

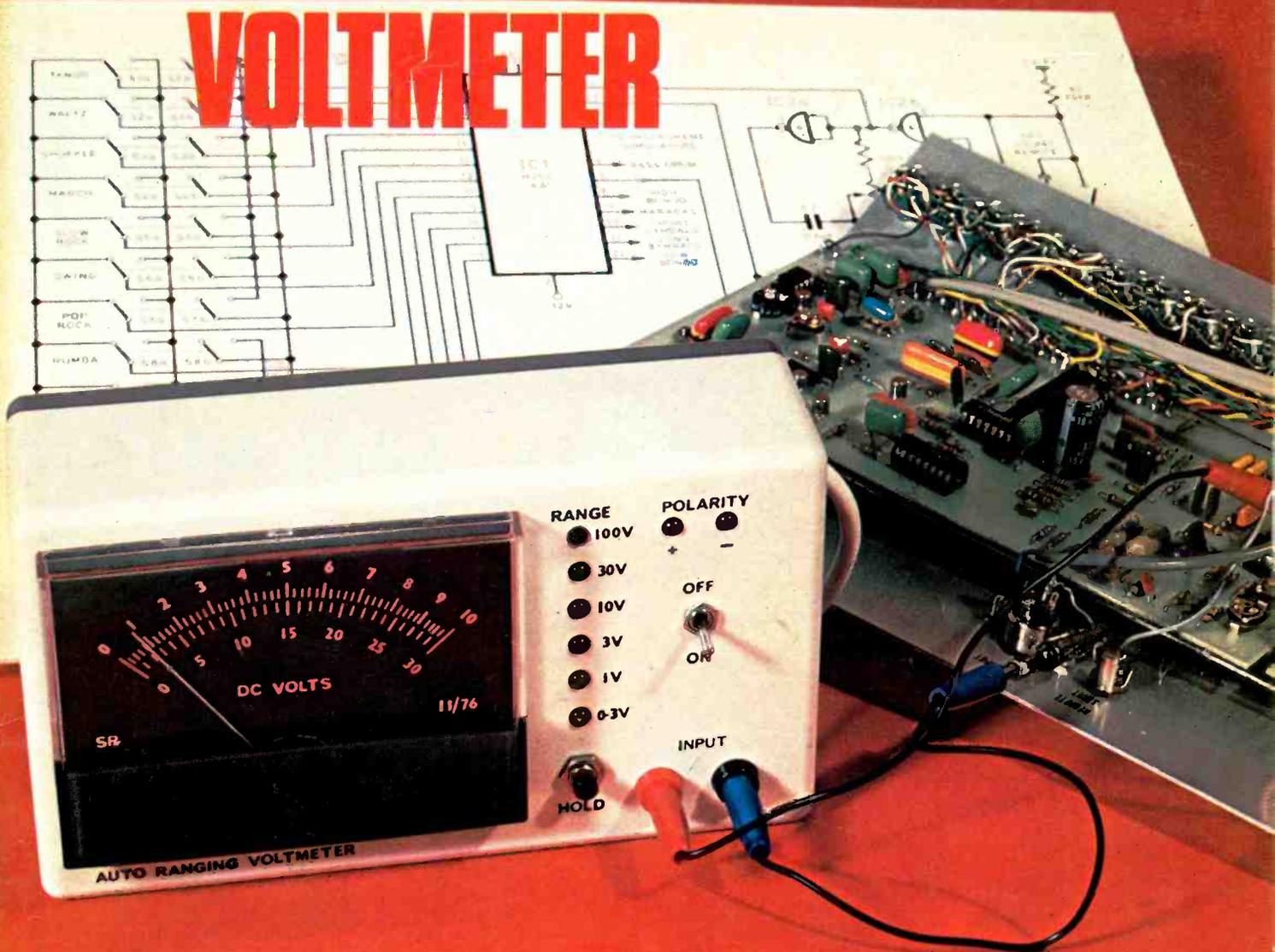
PRACTICAL

ELECTRONICS

FEBRUARY 1978

45p

AUTO RANGING VOLTMETER



ALSO INSIDE...

KIM Hobby Computer Review

Part 2 of our New FAULT FINDING Series

WATFORD ELECTRONICS

33 CARDIFF ROAD, WATFORD, HERTS., ENGLAND
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POLYESTER CAPACITORS: Axial lead type. (Values are in µF)
400V: 0.001, 0.0015, 0.0022, 0.0033 8p; 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 33p; 0.68, 45p.
160V: 0.039, 0.15, 0.22 13p; 0.33, 0.47 22p; 0.68, 1.0 22p; 1.5 33p; 2.2 39p; 4.7 47p.
DUBILIER: 1000V: 0.01, 0.015 16p; 0.022 18p; 0.047 16p; 0.1 34p; 0.47 43p.

POLYESTER RADIAL LEAD (Values in µF) 250V:
0-01 0.015 6p; 0-022 0.027 7p; 0-033, 0.047, 0.068, 0.1 8p; 0-15 12p; 0-22, 0.33 14p; 0-47 16p; 0-68 20p; 1-0 24p; 1-5 27p; 2-2 31p.

ELECTROLYTIC CAPACITORS: Axial lead type (Values are in µF)
63V: 0.47 1.0 1.5 2.2 2.5 3.3 4.7 5.6 8.0 10 15 22 29p; 47 32 50 12p; 63 100 27p; 50V: 100 7p; 50 100 22p 25p; 470 50p; 1000 2200 68p; 40V: 22 33 9p; 100 12 3300 62p; 4700 64p; 35V: 10 33 7p; 330 47 32p; 1000 49p; 25V: 10 22 47 6p; 80 100 160 8p; 220 250 13p; 470 640 25p; 1000 27p; 1500 30p; 2000 34p; 3300 52p; 4700 54p; 16V: 10 40 47 68 7p; 100 125 8p; 220 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 55p; 325V: 200 + 100 + 50 + 100 190p.

TANTALUM BEAD CAPACITORS
35V: 0.1µF, 0.22, 0.33, 0.47, 0.68 1p
1.0 2.2µF, 3.3, 4.7 68 25V: 1.5, 1.0 20V: 1.5 16V: 10µF 13p each
10V: 22µF, 33 47 68: 47 68 100 3V: 68, 100µF 20p each

POTENTIOMETERS (AB or EGEN)
Carbon Track, 1/8W Log & 1/8W Linear values
1KΩ & 2KΩ (lin only) Single gang 28p
5KΩ-20KΩ single gang 55p
5KΩ-20KΩ single gang D/P switch 26p
5KΩ-20KΩ dual gang stereo 70p

FEED THROUGH CAPACITORS
100µF 350V 8p

MYLAR FILM CAPACITORS
100V: 0.001, 0.002, 0.005, 0.01µF 5p
0.015, 0.02, 0.04, 0.05, 0.056µF 6p
0.1µF 0.15, 0.22 7p 50V: 0.47µF 10p

SLIDER POTENTIOMETERS
0.25W Log and linear values 60mm
5KΩ-50KΩ single gang 70p
10KΩ-50KΩ dual gang 80p
Self Stick Dialed Bezels 20p

OPTO ELECTRONICS*
LEDs - chip
TIL209 Red 13
TIL211 Gm 27
ORP12 Yellow 27
T110 2M
2 Red 17
2 Yellow Green 21
OCF10 46
2N5777 54
7 Seg Displays
TIL312 C An 3 125
TIL313 C Ch 3 125
TIL321 C An 5 130
TIL322 C Ch 5 130
DL704 C A 99
DL707 C A 99
DL747 C A 180
FND 357 140
DR ZERS
75491 75492 85

CERAMIC CAPACITORS
0.5pF to 10nF
15nF 22nF 33nF 47nF
0.1µF

PRESET POTENTIOMETERS
0.1W 50Ω - 50MΩ Miniature
Vertical & Horizontal
0.25W 100Ω - 3MΩ Horiz
0.25W 200Ω - 4.7MΩ Vert

RESISTORS - Eric make 5% Carbon
Miniature High Stability Low noise

CERAMIC TRIMMER CAPACITORS
2.7pF 4.15pF 6.25pF 8.30pF 20p

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We stock thousands more items. Please send a large SAE for our free list.

SWITCHES*
TOGGLE 2A 250V
SPST 26p
DPDT 34p
4 pole on/off 58p
SP - MIN TOGGLE
SP changeover 59p
SPST on/off 54p
DPDT Centre off 92p
DPDT Biased 115p
SLIDE 250V
1A DPO 14p
1A DP C/over 16p
1A DPDT 13p
4 pole on/off 24p
PUSH BUTTON
Spring loaded
SPST on/off 55p
SPDT on/off 65p
DPDT 6 Tag 85p

MINIATURE TYPE TRIMMERS
2.5-6pF 3-10pF 10-40pF
5-25pF 5-45pF 60pF 88pF

JACK PLUGS
Screened chrome Plastic body open metal moulded with ferric chloride*
2.5mm 12p 8p 8p 8p
3.5mm 15p 10p 8p 10p
MONO 23p 15p 10p 24p
STEREO 31p 18p 15p 24p

SOCKETS
In Line
2 Pin Loudspeaker 13p
2.5 Pin Audio 8p
CO-AXIAL (TV) 14p
PHONO assorted colours 9p
Metal Screened 10p
BANANA 4mm 12p
2mm 10p
1mm 8p
WANDER 3mm 9p

CO-AXIAL (TV) 14p

SWITCHES * Miniature Non-Locking
Push to Make 15p
ROCKER (white) 10A 250V 28p
SP changeover centre off
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 42p

DIL SOCKETS* (Low Profile - Texas)
8 pin 10p; 14 pin 12p; 16 pin 13p; 18 pin 20p; 20 pin 26p; 24 pin 30p; 28 pin 42p; 40 pin 58p.

PHONO assorted colours 9p
Metal Screened 10p

DIAGRAM
DALO ETCH Resist Pen Spare Tip 75p*

COPPER BOARDS*
Fibre Glass Single Sided 6x6 78p
6x12 130p
S R B P
8 x 10 70p

BANANA 4mm 12p
2mm 10p
1mm 8p
WANDER 3mm 9p

VOLTAGE REGULATORS
723C 48p
TA6258 95p
TO3 Can
1A 5V 170p
1A 12V 180p
1A 15V 190p
1A 18V 210p
LM323K 625p
1A - 5V 220p
1A - 12V 220p

PLASTIC
1A 5V 118p
1A 12V 118p
1A 15V 120p
1A 18V 125p
1A 24V 130p
0.1A 5V 51p
0.1A 6V 51p
0.1A 8V 51p
0.1A 12V 51p
0.1A 15V 51p

SPECIAL OFFER

TV GAMES
"Olympic Kit" £20.80*
"Olympic" Colour Kit £28.50* (p&p insured add 95p)
EconoGame Kit £8.99*
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"Sure Fire Rifle" Kit for "Olympic" Game £8.50*
"Sure Fire Rifle" Kit for other makes £9.25* (p&p insured add 48p)
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IC AY-3-8500 £4.50*
IC AY-3-8550 £7.50*
IC AY-3-8600 £9.00*
(TV Games & Rhythm Gen. Demonstration on at our shop)

RHYTHM GENERATOR
Build this PE (Jan. '78) Easy-build Low cost Rhythm Generator. We are the sole suppliers of the complete Kit including the case, pre-drilled printed front panel and the printed Circuit Boards.
Complete Kit price incl. VAT £49.95 only. P & P £1.10 insured. Send S.A.E. for descriptive leaflet.



SPECIAL ADDITIONAL DISCOUNTS ON OUR LOW PRICED TEXAS TTL - MOTOROLA CMOS. Due to massive purchases we are now able to offer the following discounts on published prices.
LESS 5% 10- mixed
LESS 7½% 25- mixed
LESS 10% 50- mixed
LESS 15% 75- mixed
LESS 20% 100- mixed
even more discount on larger quantities.

TTL 74*		CMOS*		LINEAR IC'S		M253AA*	
7400	7483 95	75491	75 4053 89	4450	295 4512	98 4527	152
7401	14 7484 95	75492	80 4054 120	4451	295 4512	98 4527	152
7402	16 7485 110		4055 134	4490F	695 4514	265 4529	165
7403	16 7486 320		4056 2570	4490V	625 4515	299 4530	85
7404	20 7490 36		4000 15 4057 480	4501	17 4516	125 4531	165
7405	22 7492 53		4002 17 4060 115	4502	120 4517	382 4532	127
7406	38 7493 35		4006 105 4061 2380	4503	69 4518	102 4534	788
7407	38 7495 85		4008 92 4062 999	4506	51 4519	59 4536	20
7408	20 7496 82		4009 58 4063 110	4507	55 4520	108 4538	160
7409	20 7497 125		4010 15 4064 21	4508	298 4521	268 4539	110
7410	15 7498 262		4012 9 4065 22	4510	136 4522	199 4545	101
7411	24 7499 402		4013 55 4066 22	4511	168 4526	199	
7412	37 7499 62		4014 99 4067 22				
7413	37 7499 62		4015 93 4068 22				
7414	74 74105 84		4016 92 4069 22				
7415	35 74110 70		4017 95 4070 32				
7416	35 74110 70		4018 99 4071 40				
7417	39 74116 198		4019 60 4072 21				
7420	16 74118 90		4020 102 4073 21				
7421	33 74127 111		4021 99 4074 21				
7422	24 74121 28		4022 96 4075 23				
7423	32 74122 48		4023 20 4076 129				
7425	30 74123 70		4024 96 4077 21				
7426	36 74125 65		4025 109 4078 21				
7427	36 74126 60		4026 98 4079 21				
7428	38 74128 60		4027 98 4080 21				
7430	18 74136 73		4028 98 4081 21				
7432	32 74141 72		4029 98 4082 21				
7433	40 74143 314		4030 58 4083 21				
7437	30 74144 314		4031 230 4084 21				
7438	33 74145 85		4032 90 4085 21				
7439	17 74147 175		4033 145 4086 21				
7441	74 74148 143		4034 105 4087 21				
7442	68 74150 118		4035 120 4088 21				
7443	115 74153 75		4036 325 4089 21				
7444	112 74154 140		4037 109 4090 21				
7445	94 74155 82		4038 109 4091 21				
7446	94 74156 80		4039 109 4092 21				
7447	82 74159 225		4040 109 4093 21				
7448	78 74160 116		4041 98 4094 190				
7450	17 74162 118		4042 98 4095 105				
7451	17 74166 141		4043 98 4096 105				
7452	32 74185 146		4044 98 4097 105				
7454	17 74170 240		4045 98 4098 105				
7460	17 74172 625		4046 98 4099 105				
7470	30 74173 175		4047 98 4100 105				
7472	28 74177 116		4048 98 4101 105				
7473	32 74186 146		4049 98 4102 105				
7474	32 74188 65		4050 98 4103 105				
7475	42 74190 140		4051 98 4104 105				
7476	30 74194 140		4052 89 4440 1275				
7480	50 74195 95						
7481	48 74198 248						
7482	82 75150 110						

TRANSISTORS

AC117	35	BC168C	12	BF198	18	OC46*	35	ZTX504	25	2N3702	10
AC125*	19	BC169C	14	BF200	18	OC70*	30	ZTX531	25	2N3703	11
AC126*	15	BC170	14	BF224A	18	OC71*	30	ZTX550	25	2N3704	10
AC127*	18	BC171	11	BF256*	50	OC72*	30	ZN526*	58	2N3705	11
AC128*	18	BC172	11	BF257*	29	OC77*	76	ZN696*	35	2N3706	10
AC141*	24	BC177*	18	BF258*	29	OC79*	76	ZN697*	21	2N3707	10
AC141K*	38	BC178*	16	BF259*	30	OC81*	28	ZN698*	20	2N3708	10
AC142*	38	BC179*	16	BF294	22	OC82*	45	ZN699*	50	2N3709	11
AC142K*	38	BC182	10	BF594	22	OC83*	35	ZN706A*	19	2N3710	16
AC176*	18	BC181	13	BF595	38	OC83*	48	ZN707*	50	2N3711	12
AC187*	20	BC183	10	BF596	25	OC84*	44	ZN708*	19	2N3715*	250
AC188*	20	BC183L	12	BF620	25	OC85*	115	ZN712*	32	2N3724*	80
AC191*	35	BC184	11	BF679	28	OC85*	140	ZN713*	26	2N3731*	268
AC198*	40	BC184L	14	BF680	28	OC140	125	ZN918*	30	2N3819	22
AC199*	40	BC186	24	BFX29	28	OC141*	157	ZN920*	51	2N3820	38
AC20*	35	BC187*	28	BFX81*	130	OC170*	40	ZN930*	18	2N3823*	65
AC21*	35	BC212	11	BFX85*	24	OC171*	40	ZN961*	61	2N3824*	70
AC222*	40	BC212L	13	BFX86*	28	OC202*	140	ZN1132*	25	2N3903	20
AC23*	40	BC213	11	BFX87*	23	OC203*	150	ZN1302*	35	2N3904	18
AC239*	78	BC213L	14	BFX88*	26	OC204*	150	ZN1303*	50	2N3905	18
AC240*	48	BC214	14	BFY18	50	OT29*	43	ZN1304*	50	2N3906	17
AC244	39	BC241L	15	BFY50	17	OT29A	44	ZN1305*	28	2N4037*	52
AD140	69	BC307B	20	BFY51*	17	OT29C	50	ZN1306*	20	2N4058	17
AD149*	70	BC328	15	BFY52*	17	OT30	52	ZN1307*	50	2N4061	17
AD151*	48	BC329	15	BFY53*	17	OT30A	52	ZN1308*	46	2N4064*	120
AD162*	42	BC441*	45	BFY71	47	OT30B	64	ZN1613*	20	2N4236*	145
AF114*	20	BC461*	38	BSX20	18	OT30C	70	ZN1671*	190	2N4289	20
AF115*	20	BC462*	45	BSX20*	18	OT31*	50	ZN1671B*	195	2N4859	65
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PRACTICAL ELECTRONICS

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EASY BUILD SPEAKER DIY KITS

Specially designed by RT-VC for cost-conscious hi-fi enthusiasts, these kits incorporate two teak-simulate enclosures, two EMI 13" x 8" (approx.) woofers, two tweeters and a pair of matching crossovers.

£2800
STEREO PAIR Input 15 watts rms, 30 watts peak, each unit, + p & p £5.50 Cabinet size 20" x 11" x 9 1/2" (approx.).

SPEAKERS AVAILABLE WITHOUT CABINETS.
It's the units which we supply with the enclosures illustrated. Size 13" x 8" (approx.) woofer. (EMI), 2 1/2" app. **£1700** per tweeter, and matching crossover components. stereo pair Power handling 15 watts rms, 30 watts peak, + p & p £3.40

COMPACT FOR TOP VALUE These infinite baffle enclosures come to you ready mitred and professionally finished. Each cabinet measures approx. per stereo pair 12" x 9" x 5" deep, and is in wood simulate. Complete with two 8" (approx.) speakers for a maximum power handling of 7 watts. 8Ω. **£850** + p & p £2.20

SPEAKERS Two models - Duo IIb, teak veneer, 12 watts rms, 24 watts peak, 18 1/2" x 13 1/2" x 7 1/2" (approx.). Duo III, 20 watts rms, 40 watts peak, 27" x 13" x 11 1/2" app. Duo IIb **£17** PER PAIR Duo III **£52** PER PAIR p & p £6.50 p & p £7.50

DECCA 20 WATTS STEREO SPEAKER stereo pair This matching loudspeaker system is hand made, kit comprises of two 8" diameter approx. base drive unit, with heavy die cast chassis laminated cones with rolled P.V.C. surrounds, two 3 1/2" diameter approx. domed tweeters complete with crossover networks. 8Ω. **£4.00 p & p. £20.00**

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STEREO CASSETTE record/replay fully built P.C. board **£275**

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100K Multiturn Varicap tuning pots, 6 for **£1.00**

PAIR STEREO 8 WATT SPEAKERS 8" bass units with 3 1/2" approx. tweeters Size 16 1/2" x 11" x 8 1/2". **£12.95**

Plinth & cover BSR or Garrard teak finish **£6.00**

DECCA DCI000 Stereo Cassette P.C.B. complete with switch oscillator coils and tape-heads **£2.95**

AM. FM. Stereo Multiplex Car Radio/cassette player in dash fixing Negative earth 5 watts output **£36.00**

I.C. Stereo 8 Track to Cassette adaptor converts, any 8 track player to cassette player. **£18.95**



20 x 20 WATT STEREO AMPLIFIER **£2990**

Superb Viscount IV unit in teak-finished cabinet. Silver fascia with aluminium rotary controls and pushbuttons, red mains indicator and stereo jack socket. Function switch for mic, magnetic and crystal pick-ups, tape, tuner, and auxiliary Rear panel features two mains outlets, OIN speaker and input sockets, plus fuse. 20 + 20 watts rms, 40 + 40 watts peak.

30 x 30 WATT AMPLIFIER KIT Specially designed by RT-VC for the experienced constructor, complete in every detail. Same facilities as Viscount IV amplifier. 60 + 60 peak, p & p £2.50 **£2900**

NOW AVAILABLE fully built and tested. **£3500** Output 30 + 30 watts rms, 60 + 60 peak. p & p £2.50

FREE To cash or cheque personal shoppers A 4 channel Stereo Adaptor to all buyers of the Viscount 20 x 20 **£2900** Available separately **£395** Amplifier at + £1.00 p & p.

ADD-ON STEREO CASSETTE TAPE DECK KIT

Designed for the experienced D.I.Y. man. This kit comprises of a tape transport mechanism, ready built and tested record/replay electronics with twin V.U. meters and level control for mating with mechanism. Specifications: Sensitivity - Mic. 0.85 mV @ 20K OHMS; Din. 40mV @ 400K OHMS; Output - 300mV RMS per channel @ 1KHz from 2K OHMS source; Cross Talk - 30db; Tape Counter - 3 Digit, Resettable; Frequency Response - 40Hz - 8KHz ± 6db; Deck Motor - 9 Volt DC with electronic speed regulations; Key Functions - Record, Rewind, Mains Transformer **£19.95** Fast Forward, Play, Stop & Eject. **£2.50** + £1 p & p & p £2.50. Opt. extras: Pair of Dynamic microphones **£3.95** + £1.00 p & p.



323 EDGWARE ROAD, LONDON W2
210 HIGH STREET, ACTON W3 6NG
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£3500 p & p £2.50
Size approx. 13 1/2" x 5 1/2" x 6 1/2"
45 watts rms, 90 watts peak output. Big features include two disc inputs, both for ceramic cartridges, tape input and microphone input. Level mixing controls fitted with integral push-pull switches. Independent bass and treble controls and master volume.



70 & 100 WATT MONO DISCO AMP

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Brushed aluminium fascia and rotary controls. Five vertical slide controls - master volume, tape level, mic level, deck level, PLUS INTER-DECK FAOER for perfect graduated change from record deck No. 1 to No. 2, or vice versa. Pre-fade level control 70 watt (PFL) lets YOU hear next disc before fading 140 watt peak in. VU meter monitors output level. 100 watt **£65**



CHASSIS RECORD PLAYER DECKS

BSR BD S 95 TYPE II ILLUS. **£24.95**
Belt drive turntable unit, 2 speed, semi automatic p & p £2.55
BSR MP60 TYPE Single play record deck less cartridge. p & p £2.55
Cartridges to suit above
Acos. magnetic stereo **£4.95**
Ceramic stereo **£1.95**
BSR automatic record player deck cueing device and stereo ceramic head, p & p £2.55 **£9.95**

BSR MP 60 type, complete with magnetic cartridge, diamond stylus, and de luxe plinth and cover. p & p £4.50
Home 8 Track cartridge player. This unit will match with the Viscount IV 9" x 8" x 3 1/2". p & p £2.50 **£16.50**

Tourist IV CAR RADIO KIT

For the experienced constructor only
Output 4 watts into 4 ohms.
12 volts pos or neg (altered internally) **£12.50** p & p £1.50
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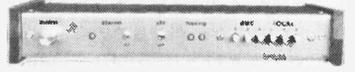
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ORION Complete set of semiconductors **£4.99**
tuner LP1186 Tuner Head **£9.60**
Glass fibre PCB, printed with component locations **£2.45**

ORION Complete set of semiconductors **£9.40**
amplifier Glass fibre PCB, printed with component locations **£2.99**

PE DIGITAL VOLTMETER (APRIL 1977) ZNA116 *£6.00 with circuits and data

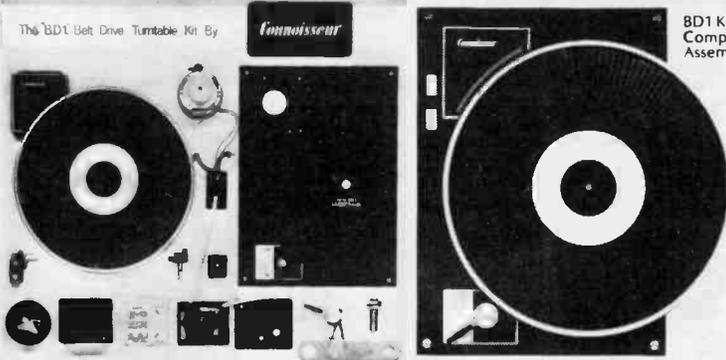
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Connoisseur

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Telephone: Brighouse (0484) 712 142, Telex: 517144 Sugden Crighouse,
Telegrams & Cables: Connoisseur Brighouse.

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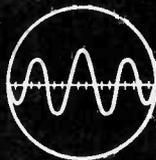
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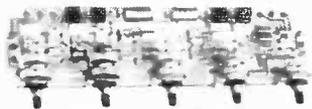
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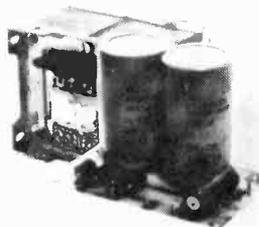
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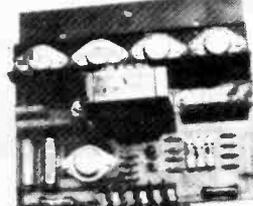
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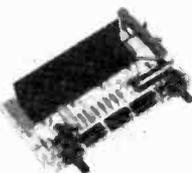
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- Full wave control
- RCA 8A Triacs
- 1000W per channel
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FRONT PANEL FOR LIGHTING EFFECT MODULES

(complete with switches, neons and knobs) as illustrated



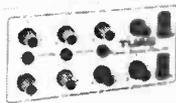
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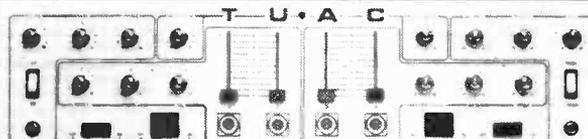
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With touch sensitive switching and auto fade

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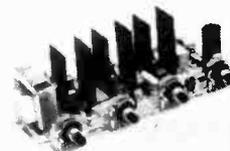
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- 1000W per channel
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- Full wave control

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Single Channel Version 1500 Watts

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- Full logic integrated circuitry
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3SDM1

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RMS continuous sine wave output
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VOTED BEST OF 8 SYSTEMS TESTED BY 'POPULAR MOTORING' MAGAZINE OCT. 74



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- * Improved acceleration/top speeds
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Includes 150 sq. ins. copper clad f/g board, 1 lb ferric chloride, 1 dalo etch resist pen, abrasive cleaner, 2 mini drill bits, etch tray and instructions / only £5.30

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- Semiconductor Bargains**
TH3 Thermistors. 10 for £1.
100 new & marked silicon and germanium transistors including BC148, 8F194, BC183, etc. £3.95
200 new & marked transistors, including 2N3055, AC128, BFY50, BD131, etc. £6.95
100 mixed diodes IN4148, etc. £1.20
100 mixed diodes including zener, power and bridge types £3.30
- Bridge rectifier 100v 2.5 amp. 4 for £1.
5 lbs ferric chloride to mil spec **£4.00**
Instruction sheet **20p**
200 unmarked mixed transistors, lots of interesting types including power. Send 60p for samples £4.50
25 New & marked integrated circuits including 555, 741, 7400, 7490, TBA 800, CD4001, etc. £4.70
BR 101 full spec. 5 for £1.00
DY 51 EHT Rectifier £1.00
TBA 120A 50p each
20 mm anti-surge fuses your selection 500mA to 3.15A. 12 for £1.00
- Component Bargains**
300 mixed resistors 1/2 & 3/4 watt £1.00
200 modern mixed caps most types £3.30
125 mixed resistors, mostly 1 & 2 watt £1.
100 mixed polyester caps £1.40
100 mixed modern miniature ceramic plate caps, most values to 1000 PF £3.30
100 mixed polystyrene caps to 5000 PF £2.20
100 mixed electrolytics £2.20
100 mixed wirewounds £1.00
200 printed circuit resistors £1.00
25 mixed pots & presets £1.00

40p P & P ON ALL ABOVE ITEMS. SEND CHEQUE OR POSTAL ORDER WITH ORDER TO SENTINEL SUPPLY, DEPT PE, 20A WADDON ROAD, CROYDON, SURREY.

G8CZW Digital Frequency Meter

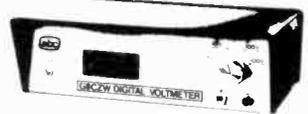


Complete 50MHz kit £54.00 inc. VAT, post free (U.K.)

ZN1040E Count/Display I.C.	£ 8.10	Hardware and Wire Pack	£ 1.45
Integrated Circuit Pack	9.25	Case, Two-tone p.v.c.-faced steel, punched and lettered (+95p P. & P.)	5.75
Displays and Filter Pack	7.78	Min BNC Sockets (50 ohm)	0.65
Semiconductor and Diode Pack	2.47	Min BNC Plugs (50 ohm)	0.70
Resistor and Capacitor Pack	3.10	500MHz Prescaler Kit	1.78
Logic and Display P.C.B.s	4.84	SP8631B 500MHz I.C.	8.96
5MHz Crystal	3.45	NE592 Wideband Video Amp	1.43
Transformer 8-0.8V 0.5A (+75p P. & P.)	2.48	D.F.M. Reprint (post free)	0.50
Switches, Knob, BNC's etc.	4.15		

NEW! Hi-Z Buffer Kit enables D.F.M. to count below 100Hz £6.50 (inc. P & P)

G8CZW Digital Voltmeter



Complete kit £44.30 inc. VAT, post free (U.K.)

ZNA116E 3 $\frac{1}{2}$ Digit I.C.	£ 6.48	Hardware and Wire Pack	£ 1.20
Integrated Circuit Pack	5.24	Case, Two-tone p.v.c.-faced steel, punched and lettered (+95p P. & P.)	5.75
Displays and Filter Pack	7.78	I.C. Sockets Pack	1.08
Semiconductor and Diode Pack	2.60	Transformer (+75p P. & P.)	2.48
Resistor Pack inc. cermet	4.64	5V Reg., 2 Rect., 2,000 μ F Cap., Mains SW., Fuse and Holder	3.75
Capacitor Pack	1.58	D.V.M. Reprint (post free)	0.35
Logic and Display P.C.B.s	2.05		
Voltage Attenuator Pack	0.68		
Range Switch 6P, 4-way	2.38		

All prices inc. VAT at the standard rate. Please add 20p P. & P. for packs. S.A.E. for full lists. Overseas—Deduct 8% off these prices.

Designer approved

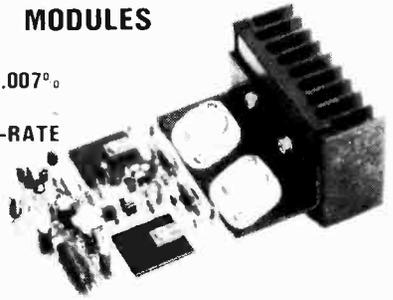


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Tel. 061-624 8812

AUDIBLY SUPERIOR AMPLIFICATION

HIGH DEFINITION — 'MUSICAL' — POWER AMP MODULES

- ★ T.H.D. TYPICALLY .007%
- ★ ZERO T.I.D. (SLEW-RATE LIMIT 16 V / -S)



Module size: 120 x 80 x 25 mm, using glass fibre pcb with ident and solder resist. Illustrated with light duty heatsink.

CRIMSON ELEKTRIK power amplifier modules are fast gaining a reputation as the best sounding, most musical modules available. Perhaps the most important features of this design are exceptional freedom from crossover distortion (due to the use of output triodes) and zero T.I.D. The amplifier is protected against open and short circuit loads and yet will drive a highly reactive lower impedance load which is more representative of a real loudspeaker. Square waves maintain their rise times up to full power whilst simulated electrostatic loads are easily handled with negligible overshoot and a settling time of 12 μ s. Other specs: S/N > 110dB. Rise time 10 μ s. Sensitivity 775mV. DC coupling. 5Hz-35kHz (-3dB) THD < 0.15%. 100mW clipping, 500Hz.

CRIMSON ELEKTRIK power supplies are in kit form for maximum flexibility and feature a low field silicone toroidal transformer with a 120-240V primary and screen, two large capacitors bridge rectifier and all fixings. Heatsinks are attractive black anodised extrusions, 80mm wide.

POWER AMP MODULES	HOME	EUROPE
CE 508 50W/8ms 8 ohms 35v dc	£16.30	£16.30
CE 1004 100W/8ms 3 ohms 35v dc	£19.22	£19.00
CE 1008 100W/8ms 8 ohms 35v dc	£23.22	£22.70

POWER SUPPLIES	HOME	EUROPE
CPS 1 For 24CE508 or 14CF1004	£12.85	£14.20
CPS 2 For 24CE1004 or 2 or 34CE608	£14.55	£17.90
CPS 3 For 24CE1008	£15.85	£19.20

HEATSINKS	Home	EUROPE
Light Duty 50mm x 2 C W	90	£2.40
High power 100mm x 1.3 C W	£1.60	£2.40
Disc group 150mm x 1.1 C W	£2.30	£3.85

CRIMSON ELEKTRIK (PE)
1A STAMFORD STREET, LEICESTER LE1 6NL.
Telephone: (0533) 537722.

Home prices include VAT and carriage. Payment by cheque. PO COD 60p (£50 limit). Export no problem. European prices include carriage, insurance and handling payment in Sterling by bank draft, PO, International Giro or Money Order. Outside Europe please write for specific quote by return. Send SAE or two International Reply Coupons for full literature. Favourable trade quantity price list on request. Suitable pre-amp circuit 20p.

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TOP SPEC IN 914 Packet of 10 25p.
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7402 18p	7443 123p	7497 130p	7497 130p	CD4002 18p	CD4024 83p	CD4056 180p		CD4090 117p	CD4090 117p
7403 18p	7444 123p	7498 130p	7498 130p	CD4003 18p	CD4025 29p	CD4057 180p		CD4091 117p	CD4091 117p
7404 22p	7447 182p	7499 130p	7499 130p	CD4004 18p	CD4026 190p	CD4058 180p		CD4092 117p	CD4092 117p
7405 22p	7448 130p	7499 130p	7499 130p	CD4005 18p	CD4027 50p	CD4059 180p		CD4093 117p	CD4093 117p
7406 44p	7454 18p	7499 130p	7499 130p	CD4006 18p	CD4028 82p	CD4060 22p		CD4094 117p	CD4094 117p
7407 44p	7470 20p	7499 130p	7499 130p	CD4007 18p	CD4029 82p	CD4061 110p		CD4095 117p	CD4095 117p
7408 23p	7472 20p	7499 130p	7499 130p	CD4008 18p	CD4030 82p	CD4062 22p		CD4096 117p	CD4096 117p
7409 23p	7473 20p	7499 130p	7499 130p	CD4009 18p	CD4031 130p	CD4063 22p		CD4097 117p	CD4097 117p
7410 15p	7475 20p	7499 130p	7499 130p	CD4010 18p	CD4032 82p	CD4064 110p		CD4098 117p	CD4098 117p
7411 24p	7475 40p	7499 130p	7499 130p	CD4011 18p	CD4033 130p	CD4065 110p		CD4099 117p	CD4099 117p
7412 24p	7476 40p	7499 130p	7499 130p	CD4012 20p	CD4034 130p	CD4066 110p		CD4100 117p	CD4100 117p
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7427 20p	7490 37p	7499 130p	7499 130p	CD4019 85p	CD4041 130p	CD4073 117p		CD4107 117p	CD4107 117p
7430 20p	7491 82p	7499 130p	7499 130p	CD4020 110p	CD4042 130p	CD4074 117p		CD4108 117p	CD4108 117p
7432 20p	7492 57p	7499 130p	7499 130p	CD4021 90p	CD4043 130p	CD4075 117p		CD4109 117p	CD4109 117p
7437 20p	7493 57p	7499 130p	7499 130p		CD4044 130p	CD4076 117p		CD4110 117p	CD4110 117p
					CD4045 150p	CD4077 117p		CD4111 117p	CD4111 117p
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NOW OFFER PACKAGE DEALS AT INCOMPARABLE PRICES

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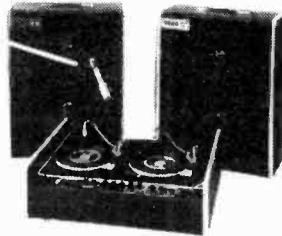


illustration shows GXL Centaur System

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

JUST PLUG IN AND GO!

MINI DISCO 100 WATT MONO SYSTEM

£159.50 Deposit **£22.66**

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or 24 Months @ £8.14

Similar in appearance to the Centaur and complete with loudspeakers and leads.

Headphones to suit any system **£7.50**
EM507 Electret Mic **£15.00**
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Carriage on all disco systems **£10.00**
(Included in H.P. Prices)

**10% Deposit Terms
On All Orders
Over £150 – 12 or 24
Months – Low Interest**

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SA308 30W 8 ohms 45V	£9.95*	SUPPLY FOR TWO MODULES	£10.90*
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SA1204 120W 4 ohms 75V	£15.95	SUPPLY FOR ONE MODULE	£22.50
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SA2404 240W 4 ohms 95V	£29.50	SUPPLY FOR ONE MODULE	

0.2% Distortion, 30Hz-20, KHz ± 2dB, Fully Short/Open Circuit proof input sensitivity 240 mV to suit most mixers – D.C. & Output Fuses fitted.

TOP QUALITY COMPONENTS THROUGHOUT



DISCO MIXERS – COMPLETE OR MODULAR



MONO OR STEREO
WITH AUTOFADE

Available complete and ready to plug in or as an easy to connect module with all controls except monitor switch already fitted – full instructions supplied.

FEATURES INCLUDE:

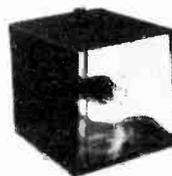
Twin Deck – Mic & Tape Inputs – Wide range bass & treble controls – Full headphone monitoring – Crossfade – Professional standard performance.

MODULES	
Mono module	£22.50
Stereo module	£33.50
Panel	£3.95
Kit of knobs/sockets etc	£5.50
COMPLETE MIXERS (with case)	
Mono 18V	£39.50
Stereo 18V	£57.50
Mono mains	£45.75
Stereo mains	£63.75

COMPLETE LIGHTING CONTROL AT YOUR FINGERTIPS!



Lighting Control Unit Mk II	£44.50
4kW Sequencer + Sound Light + Dimmers	
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(Pro-Strobe has external trigger facility).

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		(Wide choice available)	

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	£15.50, Large 2 x 12"		£28	£22.50

Projector lamps: A1167 **£2.90**, M6 **£5.65**.
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£1.50 ea £13.50 for 10
MD Spot Banks: 3-way 300W **£19.50**,
4-way 400W **£22.50**.
Bubble machines (optikinetics) **£36.50**

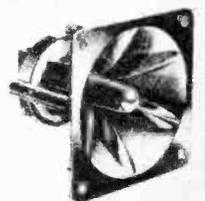
Strobe tubes 80W **£8.50**
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Kick Resistant Grill 50" wide **£3.25** Metre.
FULL RANGE OF RE-AN PRODUCTS IN STOCK
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PIEZO HORNS only £7.50 YES! – only £7.50

(As fitted to our package PA system)

Direct from Motorola Inc., USA at an
UNBEATABLE PRICE

No crossover required 4kHz – 30kHz rated
75W/8 ohms 150W/4 ohms use two per 100W
amplifier – Full instructions supplied.





PACKAGE P.A. SYSTEMS (2 Year Guarantee)

Complete with PIEZO horn columns fitted with 100 watt units (100 watt system illustrated)

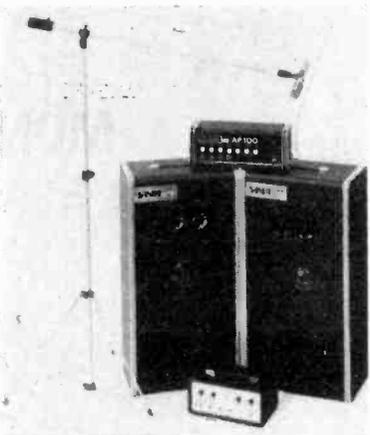
100 Watt £145
Deposit £19.70

12 Months @ £13.66 or 24 Months @ £7.61

200 Watt £225
Deposit £28.80

12 Months @ £21.18
24 Months @ £11.81

These systems come complete with a Four Channel Amplifier, Leads etc. The 200 Watt system features Twin 100 Watt drive units in each cabinet.

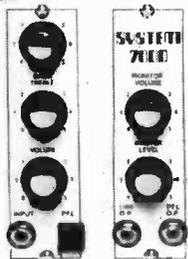


ALSO ILLUSTRATED:

Melos Echo Unit £59.00 Boom Stand £15.50 Electret Mic ECM81 £19.95* Floor Stands £9.90 EM507 Mic* £15.00 Phasers £19.80

D.I.Y. MODULES FOR P.A. SYSTEMS Mono or Stereo

Make your own mixer - Mono/Stereo - up to 20 channels with these, easy to wire modules - Available as PCB's or assembled on panels.



Input Stages Up to 20	Mono PCB	£5.95	Mono C/W panel etc.	£8.95
	Stereo PCB	£9.50	Stereo C/W panel etc.	£12.50
Mixer/Monitor (One only per system)	Mono PCB	£5.95	Mono C/W panel etc.	£8.95
	Stereo PCB	£9.50	Stereo C/W panel etc.	£12.50
Power supply for up to 20 channels		£9.50	Blank panel	£1.00

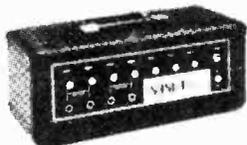
Send for free brochure for complete specification

Saxon AP100 Amplifier £45

Four mixing inputs - 100W into 4 ohms
Wide range bass & treble controls
+ master - Twin outputs

Saxon 150 Amplifier £59

Four mixing inputs - 100W into 8 ohms
150W into 4 ohms - wide range bass & treble controls + master



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Shop premises open Mon to Sat 9 am - 5 pm Lunch 12.30 - 1.30 pm
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ME, semiconductor teaching kit



the most MODERN, RAPID, ECONOMIC way to master space age electronics. Starting even from ZERO, by performing over,

100 EXPERIMENTS
and creating more than 20 practical applications

You learn all about the most up to date electronic circuits: how to calculate, repair, and design them, while pursuing your favorite hobby. Start from scratch, or improve your present knowledge. Train and earn money in your spare time turn your pastime into valuable job opportunities. Compare our price: you receive the entire course, "mini laboratory" and components for LESS than the price of the components alone.

