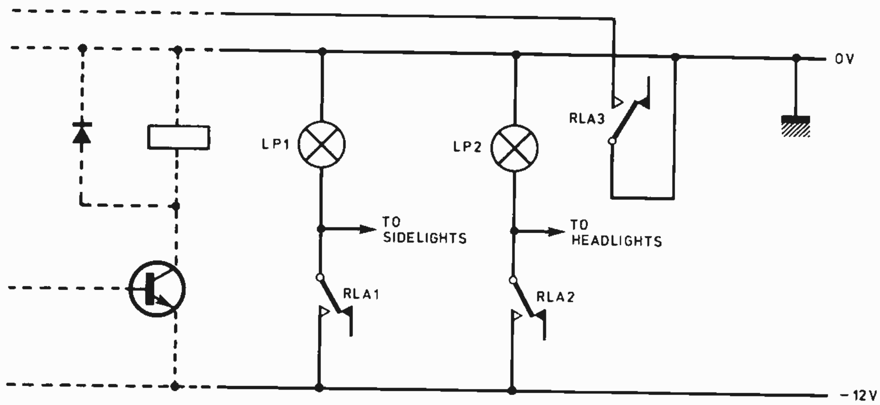


Fig. 3. Circuit of Auto-Light

Fig. 4 (below). Modification for positive earth



The following stages are therefore essential for correct operation of the circuit for the application with which we are concerned.

Components R6 and C1 form a charging circuit which produces a 20 second delay in conjunction with IC2. C1 has been taken to +V so that at switch-on, it will be discharged and will hold IC2 input high, keeping the output low.

If the situation was reversed and C1 was returned to 0V, when the ignition was switched on, there would be a momentary flicker of the lights in daylight. This could be put to good use if a momentary delay was introduced to the output to combat this pulse, as a delay defeat would be realised at ignition switch-on.

However, for the sake of reliability and simplicity this feature has been omitted from the present circuit.

D1 ensures that the delay is not cumulative—a succession of short tunnels will not trigger the relay.

In this situation without D1, the motorist would find his lights triggering prematurely which, to say the least, might annoy other motorists.

TR1 is the relay driver, with C2 preventing any supply generated pulses from reaching the relay.

D3 is not used as an indicator (although there is no reason why it should not be brought out to the front panel if desired) but is used as a form of Zener to ensure that TR1 receives no input when IC2 output is low.

Feedback is applied from the relay back to IC2 pin 3 to ensure that any battery voltage changes do not cause relay chatter. Normally this would not occur but it has been found that in freak conditions this can occur if R7 is not present. It is essential to prevent relay chatter in this application in order to prolong the life of the relay contacts.

In this circuit, use is made of the output current limiting of the 741 op amp in restricting the current to D3, therefore it is not recommended to use any other type of op amp. However, most *npn* power transistors are suitable for TR1 and the relay is not critical provided it has a 12V coil and that the contacts are capable of handling the current.

CONSTRUCTION

Construction and layout are not critical as there are no particularly sensitive sections in the unit. However, good soldering is essential in any gadget for use in a vehicle because of vibration effects.

In the prototype, a copper-clad etched circuit board was used, details of which are given in Figs. 5 and 6.

A relay with 5 amp contacts was used in this prototype as the headlights in many modern cars have their own relay drive. If the unit is to be used in a vehicle without this facility (particularly if extra lights have been fitted) a relay with 10A contacts may be better.

Tandy sell a very nice enclosed relay with DPCO contacts with this rating. However, a bigger case will be required than that shown unless the relay is housed separately to the main unit.

FITTING AND SETTING UP

The unit should be mounted as near to the lights switch as possible. From that switch it will be possible to obtain tappings into dipped lights, side lights and in some cases a live switched through the ignition. An earth will have to be found elsewhere.

Finding out which wire is which on the car lights switch is a matter of consulting the vehicle wiring diagram and no advice can be given as all cars are different in this respect.

The sensor should not be mounted in a position where it is in direct line with any strong source of artificially generated light, i.e. opposing traffic headlights, although the unit is not particularly sensitive to this light. The best place to mount it is in the left hand corner of the dash, preferably out of sight. Positioning is not critical, however.

Having wired the unit up, it is simply a matter of waiting till lighting up time for final adjustment of VR1. A voltmeter across 0V and IC1 output will give an

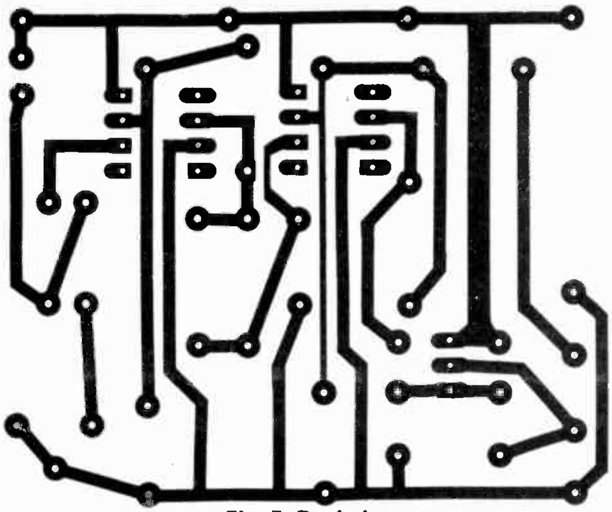


Fig. 5. P.c.b. layout

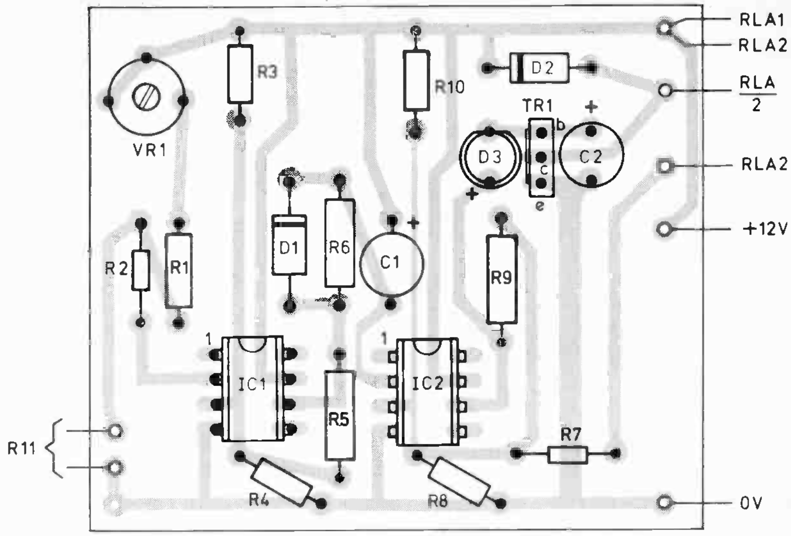


Fig. 6. Component layout

instantaneous indication of triggering rather than having to wait out the delay after every small adjustment.

Adjust VR1 until the exact point at which IC1 output goes low is found and leave the preset at this exact point. Now fasten the case up and that is all there is to it.

The car lights should now come on after about 20 seconds, and should go off immediately the ignition is switched off. On turning the ignition back on, there should be a further 20 second delay before the lights come back on. Check to make sure the correct lights are operating and also that both of the indicators on the unit itself are working correctly. If the auto/manual switch is fitted, switch to manual, put side lights on manually in the normal way, and make sure the correct indicator shows on the unit.

COMPONENTS . . .

Resistors

R1	100Ω
R2	10kΩ
R3	15kΩ
R4	15kΩ
R5	27kΩ
R6	470kΩ
R7	15kΩ
R8	15kΩ
R9	56kΩ
R10	10kΩ
R11	ORP12

All resistors $\frac{1}{8}$ watt 5% carbon.

Potentiometer

VR1 10kΩ preset

Capacitors

C1, C2 22μF elect 16V (2 off)

Semiconductors

D1	1N4001
D2	1N4001
TR1	BD131
IC1, IC2	741 (2 off)
D3	TIL209

Relay

RLA 12V d.c. 110Ω coil two-pole changeover (R.S Cat. No. 348–835).

Miscellaneous

S1* S.p.s.t. miniature on/off (if required)

LP1-LP2 12V indicator lamps

VARI-WIPE

B. A. Bell

An intermittent wiper control facility is now standard equipment of many new cars. Such a unit proves indispensible in British weather, and the present design allows a wiper delay to be added to any car. It is of very simple design, making it easy to build successfully. The small number of components make the unit reliable, and keeps the cost below that of four gallons of petrol.

CIRCUIT DESCRIPTION

The circuit is shown controlling a two-speed wiper motor with a motor-shorting parking switch; this represents the arrangement on most recent cars. The simpler circuit used on older cars, with a non-shorting parking switch, will also work with this design.

In normal operation of the wipers, with the unit turned off by S1, RLA/1 restores the original connection which is broken on installation. When the wiper switch is moved to "Slow" or "Fast", the appropriate winding on the motor is disconnected from the limit switch and connected to the 12 volt supply, the motor running continuously. On switching the wipers off, the motor is connected to the limit switch which maintains the 12 volt supply until the park position of the wipers is reached. The limit switch then disconnects the 12 volt supply and short circuits the motor, providing rapid braking.

If the intermittent control is now switched on with S1, C2 begins to charge at a rate determined by R2 and VR1. When the voltage across C2 exceeds the Zener voltage of D1, the Zener diode conducts and switches TR1 on. RLA/1 operates and connects the 12 volt supply to the motor "slow" winding via the wiper switch. As the motor runs, the limit switch moves to the "Run" position to maintain the motor supply, and also short circuits the intermittent control unit, discharging C2 via D2 and S1, and resetting the circuit completely. At the completion of one sweep of the wipers, the limit switch parks the motor and removes the short circuit across the intermittent control, restarting the cycle.

The repetition rate of the cycle depends on the setting of VR1, and the values given in the circuit provide a delay adjustable between five and 30 seconds. R2 may be decreased in value if a shorter sweep delay should be required. R1 limits the base current in TR1 when D1 conducts, and C1 charges rapidly when RLA/1 operates to hold the relay closed until the limit switch takes over the supply to the motor.

CONSTRUCTION

The components making up the circuit can be conveniently housed in a small plastics box.

The box may be mounted underneath the dashboard or may be mounted remotely, with VR1 connected by flying leads. Only three connections are required to the vehicle, a 12 volt supply from the ignition switch, and an interruption in the wire which connects the wiper switch to the motor.

This connection can be made by unplugging this wire from the switch behind the dashboard, and connecting the unit to the now vacant terminal on the switch and to the free end of the unplugged wire. If the unit is removed from the car at a future date, this wire must be replaced.

COMPONENTS . . .

Resistors
R1 39Ω
R2 1kΩ
All ¼ watt 10% carbon

Potentiometer
VR1 10kΩ

Capacitors
C1 1,000μF elect 15V
C2 1,000μF elect 15V

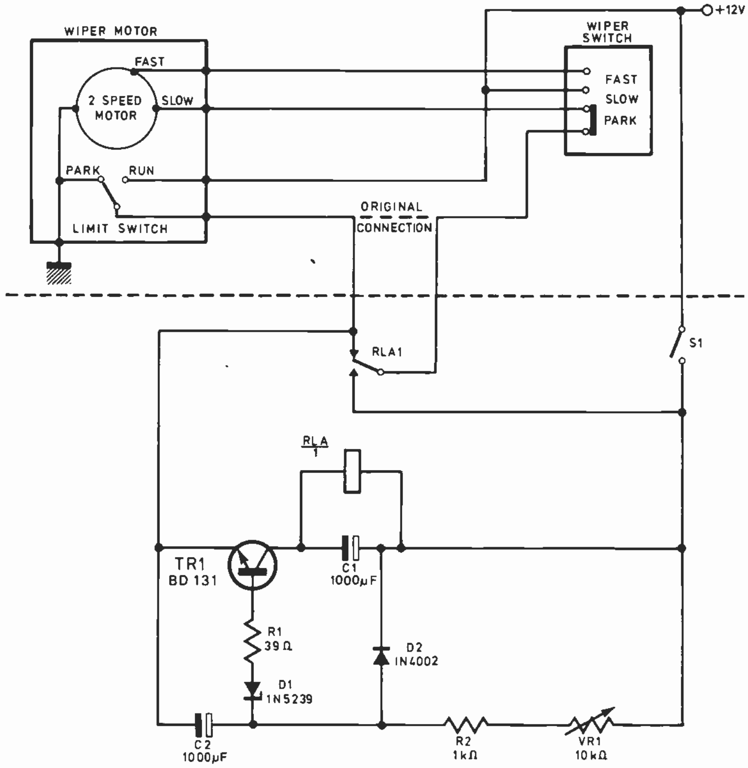
Semiconductors
D1 1N5239
D3 1N4002
TR1 BD131

Relay
RLA KMK1/12DC Keyswitch

Miscellaneous
Plastics box 5in x 2in x 2in with lid
S1 on/off switch

IN USE

The unit is operated by rotating VR1 and setting the desired delay. If there is a temporary increase in spray or rainfall, the intermittent action is over-ridden by operating the wiper switch in the normal way. This automatically disconnects the unit until the wiper switch is turned off, when the intermittent action will be resumed. The prototype has functioned faultlessly for two years on a number of cars, and worked first-time when it was assembled.



Vari-Wipe circuit

ASSISTED IGNITION SYSTEM

G. C. Wride

BACK in the early 1900's a man invented an ignition system comprising of two coils of copper wire, one with a large number of turns, the secondary, and the other a few turns, the primary; he then connected the primary across the battery via a pair of contact breakers across which he connected a condenser. This is the Kettering system which has changed very little since then with the exception of improved materials. Well, way back in 1905 I doubt if they had an engine which would rev much over 2,500 r.p.m. so the system worked very adequately, but most cars these days can rev to at least 5,500 and quite a few to 7,000 and the Kettering system starts to have a hard time keeping up.

Let's look at the low rev end first, for instance, tick over—the points are opening slowly, this gives some of the stored energy in the coil time to arc across the gap so not only burning the points but losing valuable output to the plugs. At the mid range, say, between 2,000 to 4,000, things are not so bad, the output rising to about the maximum to be expected. Things start to go wrong at about 5,000 and above as the available time for the coil to recharge itself is very short (coil recovery time).

Points may bounce, further reducing coil current, and to make matters even worse, because of high cam speed the points tend to close late and the net result of all this is very low output to the plugs.

Finally, after 5,000 miles, the points are so burned that they have to be thrown away and the timing re-done.

SYSTEMS COMPARED

Now we've looked at the problems, let's see how we can get over them. About 10 years ago the "Capacitive Discharge System" arrived on the scene; this was really excellent but in the early days it suffered from s.c.r. "hang-up's" or "latch on's", also the discharge capacitor was somewhat unreliable.

It operated by inverting the 12 volt supply up to 350 volt with a pair of 2N3055s, charging a capacitor then dumping the lot across the coil via the s.c.r. which was triggered by the points.

Its counterpart the "Points Assisted System" basically replaces the points with a power transistor capable of withstanding 300–400 volts or so, which is a very good move since the transistor in this position is a far better switch; secondly, point burn is eradicated, other than this, unfortunately, the system mimics the points exactly. Taking a long look at the aforementioned system I decided there were a number of improvements that could be made.

The ignition coil is basically efficient, its losses mainly being due to its own internal resistance, which we can't do anything about and the external components, which we can. Firstly, we replace the points with a transistor, preferably the type specially designed for switching; secondly we can "tune" the coil to the engine's requirements, these being:

(a) A fast rising waveform
(b) Large amplitude
(c) A slow decay

Unfortunately, none of these conditions are complementary so a compromise must be found.

This design ensures that the maximum possible current for the longest possible time flows in the primary of the ignition coil, this being determined very simply by the use of a monostable; the only work that the contact breaker does is to trigger the monostable via a differentiator so their life is only determined by mechanical wear.

By careful differentiator design it was possible to build in three other innovations, these being:

(a) Contact bounce suppression
(b) Over-rev limitation
(c) Anti-theft provision

The system was tried on varous makes of car and was found to work very well, even on those with very dubious electrical systems. Four connections are all that are required and *no* modifications need be carried out to rev counters or tachometers.

It should be noted that although the cars tested were four cylinder, I see no reason why the system shouldn't work equally well on six or eight cylinder engines.

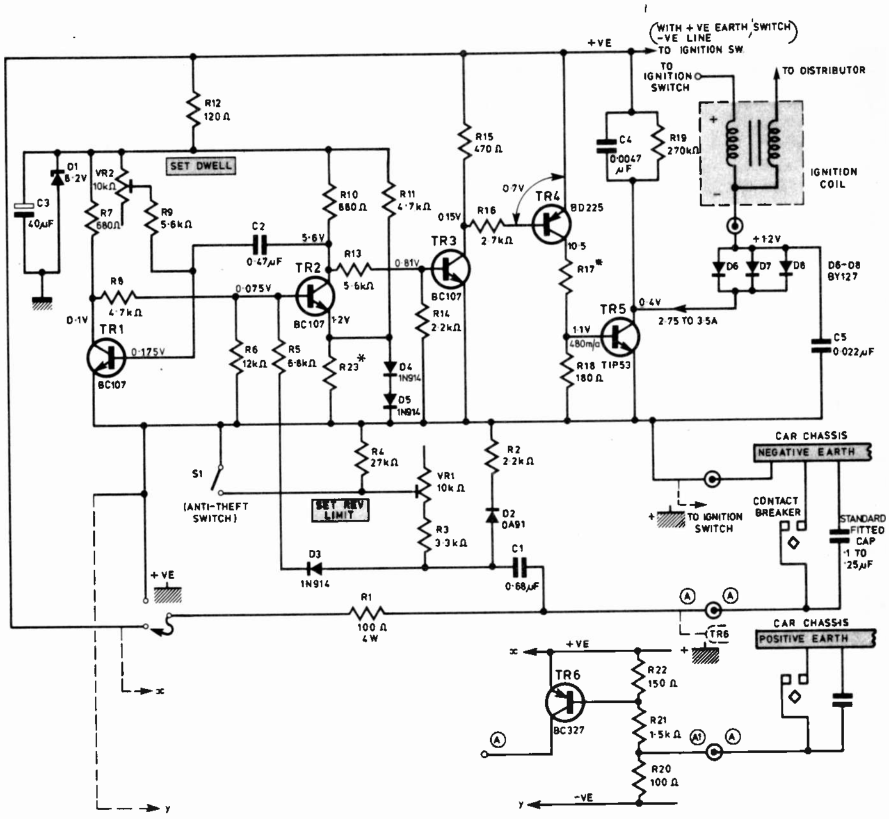


Fig. 1. Assisted Ignition System

CIRCUIT

Resistor R1 supplies the contact breaker with approximately 120mA. This is sufficient current to wet the points to prevent corrosion and provide a low impedance source for the differentiator (Fig. 1).

The differentiator is formed by components C1, R1, D3, R2, R3, VR1, R4, D2, R5 and R8. R5 and R8 are also a potential divider to the input of TR2. VR1 sets the upper revolution limit, R4 being normally short circuited by the anti-theft switch and is selected according to the maximum revs required before the engine starts to misfire.

The anti-theft switch is obviously mounted discretely under the dash or other convenient place.

The time constants on the positive half cycle of the differentiator (as the points open) mainly consists of R2 as D2 is conducting; D3 also conducts, raising the base of TR2 to its triggering potential, i.e. 2 volts. As the points close the output across C1 swings negative, D2 and D3 are non-conducting and C1 now discharges through R3 and VR1.

The time constant on the positive swing (points open) is arranged to allow C1 to be fully charged at the shortest dwell time or maximum revs (Fig. 2a). When the points close the negative output swings to −12 volts approximately, Fig. 2b. Now as the time constant is longer the voltage across C1 becomes progressively larger (−ve) as the revs are increased, therefore, eventually a point will be reached where the positive output pulse will be below the trigger voltage of TR4 and engine misfire will result (Fig. 2c). Point bounce suppression is effected in the same way. The bounce occurs just after closure so as C1 has had very little time to discharge the resulting pulse is well below the trigger potential of TR2 (Fig. 2c).

MONOSTABLE AND OUTPUT STAGE

The monostable is conventional except for the offset diodes D4 and D5 which, in conjunction with the base emitter voltage of TR2 and D3, define the triggering potential.

The output pulse width is set within the limits of 1·9ms to 5·5ms with VR2 ("Set Dwell").

Regulating the 6·2 volt supply ensures a constant pulse width, even if there is a considerable change in battery voltage.

The negative going pulse is taken from TR2 collector to TR3 base via R13 which turns off TR3, TR4 and TR5. R17 is chosen to fully bottom TR4.

The output transistor TR5 carries all the coil current and is driven as a fast switch. D6, 7 and 8 protect TR5 from the negative swing from the ignition coil. When TR5 is turned off the collector swings to approximately 400 volts. D6, 7 and 8 conduct, charging C4 to this potential, as the potential at the anodes of the diodes moves below that on the cathode D6, 7 and 8 become non-conducting so isolating TR5 from the negative transient. The discharge time of C4 is through R19.

By the time TR5 is ready to turn on again the voltage across C4 will be approximately +24 volts, so the remaining charge left in C4 will not damage TR5.

TR5 must be mounted on a heatsink of 18 s.w.g. aluminium of not less than 4 square inches.

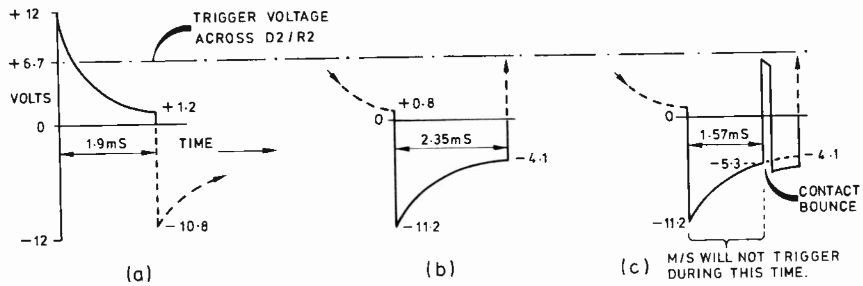


Fig. 2. Differentiator output waveforms at 7,000 rpm

CONSTRUCTION

The prototype was constructed on 0·1in copper strip board and mounted in an "MK" wall mounting box with a cover plate; this was found to be eminently suitable as it can be made almost watertight. There is no need to screw down the component board as this can be made a snug fit, also if the cables are all taken out from one side in the event of service, the top plate can be unscrewed and the whole panel hinged out for service.

A recommended layout is shown in Fig. 4 and is by no means critical with the exception of the components R17, D6, 7 and 8 which run warm; these must be mounted away from the panel.

Leads carrying high currents, i.e. 100 milliamps or more, should not have long lengths of print between them unless a wire link is also inserted (my experience is that if you don't do this, the print will fuse at the holes, this of course being the weakest point).

If the construction is done on 0·1in matrix board, the heavy duty auto cables will not pass through the holes so the use of Veropins is a good idea.

The cover plate can be drilled to accept TR5 and heat sink.

COMPONENTS . . .

