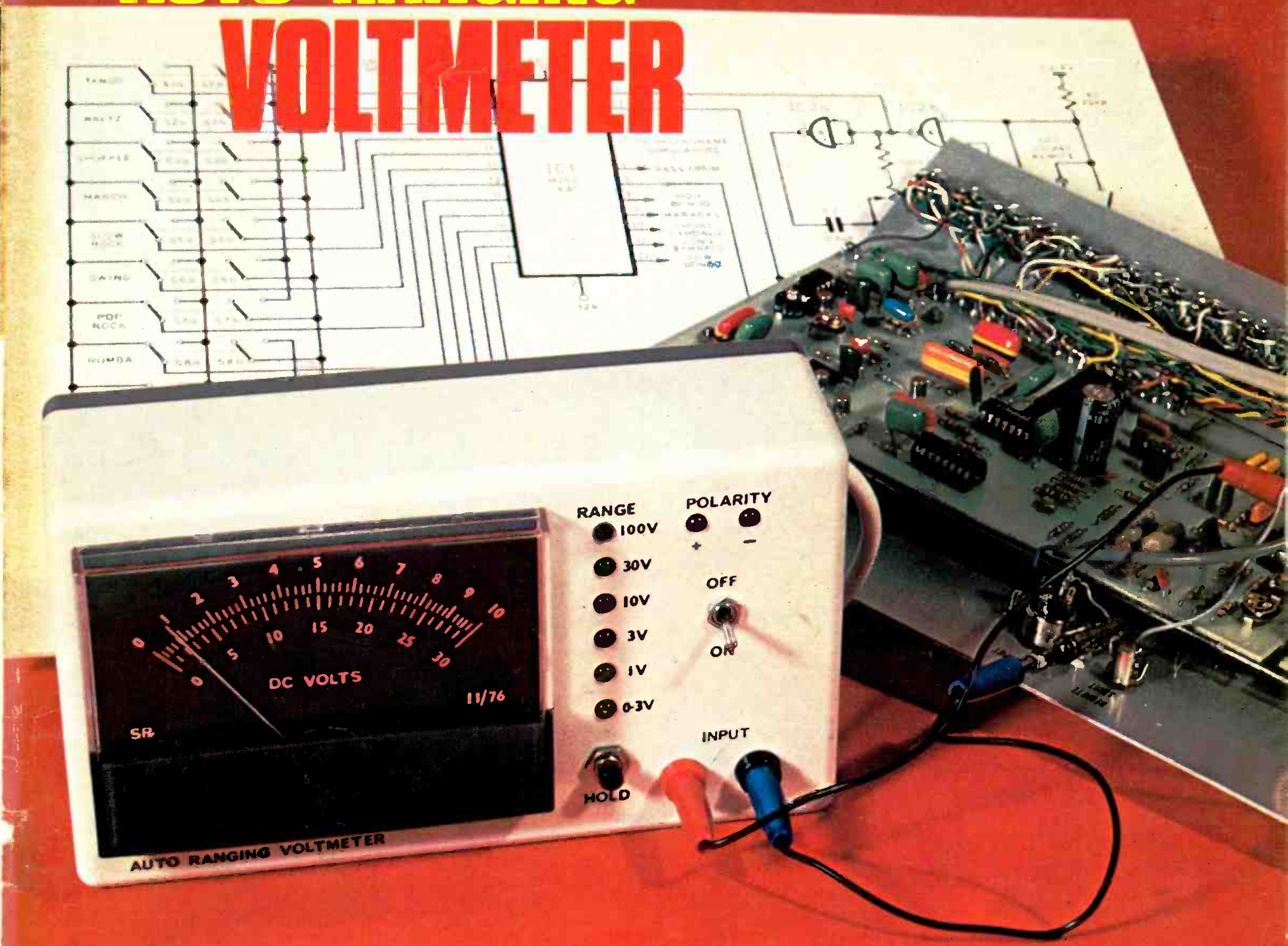
PRACTICAL
ELECTRONICS

FEBRUARY 1978 45p

AUTO RANGING VOLTMETER



ALSO INSIDE...

KIM Hobby Computer Review

Part 2 of our New FAULT FINDING Series

PRACTICAL
ELECTRONICS

VOLUME 14 No. 6 FEBRUARY 1978

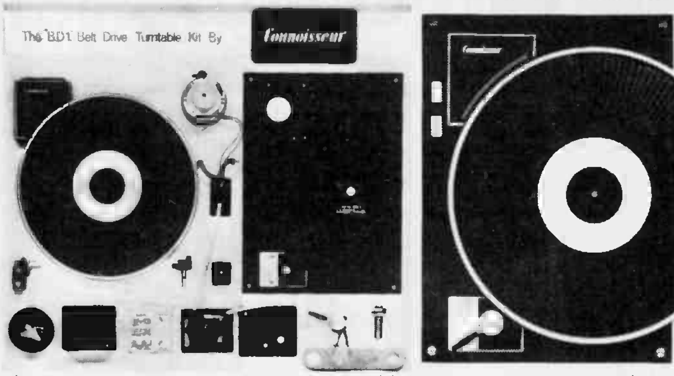
CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

Our March issue will be on sale Friday, 10 February, 1978
(for contents see page 407)

BD1-The Connoisseur's Budget Choice



BD1 Kit & Completed BD1 Assembly

BD1 with Plinth, Cover & SME Arm.

The Connoisseur BD1 transcription turntable is a precision engineered product designed to provide top grade performance at a moderate cost. Simplicity is the main feature of this unit giving excellent performance and reliability.
A slow speed synchronous motor is used and because of its construction the hum field is very low, so that even the most sensitive of pickups can be used, including the Connoisseur SAU2 or the SME 3009 Series II.
Speed change is achieved by a press button unit at the rear of the platform which automatically moves the drive belt from one pulley groove to the other whilst the turntable is turning.
The BD1 turntable kit can be assembled by the home constructor within the hour and when completed will give top quality performance. No soldering is required. Complete the unit with a modern BD1 plinth and cover. The plinth is finished in walnut veneer and fitted with spherical, anti-vibration feet. Add to this a strong Acrylic, bronze cover, hinged with 2-position lid stay and you have a first class turntable at a budget price!

Connoisseur

Write for further details to:
A. R. Sugden & Co. (Engineers) Ltd.
Manufacturers of Connoisseur Sound Equipment, Connoisseur Works, Atlas Mill Road, Brighouse, West Yorkshire HD6 1ES
Telephone: Brighouse (0484) 712 142, Telex: 517144 Sugden Crighouse,
Telegrams & Cables: Connoisseur Brighouse.

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A RANGE OF DRAPER TOOLS FOR THE ELECTRONICS ENTHUSIAST
MAINS TESTER SCREWDRIVERS 100 to 500V Standard size **50p, Large 70p**
RADIO PLIERS 5½" £1.60, 6½" £1.80.
DIAGONAL SIDE CUTTERS 6½" £1.90.
SMALL SIDE CUTTERS LJ2. Standard £3.70, LJ7 (with wire holding device) **£4.10.**
MIDGET OPEN ENDED SPANNER SETS
0+1 2+2 3+5 4+6 6+8BA SIZES £2.85 set of 5.
4+4.5 5+5.5 4+6 6+7 8+9 10+11 mm SIZES **£3.50 set of 6.**
MINIATURE FILE SETS. Set of 6 **£1.90.** Set of 10 **£3.25** (Round, flat, etc.).
TAP AND DIE SETS (18 piece) contain 1 each of 0, 2, 4, 6, 8, BA SIZES in Dies, Plug Taps, Taper Taps + American type tap wrench, T type tap wrench, Die Holder. **£11.60.**

LARGE ELECTROLYTIC PACKS. Contain range of large electrolytic capacitors, low and high voltage types, over 40 pieces, £3.00 per pack (+12½% VAT).

Slider Switches, 2 pole make and break (or can be used as 1 pole change-over by linking the two centre pins). 4 for 50p.

A NEW RANGE OF QUALITY BOXES & INSTRUMENT CASES.
Aluminium Boxes with Lids.

AB10	5½ × 4 × 1½	60p
AB13	6 × 4 × 2	80p
AB14	7 × 5 × 2½	£1·00
AB15	8 × 6 × 3	£1·30
AB16	10 × 7 × 3	£1·50
AB17	10 × 4½ × 3	£1·30
AB25	6 × 4 × 3	£1·00

Vinyl Coated Instrument Cases
Light Blue tops and White lower sections. Very smart finish.

WB1	5 × 2½ × 2½	60p
WB2	6 × 4½ × 1½	£1·10
WB3	8 × 5 × 2	£1·60
WB4	9 × 5½ × 2½	£1·80
WB5	11 × 6½ × 3	£2·00
WB6	11 × 7½ × 3½	£2·25
WB7	12 × 6½ × 5½	£2·60
WB853	8 × 5½ × 3½	£2·00

MAINS TRANSFORMERS. Type 60/2, Mains input 200-210-220-230-240-250V a.c., output 0-20-40-60V at 2A, in Metal and Plastic case, approx. 7½ × 4½ × 4, fully fused (ideal for PSU) £3·00 each.