COMPLETE KIT: nothing else to buy*

you get:

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 - measuring instruments (you assemble yourself from among components furnished in kit.)
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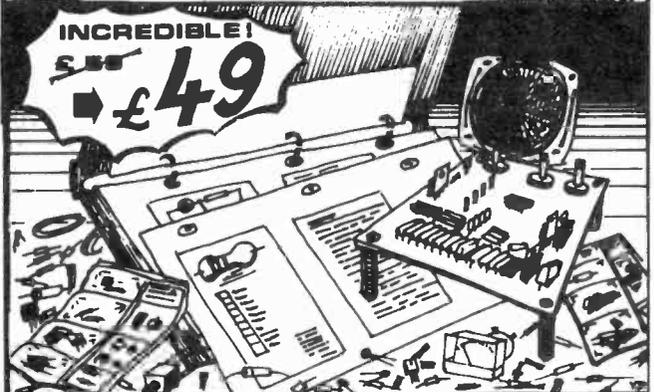
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No. THY3A/200	3 Amp.	200 volt	T064	32p
No. THY3A/400	3 Amp.	400 volt	T064	40p
No. THY5A/50	5 Amp.	50 volt	T066	25p
No. THY5A/400	5 Amp.	400 volt	T066	40p
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No. MVR7818	µA7818	T0220	85p
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TRANSISTORS

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AC107	25p	BC177	12p	BF194	9p	TIP32A	34p	2N1613	15p
AC126	14p	BC178	12p	BF195	9p	TIP32B	35p	2N1711	15p
AC127	16p	BC179	12p	BF196	9p	TIP32C	36p	2N1893	25p
AC128	16p	BC182	9p	BF197	12p	TIP41A	34p	2N2218	18p
AC128K	24p	BC182L	9p	BF200	25p	TIP41B	35p	2N2218A	18p
AC176	16p	BC183	9p	BF229	22p	TIP41C	36p	2N2219	18p
AC176K	24p	BC183L	9p	BFX84	18p	TIP42A	36p	2N2219A	18p
AC187	16p	BC184	9p	BFY50	12p	TIP42B	37p	2N2221	15p
AC187K	26p	BC184L	9p	BFY51	12p	TIP42C	38p	2N2221A	16p
AC188	16p	BC212	10p	BFY52	12p	TIP2955	65p	2N2222	15p
AC188K	26p	BC212L	10p	MPSA05	22p	TIP3055	62p	2N2222A	16p
AD161/162 MP	80p	BC213	10p	MPSA06	22p	ZTX107	6p	2N2369	10p
AF139	30p	BC214	10p	MPSA55	22p	ZTX108	6p	2N2904	14p
AF239	30p	BC214L	10p	MPSA56	22p	ZTX109	7p	2N2904A	15p
8C107	6p	BC251	10p	OC44	12p	ZTX300	7p	2N2905	14p
8C108	6p	BCY70	12p	OC45	12p	ZTX301	7p	2N2905A	15p
8C109	6p	BCY71	12p	OC71	9p	ZTX302	9p	2N2906	12p
8C118	10p	BCY72	12p	OC72	12p	ZTX501	10p	2N2907	12p
8C147	8p	BD115	40p	OC75	10p	ZTX502	12p	2N2907A	13p
8C148	8p	BD131	37p	OC81	14p	2N696	10p	2N2926G	8p
8C149	8p	BD132	37p	TIP29A	35p	2N706	7p	2N3053	12p
8C154	8p	BF115	17p	TIP29B	36p	2N708	8p	2N3055	35p
8C157	9p	BF167	19p	TIP29C	38p	2N708	8p	2N3072	7p
8C158	9p	BF173	20p	TIP30A	36p	2N1302	12p	2N3703	7p
8C159	9p	BF180	25p	TIP30B	37p	2N1303	15p	2N3704	6p
8C169C	9p	BF181	25p	TIP30C	38p	2N1304	15p	2N3903	11p
8C170	6p	BF182	25p	TIP31A	32p	2N1307	18p	2N3904	11p
8C171	6p	BF183	25p	TIP31B	33p	2N1309	22p	2N3905	11p
8C172	6p	BF184	25p	TIP31C	34p	2N1309	22p	2N3906	11p
8C173	7p	BF185	25p						

DIODES

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AA119	5p	8AX16/		BY216	30p	OA85	7p	IS44	3p
AAZ13	4p	OA202	5p	BY217	28p	OA90	6p		
BA100	6p			BY218	28p	OA91	7p	IN5400	10p
BA115	5p	BY100	15p	BY219	28p	OA95	7p	IN5401	11p
BA144	5p	BY127	10p					IN5402	12p
BA148	10p	BY210	32p	OA47	5p	IN34	5p	IN5404	13p
BA173	10p	BY211	32p	OA70	5p	IN60	6p	IN5406	16p
BAX13/		BY212	32p	OA79	7p	IN94	4p	IN5407	17p
OA200	5p	BY213	30p	OA81	7p	IN4148	4p	IN5408	19p

LINEAR I.C.'s

TBA800	12 pin QIL	*75p	UA711C T099	25p	UA748 T099	28p
TBA810	12 pin QIL	*£1.00	UA703 T099 (Plastic)	20p	72558 (Dual 748) T099	45p
TBA820	14 pin QIL	*80p	741P 8 pin DIL	18p	MC1310P 14 pin DIL	*£1.25
LM380	14 pin DIL	*80p	7274 14 pin DIL	20p	76115 14 pin QIL	*£1.25
LM381	14 pin DIL	*£1.35	UA741C T099	20p	NE555 8 pin DIL	32p
72709	14 pin DIL	28p	72747 14 pin DIL	55p	NE556 14 pin DIL	60p
UA709 T099	28p		748P 8 pin DIL	28p	SL414A 10 pin	*£1.80

NEW CONSIGNMENT ZN 414 RADN CHIP 75p*

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Displays		2nd QUALITY LED PAKS			
No. 1510	707 LED Display	70p each	No. 1507	10 x LED's Assorted	75p
No. 1511	747 LED Display	£1.50 each	LED CLIPS		
No. S53	DL33 Triple 7 Segment LED Display Character height .11" Common Cathode 12 pin DIL	30p each	No. 150B/125	.125	5 for 12p
			No. 150B/2	.2	5 for 15p
LED's		SPECIAL REDUCTIONS			
No. S51	Red TIL209 (5 x .125")	50p	No. 1514	NORP 12	45p each
No. S52	Red FLV117 (5 x .2")	50p	No. S76	OC71	5 for £1.00
No. 1502	Green .125"	18p each	No. S83 5	NIXIE Tubes ITT 5870 ST	£2.00 (including Data)
No. 1505	Green .2"	18p each	No. S77	Neon Indicator Lamps 230V A.C. State Colour (Red, Amber and Green.)	25p each
No. 1503	Yellow .125"	18p each			
No. 1506	Yellow .2"	18p each			
No. S82	Clear .2" (illuminating red)	12p			

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Full easy to follow instructions.
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Code No's shown below are given as a guide to the type of device. The devices themselves are normally unmarked.

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No. 16131	150 Germ. Point contact diodes like OA70/B1	40p
No. 16132	100 200mA Sil. diodes like OA200	40p
No. 16133	150 75mA Sil. Fast switching diode like IN4148	40p
No. 16134	50 750mA Sil. top hat Rects. like OA70/B1	40p
No. 16135	20 3 amp Sil. stud Rect.	40p
No. 16136	50 400mw Zeners D.O.7 case	40p
No. 16137	30 PNP Plastic trans. like BC107/8	40p*
No. 16138	30 PNP Plastic trans. like 8C177/8	40p*
No. 16139	25 PNP trans. like 2N697/2N1711 T039	40p
No. 16140	25 PNP trans. like 2N2905 T039	40p
No. 16141	30 NPN trans. like 2N706 T018	40p
No. 16143	30 PNP Plastic trans. like 2N3906 40p*	
No. 16144	30 PNP Plastic trans. like 2N3906 40p*	
No. 16145	30 PNP Germ. trans. like OC71	40p
No. 16147	10 NPN to 3 Power trans. like 2N3055	80p

I.C. SOCKET PAKS

No. S66	11 x 8 pin DIL Sockets	£1.00
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No. S68	9 x 16 pin DIL Sockets	£1.00
No. S69	4 x 24 pin DIL Sockets	£1.00
No. S70	3 x 28 pin DIL Sockets	£1.00

TRANSISTOR SOCKETS

No. S71	15 x T018 Sockets	£1.00
No. S72	10 x T05 Sockets	£1.00

MOUNTING PADS

No. S73	50 Mixed Transistor Pads T018 and T05	40p
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TRANSISTOR HEATSINK PAK

20 Assorted types. T01, T05, T018, T092
Our Mix
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Mica washers and bushes assorted types i.e. T0220, T066, T03 etc. Approx. 100 pieces. (Approx. 40 sets).
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70 watt 8 amp NPN and PNP in plastic case 199 High Voltage (Typ. 80V). High gain. 10 pieces 5 NPN and 5 PNP. Data Sheet supplied.
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MATCHED PAIRS OF PNP GERMANIUM MED. POWER TRANS

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No. S48	40 x 50V	60p
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GR559	10mA 14KV (14,000)	20p each
GA432	1 AMP. 2 KV (2,000)	20p each
FD025	2.5 KV Voltage Doubler	20p each

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Slider 40mm TRAVEL		
Order No.	Description	Price
16191	6 x 470 Ohm LIN Single	40p*
S24	6 x 1 K LIN Single	40p*
S25	6 x 5 K LIN Single	40p*
16192	6 x 10 K LIN Single	40p*
S26	6 x 10 K LOG Single	40p*
16193	6 x 22 K LIN Single	40p*
16195	6 x 47 K LOG Single	40p*
16194	6 x 47 K LIN Single	40p*
S27	6 x 100 K LIN Single	40p*
S28	6 x 100 K LOG Single	40p*
S29	6 x 500 K LOG Single	40p*
Slider 60mm TRAVEL		
S30	6 x 2.5 K LOG Single	40p*
S31	6 x 10 K LIN Single	40p*
S32	6 x 50 K LIN Single	40p*
S33	6 x 250 K LOG Single	40p*
S34	4 x 5 K LOG Dual	40p*
S35	4 x 10 K LIN Dual	40p*
S36	4 x 100 K LOG Dual	40p*
S37	4 x 1.3 MEG LOG Dual	40p*
S38 MIXED SLIDER POTS - VARIOUS VALUES AND SIZES - OUR MIX ONLY £1.00*		
S39 6 x CHROME SLIDER KNOBS 40p*		

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A range of wirewound single gang pots. with linear tracks of 1 watt rating.

Order No.	Value	Order No.	Value
1891	10 ohms	1894	100 ohms
1893	47 ohms	1895	220 ohms
1896	470 ohms	1898	2K2
1897	1K	1899	4K7

NOW 35p* each

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S40 3 x 100 K LIN ONLY 50p*

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S1	5 x 3.5 mm Plastic Jack Plugs	40p*
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S3	4 x Std. Plastic Jack Plugs	50p*
S4	2 x Stereo Jack Plugs	30p*
S5	5 x 5 Pin 180° DIN Plugs	50p*
S6	8 x 2 Pin Loudspeaker Plugs	50p*
S7	6 x Phono Plugs Plastic	50p*
S8	5 x 3.5 mm Chassis Sockets (Switched)	25p*
S9	5 x 2.5 mm Chassis Sockets (Switched)	25p*
S10	4 x Metal Std. Chassis Switched Jack Sockets	50p*
S11	2 x Stereo Jack Sockets with instruction leaflet for H/Phone connection.	50p*
S12	5 x 5 Pin 180° DIN Chassis Sockets	40p*
S13	8 x 2 Pin DIN Chassis Sockets	50p*
S14	6 x Single Phono Sockets	40p*

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Order No.	Description	Price
117	A.C. Mains connecting lead for cassette recorders and radios Telefunken type	45p*
118	5 pin DIN headphone plug to stereo socket	78p*
119	2 x 2 pin plug to inline stereo socket for headphones	60p*
123	20 ft. of coiled guitar lead	£1.15*
124	3 pin to 3 pin DIN plug	50p*
125	Audio lead 5 pin plug to 5 pin DIN plug	50p*
126	Audio lead 5 pin DIN plug to tinned open ends	50p*
127	Audio lead 5 pin DIN plug to 4 phono plugs	90p*
129	Audio lead 5 pin plug to 5 pin DIN plug - Mirror Image	70p*
130	5 metre lead 2 pin DIN plug to 2 pin DIN inline socket	45p*
132	10 metre lead 2 pin DIN plug	65p*

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With aluminium lid and fixing screws. Size 6 1/2" x 3 1/2" x 2" Order No. S16 Only 75p

74 SERIES TTL ICs

TYPE	QUANTITY		TYPE	QUANTITY		TYPE	QUANTITY	
	1	100		1	100		1	100
	Ep	Ep		Ep	Ep		Ep	Ep
7400	0.09	0.08	7448	0.70	0.68	74122	0.45	0.42
7401	0.11	0.10	7450	0.12	0.10	74123	0.65	0.62
7402	0.11	0.10	7451	0.12	0.10	74141	0.68	0.65
7403	0.11	0.10	7453	0.12	0.10	74145	0.75	0.72
7404	0.11	0.10	7454	0.12	0.10	74150	1.10	1.05
7405	0.11	0.10	7460	0.12	0.10	74151	0.65	0.60
7406	0.28	0.25	7470	0.24	0.23	74153	0.70	0.68
7407	0.28	0.25	7472	0.20	0.19	74154	1.20	1.10
7408	0.28	0.25	7473	0.26	0.22	74155	0.70	0.68
7409	0.12	0.11	7474	0.24	0.23	74156	0.70	0.68
7410	0.09	0.08	7475	0.44	0.40	74157	0.70	0.68
7411	0.22	0.20	7476	0.26	0.25	74160	0.95	0.85
7412	0.22	0.20	7480	0.45	0.42	74161	0.95	0.85
7413	0.26	0.25	7481	0.90	0.88	74162	0.95	0.85
7416	0.28	0.25	7482	0.75	0.73	74163	0.95	0.85
7417	0.26	0.25	7483	0.88	0.82	74164	1.20	1.10
7420	0.11	0.10	7484	0.85	0.80	74165	1.20	1.10
7422	0.19	0.18	7485	1.10	1.00	74166	1.20	1.10
7423	0.21	0.20	7486	0.28	0.26	74174	1.10	1.00
7425	0.25	0.23	7489	2.70	2.50	74175	0.85	0.82
7426	0.25	0.23	7490	0.38	0.32	74176	1.10	1.00
7427	0.25	0.23	7491	0.65	0.62	74177	1.10	1.00
7428	0.36	0.34	7492	0.43	0.35	74180	1.10	1.00
7430	0.12	0.10	7493	0.38	0.35	74181	1.90	1.80
7432	0.20	0.19	7494	0.70	0.68	74182	0.80	0.78
7433	0.38	0.36	7495	0.60	0.58	74184	1.50	1.40
7437	0.26	0.25	7496	0.70	0.68	74190	1.40	1.30
7438	0.26	0.25	74100	0.95	0.90	74191	1.40	1.30
7440	0.12	0.10	74104	0.40	0.35	74192	1.10	1.00
7441	0.60	0.57	74105	0.30	0.25	74193	1.05	1.00
7442	0.80	0.70	74107	0.30	0.25	74194	1.05	1.00
7443	0.95	0.90	74110	0.48	0.45	74195	0.80	0.75
7444	0.95	0.90	74111	0.75	0.72	74196	0.90	0.85
7445	0.80	0.75	74118	0.85	0.82	74197	0.90	0.85
7446	0.80	0.75	74119	1.30	1.20	74198	1.90	1.80
7447	0.70	0.68	74121	0.28	0.26	74199	1.80	1.70

Devices may be mixed to qualify for quantity price. Data is available for the above series of ICs in booklet form price 35p.

CMOS ICs

Type	Price	Type	Price	Type	Price	Type	Price
CD4000	£0.14	CD4018	£0.85	CD4035	£1.40	CD4056	£1.15
CD4001	£0.16	CD4019	£0.45	CD4037	£0.78	CD4069	£0.32
CD4002	£0.16	CD4020	£0.95	CD4040	£0.78	CD4070	£0.32
CD4006	£0.80	CD4021	£0.85	CD4041	£0.68	CD4071	£0.20
CD4007	£0.17	CD4022	£0.80	CD4042	£0.68	CD4072	£0.20
CD4008	£0.80	CD4023	£0.18	CD4043	£0.78	CD4081	£0.20
CD4009	£0.90	CD4024	£0.64	CD4044	£0.78	CD4082	£0.20
CD4010	£0.90	CD4025	£1.18	CD4045	£1.15	CD4510	£1.10
CD4011	£0.18	CD4026	£1.85	CD4046	£0.95	CD4511	£1.25
CD4012	£0.17	CD4027	£0.48	CD4047	£0.75	CD4516	£1.10
CD4013	£0.42	CD4028	£0.80	CD4049	£0.46	CD4518	£1.10
CD4015	£0.80	CD4029	£0.95	CD4050	£0.46	CD4520	£1.10
CD4016	£0.42	CD4030	£0.46	CD4054	£0.95		
CD4017	£0.80	CD4031	£1.80	CD4055	£1.60		

AUDIO MODULE SALE

Type	Description	Normal Price	Sale Price
AL30A	10W RMS Power Amp	£3.65*	£2.95*
AL60	25W RMS Power Amp	£4.95*	£3.55*
AL80	35W RMS Power Amp	£6.95*	£5.95
AL250	125 W RMS Power Amp	£15.95*	£14.45
SPM80	35V Power Supply	£3.75*	£3.10*
PS12	20-30V Power Supply for AL30A	£1.30*	£1.15*
PA12	Stereo Pre-Amp for AL30A	£6.70*	£5.95*
PA100	Stereo Pre-Amp for AL60/AL80	£13.75*	£12.45*
S450	Stereo F.M. Tuner	£20.45*	£18.65*
MPA30	Magnetic-Ceramic Pre-Amp	£2.85*	£2.55*
Stereo 30	Complete Audio Chassis 7W x 7W RMS	£16.25*	£14.95*

LOOK & LISTEN

GE 100 NINE CHANNEL MONO-GRAPHIC EQUALIZER MODULE

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., 0.5%, input impedance 100 K, output impedance less than 10 K. Frequency response 20 Hz-20 KHz (3db). The nine gain controls are centred at 50, 100, 200, 400, 800, 1600, 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.

ONLY £19.50

SG30 Power supply board for GE100 15-0-15 Volt **£4.50**

SEND SAE FOR TECHNICAL DATA ON ANY OF THE AUDIO MODULES.

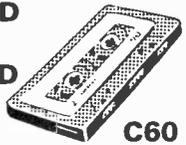
SPECIAL OFFER! COMPONENT PAKS

Order No.	Quantity	Price
16164	200 approx. Resistors mixed values. (Count by weight)	40p*
16165	150 approx. Capacitors mixed values. (Count by weight)	40p*
16167	80 1/2W Resistors mixed values	40p*
16168	5 pieces Assorted Ferrite rods	40p*
16169	2 pieces Tuning gangs MW/LW	40p*
16170	50 metres Single strand wire assorted wire	40p
16171	10 Reed switches	40p*
16172	3 Micro switches	40p*
16176	20 Assorted electrolytics Trans types	40p*
16177	1 pack Assorted hardware nuts/bolts etc.	40p
16179	20 Assorted tag strips and panels	40p
16180	15 Assorted control knobs	40p*
16184	15 Assorted Fuses 100mA - 5 amp	40p*
16188	60 1/2W resistors mixed values	40p*
16187	30 metres stranded wire assorted colours	40p

1/2 PRICE BARGAIN!

£4 worth (Min. Value) of Electronic Project Books, Technical, Semiconductor Data and Equivs - Books of Assorted Titles. **OUR CLEARANCE PRICE £2 per bundle**

SUPER SOUND SAVING METRO SOUND LOW NOISE CASSETTES



Order No. S53 **10 for £2.50***

BIB GROOVE CLEAN

Model 60. Chrome Finish Plastic Order No. 829 **£1.40***

HOT OFFER

ANTEX SOLDERING IRONS

Order No. 1931 X25 15 watt. LOW LEAKAGE **Usually £3.40 SALE PRICE £2.95**

PLUS FREE Heatshunt

1948 Model C 15 watt General purpose **Usually £3.40 SALE PRICE £2.95**

PLUS FREE Heatshunt

1939 ST3 Soldering Iron Stand suitable for either Iron. **£1.20**

NEW 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 **£3.50**

AVDEL BOND

Cyanocrylate adhesive bonds - plastic, rubber, transistors, components in seconds. Order No. 143 **55p per 2 gm. phial**

ORDERING

Please word your orders exactly as printed, not forgetting to include our part number.

VAT

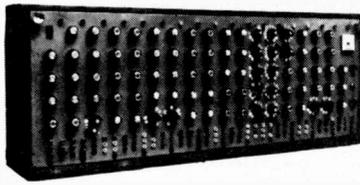
Add 12 1/2% to prices marked* Add 8% to others excepting those marked †. These are zero.

BI-PAK

Dept. PE2, P.O. Box 6, Ware, Herts
COMPONENTS SHOP: 18 BALDOCK STREET, WARE, HERTS.

FOR RELIABLE JOINTS - ANTEX IRONS!

KITS FOR SYNTHESISERS, SOUND EFFECTS



PHONOSONICS

MAIL ORDER SUPPLIERS OF QUALITY PRINTED CIRCUIT BOARDS, KITS AND COMPONENTS TO A WORLD-WIDE MARKET.

COMPONENTS SETS include all necessary resistors, capacitors, semiconductors, potentiometers and transformers. Hardware such as cases, sockets, knobs, etc. are not included but most of these may be bought separately. Fuller details of kits, PCBs and parts are shown in our lists.

CIRCUIT AND LAYOUT DIAGRAMS are supplied free with all PCBs designed by Phonosonics.

PHOTOCOPIES of the P.E. texts for most of the kits are available—prices in our lists.

P.E. MINISONIC Mk. 2 SYNTHESISER

A portable mains-operated Miniature Sound Synthesiser, with keyboard circuits. Although having slightly fewer facilities than the large P.E. Synthesiser the functions offered by this design give it great scope and versatility. Consists of 2 log VCOs, VCF, 2 envelope shapers, 2 voltage controlled amps, keyboard hold and control circuits, HF oscillator and detector, ring modulator, noise generator, output amp and mixer, power supply.

Set of basic component kits £64.25
Set of printed circuit boards £9.71

P.E. SYNTHESISER (P.E. Feb. 73 to Feb. 74)

The well acclaimed and highly versatile large-scale mains-operated Sound Synthesiser complete with keyboard circuits. Other circuits in our lists may be used with the Synthesiser to good advantage, notably P.E. Minisonic, Phasing Unit, Wind and Rain, Rhythm Generator, Sound Bender, Voltage Controlled Filter, Guitar Effects Pedal and Overdrive, Fuzz, Tremolo and Wah-Wah units. The Main Synthesiser: PSU, 2 linear VCOs, 2 ramp generators, 2 input amps, sample hold, noise generator, reverb amp, ring modulator, peak level circuit, envelope shaper, voltage controlled amp. Full details in lists.

Set of basic component kits £83.03
Set of printed circuit boards £13.20

The Synthesiser Keyboard Circuits (can be used without the Main Synthesiser to make an independent musical instrument): 2 logarithmic VCOs, divider, 2 hold circuits, 2 modulation amps, mixer, 2 envelope shapers and additional PSU. Full details in our lists.

Set of basic component kits £48.18
Set of printed circuit boards £7.66

GUITAR EFFECTS PEDAL (P.E. July 75)

Modulates the attack, decay and filter characteristics of an audio signal not only from a guitar but from any audio source, producing 8 different switchable effects that can be further modified by manual controls. Possibly the most interesting of all the low-priced sound effects units in our range. Circuit does not duplicate effects from the Guitar Overdrive Unit.

Component set with special foot operated switches £7.59
Alternative component set with panel mounting switches £4.96
Printed circuit board £1.43

SOUND BENDER (P.E. May 74)

A multi-purpose sound controller, the functions of which include envelope shaper, tremolo, voice-operated fader, automatic fader and frequency-doubler.

Component set for above functions (excl. SWs) £7.84
Printed circuit board £1.81

Optional extra—additional Audio Modulator, the use of which, in conjunction with the above component set, can produce "jungle-drum" rhythms.

Component set (incl. PCB) £2.88

PHASING UNIT (P.E. Sept. 73)

A simple but effective manually controlled unit for introducing the "phasing" sound into live or recorded music.

Component set (incl. PCB) £2.87

PHASING CONTROL UNIT (P.E. Oct. 74)

For use with the above Phasing Unit to automatically control the rate of phasing.

Component set (incl. PCB) £4.48

SOPHISTICATED PHASING AND VIBRATO UNIT

A slightly modified version of the circuit published in "Elektron", December 1976, and includes manual and automatic control over the rate of phasing and vibrato.

Component set £17.69
Printed circuit board £2.33

WAH-WAH UNIT (P.E. Apr. 76)

The Wah-Wah effect produced by this unit can be controlled manually or by the integral automatic controller.

Component set (incl. PCB) £3.55

AUTOWAH UNIT (P.E. Mar. 77)

Automatically produces Wah-pedal and Swell-pedal sounds each time a new note is played.

Component set, PCB, special foot switches £7.27
Component set and PCB, with panel switches £4.83

P.E. JOANNA (P.E. May/Sept. 75)

A five-octave electronic piano that has switchable alternative voicing of Honky-Tonk piano, ordinary piano, harpsichord, or a mixture of any of the three, together with facilities including fast and slow tremolo, loud and soft pedal switching, and sustain pedal switching. The power amplifier typically delivers 24 watts into 8 ohms. The PCBs have been redesigned by ourselves making improved use of the space available.

Main power supply, tone generator, 61 envelope shapers, voicing and pre-amp circuits.

Set of basic component kits for above £75.29
Set of printed circuit boards for above £20.35
Power amplifier £15.97
Printed circuit board for power amp 95p

ELECTRONIC ORGAN

5-octave electronic organ with 5 basic voices that can be used individually or together, 5 pitches (2ft, 4ft, 8ft, 16ft, 32ft), variable attack, tremolo, vibrato, phasing, and variable sustain. Details in our list.

ORGAN CONVERSION KIT

Converts the P.E. Joanna electronic piano to also provide most of the facilities offered by the above electronic organ.

Basic component set and PCB £12.34

SYNTHESIZER TUNING INDICATOR (P.E. July 77)

A simple 4-octave frequency comparator for use with synthesizers and other instruments where the full versatility of the P.E. Tuning Fork is not required.

Component and PCB (but excl. sw.) £7.45

GUITAR FREQUENCY DOUBLER (P.E. Aug. 77)

A modified and extended version of the circuit published. Details in list.

SEE OTHER PAGE FOR KEYBOARDS, AND OUR LISTS FOR OTHER COMPONENTS AND ACCESSORIES STOCKED

WIND AND RAIN UNIT

A manually controlled unit for producing the above-named sounds.

Component set (incl. PCB) £3.72

GUITAR OVERDRIVE UNIT (P.E. Aug. 76)

Sophisticated, versatile Fuzz unit, including variable and switchable controls affecting the fuzz quality whilst retaining the attack and decay, and also providing filtering. Does not duplicate the effects from the Guitar Effects Pedal and can be used with it and with other electronic instruments.

Component set using dual slider pot £6.86
Component set using dual rotary pot £6.20
Printed circuit board £1.62

FUZZ UNIT

Simple Fuzz unit based upon P.E. "Sound Design" circuit.

Component set (incl. PCB) £2.03

TREMOLO UNIT

Based upon P.E. "Sound Design" circuit.

Component set (incl. PCB) £3.64

TREBLE BOOST UNIT (P.E. Apr. 76)

Gives a much shriller quality to audio signals fed through it. The depth of boost is manually adjustable.

Component set (incl. PCB) £2.40

P.E. TUNING FORK (P.E. Nov. 75)

Produces 84 switch-selected frequency-accurate tones. A LED monitor clearly displays all beat note adjustments. Ideal for tuning acoustic and electronic musical instruments alike.

Main component set (incl. PCB) £15.59
Power supply set (incl. PCB) £7.03

P.E. SYNCHRONOME (P.E. Mar. 76)

An accented-beat electronic metronome, providing duplo, triple and quadruple times with full control over the beat rate. Can also be used as a simple drum-beat rhythm generator. Includes power supply.

Component set (incl. loudspeaker) £11.62
Printed circuit board £2.04

TAPE NOISE LIMITER

Very effective circuit for reducing the hiss found in most tape recordings. All kits include PCBs.

Standard tolerance set of components £2.96
Superior tolerance set of components £3.76
Regulated power supply (will drive 2 sets) £4.69

ENVELOPE SHAPER WITHOUT VCA (P.E. Oct. 75)

Provides full manual control over attack, decay, sustain and release functions, and is for use with an existing voltage controlled amplifier.

Component set (incl. PCB) £4.66

ENVELOPE SHAPER WITH VCA (P.E. Apr. 76)

This unit has its own voltage controlled amplifier and has full manual control over attack, decay, sustain and release functions.

Component set (incl. PCB) £6.68

TRANSIENT GENERATOR (P.E. Apr. 77)

An envelope shaper, without VCA, having the usual attack, decay, sustain and release functions, and in addition it also provides a "Repeat Effect" enabling a synthesiser to be programmed to imitate such instruments as a mandolin or banjo.

Component set £4.52
Printed circuit board £1.82

WAVEFORM CONVERTER

Slightly modified from a circuit published in a German edition of "Elektron". Converts a saw-tooth waveform into four different waveforms sine-wave, mark-space saw-tooth, regular triangle form, and squarewave with an externally variable mark-space ratio.

Component set (incl. PCB but excl. sw's) £8.19

VOLTAGE CONTROLLED FILTER (P.E. Dec. 74)

Part of the P.E. Minisonic now released as an independent kit for use with other synthesizers.

Component set (incl. PCB) (Order as Kit 65-1) £8.22

RING MODULATOR (P.E. Jan. 75)

Part of the P.E. Minisonic now released as an independent kit for use with other synthesizers.

Component set (incl. PCB) (Order as Kit 59-1) £5.50

NOISE GENERATOR (P.E. Jan. 75)

Part of the P.E. Minisonic now released as an independent kit for use with other synthesizers.

Component set (incl. PCB) (Order as Kit 60-1) £3.35

SOPHISTICATED POWER SUPPLIES

A wide range of highly stabilised low noise power supply kits is available—details in our lists.

MICROPHONE PRE-AMP (P.E. Apr. 77)

Component set (incl. PCB) £3.78

VOICE OPERATED FADER (P.E. Dec. 73)

For automatically reducing music volume during "talk-over"—particularly useful for Disco work or for home-movie shows.

Component set (incl. PCB) £3.97

DYNAMIC RANGE LIMITER (P.E. Apr. 77)

Automatically controls sound output to within a preset level.

Component set (incl. PCB) £4.58

POST AND HANDLING

U.K. orders—under £15 add 25p plus VAT, over £15 add 50p plus VAT. Keyboards £2.00 plus VAT. Optional insurance for compensation against loss or damage in post, add 35p in addition to above post and handling. Eire, C.I., B.F.P.O., and other countries are subject to Export postage rates.

DON'T FORGET VAT!

Add 12½% (or current rate if changed) to full total of goods, post and handling. (Does not apply to export orders).

EXPORT ORDERS are welcome, though we advise that a current copy of our list should be obtained before ordering as it also shows Export postage rates. All payments must be cash-with-order, in Sterling and preferably by International Money Order or through an English Bank. To obtain list send 40p.

PHONOSONICS · DEPT. PE5N · 22 HIGH STREET · SIDCUP · KENT DA14 6EH

MAIL ORDER AND C.W.O. ONLY
SORRY BUT NO CALLERS PLEASE

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 40p.



KEYBOARDS AND CONTACTS

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

3 Octave (37 notes) £25-50, 4 Oct (49 notes) £32-25, 5 Oct (61 notes) £39-75.
Contact Assemblies for use with above keyboards: Single-pole change-over (type SP) as for P.E. Joanna and P.E. Minisonic. Two-pole normally-open make-break (type DP) as for P.E. Synthesizer. Special contact assembly (type 4PS) having 4 poles, 3 of which are normally-open make-break contacts and the fourth is a change-over contact—this special assembly enables THE SAME KEYBOARD to be used with the P.E. Synthesizer, P.E. Minisonic and the P.E. Joanna simultaneously thus avoiding the cost of more than one keyboard. See our list for other contacts.

Contact	Each	3 Octave Set	4 Octave Set	5 Octave Set
SP	£ 8-88	£11-76	£14-64	
DP	£ 9-99	£13-23	£16-47	
4PS	£ 5-30	£10-61	£25-97	£32-33

PRINTED CIRCUIT BOARDS for use with the above contacts and thus eliminating most of the inter-wiring required, are available. Details in our lists.

MORE NEW KITS!

NEW RHYTHM GENERATOR

Redesigned, improved and extended version of the PE 1974 design and including new automatic rhythm programme selector.

TUNE-PROGRAMMABLE SEQUENCER

(PE Nov. 77) The new music unit currently being published.

FORMANT SYNTHESIZER

(Elektr Magazine 1977). Very sophisticated music synthesiser for the advanced constructor and for whom cost is secondary to performance.

GUITAR SUSTAIN UNIT

(PE Oct. 77).
 Details in lists. Please send S.A.E.

SOUND-TO-LIGHT (P.E. Aurora) (P.E. Apr.-Aug. 71)

Four channels each responding to a different sound frequency and controlling its own light. Can be used with most audio systems and lamp intensities.

Basic component set (excl. thyristors)	£15-92
Printed circuit board for above	£3-90
Power supply	£5-78
PCB for power supply	£1-79

3-CHANNEL SOUND-TO-LIGHT (P.E. Apr. 76)

A simple but effective sound-to-light controller capable of operating 3 lamps each of approximately 700 watts. Includes power supply, thyristors, and by-pass switches.
 Component set (incl. PCB) £11-95

DISCOSTROBE (P.E. Nov. 76)

4-channel light-show controller giving a choice of sequential, random, or full strobe mode of operation.
 Basic component set £18-19
 Printed circuit board £3-45

BIOLOGICAL AMPLIFIER (P.E. Jan./Feb. 73)

Multi-function circuits that, with the use of other external equipment, can serve as lie-detector, alphaphone, cardiophone etc.

Pra-Amp Module Component set (incl. PCB)	£4-22
Basic Output Circuits—combined component set with PCBs for alphaphone, cardiophone, frequency meter and visual feedback lampdriver circuits	£6-59
Audio Amplifier Module Type PC7	£7-35

SEMI CONDUCTOR TESTER (P.E. Oct. 73)

Essential test equipment for the enterprising home constructor. While stocks last.
 Set of resistors, capacitors, semiconductors, potentiometers, makaswitches and PCB Panel meter (500µA) £9-63
 £5-70

TRANSISTORS

AC128	26p
AC176	26p
BC107	14p
BC108	14p
BC109	14p
BC147	12p
BC148	12p
BC149	12p
BC157	13p
BC158	13p
BC159	13p
BC182L	12p
BC184	12p
BC187	25p
BC204	14p
BC209C	14p
BC212L	15p
BC213	15p
BC478	29p
BCY71	22p
BD131	44p
BD132	54p
BFY50	22p
BFY51	22p
BFY52	24p
BSY95A	22p
MD8001	172p
OC28	60p
OC71	20p
OC72	25p
OC84	25p
ORP12	79p
ZTX107	12p
ZTX108	9p
ZTX501	13p
ZTX503	15p
ZTX531	23p
2N706	13p
2N914	22p
2N1304	22p
2N2219	27p
2N2905	35p
2N2905A	36p
2N2907	22p
2N3053	18p
2N3054	66p
2N3055	48p
2N3702	12p
2N3703	12p
2N3704	12p
2N3819	35p
2N3820	64p
2N3823E	39p
2N4060	12p
2N5245	51p
2N5459	33p
2N5777	45p

INTEGRATED CIRTS.

318	230p	
718	TO5	40p
709	8-pin DIL	48p
723	TO5	105p
741	8-pin DIL	32p
748	TO5	63p
748	8-pin DIL	63p
µA7805	TO220	205p
µA7808	TO220	205p
µA7812	TO220	205p
µA7815	TO220	205p
µA7818	TO220	205p
AY-1-0212		650p
AY-1-6721/6		185p
CA3046		90p
MC3340		150p
SG3402N		282p

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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 100pF. 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, 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 27V to 36V, E24 series. Total 280 for £15.30
K042 As above but 5 of each value £8.70

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. £4.15.

FERRIC CHLORIDE

Anhydrous technical quality, 1lb double sealed packs. 1lb £1.00; 3lb £2.18; 10lb £5.60; 100lb £39.00

SIRENS

Work off 4 x HP7 batteries, emit very loud noise. Overall size 110 x 75 x 60mm. Use as Burglar Alarm in car, house, workshop etc. ONLY £1.95.

VERO OFFCUTS

Pack A, All 0.1"; Pack B, All 0.15"; Pack C, Mixed; Pack D, All 0.1" plain
 Each pack contains 7 or 8 pieces with a total area of 100 sq. in. Each pack is £1.30. Also available by weight, 1lb £3.45, 10lb £31.
 17 x 3 1/2" strips: 0.1" £2.20, 10 for £15; 0.15" £1.96; 0.1" plain £1.83.

TEXAS 741
8 PIN DIL
FULL SPEC.
100 off £19.50
25 off £5.50

TRANSFORMERS

Special - 12V 8A for only £4.00. 6-0-6V 100mA 85p; 9-0-9V 75mA 85p; 12-0-12V 50mA 85p; 100mA 95p; 12-0-12V 1A £2.90; 20-0-20V 2A £4.70; 20V 2.75A £4.

VERO PLASTIC BOXES

Professional quality, two tone grey polystyrene with threaded inserts for mounting PC Boards.

Type		
2518 120	65 x 40mm	£2.24
2520 150	80 x 50mm	£2.68
2522 188	110 x 60mm	£3.72

Sloping front versions:
 Type
 2523 220 174 x 100/52mm £6.90
 1798 171 x 121 x 75/37.5mm £4.65
 Gen. purpose plastic potting box 71 x 49 x 24, in black or white 40p.
 Hand controller box, shaped for ease of use in the hand, 94 x 61 x 23mm 64p.

S-DECS & T-DECS

S-DEC Breadboard £2.25
 T-DEC Breadboard £3.95

RELAYS AND SOLENOIDS

12V DC enclosed, 2 10A c/o contacts £1.00

Open construction relay with 2 10A c/o contacts, coil rated 24V AC, but works well on 6V DC 60p

240V AC enclosed, 11 pin plug in base, 3 10A c/o contacts, £1.20

240V AC open, 2 15A c/o contacts £1.50

6V miniature low profile for PC mounting, 0.1" pitch 2 pole c/o 137R coil - RS price £2.71 - our price £1.00

Solenoid, rated 48V DC, but work on 24V, 10mm push or pull action. Single hole fixing. Size 27 x 18 x 15mm. Made by Varley. Only 40p.

1977/8 CATALOGUE NOW AVAILABLE - MUCH BIGGER AND BETTER, WITH 50p DISCOUNT VOUCHERS. ONLY 30p plus 15p POST.

WIRE AND FLEX

Flex pack - 5m of 5 diff colours, thick or thin, 25m for 30p. 25 way (14/0076) cable with braided overall screen and PVC sheath, 40p/m.

POWER PACK

Wood grained metal case 90 x 80 x 75mm containing mains transformer giving 6V at 200mA, 2 co-ax sockets, PC board with 1 1/2 fuseholder R's C's etc. Only £1.

EDGE CONNECTORS

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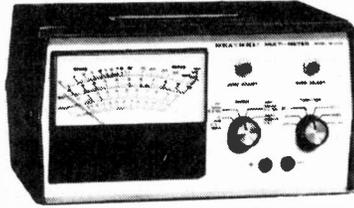
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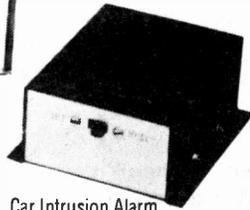
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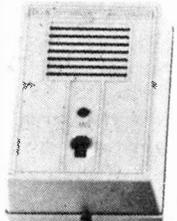


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4007	20p	4076	118p	7417	40p	74100	120p	74178	110p
4008	99p	4077	48p	7420	20p	74104	73p	74179	138p
4009	57p	4081	20p	7421	40p	74105	73p	74180	106p
4010	57p	4082	25p	7422	26p	74107	39p	74181	262p
4011	20p	4083	95p	7423	32p	74109	75p	74182	83p
4012	20p	4502	123p	7425	32p	74110	50p	74184	234p
4013	51p	4510	139p	7428	107p	74111	86p	74185	187p
4014	107p	4511	150p	7427	89p	74116	251p	74190	134p
4015	114p	4512	81p	7428	81p	74120	155p	74191	134p
4016	51p	4514	264p	7430	20p	74121	38p	74192	115p
4017	114p	4515	264p	7432	29p	74122	53p	74193	115p
4018	110p	4516	123p	7433	118p	74123	61p	74194	107p
4019	62p	4518	123p	7437	39p	74125	59p	74195	102p
4020	115p	4520	123p	7438	38p	74126	59p	74196	134p
4021	101p	4522	122p	7440	20p	74128	98p	74197	130p
4022	99p	4526	122p	7442	69p	74132	75p	74198	124p
4023	20p	4527	140p	7443	130p	74142	302p	74199	199p
4024	79p	4528	115p	7444	130p	74143	348p	74221	109p
4025	20p	4531	115p	7445	105p	74144	348p	74246	205p
4026	158p	4543	115p	7447	90p	74145	90p	74247	195p
4027	60p	4555	115p	7448	90p	74147	148p	74248	171p
4028	95p	4556	115p	7450	20p	74148	150p	74249	171p
4029	123p	4581	348p	7451	20p	74150	150p	74251	170p
4030	59p	4582	140p	7453	20p	74151	78p	74265	94p
4033	155p	4584	99p	7454	20p	74153	78p	74278	331p
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4035	118p			7470	33p	74155	90p	74283	9p
4040	132p			7472	30p	74156	90p	74284	712p
4041	84p			7473	33p	74157	82p	74285	712p
4042	89p	7400	18p	7474	33p	74158	140p	74290	122p
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CHIPS UP!

CHIPS could be going up in the next few months! There have been various guarded comments about the cost of i.c.s, and the more popular l.s.i. devices, over the last few months; some time ago at least one of the larger manufacturers rationalised their range and increased the price of a number of items—some by very large factors.