Resistors

R1	100Ω 4W wirewound
R2	2·2kΩ
R3	3·3kΩ
R4	27kΩ
R5	6·8kΩ
R6	12kΩ
R7	680Ω
R8	4·7kΩ
R9	5·6kΩ
R10	680Ω
R11	4·7kΩ
R12	120Ω 0·5W 5% carbon film
R13	5·6kΩ
R14	2·2kΩ
R15	470Ω 0·5W 5% carbon film
R16	2·7kΩ
R17	18–22Ω 11W wirewound (see text)
R18	180Ω
R19	270kΩ

All ¼W 5% carbon film except where otherwise stated

Capacitors

C1	0·68μF 63V
C2	0·47μF 63V
C3	40μF 16V
C4	0·0047μF 1,500V polyester paper
C5	0·022μF 1,500V polyester paper

Potentiometers

VR1	10kΩ miniature preset
VR2	10kΩ miniature preset

Diodes

D1	BZY88–6·2 400mW Zener
D2	OA91
D3–D5	1N914 (3 off)
D6–D8	BY127 (3 off)

Transistors

TR1-TR3	BC107 (3 off)
TR4	BD225 or TIP30
TR5	TIP53

For positive earth systems the following are required:

TR6	BC327
R20	100Ω 4W wirewound
R21	1·5kΩ ¼W 10% carbon
R22	150Ω ¼W 10% carbon

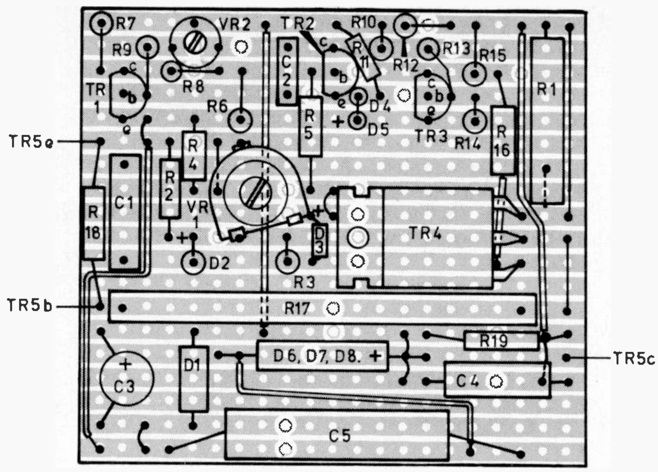


Fig. 4. Component layout on Veroboard

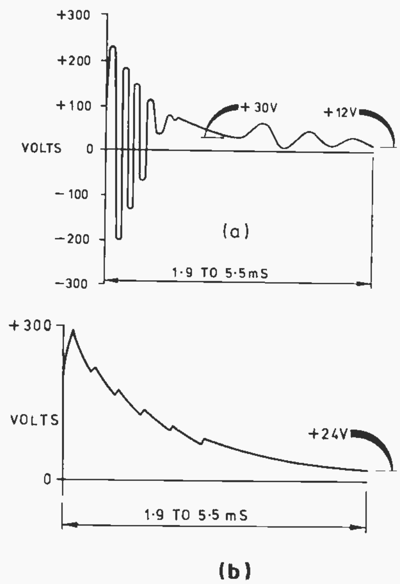


Fig. 3(a). Waveforms at anodes of D6, 7, 8; (b) at collector of TR5

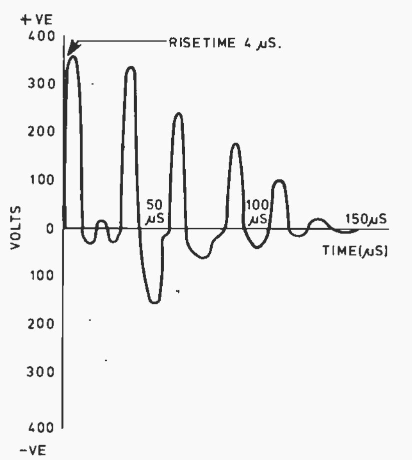


Fig. 5. Output across coil primary

SETTING UP

Set VR1 to its minimum resistance and run the engine to its correct operating temperature.

With standard production car engines VR2 can be set to the centre or three-quarters of its maximum travel; with high performance engines (where revs of 7,000 or more are to be expected) VR2 must be set with a 'scope connected to the anodes of D6, 7 and 8.

With the engine at tick-over the waveform should be that shown in Fig. 3a. Adjust VR2 to show facsimile ringing.

VR1 can now be set to limit maximum revs. With the car at rest bring the revs up to the required maximum and adjust VR1 so that the engine just begins to misfire. Now seal both components with sealing wax.

COIL TUNING

This can only be done using an oscilloscope. Start with a value of 500 pf and bridging with progressively larger values; aim for a waveform approximately as that in Fig. 5. If an oscilloscope is not available the specified value will be approximately correct.

If the unit is going to be used on racing engines and revs in excess of 7,000 are to be expected, the monostable time constant can be reduced down to the actual active period of the coil, 150 to 200 microseconds, this being done by lowering the value of C2 only.

INTRUDER ALARM

A. Chadwick

THIS car burglar alarm incorporates many of the attractive features of previously published circuits.

In operation is is enabled and disabled by a hidden switch in the interior of the car. There is a delay between applying the switch and the enabling of the alarm, giving time for leaving the vehicle.

The alarm is triggered by any load put on the battery; for example the interior light on opening the door.

A shorter delay exists between triggering and any audible output, giving time for the circuit to be disabled.

ALARM

The actual alarm consists of pulsed operation of the horn. After a set time the horn is switched off, and the alarm reverts to the enabled state, ensuring that false triggering does not lead to a flat battery.

CIRCUIT

Operation of the enable switch S1 causes the output of the R-S flip-flop, formed by IC1a and IC1b, to go to logical zero. After a delay determined by VR1 and C2, the input to IC1c goes to zero. This allows any triggering pulses from TR1, C5, D2 and VR3 caused by a load being put on the battery to set the output of the R-S flip-flop IC2a, IC2b to logical one.

After another delay, caused by VR2/C4 monostable IC2c, IC2d is triggered, enabling the astable multivibrator IC3a, IC3b and thus producing pulsed operation of the horn via TR2, TR3, D6 and relay RLA.

TRIGGER GUARD

Triggering of the monostable causes flip-flop IC2a, IC2b to be reset via IC3c, IC3d. R4, C3 cause the reset to IC2b to be held for a short interval after the end of the monostable timing cycle to prevent re-triggering of the alarm by the horn or relay RLA.

Disabling of the alarm resets both the flip-flops and the monostable.

All i.c.s are CMOS 4001 quad 2-input NOR gates. D4 protects the circuit against incorrect supply polarity which would quickly destroy the i.c.s. The contacts of RLA must be fairly substantial, as they carry the full horn current.

VR1, VR2 were set to give exit and entry delays of 80 seconds and 15 seconds respectively. R9, C6 gave an alarm time of about 3·5 minutes, at a frequency (governed by R10, C7) of 0·4Hz.

COMPONENTS . . .

Resistors

R1, R2	1MΩ (2 off)
R3	1kΩ
R4	470kΩ
R5	1kΩ
R6	1MΩ
R7, R8	1kΩ (2 off)
R9	10MΩ
R10	4·7MΩ

All 10% $\frac{1}{2}$W carbon

Capacitors

C1	150μF elect 25V
C2	150μF elect 16V
C3	4·7μF elect 63V
C4	150μF elect 16V
C5	0·1μF
C6	22μF elect 16V
C7	0·33μF

Potentiometers

VR1, VR2	1MΩ miniature preset (2 off)
VR3	100kΩ miniature preset

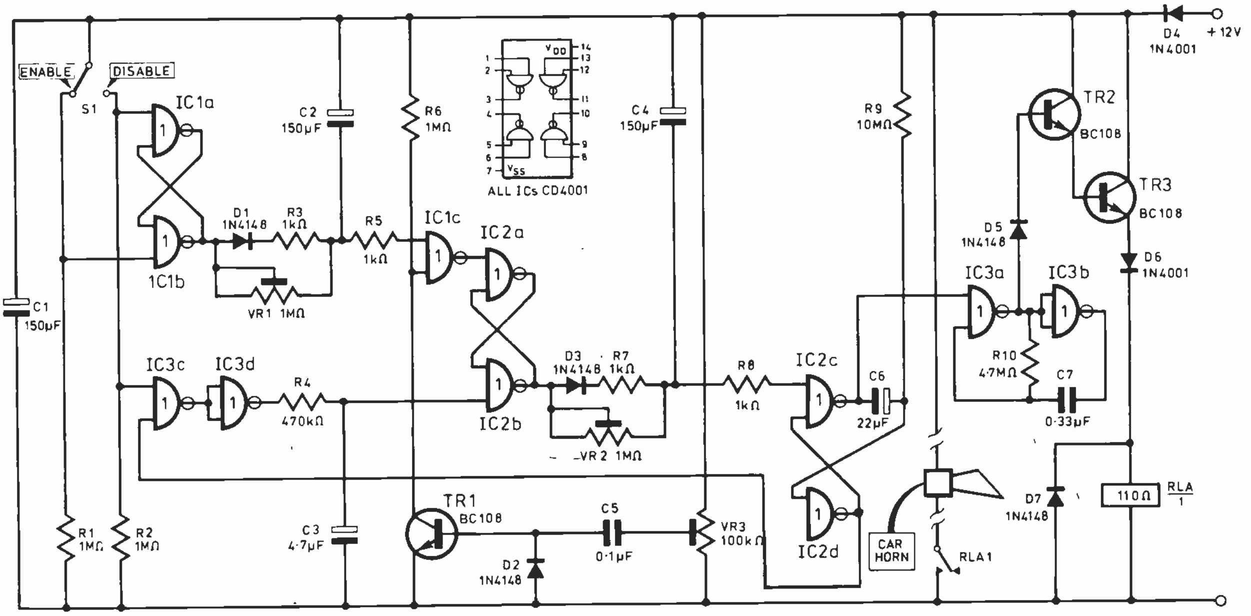
Semiconductors

IC1–IC3	CD4001 (3 off)
TR1–TR3	BC108 (3 off)
D1–D3	1N4148 (3 off)
D4, D6	1N4001
D5, D7	1N4148

Miscellaneous

S1—Single pole double throw switch

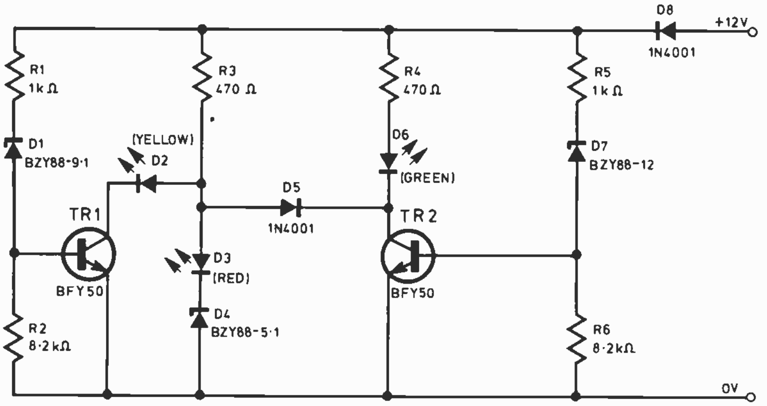
RLA—12V, 110Ω (R.S. 348–835)



Circuit of Intruder Alarm

BATTERY STATE INDICATOR

A. M. Owen



MANY car owners take their battery for granted, rarely giving it the maintenance it requires. As the winter nights advance the demands made on this vital power source increase. When you combine this with the inevitable ageing process and the diminishing ability to store a charge for a long period, the requirement for a simple aid to continuous battery voltage monitoring is obvious.

The indicator was therefore designed to forestall any incipient failure by providing "at a glance" information on battery state with three coloured l.e.d.s; green indicating a battery voltage adequate for normal use; yellow, that the voltage is fairly low and red that there is a failure in the electrical system, such as a dead cell, poor connection, defective regulator or generator.

PRINCIPLE OF OPERATION

An upper and lower battery voltage limit is set by selection of two Zener diodes which allow the transistors to be turned on at set points. These are in turn interconnected via a conventional diode and l.e.d.s to give a display of the state of the car's battery.

When the car's battery is in top condition, its output voltage will be around 14V and of course even higher when charging. This potential is applied, via D8 (reducing it by some 0·8V), through R5, D7 and R6 to the base of TR2 which will be turned "on" causing D6 to illuminate via R4. TR2 at this time, effectively places a short-circuit across the rest of the circuit via D5 preventing D2 and D3 from emitting light as the potential across them is only some 2V.

As the battery voltage becomes lower, TR2 begins to turn off as the threshold of D7 is reached. This allows D2 to start to come on as TR1 has all the time been turned on via R1, D1, R2. The current thus drawn via R3 precludes D3 from illuminating as the potential across it and D4 is not above the Zener level.

Eventually, at still lower battery voltage, TR1 will begin to turn off in the same manner as for TR2, allowing the potential at the junction of D2, D3, D5 to rise in excess of the 5V Zener level of D4 which begins to pass current and illuminates D3.

Zener diodes may be selected for other switching points and/or battery voltages.

COMPONENTS . . .

Resistors

R1/R5	1kΩ
R2/R6	8·2kΩ
R3/R4	470Ω

All ½W 10% carbon

Semiconductors

TR1, TR2	BFY50 (2 off)
D1	BZY88-9·1
D2, D3	TIL209 (Yellow, red)
D4	BZY88-5·1
D5	1N4001
D6	TIL209 (Green)
D7	BZY88-12
D8	1N4001

Battery Voltage (Vb)	L.e.d. Illuminated
Vb⩽10V	Red (D3)
10V<Vb<12V	Yellow (D2)
Vb⩾12V	Green (D6)

POLARITY INVERTER

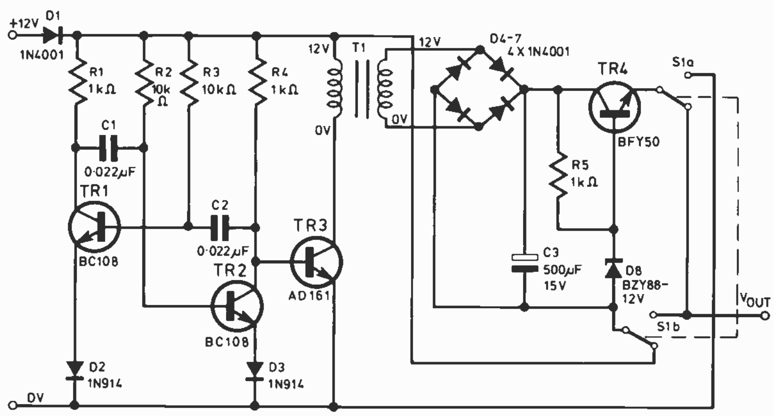
C. D. Williams

THE circuit illustrated was originally designed to enable a negative earth eight-track player to be used in a car with a positive earth, but other uses are obvious, since polarity is reversible.

CIRCUIT

Diode D1 is arranged to prevent incorrect connection to supply. D2 and 3 increase the V_{be} ratings of TR1 and 2 which are connected as a multivibrator operating at about 700Hz.

The output of this is buffered by the AD161 which drives the transformer T1. This must be a low voltage (12V) high current (~1A) one to one transformer, which are rare and expensive. The solution was to use a low voltage mains transformer with individual 12V secondaries and ignore the primary and use the two secondaries. Components D4–8, C3, R5 and TR4 rectify and stabilise the output at 12·6V which is floating relative to the supply rails.



COMPONENTS . . .

Resistors

R1	1kΩ
R2/R3	10kΩ
R4/R5	1kΩ

Capacitors

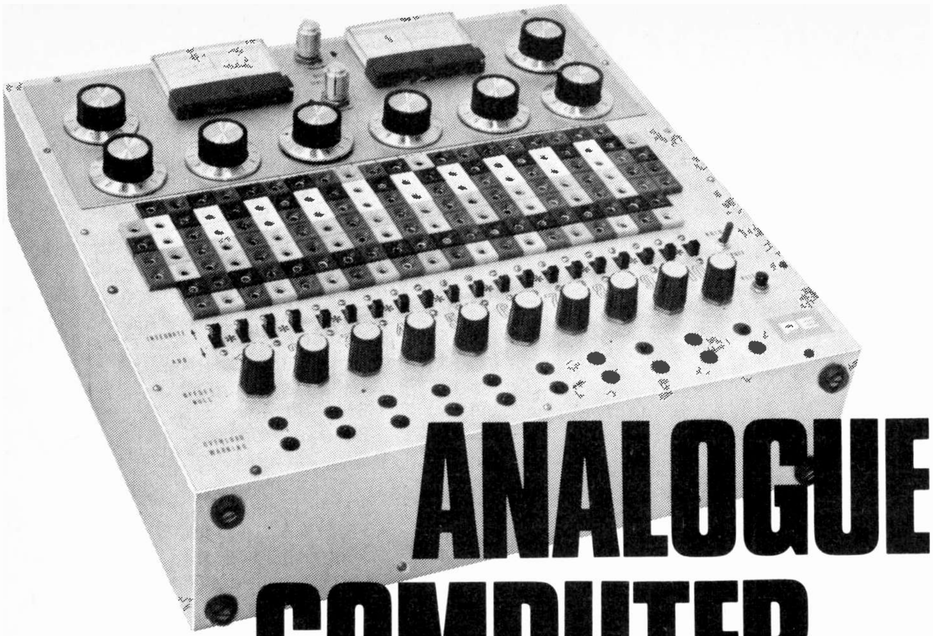
C1, C2	0·022uF (2 off)
C3	500μF elect. 15V

Semiconductors

TR1, TR2	BC108 (2 off)
TR3	AD161
TR4	BFY50
D1, D4–D7	1N4001
D2, D3	1N914
D4	BZY88-C12V 400mW

Miscellaneous

S1 s.p.d.t. T1–240V prim, 12–0–12V, 0·8A sec



★ Wiring

★ Testing

★ Programming

ANALOGUE COMPUTER

P. J. KRONIS B.Sc.

PART 3

AFTER the p.c.b.s have been assembled and checked, all the components should be fitted into the case with the overload warning p.c.b. mounted on the base of the box using 6BA screws. With all the components mounted in the case the coefficient multipliers and the two panel meters should be wired first, following the wiring diagram shown in Fig. 3.1. Resistors R6, R7 and the links shown in Fig. 3.2 should be wired to each of the ten computing amplifiers. The wiring to the relay board and main p.c.b. is via eight edge connectors and to ease the problem of wiring these connectors a wiring schedule is given in Fig. 3.3. The numbering and layout arrangement of the patch panel and switches is given in Fig. 3.4.

The main p.c.b. is mounted above the patch panel and the relay board above the offset null potentiometers as shown in the photograph. After the computer wiring has been completed and checked a ±15V power supply should be connected to the unit and the following test procedures followed.

THE OFFSET NULL TRIM PROCEDURE

Set all the amplifiers to "add" by pushing all the slide switches down. Put the computer into the "compute" mode using the mode control switch and turn the sensitivity of the meters down as far as possible. Connect the output of the first amplifier (A1) to meter 1 (M1). Ground one of the ×10 inputs of A1. This can be done by touching one end of the wire lead on the case. Connect the power supply and switch on. Increase the sensitivity of M1 gradually until the needle deflects to maximum if possible. Bring the needle back to zero by adjusting the offset null potentiometer of amplifier A1. Increase the sensitivity of the meter and repeat the same procedure until the needle is on zero when the meter is at maximum sensitivity.

Decrease the sensitivity fully and repeat the trim procedure for all amplifiers in the same way.

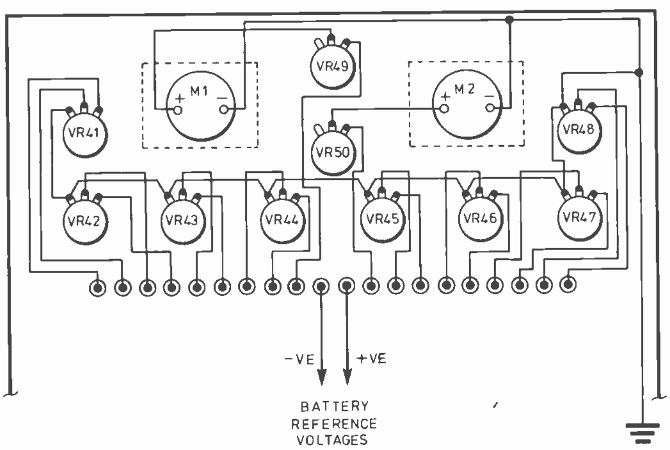


Fig. 3.1. Wiring diagram for the coefficient multipliers and panel meters

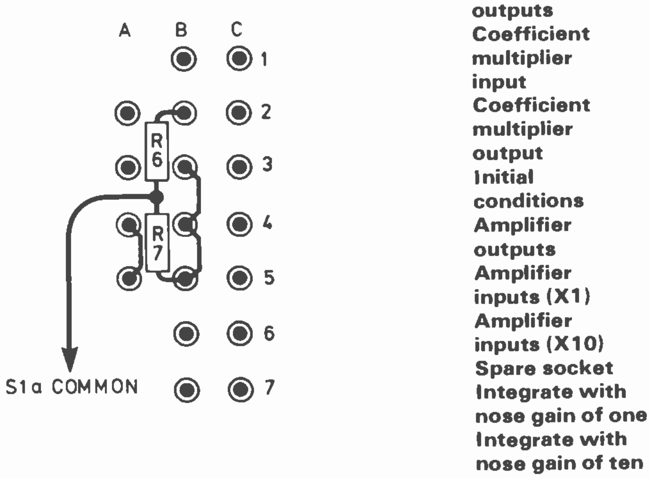


Fig 3.2. Link wiring for amplifiers and multipliers

Edge Connector 1

From	To
pin 3	A3 Patch Panel
pin 4	Earth
pin 5	A2 Patch Panel
pin 6	−15V Supply
pin 7	A4 Patch Panel
pin 8	Edge Connector 6 pin 10
pin 9	C5 Patch Panel
pin 10	C4 Patch Panel
pin 11	C3 Patch Panel
pin 12	C2 Patch Panel
pin 13	TB1 Terminal Block
pin 14	VR51
pin 15	Edge Connector 6 pin 11
pin 16	E5 Patch Panel
pin 17	E4 Patch Panel
pin 18	E3 Patch Panel
pin 19	E2 Patch Panel
pin 20	TB2 Terminal Block
pin 21	VR52
pin 22	Edge Connector 6 pin 14
pin 23	G5 Patch Panel
pin 24	G4 Patch Panel
pin 25	G3 Patch Panel
pin 26	G2 Patch Panel
pin 27	TB3 Terminal Block
pin 28	VR53

Edge Connector 2

From	To
pin 1	Edge Connector 6 pin 15
pin 2	J5 Patch Panel
pin 3	J4 Patch Panel
pin 4	J3 Patch Panel
pin 5	J2 Patch Panel
pin 6	TB4 Terminal Block
pin 7	VR54
pin 8	Edge Connector 6 pin 18
pin 9	L5 Patch Panel
pin 10	L4 Patch Panel
pin 11	L3 Patch Panel
pin 12	L2 Patch Panel
pin 13	TB5 Terminal Block
pin 14	VR55
pin 15	Edge Connector 5 pin 19
pin 16	N5 Patch Panel
pin 17	N4 Patch Panel
pin 18	N3 Patch Panel
pin 19	N2 Patch Panel
pin 20	TB6 Terminal Block
pin 21	VR56
pin 22	Edge Connector 5 pin 20
pin 23	Q5 Patch Panel
pin 24	Q4 Patch Panel
pin 25	Q3 Patch Panel
pin 26	Q2 Patch Panel
pin 27	TB7 Terminal Block
pin 28	VR57