MAINS TRANSFORMERS. Type 15/300 240V input, 15V at 300mA output. £1·50 each.

MAINS TRANSFORMERS. Type 45/100, 240, 220, 110, 20, 0V input. 45V at 100mA output. £1·50 each.

VIDICON SCAN COILS (Transistor type, but no data) complete with vidicon base £6·50 each. Brand New.

FULL RANGE OF BERNARDS/BABANI ELECTRONICS BOOKS IN STOCK. S.A.E. FOR LIST.

NEW FOR THE VHF CONSTRUCTOR. A range of tuned circuits on formers with slugs and screening cans. Frequencies quoted are approximate, and range can be greatly extended by using varying capacitors in parallel.
Type S (½in. square, dumpy type).
Type SA 20 to 30MHz (when 33pf fitted in parallel).
Type SB 35 to 50MHz (with link winding).
Type SC 70 to 100MHz (with link winding).
Type SD 135 to 175MHz (with link winding)
Type M (Min. ½in. square types).
Type MA 19 to 28MHz (when 33pF fitted in parallel).
Type MB 22 to 32MHz (when 33pF fitted in parallel).
Type MC 25 to 35MHz (when 33pF fitted in parallel).
Type MD 38 to 50MHz (when 33pF fitted in parallel).
Type ME 45 to 60MHz (when 33pF fitted in parallel).
Type MF 100 to 200MHz (without slug) when 0 to 30pF variable fitted in parallel.
All the above coils available in packs of five only (same type) at 50p per pack of 5.

SEMICONDUCTORS
BSX20 (VHF Osc/Mult). 3 for **50p.**
BC108 (metal can), 4 for **50p.**
PBC108 (plastic BC108), 5 for **50p.**
BFY51 Transistors, 4 for **60p.**
BCY72 Transistors, 4 for **50p**
PNP audio type TO5 Transistors, 12 for 25p.
BF152 (UHF amp/mixer), 3 for 50p.
2N3819 Fet., 3 for **60p,**
BC148 NPN SILICON, 4 for **50p.**
BC158 PNP SILICON, 4 for **50p.**
BAY31 Signal Diodes, 10 for 35p.
BA121 Varicap Diodes, 4 for 50p.

741CG op amps by RCA, 4 for **£1**

RED LEDs (Min. type) 5 for 70p.

PLEASE ADD 8% VAT UNLESS OTHERWISE STATED

PLASTIC PROJECT BOXES with screw on lids (in black ABS) with brass inserts.
Type NB1 approx 3in. × 2½in. × 1½in. **40p** each.
Type NB2 approx. 3½in. × 2½in. × 1½in. **50p** each.
Type NB3 approx. 4½in. × 3½in. × 1½in. **60p** each.

MULLARD 85A2 85V STABILISER VALVES (Brand New) 70p each or 2 for £1·20.

TO3 transistor insulator sets, 10 for **50p**

PERSPEX TUNER PANELS (for FM Band 2 tuners) marked 88–108MHz and Channels 0–70, clear numbers, rest blacked out, smart modern appearance, size approx. 8½in × 1½in., 2 for 35p.

PLUGS AND SOCKETS
N-Type Plugs 50 ohm, 60p each, 3 for £1·50.
PL259 Plugs (PTFE), brand new, packed with reducers, 65p each
SO239 Sockets (PTFE), brand new (4-hole fixing type). 50p each

SOLDER SUCKERS (Plunger type). Standard Model, £5. Skirted Model £5·50. Spare Nozzles 60p each.

NEW MARKSMAN RANGE OF SOLDERING IRONS.
S125D 25W 240V **£3·80.**
S140D 40W 240V **£4·20.**
S125DK 25W 240V + bits etc., **KIT £4·90.**

BENCH STAND with spring and sponge for Marksman Irons **£2·38.**
Spare bits MT9 (for 15W) **50p**, MT5 (for 25W) **45p**, MT10 (for 40W) **50p.**
ALL PRICES + 8% VAT.

TCP2 TEMPERATURE CONTROLLED IRON.
Temperature controlled iron and PSU. £30 + VAT (£2·40).
SPARE TIPS
Type CC single flat, Type K double flat fine tip, Type P, very fine tip. £1 each + VAT (8p).
MOST SPARES AVAILABLE.

MULTICORE SOLDER
Size 5 Savbit 18 s.w.g. in alloy dispenser, **32p** + VAT (3p).
Size C1SAV18 Savbit 18 s.w.g., **56p** + VAT (4p).
½ Kg. (1·1lb) 60 × 40, 20 s.w.g. on plastic reel £3 + VAT (24p).

WELLER SOLDERING IRONS
EXPERT. Built-in-spotlight illuminates work. Pistol grip with fingertip trigger. High efficiency copper soldering tip.
EXPERT SOLDER GUN 8100D £9·90.
EXPERT SOLDER GUN KIT (spare bits, case, etc.) **£12·90.**
Spare bits 35p pair.

A LARGE RANGE OF CAPACITORS AVAILABLE AT BARGAIN PRICES, S.A.E. FOR LIST.

MIXED COMPONENT PACKS, containing resistors, capacitors, pots, etc. All new. Hundreds of items. £2 per pack, while stocks last.

ALU-SOL ALUMINIUM SOLDER (made by Multicore). Solders aluminium to itself or copper, brass, steel, nickel or tinplate, 16 s.w.g. with multicore flux, with Instructions, Approx. 1 metre coil 40p pack. Large reel £2·75.

VARICAP TUNERS Mullard type ELC1043/05. Brand New, £4·40 + 12½% VAT.

BARGAIN PACK OF LOW VOLTAGE ELECTROLYTIC CAPACITORS. Up to 50V working. Seatronic Manufacture. Approx. 100. £1·50 per pack + 12½% VAT.

OSMOR REED RELAY COILS (for reed relays up to ½in dia., not supplied) 12V, 500 ohm coil, 2 for **50p.**

We now stock Spiralux Tools for the electronic enthusiast. Screwdrivers, Nut spanners, BA and Metric sizes, pop rivet guns, etc. S.A.E. for list.

Dubilier Electrolytics, 50µF, 450V, 2 for **50p.**
Dubilier Electrolytics, 100µF, 275V, 2 for **50p.**
Plessey Electrolytics, 470µF, 63V, 3 for **50p.**
TCC Electrolytics, 1000µF, 30V, 3 for **60p.**
Dubilier Electrolytics, 5000µF, 35V, **50p** each.
Dubilier Electrolytics, 5000µF, 50V, **60p** each.
ITT Electrolytics, 6800µF, 25V, high grade, screw terminals, with mounting clips, **50p** each.
PLEASE ADD 12½% VAT TO ALL CAPACITORS.

TV PLUGS AND SOCKETS
TV Plugs (metal type), 4 for **50p.**
TV Line Connectors (back-to-back sockets), 4 for **50p.**
Please add 12½% VAT.

Terms of Business: CASH WITH ORDER. MINIMUM ORDER £2. *ALL PRICES INCLUDE POST & PACKING (UK ONLY) SAE with ALL ENQUIRIES*
Please PLEASE ADD VAT AS SHOWN. *ALL GOODS IN STOCK DESPATCHED BY RETURN CALLERS WELCOME BY APPOINTMENT ONLY*

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Designed for use with TUAC power amplifier modules.

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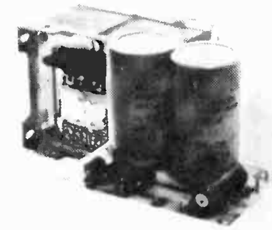
Vol. Treb. Mid. and Bass controls. HI. IMP. FET. I/P suitable Mid. Guitar, Radio Crystal/Ceramic P.U. Sensitivity 4mV. Treble + 35dB at 16kHz. Mid + 20 -15dB at 1kHz. Bass + 20 - 10dB at 40Hz. **£9.00**

VA06
Vol Treb. and Bass controls. Sensitivity 8mV. Treb + 28 -15dB at 12kHz. Bass ± 18dB and 40Hz. **£7.75**

SVA08 STEREO PRE AMP
Vol. Treb. Mid and Bass controls. I/P suitable Guitar, Radio, Crystal/Ceramic P.U. Sensitivity 4mV. Treble +35dB at 16kHz. Mid + 20 -7dB at 4kHz. Bass + 20 - 18dB at 30Hz Plus Full Balance Control. Fully I/C operation supply voltage ± 25VDC. **£15.00**

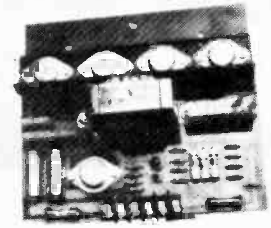
POWER SUPPLIES



Vacuum varnish impregnated. Transformers with supply board incorporating pre-amp supply:

PS250 for supplying 2 TP125s	£28.50
PS200 for supplying 2 TP100s	£28.50
PS60/60 for supplying 2 TL60s	£25.00
PS125 ±45 volts for TP125	£17.75
PS100 ±43 volts for TL100	£16.25
PS60 ±38 volts for TL60	£15.25
PS30 ±25 volts for TL30	£11.75
PSU 2 for supplying disco mixer	£7.50

AMPLIFIER MODULES



TL30 D.C. COUPLED 5 × 5 × 1¼in.
- 35 watt R.M.S. continuous sine wave output
- 8 transistors 4 diodes

£12.75

TL60 5 × 5 × 3in
- 60 watt R.M.S. continuous sine wave output
- 2 R.C.A. 110 watt 15 amp transistors

£18.25

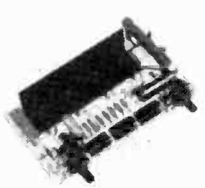
TL100
- 100 watt R.M.S. continuous sine wave output
- 2 R.C.A. 150 watt 15 amp transistors

£20.75

TP125 7 × 6½ × 3in
- 125 watt R.M.S. continuous sine wave output
- 4 R.C.A. 150 watt 15 amp output transistors

£25.75

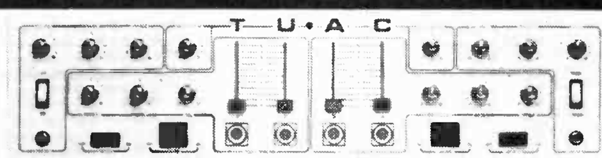
4 CHANNEL SOUND TO LIGHT SEQUENCE CHASER - 4LSMI



- Full wave control
- RCA 8A Triacs
- 1000W per channel
- Fully supressed and fused
- Switched master control for sound operation from ½W to 125W
- Speed control for fixed rate sequence from 8 per minute to 50 per second
- Full logic integrated circuitry with optical isolation for amplifier protection

£20.75

Model 501 500W per channel as above without sound triggering **£12.25**



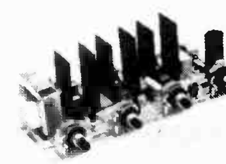
STEREO DISCO MIXER

With touch sensitive switching and auto fade

INPUTS: Four identical stereo inputs available with any equalisation. Two magnetic and two flat supplied as standard. High quality slider control on each channel. Volume, treble and bass controls for each pair of sliders. Sensitivity mag., 3mV (R.I.A.A. comp.). Flat 50mV at 1kHz. Bass controls ± 18dB at 60Hz. Treble controls ± 18dB at 15kHz.
OUTPUT: Up to 3 volts (+ 12dB) available. Attenuated output for TUAC Power Modules. Rotary master and balance controls. Band width 15Hz - 25kHz ± dB.
P.F.L.: Output 250mV into 8 ohms. Rotary volume control. Monitoring facility for all 4 channels. Selection via touch sensitive illuminated switches. Switched visual cue indicator.
Miscellaneous Facilities: Two illuminated deck on/off switches. Mains illuminated on/off switches. Auto fade illuminated on/off switch. Mains powered with integral screen and back cover. Complete with full instructions.
Size: 25in long × 6in high × 3in deep.

Mono Disco Mixer with autofade **£45.00** **£129.00**

3 CHANNEL LIGHT MODULATOR SILMB



- RCA 8A Triacs
- 1000W per channel
- Each channel fully suppressed and fused
- Master control to operate from 1W to 125W
- Full wave control

£20.25

Single Channel Version 1500 Watts **£9.75**

new from TUAC...

ULTRA QUALITY HIGH POWER TD 500 POWER AMPLIFIER

New DC coupled design

Output power using PS250
300w into 2 Ohms
220w into 4 Ohms
140w into 8 Ohms
75w into 15 Ohms
RMS continuous sine wave output
INPUT Sensitivity 0.775V RMS (ODB) at 25 KOHMS
Hum and Noise - 100dB
Relative full output
THD = at Full Power 0.1%

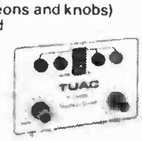
7" × 9" × 1¾" **£45**

PIEZO SUPER HORN £10.95

FRONT PANEL FOR LIGHTING EFFECT MODULES

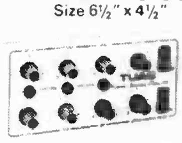
(complete with switches, neons and knobs) as illustrated

For S1LMB **£6.50**
Size 8" × 4½"



4LSM1 **£5.50**
Size 6½" × 4½"

FUZZ LIGHTS
Red, Green, Blue, Amber. **£23.50**



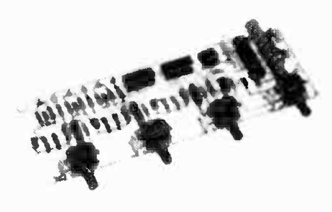
S1LMB **£7.50**
Combined with 3SDM1
Size 9" × 4½"

STOCKISTS - CALLERS ONLY

A1 Music, 88 Oxford Street, Manchester (Tel. 061-236 0340)
Geo Mathews, 85/87 Hurst Street, Birmingham (Tel. 021-622 1941)
Bristol Disco Centre, 25 The Promenade, Gloucester Road (Tel. Bristol 41666).
Soccodi, 9 The Friars (Tel. Canterbury 60948)
Cookies Disco Centre, 132 West Street (Tel. Crewe 4739).
Garland Bros. Ltd., Deptford Broadway, London 01-692 4412
Luton Disco Centre, 88 Wellington Street, Luton (Tel. Luton 411733)
Mitchell Electronics, 7 Queen Street (Tel. Salisbury 23689).

Session Music, 163 Mitcham Road, Tooting (Tel. 01-672 3413).
Mon-Sat 10 a.m. - 6 p.m. Closed Wed.

ADD SEQUENCE CHASING + DIMMING EFFECTS FOR TUAC 3 CHANNEL LIGHT MODULATOR



- Speed Control 3 per min. to 10 per sec.
- Full logic integrated circuitry
- Dimmer control to each channel

3SDMI **£14.50**

SUPPLIERS TO H.M. GOVT. DEPTS. MANUFACTURED AND ASSEMBLED IN GT. BRITAIN FULLY TESTED AND GUARANTEED
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THE PIONEERS OF MODULAR DISCO/P.A. EQUIPMENT NOW OFFER PACKAGE DEALS AT INCOMPARABLE PRICES

CENTAUR STEREO DISCOS

C/W LIGHT SHOW & DISPLAY, TWIN SPEAKERS & LEADS

Standard 100W

£225 or Deposit £28.80
12 Months @ £21.18 or 24 Months @ £11.81

Super 200W

£275 or Deposit £32.80
12 Months @ £25.89 or 24 Months @ £14.44

GXL 200W (with twin 200 watt cabinets)

£349 or Deposit £42.72
12 Months @ £32.49 or 24 Months @ £18.11

COMPLETE STEREO ROADSHOWS – BUILT IN SOUND TO LIGHT/SEQUENCER & DISPLAY

TWO YEAR GUARANTEE

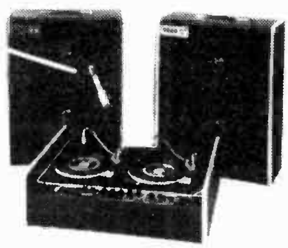


illustration shows GXL Centaur System

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

JUST PLUG IN AND GO!

BSR Decks – 17,000 Line Loudspeakers – Rugged Aluminium Trimmed Cabinets – Cue Light And Phones Output – Slave Output – Deck Lights/Motor Starts (GXL)

MINI DISCO 100 WATT MONO SYSTEM

£159.50 Deposit £22.66
12 Months @ £14.60
or 24 Months @ £8.14

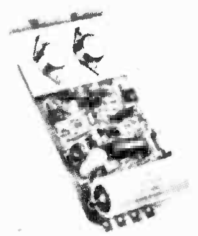
Similar in appearance to the Centaur and complete with loudspeakers and leads.

Headphones to suit any system	£7.50
EM507 Electret Mic	£15.00
ECM 81 Electret Mic	£19.95
Boom Stand	£15.50
Carriage on all disco systems (Included in H.P. Prices)	£10.00

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

D.I.Y. MODULES FOR ALL DISCO/P.A. AMPLIFIERS

SA308 30W 8 ohms 45V	£9.95*	SUPPLY FOR TWO MODULES	£10.90*
SA604 60W 4 ohms 50V	£13.25	SUPPLY FOR TWO MODULES	£13.50
SA608 60W 8 ohms 65V	£14.25	SUPPLY FOR TWO MODULES	
SA1204 120W 4 ohms 75V	£15.95	SUPPLY FOR ONE MODULE	
SA1208 120W 8 ohms 95V	£21.00	SUPPLY FOR TWO MODULES	£22.50
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

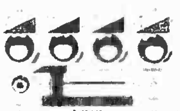
MONO OR STEREO WITH AUTOFADE

Available complete and ready to plug in or as on 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.