It is not the cost of production which is likely to send prices up, since it is well known that the production cost of each item is an insignificant part of the total price. However, manufacturers have followed a policy of price reduction and this must soon (and is now in some cases) come to an end, since the major part of the cost of each item is the marketing, distribution and back up which all the devices require.

Unfortunately this price factor will probably not affect the multinational concerns that can buy tens or even hundreds of thousands of devices but it will affect the smaller companies and, of course, the hobbyist since neither he nor the component supplier is

able to purchase in vast quantities. Admittedly some suppliers are connected with distribution houses and the advantage that they already have appears likely to be increased.

MADE IN SPACE

Looking ahead rather further, it seems likely that some devices may be manufactured in space and will thus be coming down an even greater path to us! It has been muted that the space (area?) availability on some space shuttle flights could be used for the manufacture of integrated devices with the obvious advantages of clean "air" etc. The technology would obviously add to the 5,000 pounds (weight) of electronics which will be a permanent part of each shuttle.

HOBBY COMPUTERS

Having indicated that we may well be in for some cost increases in devices, we must hasten to add that we fully expect to see the cost of many complete systems to continue in a downward direction. The major one—and obviously the one that many are watching at the present time—being the microprocessor based systems and

the "hobby computer". You will find a review of the KIM I system in this issue and also mention of a British designed system in kit form which is now available (NASCOM I).

NEW TECHNOLOGY

We do not intend to "bury our (editorial) head in the sand" when it comes to any new technology and its possible use by the hobbyist. In fact we believe that it is part of our job to help the introduction of new systems and devices to your home and workbench. This policy is borne out by the use of modern phasing devices—c.c.d.s. or bucket brigade, call them what you will—in the *P.E. String Ensemble* to be featured in next month's issue. Even if the actual unit does not interest you as a constructional project, the use of these devices and the circuitry must.

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Letters

Queries regarding articles published in PE should be addressed to the Editor, at the Editorial Offices, and a stamped, addressed envelope enclosed. We cannot undertake to answer questions regarding other items, nor to answer technical queries over the telephone.

AUTO-RANGING VOLTMETER

STEVE ROBERTS



TO ANYONE concerned with practical work with electronic circuits, the type of measurement most frequently required is undoubtedly voltage. Many instruments are available today which enable voltages to be measured with various degrees of accuracy, clarity or ambiguity, and which present the information on one of two types of readout—linear or digital.

The cost effective digital meter is relatively new upon the scene, but is felt by many people to have disadvantages over its analogue counterpart. One problem is its tendency to create false confidence; 1.32 volts displayed probably means 1.32 ± 0.015 volts. The analogue meter, by its very nature, serves as a constant reminder that the reading is not an absolutely indisputable value. Needle width and parallax effects are two sources of reminder. Another shortcoming of the digital display is its inability to provide qualitative information. A meter needle spinning wildly up to the top end of the scale, or vibrating about a reading, is much more evocative than a simple overrange indication, or a number that keeps changing.

It may also appear to be something of a paradox that when it is required to measure a voltage (implying that the voltage is initially unknown), it is first necessary to select the meter range appropriate to the measurement, for which it is required to know the voltage. This is of course not normally a problem, since the approximate voltage can usually be anticipated, and confirmation or greater accuracy is all that is required.

Much more of a problem is that of remembering to change the meter range for each measurement, or even changing the test leads over when the polarity is reversed. An auto-ranging facility overcomes these problems, and in doing so aids continuity of mental effort, not to mention prevention of damage to meters!

SPECIFICATION

Input resistance	10M Ω
Ranges	0.3V, 1V, 3V, 10V, 30V, 100V automatically selected
Polarity	Either + or - accepted and indicated
Accuracy	2% attainable
Power requirements	Optional mains supply, or $\pm 6V$ batteries
Size	110mm \times 188mm \times 60mm (mains option)

The design to be described is therefore a combination of the best features of analogue and digital instrumentation. It is adequate for all the more usual voltage measurements, and takes up no more room on the bench than the average multimeter.

DESIGN CRITERIA

The instrument was designed with the following points in mind:

- Accuracy comparable with better quality analogue meters.
- High input resistance.
- As clear a display as possible.
- As few controls as possible to leave hands free.
- Total measurement range to cover all normal d.c. voltage reading requirements for i.c. and transistor work.
- Foolproof in use.

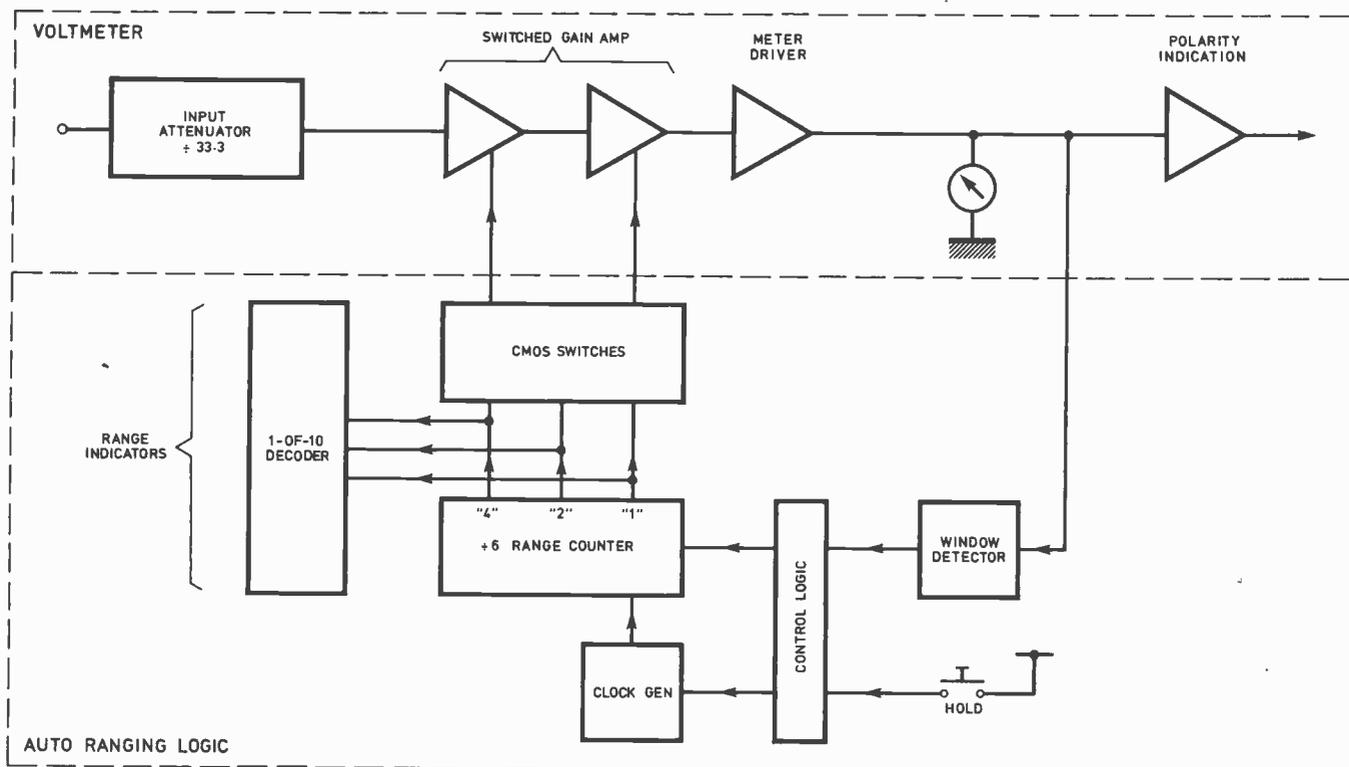


Fig. 1. Block diagram of Auto-Ranging D.C. Voltmeter

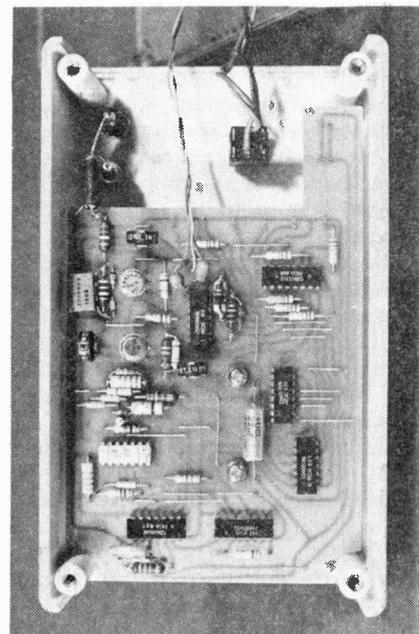
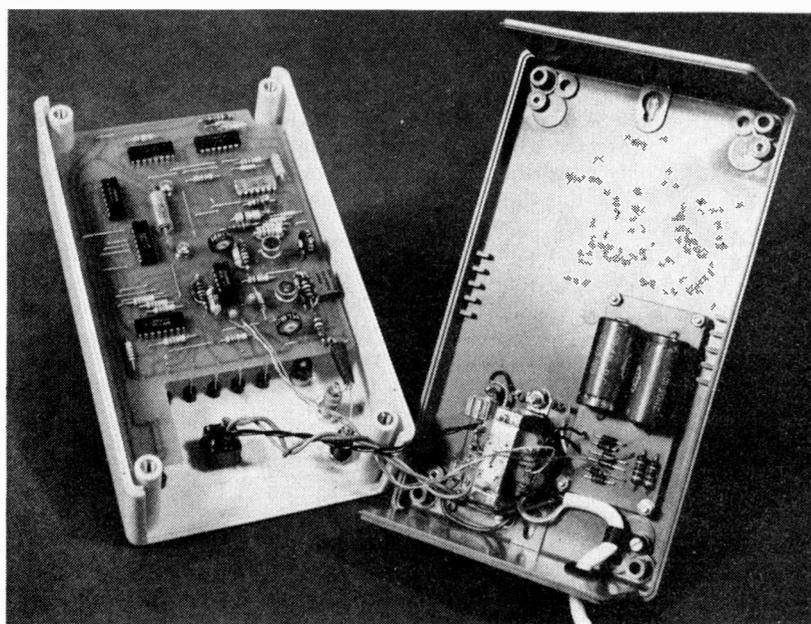
CIRCUIT DESCRIPTION

Referring initially to the block diagram of Fig. 1, the voltmeter section consists of an input attenuator, a two stage amplifier and a rectifier/meter driver.

Referring to the auto-ranging logic section, if the voltage present at the moving-coil meter does not fall within a predetermined window (between 20 per cent and 90 per cent of full scale), the output of the window detector enables the range counter on the next pulse of the clock oscillator. The range counter output controls the status

of the CMOS range selector switches, and thus the gains of the voltmeter amplifiers are changed. The whole process is repeated until a gain has been selected which causes the voltage being displayed to fall within the range of the window detector, at which time the range counter is inhibited and the range remains selected. A decoder is provided which decodes the output of the range counter and drives the range indicating i.e.d.s.

For the detailed circuit description, we must now refer to the full circuit diagram, Fig. 2.



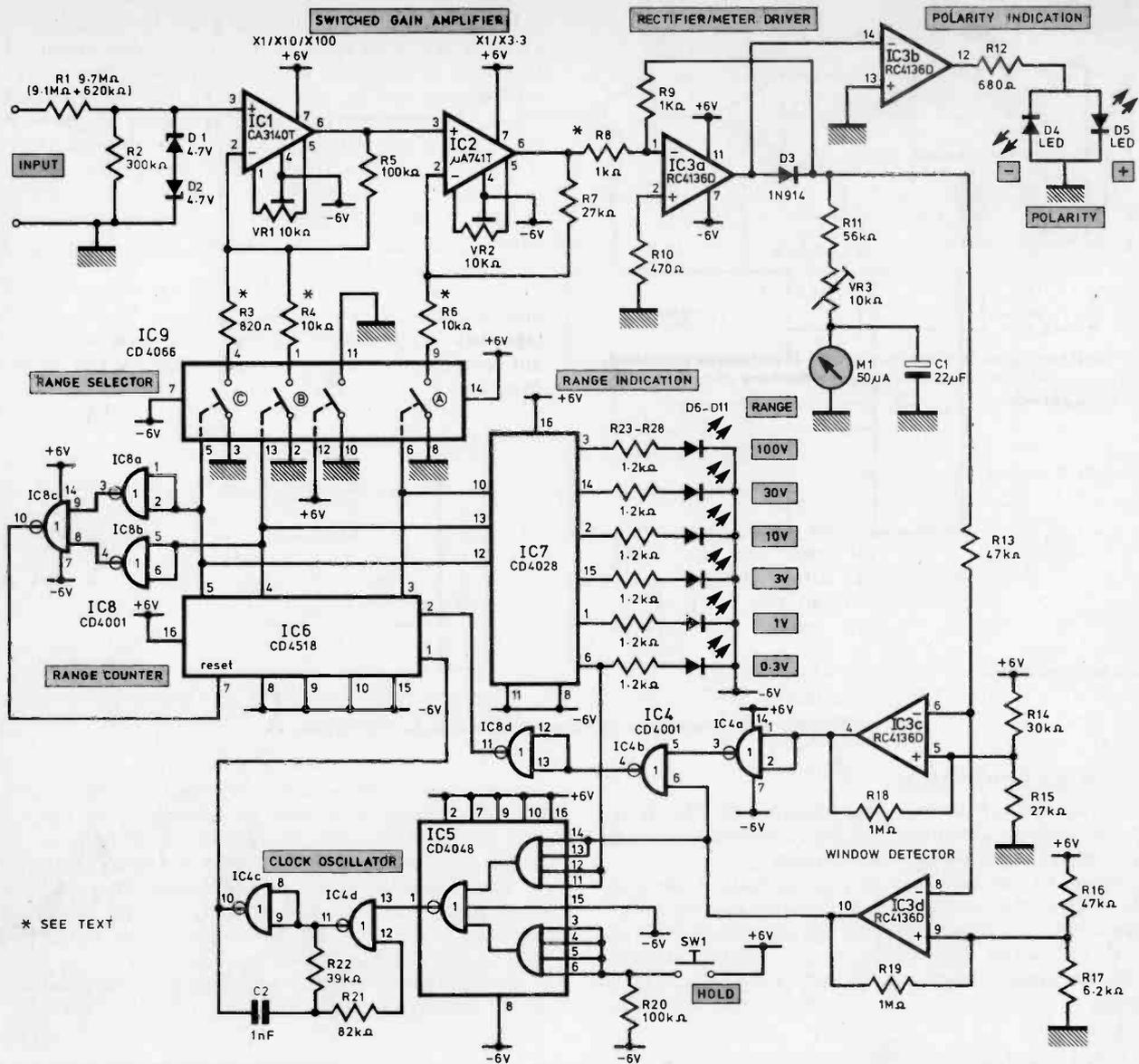


Fig. 2. Full circuit diagram of Voltmeter unit. Although the circuit contains a rectifier, it will not give the conventional true r.m.s. reading for an a.c. input

The input attenuator, R1 and R2, determines the input resistance of the instrument, and reduces the highest possible voltage presented for measurement to a level that can be handled by the input circuitry. Diodes D1 and D2 prevent damage to the circuit should a very high input voltage be applied inadvertently.

The switched-gain amplifier is formed by IC1 and IC2. Op amp IC1 is a very high input resistance device, which is necessary to preserve the integrity of the input attenuator. The gain of the amplifier is adjusted by changing the degree of negative feedback through the CMOS switches.

A conventional full-wave rectifier circuit is formed by IC3a, which presents about +3V at the cathode of D3 for full scale deflection of the meter. The polarity of the voltage at IC3 pin 3 is monitored by IC3b, and this in turn causes the appropriate polarity indicator to be illuminated.

The meter drive voltage is also presented to IC3c and IC3d, which are connected as voltage comparators. If the meter drive voltage is higher than the reference voltage provided by R16 and R17, the pin 10 output is "Low". Similarly, if the voltage is lower than the reference

voltage from R14 and R15, the pin 4 output is "High", and IC4 pin 3 is therefore "Low". The two low inputs presented to IC4b produce a high output, which is present *only* when the two inputs are both low. After inversion by IC8d, this output is used to inhibit the range counter IC6. Note the hysteresis resistors R18 and R19 (giving slight positive feedback) which eliminate any tendency to indecision around the comparison voltage.

NOR gates IC4c and IC4d form an oscillator of around 10kHz. The actual frequency is uncritical as it only affects the search rate of the instrument. The oscillator may be disabled by a high input from IC5, to which reference will be made later.

The dual 4-bit binary counter (IC6), has only half in use. IC8a, b and c, cause the counter to reset on a count of six, thus preventing the selection of invalid gain settings occurring. The binary outputs of the counter are used to activate the CMOS switches, thus selecting the different gain values. See Table 1 under "Test And Calibration".

The binary-to-decimal decoder IC7 provides a "1 of 10" output, which is used to drive directly the range i.e.d.s.

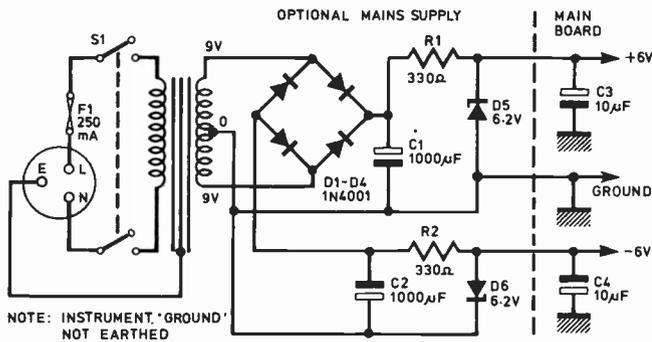


Fig. 3. Optional power supply circuit. If batteries are used, a larger case will be necessary, and a battery check facility would be advisable

LOW READING STABILITY

A problem could occur when the meter has a zero or near-zero input. The window detector would see a voltage too low for the 0.3V range, and would therefore change scales in an attempt to locate the correct range. As there is no more sensitive range, the circuit would search continuously and prevent very low voltage measurements from being made.

The output from pin 6 of IC7, which is high when the most sensitive range is selected, is monitored by IC5, as is the output of IC3d. If the lowest range is selected now, and if the measured voltage falls below the magnitude window, the clock oscillator is inhibited, thus preventing further searching.

Occasions may arise when it is desirable that the range does not automatically change; for example, when examining a voltage that is fluctuating between 8.5 and 9.5 volts. As these figures embrace a range change, meter indications would largely be meaningless unless the range is "held" at, say, 10V. The exact behaviour of the input may then be observed as long as the Hold button is pressed. Pressing this button has the effect of inhibiting the clock oscillator as before.

CONSTRUCTION

The prototype was built in a Type 103 Verobox which provided an attractive and durable housing.

Constructors should decide, before choosing a case, whether the mains, or a battery supply is to be used. As there is no 6V battery of modest dimension readily available, a somewhat larger case than the suggested Verobox would be required. This factor, and the cost of replacement batteries, led to the author's choice of a mains power supply for the prototype. See Fig. 3.

The main printed circuit board (Fig. 4) was secured by means of the meter terminals only; a method found to be quite satisfactory. With the depth of meter body used, the leads of the eight l.e.d.s were found to be just long enough to allow them to protrude through the front panel (see photograph). Mounting clips were not used as these would have made assembly and subsequent removal very difficult, and with the correct size holes a more attractive appearance is presented. Note from the photograph that the l.e.d.s are mounted on the *copper* side of the p.c.b. See Fig. 5 for assembly of the p.c.b.

Use of the suggested printed circuit board layout is to be recommended due to the complexity of the design. There is, however, no reason why other forms of construction may not be used.

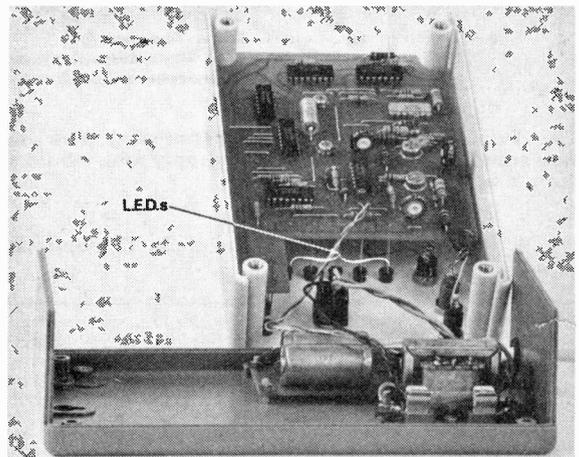
If a mains supply is decided upon, note that the mains earth is *not* connected to the instrument ground. It is desirable, therefore, to use a transformer with an earthed interwinding screen, and to ensure that the instrument is connected particularly carefully where the mains wiring is concerned. Care should also be taken to ensure that this mains wiring is kept as far away as possible from the high impedance input components, as this area is susceptible to hum pick-up. Because of the rectifying action of the meter driver, any a.c. signal present at the input will register as a d.c. voltage on the meter.

The resistors used to select the amplifier gains (R3, R4 and R6) and the \pm balance resistor R8 might advantageously be mounted on extension pins which would aid component changing if required during the calibration procedure.

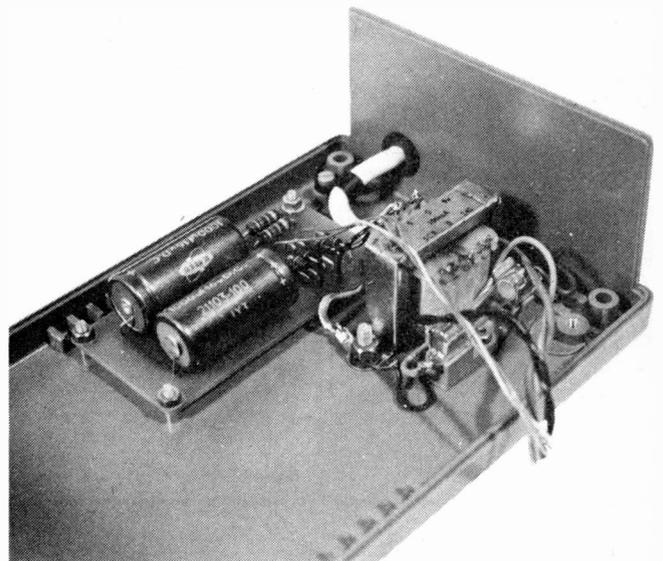
As most of the i.c.s use MOS technology, the appropriate handling precautions should be taken.

The CA3140 was chosen for IC1 as it requires no phase compensation. If this fairly new device is not readily available, a CA3130 may be used instead, with a 47pF ceramic capacitor connected between pins 1 and 8 on the copper side of the board.

If the recommended meter is used, it will need to be re-scaled as shown in Fig. 6.



Note the cut out power supply section from the main p.c.b. Also that the l.e.d.s are mounted at maximum length from the board on the conductor side



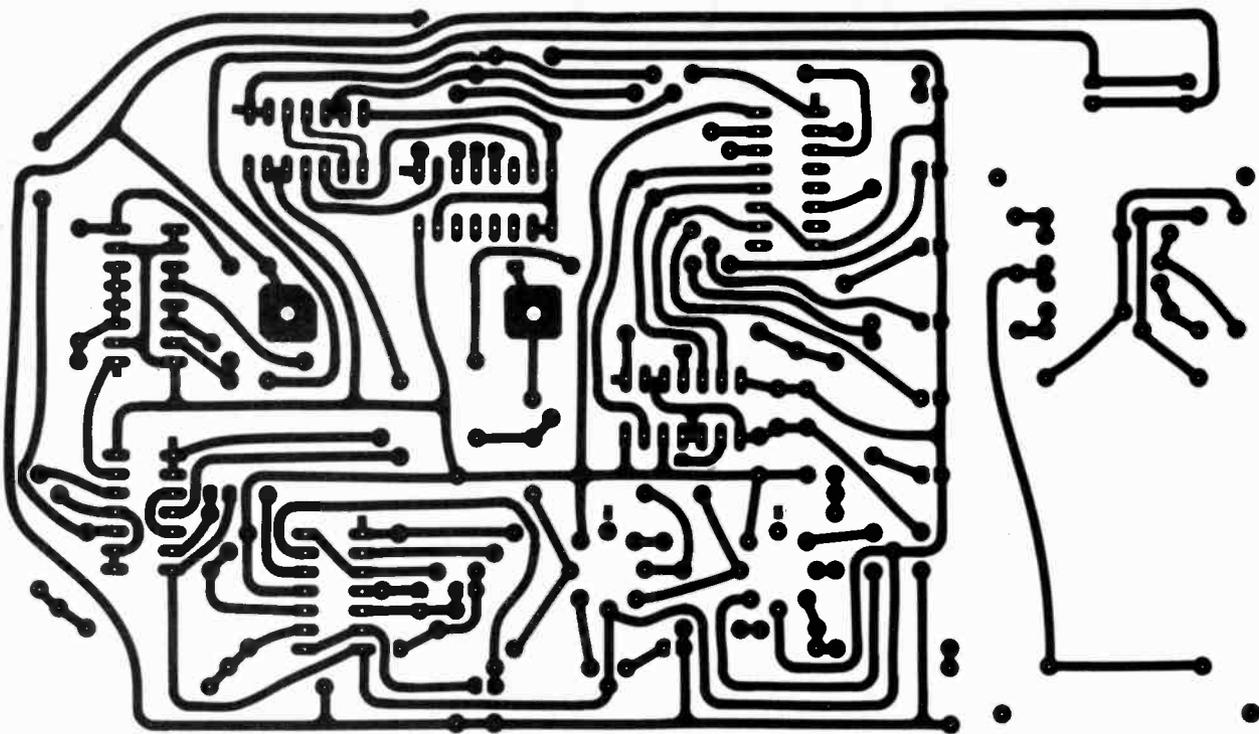
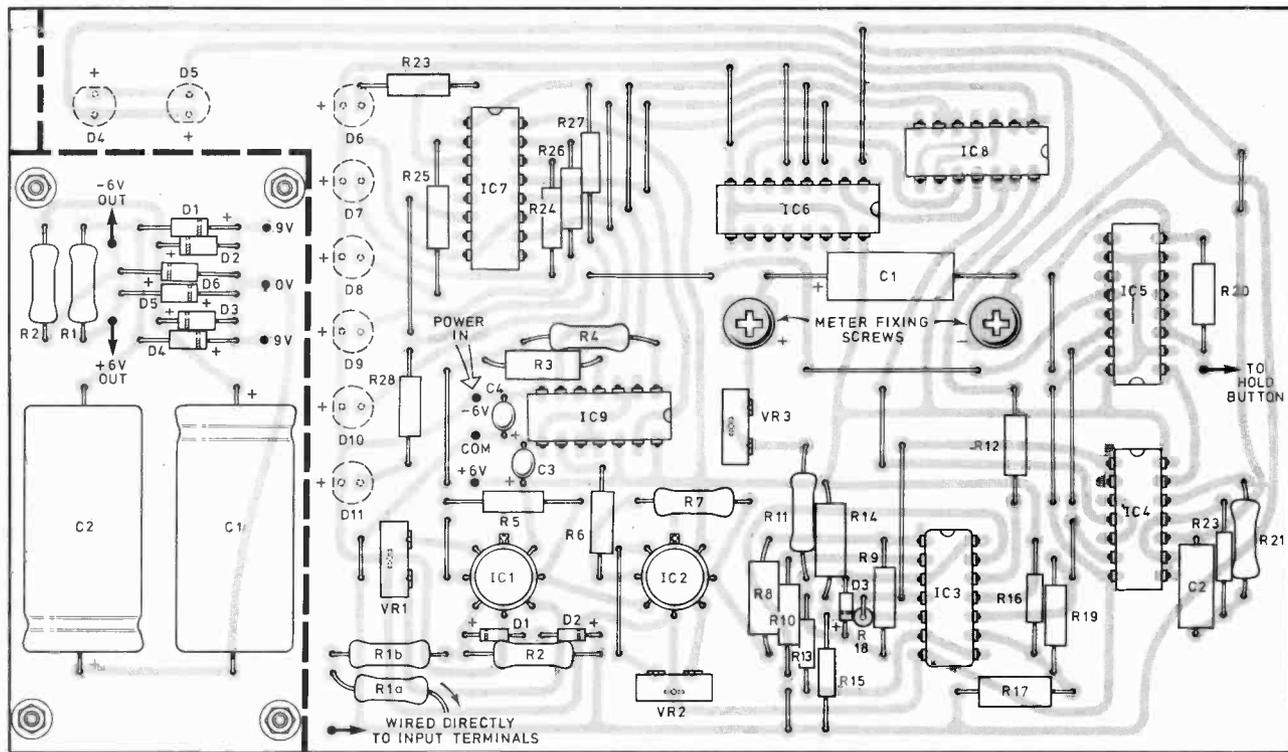


Fig. 4. Printed circuit board layout (full size). The power supply board is included on the same layout so that both can be etched simultaneously. The power supply area would still need to be cut out even if batteries are to be used. Note the shape of the p.c.b. in the photographs

Fig. 5. Component layout of the p.c.b. The optional power supply portion of the circuit board is shown by dotted line



AUTO-RANGING

D.C. VOLTMETER



COMPONENTS . . .

BASIC AUTO-RANGING D.C. VOLTMETER

Resistors

R1	9.1M Ω + 620k Ω in series
R2	300k Ω
R3	820 Ω *
R4	10k Ω *
R5	100k Ω
R6	10k Ω *
R7	27k Ω
R8	1k Ω *
R9	1k Ω
R10	470 Ω
R11	56k Ω
R12	680 Ω
R13	47k Ω
R14	30k Ω
R15	27k Ω
R16	47k Ω
R17	6.2k Ω
R18, R19	1M Ω (2 off)
R20	100k Ω
R21	82k Ω
R22	39k Ω
R23-28	1.2k Ω (6 off)

All resistors are $\frac{1}{4}$ W 5% carbon.

*Resistors to be selected on test, see text.

Potentiometers

VR1-VR3 10k Ω vertical preset (sub min)

Capacitors

C1 1000pF polyester
C2 22 μ F 25V
C3, C4 10 μ F 10V tant (2 off)

Diodes

D1, D2 BZY88C4V7 zener (2 off)
D3 1N914
D4-D11 0.2" red l.e.d. (8 off)

Integrated Circuits

IC1 CA3140T
IC2 μ A741T
IC3 RC4136D
IC4 CD4001
IC5 CD4048
IC6 CD4518
IC7 CD4028
IC8 CD4001
IC9 CD4066

Miscellaneous

S1 Single pole, push-to-make
Case 110mm \times 188mm \times 60mm
M1 50 μ A panel meter (with scale recalibrated)
P.c.b.
4mm plugs and sockets, wire, and prods for probes

COMPONENTS . . .

OPTIONAL MAINS SUPPLY

Resistors

R1, R2 330 $\frac{1}{4}$ W carbon (2 off)

Capacitors

C1, C2 1000 μ F 25V (2 off)
C3, C4 10 μ F 10V (2 off)

Diodes

D1-D4 1N4001 (4 off)
D5, D6 BZY88C6V2 Zener (2 off)

Miscellaneous

S1 Sub min d.p.s.t.
F1 250mA and suitable holder
T1 9-0-9V mains transformer with screen
P.c.b. to design given

CONSTRUCTOR'S NOTE

If the recommended p.c.b. design is used, the CA3140T type should be ordered for IC1 (T stands for 8-lead TO5 package).

Since P.E. does not operate a p.c.b. service we cannot quote a supplier of ready made boards for those who do not wish to make their own, but we can advise that readers keep an eye on P.E. advertisers who specialise in p.c.b. manufacture, and have in the past generally followed up with a service.

The "Large Moving Coil Meter" is available from **Maplin Electronic Supplies** (see advertisers' index for address).

The RC4136D (IC3) is made by Raytheon, and available from **Distronic Ltd., 50/51 Burnt Mill, Elizabeth Way, Harlow, Essex.** Tel: Harlow 32947. Type RC4136DP may be used (D stands for d.i.l. and P for plastic).

The estimated cost to build this unit using all new parts, is in the region of £25.

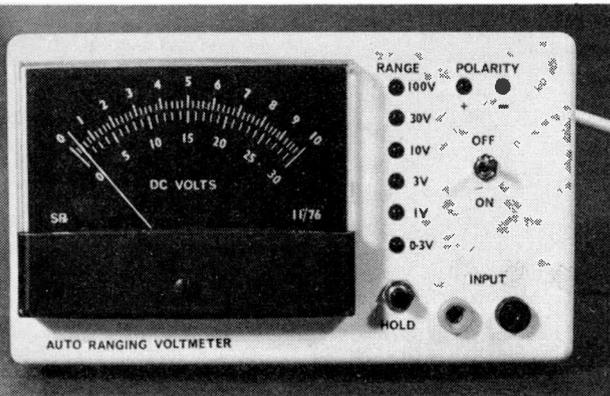
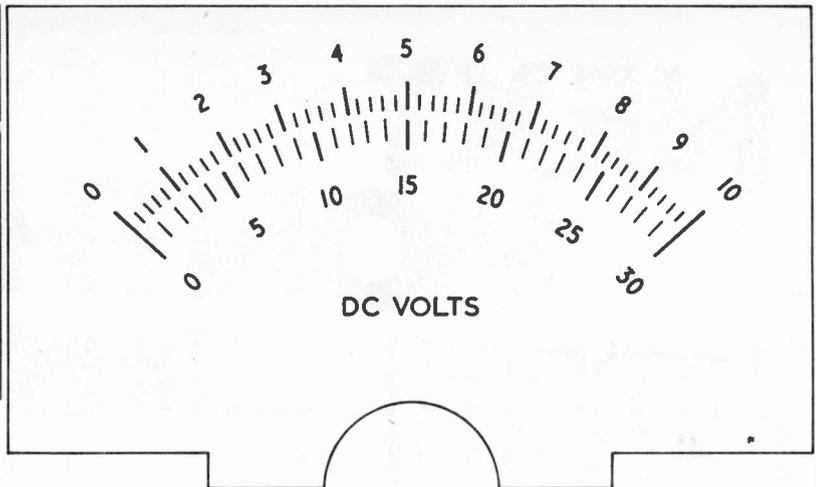


Fig. 6. Meter scale required by the Auto-Ranging D.C. Voltmeter



TEST AND CALIBRATION

Before first switch-on, all preset pots should be at approximately mid-range. Any meter reading should be ignored for the present, although a large offset in IC1 may cause a range change, necessitating adjustment of VR1 to cancel this effect.

Odd combinations of RANGE l.e.d.s, or "searching" should be resolved during calibration, and this procedure is as follows:

(A) Set zero

- (1) With the power off, set the meter mechanically to zero.
- (2) Switch on. Check that the 0.3V range is indicated, and allow a few minutes for thermal stabilisation.
- (3) Short IC2 pin 3 to the zero volt rail. Adjust VR2 for minimum reading on the meter. Remove short.
- (4) Short input. Adjust VR1 for minimum reading. The meter should now read zero.

(B) Set positive/negative balance

- (1) Apply an input to the meter and adjust for a convenient reading.
- (2) Reverse the connections to the meter and check that exactly the same reading is displayed. If not, adjust R8 as necessary.

Table 1. Should a fault exist, this table may be used to check the switching functions. Check all supply voltages first

COUNTER CONTENT	SWITCHES CLOSED	IC 1 GAIN	IC 2 GAIN	TOTAL GAIN	RANGE
0	-	x1	x1	x1	100V
1	A	x1	x3.3	x3.3	30V
2	B	x10	x1	x10	10V
3	A,B	x10	x3.3	x33	3V
4	C	x100	x1	x100	1V
5	A,C	x100	3.3	x333	0.3V
6	B,C	INVALID SETTINGS WHICH DO NOT APPEAR - COUNTER RESETS AT 6			
7	A,B,C				

(C) Set meter calibration

This adjustment compensates for any small inaccuracy in the input attenuator.

- (1) Apply about 50V to the meter input, thereby selecting the 100V range.
- (2) Check meter reading against a known good meter.
- (3) Adjust VR3 for correct reading.

(D) Check $\times 100$ amp gain

- (1) Apply about 0.5V to input, thereby selecting 1V range.
- (2) PRESS HOLD. Adjust input voltage to 1V exactly
- (3) Check that meter reads 1V. If not, adjust R3 for an acceptable result.

(E) Check $\times 10$ amp gain

- (1) Apply about 5V to input, thereby selecting 10V range.
- (2) Press HOLD. Adjust input to 10V exactly.
- (3) Check that the meter reads 10V. If not, adjust R4 for an acceptable result.

(F) Check $\times 3.3$ amp gain

- (1) Apply about 15V to input thereby selecting 30V range.
- (2) Press HOLD. Adjust input voltage to 30V exactly.
- (3) Check that the meter reads 30V. If not, adjust R6 for an acceptable result.

(G) Check upper range-change point

- (1) The range should change to the next highest at about 90 per cent of full-scale reading. If not, adjust R14/R15 as necessary.

(H) Check lower range-change point

- (1) The range should change to the next lower at about 20 per cent of full scale. Adjust R16/R17 if necessary.

This completes the calibration, and the instrument, if correctly set up, should conform to the figures in the specification.

Acknowledgement

The author would like to thank Mr. D. Bowers for his helpful comments and suggestions during this project. ★

NEXT MONTH...

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...a useful tool for constructors

PE STRING ENSEMBLE

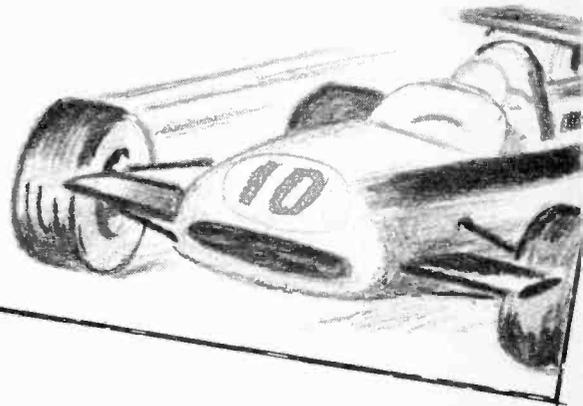


Employing modern delay line technology this instrument produces rich reverberant orchestral string sounds. Additional time and variable envelope controls can be mixed to produce a wide spectrum of sound. Features include:

- * Split keyboard with register variance in both hands
- * Four selectable pitches to match accompanying musical instruments
- * Single contact electronic keyswitch action
- * CMOS i.c.s throughout divider circuitry
- * Unique CMOS chorus drive circuitry
- * Third cost of equivalent commercial instrument

DIGITAL LAP COUNTER

Eliminates any argument when staging a model car race. This system does not impede the cars in any way and can be used to turn off the power after a preset number of laps.



PRACTICAL ELECTRONICS

OUR MARCH ISSUE WILL BE ON SALE FRIDAY, FEBRUARY 10, 1978

KIM HOBBY COMPUTER REVIEW

R.W. COLES

THE LAST twelve months have been very exciting for anyone interested in microprocessors and their application.

Of course, these fascinating and powerful devices have been around for several years now and have already taken the professional electronics industry by storm, but it is really only in the last year or so that microprocessor manufacturers have turned their attention squarely towards the needs of the electronic and computer hobbyist, with some very interesting results.

The hobby market trail blazer (in terms of wide availability anyway) was the National Introkkit which featured the SC/MP microprocessor. The Introkkit was of course reviewed within these pages earlier in the year, and reviews of other units like the Intercept Junior, featuring the IM6100 MPU chip, and the Motorola D2 kit featuring the M6800, were soon to follow.

To start with, manufacturers were a little lazy about just *who* they were aiming their "small system" designs at. Their cautious approach was obvious from the way systems were described as "Prototyping systems", "Introductory systems", and "Tutorial systems" with manuals written, it seemed, for professional engineers who were expected to rapidly move on to bigger and better things, with their loyalty to a particular MPU chip already established! With the unexpected mushrooming of the hobby computer market in the U.S.A. manufacturers soon realised that a huge new market had arisen, and also that this new breed of hobbyist was *not* going to be satisfied with a cheap system which had a limited usefulness and future. The average amateur was not likely to move on to a de-luxe development system with floppy discs and a teletype; he wanted a low cost system which nevertheless could be used to do practical things, a system which had inputs and outputs available for his use, a system with a self-contained keyboard and display, a system with a reasonable RAM memory capacity, a system which could use *low cost* peripherals such as cassette tape recorders, and of course, above all, a system which he could expand when he felt the need for more performance.

HOBBY COMPUTER

KIM-1 is the result of a deeper understanding of the requirements of hobbyists, and is a successful attempt to provide the amateur with the things he needs at a realistic price. KIM-1 is a design from M.O.S. TECHNOLOGY, INC. and uses their own 6502 microprocessor array in a ready built system which arrives

tested and guaranteed for 90 days. The cost of KIM-1 is around the £200 mark, but for this you get a well made micro-computer circuit board which includes a hexadecimal keyboard and 8 digit l.e.d. display, an audio cassette interface, 1,024 words of RAM storage, a comprehensive monitor program in 2,048 words of ROM and 15 input/output lines available on an edge connector. In addition to the KIM-1 board itself, you get a User Manual, a Programming Manual, a Hardware Manual, a system wall chart and a programmer's reference card. The three manuals together are no less than 4cm thick, and even at first glance these appeared to be *very* comprehensive to us!

With a full 1k of user RAM available from the start, a KIM-1 owner is unlikely to feel cramped for space for quite a while, especially since programs can be stored on, and retrieved

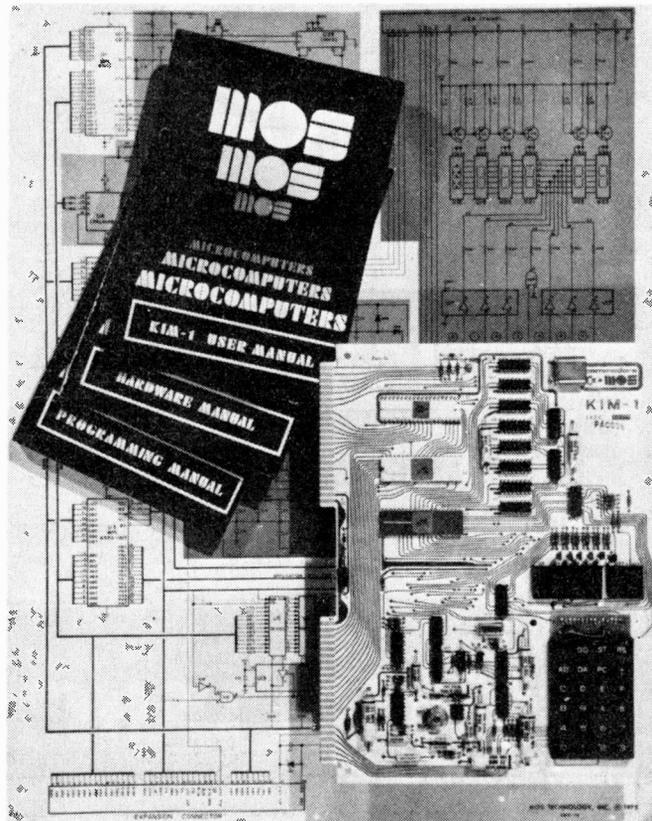
from, conventional cassette tapes with the simple addition to the system of a low cost audio cassette recorder. As a user becomes more ambitious however, the KIM-1 board can be augmented with the KIM-2, 3, 4, or 5 boards which will provide sufficient extra RAM memory to run sophisticated high level software, like BASIC for example, when this becomes available.