Edge Connector 3

From	To
pin 3	Edge Connector 5 pin 23
pin 4	S5 Patch Panel
pin 5	S4 Patch Panel
pin 6	S3 Patch Panel
pin 7	S2 Patch Panel
pin 8	TB8 Terminal Block
pin 9	VR58
pin 10	Edge Connector 5 pin 24
pin 11	U5 Patch Panel
pin 12	U4 Patch Panel
pin 13	U3 Patch Panel
pin 14	U2 Patch Panel
pin 15	TB9 Terminal Block
pin 16	VR59
pin 17	Edge Connector 5 pin 27
pin 18	W5 Patch Panel
pin 19	W4 Patch Panel
pin 20	W3 Patch Panel
pin 21	W2 Patch Panel
pin 22	TB10 Terminal Block
pin 23	VR60
pin 24	X2 Patch Panel
pin 25	X4 Patch Panel
pin 27	X3 Patch Panel

Edge Connector 4

From	To
pin 2	+15V Supply
pin 3	VR51
pin 4	B6 Patch Panel
pin 5	S1d Add
pin 6	B5 Patch Panel
pin 7	C6 Patch Panel
pin 8	VR52
pin 9	D6 Patch Panel
pin 10	S2d Add
pin 11	D5 Patch Panel
pin 12	E6 Patch Panel
pin 13	VR53
pin 14	F6 Patch Panel
pin 15	S3d Add
pin 16	F5 Patch Panel
pin 17	G6 Patch Panel
pin 18	VR54
pin 19	H6 Patch Panel
pin 20	S4d Add
pin 21	H5 Patch Panel
pin 22	J6 Patch Panel
pin 23	VR55
pin 24	K6 Patch Panel
pin 25	S5d Add
pin 26	K5 Patch Panel
pin 27	L6 Patch Panel

Edge Connector 5

From	To
pin 2	VR56
pin 3	M6 Patch Panel
pin 4	S6d Add
pin 5	M5 Patch Panel
pin 6	N6 Patch Panel
pin 7	VR57
pin 8	P6 Patch Panel
pin 9	S7d Add
pin 10	P5 Patch Panel
pin 11	Q6 Patch Panel
pin 12	VR58
pin 13	R6 Patch Panel
pin 14	S8d Add
pin 15	R5 Patch Panel
pin 16	S6 Patch Panel
pin 17	VR59
pin 18	T6 Patch Panel
pin 19	S9d Add
pin 20	T5 Patch Panel
pin 21	U6 Patch Panel
pin 22	VR60
pin 23	V6 Patch Panel
pin 24	S10d Add
pin 25	V5 Patch Panel
pin 26	W6 Patch Panel

Edge Connector 6

From	To
pin 3	−15V Supply
pin 4	S2c Common
pin 5	S1c Common
pin 9	TB1 Terminal Block
pin 10	S1b Add
pin 11	S2b Add
pin 12	TB2 Terminal Block
pin 13	TB3 Terminal Block
pin 14	S3b Add
pin 15	S4b Add
pin 16	TB4 Terminal Block
pin 17	TB5 Terminal Block
pin 18	S5b Add
pin 19	S5a Common
pin 20	S4c Common
pin 21	S3c Common
pin 22	S11a Compute
pin 23	TB2 Terminal Block
pin 24	TB1 Terminal Block
pin 28	Earth, Edge Connector 7 pin 3

Edge Connector 7

From	To
pin 1	S1a Integrate
pin 2	S2a Integrate
pin 3	Edge Connector 7 pin 4
pin 4	Edge Connector 7 pin 7
pin 5	S3a Integrate
pin 6	S4a Integrate
pin 7	Edge Connector 7 pin 8
pin 8	Edge Connector 8 pin 9
pin 9	S5a Integrate
pin 10	TB5 Terminal Block
pin 11	TB4 Terminal Block
pin 12	TB3 Terminal Block
pin 13	S7c Common
pin 14	S6c Common
pin 18	TB6 Terminal Block
pin 19	S6b Add
pin 20	S7b Add
pin 21	TB7 Terminal Block
pin 22	TB8 Terminal Block
pin 23	S8b Add
pin 24	S9b Add
pin 25	TB9 Terminal Block
pin 26	TB10 Terminal Block
pin 27	S10b Add
pin 28	S10c Common

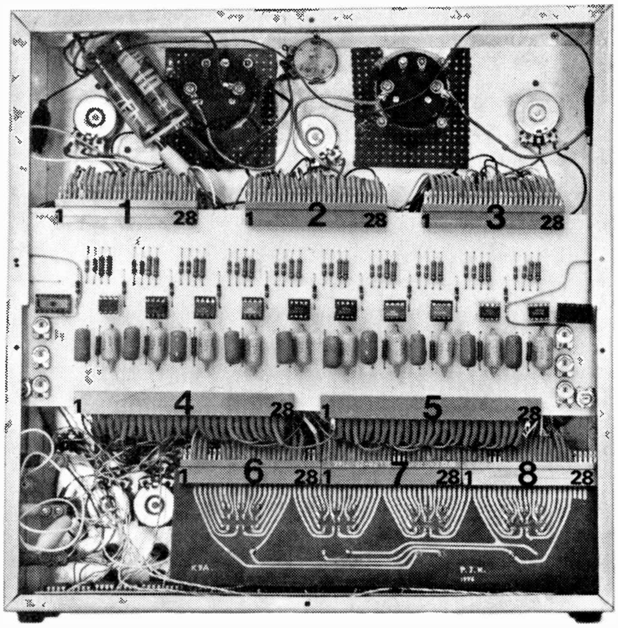
Edge Connector 8

From	To
pin 1	S9c Common
pin 2	S8c Common
pin 3	+15V Supply
pin 4	TB7 Terminal Block
pin 5	TB6 Terminal Block
pin 9	Edge Connector 8 pin 12
pin 10	S6c Integrate
pin 11	S7a Integrate
pin 12	Edge Connector 8 pin 13
pin 13	Edge Connector 8 pin 16
pin 14	S8a Integrate
pin 15	S9a Integrate
pin 16	Edge Connector 8 pin 17
pin 18	S10a Integrate
pin 19	TB10 Terminal Block
pin 20	TB9 Terminal Block
pin 21	TB8 Terminal Block
pin 22	Reset Switch (S12)

Fig. 3.3. Wiring Schedule

Wiring Schedule—*cont.*

From	To
S1b, S1d Common	TB1 Terminal Block
S2b, S2d Common	TB2 Terminal Block
S3b, S3d Common	TB3 Terminal Block
S4b,S4d Common	TB4 Terminal Block
S5b, S5d Common	TB5 Terminal Block
S6b, S6d Common	TB6 Terminal Block
S7b, S7d Common	TB7 Terminal Block
S8b, S8d Common	TB8 Terminal Block
S9b, S9d Common	TB9 Terminal Block
S10b, S10d Common	TB10 Terminal Block
Reset Button (S12)	S11b Compute
S11a	+15V Supply
S11b	−15V Supply
−15V Supply	VR51 Wiper
VR51 Wiper	VR52, 53, 54, 55, 56, 57, 58, 59, 60 (Wipers)



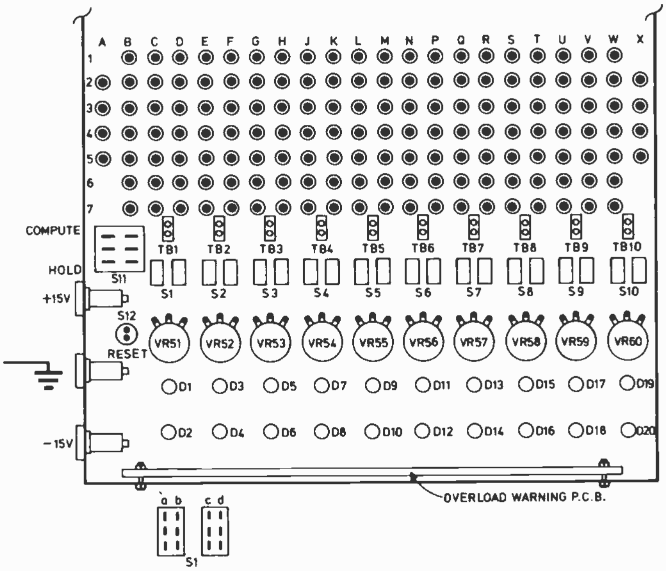


Fig. 3.4. Layout arrangements for edge connectors, patch panel and switches

MODE CONTROL TEST

Set amplifier A1 to "integrate", and the mode to "compute" and monitor the output with one of the meters. Apply a voltage to a ×1 input. The needle should deflect gradually in the positive direction, if the applied input voltage is negative, and vice-versa, until the amplifier saturates. When this happens, adjust the meter sensitivity so that the needle is at maximum deflection. Put the computer in the "hold" mode and press the "reset" switch. The needle should go to zero. Release "reset" and switch to "compute". The needle will again start to deflect and this time switch the mode to "hold" before the amplifier saturates. The needle should then stop moving. Carry out this test with all the amplifiers. While doing this, observe the operation of the overload warning circuit. The appropriate l.e.d. should come on when the amplifier output exceeds +11V or goes below −11V. Check both positive and negative operation by applying both positive and negative input voltages.

The above tests are not complete by any means but any remaining problems will show up when the examples described under "programming" are attempted.

COMPONENTS . . .

Resistors

R6, R7 100kΩ ¼W carbon (2 off)

Potentiometers

VR41–VR48 100 kΩ linear (8 off)
VR49–VR50 300 kΩ linear (2 off)

Miscellaneous

1 off d.p.d.t. switch (R.S. type 316–793)
20 off d.p.d.t. sub-min slide switch
2 off 50–0–50μA (ME15 T40 Watford Electronics)
1 off Push button (R.S. type 337–914)
151 off Square 4mm panel mounted sockets (55 red, 32 yellow, 22 green, 21 white, 21 black)
8 off Skirted knob
12 off Plain knob
6 off 28 way edge connector 0·1in matrix
2 off 28 way edge connector 0·15in matrix
Banana plugs (as required)

PROGRAMMING

It has already been mentioned, that it is necessary to form a mathematical model of the problem to be solved and the computer cannot help us to do this, but being very faithful however, it will happily try to solve a problem even if the wrong information is fed into it. Fortunately, in such cases the programmer could get an indication that something had gone wrong by studying the results which are usually meaningless. The general rule "Garbage In, Garbage Out" (well known to digital computer programmers) applies here also. Unfortunately, error checks cannot be incorporated in the analogue programs, as is the case with digital programs. It is important therefore to adopt a methodical procedure for programming to avoid errors.

Having formed the mathematical model, the equations are rearranged and a flow diagram is constructed which satisfies the equations. All values to be input and all computing elements to be used, are marked on the flow diagram to avoid confusion. Referring to the diagram the computer is then programmed by patching the panel. This procedure will be illustrated by several examples. The flow diagrams are constructed using standard symbols representing computing elements. Some of these have already been given. Fig. 3.5 shows all the symbols to be used in this article.

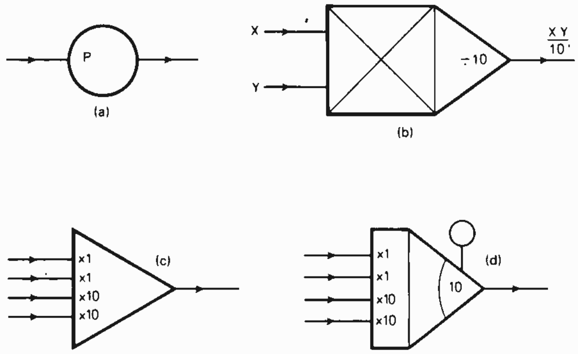


Fig. 3.5. Computing element symbols: (a) coefficient multiplier; (b) Four quadrant multiplier; (c) Summer; (d) Integrator with initial conditions.

As a first example let us examine the operation of potentiometers, adders and integrators, using simple experiments.

Apply a reference voltage to the input of P1 and connect the output to M1. Adjust the sensitivity of M1 so that when P1 is at maximum, M1 deflects fully. Operate the potentiometer and observe the results.

Switch the power on and calibrate M1 by applying a known voltage (e.g. supply voltage), to read 15V at full deflection. Switch A1 to "add" and apply the output of P1 to the input of A1 and the output of A1 to M1. The flow diagram and patch panel connections are shown in Fig. 3.6. Test all A1 inputs in turn and observe the gain of the adder each time.

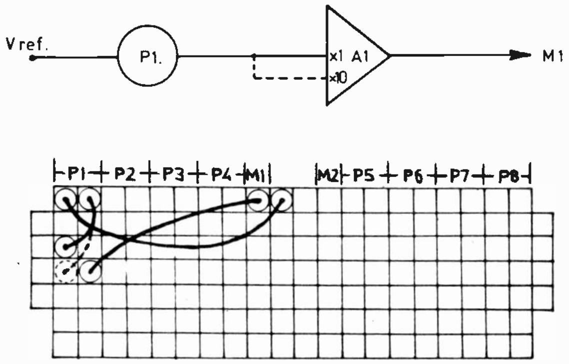
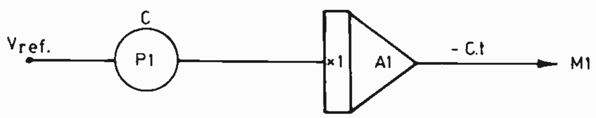


Fig. 3.6. Flow diagram and patch panel layout for the potentiometer example

To examine the operation of the integrators, we can integrate various functions and study the results. First let us see what happens when we integrate a constant, C. The mathematicians will immediately give us the answer as C.t + K, where t is the variable (time in this case) and K is another constant. This is a straight line, of gradient C and passing through the origin, if we have no initial conditions, i.e. C = 0 at t = 0. To verify this we can set up the program shown in Fig. 3.7.



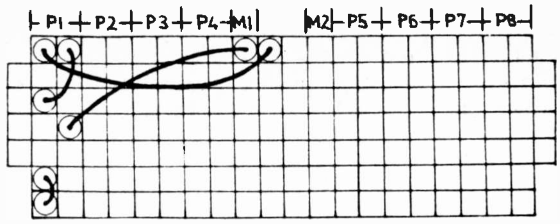


Fig. 3.7. Flow diagram and patch panel layout for the integration example

To run this program follow these steps:

(1) Check A1 is in "integrate"
(2) Computer mode: "hold"
(3) Switch power on
(4) Press reset for a few seconds and release
(5) Switch to "compute" and observe the meter.

Vary the value of C by adjusting P1 and repeat the above steps. If an X–Y plotter is available the results can be plotted for different values of C. The graph would look like Fig. 3.8. With C set to 1 volt the output should increase at 1 volt per second (C = C.t). This can be verified by timing the deflection of the needle.

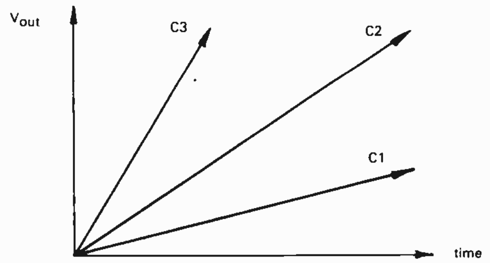


Fig. 3.8. Graph showing the resultant curves when various values for the constant C are integrated

These examples serve to illustrate the use of the analogue computer as a function generator. By integrating a step function we obtained a ramp function, the slope of which we could easily control. The ramp function can be integrated again to produce a square law function. This is shown in the flow diagram in Fig. 3.9. Still higher power functions can be obtained by successive integrations.

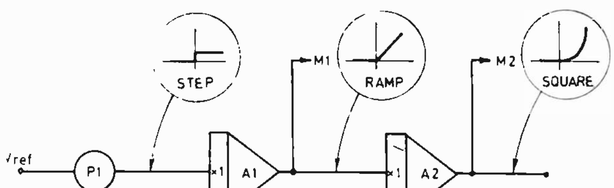


Fig. 3.9. By integrating waveforms the analogue computer can be used as a function generator

INITIAL CONDITIONS EXAMPLE

In the previous integrator examples we assumed that at time t = 0 all variables had zero value. Suppose that we wanted to give a value to the output of the integrator, before the computation begins. It is not difficult to imagine examples where this might be used. We may for example like to investigate the flight of a rocket, not from the point of launch but from some height above the launching pad, at which the rocket will have some velocity and acceleration. To illustrate the use of initial conditions we can repeat the first integrator example, but this time we are going to give an initial value to the integrator output of 5V. We therefore require 5V to be applied to the initial condition socket of A1. Since the value of the reference voltages is only about 1·5V, we shall have to multiply this value. This we can do with the aid of an adder and a potentiometer. The flow diagram and patch panel connections are shown in Fig. 3.10.

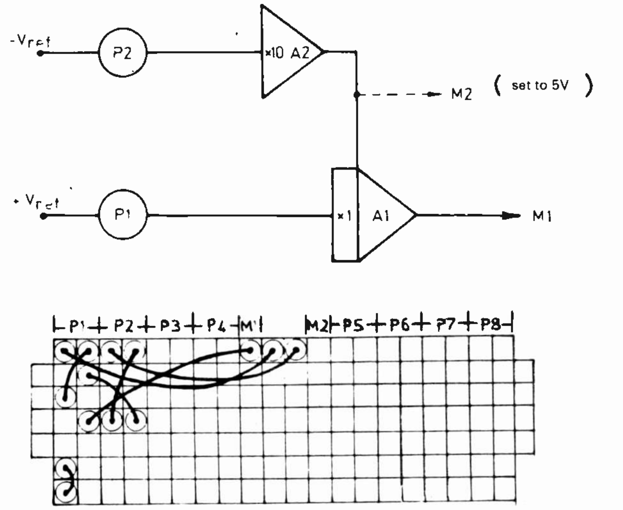


Fig. 3.10. Flow diagram and patch panel layout for the initial condition example

To run this program follow these steps after the panel has been patched.

(1) Switch power on
(2) Amplifier A1 integrating and A2 adding
(3) Computer mode: "hold"
(4) Monitor A2 output and adjust to 5V using P2
(5) Set output of P1 to 1V
(6) Press "reset" for a few seconds and release (Output of A1 should now show 5V)
(7) Switch mode to "compute" and observe M1.

The initial condition value is invariably formed using an adder and a potentiometer, unless of course the exact value is available. It is therefore common practice not to show these two computing elements, but simply to note the value being applied to the initial condition socket as shown in Fig. 3.11.

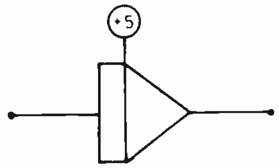


Fig. 3.11. Initial condition symbol

Another point worth noting here is that it is not essential for the potentiometer to precede the adder as shown in the flow diagram. In fact in such cases it is better for the amplifier to precede the potentiometer, as the former presents a higher input impedance to the battery than the latter and therefore saves battery energy.

ENGINEERING PROBLEMS

Consider a mass M supported on a spring of stiffness K. If the mass is disturbed, the system will begin to oscillate about the equilibrium position. Mechanical systems usually have electrical equivalents or vice-versa. The electrical equivalent to the spring mass system is the capacitor inductor series circuit. Both systems are shown in Fig 3.12.

The equation of motion of the spring mass system is $M\ddot{x} + Kx = 0$. The electrical system is described by a similar

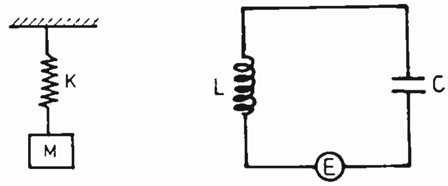


Fig. 3.12. The mechanical spring/mass circuit and its electrical equivalent the inductor/capacitor series circuit

equation but with electrical symbols substituted for the mechanical ones. The "dot" notation is used where time derivatives are involved. For example, one dot means the first derivative of the variable in question, with respect to time, two dots mean the second derivative and so on. So if x represents displacement, then $\dot{x}$ represents velocity, and $\ddot{x}$ acceleration. The equation can be rearranged so that the highest derivative appears on the left-hand side, with everything else on the right-hand side. This is normal practice when solving a problem on the analogue computer. The equation becomes $\ddot{x} = -\frac{K}{M}x$ and the flow diagram is shown in Fig. 3.13.

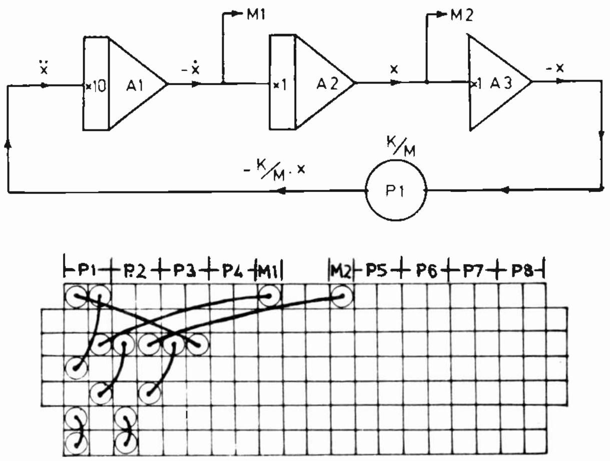


Fig. 3.13. Flow diagram and patch panel layout for the spring/mass example

By integrating $\ddot{x}$ twice we obtain $-\dot{x}$ and x. In our equation, however, we require $-x$ and so A3 is used as a sign inverter. The value K/M is set up on potentiometer P1, the output of which becomes $-K/M \cdot x$. This is equal to $\ddot{x}$ and therefore we can close the loop by connecting the output of P1 back to the input of A1. The system as it stands will not vibrate unless it is disturbed. Theoretically once it is disturbed, it should go on vibrating for ever. In practice, however, we know that this is not true, because of the presence of some damping, due to air resistance in the case of the mechanical system and electrical resistance in the case of the electrical system. The analogue computer should produce results very near to the theoretical predictions, i.e. very little damping should be present. To run this program follow these steps.

(1) Check A1 and A2 are integrating and A3 is adding.
(2) Switch power on.
(3) Switch mode to "compute".
(4) Apply a disturbance to the input of A2 or A3. (This can be done by momentarily touching the input socket, with a wire lead connected to a reference voltage socket. This is equivalent to giving the weight a gentle push.)

(5) Observe the meters and adjust the sensitivity to produce a reasonable needle deflection.

(6) Operate P1 and see what happens to the frequency and amplitude of oscillation.

You should find that a high value of K/M (i.e. high spring stiffness or small mass or both) gives a high frequency and vice versa. The other point to note is that the oscillation is sinusoidal. The output of A1 (i.e. the velocity) is a cosine function, whereas that of A2 (the displacement) is a sine function. There is a phase difference of 90 degrees between the velocity and the displacement. (The mass comes to a momentary stop when the displacement is at a maximum.) This is shown in the graph in Fig 3.14.