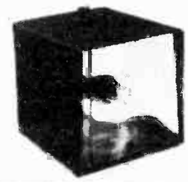
MODULES	
Mono module	£22.50
Stereo module	£33.50
Panel	£3.95
Kit of knobs/sockets etc	£5.50
COMPLETE MIXERS (with case)	
Mono 18V	£39.50
Stereo 18V	£57.50
Mono mains	£45.75
Stereo mains	£63.75

COMPLETE LIGHTING CONTROL AT YOUR FINGERTIPS!



Lighting Control Unit Mk II		£44.50
4kW Sequencer + Sound Light + Dimmers + Automatic Level Integrated Logic Circuitry	Module	£32.50
	Panel	£2.95
Three Channel Sound to Light		£26.75
3kW 1-240W input – master Plus channel controls	Module	£19.75
	Panel	£2.95

STROBE UNITS



Pro-Strobe 4-6 Joules £37.50
Super Strobe 2-3 Joules £22.50
(Pro-Strobe has external trigger facility).

SPARES & ACCESSORIES – LOUDSPEAKERS & CABINETS

Rope Lights – Red or Multicolour £22.00 per 12 ft.
Rope Light Controller for up to 120 ft £30.00
Fuzz Lights–Red/Blue/Yellow/Green £22.80
Magnetic Cartridge Equalisers £3.50*
Melos Echo Chamber £59.00
Headphones £7.50*
Sirens: English Police, USA Police, Destroyer, Alien Voice Simulator £7.50
Bulgin 8 way lighting plug/socket £1.90

100 Watt Chassis Loudspeakers 12" £23.50 18" £47.50 (Add £1.50 carr.)
Empty Loudspeaker Cabinets: Small 12" £15.50, Large 2 x 12" £28 Large 12" £21.50 1 x 18" £29.50 Small 2 x 12" £22.50

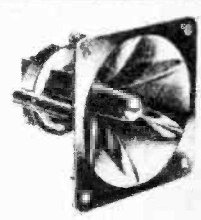
Projector lamps: A1167 £2.90. M6 £5.65.
100W Spot lamps Red/Blue/Yellow/Green £1.50 ea £13.50 for 10
MD Spot Banks: 3-way 300W £19.50, 4-way 400W £22.50.
Bubble machines (optikinetics) £36.50

Strobe tubes 80W £8.50
ICI Vynide 50" wide £3.50 Metre
Kickproof Grille 24" wide £3.25 Metre
Kick Resistant Grill 50" wide £3.25 Metre.
FULL RANGE OF RE-AN PRODUCTS IN STOCK
SEND FOR OUR BROCHURE NOW!!

PROJECTORS – PLUTO – NEW LOW PRICES!!! CHOICE OF WHEEL/CASSETTE

P150 150W Tungsten	£34.00	Liquid wheels	£7.50
P500 100W Q.I.	£69.50	Cassettes	£8.00
P500 250W Q.I.	£79.50	Picture wheels from (Wide choice available)	£4.75

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.

AUDIO MODULES—ALL REDUCED! TRANSISTOR PRICES SLASHED! MANY PAKS 33% OFF

BI-PAK GREAT SPACE
WE NEED THE SPACE

THYRISTORS

No. THY1A/50	1 Amp.	50 volt	TO5	18p
No. THY1A/400	1 Amp.	400 volt	TO5	32p
No. THY3A/50	3 Amp.	50 volt	TO64	25p
No. THY3A/200	3 Amp.	200 volt	TO64	32p
No. THY3A/400	3 Amp.	400 volt	TO64	40p
No. THY5A/50	5 Amp.	50 volt	TO66	25p
No. THY5A/400	5 Amp.	400 volt	TO66	40p
No. THY5A/600	5 Amp.	600 volt	TO66	50p
No. C106/4	6 Amp.	400 volt	TO220	42p

TRIAC

SB4 8 Amp. 400 volt TO220 Plastic 80p
(Non Isolated Tab)

DIACS

BR100 15p
D32 15p

SWITCHES

No. 16178	5 x Mains Slide Switches	40p*
No. S17	5 x Miniature Slide Switches	40p*
No. S18	4 x Standard Slide Switches	40p*
No. S19	4 x Miniature Push to Make single hole mounting	40p*
No. S20	3 x Miniature Push to Break single hole mounting	40p*
No. S21	Push button Switch Pak 4 x Assorted types multi bank and singles Latching and non-Latching	£1.00*

CAPACITOR PAKS

16201	18 Electrolytics	4.7μF – 10μF
16202	18 Electrolytics	10μF – 100μF
16203	18 Electrolytics	100μF – 680μF

All 3 at SPECIAL PRICE of £1.20*

16160	24 Ceramic Caps	22pF – 82pF
16161	24 Ceramic Caps	100pF – 390pF
16162	24 Ceramic Caps	470pF – 3300
16163	21 Ceramic Caps	4700pF – 0.047μF

All 4 at SPECIAL PRICE of £1.60

RESISTOR PAKS

Order No.		
16213	60 ⅛W.	100 ohm – 820 ohm
16214	60 ⅛W.	1K – 8.2K
16215	60 ⅛W.	10K – 82K
16216	60 ⅛W.	100K – 820K

All 4 at SPECIAL PRICE of £1.60*

16217	40 ½W.	100 ohm – 820 ohm
16218	40 ½W.	1W – 8.2K
16219	40 ½W.	1K – 8.2K
16220	40 ½W.	100K – 820K

All 4 at SPECIAL PRICE of £1.60*

TRANSISTOR *FALL-OUT* PACK, GERM, SILICON, POWER, NPN, PNP. ALL MIXED. YOURS TO SORT AND TEST.

Approx. 500 Pieces.
Order No. S23
£1.25 per pack.

VOLTAGE REGULATORS

Positive			
No. MVR7805	μA7805	TO220	85p
No. MVR7812	μA7812	TO220	85p
No. MVR7815	μA7815	TO220	85p
No. MVR7818	μA7818	TO220	85p
No. MVR7824	μA7824	TO220	85p
Negative			
No. MVR7905	μA7905	TO220	£1.10
No. MVR7912	μA7912	TO220	£1.10
No. MVR7915	μA7915	TO220	£1.10
No. MVR7918	μA7918	TO220	£1.10
No. MVR7924	μA7924	TO220	£1.10

μA723C TO99 38p 72723 14 pin Dil 38p
LM309K TO3 £1.20

MICROPHONES

DYNAMIC DUAL IMPEDANCE UNI DIRECTIONAL CARDIOID MICROPHONE
Impedance 600 ohms and 50K. Response 50–14,000 Hz. Sensitivity 54db at 50K.
Size 1½" Dia. x 6¼" Long
Order No. 1328 **£7.50***

DYNAMIC CASSETTE MIC

Fitted with On/Off switch. 1 metre of tough lead with floating 2.5 and 3.5 mm plugs.
Impedance 200 ohms. Sensitivity 90db.
Frequency 90-10,000 Hz.
Size 20mm Dia. x 120mm Long
Order No. 1326 **£1.15***

LOGIC PROBE

A pocket size instrument capable of detecting T.T.L., D.T.L Flip Flop and other pulse circuits. It is easy to use and operates from the 5V. D.C. supply of the circuit under test. The logic levels are indicated by 2 red LED's one for High and the other for Low. There is also a green LED for the Pulse Mode of the unit.
No. S59 Our Special Price £15.95.