The 6502 microprocessor and associated circuits require only a single 5 volt supply which can be easily put together using a fixed voltage LM309K regulator. When a cassette recorder is used, an additional low current 12 volt supply is required to power the interface circuitry.

THE MPU CHIP FAMILY

The MCS6502 chip used as the heart of KIM-1 is one member of a large family of microprocessor chips produced

At a price of £199 upwards, the KIM-1 is supplied as an assembled and tested microcomputer with keyboard, display and full documentation. Available from GR Electronics Ltd., Newport, Gwent



V _{ss}	1	40	RES
RDY	2	39	θ ₂ (DUT)
φ ₁ (OUT)	3	38	S.O.
IRQ	4	37	θ ₀ (IN)
N.C.	5	36	N.C.
NMT	6	35	N.C.
SYNC	7	34	R/W
V _{cc}	8	33	DB0
AB0	9	32	DB1
AB1	10	31	DB2
AB2	11	30	DB3
AB3	12	29	DB4
AB4	13	28	DB5
AB5	14	27	DB6
AB6	15	26	DB7
AB7	16	25	AB15
AB8	17	24	AB14
AB9	18	23	AB13
AB10	19	22	AB12
AB11	20	21	V _{ss}

MCS6502

The MCS6502 microprocessor chip used in KIM-1.

by M.O.S. TECHNOLOGY, INC. Many readers may be unfamiliar with this manufacturer and the MCS 65XX series of MPU chips, although they are fairly well known in the U.S.A. The family is described by M.O.S. as "Third generation" and it is certainly true to say that several advanced features are available within the family, which obviously owes a lot of its basic design to the Motorola M6800 chip with which its members are bus compatible.

There are nine microprocessors in the family and these offer complete software compatibility (the same instruction set) but differing hardware features such as 28 or 40 pin package, on or off chip clocks, varying address range from 4k to 65k words, and choice of interrupt facilities. All members of this family offer NMOS high speed (2MHz maximum) operation and a very efficient in-

struction set with 56 basic instructions. The MCS6502 is an on chip clock, 40 pin package version with an address range of 65k words, making it a very sophisticated device with lots of potential.

PERIPHERAL CHIPS

Also on the KIM-1 board are two MCS6530 chips, and these devices are not microprocessors but a powerful combination of a ROM array, a RAM array, an Interval timer and two eight bit input/output ports, all in a single 40 pin package! It is probably the availability of these devices which makes the KIM-1 possible at such a low price, because providing these facilities separately would certainly be expensive!

Each MCS6530 contains 1,024 words of mask programmed ROM normally used to hold programs, and 64 words of RAM which can be used for scratch pad storage, stacks, etc. The interval timer is a down counter which can be preset under program control, and which will interrupt the MPU chip when a count of zero is reached. Under program control the MCS6530 timer can be used to generate a wide variety of timing functions which allows this important system task to be unloaded from the microprocessor itself, promoting software efficiency.

The sixteen input/output lines are individually programmable as either inputs or outputs under software control, and they can source 3mA at 1.5 volts when used as outputs, making interfacing straightforward.

CAUTION

One word of caution on the MCS6530; its ROM section, being mask programmable, is unsuitable for use in any "homebrew" system, although of course,

it is ideal for the KIM-1 itself where the monitor program is loaded during manufacture by M.O.S. themselves. A homebrew system *would* be possible using external EPROM chips such as the 2708 or 1702A, if required.

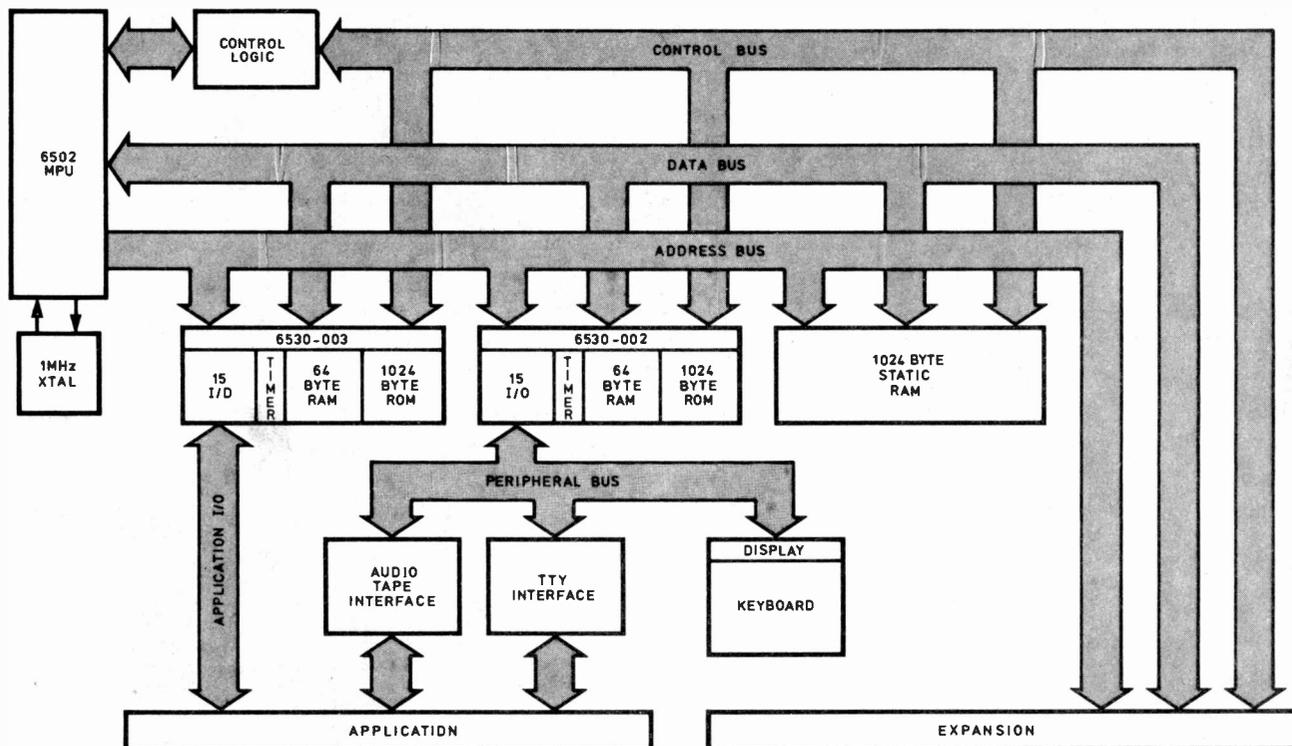
User program storage on the KIM-1 board is provided by eight 1024 by 1 bit 2102 type NMOS RAM chips, although as you will have gathered from the description of the MCS6530 chip, a further 128 words is available if required. The basic address range of KIM-1 is 8k words, with the MCS6530 ROM, RAM I/O and TIMERS mapped into the upper three 1k pages, and the user RAM mapped as the lower 1k page. Expansion to the full 65k words can be carried out externally at a later date if desired.

OUR EXPERIENCES

With the system up and running with the aid of a bench 5 volt supply, we tried out the simple program on page 9 of the User Manual. The method of program entry is, in our opinion, better than the MEM, TERM system used on the SC/MP Introkit, because it is much simpler. To set an address you press the AD key followed by *four* HEX digits. To enter instructions or data you press the DA key followed by *two* HEX digits, and to increment to further locations for further entries you press the + key followed by the next two HEX digits and so on. To run a program you enter its start address using the AD mode, and press the GO key.

The other keys available are RS, which causes system reset, ST which terminates the current program and PC which allows you to display the value of the program counter at the time that an interrupt occurred or the ST key was pressed. Execution can be continued from where it was stopped by the ST key by pressing

KIM-1 block diagram.



the GO key. A slide switch on the keyboard allows you to enter the "single-step" mode so that single instructions are executed for each press of the GO key.

With a feeling of "So far so good", we hooked up a 12 volt supply in addition to the 5 volts already connected then blew the dust off of our portable cassette recorder and connected it up, too, following the simple diagram in the manual.

CASSETTE

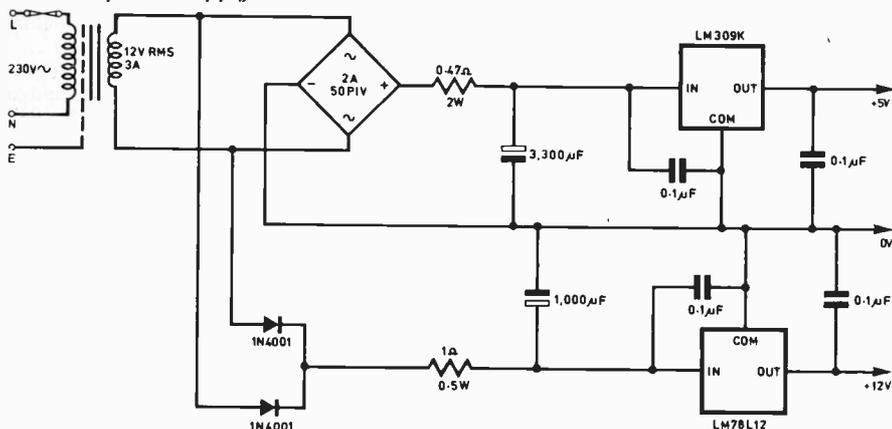
The KIM-1 monitor program controls the storage and retrieval of data on the cassette, and when recording a program a checksum is added in at the end so that verification is possible during replay into KIM-1 RAM. Each program must be given a unique "name" before recording takes place, and this "name" (actually a two digit HEX code) is used to identify the required program on replay. We dumped the simple trial program from RAM onto a cassette, switched off the power, and then attempted to reload it into RAM—failure!

After a lot of experimentation we discovered that it was necessary to use different volume control settings for record and replay to get the system to work. Now this might have been the fault of our cassette recorder, which was not new but seemed perfectly serviceable, but the manual certainly led us to understand that a unit of the type we used would be quite satisfactory, and that no adjustment of the controls would be required.

After some practice the record and replay functions were operating correctly most of the time, and we began to realise the enormous advantages of the cassette system compared with the pencil and paper method of storing programs! By hooking up a microphone to the recorder it is also possible to cue programs verbally on the tape, so that both you and your KIM-1 know what's going on! (Voice signals are ignored by the monitor routines on replay.)

KIM-1 also comes with a routine for handling teletypes or VDUs of any standard baud rate, and is equipped with a 20mA current loop interface for this purpose. We were unable to try out this particular aspect of system operation however.

Suitable power supply for KIM-1



MCS6502 MICROPROCESSOR INSTRUCTION SET—ALPHABETIC SEQUENCE

ADC	Add Memory to Accumulator with Carry	JSR	Jump to New Location Saving Return Address
AND	"AND" Memory with Accumulator	LDA	Load Accumulator with Memory
ASL	Shift Left One Bit (Memory or Accumulator)	LDX	Load Index X with Memory
BCC	Branch on Carry Clear	LDY	Load Index Y with Memory
BCS	Branch on Carry Set	LSR	Shift One Bit Right (Memory or Accumulator)
BEQ	Branch on Result Zero	NOP	No Operation
BIT	Test Bits in Memory with Accumulator	ORA	"OR" Memory with Accumulator
BMI	Branch on Result Minus	PHA	Push Accumulator on Stack
BNE	Branch on Result not Zero	PHP	Push Processor Status on Stack
BPL	Branch on Result Plus	PLA	Pull Accumulator from Stack
BRK	Force Break	PLP	Pull Processor Status from Stack
BVC	Branch on Overflow Clear	RORL	Rotate One Bit Left (Memory or Accumulator)
BVS	Branch on Overflow Set	RORR	Rotate One Bit Right (Memory or Accumulator)
CLC	Clear Carry Flag	RTI	Return From Interrupt
CLD	Clear Decimal Mode	RTS	Return From Subroutine
CLI	Clear Interrupt Disable Bit	SBC	Subtract Memory from Accumulator with Borrow
CLV	Clear Overflow Flag	SEC	Set Carry Flag
CMP	Compare Memory and Accumulator	SED	Set Decimal Mode
CPX	Compare Memory and Index X	SEI	Set Interrupt Disable Status
CPY	Compare Memory and Index Y	STA	Store Accumulator in Memory
DEC	Decrement Memory by One	STX	Store Index X in Memory
DEX	Decrement Index X by One	STY	Store Index Y in Memory
DEY	Decrement Index Y by One	TAX	Transfer Accumulator to Index X
EOR	"Exclusive-or" Memory with Accumulator	TAY	Transfer Accumulator to Index Y
INC	Increment Memory by One	TSX	Transfer Stack Pointer to Index X
INX	Increment X by One	TXA	Transfer Index X to Accumulator
INY	Increment Y by One	TXS	Transfer Index X to Stack Pointer
JMP	Jump to New Location	TYA	Transfer Index Y to Accumulator

VERDICT

The thing which impressed us most about the KIM-1 system was the provision of the three excellent manuals which between them covered all aspects of system operation and programming in minute detail. Anyone with a basic knowledge of microprocessors, or computers in general, should be able to find their way around easily with the aid of these books. The User Manual is written in a chatty informal style which puts the reader at ease right from the word "go". Following this book in step-by-step fashion is rather like taking a programmed learning course, and most KIM-1 owners will find themselves eager to delve into the other two manuals, which are rather more formal, once they have mastered its contents.

On the hardware side, the powerful MCS6502 chip, the full 1k of user RAM and the cassette interface, speak for themselves.

KIM-1 also has that magic ingredient "expendability" so that owners need not feel boxed in. Expansion can be carried out *without* a soldering iron, and those who look forward to a powerful "Home computer" have every chance of achieving this later if a VDU or teletype is added to the system, and the manufacturers start to provide software on cassette (which is likely). As it is, the basic KIM-1 can be programmed easily in machine code, and can of course be connected up directly to external gadgetry by means of the input output lines, if required.

The instruction set of the MCS6502 has some powerful features, like I3 addressing modes, and the ability to set the arithmetic unit to "Decimal mode" for the duration of a B.C.D. calculation rather than having to use "Decimal adjust" instructions as is the case with other devices. The mnemonics looked easy to learn to us, although they are different to those used with the 8080, or the 6800 its two major competitors.

The construction and component quality looked good. We noticed that the cassette recording format is not of the "Kansas City" type, which means a black mark, although the system used *is* self clocking which is to its credit. The seven segment displays were a little difficult to decipher in high ambient lighting, but we soon cured this by adding a piece of red filter material.

All in all then, the KIM-1 seems a good buy for all low-budget micronuts, and a useful step nearer that impossible dream, the "perfect" system.

ANYONE looking for a simple and novel project to build, just for fun, may be interested in the Strength Meter described in this article.

The power of the contestant's grip is displayed on a row of l.e.d.s while he squeezes two cannisters as tight as he can. However, the indicator is not to be treated with scientific reverence since it *really* works by measuring the resistance between the hand-grips.

CIRCUIT DESCRIPTION

The circuit shown in Fig. 1 is designed so that the number of l.e.d.s which illuminate along the row comprising D1 to D4, increases as the resistance between the hand-grips falls; which of course happens when the contestant squeezes harder.

A potential divider is produced between 0V and +9V by R1 and R2, and since their resistance ratio is 1:1, the voltage at point "B" will be half the supply, which is +4.5V. The differential amplifier formed by IC1 uses this voltage as a reference, so that it amplifies the difference between points "A" and "B".

Voltage "A" however, is produced by a potential divider of variable ratio, which is dependent on the hand-grip resistance. This voltage, for any given degree of hand-grip squeeze, can be set using VR1, but the voltage generated by zero squeeze (no hand-grip contact at all) always starts off from 0V. This "slope" setting will also determine the amount of grip necessary to pull up all four l.e.d.s.

After amplification in the non-inverting amplifier IC1, the generated voltage is fed to the base of TR1. This stage has no voltage gain (some voltage will in fact be

lost across the base-emitter junction), but simply multiplies the output current capability of the 741 by the gain figure of the BC107, a figure which of course will vary from one such transistor to another due to production spread. But in any case TR1 will add sufficient current drive to take the load consisting of the resistor chain R5 to R9.

The point of the resistor chain is to divide the voltage produced at point "C" into five equally spaced potentials. This way, as the voltage at "C" increases, the voltage at "D" will eventually become sufficient to overcome the base-emitter junction potential of TR2, plus a little more to push some current through R10. When this happens D1 will illuminate as TR2 switches into conduction.

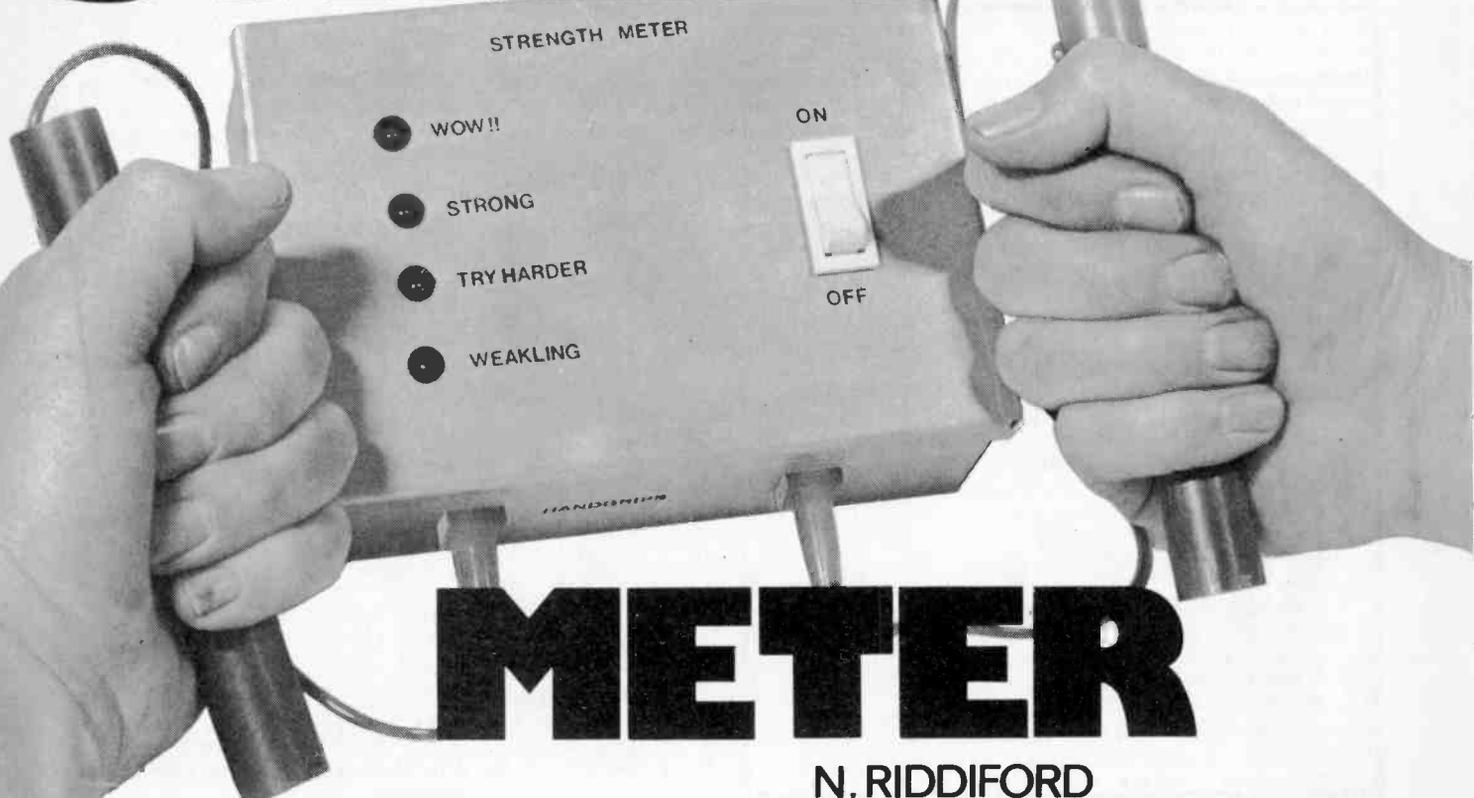
If the voltage at "C" continues to increase, then the voltage at "E" will become sufficient to bias TR3 into conduction, and so on, until all the l.e.d.s are illuminated. Just as R10 to R13 limit the base current to their respective transistors, resistors R14 to R17 limit the l.e.d. currents to around 17mA.

CONSTRUCTION

The circuit was built on a piece of 0.1 inch matrix stripboard and the layout, shown in Fig. 2, will accommodate either an 8-pin d.i.l. or the 14-pin version of the 741 amplifier. Care should be taken to ensure that the appropriate breaks are made to the copper tracks, and that no blobs of solder or shavings of copper form a bridge between conductors.

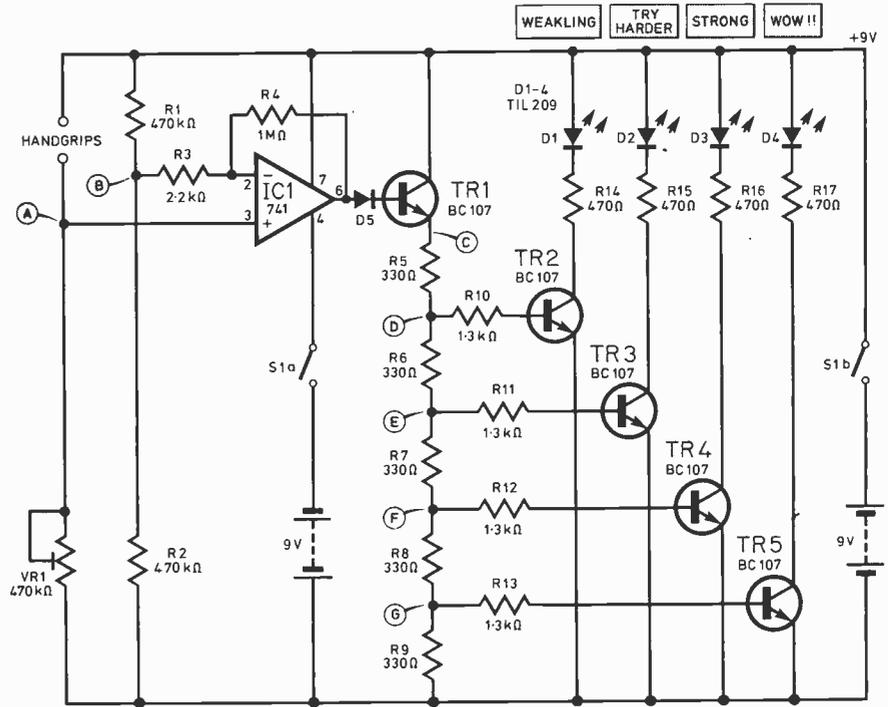
A simple aluminium box was used for the prototype, and this could be formed from a sheet of metal if a

STRENGTH



N. RIDDIFORD

Fig. 1. Complete circuit diagram of Strength Meter. The diode D5 protects TR1 from a negative voltage swing at IC1 output. Although the photographs show a single-pole on/off switch, the arrangement detailed in this circuit diagram is recommended, and uses a two-pole rocker for total switch-off



COMPONENTS . . .

Resistors

R1, R2	470kΩ
R3	2.2kΩ
R4	1MΩ
R5-R9	330Ω (5 off)
R10-R13	1.3kΩ (4 off)
R14-R17	470Ω (4 off)
All resistors ½W 5% carbon film	

Potentiometers

VR1 470kΩ horizontal preset

Semiconductors

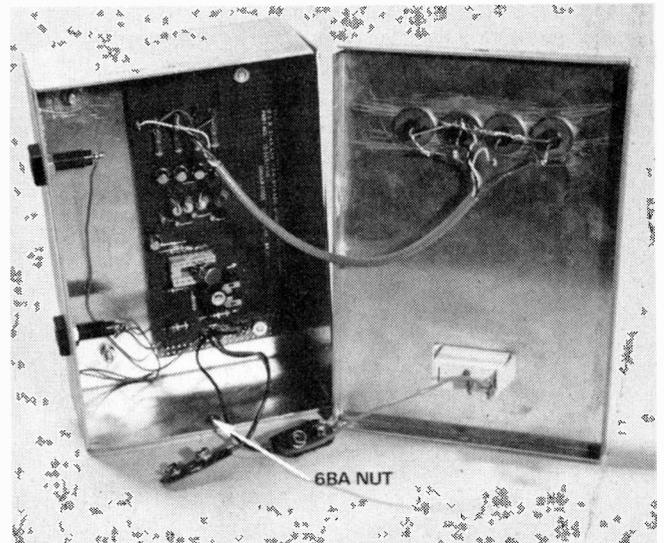
IC1	741 8- or 14-pin d.i.l.
TR1-TR5	BC107 or similar (5 off)
D1-D4	0.2 inch red l.e.d. (4 off)
D5	1N4148 or similar

Miscellaneous

0.1 inch stripboard 127 × 63mm
 14-pin i.c. socket (optional)
 4mm plugs and sockets (2 of each)
 PP3 batteries (2 off)
 Case: 155 × 105 × 53mm, or sheet alloy to form
 Suitable battery studs (2 off)
 Plastics l.e.d. bezels (4 off)
 Rocker type on/off switch D.P.C.O.
 Tubing for handgrips

suitable size cannot be found ready made. Four holes should be drilled in the base to accommodate 4BA screws for fixing rubber feet to the unit. Two of these screws should be long enough to take spacers, the stripboard and fastening nuts. Two holes need to be drilled to mount the 4mm sockets, and a further four in the lid to house the l.e.d. bezels. Finally an oblong hole should be cut out (using an Abrafile) if the R.S. type switch is used for the ON/OFF function.

The prototype box which was "home made" had 6BA nuts held in place on the side of the base, by an epoxy resin glue, to take the lid retaining screws (see photograph).



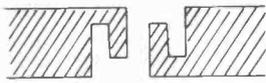
The 741 op amp in this photograph is a TO5 type, which is not the recommended i.c. package. If the box is "home made", 6BA nuts to take the lid retaining screws can be fixed to the case using Araldite Rapid or similar resin based adhesive.

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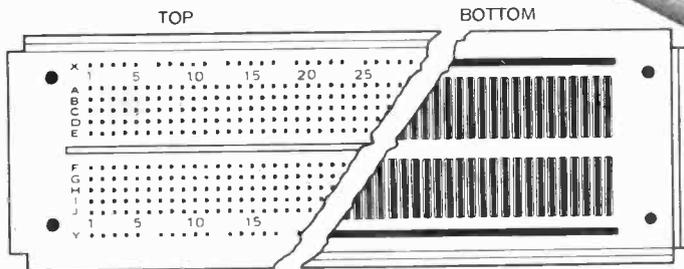
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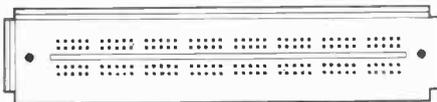


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Experimenter 600 and 650 models are ideal for RAM's ROM's and PROM's (0.6" centre IC's) while the 300 and 350 models are for smaller DIP's (0.3" centres). All four models, of course, also take all standard components, the 0.1" grid being compatible with transistors, diodes, LED's, capacitors, resistors, pots—in fact any component with lead sizes between 0.015" and 0.032"



A useful quad bus strip (EXP4B) further

Model	Length"	Width"	Centre channel"	5-way tie points	Bus	Price
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EXP350	3.6	2.1	0.3	46(230)	2(40)	£3.69
EXP600	6.0	2.4	0.6	94(470)	2(80)	£7.35
EXP650	3.6	2.4	0.6	46(230)	2(40)	£3.99
EXP4B	6.0	1.0	N/A	N/A	4(160)	£2.83

All units are 0.330" deep. Prices include VAT (8%) and p&p for UK Orders. Add 5% to all orders outside UK. All prices and specifications correct at the time of going to press.

expands the versatility of the system for the MPU user.

Experimenter breadboards can be used alone or mounted on any convenient flat surface, thanks to moulded-in mounting holes and vinyl insulation backing that prevents short circuits. Mount them from the front with 4-40 flathead screws or from the rear with 6-32 self tapping screws.

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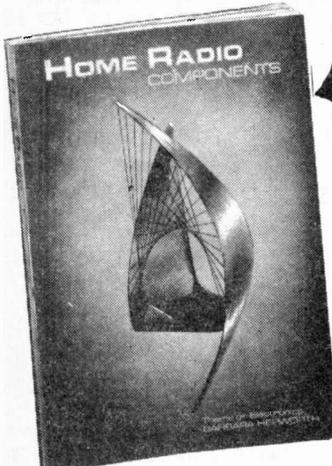
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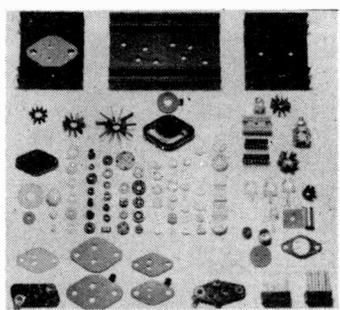
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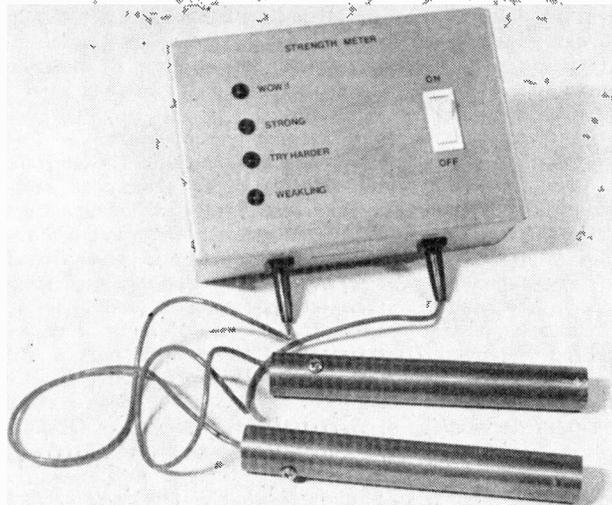


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HAND-GRIPS

The hand-grips can be made from a number of things such as curtain or stair rod, or as in the prototype, 18mm diameter brass tubing. To connect wires to these it is necessary to drill a hole in each, so that a 6BA nut and bolt can be passed through to clamp a solder tag. The wires should be soldered to the tags *before* clamping them, as objects showing thermal inertia of this magnitude will not solder readily without a very large soldering iron indeed.

The prototype used 4mm plugs and sockets to terminate the hand-grips, so that they can be disconnected, wrapped in something soft, and then stored inside the case. If the recommended size is used, there will be ample room for this.

SETTING UP

The potentiometer VR1 should be adjusted so that a gentle hold on the hand-grips will just illuminate D1, the WEAKLING light. ★

NEWS BRIEFS

Exhibition

THE 1978 IEA (Instruments, Electronics and Automation) Exhibition will be held at the National Exhibition Centre, Birmingham, from March 13-17.

A computerised visitor registration and enquiry system will be operating in four languages, and this will give specific information on product categories and exhibitors to the visitor, thus providing a mutually beneficial two-way service.

The exhibitors will be of a highly international mixture, consisting of manufacturers ranging from passive components right through to computerised machine automation, and they will occupy the largest hall at the centre.

The exhibition is claimed to be the only recognised trade fair of 1978 in the U.K. covering the electronic instruments industries, and will again be held alongside ELEC-TREX, following their successful coming together in 1976.

Watts On The Road

THE first three of a planned 62 strong fleet of electric delivery vans hit the roads of London in November last year, as part of a three year plan to assess the performance of electric vehicles in urban conditions.

The machines are confined to the 0.75-1.75 tonne range, with high acceleration, regenerative braking, top speeds of around 50 m.p.h., and a realistic range of up to 60 miles per charge-up.

Under the scheme the Department of Industry is contributing in all, up to £400,000 to users of these vehicles to offset the cost over that of conventional vans.

Co-operation between the DoI, the manufacturers, the operators, the Department of Transport and the GLC, has led to the use of three types of electric vehicle being used in the scheme: 12 vehicles from Crompton Electriccars, 25 "Silent Karriers" from a consortium of Chloride Technical, Chrysler Motors and the National Freight Corporation,

and 25 "Bedford CF Vans" from Joseph Lucas Ltd. in association with Vauxhall Motors.

The GLC will collect data from such operators as Initial Services and National Carriers for collating, and a final report will be published by the DoI upon conclusion of the scheme.

Microcomputer Kit

IN the face of much criticism concerning the potential usefulness of microcomputers in the home, Lynx Electronics have launched the NASCOM 1 microcomputer kit which carries a basic price tag of £197.50 plus VAT. The launch came as part of a seminar entitled Home Microcomputer Symposium which was attended by some 550 people. Over 300 kits were sold in the two weeks following the launch.

The concepts of NASCOM 1, as described by Mr K. Borland of Lynx, were: "To produce for sale a complete microprocessor system that is of intelligent use to the home users and is priced around £200.00.

By using the best available product on the market, within our price range, to design the maximum possible system. This is an advantage that an independent design has over an in-house design by a manufacturer with his own product range.

To design for maximum control by software. By the choice of components it should be possible to totally minimise the constrictions of hardware.

To design a system that offers major future expansion. Either expansion by the user to his own design, or by additional Lynx products.

These were the four main ideas. It followed on that certain other details were going to be necessary.

Firstly, it would be essential in providing an intelligently usable system, to have a full keyboard. The limitations of a calculator type keyboard are now well known. Also any major expansion would make a full keyboard essential.

Secondly, there must be sufficient memory for the user to load and execute reasonably sized programs.

Thirdly, incorporate a fixed command program to allow easy user communication with the system.

We are delighted that it has been possible to achieve all these goals in the NASCOM 1."

For full details write to Lynx Electronics (London) Ltd., 92 Broad Street, Chesham, Bucks.

MARKET PLACE

Items mentioned in this feature are usually available from electronic equipment and component retailers advertising in this magazine. However, where a full address is given, enquiries and orders should then be made direct to the firm concerned. All quoted prices are those at the time of going to press.

DESK CALCULATOR

The newest calculator to be added to the Sinclair range is a desk top machine, the Sinclair President. This calculator has been specifically designed for the businessman whatever the task, be it balancing the yearly budget or working out the week's expense account. The President is exactly suited to the needs of the executive.

In style, the calculator strikes a well proportioned balance—not too heavy, yet not too light to serve as a genuine desk top model—the President will fit comfortably into a slimline briefcase.

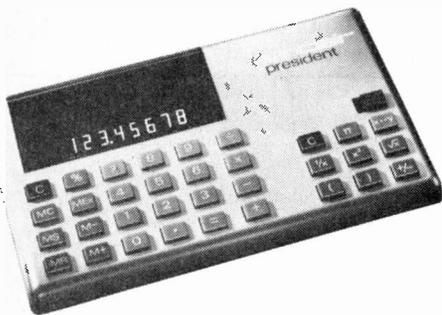
Sinclair commissioned a consumer research programme among leading executives, and found that what was required was: a battery powered unit, but with mains option, a six function memory, a bright easy to read display, and single function keys. The President incorporates all of these!

The keyboard has a split layout. On the left are found the standard numerical and arithmetical functions, % key and six function memory. To the right are located functions specifically for business use, parenthesis, $+/-$, $x < > y$, \sqrt{x} , $1/x$, x^2 , and π .

Reflecting its desk top role, the elegant satin silver President has a large bright blue angled display, and rubber feet which keep it stable during use.

Priced at £17.95 + VAT the President is available at all leading stores, and carries the usual Sinclair 12 month unconditional guarantee.

Sinclair Radionics Ltd., London Road, St Ives, Huntingdon, Cambs, PE17 4HJ.



Sinclair President desk top calculator

STOPWATCH

One of the pities of metrication is that it does not extend to time measurement. With a stopwatch you can assess quite accurately the length of one cycle in hours, minutes and seconds. But you can't immediately tell how long 100 cycles will take simply by shifting the decimal point two places. You have to work instead in sexagesimal arithmetic.

To the rescue come Casio Electronics Co with their new ST-1 stopwatch/calculator. It will time any operation up to a maximum of about ten hours, to an accuracy of a tenth of a second, and then its calculator section will perform any of the four arithmetic functions you like, on that, or any other time. It can yield an answer in decimal hours and/or conventional hours, minutes and seconds.

Alternatively, the Casio ST-1 will handle ordinary decimal arithmetic, complete with independent memory, per cent and square root keys.

As a stopwatch, this instrument offers a choice of four modes: standard start/stop with automatic reset at every start, time-out or net timing where a restart carries on from the previous stop time, and lap timing with or without reset at each start. There is also a totalling feature whereby in standard stop timing, it tells you the total of say, a series of separately timed operations (from which the average can be calculated on the same machine). In the time-out mode it can indicate time loss during stoppages, and in split lap timing it adds the "splits" to give an overall time.

The calculation capacity is eight digits, or one second short of 100 hours, and there is a clip-on hood for increasing readout contrast in strong ambient light.

Measuring approximately 127mm x 76mm x 25.4mm and weighing under 5 ounces complete with AA size battery, Casio ST-1 sits neatly in the hand. Supplied with security wrist strap, this amazing little instrument has a recommended retail price of only £29.95.

Casio Electronics Co. Ltd., 28 Scrutton Street, London, EC2A 4TY.



SCRUMPI 2

Following the microprocessor development kit Scrumpi 1, comes Scrumpi 2 which has all the facilities of the former system plus additional PROM and RAM.

The new kit is still mounted on a single p.c.b. but increased in size to include two edge connectors for interfacing with extender cards. Developed around the new NMOS National Semiconductor SC/MP2 microprocessor, Scrumpi 2 from Bywood Electronics Ltd gives reduced power consumption and increased speed.

The memory consists of 768 bytes of RAM and 512 bytes of PROM. Two 4-bit latches act as an 8-bit I/O port in which each set of four can be wired as either inputs or outputs. The various functions of the kit are controlled by a flip-flop, a 555 Timer, and NAND gates, all of which are selected by eight toggle switches: RESET, SLOW, STOP, PROTECT, SENSE-A, SENSE-B, ROM/RAM START and LOAD. Programming can only be carried out during a read cycle, since during a write cycle the microprocessor is putting data on the data bus.

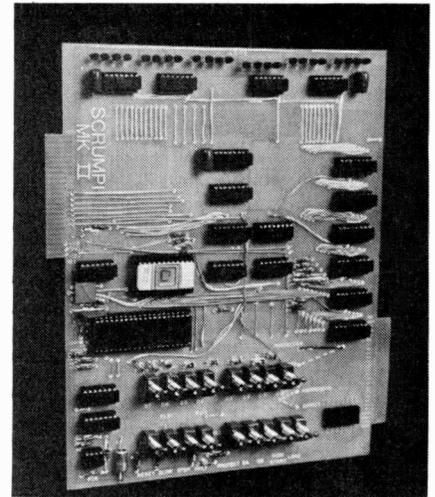
Interfacing facilities on Scrumpi 2 are suitable for either 4-bits or 8-bits and simple VDUs.

Scrumpi 2 will also drive several MM2112 RAM chips and/or PROM on EAROM chips without further buffering.

The basic kit (without RAM and ROM i.c.s) costs £55.56 and with the extra memory facilities £74.07. The PROM can be supplied blank or programmed by Bywood to customer specification for an extra £20.

All parts are supplied in the kit, including sockets for all i.c.s. The switches are soldered directly to the board, and the circuit needs supplies of +5V, -7V and -12V (which could be derived from a 17V supply with a 5V Zener diode).

Further information from Bywood Electronics Ltd, 68 Ebbens Road, Hemel Hempstead, Herts, HP3 9QR.

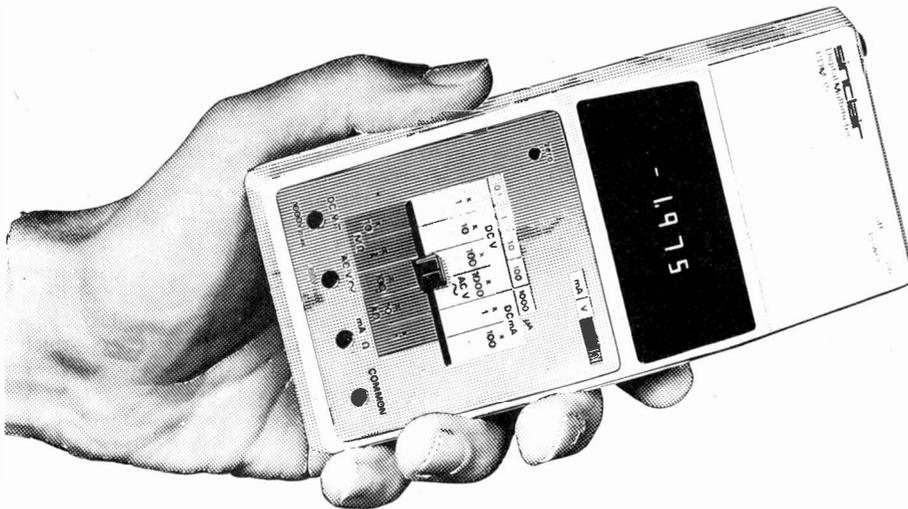


Scrumpi 2 from Bywood

The Sinclair PDM35.

A personal digital multimeter for only £29.95

(+8% VAT)



Now everyone can afford to own a digital multimeter

A digital multimeter used to mean an expensive, bulky piece of equipment.

The Sinclair PDM35 changes that. It's got all the functions and features you want in a digital multimeter, yet they're neatly packaged in a rugged but light pocket-size case, ready to go anywhere.

The Sinclair PDM35 gives you all the benefits of an ordinary digital multimeter – quick clear readings, high accuracy and resolution, high input impedance. Yet at £29.95 (+8% VAT), it costs less than you'd expect to pay for an analogue meter!

The Sinclair PDM35 is tailor-made for anyone who needs to make rapid measurements. Development engineers, field service engineers, lab technicians, computer specialists, radio and electronic hobbyists will find it ideal.

With its rugged construction and battery operation, the PDM35 is perfectly suited for hand work in the field, while its angled display and optional AC power facility make it just as useful on the bench.

What you get with a PDM35

- 3½ digit resolution.
- Sharp, bright, easily read LED display, reading to ±1.999.
- Automatic polarity selection.
- Resolution of 1 mV and 0.1 nA (0.0001 μA).
- Direct reading of semiconductor forward voltages at 5 different currents.
- Resistance measured up to 20 MΩ.
- 1% of reading accuracy.

Operation from replaceable battery or AC adaptor.
Industry standard 10 MΩ input impedance.