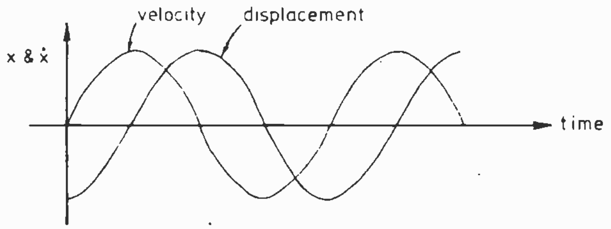


Fig. 3.14. Graph showing the phase difference between velocity and displacement

In this last example we have seen how the analogue computer can be used as a function generator for sine or cosine functions, with variable frequency. The frequency of oscillation is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{K}{M}} \text{ Hz (cycles per second)}$$

This can be checked by counting the number of cycles in one minute and dividing by 60 to convert to cycles per second. If the value of P1 is set to 1·0 and the input of A1 is multiplying by 10 then K/M = 10 and the fréquency should be $f = 1/2\sqrt{10} = 0{\cdot}503$Hz.

NEXT MONTH: PROGRAMMING AND SPECIAL CIRCUITS (conclusion of series)

News Briefs

by Mike Abbott

BUBBLING WITH BITS

THE IDEA of the magnetic bubble conjures up a picture of quivering clusters gurgling their way to the North Pole. In fact powerful magnetic bubble memories are about to "pop" onto the scene from at least two major electronics manufacturers in the near future, one of which is Texas Instruments.

Sample quantities of a new quarter-million-bit bubble memory will be available from T.I. before the end of this year, but at $500 each there probably won't be many P.E. constructors in the queue. (A 92k—bit bubble memory is now in volume production at a price of $100 in 100 unit quantities). The big one however, designated the TIB0303, is full of three micron diameter magnetic bubble domains, and uses separate I/O, minor loop architecture, and features block replication of data. Separate read and write tracks with minor loop data storage are at the heart of this block replicate-based architecture to provide improved performance.

A total of 252 minor loops, each consisting of 1,137 bubble positions, results in a single-chip memory capacity of 286,524 bits. However, 224 loops are utilised resulting in a minimum data capacity of 254,688 bits.

Data bits are written into the write track and exchanged with stored data in the minor loops via swap gates. Data blocks are replicated simultaneously at minor loop and output track junctions, rather than serial duplication which is characteristic of major/minor loop architecture. Consequently, power-down cycle time is significantly reduced from 12·8 milliseconds in the 92K-bit major/minor loop configuration to 12·5 microseconds for block replicate, representing three orders of magnitude improvement.

Other key features include: advanced asymmetric chevron design for improved bubble propagation and transfer, merged data that allows a continuous flow of data bits at the read track, and a dedicated loop for storage of on-chip redundancy information and address synchronisation.

Performance specifications at 100 kilohertz operation are an average access time of 7·3 milliseconds for the first bit of the 224-bit page and a typical power consumption of 0·9 watt for continuous operation. A data-merge function allows a read data of 100K bits per second. Operating temperature is 0° to 50°C with non-volatile storage range of −40° to 85°C.

Bubble control functions are executed by providing current pulses through the appropriate control element on the chip.

The bubble chip is comprised of a gadolinium-gallium garnet substrate upon which a magnetic epitaxial film is grown. Patterns of permalloy metal are deposited on the epitaxial film to define the path of the bubble domains in the presence of a rotating magnetic field. As the field rotates, the bubble domains move under the permalloy pattern in shift register fashion.

The TIB0303 will be offered in a 20-pin dual-in-line package, measuring 30 × 30 × 10mm. The package contains the quarter-million-bit bubble chip surrounded by two orthogonal coils that provide the rotating magnetic field, a permanent magnet set, and a magnetic shield to protect data from external fields.

Taking a systems approach, TI will offer a family of interface and control circuits for the TIB0303 in the second quarter of 1979.

BLINKING GOOD

IF ONE of your projects requires an l.e.d. to wink on-and-off to catch someone's eye, here's something to save you the effort of building a multivibrator to do it.

Available from the Norbain Optoelectronics Division is the first Flashing Light Emitting Diode, Type FRL 4403, to appear on the market. The T 1¾ l.e.d. is manufactured in Gallium Arsenide Phosphide technology with a red diffused plastic lens. The built-in integrated circuit flashes the l.e.d. on and off at roughly 3 pulses per second, and can be driven directly by standard TTL and CMOS devices, eliminating the need for external switching circuitry.

Optoelectronic characteristics include a luminous intensity of 1·2mCd (typ), an emission peak wavelength of 650nm, spectral line half width 40nm, operating voltage 5 volts (typ), and current of 20 milliamps (typ).

The l.e.d. gives a large full flood radiating area, wide viewing angle and finds application as a condition warning light, monitoring process control system and in many other applications where warning of failure is essential.

Norbain Optoelectronics Division, Norbain House, Arkwright Road, Reading, Berkshire RG2 0LT.

ON THE LEVELL

THE very popular and stout a.c. microvolt meters, type TM3B, made by Levell Electronics Ltd., have just been upgraded.

The improvements include increased input impedance and meter scale length. A brief specification follows:

VOLTAGE and dB RANGES: 15μV to 500V. f.s.d. Acc. ±1% f.s.d. ±1μV at 1kHz, −100, −90 . . . +50dB. Scale −20dB/+6dB ref. 1mW/600Ω.

RESPONSE: ±3dB from 1Hz to 3MHz, ±0·3dB from 4Hz to 1MHz above 500μV.

INPUT IMPEDANCE: Above 50mV: 10MΩ<20pf. On 50μV to 50mV: >5MΩ<50pf.

A selection of readers' original circuit ideas. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.

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

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

Each idea submitted must be accompanied by a declaration to the effect that it is the original work of the undersigned, and that it has not been accepted for publication elsewhere.

741 SUPPLY

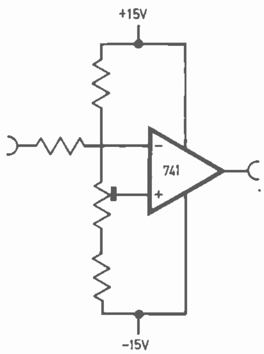


Fig. 1

WHEN two independent power supplies are used to run 741 circuits, problems can arise if one is loaded more than the other. This is particularly so if the circuits use reference voltages taken from the supply rails, e.g. the comparator in Fig. 1.

The power supply circuit shown (Fig. 2) avoids this by using a negative feedback loop; a 741 sensing the mid-voltage between the two supply rails and controlling the voltage at the bases of the transistor pairs. This feedback keeps the point "A" at zero volts so, provided that the two sensing resistors (R6 and R7) are equal, the two output voltages are equal and opposite.

In the circuit tested AD161, 162 and AC127, 128 transistors were used which could give a ½ amp supply.

M. G. Kiff,
Wallingford, Oxon.

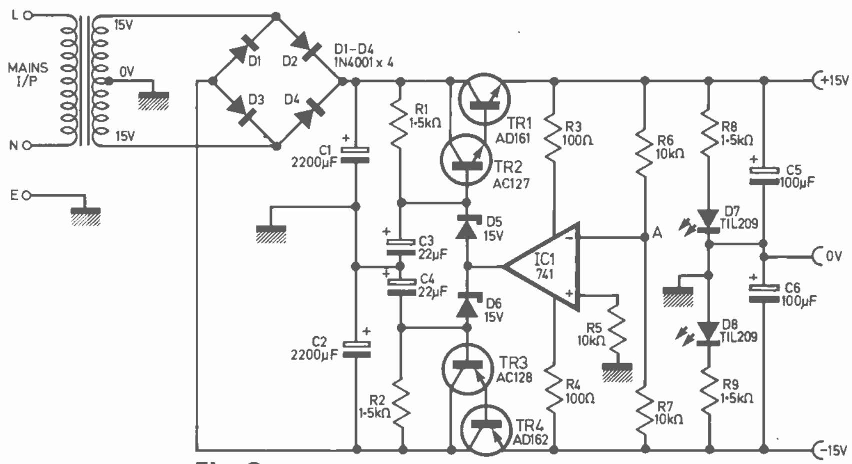


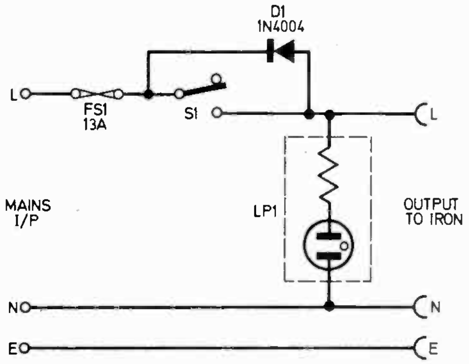
Fig. 2

SOLDERING IRON SIMMER CONTROL

WHEN soldering intermittently it is annoying to wait for the iron to heat up each time, while leaving it on uses up both the bit and electricity. This circuit supplies half power to keep the iron just warm, giving rapid rise to full temperature.

A common type of switched 13A plug is used with a rectifier in parallel with the switch. The rectifier (type 1N4004 is suitable) is soldered, either way round. The neon is left connected as before, giving full and half brightness to indicate power selected.

M. A. Wheatley,
Maidenhead,
Berkshire.



L.F. FREQUENCY METER

THIS instrument is capable of measuring frequencies in the range 10Hz to 100kHz. Four switched ranges are available, these being:

1. 0–100Hz
2. 0–1kHz
3. 0–10kHz
4. 0–100kHz

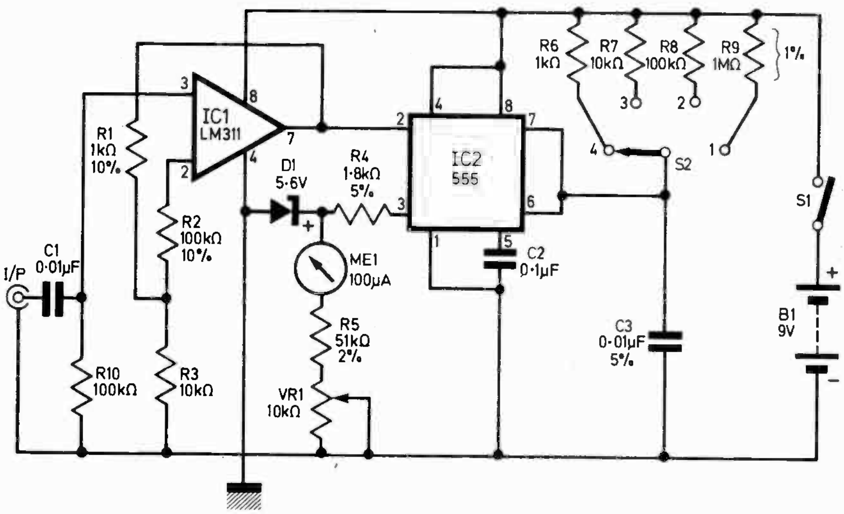
The meter scale is linear to facilitate reading the frequency. The power consumption is 9V at 10mA, and this may be conveniently supplied from a battery.

The first stage of the circuit is an LM311 comparator which converts the input waveform into a square-wave. The LM311 i.c. was chosen because of its low input current and because of its ability to run off a single supply. The output of this i.c. is then fed to the 555 which is connected as a monostable. Hence, the average voltage at the output of IC2 is directly proportional to the frequency at its input. The length of the pulses from the 555 depends on the value of C3 and R6, R7, R8 or R9.

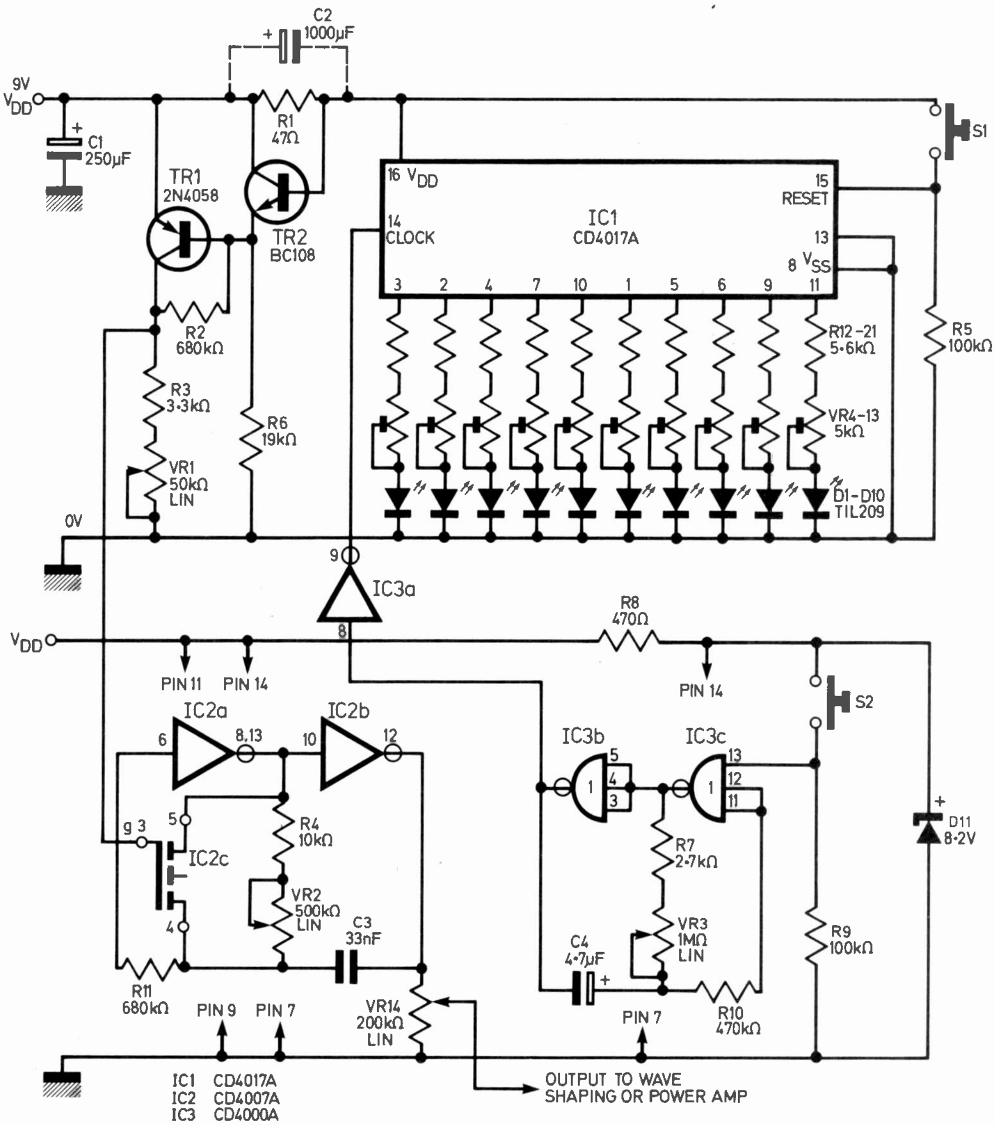
The output of IC2 is fed first to a 5·6V Zener diode via a current limiting resistor. This has the effect of preserving instrument accuracy despite fluctuations in supply voltage. The output from the Zener is then fed to the meter. VR1, a preset potentiometer, is adjusted to calibrate the instrument.

Finally, components that govern the pulse length should be high quality types. R6–R9 need to be 2% or better, and C3 must be a 5% polycarbonate type.

D. P. Akerman,
Dagenham,
Essex.



AUTO-TUNE GENERATOR



THIS circuit enables a preset series of 10 notes to be played over and over again.

With this basic operation, possible applications could be: novel doorbells; background to music synthesis; audio-visual displays, etc. IC1 (CD4017A) is a decade counter which counts one on each positive transition of a clocking oscillator. That is, it applies a high signal to D1, then D2, then D3 and so on up to D10. Depressing S1 resets the counter.

Each note is set by adjusting the current drawn from a particular output (D1 to D10), with VR4–13. A l.e.d. is placed on each output to indicate which note is being played at that moment; they are optional and can be omitted (tuning is much harder without the l.e.d.s). The varying current taken by IC1, as it counts along the preset notes, is monitored by TR2 and R1 which convert the current into a corresponding, changing voltage. TR1 amplifies this and presents it to an audio VCO. VR1 varies the range of notes over which each preset note can be tuned.

IC2 forms the VCO from a CD4007A, IC2a, b being the audio oscillator tuned manually with VR2. IC2c, which is a CMOS f.e.t., is in parallel to VR2 and R4 and so a changing potential on the f.e.t.'s gate will cause a changing frequency. VR14 then attenuates the output signal for an amplifier.

The clock oscillator is a CD4000A (IC3) and oscillates from about 0·2Hz to 5Hz—fully variable with VR3. S2 will stop the oscillator (a tuning aid), and D11 and R8 ensure that the oscillator's fluctuating current doesn't affect the VCO's steady tone.

Finally, C2 can be added for an interesting effect. The whole unit will run from a small 9V battery. IC1, 2 and 3 are CMOS and should be handled with care.

T. D. Davey,
Berkhamsted,
Herts.

TOUCH TUNER

THE circuit shown forms a simple "touch tuner" for use with varicap devices. It is based on the CMOS integrated circuit MC14514 which is a 4 line to 16 line latch/decoder, so up to 16 channels can be switched (if only 8 are required input D can be grounded as shown).

When the strobe input is high the BCD inputs to the i.c. are encoded as 1 of 16 outputs.

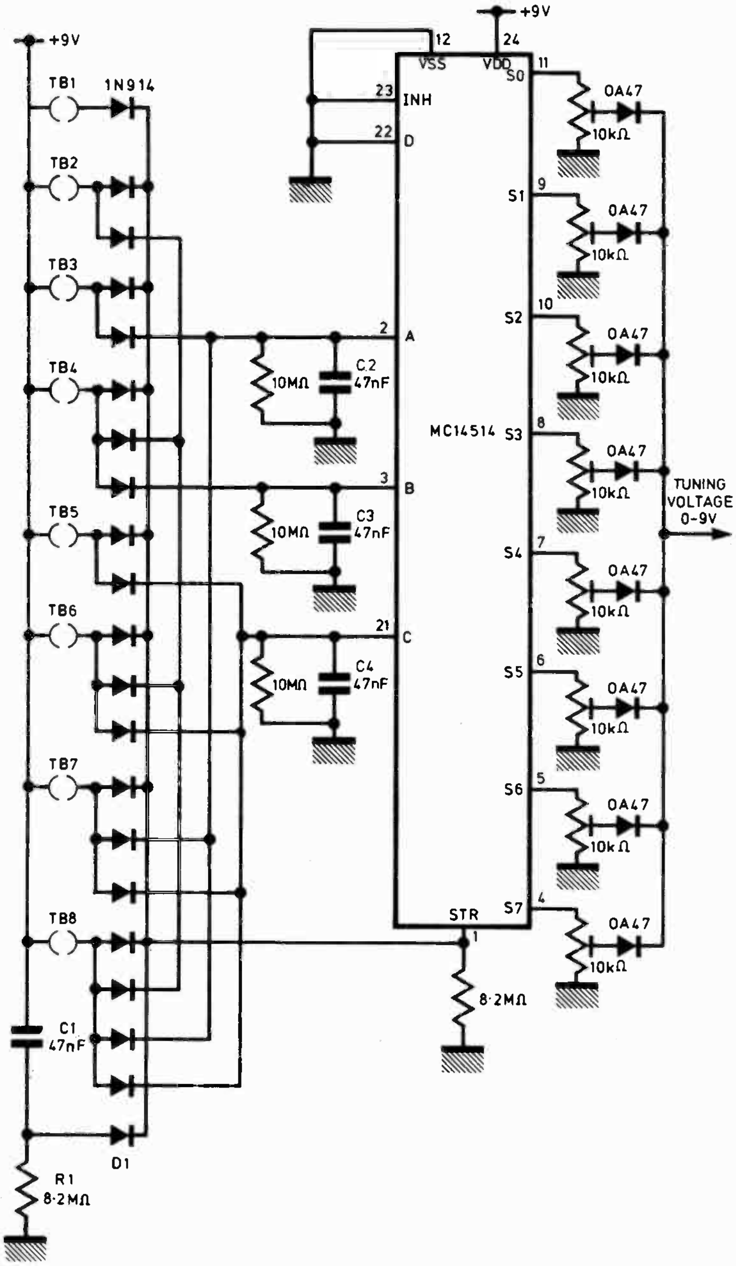
The touch buttons are decoded by the diodes to produce the BCD pattern, at the same time pulling the strobe input high (STR). This selects one of the 16 outputs which drive up to almost V_{dd} which is in turn divided down, by preset potentiometers, to give the tuning voltage that is applied to the tuner via the isolating diodes.

When the touch button is released the state at the BCD input is retained for a short time by the capacitors C2–C4, but the strobe input immediately goes low thus latching the BCD inputs and retaining the selected output.

The circuit formed by C1 and R1 cause a pulse on the strobe input during switch on to reset the tuner to the station selected by the S_0 output.

If it is required that the common contact of the touch buttons be at earth, the decoding diodes could be reversed, the BCD inputs pulled up to V_{dd} together with the capacitors and the strobe input inverted.

K. R. Drage,
Edmonton,
London N9.



Semiconductor UPDATE...

FEATURING: TDA2002 TDA 1083 HSCH1001

R.W. Coles

BRICK OUTHOUSE

The first integrated circuit I managed to lay my hands on, way back in 1966 I think, was an audio amplifier device from R.C.A. By today's standards, that pioneering miracle would be a joke, needing transformers on the input and output and delivering only about 250mW, but to me at the time it was pure magic!

Apart from the fact that you could hardly see the i.c. for its supporting "cast-of-thousands", the thing which eventually disappointed me the most about it was its short life.

Yes, you guessed it, whilst trying my precious miracle in one of a variety of data sheet applications circuits there was a wisp of smoke—then silence.

Now all that is behind me. We have become accustomed to the blow out proof, short circuit proof devices which the wise chip designers provide for us.

Or have we? I still see *myself* as the arch enemy of the audio amplifier chip, blow-out proof or not, and wisps of smoke are by no means unknown on my breadboard socket!

With this sort of background, then, I am always interested in the latest "built-like-a-brick-outhouse" claim for a new audio amplifier chip. Take the **TDA2002** device from Fairchild for example, a much more difficult nut to crack than any I have come across lately.

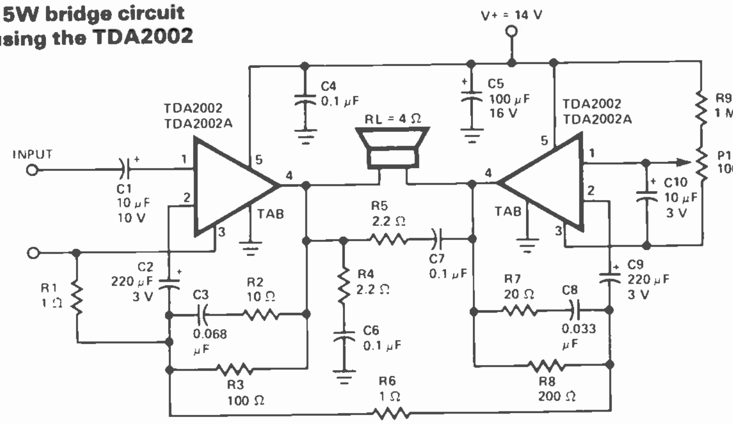
It comes in a tiny five pin plastic power-tab package and yet boasts an output power of 8W with loads down to 1·6 ohm and output currents of up to 3·5A.

The thing that makes the TDA2002 such a worthy adversary is its long list of fiendish protective measures, Thermal Shutdown, Short Circuit Protection *and* Overvoltage Protection, not bad for a chip which boasts a typical T.H.D. of 0·2 per cent at 5W.