TRANSISTORS

BRAND NEW – FULLY GUARANTEED

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
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	*12p	TIP32C	36p	2N1893	28p
AC128	16p	BC182	*9p	BF197	*12p	TIP41A	34p	2N2218	15p
AC128K	24p	BC182L	*9p	BF200	25p	TIP41B	35p	2N2218A	18p
AC176	16p	BC183	*9p	BFX29	22p	TIP41C	36p	2N2219	15p
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			TIP3055	42p	2N2222A	16p
AD161/		BC213	*10p	MPSA05	*22p	ZTX107	*6p	2N2369	10p
162 MP	80p	BC213L	*10p	MPSA06	*22p	ZTX108	*6p	2N2904	14p
AF139	30p	BC214	*10p	MPSA55	*22p	ZTX109	*7p	2N2904A	15p
AF239	30p	BC214L	*10p	MPSA56	*22p	ZTX300	*7p	2N2905	14p
BC107	6p	BC251	*10p	OC44	12p	ZTX301	*7p	2N2905A	15p
BC108	6p	BCY70	12p	OC45	12p	ZTX302	*9p	2N2906	12p
BC109	6p	BCY71	12p	OC71	9p	ZTX500	*8p	2N2906A	14p
BC118	*10p	BCY72	12p	OC72	12p	ZTX501	*10p	2N2907	12p
BC147	*8p	BD115	40p	OC75	10p	ZTX502	*12p	2N2907A	13p
BC148	*8p	BD131	*35p	OC81	14p	2N696	10p	2N2926G	*8p
BC149	*8p	BD132	*37p			2N697	10p	2N2926Y	*7p
BC154	*16p	BF115	17p	TIP29A	35p	2N706	7p	2N3053	12p
BC157	*9p	BF167	19p	TIP29B	36p	2N706A	8p	2N3055	35p
BC158	*9p	BF173	20p	TIP29C	38p	2N708	8p	2N3702	*7p
BC159	*9p	BF180	25p	TIP30A	36p	2N1302	12p	2N3703	*7p
BC169C	*10p	BF181	25p	TIP30B	37p	2N1303	15p	2N3704	*6p
BC170	6p	BF182	25p	TIP30C	38p	2N1304	15p	2N3903	*11p
BC171	*6p	BF183	25p	TIP31A	32p	2N1307	18p	2N3904	*11p
BC172	*6p	BF184	25p	TIP31B	33p	2N1308	22p	2N3905	*11p
BC173	7p	BF185	25p	TIP31C	34p	2N1309	22p	2N3906	*11p

DIODES

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AA119	5p	BAX16/		BYZ16	30p	OA85	7p	IS44	3p
AAZ13	4p	OA202	5p	BYZ17	28p	OA90	6p		
BA100	6p			BYZ18	28p	OA91	7p	IN5400	10p
BA115	5p	BY100	15p	BYZ19	28p	OA95	7p	IN5401	11p
BA144	5p	BY127	*10p					IN5402	12p
BA148	10p	BYZ10	32p	OA47	5p	IN34	5p	IN5404	13p
BA173	10p	BYZ11	32p	OA70	5p	IN60	6p	IN5406	16p
BAX13/		BYZ12	32p	OA79	7p	IN914	4p	IN5407	17p
OA200	5p	BYZ13	30p	OA81	7p	IN4148	4p	IN5408	19p

LINEAR I.C.'s

TBA800	12 pin QIL	*75p	UA711C	TO99	25p	UA748	TO99	28p
TBA810	12 pin QIL	*£1.00	UA703	TO99 (Plastic)	20p	72558	(Dual 748) TO99	45p
TBA820	14 pin QIL	*80p	741P	8 pin DIL	18p	MC1310P	14 pin DIL	*£1.25
LM380	14 pin DIL	*80p	72741	14 pin DIL	20p	76115	14 pin QIL	*£1.25
LM381	14 pin DIL	*£1.35	UA741C	TO99	20p	NE555	8 pin DIL	32p
72709	14 pin DIL	28p	72747	14 pin DIL	55p	NE556	14 pin DIL	60p
UA709	TO99	28p	748P	8 pin DIL	28p	SL414A	10 pin	*£1.80

NEW CONSIGNMENT ZN 414 RADIO CHIP 75p*

OPTOELECTRONICS

Displays

No. 1510	707 LED Display	70p each
No. 1511	747 LED Display	£1.50 each
No. S53	DL33 Triple 7 Segment LED Display Character height .11" Common Cathode 12 pin DIL	30p each

LED's

No. S51	Red TIL209 (5 x .125")	50p
No. S52	Red FLV117 (5 x .2")	50p
No. 1502	Green .125"	18p each
No. 1505	Green .2"	18p each
No. 1503	Yellow .125"	18p each
No. 1506	Yellow .2"	18p each
No. S82	Clear .2" (illuminating red)	12p

2nd QUALITY LED PAKS

No. 1507 10 x LED's Assorted 75p

LED CLIPS

No. 1508/.125	.125	5 for 12p
No. 1508/.2	.2	5 for 15p

SPECIAL REDUCTIONS

No. 1514	NORP 12	45p each
No. S76	OCP71	5 for £1.00
No. S83	5, NIXIE Tubes ITT 5870 ST (including Data)	£2.00
No. S77	Neon Indicator Lamps 230V A.C State Colour (Red, Amber and Green.)	25p each

D.I.Y. PRINTED CIRCUIT KIT

Contains 6 pieces of copper laminate board, box of etchant powder, measure, tweezers, marker pen, high quality pump drill, Stanley knife and blades and 6 in. metal rule.
Full easy to follow instructions.
Order No. S64 **Sale Price £5.50**

MAMMOTH I.C. PAK

Approx. 200 Pieces. Assorted fall-out integrated circuits, including: Logic, 74 series, Linear, Audio and D.T.L. Many coded devices, but some unmarked – you to identify.
Order No. 16223 **£1.00**

P.C.B. BOARDS

S61	8 pieces 8" x 3½" (approx.) single sided paper	50p
S62	4 pieces 8" x 3½" (approx.) single sided fibreglass	50p
S63	3 pieces 7" x 3½" (approx.) double sided fibreglass	50p

POWER SUPPLY STABILIZER BOARD

Unused ex-equipment stabilizer board. Input 30V. D.C. Output 20V. Complete with circuit diagram.
Order No. S81 **£1.25**

ETCH RESIST PENS

Order No. 1609 **50p each**

P.O. RELAYS

S85 – 2 Off Post Office relays **40p**

SOLDER

5m of 18 sw Multi-core Solder.
Order No. S60 **50p**

BATTERY HOLDERS

to take 6 x HP7's
Order No. 202 **10p each**

I.C. INSERTION EXTRACTION TOOL

Order No. 2016 **30p**

EX. G.P.O. MICROSWITCHES

Order No. S51 4 for **50p**

CABLE CLIPS

S84 – 50 2.5mm round single pin fixing **30p**

SPECIAL OFFER!

UNTESTED SEMICONDUCTOR PAKS

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

No. 16130	100 Germ. Gold bonded diodes like OA47	40p
No. 16131	150 Germ. Point contact diodes like OA70/81	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.	40p
No. 16135	20 3 amp Sil. stud Rect.	40p
No. 16136	50 400mw Zeners D.O.7 case	40p
No. 16137	30 NPN Plastic trans. like BC107/8	40p*
No. 16138	30 PNP Plastic trans. like BC177/8	40p*
No. 16139	25 NPN trans. like 2N697/2N1711 TO39	40p
No. 16140	25 PNP trans. like 2N2905 TO39	40p
No. 16141	30 NPN trans. like 2N706 TO18	40p
No. 16143	30 NPN Plastic trans. like 2N3906	40p*
No. 16144	30 PNP Plastic trans like 2N3905	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
No. S67	10 x 14 pin DIL Sockets	£1.00
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 TO18 Sockets	£1.00
No. S72	10 x TO5 Sockets	£1.00

MOUNTING PADS

No. S73 50 Mixed Transistor Pads TO18 and TO5 **40p**

TRANSISTOR HEATSINK PAK

20 Assorted types. TO1, TO5, TO18, TO92
Our Mix
Order No. S75 **60p**

TRANSISTOR INSULATING KITS

Mica washers and bushes assorted types i.e. TO220, TO66, TO3 etc. Approx. 100 pieces. (Approx. 40 sets).
Order No. S74 **50p**

DARLINGTON POWER TRANSISTORS

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.
Order No. S78 **£1.00 per Pak**

MATCHED PAIRS OF PNP GERMANIUM MED. POWER TRANS

2 amp 750mW

	VCE	VCB	HFE	
NKT301	40	60	30-100	35p per pair
NKT302	40	60	50-150	35p per pair
NKT303	20	30	30-100	25p per pair
NKT304	20	30	50-150	25p per pair

ZENER PAKS

No. S55	20 mixed values 400mW Zener diodes 3-10V	£1.00
No. S56	20 mixed values 400mW Zener diodes 11-33V	£1.00
No. S57	10 mixed values 1W Zener diodes 3-10V	£1.00
No. S58	10 mixed values 1W Zener diodes 11-33V	£1.00

UNIJUNCTION TRANSISTORS

UT46 TIS43 **20p**

FET's

2N3819 **15p** 2N5458 **18p**

2 AMP. BRIDGE RECTIFIERS

Metal Stud Mounting

No. S45	50V	(KBS 005)	28p
No. S46	100V	(KBS 01)	30p
No. S47	200V	(KBS 02)	34p

10 AMP. BRIDGE RECTIFIERS 200V ON HEATSINK –
SPECIAL CLEARANCE ORDER NO. S22 – £1.00
SILICON RECTIFIERS G.E. 1 Amp.

SIMILAR IN4000 SERIES

No. S41	25 Like IN4001 (1A 50V)	60p
No. S42	20 Like IN4002 (1A/100V)	60p
No. S43	18 Like IN4003 (1A/200V)	60p
No. S44	15 Like IN4004 (1A/400V)	60p

DON'T MISS OUR SPECIAL CASSETTE OFFER! LOOK AT OUR BOOKS

SAVING SALE BI-PAK

YOU MAKE THE SAVING!