Compare it with an analogue meter!

The PDM 35's 1% of reading compares with 3% of full scale for a comparable analogue meter. That makes it around 5 times more accurate on average.

The PDM35 will resolve 1 mV against around 10 mV for a comparable analogue meter – and resolution on current is over 1000 times greater.

The PDM35's DC input impedance of 10 MΩ is 50 times higher than a 20 kΩ/volt analogue meter on the 10 V range.

The PDM35 gives precise digital readings. So there's no need to interpret ambiguous scales, no parallax errors. There's no need to reverse leads for negative readings. There's no delicate meter movement to damage. And you can resolve current as low as 0.1 nA and measure transistor and diode junctions over 5 decades of current.

Technical specification

DC Volts (4 ranges)

Range: 1 mV to 1000 V.
Accuracy of reading: 1.0% ± 1 count.
Note: 10 MΩ input impedance.

AC Volts (40 Hz-5 kHz)

Range: 1 V to 500 V.
Accuracy of reading: 1.0% ± 2 counts.

DC Current (6 ranges)

Range: 1 nA to 200 mA.
Accuracy of reading: 1.0% ± 1 count.
Note: Max. resolution 0.1 nA.

Resistance (5 ranges)

Range: 1 Ω to 20 MΩ.
Accuracy of reading: 1.5% ± 1 count.
Also provides 5 junction-test ranges.

Dimensions: 6 in x 3 in x 1½ in.

Weight: 6½ oz.

Power supply: 9 V battery or Sinclair AC adaptor.

Sockets: Standard 4 mm for resilient plugs.

Options: AC adaptor for 240 V 50 Hz power. De-luxe padded carrying wallet. 30 kV probe.

The Sinclair credentials

Sinclair have pioneered a whole range of electronic world-firsts – from programmable pocket calculators to miniature TVs. The PDM35 embodies six years' experience in digital multimeter design, in which time Sinclair have become one of the world's largest producers.

Tried, tested, ready to go!

The Sinclair PDM35 comes to you fully built, tested, calibrated and guaranteed. It comes complete with leads and test prods, operating instructions and a carrying wallet. And getting one couldn't be easier. Just fill in the coupon, enclose a cheque/PO for the correct amount (usual 10-day money-back undertaking, of course), and send it to us.

Sinclair Radionics Ltd, London Road, St Ives, Huntingdon, Cambs., PE17 4HJ, England. Regd No: 699483.

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..... (qty) De-luxe padded carrying case(s) @ £3.00 (inc VAT and P&P) each:..... £.....

..... (qty) AC adaptor(s) for 240 V 50 Hz power @ £3.00 (inc VAT and P&P) each:..... £.....

I enclose cheque/PO made payable to Sinclair Radionics Ltd for (indicate total amount):..... £.....

I understand that if I am not completely satisfied with my PDM35, I may return it within ten days for a full cash refund.

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- ★ 2-year guarantee
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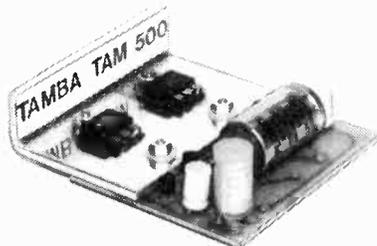
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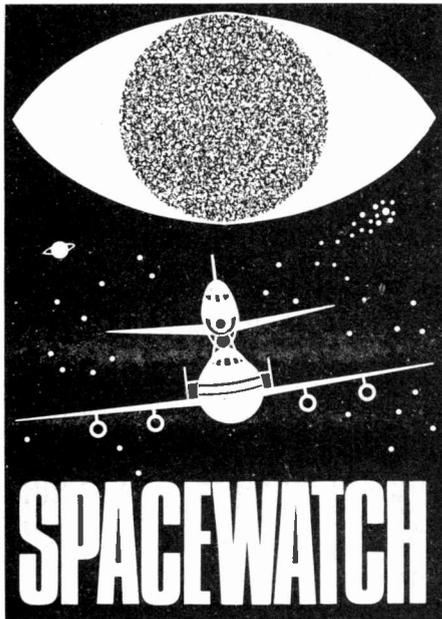
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FRANK W. HYDE

UN-IDENTIFIED FLYING OBJECT

Now that the excitement of a possible new planet has died down it is perhaps a good time to look at the facts that are available. The suggested size is between 100 and 400 miles in diameter, that the orbit is near circular and that the orbit lies between Saturn and Uranus.

From these data it can be deduced that the object is not a comet because a comet has a highly eccentric orbit. The orbit was determined by sequential photographs so that the circular orbit is now confirmed. The probable distance from the Sun is about 1,500 million miles. It is possible that this "Object Kowal" is the first of a new swarm of asteroids. If a regular watch is kept, it could well be possible that the computation of the orbit, would show that Voyager I might observe it after leaving the vicinity of Saturn and on its way to Uranus.

Many of these small bodies are now on record and Charles Kowal now has the right to choose a name for his discovery. The number of the planetoid is 2042. It is interesting to record that by about 1890 some three hundred of these small planetary bodies were known. A year later another of those new applications of technology which open up new vistas took place. This time it was the advent of photographic methods which widened the horizons. Very quickly many hundreds of faint objects were identified as coming from the asteroid belt which lies between the orbits of Mars and Jupiter.

Another spurt was given when computers appeared and now over 2,000 are numbered, and at least a similar figure covering those lost or not yet determined

exactly. Since they can be accurately timed both into the future and back into the past their behaviour in relation to other planets in the solar system can be examined; even so, many of these bodies are just accidental discovery.

So scarce is time on the world's telescopes that searches for those lost is not economically possible. This emphasises the value of orbiting telescopes with continuous operation. In fact technically there is a great advantage, for only small telescopes are required in space for purposes of this kind. That there is very great scientific interest in knowing about these bodies is shown by the fact that already there are a number of projects for sending probes to land on or take samples from them. A great deal is already known and it would need a lengthy article to describe the present state of the art.

LIFE AND DEATH FROM OUTER SPACE

Whenever something unusual occurs in the environment or in space, outside agencies are postulated as being concerned with the welfare of the human race. Scarcely a week passes without some past happening being brought out as support for unknown origins of events. It is not surprising therefore that from science fiction and "new thought" a new look at data takes place. Much of it may be discarded at once but always there is left a glimpse of what might be. If it stirs someone or some team to relook at past happenings and link them with new possibilities then it is worth while as an exercise. In the dissemination of knowledge the negative results often have the greatest impact.

The sensational situation has arisen about the star Sirius and its "companions". On the strength of some "evidence" from religious beliefs a whole edifice of presumed happenings has been raised. Many people are now convinced that the skills and ills were brought by someone from outer space. Diagrams and pictures are produced in support of the idea mostly without careful examination and indeed in some cases manipulation to support the theory. On this particular theory great claims have been made that scientists are actively, and keenly supporting the theory. In fact this is not so.

To set the scene for this Sirius mystery, the first point of importance is that Sirius is an extremely unlikely candidate for the support of a planetary system. It is true that some very eminent astronomers have indeed been active in their examination of certain data. However, no evidence has been found to support the claims as made. There is the existence of the folk lore, which at first sight is difficult to evaluate. However, this is not really the field of astronomy or space science, still less can it be justified when more specialised branches of science engage in such matters.

Two radio observatories have just released information of their previously unpublished activities. One of these in Canada used a 46 metre radio telescope with entirely negative results. No intelligible signals were received. The other observatory is that of Ohio State University where Dr. R. S. Dixon used the 21 centimetre hydrogen line frequency. Over a period of search, carried out each day, there were no detectable transmissions. The publications from the sensational media do not take into account these tests. Indeed two British scientists found it necessary to insist on a disclaimer that they supported the theories. This particular case has been cited because it is concerned with space. It follows then that the less fanciful but certainly more tenable cases should be in the same area. Both are concerned with life on earth as well as in space.

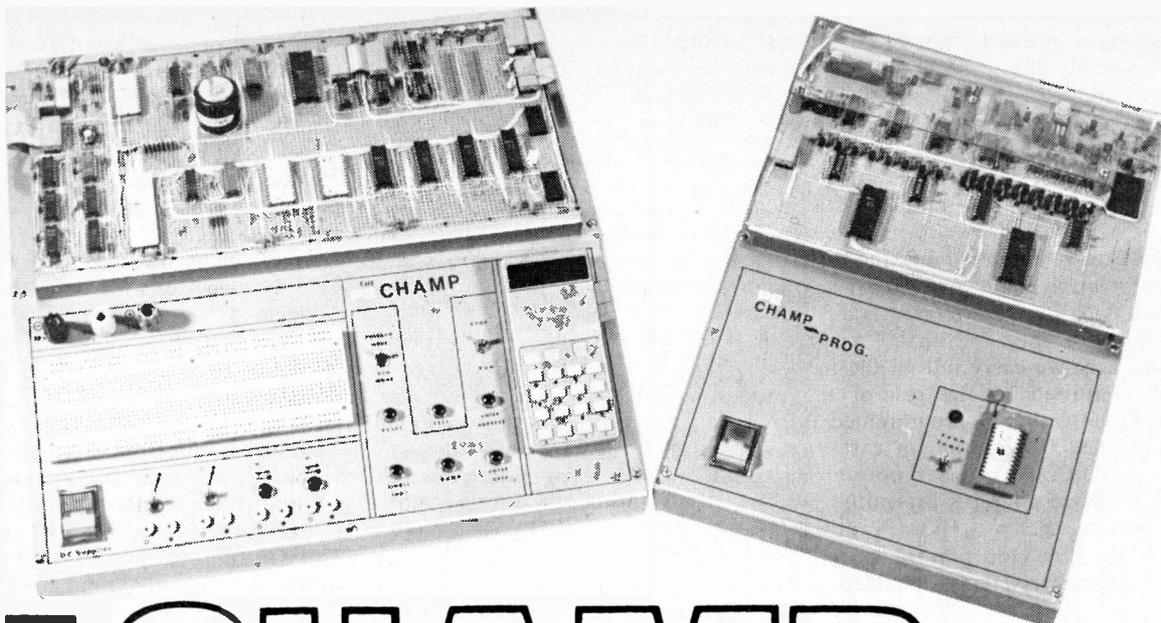
A number of disciplines have been concerned with the possibility of life having begun outside the earth and found its way to the planet. It is so frequent for the work of some individuals and groups to be quoted out of context in support of sensation, yet in the cases now to be detailed there are sensational features. It has often been put forward that cometary bodies could be carriers of some form of life. The earth passing through a tenuous medium would not, except by the use of highly sophisticated techniques, show any indication that anything had happened.

Scientists Sir Fred Hoyle and Chandra Wickelmaier announced that they favour the theory that in the centres of comets there exist the building blocks of life and disease. As the comets travel through the solar system changes take place which lead to the formation of new viruses and bacteria. When a comet brushes the Earth these are released. The two scientists suggest that this is a far more plausible account of new epidemics.

A number of groups are investigating the possibilities of life being brought to Earth by means of meteorites and other interplanetary debris. In Russia V. I. Goldanski of the Institute of Chemical Physics of the Academy of Sciences in Moscow is known to be working in this area. Certain changes take place near absolute zero temperature and interstellar clouds could be a source of the grains of cold life. A new planetary system rich in dust would be an ideal situation for this kind of evolution.

LANDSAT

The Landsat vehicle is to help the Navajo Indians to assess the resources of their 16 million acres of reservation, the volume of timber and its condition. This is the first time a private company has had this kind of co-operation with NASA. The activity will eventually range over five states. A great deal of headway has been made with this satellite which has justified the project.



PE CHAMP

R.W. COLES
B. CULLEN

PART SIX

Now that the "hardware" description of CHAMP is complete, we can move on to consider that magic new ingredient, "software". As you will no doubt recall, the program which makes CHAMP work is called CHOMP (CHamp Operating system and Monitor Program), and this month we shall examine the program.

COMMERCIAL KITS

Most commercial microprocessor development kits provide the user with only a simple listing of their operating programs, and ploughing through these listings to gain an understanding of how the system operates can be a painful experience.

CHAMP is for hardware oriented people; not the software genius; so we have done more than just provide a simple listing of the code you will need in PROM chip zero to get CHAMP to work. We cannot, for space reasons, give an intimate description of every line in the program, but we will be discussing the overall program flow chart. As an introduction to programming techniques, we will be showing how segments of the overall flow chart are converted first into more detailed flow charts, and then into hexadecimal code. In this way we hope to use CHOMP not only as an essential part of CHAMP, but also as a sort of software training ground for fledgling CHAMP programmers!

Constructors are advised to spend some time developing a familiarity with this program, and also of course with the 4040 instruction set which it uses.

4702A PROM

CHOMP should, strictly speaking, be called a firmware program, because it resides not on paper tape or magnetic cassette, but in a ROM or Read Only Memory. The type of ROM used is in fact an erasable and reprogrammable type using the FAMOS technology, and these devices are

more properly described as EPROMS, or just PROM for short. The actual device used is the 4702A chip which contains 256 eight bit words, has supply requirements compatible with the 4040, and can be erased by means of exposure to short wave ultra violet light. The 4702A is a selection from the 1702A family, characterised to work on +5V and -10V supplies over the full temperature range, instead of the usual +5V and -9V of the 1702A. The 4702A is also a less speedy device than the 1702A, having a 1.7 μ s maximum access time. The only extra requirement the 4702A has, is for that extra volt on the supply rails, and in fact it is virtually certain that any 1702A chip will work well in the CHAMP circuit, at least over the usual domestic temperature range. This has been tried on the prototype with complete success, and opens up the possibility of using the low cost 1702As now being advertised. Of course, it is not possible for us to *guarantee* success with anything other than the 4040 manufacturers' recommended 4702A devices.

CHOMP uses 248 locations out of the 256 available in a 4702A, and the PROM containing CHOMP has to be plugged into the CHIP ZERO location, i.e. the left hand PROM socket.

MAIN FLOW CHART

Figure 6.1 shows the main flow chart of CHOMP, and this is in effect an overview of the whole program in a much simplified form. We have chosen to use just four symbols to draw the flow chart:

- Circles represent the beginning and end of events.
- Oblong boxes represent actions to be performed.
- Diamonds represent decision points with two possible exits.
- Square arrows represent "Jumps" to other pages of memory.

When power is first applied to CHAMP, or when the

RESET button is pressed, the 4040 address counter is cleared to address 000H, and it fetches its next instruction from this address, which is of course the first location in chip zero, and the beginning of CHOMP. The flow chart can be traced from this RESET point which is located at the top left of Fig. 6.1.

The first box is not very exciting; it simply tells us that we must jump past address 003H, because this is the program location which contains the first instruction of the Interrupt routine, and we only want to go to *that* address when a hardware interrupt is acknowledged.

Box three represents the first "meaty" part of the program, and here we carry out all the preliminary house-keeping jobs required by the rest of the program. The 4265 INPUT/OUTPUT chip is programmed into mode 9; the switch flag latches are cleared (in case any were already indicating a switch closure when power was applied), and the various software counters are initialised to a required starting condition (i.e. the CHOMP address counter is set to point to the first location in program RAM, 200H). Finally, the interrupt system is enabled so that any interrupt signal from now on will cause the 4040 to save the current address on its internal stack, and jump to 003H, the interrupt vector. The only source of interrupt recognised by CHOMP itself is the keyboard, but for the moment let's assume that no interrupt has been received and continue on to box 4.

After initialisation, the CHOMP address counter holds 200H, and this box is present to load that address value into the display buffer register, so that we can see it on the right hand three display digits. Notice that box 4 is also entered via LOOP 2, and in this case the current address value (whatever it is) will be displayed.

Box 5 performs the vital job of refreshing the l.e.d. display. Each time this box is entered, a new eight bit word is presented to the segment lines and the display shift register is stepped on one position. Eight entries are required to refresh the complete display, and to ensure regular use, box 5 is made part of LOOP 1, through which the 4040 cycles continuously as long as no control switches are pressed.

Box 6 is also part of LOOP 1, and the main purpose of this box is to read into the 4040 accumulator register the state of the four control switches, so that the state of these may be checked and appropriate action taken. The interrupt system is again disabled at this point to prevent interference with switch responses. The INTERRUPTS RECOGNISED zone is quite extensive enough for a prompt response to any key press, and making the rest of the program interruptible would be an unnecessary complication.

Box 7 is a decision based not upon the switch flags, but upon the separate 4040 TEST input. If the TEST button is pressed, box 7 ensures a jump to the start of Chip 1, address 100H. Chip 7 is normally used for the PROMPT programmer software of course, but if the programmer is not in use, any 4702A resident program can be started by pressing TEST.

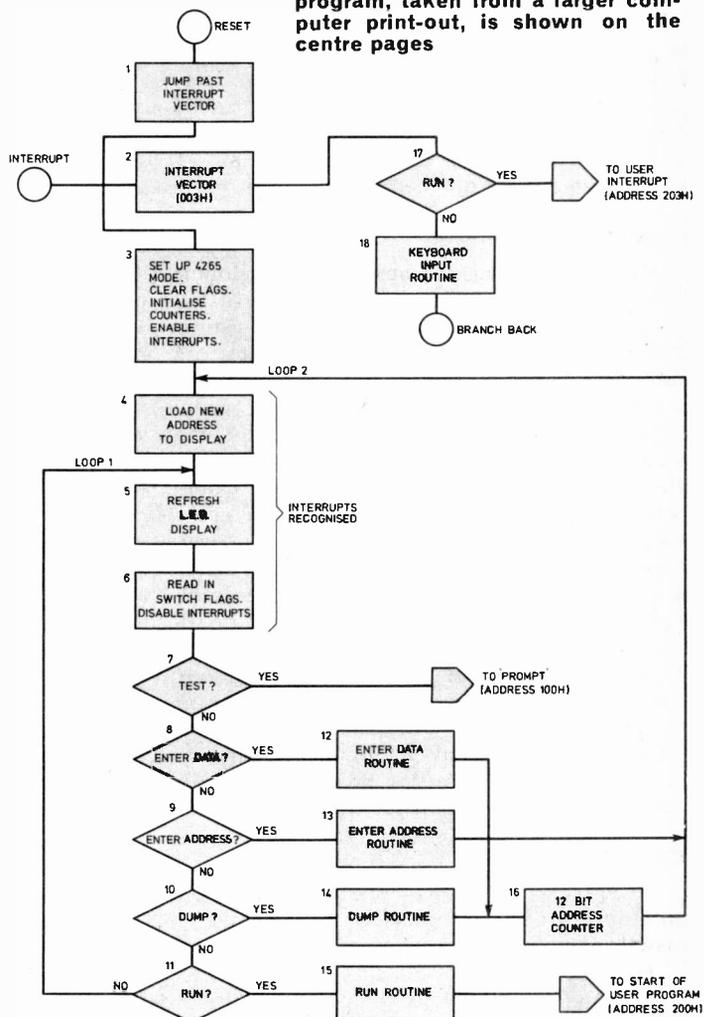
Boxes 8, 9, 10 and 11, check each of the switch flag bits in the accumulator in turn, by shifting them into the carry flip-flop and performing a JCN instruction. If no switches are pressed at box 6 time, then LOOP 1 is completed, and is in fact repeated indefinitely, refreshing the display and checking the switches on each pass. Needless to say, CHAMP spends most of its time in this loop when CHOMP is running, only leaving it intermittently, to respond to control switch closures.

If the ENTER DATA switch is pressed then CHAMP exits from LOOP 1 at box 8. Box 12 represents a routine which takes data previously entered via the keyboard and stores that data (8 bits) in the program RAM location pointed to by the CHOMP address counter, before passing on to box 16 to increment to the next address in sequence. The new address is displayed by means of box 4, and then LOOP 1 is re-entered.

If the ENTER ADDRESS switch is pressed, then LOOP 1 is left at box 9. Box 13 is then executed, and this loads the three digit hexadecimal data previously entered via the keyboard into the CHOMP address counter to replace the previous contents. In this case there is no need to increment the address counter, and so LOOP 1 is re-entered via LOOP 2.

When the DUMP switch is pressed, a sequence of operations similar to those for ENTER DATA takes place, although in this case box 14 represents a routine which reads data (8 bits) from the program RAM location pointed to by the CHOMP address counter, and loads it into the display buffer for examination. When the PROGRAM MODE/RUN MODE switch is in the RUN position box 15 is entered, and a routine is executed to cause an unconditional jump to the start of the user program RAM at address 200H. From this point onwards of course, CHOMP has relinquished its control of CHAMP facilities to whatever user program is resident in RAM.

Fig. 6.1. CHOMP main flow chart. The complete CHOMP program, taken from a larger computer print-out, is shown on the centre pages



0042	AC	LD 0CH	
0043	B2	XCH 2	
0044	AE	LD 0EH	
0045	B4	XCH 4;	RELOAD COUNTER WITH 12 BIT ADDRESS CLEAR SWITCH FLAGS
0046	5097	JMS CLRFI;	
0048	400E	JUN LOOP 2	
004A	2C00	DUMP: FIM 0CH, 00H	
004C	2800	FIM 8, 00H	
004E	29	SRC 8	
004F	A4	LD 4	
0050	E1	WMP;	SELECT RAM CHIP
0051	23	SRC 2;	ADDRESS BYTE
0052	0E	RPM;	GET LS NIBBLE
0053	BC	XCH 0CH	
0054	0E	RPM;	GET MS NIBBLE
0055	BE	XCH 0EH	
0056	2A00	FIM 0AH, 00H;	CLEAR KBD COUNT
0058	2850	FIM 8, 50H	
005A	29	SRC 8	
005B	E2	WRR;	CLEAR FLAGS BUT NOT KBD DISPLAY DUMP BYTE
005C	50CE	JMS LOKY	
005E	730E	COUNT: ISZ 3, LOOP 2	
0060	720E	ISZ 2, LOOP 2	
0062	740E	ISZ 4, LOOP 2	
0064	400E	JUN LOOP 2;	ADDRESS COUNTER
0066	0B	INTER: SB1	
0067	B6	XCH 6	
0068	F7	TCC;	SAVE AC AND CARRY
0069	B7	XCH 7	
006A	2240	FIM 2, 40H	
006C	23	SRC 2	
006D	EA	RDR;	GET PROG/RUN SWITCH
006E	F5	RAL;	PUT IN CY
006F	1276	JC PROMO;	ARE WE IN PROG MODE?
0071	A7	LD 7;	USER IR SO RESTORE STATUS
0072	F6	RAR	
0073	A6	LD 6	
0074	4203	JUN 203H;	GO TO USER IR
0076	2480	PROMO: FIM 4, 80H;	SELECT 4265
0078	25	SRC 4	
0079	EC	RDO;	GET KBD BCD
007A	BF	XCH 0FH;	PUT IN KBD TEMP
007B	6B	INC 0BH;	BUMP TABLE INDEX
007C	6B	INC 0BH	
007D	D8	LDM 8	
007E	BA	XCH 0AH;	MS TABLE INDEX NIBBLE
007F	AF	LD 0FH;	PUT KBD IN ACC
0080	3B	JIN 0AH;	BRANCH VIA TABLE
0082		ORG 082H	
0082	4088	TABLE: JUN FIRST	
0084	408B	JUN SECON	
0086	408E	JUN THIRD	
0088	BE	FIRST: XCH 0EH;	FIRST KBD DIGIT INRE
0089	4091	JUN TERM	
008B	BC	SECON: XCH 0CH;	SECOND TO RC
008C	4091	JUN TERM	

00C9	78C9	LOOP 3: ISZ 8, LOOP 3	
00CB	79C9	ISZ 9, LOOP 3	
00CD	C0	BBL 0H	
00CE	2800	LOKY: FIM 8, 00H;	SET UP ADDRESS
00D0	AE	LD 0EH	
00D1	B1	XCH 1;	GET LOW FOUR
00D2	50DD	JMS HEXL;	CONVERT TO SEVEN SEG CODE
00D4	AC	LD 0CH	
00D5	B1	XCH 1;	
00D6	50DD	JMS HEXL;	CONVERT TO SEVEN SEG CODE
00D8	AD	LD 0DH	
00D9	B1	XCH 1	
00DA	50DD	JMS HEXL;	CONVERT TO SEVEN SEG CODE
00DC	C0	BBL 0H	
00DD	DF	HEXL: LDM 0FH;	SEVEN SEG TABLE LOOKUP
00DE	B0	XCH 0;	TABLE BASE IN RP 0
00DF	30	FIN 0;	GET SEG CODE FROM TABLE
00E0	29	SRC 8	
00E1	A1	LD 1;	FIRST FOUR TO 4002
00E2	E0	WRM;	
00E3	69	INC 9;	BUMP NIBBLE POINTER
00E4	29	SRC 8	
00E5	A0	LD 0;	LAST FOUR TO 4002
00E6	E0	WRM;	
00E7	69	INC 9;	BUMP NIBBLE POINTER
00E8	C0	BBL 0	
00F0		ORG 0F0H	
00F0	7E	DB 07EH	
00F1	0C	DB 00CH;	LOOKUP TABLE
00F2	B6	DB 0B6H	
00F3	9E	DB 09EH	
00F4	CC	DB 0CCH	
00F5	DA	DB 0DAH	
00F6	FA	DB 0FAH	
00F7	0E	DB 00EH	
00F8	FE	DB 0FEH	
00F9	DE	DB 0DEH	
00FA	EE	DB 0EEH	
00FB	F8	DB 0F8H	
00FC	72	DB 072H	
00FD	BC	DB 0BCH	
00FE	F2	DB 0F2H	
00FF	E2	DB 0E2H	

SYMBOL TABLE

CLRF	0097	COUNT	005E	DATO	00C5	DDRV	00B1
DUMP	004A	ENTAD	0040	ENTDA	0032	FIRST	0088
HEXL	00DD	INTER	0066	LADR	00A2	LOKY	00CE
LOOP 1	0010	LOOP 2	000E	LOOP 3	00C9	PASS	00C7
PROMO	0076	RUN	0028*	SECON	008B	SKIP	001D
TABLE	0082*	TERM	0091	THIRD	008E		

Fig. 6.2. Complete CHOMP program

```

000 00 NOP
0001 4005 JUN $ + 4;
0003 4066 JUN INTER;
0005 2880 FIM 8, 80H
0007 29 SRC 8
0008 D9 LDM 9
0009 E1 WPM;
000A 5097 JMS CLRF;
000C 2428 FIM 4, 28H;

000E 50A2 LOOP 2; JMS LADR;
0010 0C LOOP 1; EIN;
0011 50B1 JMS DDRV;
0013 2840 FIM 8, 40H
0015 29 SRC 8
0016 EA RDR;
0017 0D DIN;
0018 F6 RAR;
0019 111D JNT SKIP;
001B 4100 JUN 100H
001D 1A32 SKIP: JNC ENTDA;
001F F6 RAR;
0020 1A40 JNC ENTAD;
0022 F6 RAR;
0023 1A44A JNC DUMP;
0025 F6 RAR;
0026 1210 JC LOOP 1;
0028 5097 RUN: JMS CLRF
002A 2880 FIM 8, 80H
002C 29 SRC 8
002D F0 CLB
002E E5 WR1;
002F E6 WR2
0030 4200 JUN 200H;

0032 2800 ENTDA: FIM 8, 00H
0034 29 SRC 8
0035 A4 LD 4
0036 E1 WPM;
0037 23 SRC 2;
0038 AC LD 0CH
0039 E3 WPM;

003A AE LD 0EH
003B E3 WPM;
003C 5097 JMS CLRF;
003E 405E JUN COUNT;
0040 AD ENTAD: LD 0DH;
0041 B3 XCH 3

```

```

SKIP INTERRUPT
INTERRUPT VECTOR

SET UP 4265 MODE
CLEAR SWITCH FLAGS
SET MS ADDR. COUNT AND
DDRV COUNT
LOAD ADDRESS TO DISPLAY
ENABLE INTERRUPTS
DISPLAY DRIVER

READ IN SWITCHES
DISABLE INTERRUPTS
FIRST FLAG TO CY
JUMP TO CHIP 1 IF TEST SET

ENTER DATA?
NEXT FLAG TO CY
ENTER ADDRESS
NEXT FLAG TO CY
DUMP?
LAST FLAG TO CY
RUN OR BACK AGAIN

BLANK DISPLAY

JUMP TO USER PROG IN
CHIP 2

SELECT PROGRAM RAM CHIP
ADDRESS BYTE

WRITE LEAST SIG NIBBLE
TO RAM

WRITE MOST SIG NIBBLE
CLEAR SWITCH FLAGS
BUMP ADDRESS COUNT
PUT KBD IN COUNTER

```

```

008E BD THIRD: XCH 0DH;
008F 2A00 FIM 0AH, 00H;
0091 50CE TERM: JMS LOKY;
0093 A7 LD 7
0094 F6 RAR;
0095 A6 LD 6
0096 02 BBS
0097 2850 CLRF: FIM 8, 50H;
0099 29 SRC 8
009A E2 WRR;
009B 2A00 FIM 0AH, 00H;
009D 2C00 FIM 0CH, 00H
009F 2E00 FIM 0EH, 00H
00A1 C0 BBL 0H
00A2 280A LADR: FIM 8, 0AH;
00A4 A4 LD 4
00A5 B1 XCH 1
00A6 50DD JMS HEXL;

00A8 A2 LD 2
00A9 B1 XCH 1
00AA 50DD JMS HEXL;

00AC A3 LD 3
00AD B1 XCH 1
00AE 50DD JMS HEXL;

00B0 C0 BBL 0H
00B1 27 DDRV: SRC 6;
00B2 E9 RDM;
00B3 2880 FIM 8, 80H
00B5 29 SRC 8;
00B6 E5 WR1
00B7 67 INC 7;
00B8 27 SRC 6
00B9 E9 RDM;
00BA 29 SRC 8
00BB E6 WR2;
00BD 67 INC 7;
00BE 75C5 ISZ 5, DATO;
00BF DF LDM 0FH;
00C0 E0 WRM;
00C1 D8 LDM 08H;
00C2 B5 XCH 5
00C3 40C7 JUN PASS
00C5 DE DATO: LDM 0EH;
00C6 E0 WRM;
00C7 2880 PASS: FIM 8, 080H;

THIRD IN RD
CLEAR KBD CHAR COUNT
PUT NEW KBD DIGIT IN 4002
RESTORE STATUS

SELECT ROM O.P. PORT 5
CLEAR SWITCH FLAGS
CLEAR KBD REGISTERS

FETCH 4002 SRC START ADD
CODE

CONVERT TO SEVEN SEG
CODE

CONVERT TO SEVEN SEG
CODE

CONVERT TO SEVEN SEG
CODE

DISPLAY DRIVER ROUTINE
LOW FOUR FROM 4002

LOW FOUR TO 4265 PORT X
BUMP NIBBLE POINTER

HIGH FOUR FROM 4002

LOW FOUR TO 4265 PORT Y
BUMP NIBBLE POINTER
INCREMENT SHIFT COUNTER
FETCH WRM CODE
BIT SET 4265 Z3 HIGH
PRESET SHIFT COUNTER

FETCH WRM CODE
BIT SET Z3 LOW
SLOW DOWN MULTIPLEX
RATE

```

INTERRUPT

If CHOMP is running and a keyboard switch is pressed, one interrupt is latched by IC10 and CHOMP responds (from the INTERRUPTS RECOGNISED zone) with a jump to box 2 (address 003H) which is called the interrupt vector.

Box 2 contains another jump to the start of the interrupt routine proper, which just happens to be elsewhere in chip zero (actually at address 066H). Before the keyboard handler routine is entered, CHOMP makes a check to see whether it is actually in PROGRAM MODE. Interrupts to RUN MODE user programs are also vectored to address 003H, so this check is essential, and is represented by box 17. If PROGRAM MODE is current, then box 18 is entered and a routine executed to read-in a single four bit hexadecimal digit from the keyboard, and store it away in a 4040 register. The keyboard routine also updates the display buffer so that each digit appears on the left hand side of the display as it is entered.

User interrupts are re-vectored to address 203H, so that the RAM resident program can define how a response is to be made. If you want to use the keyboard interrupt routine in your own program, simply carry out a JUN (Jump UNconditional) to address 066H from address 203H. Remember to use a BBS (Branch back and SRC) at the end of any "custom" interrupt routines you write!

CHOMP LISTING

Figure 6.2 is a complete listing of the CHOMP program, showing hexadecimal address data (column 1), hexadecimal instruction code data (column 2), mnemonic instruction codes (column 3) and comment lines (column 4).

The listing of Fig. 6.2 is the output of an assembler program which runs not on CHAMP, but on a much larger computer. Before anyone cries *cheat!* let me hasten to point out that CHOMP was originally written without the benefit of any such sophisticated facilities, directly in hexadecimal code. The reasons for eventually putting CHOMP into this form are simple:

- The assembler program does produce nice neat output listings which are useful for publication purposes.
- Since we are indeed saying that you do not need assembler programs when writing CHAMP software, we thought it only fair to show you what you are doing without!

When entering programs into an assembler, you have to enter columns 3 and 4 of Fig. 6.2 via a teletype terminal. From these the assembler produces columns 1 and 2 which tell you *what* hexadecimal code to enter *where* in program memory. The advantages of using an assembler program are firstly that the mnemonic instruction codes are all you have to remember, and that is fairly easy; and secondly, that instead of having to specify addresses in hexadecimal code you can use labels (i.e. names) instead. The assembler program will turn instruction mnemonics and address labels directly into hexadecimal code, and produce neat listings like the one shown here.

These sort of facilities sound very useful of course, and we would be the first to agree that with more complicated micros such as the Z80 or the 6800 they are very helpful indeed. The disadvantages are of course that you have to have lots of RAM available to store all those useful comments, and you also need a teletype or a V.D.U. The authors have assembler facilities available to them, but even so we prefer to write our 4040 programs directly in hex, with a pencil and paper: an exercise which is quite simple after a little practice!

Before leaving the subject of assemblies, let me explain a few things about the output listing shown in Fig. 6.2 which may be puzzling some readers:

- ORG and END are pseudo instructions, nothing to do with the 4040 but understood by the assembler.
- Some lines in column 2 have four hexadecimal digits. These involve two line instructions such as JUN, and will of course occupy two consecutive bytes in program memory.
- Some lines are field separators required by the assembler program.
- Notation. The assembler requires hexadecimal data to start with a decimal digit (don't ask us why!), and to be followed by an H. This means that FF hex is written 0FFH, while 2F hex is written 2FH.
- Register references can be made in a variety of ways, but we referred to them using hexadecimal, or decimal where this was equivalent.

Putting this information together, refer to Fig. 6.3 which explains how a complete assembler line is made up.

To get a CHOMP PROM from Fig. 6.2, all you have to do is step through the PROM addresses (column 1) entering the hexadecimal instruction codes from column 2. To do this you need a PROM programmer of course, and since most constructors will not have access to such a unit, arrangements have been made for the provision of a CHAMP programming service which will carry out the programming for you. Details next month.

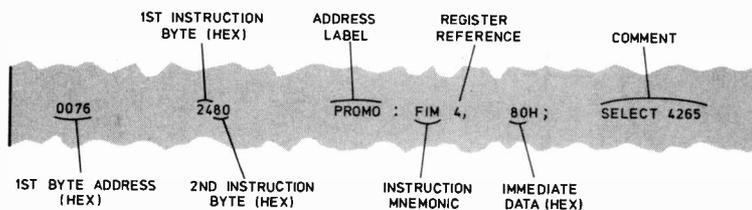


Fig. 6.3. One assembler output line and what it means

DETAILED FLOW CHARTS

No doubt many readers who felt reasonably happy with the overall flow chart in Fig. 6.1 had second thoughts when they tried to relate it to the program listing of 6.2. This is inevitable, because there is a missing link between the two, namely the detailed flow charts of each separate section of the program. Figures 6.4 to 6.8 show some of the detailed flow charts needed, but lack of space makes it impossible to reproduce all of them, so a certain amount of "unravelling" will still be necessary if any reader wishes to trace the operation of the complete program.

Let us start off with something easy, and have a look at how box 16 of Fig. 6.1 is turned into a 4040 program segment. Box 16 is a software implemented 12 bit binary counter routine which is updated each time the ENTER DATA or DUMP switches are pressed. The current count value is used during the ENTER DATA or DUMP program segments as a program memory address, and is displayed on the rightmost three display digits in hexadecimal.

Counters are implemented in 4040 software by using the ISZ (Increment and Skip if Zero) instruction which has the effect of incrementing the value of an internal four bit 4040 register by one, and jumping to a specified address if the contents of the register are not zero. If they are zero, the jump does not take place, and the next instruction in sequence is fetched. Figure 6.4 shows the implementation of the 12 bit address counter using ISZ,

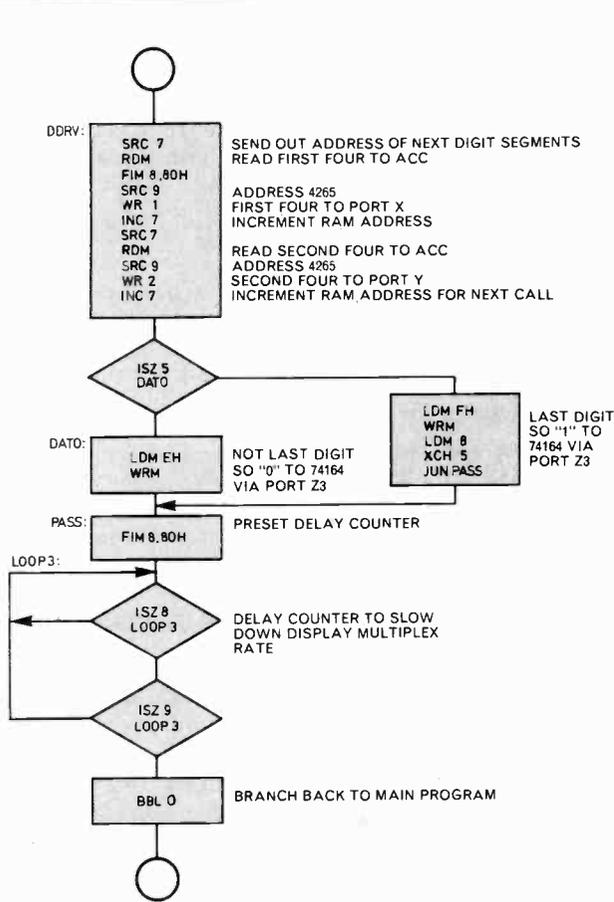


Fig. 6.5. Display driver subroutine. Refer to box 5 in CHOMP main flow chart, and address 00B1H on CHOMP program listing

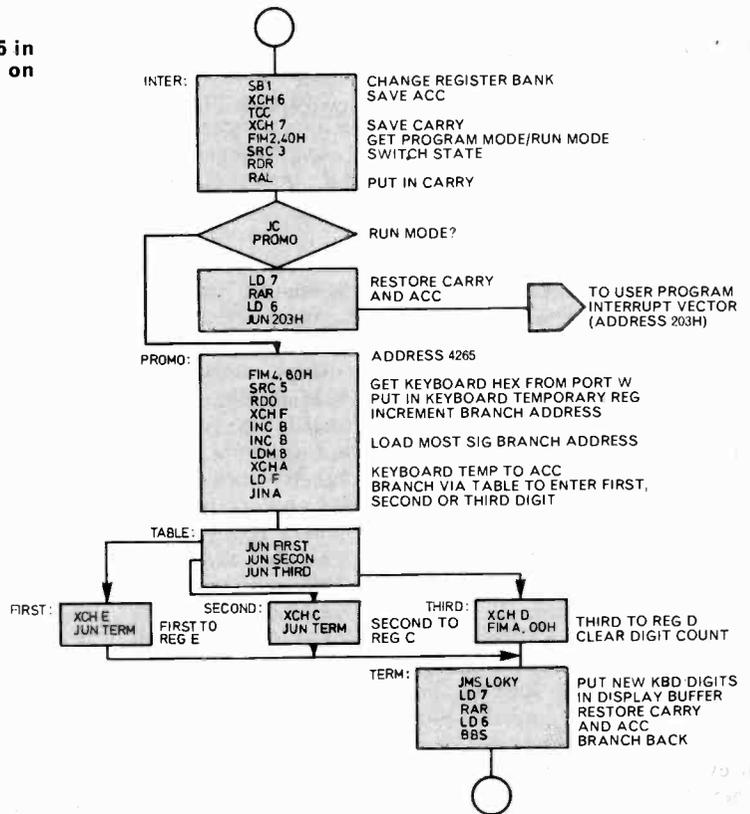


Fig. 6.6. Interrupt routine. Refer to boxes 17 and 18 in CHOMP main flow chart, and address 066H in CHOMP program listing

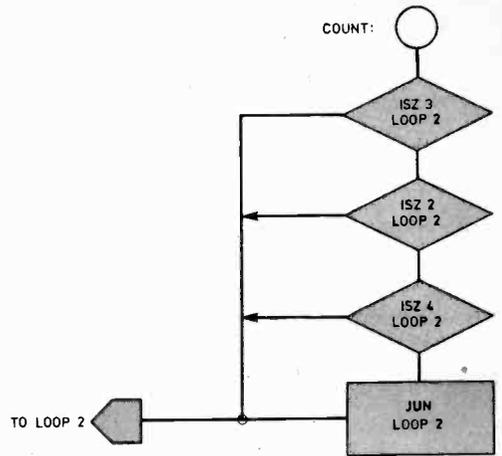


Fig. 6.4. Twelve bit address counter flow chart. Refer to box 16 in CHOMP main flow chart, and address 005EH. The CHAMP address counter should not be confused with the 4040 address counter

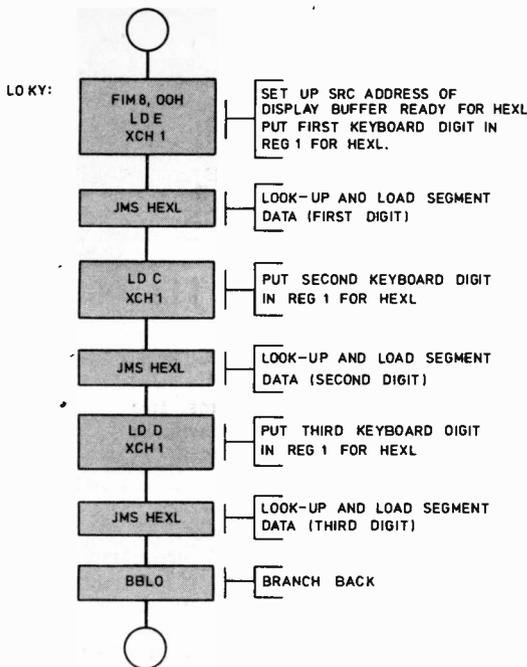


Fig. 6.7. Load keyboard subroutine. Refer to address 00CEH in CHOMP program

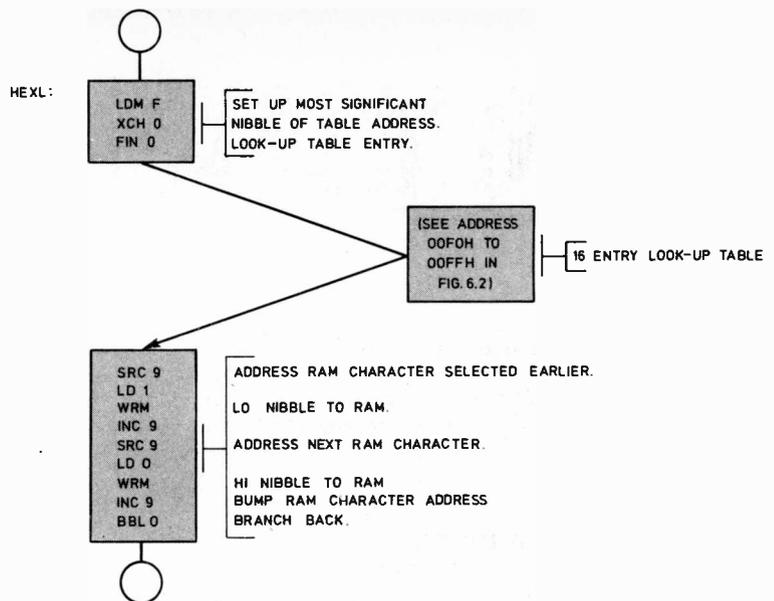


Fig. 6.8. Seven segment from hex look-up subroutine. Refer to address 00DDH in CHOMP program

the registers used being 3, 2, and 4 in that order. (The order is important because the high order address bits during an SRC instruction are taken from the lower register of a pair, and of course we use the lower eight bits of the counter as a SRC value when addressing program memory, before using RPM or WPM instructions.) The required 12 bit length of the counter is arranged by using three cascaded ISZ instructions, each with a common jump address, namely LOOP 2. You can probably see that Register 3 is incremented 16 times more often than Register 2, which itself is incremented 16 times more often than Register 4, in traditional binary counter fashion.