This apparent challenge to my reputation will not go unanswered however. I am already burnishing the tip of my soldering iron in anticipation.

Oh, and by the way Fairchild, I am into lightning-strikes at the moment!

15W bridge circuit using the TDA2002



SNUFF TIN SPECIAL

If there is *any* electronic subject likely to raise a yawn from our readers, it must surely be the prospect of an "even smaller" pocket broadcast receiver of the type I like to call squawk boxes! I must confess to having entered the electronics fraternity via the crystal set, the two valve t.r.f (ask your dad!) and the "ham-band-special", before ever discovering the delights of op-amps or logic gates, but even so, the suggestion of *yet another* advance in radio receiver miniaturisation, did not exactly have me choking on my breakfast cornflakes!

Not that I wouldn't have been keen 15 years ago mind you (as a lad, I once built a transistor set in a snuff tin) but our oriental cousins have had the whole thing so well tied up for so long now, that even before the introduction of integrated circuits, all the stuffing *(should this be snuffing?—ed)* had been knocked out of the subject as far as I was concerned. If I have *any* yen (sic) at all for broadcast receivers nowadays, it's for the antique variety with rows of fat glowing valves, solid mahogany cabinets, and the vain hope that one day whilst tuning through "Hilversum" or "Athens" I might just detect an eerie "Germany calling-Germany calling!"

But enough of my life story. The new development I am about to update you with, is, believe it or not, of the very sort to which I have just been objecting. The reason it appears at all, is because I consider it a development so final in its scope, that I confess to feeling a twinge of the old "snuff tin excitement", and if you can stifle your yawns long enough, I think you might agree with me.

The device is an integrated circuit from Sprague, coded ULN 2204A by its American maker, but already boasting a European Proelectron code of **TDA 1083.** Quite simply this new chip is a complete radio receiver in a sixteen pin dual in line package. Complete, because it contains an a.m. front end, an i.f. amplifier, an a.m. and f.m detector stage, an audio amplifier and a power supply regulator.

True, it does *not* boast a loudspeaker, and you *do* still need a couple of r.f. coil cans and a capacitor or two, but until we switch to telepathic broadcasting, it's about as integrated as a radio receiver can get.

You can't even fault it on its performance. It is a full superhet with a.g.c. facilities, and has a 20 microvolt sensitivity for full output on a.m. When used in a dual mode receiver, a.m./f.m. switching is all carried out at d.c. so you could use a D.P.S.T. toggle switch if you wanted to. The audio amplifier, depending on supply voltage (the dip works on 2 to 12 volts, or much higher voltages with a single external resistor) will provide up to a watt into an 8 ohm speaker.

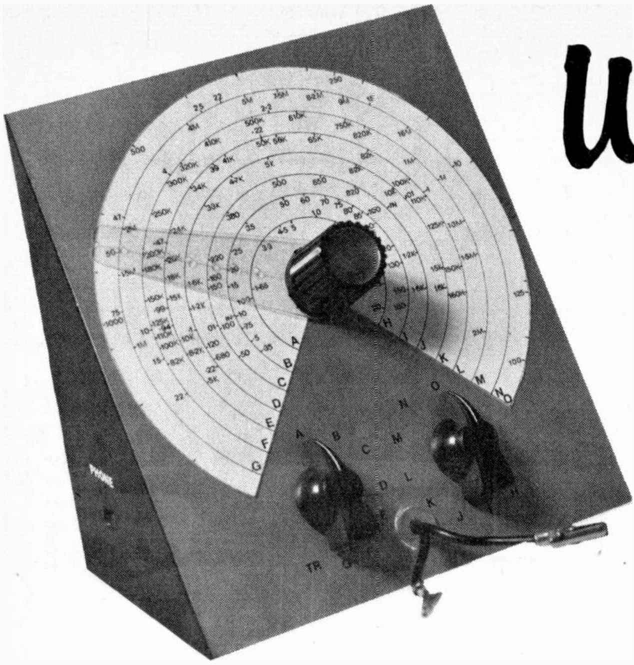
It's true that my snuff tin special needed an earphone and about 200 feet of aerial for correct operation, but how can mere technology replace it?

BARRIERS DOWN

Still using germanium diodes in low forward voltage applications such as r.f. detector circuits and logic clamps? Do yourself a favour and try a Shottky barrier diode instead.

Shottky barrier diodes have a forward drop of only about 400mV at 1mA and have low capacitance and pico-second switching speeds to match. Hewlett Packard have now introduced a low cost S.B.D. in a common or garden DO35 package, coded **HSCH1001.**

Apart from the usual advantages of S.B.D.s, the new device features a 60V reverse breakdown voltage, and only a 200nA leakage at 50V.



Wide Range C/R BRIDGE

W.ENGLISH

THIS CR bridge is a wide range instrument capable of measuring resistance values from 0·5Ω to 20MΩ and capacitance values from 0 to 1,000μF. The unit has 15 ranges (seven resistance and eight capacitance) which are arranged as follows:

Range		Range	
A	0·5Ω–20Ω	H	0–100pF
B	3·3Ω–180Ω	I	75pF–1,000pF
C	33Ω–1·8kΩ	J	800pF–0·01μF
D	470Ω–18kΩ	K	7nF–0·1μF
E	3·9kΩ–180kΩ	L	75nF–1μF
F	33kΩ–2MΩ	M	0·75μF–22μF
G	1MΩ–20MΩ	N	8μF–100μF
		O	100μF–1,000μF

The certain amount of duplication that appears is an advantage when balancing the bridge, because it allows the most open part of the scale to be selected.

CIRCUIT DESCRIPTION

The circuit diagram of the CR bridge is shown in Fig. 1. It is energised by an AF oscillator housed in a separated case and its balance or null point is detected by using a crystal earphone.

When a resistor is placed in the test clips it forms a bridge circuit with VR1, R8 and one of the resistors R1–R7 (according to the position of S1).

If a capacitor is to be measured S1 should be switched to the TR position which transfers the circuits through to the capacitor range and the bridge then balanced using VR1 and S2. When measuring the value of electrolytic capacitors it will be necessary to "bias" these with the appropriate voltage.

CONSTRUCTION

The components for the bridge are mounted on a 18 s.w.g. aluminium panel 150 × 130mm, which is fitted to two wooden side pieces so the front panel is inclined at an angle of 60 degrees.

The resistors and capacitors should be mounted on the two 12-way wafer switches as shown in the photograph before the switches are mounted onto the front panel. The free ends of the components are connected to a bus-bar across the two switches and the leads for the test clips are passed through a grommet on the front panel and have two small crocodile clips connected to them.

The scaleplate should be marked out as shown in the photograph; no component values should be marked on the scale plate until the calibration stage. The cursor consists of a piece of thin perspex sheet scribed with a centre line which is drilled so that the holes correspond with the lines on the scaleplate, enabling accurate calibration. The cursor is then fixed to a suitable knob.

AF OSCILLATOR

The circuit diagram of the AF oscillator is shown in Fig. 2. The unit consists of an astable multivibrator formed by TR1 and TR2 with TR3 used as an output amplifier stage. VR2

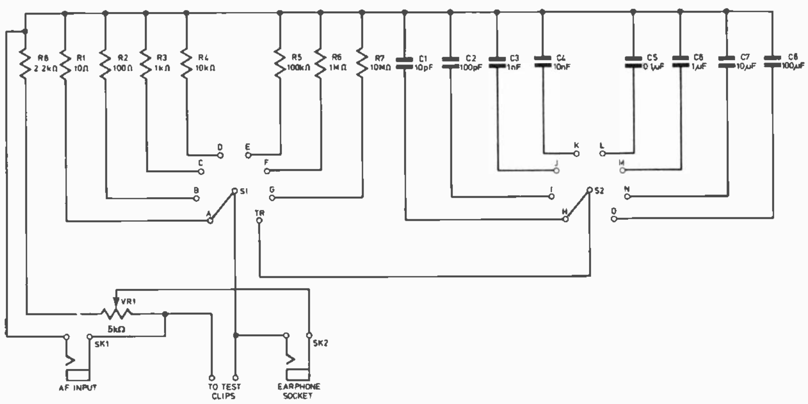
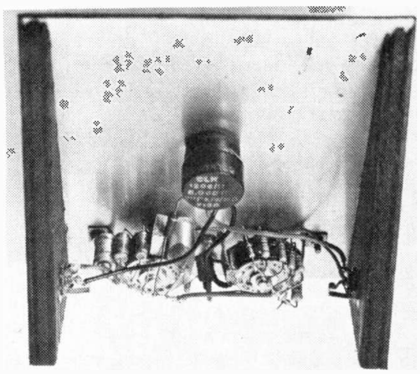


Fig. 1. Complete circuit diagram of the CR Bridge



Rear view of CR Bridge

COMPONENTS . . .

Resistors

R1	10Ω
R2	100Ω (2 off)
R3	1kΩ
R4	10kΩ
R5	100kΩ
R6	1MΩ
R7	10MΩ
R8	2·2kΩ 10% carbon
R9, R12	7·5kΩ (2 off)
R10, R11, R13	120kΩ (3 off)
R14	1kΩ $\frac{1}{8}$W 5%

All 1% $\frac{1}{4}$W unless otherwise stated

Potentiometers

VR1	5kΩ wirewound
VR2	25kΩ linear

Capacitors

C1	10pF
C2	100pF
C3	1,000pF
C4	10nF
C5	0·1μF
C6	1μF 16V tant
C7	10μF 16V tant
C8	100μF 16V tant
C9, C10	0·01μF C280 (2 off)
C11, C12	47μF tant 16V (2 off)

All 2% polystyrene unless otherwise stated

Semiconductors

TR1, TR2, TR3	BC113 (3 off)

Miscellaneous

3 off 3·5mm jack plugs and sockets
2 off 1 pole 12-way wafer switch
2 off pointer knobs
2 off crocodile clips
1 off PP3 battery
battery clips (if req)
crystal earphone

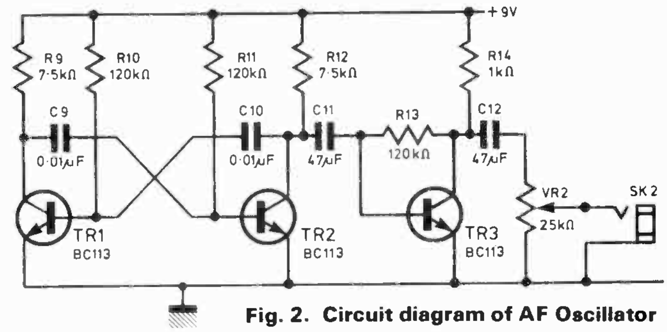


Fig. 2. Circuit diagram of AF Oscillator

Fig. 3. Printed circuit board design for the AF Oscillator

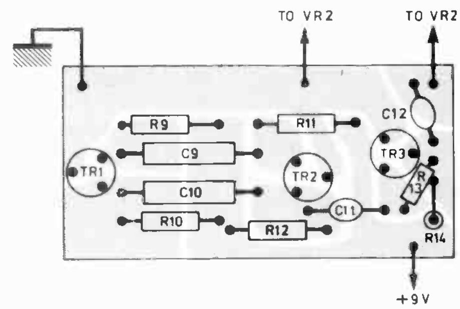


Fig. 4. Component layout for AF Oscillator

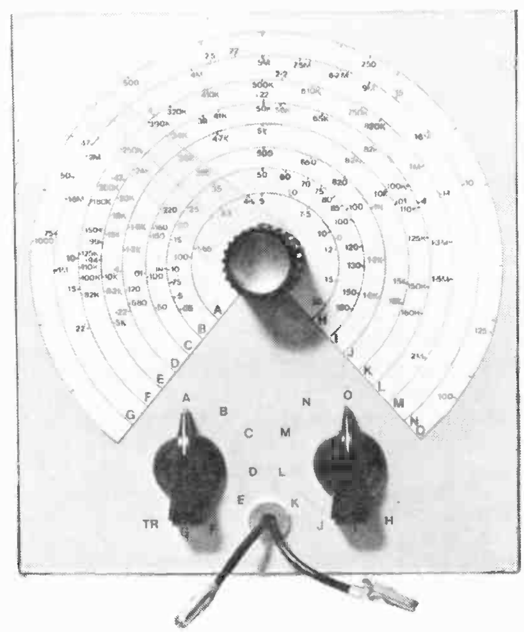
enables the output of the oscillator to be adjusted as required.

The prototype unit was constructed using the printed circuit board layout shown in Fig. 3 with the component overlay shown in Fig. 4. The unit which is connected to the bridge via 3·5mm jack plugs and sockets uses a screened lead and is powered by a PP3 battery.

CALIBRATION

After the unit has been assembled and checked the earphone should be plugged in and the AF generator connected and switched on. VR1 should be adjusted for maximum output and then VR2 adjusted so the output to the earphone is not excessive.

To calibrate the unit a wide range of close tolerance components are required. Starting at range A the upper and lower limits of each range should be marked on the



scaleplate by uitable value resistors in the test clips and adjusting VR1 until the bridge balances (when the output to the earphone is at minimum). The rest of the values can then be filled in. The null will not be so well defined on the higher ranges but the linear markings around the outside of the scale should make it easier to judge the effective null point. The capacitance ranges should be calibrated using the same method. The lettering on the scale is arranged so that the range letter is at the minimum end of the range. Resistor values increase clockwise and capacitor values anticlockwise. ★

News Briefs

by Mike Abbott

DATA ENCRYPTION UNIT

I'M SURE many readers will have been struggling for some time now, to get to grips with the bytes and bits of machine code and computer programs. Well, you've arrived just in time to be left behind again, because data encryption is here. Actually, this development shouldn't worry you unless you intend to tap confidential data lines for illicit purposes. A less impressive name for Intel's Data Encryption Unit would be data scrambler/unscrambler, and it is intended as a processing peripheral chip which prohibits "listening in" to confidential information in data form which is communicated using land lines.

Applications that immediately spring to mind are in inter-bank communication, military communications and inter-company confidential reports. The American National Bureau of Standards (NBS) have defined a Federal Information Data Encryption Standard, and Intel's new integrated circuit codes and decodes data in accordance with the NBS standard. The new chip, known as the 8294 Data Encryption Unit, has been approved by NBS.

The 8294 codes and decodes 64-bit blocks of data in accordance with a 56-bit user specified key (algorithm) to produce 64-bit cipher words. It is necessary to use the same key for both coding and decoding to produce intelligible information at the receiving end. This means that $2^{56}-1$ ways of encoding the data are provided. In other words, even with the services of a large and very fast computer, it would be virtually impossible for an unauthorised person to hit upon the right key.

The 8294 is designed to act as a peripheral chip in a processing system. The 56-bit key and the 64-bit message are transferred to the 8294 over the system data bus a byte at a time. A DMA interface and three interrupt outputs are available to minimise the software overhead associated with data transfer. With a DMA interface two or more 8294s may be used in parallel to achieve effective conversion rates which are virtually any multiple of 80 bytes per second. As a bonus, the 8294 has a general-purpose seven-bit TTL output port for user specified functions.

The 8294 operates from a 5V ± 10 per cent power supply and is based in a standard 40-pin package.

STATESIDE SCENE

I HAVE been fortunate this year that my work has taken me to New York on a couple of occasions. This has enabled me to take a quick look at the electronics hobby scene on the other side of the pond. To an outsider the market place seems to be dominated by Citizens Band radio and computers.

C.B.

The Citizens Band consists of a group of 40 channels around 27MHz set aside for private low power communication. Any U.S. national can apply for a licence and there is no test to pass. The equipment used usually runs about four watts on a.m., although s.s.b. is creeping in, and it is designed to be idiot proof. There are no tuning controls to set up, you just turn the knob to the required channel, adjust the volume as desired and press the button on the mike to speak.

Homebrew rigs are frowned upon, as are linear amplifiers. Prices range from just under 40 dollars for a mobile rig for the car to several hundred dollars for a microprocessor controlled, keyboard entry, band scanning, base station.

The system may have some faults, with a few million rigs in service there is bound to be some abuse, but it has a lot going for it too. It provides communication between home and the car and enables you to get traffic reports and directions from other drivers. It is reassuring to see a sign beside the road saying *"Nassau police monitor channel xx"*, allowing you to call for help in case of accident or emergency. The coastguard have also started to monitor one of the channels allowing small C.B. equipped boats to call for help in an emergency.

COMPUTERS

As far as home computers are concerned it seems to be a sellers market; they are selling like hot cakes. The demand is for machines with high level language with a good size memory, cassette recorder and/or floppy disc. When you consider that electronics prices in the U.S. are about half these over here and salaries over there are about three times ours, this gives the computer enthusiast in the States a 6–1 advantage over us in purchasing equipment. This means he can afford to skip the switch and l.e.d. machines and buy or build from a kit a relatively powerful machine.

For the kit builder the local Heathkit showrooms had the H8 and Heath/Dec 11 machines on display. The local computer shops stock various S100 bus compatible p.c.b. kits for memory, I/O, etc. and numerous mail order firms offer boards and card frames for this bus. There are various ready to use machines available via the computer shops and a bewildering array of books on software to get you started programming.

One machine that seems to be going to lead the field is the TRS80, retailed by the Radio Shack shops. The Radio Shack shops are not as their name might suggest ham radio shops, they sell hi-fi units, C.B. transceivers, car radios, tape players, etc. and now the TRS80 computer. As there are Radio Shack shops everywhere and each one seems to have one TRS80 in the window and a demonstration model inside, sheer weight of numbers should help the machine fight its way to the front. It also seems to be a rather nice machine *(The TRS80 is available from Tandy in the U.K.—Ed)*

It has the Z80 C.P.U., level 1 basic in 4K ROM, and 4K RAM. Level II basic and 16K RAM are available as an option, and there are printers, floppy discs, etc. available to order.

The computer section seems to be well served by magazines such as Kilobaud, Byte and Interface Age, etc. and there appears to be a thriving market in software offerings for the more popular machines, cassettes being available with games and maths programs from numerous sources.

RACING CARS

One interesting offering in the hobby shops was a radio controlled electric racing car with a single chip microprocessor in the transmitter and another one in the car. The method of encoding allows four cars to be raced together although the receivers in the cars are simple super-regen types. The frequency band it operates in is around 50MHz but it should be possible to use the sets at 27MHz with suitable mods. to the r.f. side.

I was lucky enough to visit a small exhibition put on by the Long Island Mobile Amateur Radio Club. The club is very active and they operate five repeaters on v.h.f. and above, one of them for TV. They put on quite a good show, with a couple of 2 metre stations, RTTY and slow scan using the ROBOT slow/fast scan convertor. Apparently repeaters are very thick on the ground in the area. I was told that there were 200 within a 70 mile radius of the Empire State building. This gives good coverage but interference between repeaters must be a problem!

Dave Coutts

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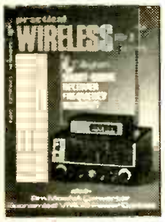

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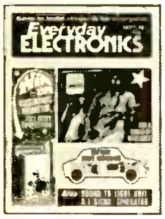

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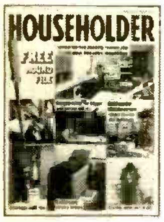

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INDUSTRY NOTEBOOK

By Nexus

The Great Debate (3)

One of the hazards of monthly comment is that of being overtaken by events. This has happened in the Great Debate. The philosophical impact of VLSI on life-style and attitudes on which I wrote two months ago still stand.

But since my comments last month on the practicality or otherwise of pushing Britain into the forefront of technology and large-scale production of VLSI circuits, there has been positive action, or at least some positive statements.

First came the news of INMOS, the completely new entrant in the field, backed by the National Enterprise Board and headed up by former Texas Instruments and Mostek employee Dr Richard Petritz, assisted by Dr Paul Schroeder, another ex-Mostek man, and Iann Barron, the British whizz-kid who founded Computer Technology some years ago and said to have been the mediator between Dick Petritz and the NEB.

Then, the well-ventilated rumour that GEC was seeking an arrangement with Fairchild was confirmed by a public statement that this was indeed the case and that a joint 50/50 GEC/Fairchild venture was going ahead.

INMOS will get £25 million of goverment backing initially, with another £25 million top-up, if necessary, later on. Headquarters will be in the UK but pilot production in the USA. Eventually, so it is claimed, INMOS will have a manufacturing plant in the UK employing 4,000 people in a depressed area. INMOS director Paul Schoeder is quoted, "We think we have the most exciting enterprise in the world."

GEC's move is more realistic. It involves a working capital of £20 million (GEC is flush with cash and will put up £10 million) and aims at a production rate of £40 million of product in the first full year in 1981. The plant will be set up in existing buildings and employ about 1,000 people, will be on-stream ahead of INMOS and using proven technology the plant will actually be producing in 1980. GEC Semiconductors, in more specialised products, will continue as a separate entity and will enjoy some of the goverment support channelled through the Department of Industry.

Good news indeed. But it doesn't take much imagination to see which of these two operations will be the more successful. Realism, the GEC approach, must be a better bet than optimism. Private cash is always spent more prudently than public cash. GEC/Fairchild is already in the business and has marketing outlets. Not to mention technology. And from the business point of view GEC's Sir Arnold Weinstock has an unparalleled track record in shrewd management.

Among the many handicaps facing INMOS is uncertainty. A change of goverment could kill the project stone dead before it gets beyond the planning stage. Powerful voices in industry regard INMOS plans as controversial, if not downright fanciful, and should the Conservatives be returned to power it is already clear that they would not encourage the establishment of any new state-backed enterprises that could become a future burden on the economy.

A factor which could affect both INMOS and the GEC/Fairchild venture and, for that matter, all the semiconductor industry in the UK is the availability of scientists and engineers. INMOS is reported to be seeking 800 graduates and development engineers. GEC/Fairchild will need 300 engineers and 150 technicians. If these, or a fair proportion of them, are milked from existing operations this could weaken the whole infrastructure of the established UK semiconductor industry. One thing is certain, that any semiconductor engineer worth his salt need never be in the dole queue.

Employment

Accompanying the immediate convenience of new microelectronic applications, welcome to most of us, is the unwelcome impact on employment. Yet another set of figures, this time from Plessey, underlines the downward trend. In financial years 1973/74 turnover was £400 million with a world total of 76,000 employees. In FY 1977/78 the figures were £611 million with only 58,700 employees. If the overseas employees are eliminated from the figures, the UK employment by Plessey has dropped from 50,600 to 43,600 in the past three years.

Plessey, of course, was particularly hard-hit by savage cut-backs in orders from the Post Office, but even allowing for that special circumstance the trend is obvious and will continue.

Economics

The economics of microcircuits are fascinating. A study by Marconi engineers points out that for a four-channel mobile radio you can break even in cost by using a frequency synthesiser rather than four separate crystals. For a ten-channel set, use of a synthesiser saves £25 per unit. The synthesiser, of course, only uses a single standard reference crystal. So on a ten-channel set there is a saving of nine crystals. The set-maker gets more profit, the set-user has a simplified and less costly spares holding, but the poor old crystal manufacturer loses 90 per cent of his business. Well, not quite, because mobile radio is still a big growth area with the world market increasing at over nine per cent a year.