SILICON RECTIFIERS – ½ AMP. G.E.

No. S48	40 x 50V	**60p**
No. S49	30 x 200V	**60p**
No. S50	20 x 700V	**60p**

G.E. HIGH VOLTAGE SILICON RECTIFIERS

GR559 10mA 14KV (14,000)	**20p each**
GA432 1 AMP. 2 KV (2,000)	**20p each**
FD2.5 2.5 KV Voltage Doubler	**20p each**

POTENTIOMETERS

Slider 40mm TRAVEL

Order No.			
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***

WIREWOUND

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

16173	15 Rotary Potentiometers. Assorted values and types.	**40p***
16186	25 Pre-sets Assorted Values and types	**40p***

SALE PRICE 40p

MULTI-TURN PRE-SETS

S40 3 x 100 K LIN **ONLY 50P***

AUDIO PLUG AND SOCKET PAKS

Order No.		
S1	5 x 3.5 mm Plastic Jack Plugs	**40p***
S2	5 x 2.5 mm Plastic Jack Plugs	**40p***
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***

AUDIO LEADS

Order No.		
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***

HEAVY GAUGE BLACK PLASTIC BOX

With aluminium lid and fixing screws. Size 6¼" x 3¼" x 2"
Order No. S16 **Only 75p**

74 SERIES TTL ICs

TYPE	QUANTITY 1 £p	QUANTITY 100 £p	TYPE	QUANTITY 1 £p	QUANTITY 100 £p	TYPE	QUANTITY 1 £p	QUANTITY 100 £p
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	**0.12**	**0.11**	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	**£0.50**	CD4024	**£0.64**	CD4044	**£0.78**	CD4082	**£0.20**
CD4010	**£0.50**	CD4025	**£0.18**	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	~~£4.35*~~	**£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 + 7W RMS	~~£16.25*~~	**£14.95***

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ONLY £19.50

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Order No.	Quantity	
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16165	150 approx. Capacitors mixed values. (Count by weight)	**40p***
16167	80 ½W 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	60¼W resistors mixed values	**40p***
16187	30 metres stranded wire assorted colours	**40p**

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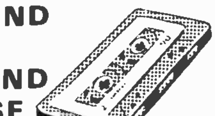

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OPT FOR OPTOELECTRONICS! PRINTED CIRCUIT KITS, BOARDS & PENS.

FOR RELIABLE JOINTS—ANTEX IRONS!

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. Synthesiser.** 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 Synthesiser. 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. Synthesiser, 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	24p	£ 8·88	£11·76	£14·64
2P	27p	£ 9·99	£13·23	£16·47
4PS	53p	£19·61	£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 SYNTHESISER
(Elektor 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.

Pre-Amp Module Component set (incl. PCB)	£4·22
Basic Output Circuits—combined component set with PCBs, for alphaphone, cardiophone, frequency meter and visual feed-back 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	£9·63
Panel meter (500µA)	£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	70p
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
709 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	195p
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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**
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K004 Mylar capacitors, min 100V type. 10 each all values from 1000pF to 10,000pF. Total 130 for **£3.75**
K005 Polystyrene capacitors. 10 each value from 10pF to 10,000pF. E12 series 5% 160V. Total 370 for **£12.30**
K006 Tantalum bead capacitors. 10 each of the following: 0·1, 0·15, 0·22, 0·33, 0·47, 0·68, 1, 2·2, 3·3, 4·7, 6·8, all 35V; 10/25 15/16 22/16 33/10 47/6 100/3. Total 170 tants for **£14.20**
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K008 Extended range, as above, also including 220, 470 and 1000µF. Total 100 for **£5.90**
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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.**

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

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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.**

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

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

Sloping front versions:

Type		
2523 220	174 · 100/52mm	£6.90
1798 171	121 · 75/37.5mm	£4.65

Gen. purpose plastic potting box 71 · 49 · 24. In black or white **40p.** Hand controller box, shaped for ease of use in the hand, 94 · 61 · 23mm **64p.**

S-DECS & T-DECS

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

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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 · 18 · 15mm. Made by Varley. Only **40p.**

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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.**

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Wood grained metal case 90 · 80 · 75mm containing mains transformer giving 6V at 200mA, 2 co-ax sockets, PC board with 1¼" fuseholder R's C's etc. Only **£1.**

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Special purchase of these 0·1" pitch double-sided gold plated connectors enables us to offer them at less than ⅓rd their original list price! 18 way **41p** 21 way **47p** 32 way **72p** 40 way **90p** 43 way **97p** 49 way **111p.**

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Has 12 60V 0.8A thyristors (gate current only 200µA!), MEU21, 2N3904, 1N4004 · 14, · R's C's etc. Only **£1.00.**

MISCELLANEOUS IC's
All supplied with data.
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Our retail shops at **21 Deptford Broadway, London, SE8 (01-692 2009)** and **38 Lower Addiscombe Road, Croydon (01-688 2950)** stock some of the advertised goods for personal callers only. Ring them for details.

All prices quoted include VAT and UK/BFPO postage. Most orders despatched on day of receipt. SAE with enquiries please. **MINIMUM ORDER VALUE £1.** Official orders accepted from schools, etc. (Minimum invoice charge £5). Export/wholesale enquiries welcome. Wholesale list now available for bona-fide traders. Surplus components always wanted.

PE VOLUME 14 No. 6 FEBRUARY 1978

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*.

In addition to the use of delay line technology to produce a rich orchestral string sound, the unit employs CMOS i.c.s. throughout the divider circuit and unique CMOS chorus drive circuitry.

Mike Kenward.

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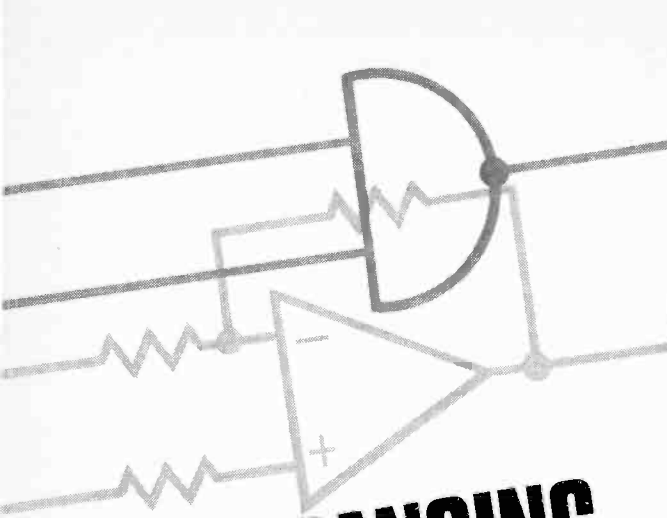
Binders for PE are available from the same address at £2·85 each to UK addresses, £3·45 overseas, including postage and packing, and VAT where appropriate. Orders should state the year and volume required.

Cheques and postal orders should be made payable to IPC Magazines Limited.

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.



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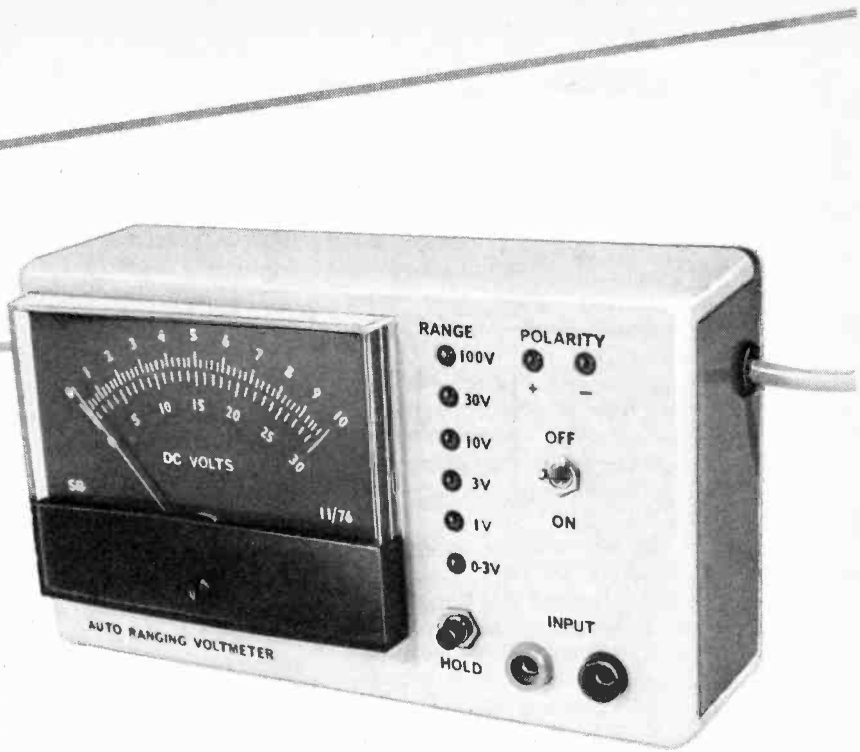


STEVE ROBERTS

SPECIFICATION

Input resistance	10MΩ
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 ±6V batteries
Size	110mm × 188mm × 60mm (mains option)

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!