DISPLAY DRIVER

The subroutine DDRV is the full version of box 5 in Fig. 6.1, and its detailed flow chart is shown in Fig. 6.5.

This subroutine increments a counter (Register 7) twice each time it is called, and uses the counter contents as part of a SRC address to the data RAM display buffer (RAM chip 0, register 0). On each call it reads two four bit locations from the 4002, and sends their contents to the 4265 output ports X and Y which control the display segment lines. After doing this it increments another counter (Register 5) which it uses as a digit counter. This counter is preset to 8 hex (using LDM) when it reaches zero, and a logic one is placed on the 74164 shift register DATA INPUT via 4265 output Z3, using the WRM command. If this counter does not reach zero during a call then a logic zero is placed on the shift register data input.

You can probably see how this subroutine displays eight digits, one per call; and how it recycles to repeat the process over and over again. On seven out of eight calls it shifts a logic zero into the register, but on the eighth it generates a new "digit strobe" for the display, to replace the one which has just "dropped off the end" of the 74164.

INTERRUPT ROUTINE

Figure 6.6 shows the interrupt routine, INTER, which is boxes 17 and 18 on the overall flow chart of Fig. 6.1. The main thing of interest here is the use of a "Branch Table" accessed using the JIN (Jump Indirect) instruction to route the program flow to the correct segment depending on whether the current keyboard digit entry is the first, second, or third in sequence. Notice also that at the start of the routine the current accumulator and carry flip-flop contents are saved in registers 6 and 7 of Bank 1, to be restored at the end of the routine so that the main program flow can continue normally. A subroutine LOKY is used to enter the newly entered keyboard data into the display buffer.

The subroutine LOKY is itself shown in Fig. 6.7. It takes the contents of the three keyboard registers (E, C, and D) and converts their hexadecimal data into seven segment code using another subroutine HEXL.

HEXL itself is shown in Fig. 6.8, and as you can see it uses a FIN (Fetch Indirect) instruction to access a look-up table with sixteen entries. To convert hex to seven segment code, the hex is used as part of an indirect address so that the correct segment data can be "looked up" in the table. Table look-up is a powerful and simple technique which is very useful when converting data from one format to another. HEXL also loads the seven segment data into the 4002 RAM buffer register, at the appropriate address passed to it in registers 8 and 9 by the subroutine LOKY.

There are several other detailed flow charts required for a full understanding of CHOMP, and it would be excellent practice for CHAMP users to try and draw these up for themselves using Figs. 6.1 and 6.2 for reference. Don't be discouraged if it takes a while for the flash of inspiration to arrive, programming a microprocessor takes some getting used to, and is invariably a frustrating business at first, particularly for us "hardware people".

NEXT MONTH: Putting CHAMP to work

MICRO-BUS

Compiled by DJD.

Appearing every two months, Micro-Bus will present ideas, applications, and programs for the most popular microprocessors; ones that you are unlikely to find in the manufacturers' data books. The most original ideas will probably come from readers working on their own microcomputer systems, and payment will be made for any contribution featured here. This is also the place to air your views, in general, on this new technology, so let's be hearing from you!

CALCULATING ON A MICRO

SINCE microprocessors are designed as controllers rather than as computers they do not lend themselves to arithmetic work, and most instruction sets do not even include multiply and divide operations. There are two ways to add the capability of a scientific calculator to a micro. One is to add a floating-point package: a collection of programs to handle calculations involving floating-point numbers, and providing trigonometrical and logarithmic functions in addition to the arithmetic operations. The disadvantage is the extra memory required—typically 1½k.

The alternative is to add a hardware "arithmetic processing unit" which performs the calculations independently of the main micro. One such device is National Semiconductor's MM57109 "Number Cruncher Unit" or NCU. This chip offers the functions of a programmable calculator (see Table 1), a four-element stack and a memory, and floating-point arithmetic to 8-digit accuracy.

NUMBER CRUNCHER UNIT

The NCU is similar in operation to a calculator; 6-bit instructions correspond to key-presses, and these are presented to it on six input lines, I1-I6. Numbers are entered digit by digit as in a calculator.

A summary of the instructions is given in Table 1. The NCU shows that it has finished executing an instruction by pulsing its RDY output high. When RDY is high you must either send it another instruction or else put HOLD high to halt it until you are ready.

The result of a calculation is obtained by presenting the OUT instruction. The NCU then puts the digits out on DO1-DO4 at regular intervals and pulses R/W low when each digit is valid. There are some test instructions, such as TX=O, and these cause the BR output to be pulsed low if the result is true.

The NCU is not directly compatible with a microprocessor bus but fortunately all the necessary logic is provided within a single device, the Motorola MC6820 Peripheral Interface Adapter or PIA, also manufactured by MOS Technology in their 6500 series as the MCS6520. The PIA is a versatile general purpose input/output circuit whose particular mode of operation is determined by numbers loaded into its two control registers. It consists of two similar halves, A and B, each with an 8-bit I/O port PA0-PA7 (or PB0-PB7) and two control lines CA1 and CA2 (or CB1 and CB2).

In the present application the PIA is configured to operate as represented in Fig. 1: DO1-DO4 input to location 0400;

R/W and BR are latched inputs which set the top two bits of control register A at location 0401; I1-I6 are fed by latched outputs from location 0402; and RDY and HOLD are in "handshake mode" with RDY setting the top bit of control register B at location 0403. In handshake mode HOLD is taken high when RDY goes high, halting the NCU, and goes low when an instruction is written to the NCU, thus releasing the NCU to execute the instruction. This handshaking makes it unnecessary for the micro to respond immediately to the RDY pulse from the NCU.

INTERFACE

The complete interface circuit is shown in Fig. 2. The NCU is a PMOS device requiring a 9V supply (at 20mA) and to make it compatible with the microprocessor system supplies of +5V and -4V are used. The PIA side A inputs PA0-PA7 and CA2 presents one TTL load, and so pull-down resistors to the -4V rail are needed on the DO1-DO4 outputs, and BR needs a buffer transistor. The CA1 and CB1 inputs are high impedance so a pull-down resistor to 0V is needed on the R/W and RDY outputs.

The HOLD and POR (Power-On Reset) inputs to the NCU must be driven between its supply rails and so transistor

Table 1. Summary of the instructions available in the MM57109.

I ₄ -I ₁	I ₆ I ₅			
	00	01	10	11
0000	0	TJC*	INV	XEY
0001	1	TX=0*	EN	EX
0010	2	TXLT0*	TOGM	10X
0011	3	TXF*	ROLL	SQ
0100	4	TERR*	SIN(SIN ⁻¹)	SQRT
0101	5	JMP*	COS(COS ⁻¹)	LN
0110	6	OUT*	TAN(TAN ⁻¹)	LOG
0111	7	IN*	SFI	1/X
1000	8	SMDC*	PF1	YX
1001	9	IBNZ*	SF2	+(M+)
1010	DP	DBNZ*	PF2	-(M-)
1011	EE	XEM	ECLR	×(M×)
1100	CS	MS	RTD	/(M/)
1101	PI	MR	DTR	PRW1
1110	AIN	LSH	POP	PRW2
1111	HALT	RSH	MCLR	NOP

*indicates a two-word instruction.

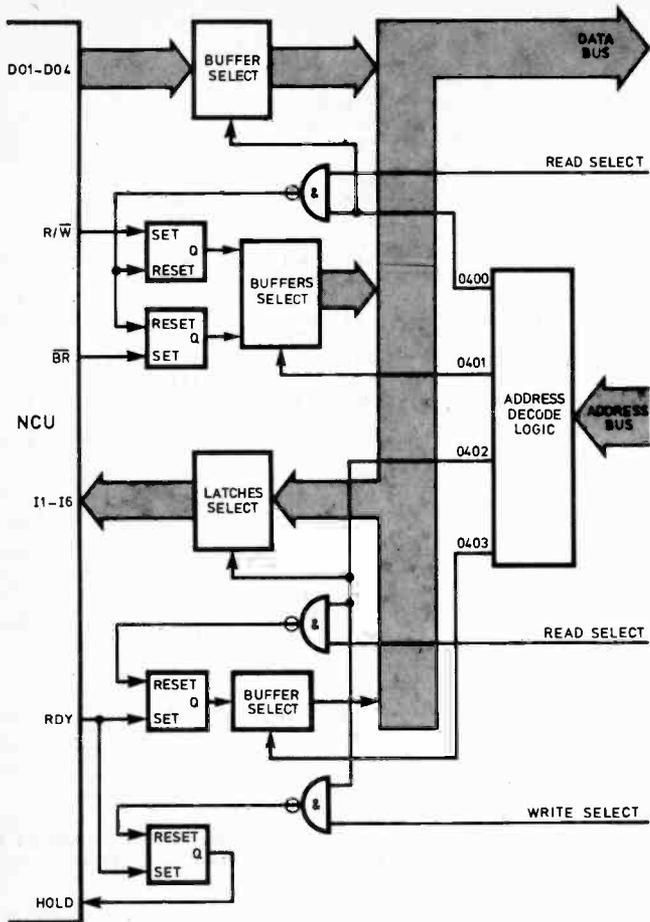
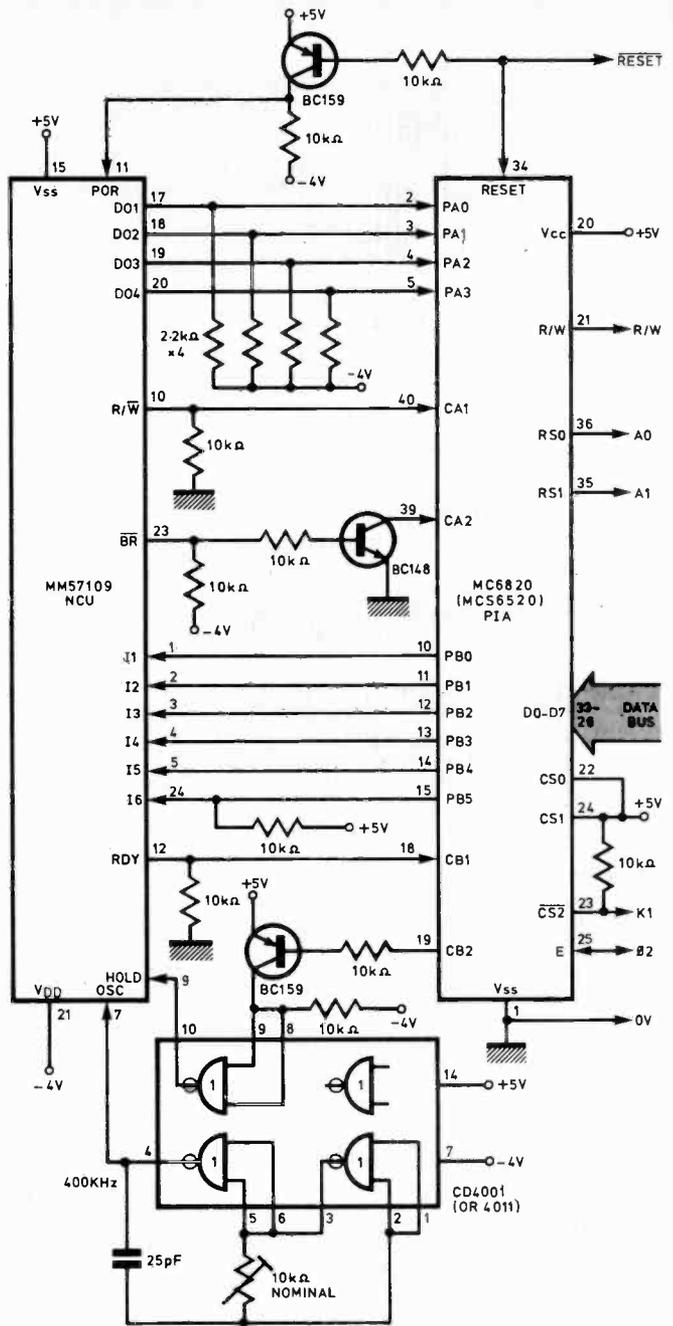


Fig. 1. Block diagram showing the logic needed to interface the Number Cruncher Unit with a micro as described. This logic is all provided in the PIA

Fig. 2. Circuit using a PIA to interface the Number Cruncher Unit with a microprocessor system such as KIM



drivers are needed, and a CMOS inverter re-inverts HOLD to active high. Two other gates in the CMOS package form a simple 400kHz oscillator to drive the OSC input. Finally, a resistor is required from I6 to +5V as shown. The circuit was constructed on a plain matrix board using wire-threading (see Fig. 3) and connected to the microprocessor system by a 16-way ribbon cable.

PROGRAM

The Number Cruncher Unit circuit was used with the MOS Technology KIM development system (see review elsewhere in this issue), which is based on their 6502 micro, and the interface program is given in Fig. 4. The 6502 is similar in some respects to the 6800 and converting the program for the latter should present few problems. The 6502 has two 8-bit index registers, X and Y, and one accumulator. In the program the X register is used to point to the next

instruction to be sent to the NCU, and the Y register points to the address at which digits output by the OUT instruction are to be stored.

The program first configures the PIA, and points X to the first instruction for the NCU. It then waits in a loop testing for a signal on one of the control inputs. The BIT instruction in the 6502 loads the top two bits of the memory word—the control register A in this case—into the N and V status flags. If R/W has gone low, bit 7 will be set and a branch to the label RW is called for. If BR has gone low bit 6 will be set and a branch

to BR is required. Finally, bit 7 of control register B will be set by RDY going high, and an instruction should be sent. If not set the program continues to wait.

The NCU's test instructions and OUT, each generate two RDY pulses; i.e. they are effectively two-word instructions. The second word is used by this program as the address (in page zero) for the jump or for the output of digits, and is ignored by the NCU. The OUT instruction causes one digit to be stored per byte, although the program could be modified to pack two per byte.

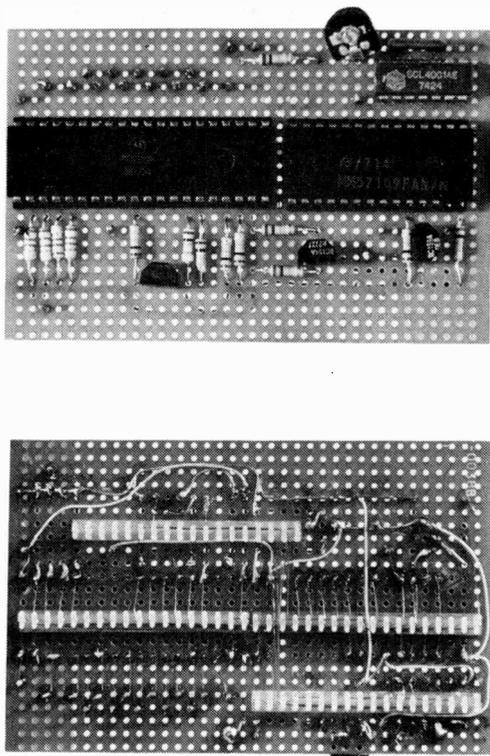


Fig. 3. The Number Cruncher Unit and interface circuits described in this article. Top and underside view

A sequence of instructions for the NCU is shown in Table 2. This finds the sum of the terms of the series $1/M^2$ for $M = 1$ to 100 and gives the result 1.6349839 (close to $\pi^2/6$, the infinite sum). The program takes 9 seconds. The NCU is slow by computer standards; the slowest instruction X^Y takes up to 1 second, and multiply takes 32 milliseconds.

One advantage of a hardware arithmetic processor over the software equivalent is that while instructions are being executed the micro is free to go away and do something else. In the program described it waits in a loop, but with a trivial modification the three inputs RDY, R/\bar{W} , and \bar{BR} could cause interrupts so that a negligible time would be taken up in servicing the NCU. Perhaps someone may be inspired to write a BASIC interpreter which uses an arithmetic processor working in parallel with the micro in this way.

GENERATING SINE WAVES

The program for generating sine waves in October's Micro-Bus used a look-up table for the values. Mr. T. Froggatt of York University has shown how this can be dispensed with:

"The problem is not to generate the sine of a given angle, but to generate the sine of an angle having just generated the sine of a nearby angle. So remembering that the rate of change of a sine wave is a cosine wave, and that the rate

of change of a cosine wave is an inverted sine wave, the following program is all we need:

Cosine = 0.0
Sine = 1.0

Loop: Output (Sine)

Cosine = Cosine - Delta x Sine
Sine = Sine + Delta x Cosine
Go to Loop.

To make this program work on an 8-bit micro the sine and cosine should each be held as two-byte items, and each time round the loop the upper byte of the sine subtracted from the cosine and the upper byte of the cosine added to the sine. This avoids the need for multi-

```

; NUMBER-CRUNCHER (MMS7109)
; INTERFACE PROGRAM
;
; PIA ADDRESSES:
AREG = $0400
ACON = $0401
BREG = $0402
BCON = $0403
;
0000          *=$0200
0200 A9 14          LDA #$04          CONFIGURE PIA:
0202 8D 01 04      STA ACON          CA1 & CA2 INPUTS,
0205 A9 FF          LDA #$FF
0207 8D 02 04      STA BREG          PB0 - PB7 OUTPUTS,
020A A9 26          LDA #$26
020C 8D 03 04      STA BCON          B HANDSHAKE MODE.
020F A2 00          LDX #0          FIRST INSTRUCTION
0211 2C 01 04      WAIT BIT ACON      GET BITS 6 & 7
0214 30 17          BMI RW          IRQA1 SET?
0216 70 1F          BVS BR          IRQA2 SET?
0218 AD 03 04      LDA BCON
021B 10 F4          BPL WAIT          IRQB1 CLEAR?
021D AD 02 04      LDA BREG          NO - CLEAR IRQB1
0220 E4 00          LDY 0,X          LOAD INSTRUCTION
0222 EB            INX              POINT TO NEXT
0223 8C 02 04      STY BREG          SEND TO NCU
0226 C0 0F          CFY #$0F        HALT INSTRUCTION
0228 D0 E7          BNE WAIT
022A 4C 4F 1C      JMP MAIN          RETURN TO MONITOR
;
; READ AND STORE DIGITS
022D AD 00 04      RW LDA AREG          CLEARS IRQA1 TOO
0230 99 00 00      STA 0,Y          STORE DIGIT
0233 C8            INY
0234 4C 11 02      JMP WAIT
;
; BRANCH INSTRUCTION
0237 98            BR TYA          GET ADDRESS
0238 AA            TAX              POINT X TO IT
0239 AD 00 04      LDA AREG          CLEAR IRQA2
023C 4C 11 02      JMP WAIT

```

Fig. 4. Complete program for the 6502 micro which sends a sequence of instructions to the Number Cruncher Unit and stores the answers received back into memory

plication and effectively fixes Delta as $1/256$."

The period of the sine wave produced is about $2\pi/\text{Delta}$ iterations of the loop. Mr. Froggatt described a program he has written which uses this method of generating a sine wave to sing Christmas carols, using a table to give the value of Delta for each note.

ADDENDUM

In December's Micro-Bus the second Chess Challenger game contained an error. The fourth move should have read:
4. 7a-6c 3h-2g

Table 2. Example of a sequence of instructions for the Number Cruncher Unit. This calculates the sum of the first 100 terms of the series $1/M^2$.

Address	Code	Mnemonic	Comments
00	3F	NOP	First 3 instructions are
01	3F	NOP	ignored by the NCU after
02	3F	NOP	a Power-on Reset
03	01	'1'	Digit input
04	0B	EE	Enter exponent
05	02	'2'	X = 100; push stack
06	1C	MS	Store X in memory
07	00	'0'	X = 0; push stack
08	1D	MR	Recall memory to stack
09	33	SQ	X = X ²
0A	37	1/X	X = 1/X
0B	39	+	X = X + Y
0C	1A	DBNZ	Decrement memory and go
0D	08		to 08 if non-zero
0E	16	OUT	Output X starting at
0F	40		40 (i.e. 0040)
10	0F	HALT	Return to monitor



PART 2

GENERATOR

N.A. COOKE

THIS month the second and final part will deal with constructional details and setting up procedures.

CONSTRUCTION

Construction is very straightforward as all components are mounted on two p.c.b.s with the exception of the three potentiometers, the switches, fuse holder, socket and indicators which are mounted on either the front or back panels.

Figs. 10 and 11 show the etching details and component layout of the main board.

It is advisable when assembling the p.c.b.s to fit the components of smallest dimensions first. Bending their leads to an angle of 45 degrees after insertion will prevent them from falling out when the board is turned over for soldering. Figs. 12 and 13 gives p.s.u. board assembly details.

Care should be taken to make sure diodes and radial lead electrolytic capacitors are fitted the right way round. With the general purpose 1N4148 the larger width band indicates the positive end of the diode. Positive or negative markings will be printed on the electrolytic capacitors.

The polyester radial lead capacitors should fit the p.c.b. exactly. They are very fragile and the leads will break off if the capacitor is forced into position.

If lead adjustment is necessary this should be carried out with the use of a small pair of pliers while firmly gripping each end of the capacitor.

SOCKETS

It is advisable to use sockets to fit the four CMOS i.c.s. These devices are supplied in a conductive foam or wrapped in tin foil and should not be removed until immediately prior to insertion. Although the devices are internally protected they are still vulnerable to high static charges and it is worth earthing oneself when handling them.

Another point to remember is that they should not be inserted or removed from their sockets while the power is switched on.

The p.c.b. should be visually checked upon completion of assembly to ensure that components are in their correct positions and the track side inspected for any dry joints or solder bridging. Figs. 14 and 15 show the positions of the components mounted to the front and back panels.

SWITCH MOUNTING

The subminiature switches used on the control panel must be tightened from the back of the panel otherwise severe scratching of the anodised finish and the legend will result. The potentiometer spindles should be cut to approximately $\frac{1}{16}$ in before fitting to the panel. The three knots used have a very fine taper on the internal $\frac{1}{16}$ in fixing bore and once pushed on and rotated into place may be difficult to remove.

The DIN socket with the 3.5mm jack socket, fuse holder and grommet are mounted to the back panel as indicated in Fig. 15.

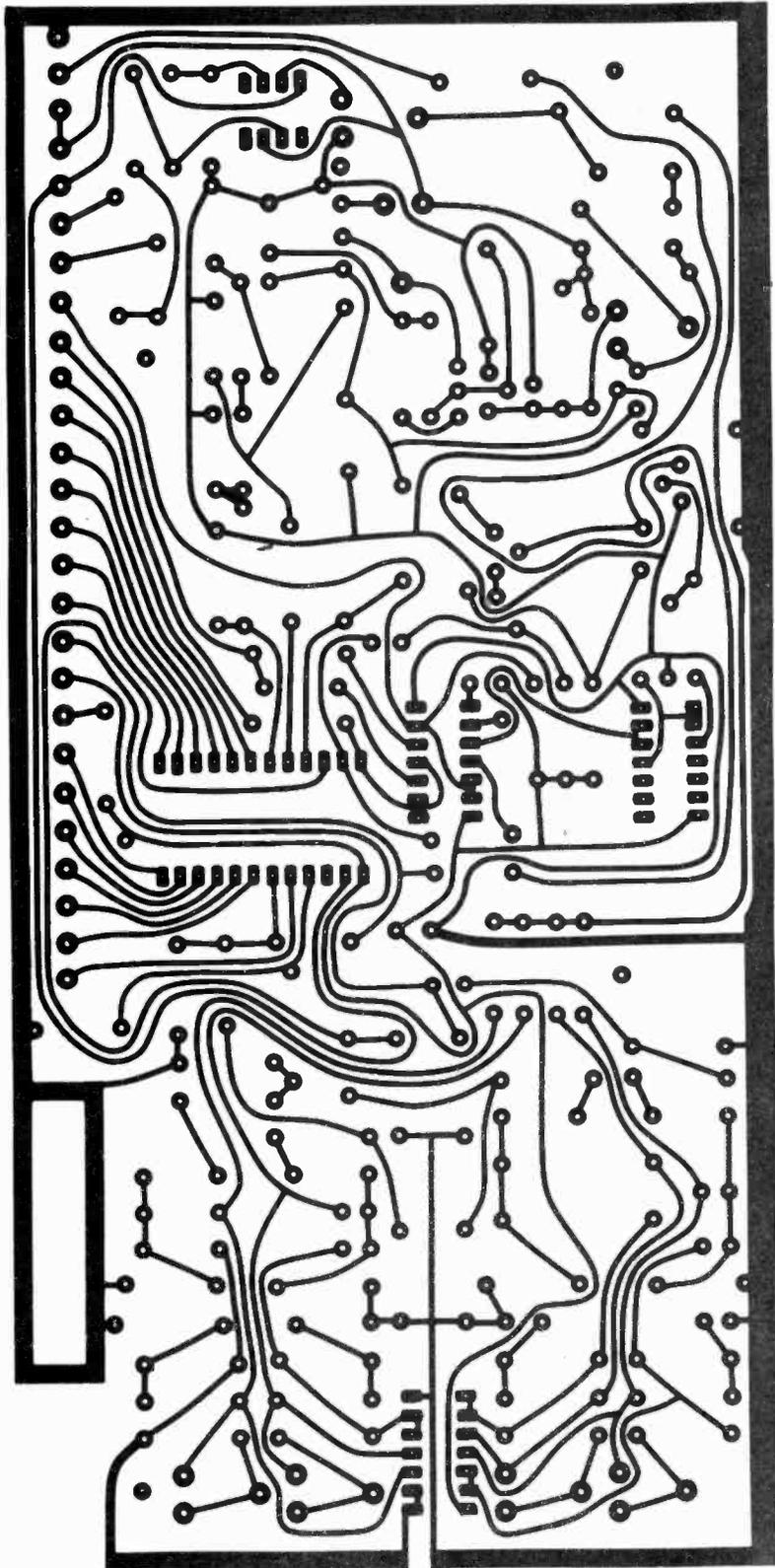


Fig. 10. Printed circuit layout of main board

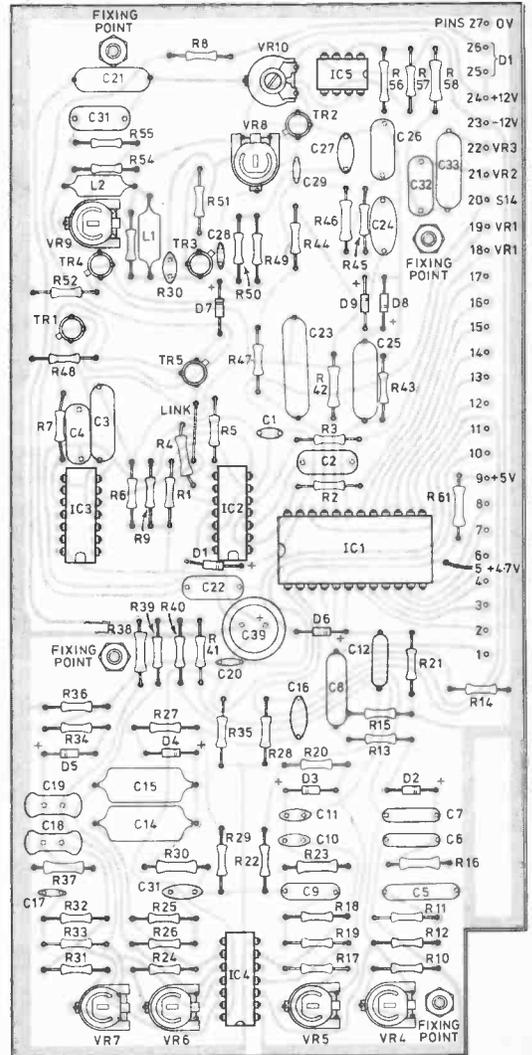
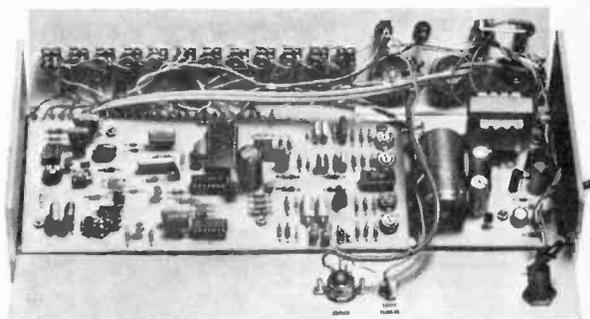


Fig. 11. Component layout on main board



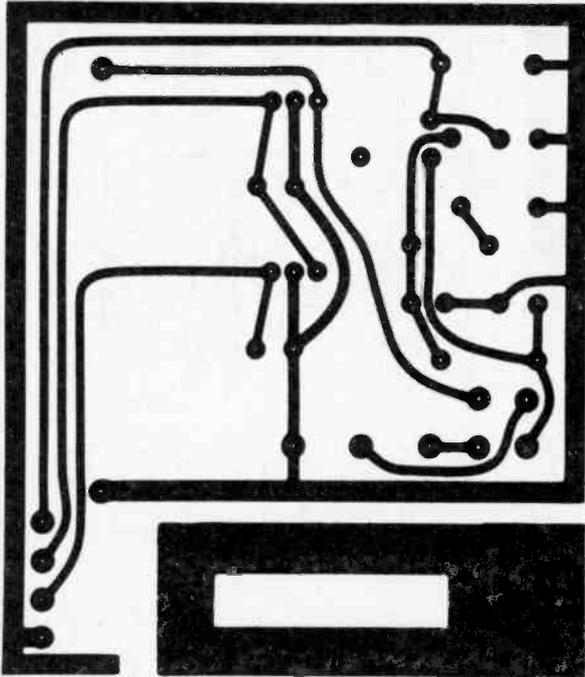


Fig. 12. Power supply board etching details

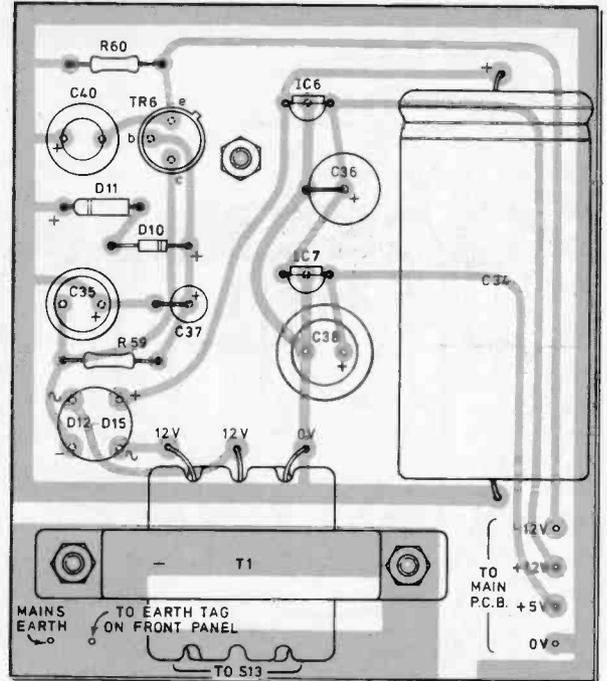
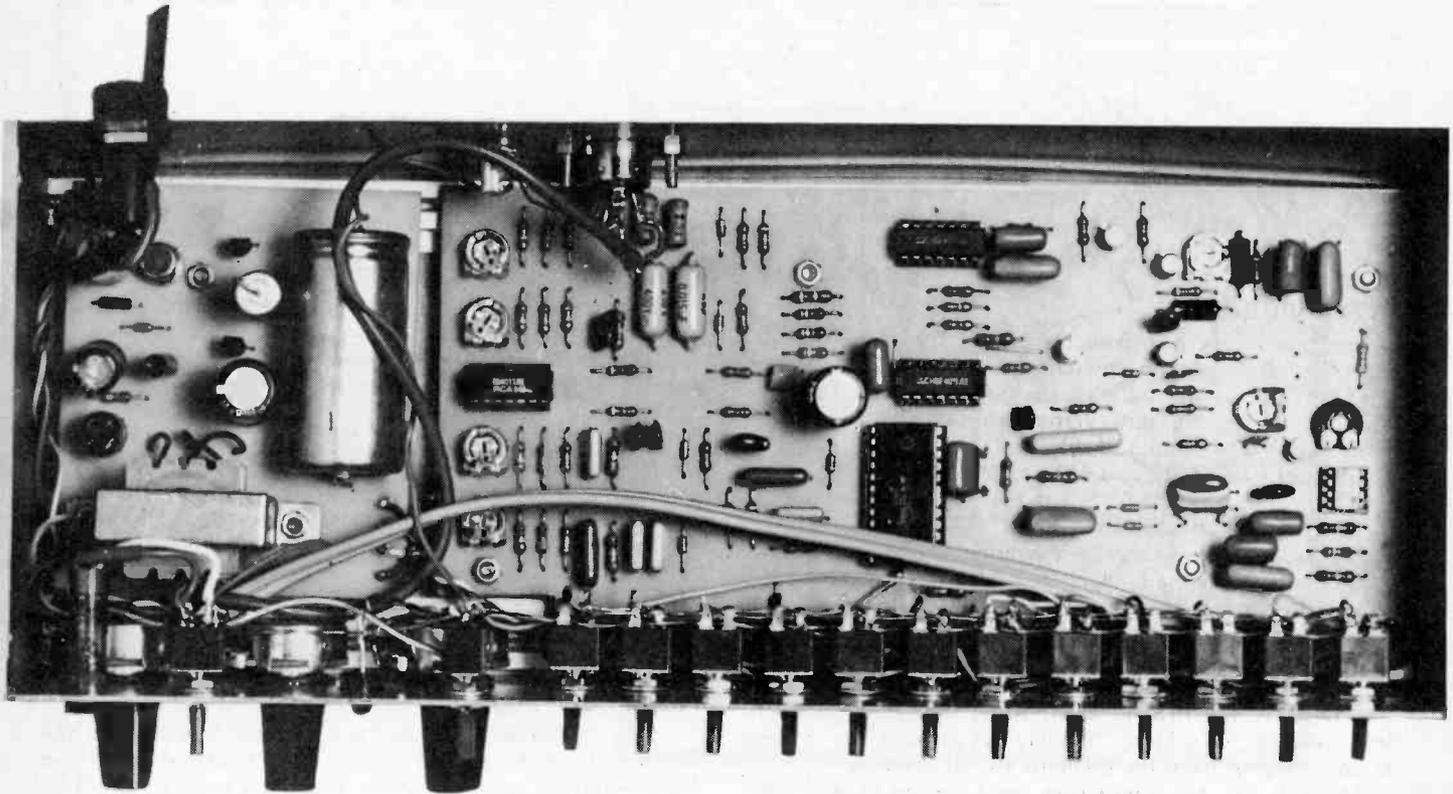


Fig. 13. Component layout of power supply board



Plan view of Generator interior

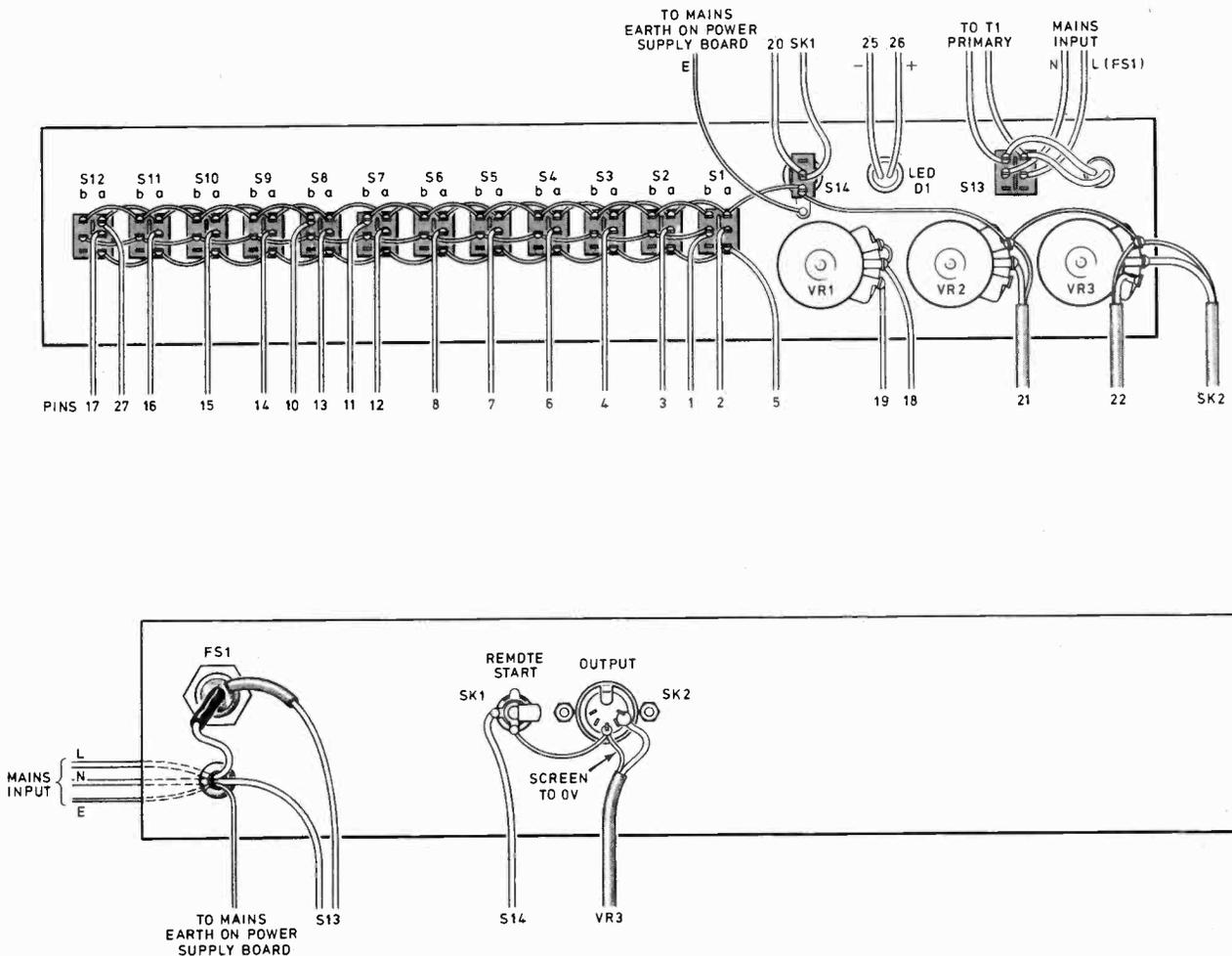


Fig. 15. Back panel wiring

INTERWIRING

The interwiring is reasonably straightforward with the exception of the selection switch wiring.

Fig. 14 shows the back of the control panel. The five common connecting rails across the switches should be fitted first. The common 0V rail not only links the switches but also VR2 and VR3 and the stop/start switch. It is suggested as this 0V rail is the most complicated of the five that this should be fitted first.

For each of the five rails a length of 22 s.w.g. tinned copper wire should be used.

Start at one end of the line of switches and terminate the wire by wrapping and soldering it into position. The wire is then wrapped over a screwdriver which spaces the bridging link to the next switch. It is not necessary to wrap the wire around each switch tag however—each joint should be soldered quickly to prevent the wiring from springing from the previous switch contacts.

The rest of this interwiring must be made with the front panel, p.c.b. and back panel lying horizontally. The front and back panels must be arranged either side of the p.c.b.

The row of Veropins should be nearest the front panel and two gaps of 30mm each should be left between the p.c.b. and front and back panel. If this gap is not left all the wires will be too short when the assembly is fitted into the case framework.

The connections from the common rails and individual switches can now be made to the p.c.b. It is worthwhile to check every joint after making it as it is possible to forget a connection and be left with one extra Veropin at the end!

SAFETY FIRST

Whenever a metal case is used to house mains operated equipment, it is advisable to take extra care with the mains wiring connections. Each joint should be inspected to ensure a good mechanical and soldering bond.

It is advisable to scrape away a small section of the anodised finish on the internal surfaces of the four aluminium extrusions and the front and back panels. This should be done to ensure a good earth contact throughout the case, as unfortunately the anodised surfaces act as an insulator.

FINAL CHECK

Apply mains voltage (without any i.c.s in place). The neon should light. Check the voltage across pin 1 (positive) and 2 (negative) of the M253AA socket. The reading should be $17 \pm 1V$. Also check that the outputs from the power supply board are +12, +5 and -12V.

If the voltages check out, again isolate the supply and carefully fit the i.c.s taking the necessary precautions described earlier with the four CMOS devices.

Check that all the chips are fitted in their correct positions, but do not turn on until you have completed the initial setting up procedures.

INITIAL SETTING UP

Set all the internal preset controls as follows:

Identification	Adjustment	Control Description
VR4	Midway	Oscillator damping
VR5	Midway	Oscillator damping
VR6	Midway	Oscillator damping
VR7	Midway	Oscillator damping
VR8	Fully anti-clockwise	white noise generation level
VR9	Midway	Balance of noise to Snare Drum simulators
VR10	Midway	Output attenuation

Set the front panel controls as follows:

VR1	Midway	Tempo
VR2	Fully clockwise	Tone
VR3	Fully anti-clockwise	Volume

S13
S3 to S14

Start
Bossa Nova on

Stop/Start Switch
"Rhythm Select"

CONNECT UP

Connect the DIN output to the radio socket of an external amplifier and turn on.