Electronic Warfare

The hush-hush business of electronic warfare (EW) is flourishing as never before. Mostly kept under security wraps in the UK, a glimpse of happenings is occasionally allowed. Decca, for example, has over a dozen equipments of various types in production for detection, analysis and jamming of radar signals. A £2 million order is in hand for the Royal Danish Navy and another £8 million of Decca EW equipment will go into Lynx helicopters for the Royal Navy.

What makes EW such good business (and so expensive) is that every advance in technology needs a new countermeasure. Marconi Radar Systems, for example, has just announced a new mobile long-range air-defence radar, the very thing for the 1980s and 1990s. Called Martello, it has every refinement to beat the hostile jammers. But back-room boffins will rise to the challenge. Marconi is one of the biggest firms in EW and it is conceivable that while Martello was in development in one laboratory, another team of engineers next door was already working on how to defeat the system.

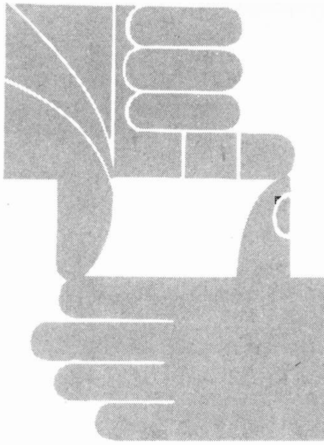
Video War

Discounts of up to 20 per cent are said to be offered by US dealers to shift home VTRs to a reluctant public. VTR sales in the USA have been only half those predicted. UK sales, however, have been as expected, according to manufacturers and dealers. But if stocks pile up in the USA it seems likely that surplus production could come to Europe and there could be some bargains in the shops, next year if not this.

TV Progress

The Matsushita factory in South Wales, opened only last year, is now stepping up production of National Panasonic colour TV sets to nearly 1,000 a week. The factory employs some 250 people.

Mullard is spending £24 million on up-dating TV tube production in the UK. The Department of Industry is helping with a £4·5 million handout. Mullard supply some 50 per cent of all tubes used in the UK and would like to supply as much as 75 per cent of the popular 22-inch size. Hopes that the tide of imports of TV tubes would be reduced by increased tariffs or import quotas are not bright. It looks therefore as if Mullard can increase market share only by intense price competition which would erode profits.



PATENTS REVIEW...

Copies of Patents can be obtained from :
the Patent Office Sales, St. Mary Cray, Orpington, Kent   Price 95p each

INCREASING SYNCHRONOUS MOTOR SPEED

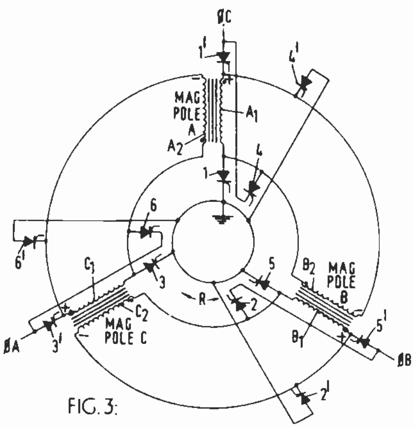


FIG. 3:

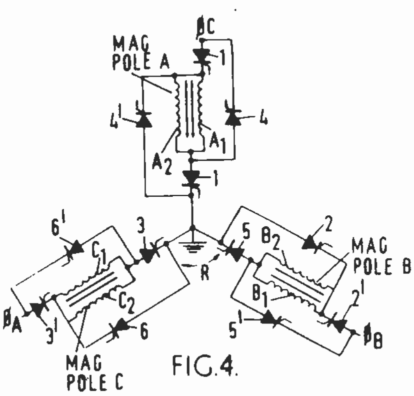


FIG.4.

Astro Dynamics of Massachusetts, USA have recently patented in BP 1 509 766 an intriguing proposal for producing high running speeds from a.c. motors, without the use of commutators, brushes, gear boxes or frequency changers.

Although the patent wording (originating from the USA) refers to 60Hz mains the principle of the invention is of course applicable to any mains frequency. On 60Hz mains the maximum running speed normally available from a synchronous motor is 3600rpm. The invention idea is to achieve higher speeds by using a three phase supply in a manner hitherto regarded as impossible.

It is, the inventors point out, an axiomatic rule for three phase power supply that two power phases must not be connected to the same load at the same time, since they differ in phase. The invention breaks this rule by the use of SCRs. The SCRs are triggered to switch on during the last half period of each phase, ideally the last 60 degrees before zero axis crossing where of course the SCR is automatically turned off again.

The motor poles are bifilar so that there are two windings around each pole, a first winding of each pole being used to pass the current from one phase and the other winding of the same pole used to pass the current from another phase. Figs. 1A, 1B and 1C show the manner in which each phase of the supply is chopped by the SCRs and figures 2A, 2B and 2C show the manner in which the chopped supply is fed to the windings on magnetic poles A, B and C respectively.

Thus the positive winding of the pole A receives its power from the C phase whereas the negative winding of the pole A obtains its power from the A phase. In similar fashion the windings of the magnetic pole B are powered by phases B and C and the windings for the pole C are powered by phases A and B. It follows that the individual magnetic poles share a different combination of excitation phases to produce 120Hz magnetomotive forces.

As the inventors point out the rules of three phase power supply, although apparently broken, are in fact observed. At no time are two phases of power applied to the same magnetic pole. For example phases A and C which are fed to pole A, are turned on alternately. To overcome the problems likely to result from current-lagging-voltage, the exact firing point of the SCRs needs careful selection.

The inventors claim to have modified and successfully operated a Westinghouse aircraft motor by re-winding it in bifilar manner. It is also suggested in passing that frequency tripling can be achieved by applying all three phases to each winding.

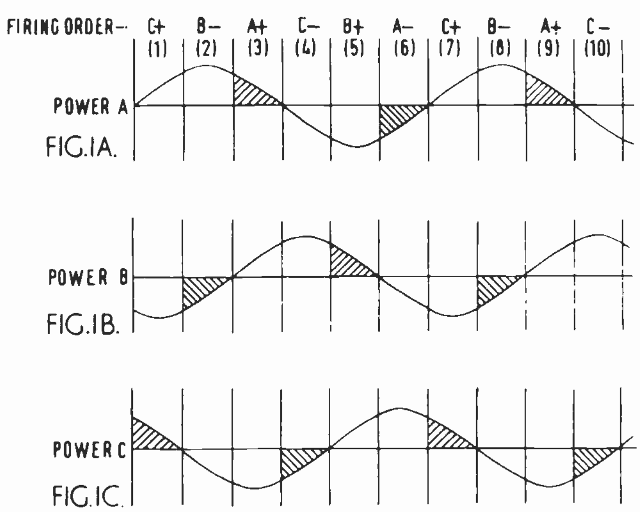


FIG.1A.
FIG.1B.
FIG.1C.

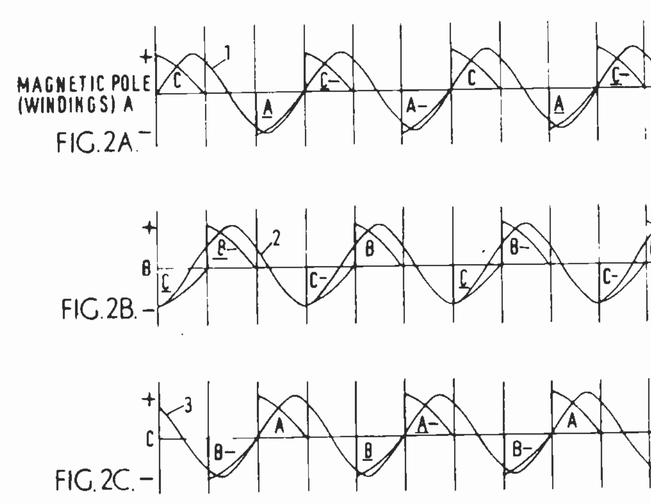


FIG.2A.
FIG.2B.
FIG.2C.

readout

... a selection from our postbag

Readers requiring a reply to any letter must include a stamped addressed envelope.
Opinions expressed in Readout are not necessarily endorsed by the publishers of Practical Electronics.

Another Range

Sir–Whilst attempting to construct the Linear Capacitance Meter, a few "deliberate mistakes", were found. After correcting these errors the instrument was tested and found to work correctly on all ranges, but 7 and 8 were found to be ×10 high.

To rectify this the 10MΩ resistor connected to S2b terminals 7 and 8 was disconnected, and terminals 7 and 8 were connected to 5 and 6 of S2b. This then brought ranges 7 and 8 into line with the others, i.e. in steps of ten. The switch used for the range selection has more than 8 positions, it was therefore decided to add another range: 1 volt = 10,000μF.

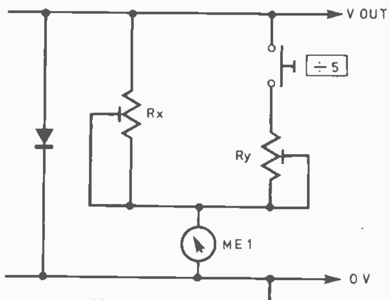
This was achieved by connecting terminal 8 of S2a to terminal 9 of S2a, and connecting the 10MΩ resistor that was removed from terminals 7 and 8 of S2b to terminal 9 of S2b.

A 50μA meter movement which was calibrated 0–5 has been used, hence the capacitance meter now has nine switched ranges:

(1) 500pF	=	1V/100pF
(2) 5nF	=	1V/1nF
(3) 50nF	=	1V/10nF
(4) 500nF	=	1V/100nF
(5) 5μF	=	1V/1μF
(6) 50μF	=	1V/10μF
(7) 500μF	=	1V/100μF
(8) 5,000μF	=	1V/1,000μF
(9) 50,000μF	=	1V/10,000μF

To increase the accuracy of the instrument a divide by 5 switch has been added as shown in the diagram. The switch used for this *must* be a push-to-make type so that it cannot be inadvertently left on, as this could lead to funny shaped meter pointers.

The meter multipliers used were miniature



$$Rx = \frac{V_{out}\,max}{Im} - Rm$$

$$\frac{Rx.Ry}{Rx + Ry} = \frac{0{\cdot}2\ V_{out}\,max}{Im} - Rm$$

Where: Im = meter f.s.d. current
and Rm = meter resistance

potentiometers. These were adjusted to obtain the correct reading on the moving coil meter, whilst observing the readout on a digital meter connected between V_{out} and 0V. The meter used to read this voltage must be a high impedance meter or an oscilloscope, not the "run of the mill" 20kΩ/V type.

This design has been proven by a friend of mine who has made the instrument incorporating the mods; needless to say he is highly delighted.

T. L. Woodger Reading.

Oh Yes!

Sir—I have just read "Readout" in P.E. October 1978 and find myself compelled to reply to R. E. Hurst's letter about pH. The concept of pH is a chemical one, and as a chemistry graduate I feel the pH scale must be looked at in context. The pH of a solution in equilibrium is equal to the negative logarithm of the hydrogen ion concentration i.e.

$$pH = -\log [H^+]$$

Using this expression the pH of a solution 1 molar in H^+ is in fact 0.

$$pH = -\log 1 = 0$$

All commercially available pH meters use a 0–14pH scale. As to R. E. Hurst's theory of "absolute acid" this is utter nonsense. If we were to push the theory to its limit a solution of 10 molar acid would have a pH of −1.

$$pH = -\log 10 = -1$$

Since concentrated acids are often stronger than 10 molar, even pH = −1 does not constitute "absolute acid". In short W. Hediger is quite correct in giving his pH meter a "0" on the scale and R. E. Hurst would do well to get his facts straight before going off the deep end over technicalities which have deeper roots than simple logarithm theory.

A. K. Strange, Grad R.I.C., F.Chem Soc
Bristol.

Okay!

Sir—When today I read what I had written in trying to make a simple point (No Oh! Readout, October 1978) my eyes nearly popped out. This is an object lesson in what can happen if you over simplify. My real point is that the logarithmic scale is an absolute with an origin which can be approached and conceived of but *never* reached. Log graduated scales disclose this, but scales which are linear because the log is used conceal the nature of the basis of the measurement. By omitting the "0" the nature of the underlying concept is shown.

Ugh! Mea culpa, mea maxima culpa. I hope the ancient alchemists will rest in peace.

R. E. Hurst
Blackpool.

(EnoupH, the matter is now at pH7—Ed.)

POINTS ARISING

TWO RANGE TIMER *(October 1978)*

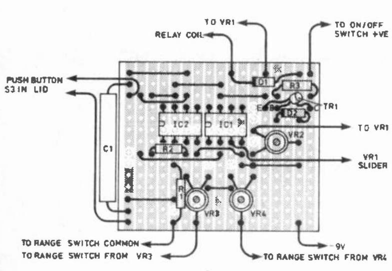


Fig. 2

FUMBLE NUDGE GAME *(April 1978)*
Resistor R23 appears correctly in the power supply diagram Fig. 5. It is shown incorrectly in the centre of the wiring diagram Fig. 6, where, in fact, IC2 pin 11 connects directly to IC11 pin 11.

KEYBOARD *(September 1978)*
Under "components", IC8 should be a 7474

METRONOME *(September 1978)*
Diode D3 should be 7·5V and not 5·1V.

CAR BURGLAR ALARM *(December 1977)*
Constructors still undertaking this project, and unable to obtain the capacitors specified for C1 and C4 should follow the author's recommendation, which is to obtain 100μF/16V tantalum bead capacitors from Watford Electronics and increase R6 and R8 to 150kΩ.

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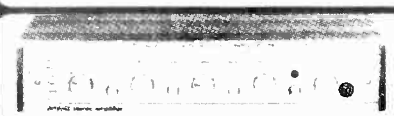

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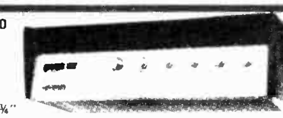

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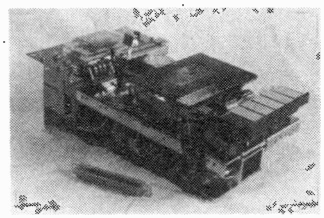

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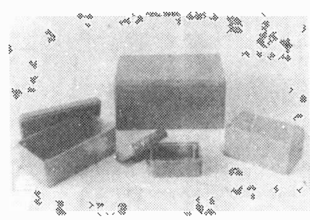

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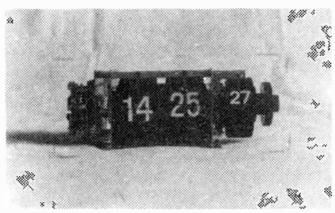

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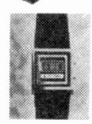

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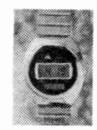

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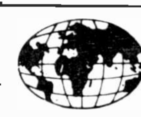

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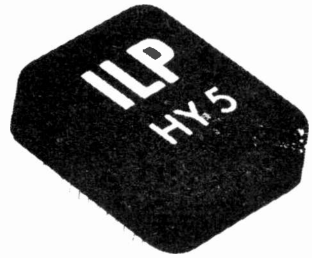
HY5
Preamplifier

The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (mag Cartridge, tuner, etc.) are catered for internally, the desired function is achieved either by a multi-way switch or direct connection to the appropiate pins. The internal volume and tone circuits merely require connecting to external potentiometers (not included). The HY5 is compatible with all I.L.P. power amplifiers and power supplies. To ease construction and mounting a P.C. connector is supplied with each pre-amplifier.

FEATURES: complete pre-amplifier in single pack, multi-function equalisation low noise low distortion high overload, two simply combined for stereo.
APPLICATIONS: hi-fi, mixers disco guitar and organ public address
SPECIFICATION: Inputs-magnetic pick-up 3mV, ceramic pick-up 30mV tuner 100mV microphone 10mV, auxiliary 3-100mV input impedance 47kΩ at 1kHz Outputs—tape 100mV, main output 500mV R M S Active Tone Controls—treble ±12dB at 10kHz, bass ±12dB at 100Hz Distortion—0 1% at 1kHz signal noise ratio 68dB Overload—38dB on magnetic pick-up Supply Voltage— ± 16-50V

Price **£6·27** + 78p VAT. P. & P. free
HY5 mounting board B.1. **48p** + 6p VAT. P. & P. free



HY30
15W into 8Ω

The HY30 is an exciting New kit from I L.P. It features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up to date technology available.

FEATURES: complete kit, low distortion short, open and thermal protection easy to build
APPLICATIONS: updating audio equipment guitar practice amplifier test amplifier, audio oscillator
SPECIFICATION: Output Power—15W R M S into 8Ω Distortion—0 1% at 15W Input Sensitivity—500mV Frequency Response—10Hz-16kHz −3dB

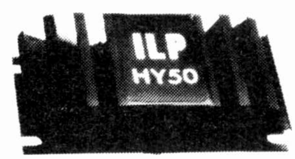
Price **£6·27** + 78p VAT. P. & P. free

HY50
25W into 8Ω

The HY50 leads I.L.P s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust High Fidelity modules in the World.

FEATURES: low distortion integral heatsink only five connections 7 amp output transistors no external components
APPLICATIONS: medium power hi-fi systems low power disco guitar amplifier
SPECIFICATION: Input Sensitivity—500mV Output Power—25W R M S into 8Ω Load Impedance—4-16Ω Distortion—0 04% at 25W at 1kHz Signal Noise Ratio—75dB Frequency Response—10Hz-45kHz −3dB Supply Voltage— ± 25V Size—105 × 50 × 25mm

Price **£8·18** + £1·02 VAT. P. & P. free

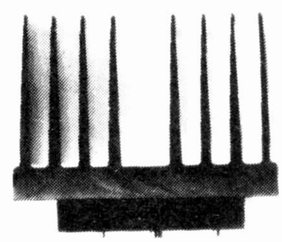


HY120
60W into 8Ω

The HY120 is the baby of I L.P s new high power range, designed to meet the most exacting requirements including load line and thermal protection this amplifier sets a new standard in modular design

FEATURES: very low distortion integral heatsink load line protection thermal protection five connections, no external components
APPLICATIONS: hi-fi high quality disco public address monitor amplifier guitar and organ
SPECIFICATION: Input Sensitivity—500mV Output Power −60W R M S into 8Ω Load Impedance—4-16Ω Distortion—0 04% at 60W at 1kHz Signal Noise Ratio—90dB Frequency Response—10Hz-45kHz −3dB Supply Voltage— ± 35V Size—114 × 50 × 85mm

Price **£19·01** + £1·52 VAT. P. & P. free



HY200
120W into 8Ω

The HY200 (now improved to give an output of 120 watts) has been designed to stand the most rugged conditions such as disco or group while still retaining true hi-fi performance.

FEATURES: thermal shutdown very low distortion load line protection integral heatsink no external components
APPLICATIONS: hi-fi disco monitor power slave industrial public address
SPECIFICATION: Input Sensitivity—500mV Output Power—120W R M S into 8Ω Load Impedance—4-16Ω Distortion—0 05% at 100W at 1kHz Signal Noise Ratio—96dB Frequency Response—10Hz-45kHz − 3dB Supply Voltage— ± 45V Size—114 × 50 × 85mm

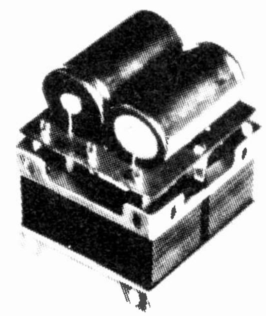
Price **£27·99** + £2·24 VAT. P. & P. free

HY400
240W into 4Ω

The HY400 is I L.P s Big Daddy of the range producing 240W into 4Ω! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module

FEATURES. thermal shutdown very low distortion load line protection no external components
APPLICATIONS: public address disco: power slave industrial
SPECIFICATION: Output Power—240W R M S into 4Ω Load Impedance—4-16Ω Distortion—0 1% at 240W at 1kHz Signal Noise Ratio—94dB Frequency Response—10Hz-45kHz −3dB Supply Voltage — ± 45V Input Sensitivity—500mV Size—114 × 100 × 85mm

Price **£38·61** + £3·09 VAT. P. & P. free



POWER SUPPLIES: PSU36—suitable for two HY30s **£6·44** + 81p VAT. P. & P. free. **PSU50**—suitable for two HY50s **£8·18** + £1·02 VAT. P. & P. free. **PSU70**—suitable for two HY120s **£14·58** + £1·17 VAT. P. & P. free. **PSU90**—suitable for one HY200 **£15·19** + £1·21 VAT. P. & P. free. **PSU180**—suitable for two HY200s or one HY400 **£25·42** + £2·03. VAT. P. & P. free.