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:

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

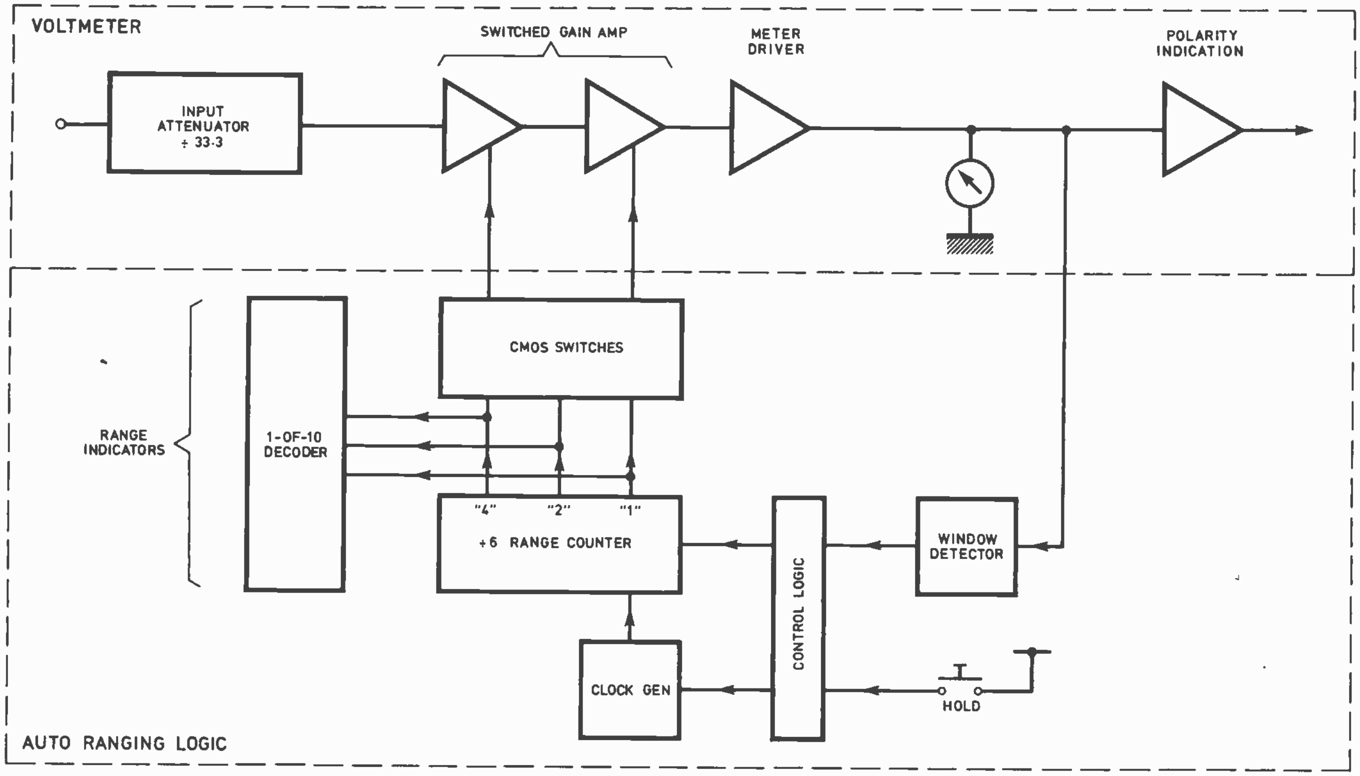


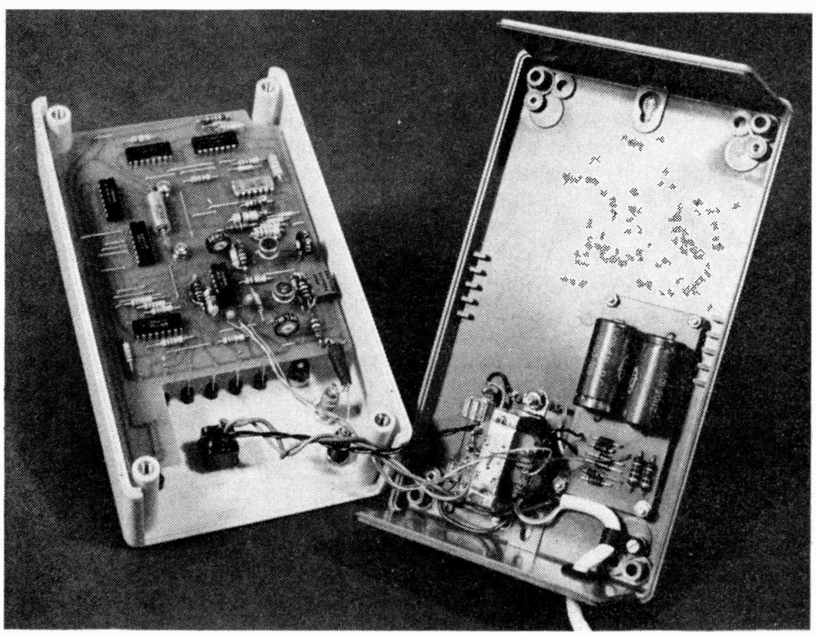
Fig. 1. Block diagram of Auto-Ranging D.C. Voltmeter

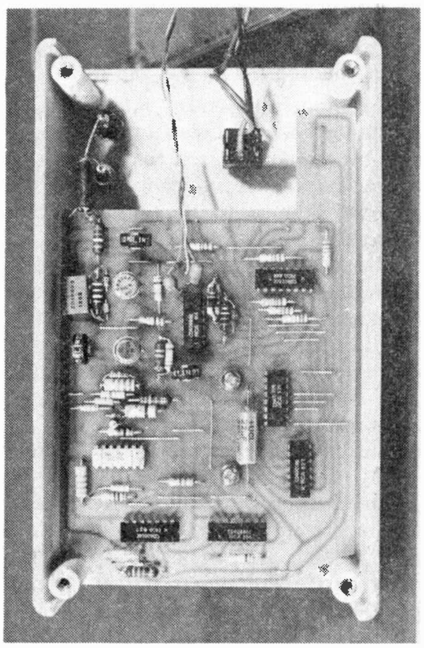
CIRCUIT DESCRIPTION

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 l.e.d.s.