The downbeat lamp should light and by advancing VR3 a rhythmic beat should be heard. The tempo control should be adjusted to suit the rhythm. Continuous oscillations may be heard as well and will be corrected in the final setting procedure.

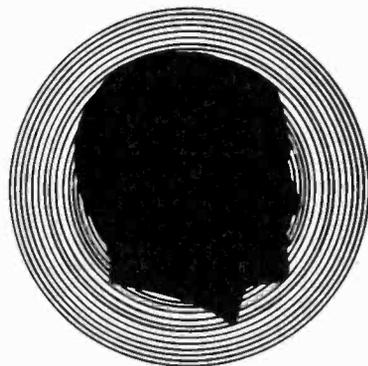
FINAL SETTING UP

With the unit operating the four presets VR4-VR7 should be adjusted just to prevent continuous oscillation. VR9 should be set to give a realistic balance between the white noise simulators and the Snare Drum. VR8 may be backed off from full anticlockwise slightly to reduce harshness of the white noise effect if necessary.

In combination with the adjustment of VR8, switch to the March rhythm and adjust VR9 to achieve the best setting for a realistic Snare Drum sound and correct Cymbals level.

VR10 controlling the output attenuation should be adjusted to suit the amplifier being used. Re-adjustment, using the prescribed procedure may be repeated once or twice to obtain the most balanced and realistic sound. ★

NOTE: In the Components List R61 is 33Ω , VR2— $25k\Omega$ logarithmic, C31— $0.1\mu F$ polyrad and ICI—M253AA. *Watford Electronics, 33-35 Cardiff Road, Watford, Herts.* can supply a complete kit of parts for £49.95 including VAT & P. & P. £1.25 (insured).

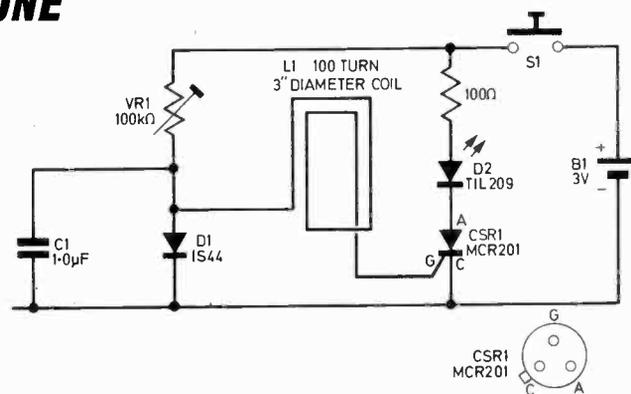


INGENUITY UNLIMITED

It is often useful to know if your telephone has been ringing while you have been away. This circuit will light an l.e.d. when it detects the magnetic field of a telephone bell. The l.e.d. remains on until it is later reset by the telephone user.

A TELEPHONE MEMORY

Fig. 1



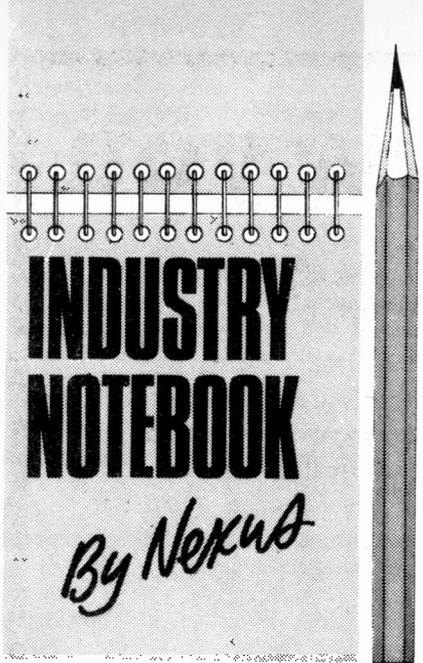
In Fig. 1 a 100-turn 3in. diameter coil of 30 s.w.g. enamelled copper wire is positioned on the underside of the telephone in a position (approximately dead centre where the bell magnetic field can be picked up. Voltage induced in the coil appears across the gate/cathode of thyristor MCR201 which is already biased close to conduction by the voltage across diode D1. This additional voltage, caused by the bell, triggers the thyristor and lights the l.e.d.

To reset the circuit a normally-closed push button is pressed to temporarily interrupt the supply to the circuit.

As the value of VR1 is reduced, a point will be reached where the thyristor will spontaneously trigger. The value of VR1 should be increased a small amount from this point to set the circuit at its most sensitive.

This circuit draws approximately $60\mu A$ when the l.e.d. is not lit, and 7mA when it is, therefore dry batteries will give quite a good life.

A. Russell,
Whinmoor,
Leeds



INDUSTRY NOTEBOOK

By Nexus

MARINE ELECTRONICS

The slump in the shipping industry and in particular in the fishing industry has gravely affected a few companies, notably Redifon now phasing out their Cwmbran, South Wales, manufacturing plant with 250 redundancies. But some companies in the marine business continue to prosper. Prime example is Decca Radar, currently selling over 5,000 marine radars a year. Starting from nothing in 1950 the grand total is 75,000 radars sold, 15,000 in the last three years of difficult trading conditions.

Another boom sector is in the North Sea drilling rigs where the chief beneficiary is Marconi with multi-channel over-the-horizon troposcatter systems coupled into the UK telephone network. The investment by the Post Office in such systems is £5 million.

Finally, there is the VLF global navigation system code-named Omega which will get its final validation for accuracy in 1982, the aim being one nautical mile accuracy in daylight and two miles at night. The market for ship-borne Omega as a master navigation system is already established but is clearly capable of enormous growth.

BIGGEST DATA BANK

Disk storage of 2,800 million bytes, all of it on-line and said to be equivalent of 10,000 books of novel length, is now available at Aberdeen University through its recently commissioned Honeywell 66/60 computer. University departments can interrogate the system through 100 remote terminals, most of them VDUs.

Of topical interest is the work of the Department of Arts and Social Science using the computer to analyse trade union bargaining and wage rounds.

How sensible it would be to feed in workers' demands on the one hand and employer's ability to pay on the other, the length of time a strike could last without the employer (or the country) collapsing, or workers starving, overall cash loss to the country (there is never a gain), damage to trade both in short and long term etc., and let the computer work out the compromise solution which is invariably arrived at. If every dispute were to be solved by computer there would be no need for strikes. I doubt if the Aberdeen researchers are thinking along these lines. I offer the idea free of charge but with little hope of its adoption. Far too many trade union officials and industrial relations officers have a vested interest in interminable argument to accept the impartial and practically instantaneous solution that the computer can and should be allowed to provide. And where could such people, if made redundant, find alternative employment?

INVENTOR'S CHANCE

Odd phenomenon of 1977 was the National Research Development Corporation's inability to attract new joint venture schemes to exploit inventions and ideas. With a pre-tax surplus of over £10 million for the year 1976-77, up from £3.7 million the previous year, NRDC has plenty of cash to back new projects but few takers. NRDC holds some 5,000 patents in the UK and overseas and is currently co-operating with nearly 1,000 companies.

Should 1978 prove to be a vintage year for inventions, NRDC has the cash but any schemes put forward needs to have originality and the prospect of profitable exploitation in the market place. Perpetual motion machines are not encouraged. In its life-time, NRDC has examined schemes from over 28,000 companies and only 7,000 have qualified for a second look.

PLESSEY STAYS FIRM

Plessey, hard hit by the Post Office cut-backs in orders, shows great underlying strength. Pre-tax profits for the quarter to last September totalled £9.6 million against £8.1 million on world sales nine per cent up at £149.7 million. Exports over a half year have increased by 51 per cent.

The weakness of being over-dependent on a single large customer, in this case the British Post Office, is illustrated by the labour force of 20,000 (slimmed down from 23,600) on telecommunications which contributed only 30 per cent of sales in the last half year. Contrast this with the 8,800 people in Plessey Electronic Systems who accounted for 37 per cent of sales and 40 per cent of the pre-tax profit.

The big breakthrough for Plessey may come next April when the International Civil Aviation Organisation (ICAO) is meeting in Montreal to decide on the next generation of instrument landing systems for airports. Plessey's doppler microwave system has a good chance of succeeding in the competition and if it does it will create work for years ahead and good profits from manufacturing and licence agreements.

Meantime, an example of Plessey's advanced technology is the recently announced PR2250 professional communications receiver which includes a microprocessor for programmed surveillance of spot frequencies and a memory module which allows instant tuning to 16 pre-set frequencies at the touch of a button. Real state-of-the-art, but it also costs real money, about £6,500 each says Plessey but you might be able to negotiate a quantity discount!

RACAL EXPANDS

It's still action all the way in the Racal Electronics Group with expansion at home and overseas. Dana Laboratories in Irvine, California is the latest acquisition together with the Dana sales affiliates in the UK and France. The Dana range of digital instruments is now added to the complementary range from Racal Instruments Ltd and the combined instrument operations will soon be trading with the new name of Racal-Dana Instruments Ltd under the overall direction of John Ceresa who heads up Racal Instruments in the UK.

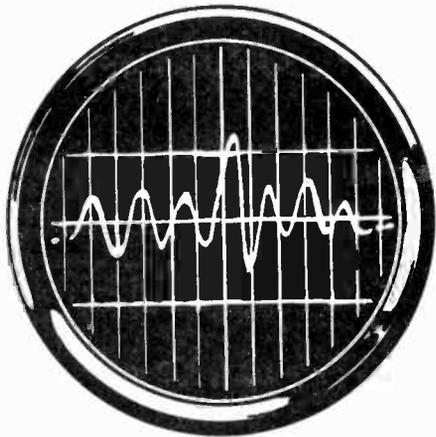
The new acquisition immediately bumps up Racal turnover in instruments by £5 million and the combined Racal-Dana is targeted for £13.8 million turnover in its first full year of operation. So Racal-Dana is now pressing hard on the heels of Marconi Instruments, at present the largest of the British-owned companies in electronic test and measuring instruments.

British Physical Laboratories, the specialist analogue panel meter company in the Racal Group has now established West Germany as its largest single export market. Among recent successes is a five-year contract for the supply of meters to Robert Bosch GmbH. Also in Germany, Racal-Redac the CAD company has opened a new sales office at Bensberg near Cologne, supplementing the Munich office which was opened in January 1977.

Of course anyone can build turnover by buying companies or selling products at give-away prices. What counts in the end is profitability and here Racal cannot be faulted, having achieved the number one spot in the profitability league table of 200 British companies published by "Management Today", topping even ICI and Shell.

LOOK! Here's how you master electronics

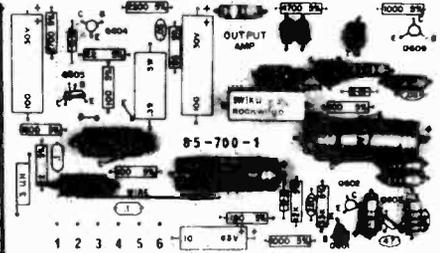
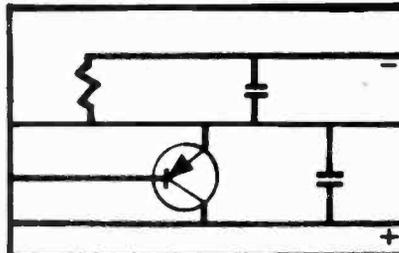
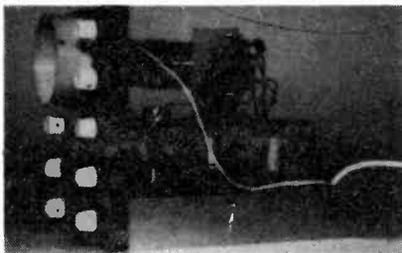
... the practical way



This new style course will enable anyone to have a real understanding of electronics by a modern, practical and visual method. No previous knowledge is required, no maths, and an absolute minimum of theory.

You learn the practical way in easy steps mastering all the essentials of your hobby or to further your career in electronics or as a self-employed electronics engineer.

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As the first stage of your training, you actually build your own Cathode ray oscilloscope! This is no toy, but a test instrument that you will need not only for the course's practical experiments, but also later if you decide to develop your knowledge and enter the profession. It remains your property and represents a very large saving over buying a similar piece of essential equipment.

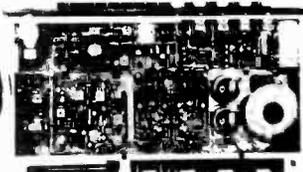
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P.O. Box 156, Jersey, Channel Islands.

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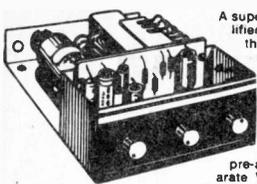
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PEB2

SUPER SOUND 13 HI-FI MONO AMPLIFIER



A superb solid state audio amplifier. Brand new components throughout. 5 silicon transistors plus 2 power output transistors in push-pull. Full wave rectification. Output approx. 13 watts r.m.s. into 8 ohms. Frequency response 12Hz-30kHz ± 3 db. Fully integrated pre-amplifier stage with separate Volume, Bass boost and Treble cut controls. Suitable for 8-15 ohm speakers. Input for ceramic or crystal. Suitable for Sensitivity approx 40mV for full output. Supplied ready built and tested, with knobs, escutcheon panel, input and output plugs. Overall size 3in high x 6in wide x 7in deep. AC 200/250V. PRICE £15.00 P. & P. £1.20.

8-15 ohm speakers. Input for ceramic or crystal. Suitable for Sensitivity approx 40mV for full output. Supplied ready built and tested, with knobs, escutcheon panel, input and output plugs. Overall size 3in high x 6in wide x 7in deep. AC 200/250V. PRICE £15.00 P. & P. £1.20.

HARVERSONIC MODEL P.A. TWO ZERO

An advanced solid state general purpose mono amplifier suitable for Public Address system, Oiac, Guitar, Gram., etc. Features 3 individually controlled inputs (each input has a separate 2 stage pre-amp.). Input 1 5mV into 47k. Input 2 5mV into 47k (suitable for use with mic. or guitar etc.). Input 3 100mV into 1 meg. suitable for gram. tuner. or tape etc. Full mixing facilities with full range bass & treble controls. All inputs plug into standard jack sockets on front panel. Output socket on rear of chassis for an 8 ohm or 16 ohm speaker. Output in excess of 20 watts R.M.S. Very attractively finished purpose built cabinet made from black vinyl covered steel, with a brushed anodised aluminium front escutcheon. For ac mains operation 200/240 volts. Size approx. 12in. wide x 5in high x 7in deep. Special introductory price £28.00 + £2.50 carriage and packing.



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MAINS OPERATED SOLID STATE AM/FM STEREO TUNER



200/240V Mains operated Solid State F.M. A.M. Stereo Tuner. Covering M.W. A.M. 540-1605kHz V.H.F. F.M. 88-108MHz. Built-in Ferrite rod aerial for M.W. Full AFC and AGC on A.M. and F.M. Stereo Beacon Lamp Indicator. Built-in Pre-amps with variable output voltage adjustable by pre-set control. Max o/p Voltage 600mV R.M.S. into 20K. Simulated Teak finish cabinet. Will match almost any amplifier. Size 6 1/2in wide x 4in high x 9 1/2in deep approx. Limited number only at £28.00 + £1.50 P. & P.

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A stylishly finished mono amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3-15 Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and E280 rectifier. Simple instruction booklet 25p + S.A.E. (Free with parts). All parts sold separately. ONLY £13.50 P. & P. £1.40. Also available ready built and tested £18.00 P. & P. £1.40.

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A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors including Silicon Transistors in the first five stages on each channel resulting in even lower noise level with improved sensitivity. Integral pre-amp with Bass, Treble and two Volume controls. Suitable for use with Ceramic or Crystal cartridges. Very simple to modify to suit magnetic cartridge—instructions included. Output stage for any speakers from 8 to 15 ohms. Compact design, all parts supplied including drilled metalwork, high quality ready drilled printed circuit board with component identification clearly marked, smart brushed anodised aluminium front panel with matching knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief specification: Power output: 14 watts R.M.S. per channel into 5 ohms. Frequency response ± 3 dB 12-30,000Hz. Sensitivity better than 80mV into 1M Ω . Full power bandwidth: ± 3 dB 12-15,000Hz. Bass boost approx. to ± 12 dB. Treble cut approx. to -16dB. Negative feedback 18dB over main amp. Power requirements 35V at 1A overall size 12in wide x 8in deep x 2 1/2in high.

Fully detailed 7 page construction manual and parts list free with kit or send 25p plus large S.A.E.

AMPLIFIER KIT £13.50 P. & P. 80p (Magnetic input components 33p extra)

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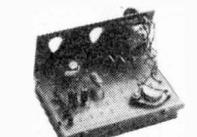
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This Board allows 2 TO5 or 1 DIL IC Station to be used and so is primarily intended for discrete work or for linear IC application where considerable numbers of discrete components may be required. (No. of Contacts: 208) PRICE £4.30 inc. VAT.



U-DEC 'A'

The μ -Dec 'A' is specially designed for ease of use with IC's and allows 2 DIL or 4 TO5 stations to be used but will accommodate discrete components with equal facility. (No. of Contacts: 208) PRICE £4.31 inc. VAT.



U-DEC 'B'

The μ -Dec 'B' is for similar uses as μ -DEC 'A', but has two 16 lead IC sockets as part of the Board. (No. of Contacts: 208) PRICE £7.55 inc. VAT.



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748 DIL 8 pin	49p	BC177/8/9	PAK T: 4 x LM301 £1*
7805 plastic or TO3	£1	BC182/3/4 A or L	PAK W: 20 x Electrolytics £1*
7812 or 15 A	£1.50*	BC212/3/4 A or L	MORE PAKS IN LISTS.
78013 or 78023	£1.49	BCY70/71/72	CAPACITORS: Ceramic 5p
8038 Sig. Gen.	£5*	BD131 or 132 each	Electrolytic 1v-200v 7p
AY51224 Clock	£2.25*	BFY 50, 51 or 52	HEATSINKS TO18/TO5 5p*
LM301 DIL 14	29p	MJ2955 (PNP)	TO3 Small 29p*
LM301 DIL 8	59p	MJE2955	Big 89p*
LM309K TO3, 5V	£1*	MJE 3055	DIL SOCKETS
LM382 (LM381)	£2	ORP 12 plastic	Low Profile 8 pin 12p*
LM380/60745	89	TIP29, 30, 31, 32C	14 or 16 pin 15p*
LM3130/CA3130	95p*	TIP41 or 42A	VERO All 0.1 in. stocked
LM3900	75p	TIP41C or 42C	2 1/2 x 3 1/2 42p*
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LEDs 1/2" x 2" dia.		2N2922 1G	POTS 25p PRESETS 2p
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NEW 6x6z LED Cover Clip	10p*	2N3819e & 23e	4009/10 59p*
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0.3" DL707/2	£1*	DIVIDER/OA81/91	7404/5 20p* 7491/2 50p*
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			10p* SHOWN.



PATENTS REVIEW...

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

The centenary year of recorded sound has now passed; so it seems fitting to mention briefly some of the most important patents relating to sound reproduction which have been granted over the past hundred years. All the patent specifications mentioned can be referred to, free of charge, at the Science Reference Library attached to the Patent Office, just off Chancery Lane in London, during Civil Service working hours. Where possible British rather than foreign specifications have been cited because many of these will also be available for reference in the two dozen public libraries in cities around the UK that hold patents.

INVENTOR

There is a dispute over who should be credited with the invention of the gramophone. One school of thought argues in favour of Frenchman Charles Cros, who, in April, 1877, deposited a sealed packet of documents at the Academy of Sciences, with instructions that it should not be opened until December 1877. The packet described a photo-mechanical process of recording sound on a disc, but it was never put into practice by Cros. Meanwhile, Thomas Alva Edison was working on improvements to the basic telephone and telegraph system.

In July 1877, Edison filed a British Patent (BP 2927/1877) for a scheme to make a permanent record of a telegraph message by making impressions in paper on a disc or cylinder backing. In the same month, Edison patented (BP 2909/1877) a microphone system which enabled the human voice to be transmitted over telegraph wires. The electrical resistance of a point of contact on a diaphragm varied as the diaphragm vibrated, so as to modulate a d.c. current. Although this patent appears to contain details for producing the first gramophone, or phonograph as Edison called it (by teaching how to use the vibrating diaphragm to cut a groove in a cylinder), the filing date for the relevant drawings and description is, in fact, much later—January, 1878. By this time Edison had

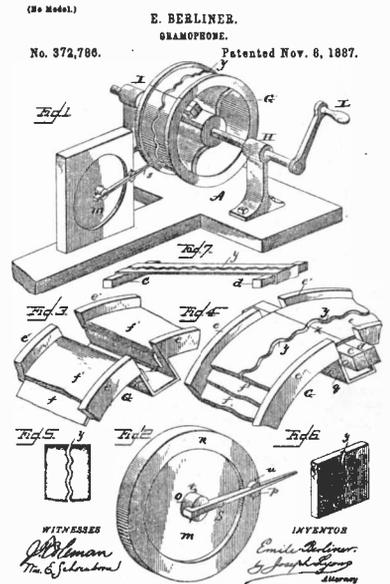
already filed what is the master patent on the Phonograph, USA Patent 200521.

This patent described a cylinder recording system for the human voice. Its filing date, December 24, 1877, is regarded by many as the birth-date of recorded sound.

LATERAL CUT

In 1887 Emile Berliner patented lateral-cut recording (USA Patent 372786) as the solution to the mass reproduction of recordings, and although Edison had already patented similar suggestions (even in the 1877 Christmas patent), Berliner's claims are regarded as the birth-date of the modern pressed disc record. Interestingly, Berliner's patent refers to a "gramophone", rather than the "phonograph" referred to by Edison.

Two years before Berliner (in 1885) Sumner Tainter had patented the basic



Edison phonograph, Home Model A, American 1898 (*Science Museum Photograph*).



concept of magnetic recording. He proposed a disc with a groove cut in its surface to induce electric currents in a coil when tracked by a needle, with the currents transduced into sound by a telephone diaphragm (USA Patent 341287). In 1899 Valdemar Poulsen of Denmark patented (BP 8961/1899) a magnetic recorder designed to function as a phonograph or a telephone answering machine. Poulsen was probably the first man actually to make a reliable magnetic recording, and at the Paris Exposition of 1900 he won the Grand Prix. In the same year, Guglielmo Marconi patented the first tunable wireless system (BP 7777/1900).

VALVE

In 1904 John Ambrose Fleming of University College, London, patented (BP 24850/1904) "a vacuum vessel having in it two conductors . . . one of them heated" and the diode valve was born. In 1907 Lee de Forest, of New York, patented (BP 1427/1908) a modified "evacuated vessel" which contained an extra electrode to make it a triode. Although de Forest is rightly credited with inventing the audion, as it was then called, it is important to note this valve really only found a valuable use, and fame, when Edwin Howard Armstrong in the USA invented and patented the feedback principle. The relevant patent is USA 1,113,149 which dates back to a notarised document of January, 1913.

It is also interesting to recall that in 1882 Edison had almost patented the valve! His USA patent No. 273,486 related to an early form of electric light bulb and described the phenomenon whereby material gradually disperses from the filament and accumulates on the inside surface of the glass envelope, blackening it and leaving the filament weak. Edison's answer, buried in the patent as an afterthought amongst other suggestions, was to use a second filament in the same envelope electrically connected to one side of the d.c. supply. This attracted or repelled the particles leaving the filament and thus prevented them from reaching the glass. In other words Edison had patented a diode, nearly twenty years before it was invented.

Incidentally, Edison as far back as 1878, had also patented disc and cylinder machines with facilities for electro-magnetic cutting and reproduction (British Patent 1644/1878). Oliver Lodge, of University College, Liverpool, in 1898, was almost certainly the first worker to invent and patent (BP 9712/1898) a moving coil microphone or speaker system.

Everything had so far, of course, been in mono, or single channel. In 1920, a Washington inventor, Samuel Waters, filed a patent (USA Patent 1520378) for a two-channel disc reproducer. The object of the exercise was

to improve signal to noise ratio rather than to create true stereo, as was interesting other workers at the same time, especially in the cinema. As early as 1911 Augustus Rosenberg of High Holborn, London, had patented a two-channel optical film recording system (BP 23620/1911). Incidentally, it was in 1925 (in British Patent 258 864) that the word "stereophonic" was used almost certainly for the first time.

STEREO

In 1927, W. Bartlett Jones, of Chicago, patented (USA Patent 1855149) the first binaural, or dummy head, stereo system. And in 1931 Alan Blumlein of EMI patented loudspeaker stereo and the 45 degrees double modulation of a 90 degrees groove, as used today (BP 394 325).

In 1936, Bell Telephone Laboratories filed a patent (USA Patent 2137032) which, buried in amongst its other disclosures, taught how the apparent direction of a sound source could be manipulated by altering volume levels to the loudspeakers—the way in which modern pan-potted recordings are made and stereo balance controls function.

Earlier, in 1929, Arthur Keller of Bell Telephone Laboratories in New York had patented the basis of modern multiplexing (USA Patent 1910254), by describing how two separate channels of sound could be recorded in a single record groove by division into two separate frequency bands.

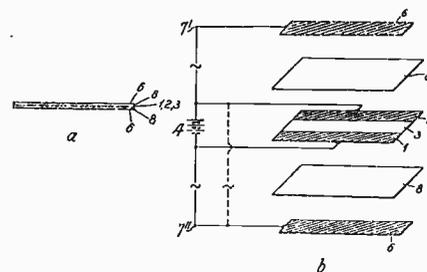
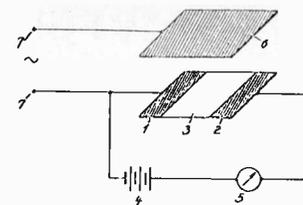
Modern multi-channel discs of discrete multiplex type (as marketed by JVC for the CD-4 system) find their origin there and in a 1946 invention made by EMI engineer William Livy (BP 612 163). The system relied on a recorded carrier to lock a demodulation oscillator to the rotational speed of the record.

Meanwhile, there was considerable invention in other closely associated areas. As early as 1900 Joseph Poliakoff of Moscow had patented (BP 18046/1900) an optical film recording system using a selenium photo-cell. The idea was taken several stages further by Eugene Lauste of London in 1906 (18057/1906). In 1924, Paul Voigt of London patented (BP 231 972) a feedback circuit for an amplifier to compensate for distortion introduced by the loudspeaker—i.e. motional feedback. In 1933, Maj. Edwin Armstrong of New York, USA, patented the basis of modern f.m. radio (USA Patent 1941069).

F.E.T.

In 1934 in Berlin, Oskar Heil invented a solid-state amplifier of semi-conductive material and patented it in Britain (BP 439 457). Oskar Heil is better known for the air-motion transformer loudspeakers sold today by ESS, but his 1934 invention was the first f.e.t.!

A workable system of video recording



Paul Voigt patent illustration of 1924

was first patented in 1955, by the Ampex Corporation of California (BP 798 927), one of the named inventors being Ray Dolby. BP 1 120 541, of 1965, is in the name of Ray Dolby alone, and constitutes the first patent disclosure of the now well known Dolby noise reduction system. Over recent years much audio patenting activity has centred around surround sound or quadraphonics, the first major matrixing patent being that filed in 1969 by Peter Scheiber of New York (BP 1 328 141 and 1 328 142). The current resurgence of interest in surround sound and the lack to-date of any standardisation on an agreed world system, suggests that the next few years will see this trend of interest continuing. Most recently, and in a slightly lighter vein perhaps, the cinema sound development, Sensurround, which enables audiences to be literally shaken in their seats by very low frequency sound waves generated by high power "effects" circuits is patented in USA Pat. No. 3 973 839. This lengthy patent and ten sheets of circuit diagrams give very full details of how the effects are generated and handled.

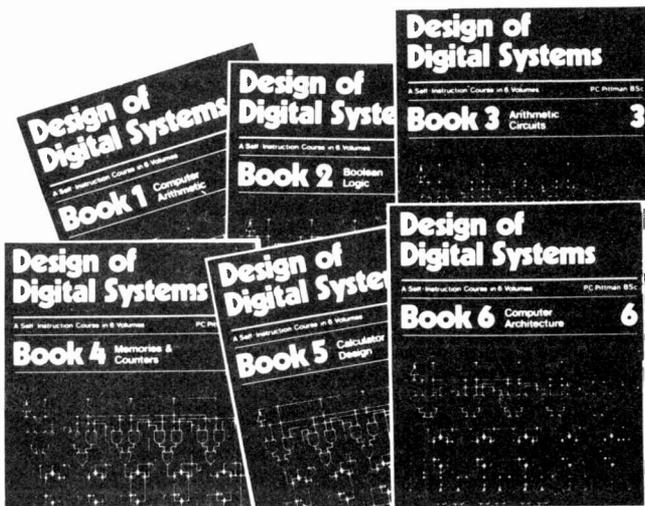
Readers who are particularly interested in the history and development of sound may find the current exhibition of over a hundred instruments from the EMI collection of vintage phonographs and gramophones, at the Science Museum, South Kensington, London, of particular interest.

Included in the display is an example of the gramophone that appears in the famous "dog-and-trumpet" trademark and an instrument that could be folded up and pocketed. The exhibited instruments illustrate developments from 1877 to about 1935 but a further display of posters, record sleeves and photographs covers the full 100 years.

The exhibition is located in gallery 1, and is open daily until April.

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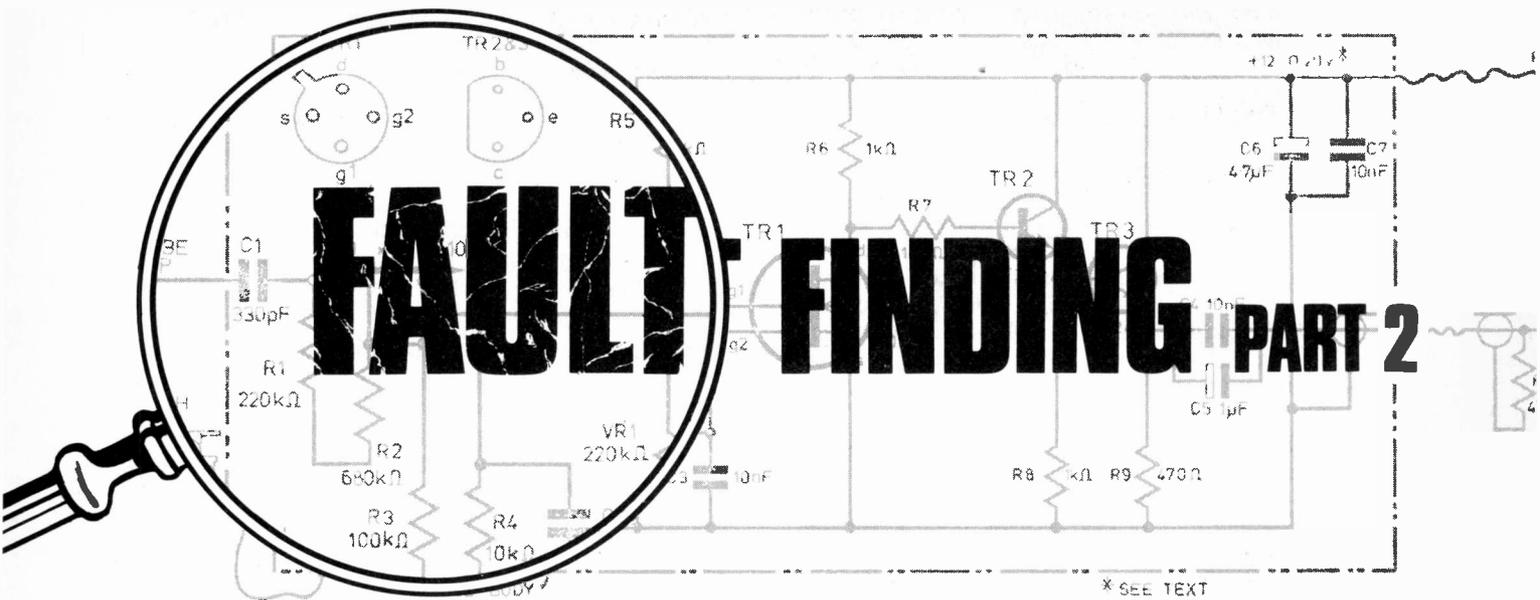
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G. LOVEDAY

Fault Finding on Systems

THE first part of this series dealt with faults caused in an electronic circuit by one component failure. It was shown that when a component fails; goes open or short circuit, then a certain set of symptoms result, and by using these symptoms it is possible to pinpoint the faulty component. The symptoms are any changes in the circuit operation, such as low output signal with distortion, and changes in the d.c. bias voltages. However, when it comes to fault finding on a complete electronic instrument, or system, the situation is made more difficult because of the size and complexity of the system. One component failure will often cause the whole system to fail, but the total number of components may number several hundred. Since time, in the service situation, is of prime importance, it's not acceptable to sit down and methodically measure every voltage and waveform until the faulty component is found. Another technique must be used.

Luckily nearly all electronic instruments can be divided up into several functioning circuit blocks and the quickest way to find the faulty component is by measuring to first of all locate which portion or block of the system has failed, then to work on that block to find the actual component.

THE BLOCK DIAGRAM

This is a really valuable aid in servicing and in helping to understand the operation of a complex piece of equipment. For example, let's look at the block diagram of a basic r.f. signal generator shown in Fig. 2.1. It is made up of six blocks, each of these performing a separate circuit function.

A variable r.f. oscillator feeds a sine wave signal to an amplifier and the output of this amplifier can either be amplitude modulated at 400Hz or constant wave (c.w.) depending upon the setting of the switch.

Since these are two output signals and two possible output conditions for the r.f. output, we can use the states of the outputs as symptoms to fault find the generator. If, for example, there were no outputs at all the fault would most probably lie in the power supply, since it would be unlikely (although possible) that both oscillators had failed. Suppose, however, that the r.f. output was correct in both the modulation and c.w. switch positions but no a.f. output could be obtained. The fault lies in the a.f. attenuator or its connections. These examples show the sort of logical approach

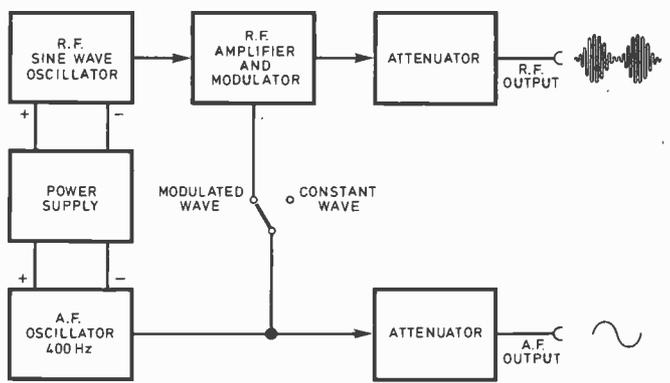


Fig. 2.1. Block diagram of r.f. generator

that's required. The various methods for system fault finding will be shown later in this article. What would be the symptoms for (a) an a.f. oscillator failure or (b) a modulator failure.

INTERPRETING IT

Now let's look at the way in which a block diagram can help in understanding how a unit operates. A switched mode power unit has a full circuit diagram that can look rather forbidding, but when it is drawn out in block form (Fig. 2.2) the operation can be more clearly understood and fault diagnosis is made much easier. Switch power supplies are used in relatively high power applications (e.g. 5 volts at 20 amps) because they have high efficiency, low heat loss and therefore use up less space than a conventional stabilised power unit. The mains voltage is itself rectified and smoothed giving about 340 volts d.c. This voltage is switched at a frequency above audio, usually 20kHz, by high voltage transistors to provide an alternating waveform to the transformer primary.

Since a fairly high frequency is used the transformer need not be so bulky as a 50Hz type. The a.c. voltage at the secondary is rectified and smoothed to give a d.c. voltage across the load. The output is stabilised by comparing it with a reference supply (usually a Zener) and using the different signal to alter the duty cycle of the switching signal to the transistors. If the d.c. output should fall when the load is increased the comparator gives a signal to the pulse width modulator that switches the transistors on for a longer time than they are off during the 20kHz switching period. This provides more power via the transformer to the load and the output voltage rises. The opposite occurs if the load current is reduced.

METHODS FOR SYSTEM FAULT FINDING

One of the first jobs when fault finding on a system is to accurately define the fault. To do this a functional check must be made and the exact symptoms noted. This usually entails making measurements and comparing the performance with the actual specification. In a service department

the engineer would need the up-to-date figures for the performance specification plus the circuits and service manuals and also the necessary test gear. In any project work we should follow the same procedure.

At this stage, depending on the symptoms, it is wise to check that the power supply rails are at their correct voltage levels before proceeding to make measurements to narrow down the search for the faulty component to one part of the block diagram.

It's possible of course to use a completely random approach to find which block is faulty, checking the circuits in any order, but usually a systematic logical approach yields the quickest results. The three methods are called:

- (1) Input to output (or beginning to end)
- (2) Output to input (or end to beginning)
- (3) Half-split.

Here we are considering actual measurements, but don't forget that a visual inspection for broken wires, dry joints, burnt components, damaged copper track, etc., can also be worthwhile. This is especially the case when a system that you have just assembled refuses to function at all.

METHODS ANALYSED

The first two methods listed above are fairly obvious and most of us used input to output checking before we knew that somebody had given it a name! A suitable input signal (if required) is injected into the first block and then measurements are made sequentially at the output of each block in turn until the faulty block is located. Output to input is the reverse; leaving the input to block (1) measurements are made from output block towards the input. This presupposes that the units are all in series, but this is rarely the case. The s.m.p.u. for example cannot be fully checked using a straightforward sequence of tests. Suppose the unit fails with the symptom of zero output. The fault could be in almost any block. One sequence of checks to find that fault could be the following:

- (a) Measure d.c. voltage from mains rectifier block (1)
- (b) Measure output of 20kHz oscillator block (2)

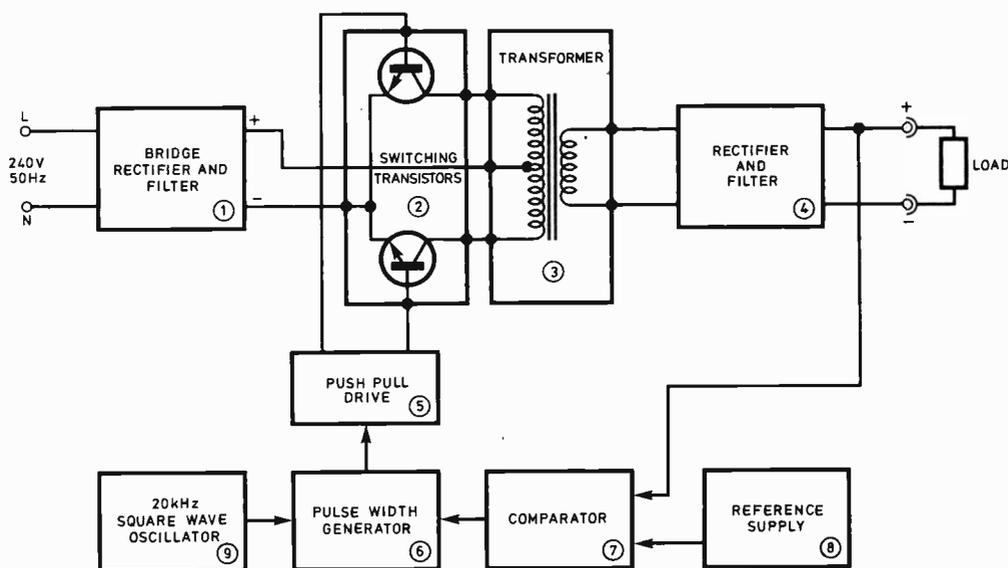


Fig. 2.2. Block diagram of switched mode power unit

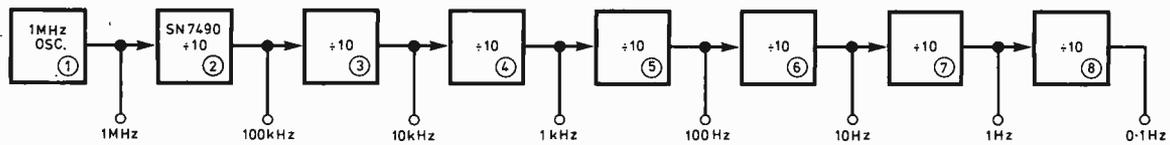


Fig. 2.3. Frequency divider chain

By doing these checks first we verify the two primary conditions for an output across the load. Assuming both these blocks are functioning correctly we can then use output to input by measuring (4), (3), (2) and then (5), (6), (7), (8) or input to output measuring from (8), (7), (6), (5), (2), (3), (4). Either method is satisfactory, but the first is probably the best as it checks early on through the circuits that probably have the highest failure rate (namely the switching transistors). Using this criterion the sequence of test could be (1), (9), then (2), (3), (4), and finally (5), (6), (7), (8). The important thing to realise is that the tests ought to follow some logical sequence.

Imagine now a fault with the symptoms of high un-stabilised output voltage. From this we can conclude that blocks (1), (2), (3), (4) and (9) are all operating. The fault is somewhere in blocks (5), (6), (7), (8). Here a good start would be to measure the output of (8) since an open circuit reference supply would give these particular symptoms.

HALF-SPLIT METHOD

The half-split method for system fault location is really useful when the instrument or system is made up of a large number of blocks in series. A good example is fault finding on the frequency divider chain of a digital frequency meter (Fig. 2.3). Here the frequency of a 1MHz crystal oscillator is divided down by decade counters to give the required timing pulses. Since eight blocks are used it is possible to divide the unit into two equal parts, test to decide

which half is working correctly, then split the non-working section into half again to locate the fault. Let's assume that block (6) has failed; the sequence of tests would be as follows:

1. Split whole unit into half by measuring output from block (4). This will be alright showing that the fault lies somewhere in blocks (5) to (8).
2. Split blocks (5) to (8) in half checking output of block (6). There will be no output.
3. Check output of block (5). This will be all right proving that the fault is in block (6).

Now try the method for yourself by assuming that block (3) or block (8) has failed, and you will find that the number of checks necessary to locate the fault is always three. On average more tests would be required using any other method. Unfortunately many instruments are not made up of many blocks in series. More often than not a system has feedback loops that are necessary for operation and which cannot be split. Also convergence, where two inputs are required to make a circuit block operate correctly, and divergence, where an output from a block feeds two or more other blocks are quite common. These situations complicate the use of the half split. When fault finding try and use the method, or a combination of methods that will locate the faulty block in the shortest possible time. This isn't always achieved with the minimum number of test measurements. A common sense logical approach to the problem is the basic requirement.