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2N697	0.31	2N2219A	0.39	2N3438	0.85	2N4064	1.35	2N5248	0.44	40411	3.10					BC214C	0.17	BC549C	0.15	BD244C	0.87	BF183	0.44	BFY50	0.27	MJE521	0.70
2N698	0.49	2N2220	0.39	2N3440	0.75	2N4074	2.65	2N5294	0.44	40594	0.87	BC147	0.13	BC182B	0.13	BC214L	0.18	BC557	0.14	BD245A	0.69	BF184	0.41	BFY51	0.27	MJE2955	1.65
2N699	0.58	2N2221	0.25	2N3441	0.92	2N4121	0.27	2N5295	0.44	40595	0.98	BC147B	0.13	BC182L	0.15	BC214LB	0.18	BC558	0.13	BD245C	0.85	BF185	0.37	BFY52	0.27	MPF3055	1.05
2N706	0.30	2N2221A	0.25	2N3442	1.45	2N4122	0.27	2N5298	0.44	40673	0.80	BC148	0.13	BC182LA	0.15	BC214LC	0.18	BC559	0.15	BD246A	0.72	BF194	0.16	BFY90	1.35	MPF102	0.33
2N706A	0.30	2N2222	0.25	2N3638	0.17	2N4123	0.19	2N5298	0.44	40669	1.30	BC148B	0.13	BC182LB	0.15	BC237B	0.15	BCY70	0.21	BD246C	0.93	BF195	0.16	BR101	0.55	MPF103	0.44
2N708	0.30	2N2222A	0.25	2N3638A	0.17	2N4124	0.19	2N5447	0.16	AC126	0.48	BC148C	0.13	BC183	0.12	BC238A	0.13	BCY71	0.26	BD433	0.44	BF196	0.16	BRY39	0.55	MPF104	0.44
2N718	0.30	2N2369	0.27	2N3702	0.14	2N4125	0.19	2N5448	0.16	AC127	0.48	BC149	0.15	BC183A	0.12	BC238B	0.13	BCY72	0.18	BD434	0.46	BF197	0.18	BSX19	0.35	MPS105	0.44
2N718A	0.54	2N2369A	0.27	2N3703	0.14	2N4126	0.19	2N5449	0.20	AC128	0.48	BC149C	0.15	BC183B	0.13	BC238C	0.13	BD115	0.88	BD435	0.46	BF198	0.19	BSX20	0.35	MPSA05	0.27
2N720A	0.85	2N2646	0.80	2N3704	0.14	2N4284	0.38	2N5457	0.38	AC151	0.43	BC157A	0.15	BC183C	0.13	BC239B	0.16	BD131	0.55	BD436	0.46	BF199	0.19	BSX21	0.35	MPSA06	0.27
2N722	0.45	2N2647	1.55	2N3705	0.14	2N4286	0.22	2N5458	0.35	AC152	0.54	BC158A	0.15	BC183L	0.15	BC239C	0.17	BD132	0.75	BD437	0.55	BF224J	0.22	BU104	1.80	MPSA12	0.44
2N727	0.50	2N2903	1.60	2N3706	0.14	2N4287	0.22	2N5459	0.32	AC153	0.59	BC158B	0.15	BC183LA	0.15	BC257A	0.18	BD135	0.40	BD438	0.55	BF225J	0.27	BU105	1.55	MPSA14	0.33
2N914	0.38	2N2904	0.31	2N3707	0.14	2N4288	0.22	2N5460	0.65	AC153K	0.59	BC159A	0.17	BC183LB	0.15	BC258B	0.19	BD136	0.40	BD529	0.49	BF244A	0.38	BU126	1.08	MPSA55	0.27
2N916	0.33	2N2904A	0.31	2N3708	0.12	2N4289	0.22	2N5484	0.37	AC176K	0.70	BC159B	0.17	BC183LC	0.15	BC259B	0.19	BD137	0.41	BD530	0.55	BF244B	0.33	BU204	2.20	MPSA56	0.27
2N917	0.38	2N2905	0.31	2N3709	0.12	2N4347	2.20	2N5485	0.40	AC176	0.54	BC160	0.38	BC184	0.12	BC300	0.43	BD138	0.41	BD535	0.70	BF245A	0.44	BU205	2.40	R2008B	2.45
2N918	0.45	2N2905A	0.31	2N3771	2.16	2N4348	2.65	2N5486	0.40	AC187	0.59	BC161	0.38	BC184B	0.13	BC301	0.43	BD139	0.43	BD536	0.70	BF245B	0.44	BU206	2.70	R2010B	2.15
2N929	0.37	2N2906	0.25	2N3772	2.20	2N4918	0.65	2N5490	0.64	AC187K	0.65	BC167	0.13	BC184C	0.13	BC302	0.37	BD140	0.43	BD537	0.74	BF257	0.35	BU208	2.70	TIP29A	0.49
2N929A	0.37	2N2906A	0.25	2N3773	3.15	2N4919	0.70	2N5492	0.64	AC188	0.54	BC167B	0.13	BC184L	0.15	BC303	0.54	BD181	1.90	BD538	0.77	BF258	0.35	ME0401	0.22	TIP29C	0.65
2N930	0.37	2N2907	0.25	2N3819	0.36	2N4920	0.83	2N5494	0.65	AC188K	0.65	BC168A	0.13	BC184LB	0.15	BC307	0.16	BD182	2.20	BD539	0.60	BF259	0.35	ME0402	0.22	TIP30A	0.54
2N930A	0.95	2N2907A	0.25	2N3820	0.39	2N4921	0.54	2N5496	0.67	AD161	1.00	BC168B	0.13	BC184LC	0.15	BC307A	0.16	BD183	2.35	BD540	0.60	BF336	0.42	ME0404	0.17	TIP30C	0.70
2N1711	0.30	2N2923	0.17	2N3821	0.96	2N4922	0.60	2N6027	0.64	AD162	1.00	BC168C	0.13	BC212	0.15	BC307B	0.16	BD187	0.95	BDX14	1.32	BF337	0.49	ME0412	0.22	TIP31A	0.54
2N1889	0.30	2N2924	0.17	2N3900	0.28	2N4923	0.75	2N6107	0.45	AF106	0.60	BC169B	0.13	BC212A	0.15	BC308	0.16	BD235	0.46	BDX18	1.90	BF338	0.52	ME0414	0.22	TIP31C	0.72
2N1890	0.30	2N2925	0.19	2N3901	0.30	2N4924	1.15	2N6108	0.55	AF109	0.52	BC169C	0.13	BC212B	0.15	BC308B	0.16	BD236	0.44	BDY20	1.10	BFR39	0.30	ME4001	0.16	TIP32A	0.59
2N1893	0.30	2N2926	0.17	2N3903	0.20	2N5086	0.30	2N6109	0.55	BC107	0.16	BC177	0.22	BC212L	0.18	BC309A	0.16	BD237	0.44	BDY55	1.90	BFR40	0.29	ME4002	0.16	TIP32C	0.82
2N2102	0.50	2N3053	0.25	2N3904	0.18	2N5087	0.30	2N6111	0.49	BC107A	0.16	BC177A	0.22	BC212LA	0.18	BC309B	0.16	BD238	0.44	BDY56	2.10	BFR41	0.30	ME4003	0.16	TIP41A	0.76
2N2192	0.58	2N3054	0.72	2N3905	0.18	2N5088	0.30	2N6121	0.41	BC107B	0.16	BC177B	0.25	BC212LB	0.18	BC309C	0.16	BD239A	0.44	BF115	0.39	BFR79	0.30	ME4101	0.11	TIP41C	0.97
2N2193	0.50	2N3055	0.75	2N3906	0.18	2N5089	0.30	2N6122	0.44	BC108	0.16	BC178	0.22	BC213	0.15	BC327	0.22	BD239C	0.59	BF160	0.33	BFR80	0.30	ME4102	0.11	TIP42A	0.86
2N2193A	0.52	2N3390	0.50	2N4031	0.55	2N5190	0.65	2N6123	0.48	BC108A	0.16	BC178A	0.25	BC213A	0.15	BC328	0.20	BD240A	0.49	BF161	0.65	BFR81	0.30	ME4103	0.11	TIP42C	1.08
2N2194	0.42	2N3391	0.40	2N4032	0.65	2N5191	0.75	2N6124	0.45	BC108B	0.16	BC178B	0.35	BC213B	0.15	BC337	0.20	BD240C	0.59	BF167	0.37	BFX29	0.34	ME4104	0.11	TIP2955	0.70
2N2194A	0.45	2N3391A	0.45	2N4036	0.72	2N5192	0.80	2N6125	0.47	BC108C	0.17	BC179	0.25	BC213C	0.15	BC338	0.23	BD241A	0.49	BF173	0.37	BFX30	0.34	ME6101	0.22	TIP3055	0.59
2N2195	0.40	2N3392	0.17	2N4037	0.60	2N5193	0.75	40361	0.55	BC109	0.16	BC179A	0.25	BC213L	0.17	BC547	0.13	BD241C	0.65	BF177	0.27	BFX84	0.30	ME6102	0.22	TIS34	1.05
2N2195A	0.40	2N3393	0.17	2N4058	0.22	2N5194	0.80	40362	0.55	BC109B	0.17	BC179B	0.25	BC213LA	0.17	BC547A	0.13	BD242A	0.55	BF178	0.27	BFX85	0.38	MJ2955	1.35	TIS42	0.50
2N2217	0.55	2N3394	0.17	2N4059	0.17	2N5195	0.97	40363	1.45	BC109C	0.18	BC179C	0.26	BC213LB	0.17	BC547B	0.13	BD242C	0.62	BF179	0.33	BFX86	0.30	MJE340	0.62	TIS43	0.47
2N2218	0.35	2N3395	0.19	2N4060	0.22	2N5245	0.37	40408	0.82	BC140	0.30	BC182	0.12	BC213LC	0.17	BC548	0.13	BD243A	0.65	BF180	0.37	BFX87	0.35	MJE370	0.62	TIS90	0.22
2N2218A	0.38	2N3396	0.19	2N4061	0.19	2N5246	0.38	40409	0.82	BC141	0.32	BC182A	0.12	BC214	0.17	BC549	0.14	BD243C	0.87	BF181	0.37	BFX88	0.30	MJE371	0.86	TIS91	0.27

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CA3018	0.75	LM379S	4.25	LM324	0.75	TAA930B	1.45
CA3018A	1.10	LM380N8	0.96	LM7815K	1.75	TAD100	2.00
CA3020	2.20	LM380N14		LM7824K	1.75	TBA120	0.80
CA3020A	2.50		1.08	LM78L05CZ		TBA500	2.24
CA3028A	0.90	LM381AN	2.70		0.30	TBA5000	2.34
CA3028B	1.25	LM381N	1.69	LM78L12CZ		TBA510	2.35
CA3030	1.50	LM382N	1.32		0.30	TBA5100	2.48
CA3030A	2.20	LM384N	1.55	LM78L15CZ		TBA520	2.60
CA3038	2.90	LM386N	0.88		0.30	TBA520D	2.70
CA3038A	4.10	LM387N	1.10	MM5314	4.60	TBA530	2.35
CA3045	1.55	LM388N	1.00	MM5316	4.60	TBA530Q	2.45
CA3046	0.77	LM389N	1.00	NE555	0.33	TBA540	2.60
CA3048	2.45	LM702C	0.81	NE556	0.85	TBA540Q	2.70
CA3052	1.78	LM709	0.70	NE558N	1.98	TBA550	3.60
CA3080	0.85	LM7098	0.50	NE560	4.50	TBA550Q	3.80
CA3080A	2.10	LM70914	0.49	NE561	4.50	TBA5600D	3.00
CA3086	0.50	LM710	0.67	NE562	4.50	TBA570	2.10
CA3088B	1.87	LM71014	0.64	NE565	1.39	TBA570Q	2.20
CA3089B	2.90	LM711CN	0.72	NE566	1.75	TBA700Q	2.20
CA3090Q	4.40	LM723C	0.75	NE567	1.90	TBA720AQ	2.06
CA3130	1.06	LM723C14	0.45	NE571N	4.95	TBA750	2.36
CA3140	1.04	LM726	5.80	SAS560	2.70	TBA750Q	2.45
LM301	0.30	LM741C	0.70	SAS570	2.70	TBA800	1.30
LM307N	0.50	LM741C8	0.30	SAJ110	2.10	TBA810S	1.30
LM308N	0.95	LM741C14	0.30	S041P	1.35	TBA820	0.80
LM309KC	1.95	LM747CN	0.99	S042P	1.35	TBA920	2.99
LM317K	3.35	LM7488	0.50	SN76001N		TCA160C	2.36
LM318N	2.45	LM74814	0.90		1.30	TCA160B	2.55
LM320TS	2.15	LM1303N	1.15	SN76003N		TCA270	2.99
LM320T12	2.15	LM1304N	1.52		2.38	TCA730	4.50
LM320T15	2.15	LM1305N	1.52	SN76013N		TCA740	4.50
LM320T24	2.15	LM1307N	1.22		1.50	TCA750	3.00
LM320P5	1.15	LM1310N	2.10	SN76023N		TCA760	2.00
LM320P12	1.15	LM1351N	1.30		1.50	TCA105	1.49
LM320P15	1.15	LM1458N	0.45	SN76033N		TCA440	1.65
LM320P24	1.15	LM1496N	0.97		2.35	TDA1022	7.50
LM323K	6.95	LM1808N	2.10	TAA263	1.35	TDA1024	1.24
LM339N	0.60	LM1812N	6.20	TAA300	3.70	TDA1034	4.75
LM340T5	0.88	LM1820N	1.16	TAA320A	1.15	TDA2020A0	
LM340T15	0.88	LM1828N	1.90	TAA350A	3.00		4.50
LM340T24	0.88	LM1830N	1.90	TAA521	1.10	UAA170	2.15
LM341P5	0.80	LM1841N	1.90	TAA522	2.10	UAA180	2.15
LM341P12	0.80	LM1845N	1.50	TAA550	0.48	TL080CP	1.25
LM341P15	0.80	LM1848N	1.98	TAA560	2.10	TL081CP	0.90
LM341P24	0.80	LM1850N	1.90	TAA570	2.20	TL082CP	1.10
LM348N	0.95	LM1889N	4.90	TAA370A	5.45	TL083CN	1.40
LM358N	0.60	LM3301N	0.60	TAA630	2.40	TL084CN	1.45
LM360N	3.00	LM3302N	0.55	TAA960	3.90	LF355N	0.80
LM370N	3.30	LM3401N	0.55	TAA970	4.20	LF356N	0.80
LM371H	2.35	LM3900N	0.68	TAA611B	2.50	LF357N	0.80
LM350K	6.45	LM3905N	1.15	TAA621	2.50	LF13201N	3.00
LM373N	3.35	LM3909N	0.78	TAA661A	1.65	LF13331N	3.00
LM374N	3.36	LM3911N	1.10	TAA661B	1.45	LF13741H	0.80
LM377N	1.80	LM7805K	1.75	TAA700	4.50	LF13741N	0.55
LM378N	2.40	LM7812K	1.75	TAA930A	1.45		

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4011B	0.22	4024B	0.76	4044	1.00	4059	6.00	4077	0.70	4510B	1.20
4012	0.22	4025B	0.22	4045	1.76	4060B	1.15	4078	0.27	4511	1.75
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74LS30N	0.26	74C00N	0.24	7413N	0.36	74122N	0.55
74LS37N	0.32	74C02N	0.24	7414N	0.80	74123N	0.55
74LS38N	0.32	74C04N	0.24	7416N	0.36	74125N	0.45
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74LS54N	0.26	74C42N	0.92	7432N	0.30	74154N	1.20
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74LS91N	1.20	74C86N	0.64	7446AN	0.90	74164N	1.36
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74LS124N	2.70	74C157N	2.21	7472N	0.30	74182N	0.80
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74LS158N	0.65	74C192N	1.11	7485N	1.36	74197N	1.00
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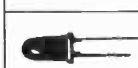

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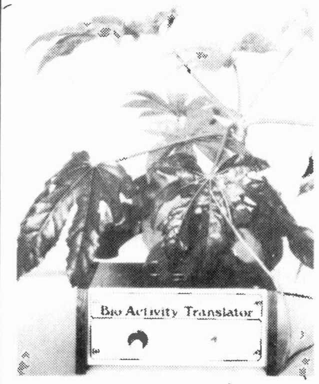
LISTEN TO THE SECRET WORLD OF PLANTS

As featured on Horizon, Nationwide, Radio & Worldwide Press

First time in the U.K. in Kit Form, the revolutionary concept of a Biological Amplifier & Sound Synthesiser in one unit, the *Amazing*

Bio Activity Translator™.



- Experience the unique Musical Form of Plants
- Hear the beautiful patterns of sound created by their natural response
- Compare house plants' reactions to people – with the distinct tunes of those outside
- Easy to operate, internal speaker & batteries

The naturally generated Bio Electric potential across a plant leaf is picked up by 2 carbon foam electrodes. When amplified and filtered, a VCO, VCA and other exclusive synthesiser circuits are programmed by the control voltage from the plant to produce tracking sequences of notes. These follow in pitch, rhythm and volume the ever changing signal from the plant.
The kit includes 6 I.C's, 3 transistors, all high quality components, tinned and drilled fibre glass P.C.B., loudspeaker and comprehensive assembly instructions. Also included is a free case, ready punched, with wooden end cheeks and stick on silkscreened front panel for a really professional finish.
Runs on 2 × 4½ volt batteries (not supplied).

SPECIAL INTRODUCTORY OFFER INCLUDES FREE CASE
KIT £19.90 ASSEMBLED AND TESTED £27.50 PRICE INCLUDES P & P AND VAT

Allow 14 days for delivery. Send Cheque or Postal Order to:

JEREMY LORD SYNTHESISERS, (Dept PE)
7 London Stile, London W.4.

TRANSISTORS	p		p
ACY 20	34	*BF 198	17
ASY 66	90	BF 200	26
BC 107	8	BF 257	26
BC 108	8	BF 258/9	24
*BC 147/A	8	BF 324	28
*BC 148	8	*BF 336	28
*BC 149/C	8	*BF 337	30
*BC 158	9	*BFR 80	25
*BC 171A	10	BFY 50	1
*BC 207B	11	BSX 19/20	16
BC 348	11	BT 106	130
BC 351	10	*BU 205	150
BCY 70	14	*BU 208	160
BCY 71	14	*BU 208A	175
BCY 72	14	MJE 340	43
BD 115	43	MJE 520	43
BD 131	33	OC 201	70
BD 135	34	TIP 31A	38
BD 139	33	TIP 42A	62
BD 695A	65	*ZTX 212/B	16
BD 696A	65	*ZTX 302	11
BF 115	18	*ZTX 502	12
BF 185	24	2N 930	16
*BF 194	9	2N 3053	20
*BF 195	9	2N 3055	50
*BF 197	11	*2N 3703	8
		*2N 3705	8

DIODES	p
*AA 119	6
*BY 127	10
1N 4001/2	4
1N 4004/5	5
1N4006/7	6
*1S 44	4
*1S 940	4
*1S 941	4

LINEAR I.C.'s	p
741 8P	19
555 8P	25

REGULATORS	p
7812	60
7815	60

TTL	p		p
7400	13	7413	30
74L00	24	7420	15
7401	13	7427	27
7404	14	7430	15
74L04	27	7440	15
7405	14	7445	80
7408	17	7472	25
7409	17	7473	30
		74L73	49
		7474	27
		74L74	43
		7476	30
		7480	45
		7482	69
		7483	72
		7490	33
		7491	75
		74L91	145
		7493	32
		7495	60
		7496	57
		74100	95
		74107	29
		74121	25
		74123	48
		74151	64
		74190	100

W/W RESISTORS	p
2.5W Axial	10
5W Radial	9
10W Axial	9
15W Radial	10

BARGAIN PAKS
ALL ITEMS NEW & MARKED

***PAK 1** 100 Gen Purpose Transistors including. BC 149, 2N 3703, etc **£5.00**
PAK 2 20 Transistors including. BF 115, BD 131, etc **£5.50**
PAK 3 100 Mixed W/W Resistors including 2.5W, 5W, 10W, etc **£3.50**
PAK 4 100 off 74 series with Pre-formed Pins including. 7440 7430, etc **£4.00**
***PAK 5** 100 Gen purpose Diodes including 1S 44, 1S 941 etc **£2**

Quantity Discounts Available Min Order £2.00, P & P 30p VAT please add 8% except those marked * which are 12.5%
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All prices quoted include VAT. Add 25p UK/BFPO Postage. Most orders despatched on day of receipt. SAE with enquiries please. MINIMUM ORDER VALUE £1. Official orders accepted from schools, etc. (Minimum invoice charge £5). Export/Wholesale enquiries welcome. Wholesale list now available for bona-fide traders. Surplus components always wanted.

EXPERIMENTERS CALCULATOR

Based on the C500 chip, this pack of parts enables the more experienced constructor to make an 8 digit 4 function calculator. The comprehensive data supplied includes full size layout of PCB required, types of suitable display and keyboard that can be used etc. Components included in the pack are C500 calculator chip, driver IC, all components for inverter/clock circuits, R's C's etc. All for only **£3·50.**

RELAYS

W847 Low profile PC mntg 10×33×20mm 6V coil, SPCO 3A contacts. **93p**
W832 Sub. min type, 10×19×10mm 12V coil DPCO 2A contacts **£1·15**
W701 6V SPCO 1A contacts 20×30×25mm Only **56p**
W817 11 pin plug in relay, rated 24V ac, but works well on 6V DC. Contacts 3 pole c/o rated 10A. **95p**
W819 12V 125OR DPCO 1A contacts. Size 29×22×18mm, min plug-in type **72p**
W839 50V ac (24V DC) coil. 11 pin plug in type, 3 pole c/o 10A contacts Only **85p**
W846 Open construction mains relay, 3 sets 10A c/o contacts. **£1·20**
Send SAE for our relay list – 84 types listed and illustrated.

AMPLIFIER KIT £1·75

Mono gen. purpose amp with tone and Vol/on-off controls. Utilizes sim. circuitry to above amp. Output 2W into 8 ohms. Input matched for crystal cartridge. 4 transistor circuit. Simple to build on PCB provided. Can be either battery or mains operated. (For mains powered version add **£2·20** for suitable transformer.) Blue vinyl covered aluminium case to suit (W372) **£1·30**

STEREO AMPLIFIER CHASSIS £5·50

Complete and ready built. Controls: bass, treble, volume/on-off, balance. 8 transistor circuit gives 2 watts per channel output. Just needs transformer and speakers for low cost stereo amp. Suitable metal cabinet (W374) **£2·00** – or buy the amp, case and transformer for **£10·00** and get DIN speaker sockets and knobs free!!

TMS4030 RAM

4096 bit dynamic RAM with 300ns access time; 470ns cycle time; single low capacitance high level clock i/p; Fully TTL compatible; Low power dissipation. Supplied with data **£2·75**

MISCELLANEOUS IC's

Supplied with data if requested. MC3302 quad comp. **120p**; 710 diff comp. (TO99) **40p**; ZN1034E precision timer **£2·25**; LM711 Dual diff comp **65p**; LM1303 dual stereo pre-amp **75p**; MC1469R voltage reg **£1·50**; UPC1025H audio **£3·50**; 575C2 audio **£2·88**; TDA2640 audio **£2·92**; SN75110 dual line driver **70p**; MC8500 CRCC gen POA

EDGE CONNECTORS

Special purchase of these 0·1" pitch double-sided gold-plated connectors enables us to offer them at less than one-third of their original price!
18 way **41p**; 32 way **72p**; 40 way **90p**.

HEAT SINK OFFER

Copper TO5 sink 17mm dia × 20mm. 10 for **40p**; 100 for **£3**; 1000 for **£25**

74 SERIES PACK

Selection of boards containing many different 74 series IC's. 20 for **£1**; 50 for **£2.20**; 100 for **£4.**

THE NEW 1978-9 GREENWELD *CATALOGUE*

FEATURES INCLUDE:

- 50p Discount Vouchers
- Quantity prices for bulk buyers
- Bargain List Supplement
- Reply Paid Envelope
- Priority Order Form
- VAT inclusive prices

PRICE **30p** + 15p POST

AIR FRESHENER KIT

As featured in Nov EE. Complete kit inc. case and instructions. Only **£7.95** + 55p p & p.

BC182B OFFER

Special Offer for quantity users 1k .035 VAT; 5k .032 VAT. Price negotiable on 10k. Approx 70k available.

DIODE SCOOP!!!

We have been fortunate to obtain a large quantity of untested, mostly unmarked glass silicon diodes. Testing a sample batch revealed about 70% useable devices – signal diodes, high voltage rects and zeners may all be included. These are being offered at the incredibly low price of **£1·25**/1000 – or a bag of 2500 for **£2·25.** Bag of 10,000 **£8.** Box of 25,000 **£17·50.** Box of 100,000 **£60.**

POLYTHENE SHEET

Size 36 x 18" 200g. Hundreds of uses around the home. 100 sheets for **£1.50.** Box of 1500 for **£19.**

PC ETCHING KIT MK III

Now contains 200 sq. ins. copper clad board, 1lb. Ferric Chloride, DALO etch-resist pen, abrasive cleaner, two miniature drill bits, etching dish and instructions. **£4·25**

BUY A COMPLETE RANGE OF COMPONENTS AND THESE PACKS WILL HELP YOU

- ★ ***SAVE ON TIME—No delays in waiting for parts to come or shops to open!***
- ★ ***SAVE ON MONEY—Bulk buying means lowest prices—just compare with others!***
- ★ ***HAVE THE RIGHT PART—No guesswork or substitution necessary!***

ALL PACKS CONTAIN FULL SPEC, BRAND NEW, MARKED DEVICES— SENT BY RETURN OF POST. VAT INCLUSIVE PRICES.