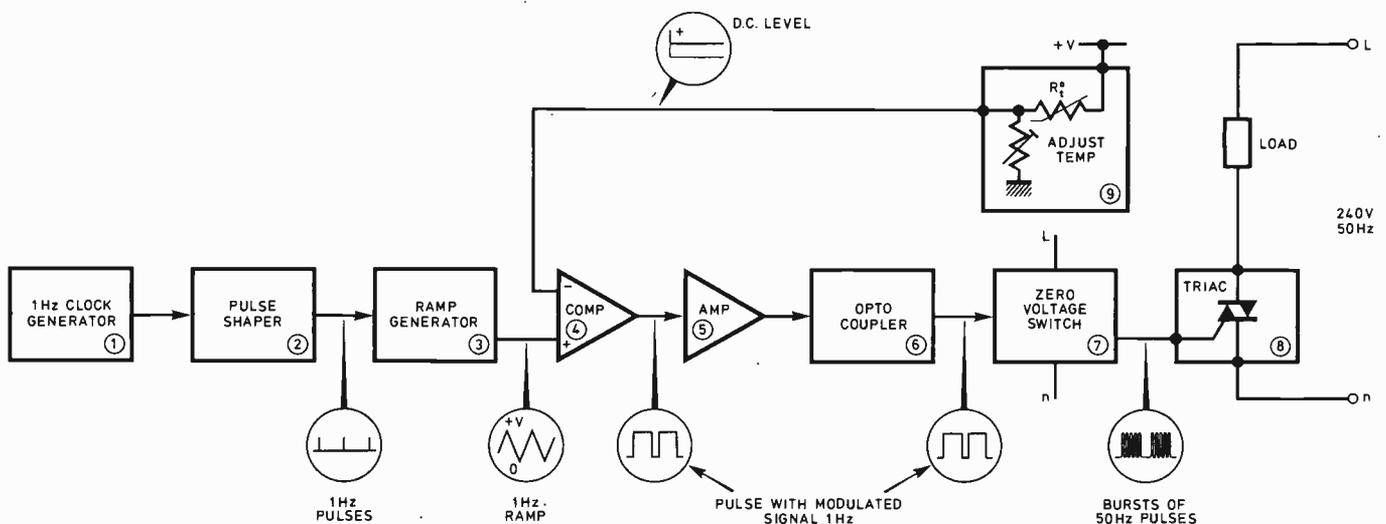


Fig. 2.4. Block diagram of temperature controller

TEMPERATURE CONTROLLER FAULT DIAGNOSIS

As a final exercise we are going to look at the block diagram of an oven temperature controller. This is a nice series type of circuit but with the added complication of feedback from the temperature sensor. The unit uses burst cycle firing of a triac to control the power dissipated in a heating element. With this type of control, power is applied for a few cycles of the mains at a time, say 40 out of 50 cycles when the temperature is lower than required, reducing to maybe 5 out of 50 cycles when the oven temperature has stabilised. A zero voltage switch ensures that the triac is only pulsed on when the mains voltage is near zero thus eliminating the generation of r.f. interference.

The operation is fairly straightforward. A clock generator gives pulses via a shaping circuit of 1Hz to a ramp generator. This ramp is compared with the d.c. level from the temperature sensor. When the temperature inside the oven is lower than required this d.c. level is also low so the output of the comparator is high. The ramp goes from a positive voltage towards zero. While the ramp voltage exceeds the d.c. voltage from the sensor the output is high. This level is amplified and then applied via an opto-coupler to the zero voltage switch. The opto-coupler ensures that the mains side of the system is isolated from the low voltage portion. While the comparator output is high the zero voltage switch delivers pulses to gate on the triac and so power is applied to the heater. As the temperature in the oven rises so does the d.c. voltage from the temperature sensor and this means that the comparator output is high for a shorter time during the 1 second clock period.

A FEW QUESTIONS

The feedback could complicate fault diagnosis but since

all the rest of the circuit blocks are in series it is possible to use any of the methods described. We just have to ensure that a reasonable d.c. level is present on the inverting terminal (-) of the comparator. Assuming that the temperature sensor is o.k. a meter could be used to monitor this d.c. voltage or alternatively the feedback line could be broken and an adjustable d.c. voltage applied in its place.

If you are still with it, try your hand at answering a few questions:

- (1) Which fault finding method should theoretically get the quickest results?
- (2) What would be symptoms for the following faults?
 - (a) Short circuit triac.
 - (b) Temperature sensor open circuit.
 - (c) No output from 1Hz unit.
 - (d) Ramp output failed with output permanently low.
 - (e) Ramp failed with reduced amplitude (lower starting voltage).

ANSWERS

- (1) Half split.
- (2) (a) Oven overheating, no control. Few pulses at the output of the zero voltage switch.
(b) Oven overheating, no control. Many pulses at the output of the zero voltage switch.
(c) Ramp output will remain at +V therefore full power will be applied to the load. Many pulses at the output of the zero voltage switch.
(d) No heating. Low d.c. level from temperature sensor. Output of comparator remaining low however.
(e) Slow response to changes in temperature control.

Next month: Fault diagnosis of thyristor and triac circuits.



BOOK REVIEWS

MODERN ELECTRONICS MADE SIMPLE

By G. H. Olsen

Published by W. H. Allen & Co Ltd
306 pages, 130 × 215mm. Price £1.75

THIS book is good value indeed! It covers a wide variety of fields, and would serve as an excellent reference to have around for those whose memories occasionally require refreshment (most of us), or for the student of "A" Levels or an ONC Course, or C&G, at college.

The author has gauged the contents so that no prior knowledge of electronics is needed, other than basic electricity, and each new device covered is explained in terms of its physics before commencing with applications and design theory. The explanations are fairly thorough; for instance, the chapter entitled "Power Supplies" starts with batteries and their very chemical structure. Questions are posed at the end of each chapter, which you should be able to answer correctly before advancing to the next section.

The final chapter, "Projects", gives a number of circuits to play around with—just to satisfy yourself that what you've learned really works! These are by no means constructional projects in the sense that P.E. presents them, but if reading is the way to learn, then this is the way to remember.

My only criticism would be against the title, in that it's not so much a case of *Modern Electronics Made Simple* as just modern electronics set out clearly; but perhaps this is a trivial point since clarity is half the battle.

M.A.

TV TECHNICIAN'S BENCH MANUAL

By G. R. Wilding

Published by Argus Books Ltd.

217 pages, 143 × 224mm. Price £4.50

IT is the objective of this hardback, to present in a handy form adequate information for the service technician or enthusiastic amateur to locate television receiver faults of all kinds, fairly promptly.

Each chapter gives a brief run-down of all important aspects of the receiver section it covers, followed by the recommended servicing procedure to break down the most likely cause of trouble in order of probability.

Circuit diagrams for *specific* television receivers are present throughout, extracted from various manufacturers, but not too many circuit diagrams from Japanese sets are given.

There are 13 chapters, covering just about all the aspects of television receivers, and the last four chapters form a section devoted to colour.

This book gives fairly thorough coverage of its subject, but assumes a certain amount of prior knowledge, and therefore is not suitable for anyone seeking to understand television for the first time. As the name suggests, it is for the technician who already understands the overall functioning of a television, but perhaps needs a reference source for the more subtle variations he may encounter with different sets, and the appropriate servicing routines.

M.A.

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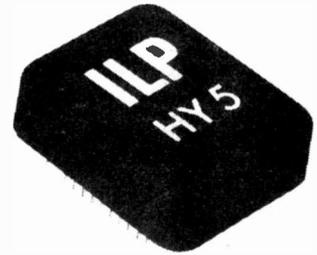
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HY30 15W into 8 Ω

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 8 Ω . Distortion—0.1% at 15W. Input Sensitivity—500mV. Frequency Response—10Hz-16kHz -3dB.

Price **£5.22** + 65p VAT. P. & P. free

HY50 25W into 8 Ω

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 8 Ω . Load Impedance—4-16 Ω . Distortion—0.04% at 25W at 1kHz. Signal/Noise Ratio—75dB. Frequency Response—10Hz-45kHz -3dB. Supply Voltage— \pm 25V. Size—105 x 50 x 25mm.

Price **£6.82** + 85p VAT. P. & P. free



HY120 60W into 8 Ω

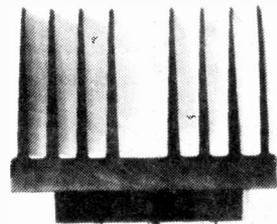
The HY120 is the baby of I.L.P.'s new high power range, designed to meet the most exacting requirements including load line and thermal protection this amplifier sets a new standard in modular design.

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 8 Ω . Load Impedance—4-16 Ω . Distortion—0.04% at 60W at 1kHz. Signal/Noise Ratio—90dB. Frequency Response—10Hz-45kHz -3dB. Supply Voltage— \pm 35V. Size—114 x 50 x 85mm.

Price **£15.84** + £1.27 VAT. P. & P. free



HY200 120W into 8 Ω

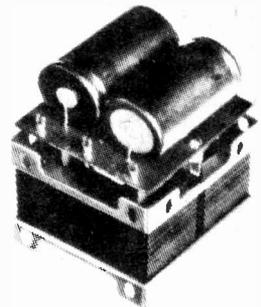
The HY200 (now improved to give an output of 120 watts) has been designed to stand the most rugged conditions such as disco or group while still retaining true hi-fi performance.

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 8 Ω . Load Impedance—4-16 Ω . Distortion—0.05% at 100W at 1kHz. Signal/Noise Ratio—96dB. Frequency Response—10Hz-45kHz -3dB. Supply Voltage— \pm 45V. Size—114 x 100 x 85mm.

Price **£23.32** + £1.87 VAT. P. & P. free



HY400 240W into 4 Ω

The HY400 is I.L.P.'s 'Big Daddy' of the range producing 240W into 4 Ω ! 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 4 Ω . Load Impedance—4-16 Ω . Distortion—0.1% at 240W at 1kHz. Signal/Noise Ratio—94dB. Frequency Response—10Hz-45kHz -3dB. Supply Voltage— \pm 45V. Input Sensitivity—500mV. Size—114 x 100 x 85mm.

Price **£32.17** + £2.75 VAT. P. & P. free

POWER SUPPLIES: **PSU36**—suitable for two HY30s **£5.22** + 65p VAT. P. & P. free. **PSU50**—suitable for two HY50s **£6.82** + 85p VAT. P. & P. free. **PSU70**—suitable for two HY120s **£13.75** + 1.10 VAT. P. & P. free. **PSU90**—suitable for one HY200 **£12.65** + £1.01 VAT. P. & P. free. **PSU100**—suitable for two HY200s or one HY400 **£23.10** + £1.85 VAT. P. & P. free.

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MC 161 x 96 x 58mm £1.53 (1-9) £1.50 (10+)
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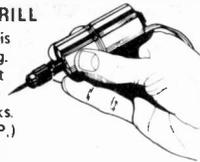
TYPE A NEON INDICATORS

Supplied with resistor for 240 Volts operation
Held in 8mm hole by plastic bezel
150mm wire leads

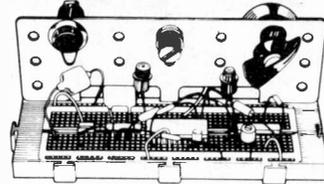

Red, Amber, Clear, Opal 19p each
Green 28p each

12 VOLTS MINI HAND DRILL

Ideal for drilling pcb, chassis etc as well as model making. Supplied with 2 collets that accept tools and drills with 3/32" and .050" dia. shanks. £7.56 (Includes VAT & P.P.)



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150mm leads, held in 6.4mm hole by nut



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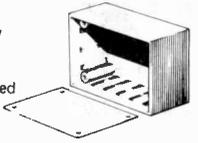
Quantity quotations on request

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SC BOXES (square corners)

Easily drilled or punched, orange, blue, black and grey ABS. Incorporate slots for holding 1.5mm thick pcb's. Aluminium panel sits recessed into front of the box and held by screws running into integral brass bushes.



SC 85 x 56 x 35mm 80p (1-9) 77p (10+)
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SC 161 x 96 x 59mm £1.49 (1-9) £1.46 (10+)
Add 25p per £1 order value for Post & Packing

240 VOLTS MINI HAND DRILLS

Ideal for drilling pcb's, chassis etc as well as model making. Supplied with 3 collets that accept tools and drills with 1mm, 2mm and 1/8" dia shanks.



£9.72 (includes VAT & P.P.)
Accessory tools... 5 Burrs, 1mm, 2mm, 1/8th Drills, 3/32" Collet Price £1.75 (Includes VAT & P.P.)

RC BOXES (round corners)



Easily drilled or punched, orange, blue, black and grey ABS. Incorporate slots for holding 1.5mm thick pcb's. Close fitting flanged lids held by screws running into integral brass bushes.

RC 100 x 50 x 25mm 51p (1-9) 49p (10+)
RC 112 x 62 x 31mm 59p (1-9) 52p (10+)
RC 120 x 65 x 40mm 68p (1-9) 62p (10+)
RC 150 x 80 x 50mm 77p (1-9) 74p (10+)
RC 190 x 110 x 60mm £1.33 (1-9) £1.30 (10+)

Polystyrene version

in grey only with no slots, no integral brass bushes
RC(P) 112 x 61 x 31mm 35p (1-9) 32p (10+)
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2N698	0-65	2N3705	0-15	40362	0-55	BC161	0-35	BD132	0-54	BFK88	0-30
2N699	0-55	2N3706	0-16	40363	1-30	BC167	0-12	BD135	0-37	BFK89	1-25
2N700	0-28	2N3707	0-18	40406	0-60	BC168	0-12	BD136	0-37	BFV50	0-25
2N706A	0-28	2N3708	0-13	40407	0-52	BC169	0-12	BD137	0-38	BFV51	0-25
2N708	0-28	2N3709	0-15	40408	0-75	BC170	0-18	BD138	0-38	BFV52	0-25
2N709	0-50	2N3710	0-16	40409	0-75	BC171	0-18	BD139	0-40	BFV53	0-34
2N718	0-27	2N3711	0-16	40410	0-75	BC172	0-14	BD140	0-40	BFV90	1-20
2N718A	0-20	2N3712	1-20	40411	2-85	BC177	0-20	BD239	0-40	BRV39	0-50
2N720A	0-30	2N3713	2-30	40594	0-80	BC178	0-20	BD240	0-40	BSK20	0-33
2N914	0-35	2N3714	2-45	40595	0-90	BC179	0-23	BD241	0-45	BSK21	0-32
2N916	0-30	2N3715	2-55	40773	0-75	BC182	0-11	BD242	0-50	BU105	1-40
2N918	0-38	2N3716	3-00	AC128	0-45	BC182L	0-14	BD243	0-60	BU205	2-20
2N920	0-25	2N3717	1-95	AC127	0-48	BC183	0-11	BD244	0-65	ME0402	2-00
2N930	0-26	2N3717	2-00	AC128	0-45	BC183L	0-14	BD245	0-65	ME0404	1-15
2N1131	0-30	2N3773	2-90	AC151V	0-40	BC184	0-12	BD246	0-66	ME0412	2-00
2N1132	0-37	2N3789	2-90	AC152V	0-50	BC184L	0-14	BD529	0-45	ME4102	1-10
2N1613	0-30	2N3790	3-10	AC153	0-55	BC206	0-16	BD530	0-50	ME4104	1-10
2N1711	0-30	2N3791	3-10	AC153K	0-55	BC206	0-16	BD531	1-00	ME4104	1-10
2N1893	0-30	2N3792	3-50	AC176	0-50	BC207	0-16	BF115	0-38	MJ490	1-35
2N2102	0-98	2N3794	2-00	AC176K	0-65	BC212L	0-17	BF121	0-55	MJ491	1-85
2N2218	0-33	2N3819	0-36	AC187K	0-60	BC213	0-14	BF123	0-55	MJ2955	1-25
2N2218A	0-37	2N3820	0-38	AC188K	0-60	BC213L	0-16	BF152	0-25	MJE340	0-58
2N2219	0-35	2N3823	0-80	AD161	1-00	BC214	0-16	BF153	0-25	MJE370	0-58
2N2219A	0-36	2N3824	0-80	AD162	1-00	BC214L	0-17	BF154	0-25	MJE371	0-58
2N2230	0-35	2N3806	0-22	AF106	0-55	BC237	0-14	BF159	0-35	MJE520	1-50
2N2221	0-25	2N4036	0-67	AF109	0-75	BC238	0-12	BF160	0-30	MJE521	0-65
2N2221A	0-26	2N4037	0-55	AF124	0-65	BC239	0-15	BF166	0-40	MJE3055	0-95
2N2222	0-25	2N4058	0-50	AF125	0-65	BC251	0-10	BF167	0-40	MJE3055	0-95
2N2222A	0-25	2N4059	0-15	AF126	0-65	BC251	0-22	BF167	0-40	MJE3055	0-95
2N2366	0-25	2N4920	0-20	AF139	0-59	BC257A	0-17	BF173	0-35	MPR112	0-40
2N2369	0-25	2N4061	0-17	AF186	0-50	BC258A	0-17	BF177	0-25	MPR113	0-45
2N2369A	0-25	2N4062	0-18	AF200	1-20	BC259B	0-18	BF178	0-25	MPP102	3-00
2N2646	0-75	2N4126	0-17	AF239	0-65	BC261A	0-24	BF179	0-30	MPSA05	0-25
2N2647	1-40	2N4289	0-20	AF240	1-14	BC262B	0-24	BF180	0-35	MPSA06	0-25
2N2904	0-36	2N4919	0-65	AF279	0-80	BC263C	0-30	BF181	0-35	MPSA12	0-40
2N2904A	0-37	2N4920	0-75	BC180	0-85	BC260	0-40	BF182	0-35	MPSA15	0-45
2N2905	0-37	2N4921	0-50	BC107	0-15	BC301	0-40	BF183	0-40	MPSA56	0-25
2N2905A	0-38	2N4922	0-55	BC108	0-15	BC303	0-50	BF184	0-38	MPSU05	0-50
2N2906	0-28	2N4923	0-70	BC109	0-15	BC307	0-15	BF185	0-35	MPSU06	0-56
2N2906A	0-35	2N5190	0-60	BC113	0-20	BC308	0-15	BF194	0-15	MPSU55	0-55
2N2907	0-25	2N5191	0-70	BC115	0-20	BC309C	0-15	BF195	0-15	MPSU56	0-60
2N2907A	0-25	2N5192	0-75	BC116	0-20	BC317	0-16	BF196	0-15	MPSA58	0-60
2N2924	0-15	2N5195	0-90	BC116A	0-20	BC318	0-13	BF197	0-17	TIP28C	0-60
2N2925	0-17	2N5245	0-34	BC117	0-22	BC327	0-20	BF198	0-16	TIP30A	0-49
2N3019	0-55	2N5294	0-40	BC118	0-20	BC328	0-19	BF200	0-35	TIP30C	0-65
2N3053	0-26	2N5295	0-40	BC119	0-30	BC337	0-19	BF225J	0-25	TIP31A	0-50
2N3054	0-30	2N5296	0-40	BC121	0-45	BC338	0-21	BF244	0-35	TIP31C	0-66
2N3055	0-70	2N5298	0-40	BC132	0-30	BC347	0-12	BF245	0-45	TIP32A	0-65
2N3390	0-20	2N5447	0-15	BC134	0-20	BC348	0-12	BF246	0-75	TIP32C	0-75
2N3391	0-20	2N5448	0-15	BC135	0-20	BC349	0-13	BF254	0-24	TIP33A	0-80
2N3391A	0-20	2N5449	0-19	BC136	0-19	BCY30	1-00	BF255	0-24	TIP33C	1-10
2N3392	0-16	2N5457	0-32	BC137	0-20	BCY31	1-00	BF257	0-37	TIP34A	0-90
2N3393	0-15	2N5458	0-33	BC140	0-35	BCY32	1-00	BF258	0-45	TIP34C	1-20
2N3394	0-15	2N5459	0-29	BC141	0-40	BCY33	1-00	BF259	0-49	TIP35A	0-80
2N3394A	0-16	2N5460	0-34	BC142	0-40	BCY34	1-00	BF259	0-49	TIP35A	0-80
2N3440	0-85	2N5485	0-38	BC143	0-30	BCY38	2-00	BF459	0-50	TIP36A	2-80
2N3441	0-81	2N6027	0-50	BC147	0-12	BCY42	0-60	BF493	0-28	TIP41A	0-70
2N3442	1-35	2N6101	0-45	BC148	0-12	BCY58	0-25	BF528	1-38	TIP41C	0-90
2N3638	0-16	2N6107	0-42	BC149	0-14	BCY59	0-25	BF528	1-38	TIP42A	0-80
2N3638A	0-16	2N6109	0-50	BC153	0-27	BCY70	0-25	BF528	1-38	TIP42C	1-00
2N3639	0-30	2N5121	0-38	BC154	0-27	BCY71	0-26	BF529	0-30	TIP2955	0-65
2N3641	0-10	2N6122	0-41	BC157	0-14	BCY72	0-24	BFX30	0-35	TIP3055	0-55
2N3702	0-23	2N6123	0-43	BC158	0-14	BD115	0-80	BFX84	0-35	TIS43	0-43

INTEGRATED CIRCUITS

CA3020	2-00	LM1800	1-76	TAA570	2-30
CA3028	2-29	LM1808	1-92	TAA611B	1-85
CA3028B	1-29	LM1828	1-75	TAA621	2-15
CA3028A	1-01	LM3301N	0-85	TAA651A	1-50
CA3030	1-35	LM3302N	1-40	TAA661B	1-50
CA3034	1-40	LM3901	0-70	TAA700	3-91
CA3046	0-89	LM3905	0-60	TAA930A	1-30
CA3048	2-23	LM3909	0-68	TAD100	1-30
CA3049	1-80	LM3035	1-75	TBA120	0-75
CA3051	2-42	MC1303	1-03	TBA120	0-75
CA3052	1-62	MC1304	1-40	TBA500	2-21
CA3080	0-75	MC1305	1-40	TBA500Q	2-30
CA3080A	1-88	MC1310	1-91	TBA510	2-21
CA3086	0-80	MC1327	1-54	TBA510Q	2-21
CA3088	1-70	MC1330	1-00	TBA520	2-21
CA3089	0-53	MC1350	1-90	TBA520Q	2-21
CA3090	4-00	MC1351	2-20	TBA530	1-98
CA3130	0-98	MC1352	1-10	TBA530Q	2-07
LM301A	0-67	MC1458	1-91	TBA540	2-21
LM301N	0-40	NE555	0-40	TBA540Q	2-30
LM304	2-45	NE556	1-10	TBA540Q	2-30
LM307N	0-65	NE557	1-65	TBA550	3-13
LM308C	0-82	NE556	1-65	TBA560	3-22
LM308N	0-85	NE567	1-80	TBA570	1-29
LM309K	1-85	SAS560	2-50	TBA570Q	1-38
LM317K	3-00	SAS570	2-50	TBA61B	2-70
LM318N	2-26	S042P	1-25	TBA651	2-20
LM323K	6-46	76011N	1-30	TBA700	1-62
LM339N	1-40	76013N	1-50	TBA700Q	1-51
LM348N	1-50	76008K	1-50	TBA720Q	2-30
LM360N	2-75	76013N	1-50	TBA750	1-98
LM370N	2-50	76013ND	1-50	TBA750Q	2-07
LM371N	1-70	76018K	1-50	TBA800	1-25
LM372N	1-70	76023N	1-45	TBA810	1-25
LM373N	2-80	76023ND	1-26	TBA820	1-25
LM374N	3-00	76033N	2-20	TBA920	2-90
LM377N	1-75	76110N	1-18	TBA920Q	2-99
LM378N	2-25	76115N	1-51	TBA940	1-62
LM379S	3-95	76116N	1-66	TCA160B	1-61
LM380B	0-90	76120N	1-56	TCA160C	1-85
LM380N	0-98	76225N	1-56	TCA270	2-25
LM381A	2-45	76227N	1-40	TCA280A	1-30
LM381N	1-60	76228N	1-21	TCA290A	3-13
LM382N	1-25	76530N	0-75	TCA420A	1-84
LM384N	1-45	76532N	1-40	TCA730	3-22
LM386N	0-80	76533N	1-65	TCA740	2-76
LM387N	0-85	76534N	1-44	TCA750	2-30
LM389N	1-00	76546N	1-44	TCA760	1-38
LM702C	0-75	76550N	0-35	TCA800	3-13
LM709C	0-65	76552N	0-95	UA170	2-00
LM709N	0-65	76570N	0-50	UA180	2-00
LM710C	0-50	76520N	0-60		
LM714N	0-40	76550N	0-60		
LM741-8	4-00	76650N	1-10		
LM742-8	4-00	76660N	1-60		
LM747N	0-90	TAA522	1-90		
LM748-8	0-55	TAA520	1-60		
LM748N	0-55	TAA560	0-75		

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Ref	12V	24V	£	P & P
111	0.5	0.25	2.20	0.45
213	1.0	0.5	2.64	0.78
71	2	1	3.41	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	17.85	2.08
226	60	30	26.82	0A

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, 30, 36, 48, 60V or 24-0-24V or 30-0-30V

Ref	Amps	£	P & P
112	0.5	2.44	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	7.60	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

60 VOLT RANGE

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 24-0-24V or 30-0-30V

Ref	Amps	£	P & P
124	0.5	3.88	0.96
126	1.0	5.58	0.96
121	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	0A
122	10.0	24.83	0A
189	12.0	27.13	0A

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, 25-0-25 or 20-0-20V

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	10.60	1.50
107	6.0	14.62	1.64
118	8.0	17.85	2.08
119	10.0	21.70	0A

MAINS ISOLATING (SCREENED)

PRIM 120/240 SEC 120/240 CT

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	0A
156	1000	37.20	0A
157	1500	45.60	0A
158	2000	54.80	0A
159	3000	71.05	0A

*This model 115 or 240V only.

HIGH VOLTAGE MAINS ISOLATING

Prim 200/220V or 400/440V
Sec 100/120V or 200/240V

Ref	Va	£	P & P
60	243	5.89	1.32
350	247	14.11	1.84
1000	250	35.65	0A
2000	252	54.25	0A

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, 30, 36, 48, 60V or 24-0-24V or 30-0-30V

Ref	Amps	£	P & P
124	0.5	3.88	0.96
126	1.0	5.58	0.96
121	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	0A
122	10.0	24.83	0A
189	12.0	27.13	0A

AUTO TRANSFORMERS

240V cable in & 115V USA 2 pin outlet

Ref	VA (Watts) Volts	£	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

CASED AUTO TRANSFORMERS

240V cable in & 115V USA 2 pin outlet

Ref	VA (Watts) Volts	£	P & P
15	4 96	0.96	113W
150	150	1.14	4W
200	9 92	1.45	65W
250	10 49	1.45	69W
350	12 53	1.64	53W
500	15 73	1.64	67W
750	18 55	1.76	83W
1000	22 88	0A	84W
1500VA	26 02	0A	93W
2000	37 65	0A	95W

SCREENED MINIATURES

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
203	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	0-15-20-15-20	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	5.38	0.96
S112	500	12-15-20-24-30	2.64	0.78
239	50	12-0-12	1.99	0.38

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AVO MMS	£24.00
AVO TT169 In circuit Transistor Tester	£30.00
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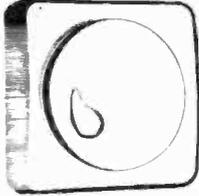
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AC125	0-25	BC179B	0-18	BF173	0-24	OC72	0-45	2N3704	0-13*
AC126	0-28	BC182B	0-18*	BF179	0-24	OC74	0-45	2N3705	0-14*
AC127	0-28	BC182B	0-18*	BF179	0-24	OC81	0-50	2N3707	0-14*
AC128	0-20	BC183B	0-10*	BF183	0-34	OC82	0-70	2N3708	0-12*
AC151	0-35	BC183L	0-10*	BF184	0-25	ORP12	0-68	2N3709	0-14*
AC153	0-35	BC184B	0-12*	BF185	0-28	TIP29A	0-47*	2N3710	0-11*
AC176	0-22	BC184L	0-11*	BF194	0-10*	TIP30A	0-58*	2N3711	0-11*
AC178	0-22	BC185	0-23	BF195	0-10*	TIP31A	0-57	2N3819E	0-25*
AC188	0-20	BC187	0-26	BF196	0-12*	TIP32A	0-47	2N3820	0-45*
AC187/188		BC204A	0-16*	BF197	0-12*	TIP33A	0-84	2N3823E	0-25*
AD149	0-68	BC204B	0-16*	BF199	0-15*	TIP34A	1-13	2N4036	0-40
AD161	0-52	BC212A	0-13*	BF200	0-38	TIP41A	0-67	2N4058	0-18*
AD182	0-52	BC212L	0-15*	BFX29	0-20	TIP42A	0-80	2N4059	0-10*
BC107	0-11	BC213B	0-12*	BFX30	0-25	TIP295S	0-87	2N4061	0-12*
BC107A	0-12	BC213L	0-14*	BFX40	0-28	TIP305S	0-60	2N4124	0-20*
BC107B	0-13	BC214	0-15*	BFX88	0-22	TIS43	0-35*	2N4126	0-30*
BC108	0-16	BC214A	0-17*	BFY50	0-25	ZTX109	0-14*	2N5298	0-50*
BC108/08		BC237A	0-16*	BFY51	0-25	ZTX300	0-13*	2N5457	0-50*
BC108B	0-11	BC300	0-35	BFY52	0-25	ZTX301	0-13*	2N5458	0-40*
BC108C	0-12	BC301	0-34	ME040	0-18*	ZTX302	0-18*	2N5459	0-40*
BC109	0-12	BC303	0-35	ME041	0-18*				

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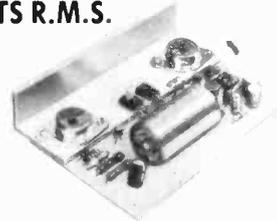
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THE CONTROL AND PRE-AMP MODULES

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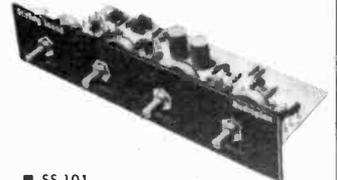
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■ CONTROL PANEL FASCIA available separately 50p

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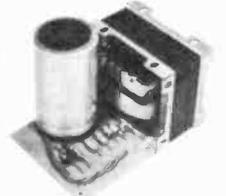
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AC125	0-30	BD131	0-51	OA5	0-75	1N4005	0-13	7410	0-20
AC126	0-25	BD132	0-54	OA7	0-55	1N4006	0-15	7412	0-26
AC127	0-25	*BD135	0-35	OA10	0-55	1N4007	0-15	7413	0-45
AC128	0-25	*BD136	0-36	OA47	0-14	1N4009	0-15	7416	0-40
AC141	0-20	*BD137	0-37	OA70	0-30	1N4148	0-07	7417	0-40
AC141K	0-30	*BD138	0-40	OA79	0-30	1N5400	0-14	7420	0-20
AC142	0-20	*BD139	0-43	OA81	0-30	1N5401	0-16	7422	0-25
AC142K	0-25	BD144	2-00	OA85	0-30	1S44	0-06	7423	0-35
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ACY20	0-65	BDX32	2-25	OA211	0-75	2N696	0-25	7437	0-42
ACY21	0-65	BDY20	1-42	OA2200	0-65	2N697	0-16	7438	0-37
ADY39	1-25	BDY60	0-75	OA2201	0-65	2N698	0-30	7440	0-22
AD149	0-70	BF115	0-39	OA2206	0-65	2N705	0-90	7441AN	0-92
AD161	0-75	BF152	0-25	OA2207	0-65	2N706	0-12	7442	0-78
AD162	0-75	BF153	0-25	OC16	1-25	2N708	0-21	7447AN	1-20
AF106	0-46	BF255	0-45	OC20	2-00	2N930	0-20	7450	0-20
AF114	0-25	BF159	0-35	OC22	2-50	2N1131	0-26	7451	0-20
AF115	0-25	BF160	0-30	OC23	2-75	2N1132	0-26	7453	0-20
AF116	0-25	BF167	0-39	OC24	3-50	2N1302	0-37	7454	0-20
AF117	0-25	BF173	0-39	OC25	0-90	2N1303	0-37	7460	0-20
AF139	0-40	BF177	0-38	OC26	0-90	2N1304	0-45	7470	0-35
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AF239	0-45	BF179	0-48	OC29	2-00	2N1306	0-50	7473	0-36
AFZ11	2-75	BF180	0-45	OC35	1-50	2N1307	0-50	7474	0-40
AFZ12	2-75	BF181	0-45	OC36	1-50	2N1308	0-60	7475	0-59
ASV26	0-45	BF182	0-45	OC41	0-50	2N1309	0-60	7476	0-42
ASV27	0-50	BF183	0-45	OC42	0-50	2N1613	0-33	7480	0-60
ASZ15	1-25	BF184	0-38	OC43	1-50	2N1671	1-50	7482	0-85
ASZ16	1-25	BF185	0-37	OC44	0-50	2N1893	0-33	7483	1-00
ASZ17	1-25	*BF194	0-12	OC45	0-50	2N2147	1-40	7484	1-00
ASZ20	0-75	*BF195	0-11	OC71	0-45	2N2148	1-65	7486	0-40
ASZ21	1-50	*BF196	0-13	OC72	0-45	2N2218	0-33	7490	0-52
AU113	1-70	BF200	0-32	OC73	1-00	2N2219	0-42	7491AN	0-85
AU110	1-10	BF200	0-32	OC74	0-75	2N2220	0-35	7492	0-60
BA145	0-15	*BF224	0-20	OC75	0-60	2N2221	0-22	7493	0-70
BA146	0-15	*BF244	0-35	OC76	0-50	2N2222	0-25	7494	0-80
BA154	0-10	BF257	0-37	OC77	1-20	2N2223	2-75	7495	0-80
BA155	0-12	BF258	0-42	OC81	0-75	2N2368	0-17	7496	0-60
BA156	0-13	BF259	0-45	OC81Z	1-00	2N2369A	0-21	7497	0-87
BAW62	0-85	*BF336	0-50	OC82	0-75	2N2484	0-21	74100	1-75
BAX13	0-07	*BF337	0-53	OC83	0-55	2N2646	0-50	74107	0-45
BAX16	0-07	*BF338	0-55	OC84	0-60	2N2904	0-35	74109	0-86
BC107	0-12	BFS21	2-27	OC122	1-50	2N2905	0-35	74110	0-57
BC108	0-12	BFS28	1-38	OC123	1-50	2N2906	0-25	74111	0-86
BC109	0-10	*BFS61	0-25	OC130	2-25	2N2907	0-21	74116	1-89
*BC113	0-15	*BFS98	0-25	OC140	1-85	*2N2924	0-15	74118	0-85
*BC114	0-18	BFW10	0-90	OC141	2-25	*2N2925	0-17	74119	2-00
*BC115	0-18	BFW11	0-90	OC170	0-75	*2N2926	0-13	74120	1-10
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*BC117	0-22	BFX85	0-41	OC200	1-00	2N3054	0-50	74122	0-60
*BC118	0-18	BFX87	0-32	OC201	1-50	2N3055	0-65	74123	1-00
*BC125	0-18	BFX88	0-32	OC202	1-25	2N3440	0-25	74125	0-90
*BC126	0-25	BFY50	0-28	OC203	1-25	2N3441	0-60	74126	0-80
*BC135	0-15	BFY51	0-26	OC204	1-25	2N3442	1-20	74128	0-80
*BC136	0-19	BFY52	0-26	OC205	1-75	2N3525	0-90	74132	0-80
*BC137	0-16	BFY64	0-30	OC206	1-75	2N3614	1-20	74136	0-68
*BC147	0-10	BFY90	0-32	OC207	1-25	*2N3702	0-15	74141	0-85
*BC148	0-10	BSX19	0-34	OC211	1-25	*2N3703	0-15	74142	0-90
*BC149	0-13	BSX20	0-34	ORP12	0-63	*2N3704	0-15	74143	3-00
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*BC167	0-07	*BU205	2-25	T1C4	0-38	*2N3708	0-15	74148	2-00
*BC170	0-16	*BU206	2-25	T1C226D	1-30	*2N3709	0-14	74150	1-75
*BC171	0-14	*BU208	2-50	T1L209	0-25	*2N3710	0-14	74151	0-90
*BC172	0-13	BY100	0-45	*T1P29A	0-50	*2N3711	0-15	74154	2-00
*BC173	0-15	BY126	0-14	*T1P30A	0-60	2N3771	1-80	74155	0-90
*BC177	0-18	BY127	0-15	T1P31A	0-62	2N3772	1-70	74156	0-80
*BC178	0-18	BZK61	0-20	T1P32A	0-75	2N3773	2-65	74157	0-90
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*BC237	0-17	CRS3/60	0-90	*ZS140	0-25	*2N4058	0-20	74178	1-85
*BC238	0-12	GEX66	1-50	*ZS170	0-12	*2N4059	0-15	74179	1-85
BC301	0-45	GEX541	1-75	*ZS178	0-54	*2N4060	0-20	74180	1-85
BC303	0-60	GJSM	0-75	*ZS271	0-22	*2N4061	0-17	74181	1-48
*BC307	0-18	GJSM	0-75	*ZS278	0-58	*2S278	0-18	74181	1-48
*BC308	0-18	GMO378A	1-90	*ZTX107	0-11	*2N4124	0-17	74192	1-25
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*BC328	0-18	MJE340	0-59	*ZTX109	0-12	*2N4286	0-20	74194	1-25
*BC337	0-19	MJE370	0-65	*ZTX300	0-12	*2N4288	0-25	74195	1-10
*BC338	0-18	MJE371	0-65	*ZTX301	0-13	*2N4289	0-25	74196	1-20
BCY30	1-00	MJE520	0-65	*ZTX302	0-17	*2N5457	0-36	74197	1-00
BCY31	1-00	MJE521	0-75	*ZTX303	0-17	*2N5458	0-35	74198	2-25
BCY32	1-00	MJE2955	1-25	*ZTX304	0-18	*2N5459	0-35	74199	2-25
BCY33	0-90	MJE3055	0-75	*ZTX311	0-12	3N125	1-75	*76013N	1-75
BCY34	0-90	*MPF102	0-30	*ZTX314	0-20	3N141	0-85		
BCY39	3-00	*MPF103	0-30	*ZTX314	0-20				
BCY40	1-25	*MPF104	0-30	*ZTX500	0-13				
BCY42	0-30	*MPF105	0-30	*ZTX501	0-14				
BCY43	0-30	*MPF106	0-30	*ZTX502	0-17				
BCY58	0-23	*MPSA08	0-25	*ZTX503	0-18				
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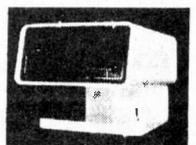


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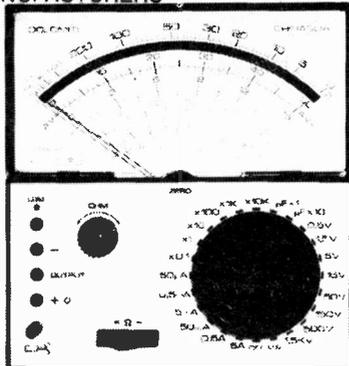
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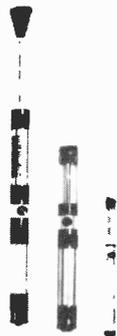
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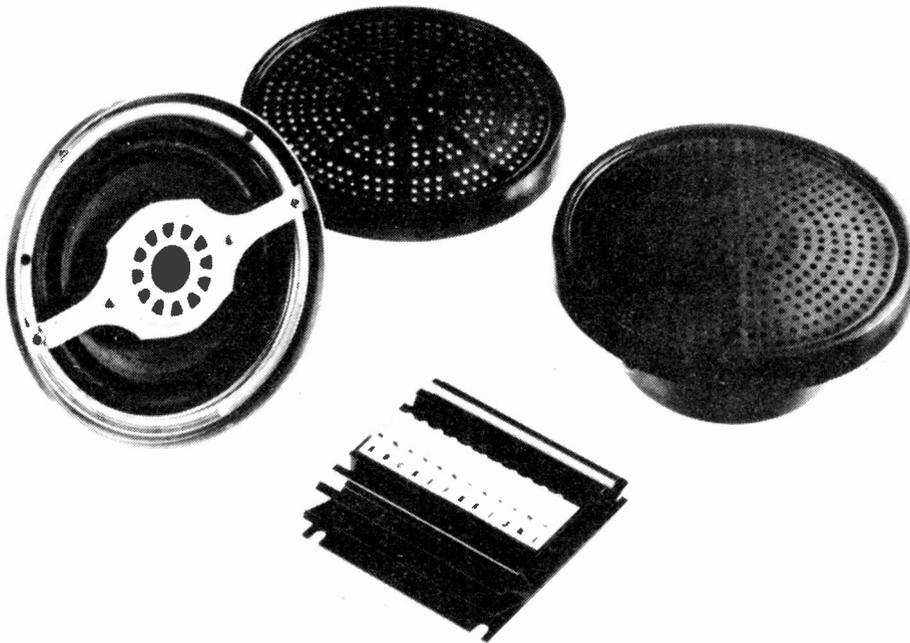
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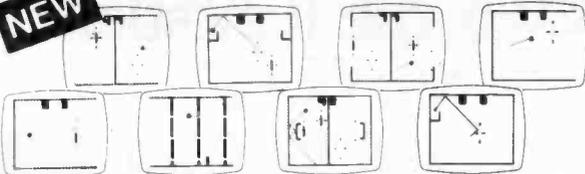
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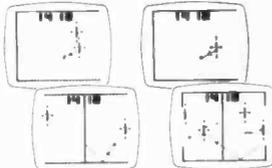
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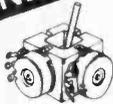
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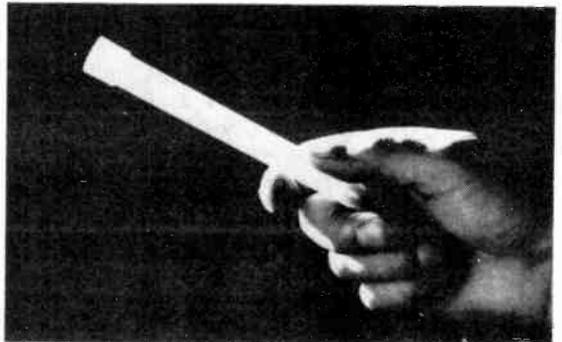
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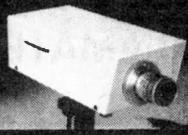
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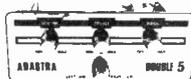
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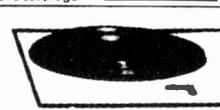
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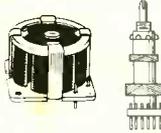
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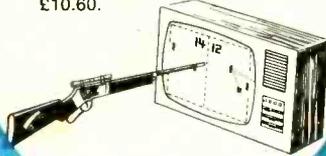
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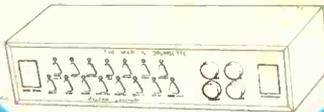
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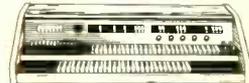
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