K001 50V ceramic plate capacitors, 5%. 10 of each value 22pF to 1000pF. Total 210. **£3·35**
K002 Extended range, 22pF to 0·1μF. 330 values **£4·90**
K003 Polyester capacitors, 10 each of these values: 0·01, 0·015, 0·022, 0·033, 0·047, 0·068, 0·1, 0·15, 0·22, 0·33, 0·47μF. 110 altogether for **£4·75**
K004 Mylar capacitors, min 100V type. 10 each all values from 1000pF to 10,000pF Total 130 for **£3·75**
K005 Polystyrene capacitors, 10 each value from 10pF to 10,000pF, E12 series 5% 160V. Total 370 for **£12·30**
K006 Tantalum bead capacitors. 10 each of the following: 0·1, 0·15, 0·22, 0·33, 0·47, 0·68, 1, 2·2, 3·3, 4·7, 6·8, all 35V; 10/25 15/16 22/16 33/10 47/6 100/3. Total 170 tants for **£14·20**
K007 Electrolytic capacitors 25V working, small physical size. 10 each of these popular values: 1, 2·2, 4·7, 10, 22, 47, 100μF Total 70 for **£3·50**
K008 Extended range, as above, also including 220, 470 and 1000μF. Total 100 for **£5·90**
K021 Miniature carbon film 5% resistors, CR25 or similar. 10 of each value from 10R to 1M, E12 series. Total 610 resistors. **£6·00**
K022 Extended range, total 850 resistors from 1R to 10M **£8·30**
K041 Zener diodes, 400mW 5% BZY88, etc. 10 of each value from 2·7V to 36V, E24 series. Total 280 for **£15·30.**
K042 As above but 5 of each value **£8·70**

TRANSFORMERS

All mains primary: 12-0-12V 50mA **85p;** 100mA **95p;** 1A **£2.50.** 6-0-6V 100mA **85p;** 1½A **£2.40.** 9-0-9V 75mA **85p;** 1A **£2.10.** Multitapped type 0-12-15-20-24-30V, 1A **£3.95;** 2A **£5.35;** 3A **£6.90.** 20V 2½A **£3.90;** 25V 1½A **£2.25;** 12V 8A **£4;** 24V 5A **£7.50;** 0-22-34-41V 4A **£7.50;** 20V @ 300mA twice **£2.50;** 12V @ 250mA twice **£2.00.**

ALL PRICES INCLUDE VAT & P/P   CATALOGUE 40p
MIN ORDER £2.00

THE COMPONENT CENTRE

7 LANGLEY ROAD - WATFORD - HERTS - WD1 3PS

Phone Watford 45335 *Callers welcome* **9.30-5.30 Mon-Sat. EC. Wed.**

TRANSISTORS

AC126	21p	BC547	14p	MJ2955	99p
AC127	21p	BC548	14p	MJE340	64p
AC128	21p	BC549	14p	MJE2955	99p
AC176	21p	BC557	14p	MJE3055	68p
AC187	23p	BCY34	74p	OC28	108p
AC188	23p	BCY70	17p	OC35	108p
AD149	65p	BCY71	20p	OC71	19p
AD161	50p	BCY72	17p	OC84	46p
AD162	50p	BD115	59p	TIP29	50p
AF114	30p	BD124	97p	TIP30	52p
AF115	27p	BD131	47p	TIP31	59p
AF116	25p	BD132	47p	TIP32	59p
AF117	23p	BD135	43p	TIP33	107p
AF118	30p	BD136	50p	TIP34	60p
AF124	32p	BD137	50p	TIP35	253p
AF125	32p	BD138	51p	TIP36	389p
AF126	32p	BD139	51p	TIP41	59p
AF139	40p	BD140	52p	TIP42	59p
AF239	45p	BF173	30p	TIP2955	126p
BC107	9p	BF179	37p	TIP3055	64p
BC108	9p	BF180	37p	ZTX108	12p
BC109	9p	BF181	37p	ZTX300	12p
BC147	10p	BF182	37p	ZTX500	12p
BC148	10p	BF183	37p	2N1305	25p
BC149	10p	BF194	13p	2N1306	39p
BC157	11p	BF195	13p	2N1711	21p
BC158	11p	BF196	13p	2N2219	21p
BC159	11p	BF197	16p	2N2904	26p
BC168	12p	BF200	36p	2N2905	26p
BC169	12p	BF224	16p	2N2906	20p
BC171	12p	BF257	37p	2N2926G	9p
BC172	12p	BF258	40p	2N2926R	9p
BC173	12p	BF259	44p	2N2955	99p
BC177	16p	BFR39	30p	2N3053	17p
BC178	16p	BFX29	34p	2N3054	54p
BC179	16p	BFX30	38p	2N3055	54p
BC182L	13p	BFX84	27p	2N3702	10p
BC183L	11p	BFX85	29p	2N703	10p
BC184L	13p	BFX86	31p	2N3704	12p
BC212L	13p	BFX87	31p	2N3705	12p
BC213L	13p	BFX88	29p	2N3706	12p
BC214L	14p	BFY50	17p	2N3708	12p
BC238	14p	BFY51	17p	2N3709	11p
BC303	30p	BSX20	21p	2N3711	10p
BC328	15p	BU105	191p	TIS43	40p
BC338	15p	BU208	299p	2N2646	56p

S.C.R. THYRISTORS

1A/50V	28p	5A/400V	59p	10A/400V	70p
1A/200V	38p	5A/600V	75p	10A/600V	83p
1A/400V	40p	5A/800V	82p	10A/800V	129p
1A/600V	58p	7A/100V	59p	16A/100V	63p
3A/100V	36p	7A/200V	68p	16A/200V	67p
3A/200V	38p	7A/400V	120p	16A/400V	82p
3A/400V	51p	7A/600V	123p	16A/600V	115p

DIODES

BY127	16p
OA47	9p
OA70	9p
OA79	14p
OA81	15p
OA85	14p
OA91	7p
OA95	9p
OA200	9p
OA202	9p
IN914	4p
IN916	6p
IN4001	6p
IN4002	6p
IN4003	6p
IN4004	7p
IN4005	10p
IN4006	10p
IN4007	11p
3A-50V	16p
3A-100V	16p
3A-200V	18p
3A-400V	20p
3A-600V	25p
10A-50V	25p
10A-100V	25p
10A-200V	28p
10A-400V	36p
10A-600V	42p

BRIDGE RECS

1A 50V	22p
1A 100V	24p
1A 200V	27p
1A 400V	30p
1A 600V	34p
2A 50V	34p
2A 100V	36p
2A 200V	38p
2A 400V	40p
2A 600V	42p

TRIACS

2A 100V	26p
2A 200V	42p
2A 400V	71p
6A 100V	50p
6A 200V	66p
6A 400V	81p
10A 100V	68p
10A 200V	100p
10A 400V	113p
10A 400V Plas.	130p

LINEAR I.C's

CA3011	86p
CA3014	190p
CA3018	86p
CA3020	174p
CA3023	186p
CA3028	85p
CA3030	120p
CA3035	190p
CA3036	115p
CA3042	198p
CA3045	275p
CA3046	90p
CA3048	205p
CA3049	154p
CA3052	152p
CA3054	73p
CA3078	136p
CA3080	57p
CA3081	148p
CA3086	47p
CA3090	329p
CA3130E	113p
CA3140E	74p
CA3160E	140p
LM301	39p
LM308	54p
LM380	106p
LM381	120p
LM710	41p
LM741	24p
LM747	73p
LM748	36p
LM3900	73p
MC1304	292p
MC1310	197p
MC1458	78p
MC1496	78p
NE555	33p
NE556	76p
NE561	385p
NE562	385p
NE565	138p
NE566	126p
NE567	175p
SN76003	185p
SN76013	185p
SN76023	160p
SN76033	259p
TAA621	257p
TAA661	175p
TBA540	236p
TBA641	281p
TBA800	102p
TBA810	113p
TBA820	90p

C.-MOS / T.T.L.

C.-MOS		T.T.L.	
4000	16p	7400	13p
4001	18p	7401	15p
4002	18p	7402	16p
4006	110p	7403	17p
4007	20p	7404	22p
4008	97p	7405	22p
4009	62p	7406	44p
4010	62p	7407	44p
4011	19p	7408	22p
4012	20p	7409	23p
4013	59p	7410	16p
4014	108p	7411	24p
4015	97p	7412	24p
4016	59p	7413	38p
4017	99p	7414	66p
4018	99p	7416	33p
4019	65p	7417	33p
4020	119p	7420	18p
4021	99p	7425	28p
4022	94p	7427	28p
4023	21p	7430	20p
4024	83p	7432	28p
4025	20p	7437	29p
4026	190p	7441	74p
4027	59p	7442	74p
4028	96p	7445	123p
4029	118p	7446	123p
4030	62p	7447	102p
4031	249p	7448	130p
4032	108p	7454	19p
4033	157p	7470	39p
4035	130p	7472	28p
4041	87p	7473	39p
4042	85p	7474	33p
4043	99p	7475	48p
4044	96p	7476	40p
4045	150p	7480	46p
4046	131p	7482	91p
4047	95p	7483	90p
4049	65p	7485	106p
4050	65p	7486	36p
4054	120p	7489	399p
4055	140p	7490	57p
4056	140p	7491	82p
4060	117p	7492	57p
4066	70p	7493	57p
4067	410p	7494	83p
4068	24p	7495	70p
4069	22p	7496	83p
4070	60p	74100	130p
4071	22p	74107	36p
4072	23p	74118	125p
4076	167p	74121	38p
4077	65p	74122	55p
4078	24p	74123	103p
4081	23p	74144	345p
4082	23p	74145	83p
4086	24p	74153	62p
4501	19p	74154	138p
4502	130p	74165	115p
4507	59p	74174	132p
4510	132p	74175	79p
4516	132p	74180	85p
4518	114p	74181	295p
4519	60p	74192	131p
4532	138p	74193	131p
4539	119p	74198	185p

D.I.L. SOCKETS

8 pin	10p	16 pin	14p
14 pin	13p	28 pin	30p

OPTO

TIL209	Red	14p
TIL209	Yellow	24p
TIL209	Green	24p
·2	Red	18p
·2	Yellow	30p
·2	Green	30p
TIL209 Clip		4p
·2 Clip		5p

NEONS

Red	39p
Green	39p
Amber	39p
Neon Bulb	20p

RESISTORS

0·3 watt 10Ω to 1MΩ E24	2p
0·5 watt 10Ω to 10MΩ E24	2½p
2·5 watt 0·22Ω to 10Ω w/w	23p
5 watt 4·7Ω to 10KΩ w/w	12p
10 watt 10Ω to 10KΩ w/w	15p

POTENTIOMETERS

1KΩ-2MΩ S/gang Lin-Log	27p
5KΩ-2MΩ S/gang Switch Log	55p
5KΩ-2MΩ D/gang Lin-Log	70p

SLIDERS

5KΩ-500KΩ S/G Lin-Log	73p
5KΩ-500KΩ D/G Lin-Log	88p
Presets sub. min. 100Ω-5MΩ	10p
Slider Bezzels	21p
Slider knobs	10p

CAPACITORS

Min ceramic
22 pf to 3300 pf — 4p each

SWITCHES

Large	SPST	27p
Toggle	SPDT	29p
	DPDT	35p
STD	SPST	66p
Toggle	SPDT	70p
	DPDT	75p
Min	SPST	54p
Toggle	SPDT	58p
	DPDT	70p
C. off	DPDT	90p
Sub. min.	SPST	48p
Toggle	SPDT	52p
	DPDT	60p
Push button	SPST	60p
	SPDT	69p
	DPDT	91p
Bias push make		15p
Bias push brake		20p
Slide sub.min.	DPDT	13p
Slide std.	DPDT	13p
Slide C. off	DPDT	15p

ROTARY (Adjustable stop)

1P/2-12 way   2P/2-6 way
3P/2-4 way   4P/2-3 way
Price each 46p

LOUDSPEAKERS

1½in	8Ω	72p
1¾in	8Ω	72p
2in	8Ω	72p
2¼in	8Ω	64p
2½in	8Ω	64p
2½in	64Ω	72p
2¾in	8Ω	76p
2¾in	80Ω	118p

TRANSFORMERS

Mains prim 220-240V

6-0-6	100M/A	93p
9-0-9	75M/A	97p
12-0-12	100M/A	99p
0-6-0-6	280M/A	150p
0-12-0-12	150M/A	150p
6-0-6	1·5A	345p
9-0-9	1A	280p
9-0-9	2A	398p
12-0-12	1A	317p
15-0-15	1A	350p
20-0-20	2A	544p
25-0-25	2A	585p
30-0-30	2A	625p
12V	2A	367p

Antex X2 5 watt Iron	385p
Antex C2 15 watt Iron	385p
Antex CX 15 watt Iron	385p
Antex stand	155p
Desoldering gun	640p
Spare nozzle	90p
PP3 Batt clips	6p
PP9 Batt clips	10p
Ferric chloride	95p
Etching pen	81p
Etching kit	245p
Telephone pickup coil	70p
Ear piece std.	16p
Ear piece crystal	33p
Speaker cloth, black 36in x 25in	120p

COMP. KIT

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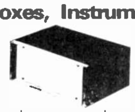

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PRIMARY 220-240 VOLTS

Ref	Amps 12V	Amps 24V	£	P & P
111	0 5	0 25	2 20	0 45
213	1 0	0 5	2 64	0 78
71	2	1	3.51	0 78
18	4	2	4 03	0 96
70	6	3	5 35	0 96
108	8	4	6 98	1 14
72	10	5	7 67	1 14
116	12	6	8 99	1 32
17	16	8	10 39	1 32
115	20	10	13 18	2 08
187	30	15	17 05	2 08
226	60	30	26 82	OA

50 VOLT RANGE
Prim 220/240V Sec 0-20-25-33-40-50V. Voltages available 5, 7, 8, 10, 13, 15, 17, 20, 33, 40 or 20V-0-20V 25V-0-25V.

Ref	Amps	£	P & P
102	0 5	3 41	0 78
103	1 0	4 57	0 96
104	2 0	6 98	1 14
105	3 0	8 45	1 32
106	4 0	10 70	1 50
107	6 0	14 62	1 64
118	8 0	17 05	2 08
119	10 0	21 70	OA

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PRIM 120/240V SEC 120/240V CT TAPPED

Ref	VA (Watts)	£	P & P
07*	20	4 40	0 79
149	60	6 20	0 96
150	100	7 13	1 14
151	200	11 16	1 50
152	250	12 79	1 84
153	350	16 28	1 84
154	500	19 15	2 15
155	750	29 06	OA
156	1000	37 20	OA
157	1500	45 60	OA
158	2000	54 80	OA
159	3000	79 05	OA

*Please specify 115 or 240V required

HIGH VOLTAGE ISOLATORS
Prim 200/220V or 400/440V
Sec 110/120V CT or 200/240 CT

Va	Ref	£	P & P
60	243	5 89	1 32
350	247	14 11	1 84
1000	250	41·76	OA
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30 VOLT RANGE
Prim 220/240V Sec 0-12-15-20-24-30V. Voltages available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or 12V-0-12V, 15V-0-15V

Ref	Amps	£	P & P
112	0 5	2 64	0·78
79	1 0	3 57	0 96
3	2 0	5 27	0 96
20	3·0	6·20	1 14
21	4 0	7·44	1 14
51	5 0	8 37	1 32
117	6 0	9 92	1 45
88	8 0	11 73	1 64
89	10 0	13 33	1 84

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Prim 220/240V Sec 0-24-30-40-48-60V. Voltages available 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60V or 24V-0-24V, or 30V-0-30V.

Ref	Amps	£	P & P
124	0 5	3 88	0 96
126	1 0	5 58	0 96
127	2 0	7 60	1 14
125	3 0	10 54	1 32
123	4 0	12 23	1 84
40	5 0	13 95	1 64
120	6 0	15 66	1 84
121	8 0	20 15	OA
122	10 0	24 03	OA
189	12 0	27 13	OA

AUTO TRANSFORMERS

Ref	VA (Watts)		£	P & P
113	15	0·115·210·240	2·48	0·71
64	75	0·115·210·240	3·95	0·96
4	150	0 115·200·220·240	5·35	0·96
67	500	0·115·200·220·240	10·99	1·64
84	1000	0 115·200·220·240	18·76	2 08
93	1500	0 115·200·220·240	23·36	0A
95	2000	0·115·200·220·240	34·82	0A
73	3000	0·115 200·220·240	48 00	0A
80S	4000	0 10 115-200·220·240	67·50	0A
57S	5000	0 10·115·200·220·240	77·48	0A

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VA	£	P & P	Ref
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75	6·03	1·14	64W
150	8 48	1 14	4W
200	9 92	1 45	65W
250	10 49	1 45	69W
500	15 73	1 64	67W
750	18 55	1 76	83W
1000	23·50	OA	84W
1500	26·02	OA	93W
2000	37 65	OA	95W

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Ref	mA	Volts	£	P&P
238	200	3-0-3	1 99	0·55
212	1A, 1A	0-6, 0-6	2 85	0 78
13	100	9-0-9	2 14	0·38
235	330, 330	0-9, 0-9	1 99	0 38
207	500, 500	0-8-9-, 0-8-9	2 59	0 71
208	1A, 1A	0-8-9, 0-8-9	3 53	0 78
236	200, 200	0-15, 0-15	1 99	0 38
214	300, 300	0-20, 0-20	2 56	0 78
221	700 (DC)	20-12-0-12-20	3 41	0 78
206	1A, 1A	0-15-20-0-15-20	4 63	0 96
203	500, 500	0-15-27-0-15-27	3 99	0 96
204	1A, 1A	0-15-27-0-15-27	5 39	0 96
239	50	12-0-12	1 99	0·38

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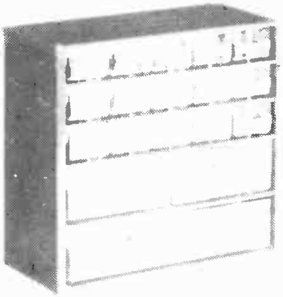

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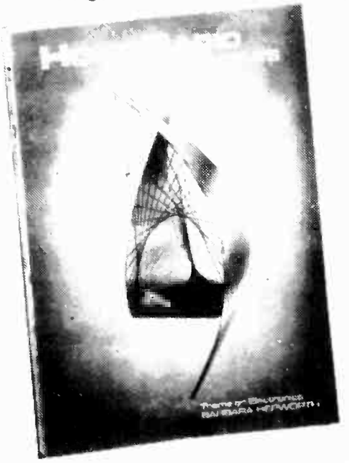

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2N2222A	20p
2N2369A	16p
2N2484	30p
2N2646	50p
2N2904/5	25p
2N2906A	24p
2N2907A	30p
*2N2926	9p
2N3053	20p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
*2N3565	30p
*2N3643/4	48p
*2N3663	30p
*2N3702/3	12p
*2N3704/5	12p
*2N3706/7	12p
*2N3708/9	12p
*2N3773	300p
*2N3819	25p

*2N3820	50p
2N3823	70p
2N3866	90p
*2N3903/4	18p
*2N3905/6	20p
*2N4036	65p
*2N4058/9	12p
*2N4060	12p
*2N4061/2	18p
*2N4123/4	22p
*2N4125/6	22p
*2N4401/3	27p
2N4427	90p
*2N4871	60p
*2N5087	27p
*2N5089	27p
*2N5172	27p
2N5179	27p
2N5191	83p
2N5194	90p
*2N5245	40p
*2N5296	55p
*2N5401	50p
*2N5457/8	40p
*2N5459	40p
*2N5460	40p
*2N5485	44p
*2N6027	48p
2N6247	190p
2N6254	130p
2N6290	65p
2N6292	65p
3N128	120p
3N140	100p
3N201	110p
3N204	100p
40290	250p
40360	40p
40361/2	45p
40364	120p
40408	70p
40409	65p
40410	65p
40411	300p
40594	97p
40595	105p
40603	58p
40673	75p
40841	90p
40871/2	90p

MEMORIES

2102	100p
2102-2	125p
2107B	600p
2111-2	325p
2112-2	300p
2114	1500p
5101	510p
6810	400p

ROM/PROMs

74S188	225p
74S287	400p
74S387	400p
93427	400p
93436	650p
93446	650p

AY5-1013	450p
AY5-2376	1000p
RO3-2513	600p
SN74S262	1450p
TMS6011	450p

EPROMS

1702A	500p
2708	900p
2716	3000p
4702	900p

CPUs

4040A	670p
8502	1200p
6800	900p
8080A	600p

OTHER

3205	320p
3245	400p
4201	390p
4289	970p
4801	500p
6820	600p
6850	700p
8205	320p
8212	225p
8216	225p
8224	400p
8228	575p
8251	700p
8255	550p
9905	200p
9906	275p

DIODES

*BY127	12p
*OA47	9p
*OA81	15p
*OA85	15p
*OA90	9p
*OA91	9p
*OA95	9p
*OA200	9p
*OA202	10p
*1N914	4p
*1N916	7p
*1S920	8p
*1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5401/3	14p
1N5404/7	19p

***ZENERS**

2.7V-33V	
400 mW	9p
1W	15p

CRYSTALS

100 KHz	300p
1 MHz	370p
3.2768 MHz	350p

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16 pin	55p
24 pin	80p
28 pin	100p
40 pin	120p

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*1A	50V	21p
*1A	100V	22p
*1A	400V	30p
*2A	50V	30p
*2A	100V	35p
*2A	400V	45p
*3A	200V	60p
*3A	600V	72p
*4A	100V	95p
*4A	400V	100p
6A	50V	90p
6A	100V	100p
6A	400V	120p
10A	400V	200p
25A	400V	400p

TRIACS PLASTIC

3A	400V	60p
3A	500V	65p
6A	400V	70p
6A	500V	88p
8A	400V	75p
8A	500V	95p
12A	400V	85p
12A	500V	105p
16A	400V	110p
16A	500V	130p
T2700D		120p
T2800D		120p

THYRISTORS

1A	50V	40p
1A	400V	65p
1A	600V	70p
3A	400V	90p
8A	600V	140p
12A	400V	160p
16A	100V	160p
16A	400V	180p
16A	600V	220p
BT106		110p
C106D		45p
*MCR101		36p
2N3525		120p
2N4444		140p
*2N5060		34p
*2N5064		40p

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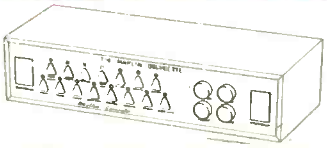

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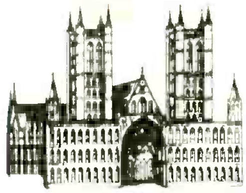

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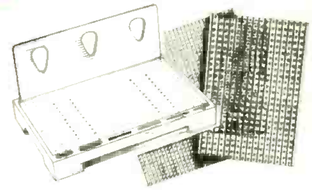

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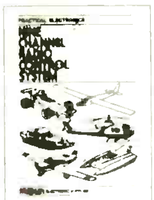

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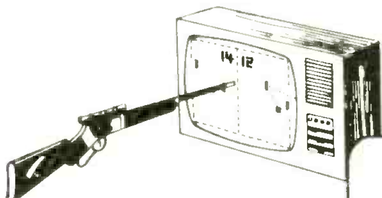

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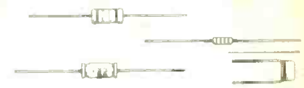

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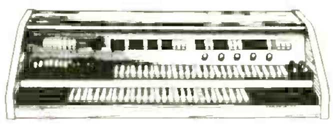

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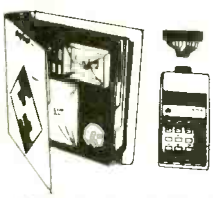

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