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





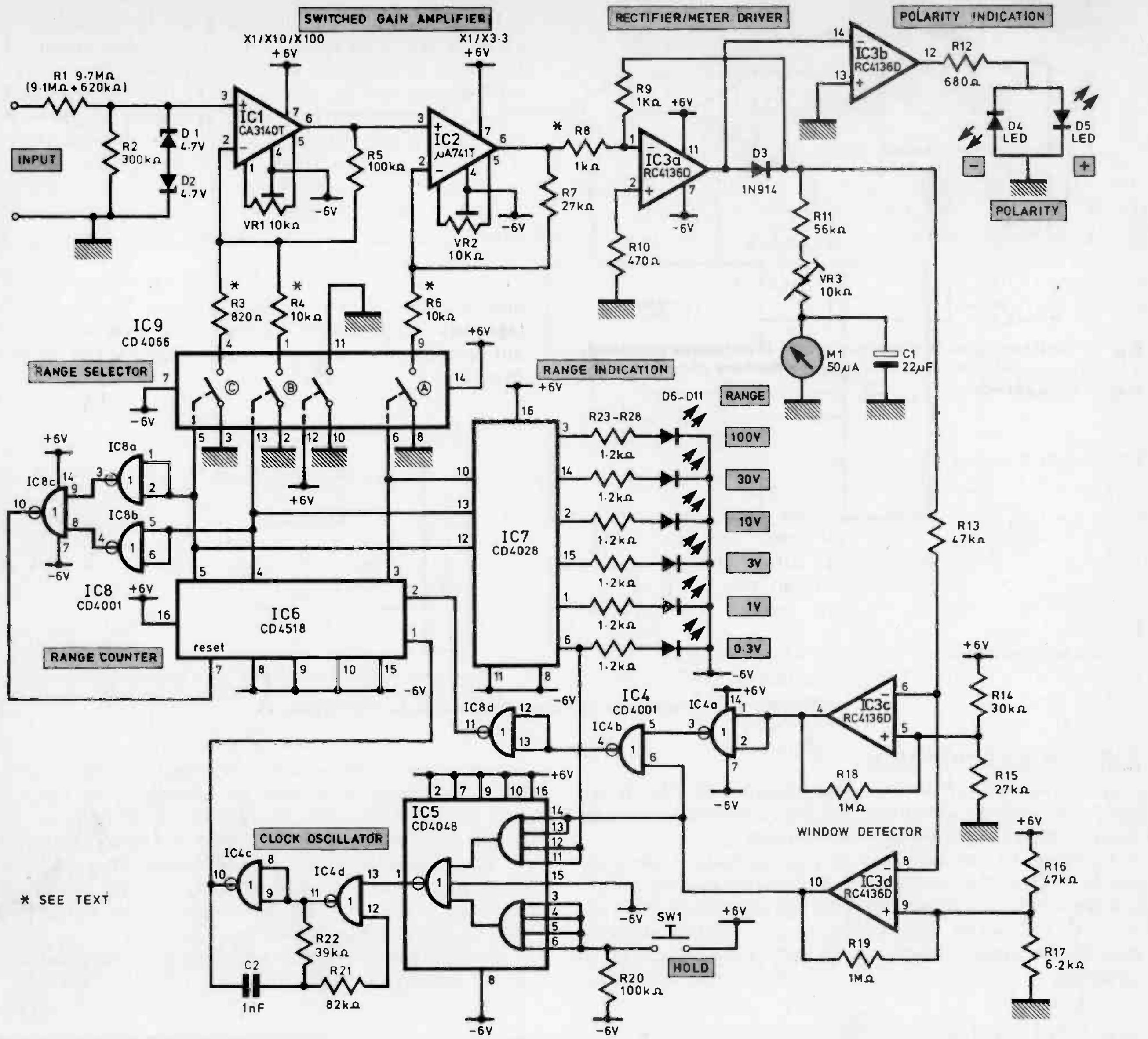


Fig. 2. Full circuit diagram of Voltmeter unit. Although the circuit contains a rectifier, it will not give the conventional true r.m.s. reading for an a.c. input

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 l.e.d.s.

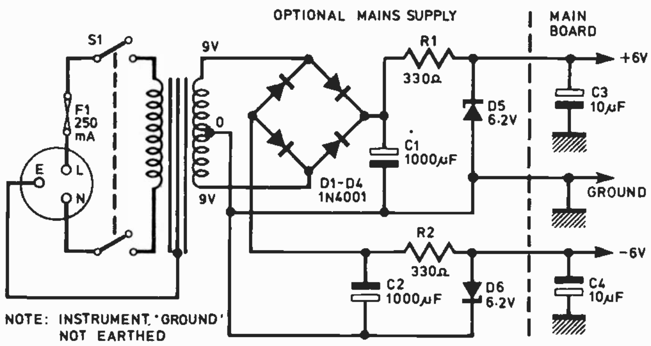


Fig. 3. Optional power supply circuit. If batteries are used, a larger case will be necessary, and a battery check facility would be advisable

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.

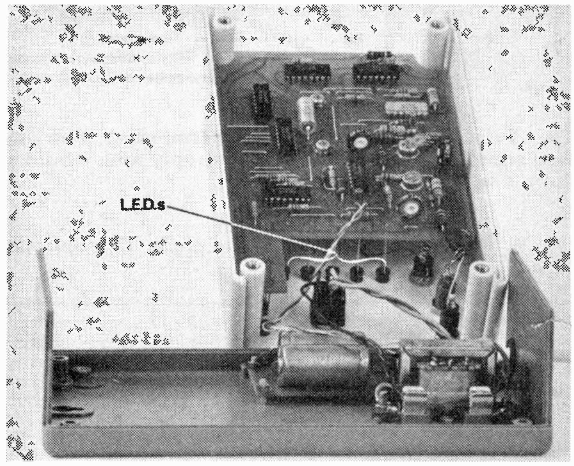
If a mains supply is decided upon, note that the mains earth is *not* connected to the instrument ground. It is desirable, therefore, to use a transformer with an earthed interwinding screen, and to ensure that the instrument is connected particularly carefully where the mains wiring is concerned. Care 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 ± balance resistor R8 might advantageously be mounted on extension pins which would aid component changing if required during the calibration procedure.

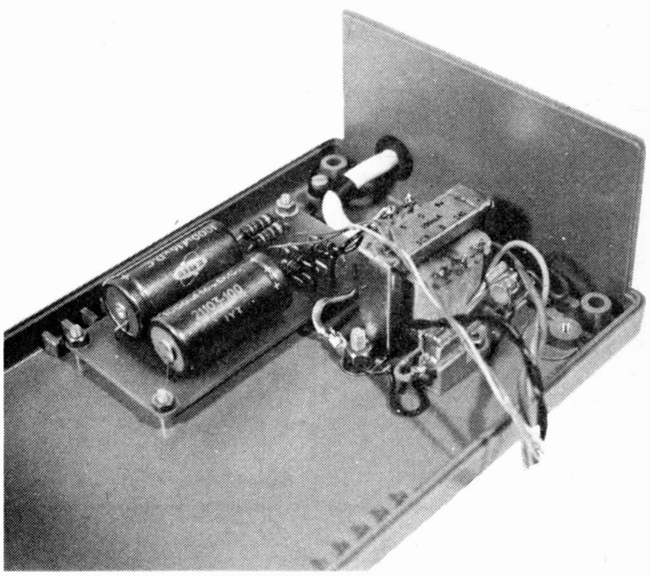
As most of the i.c.s use MOS technology, the appropriate handling precautions should be taken.

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*



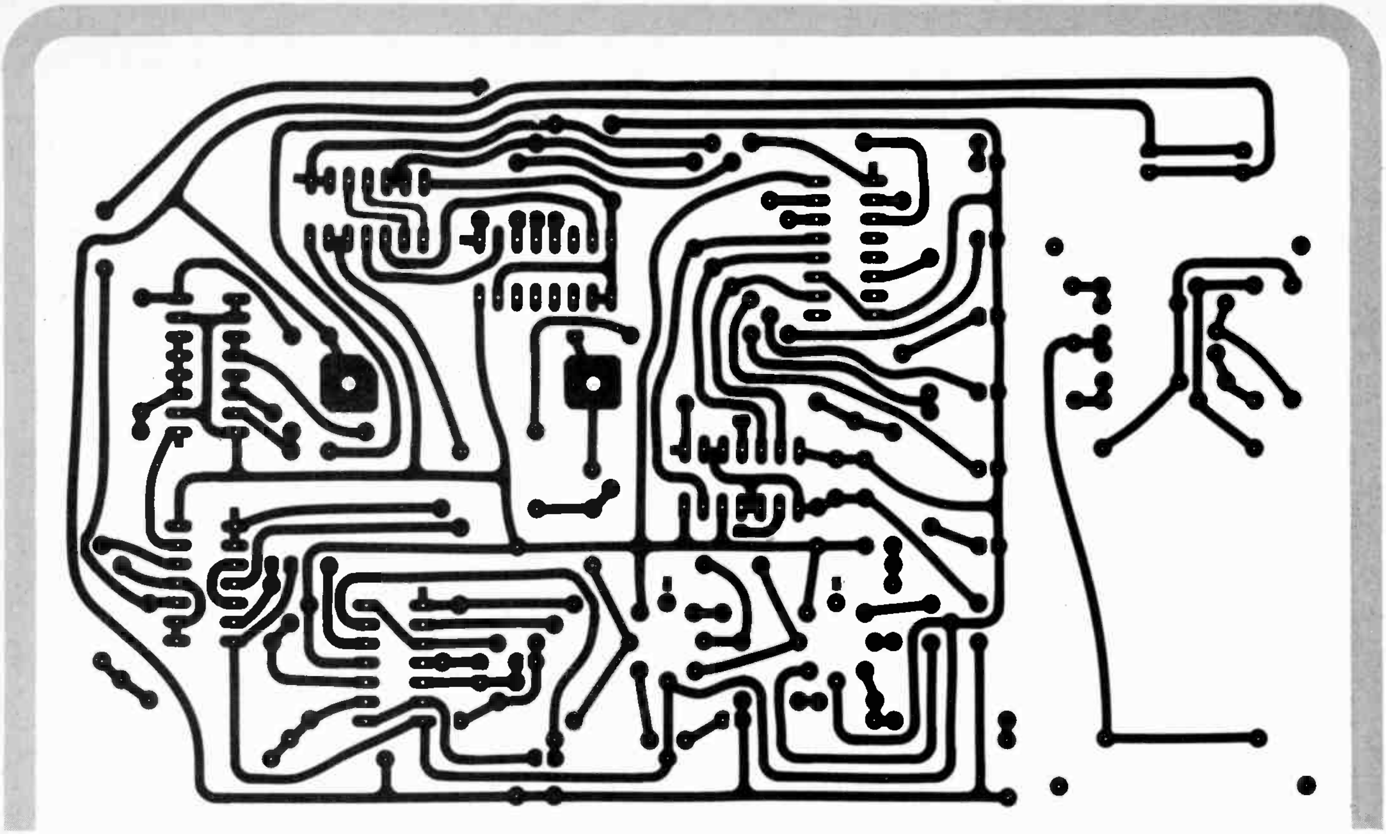
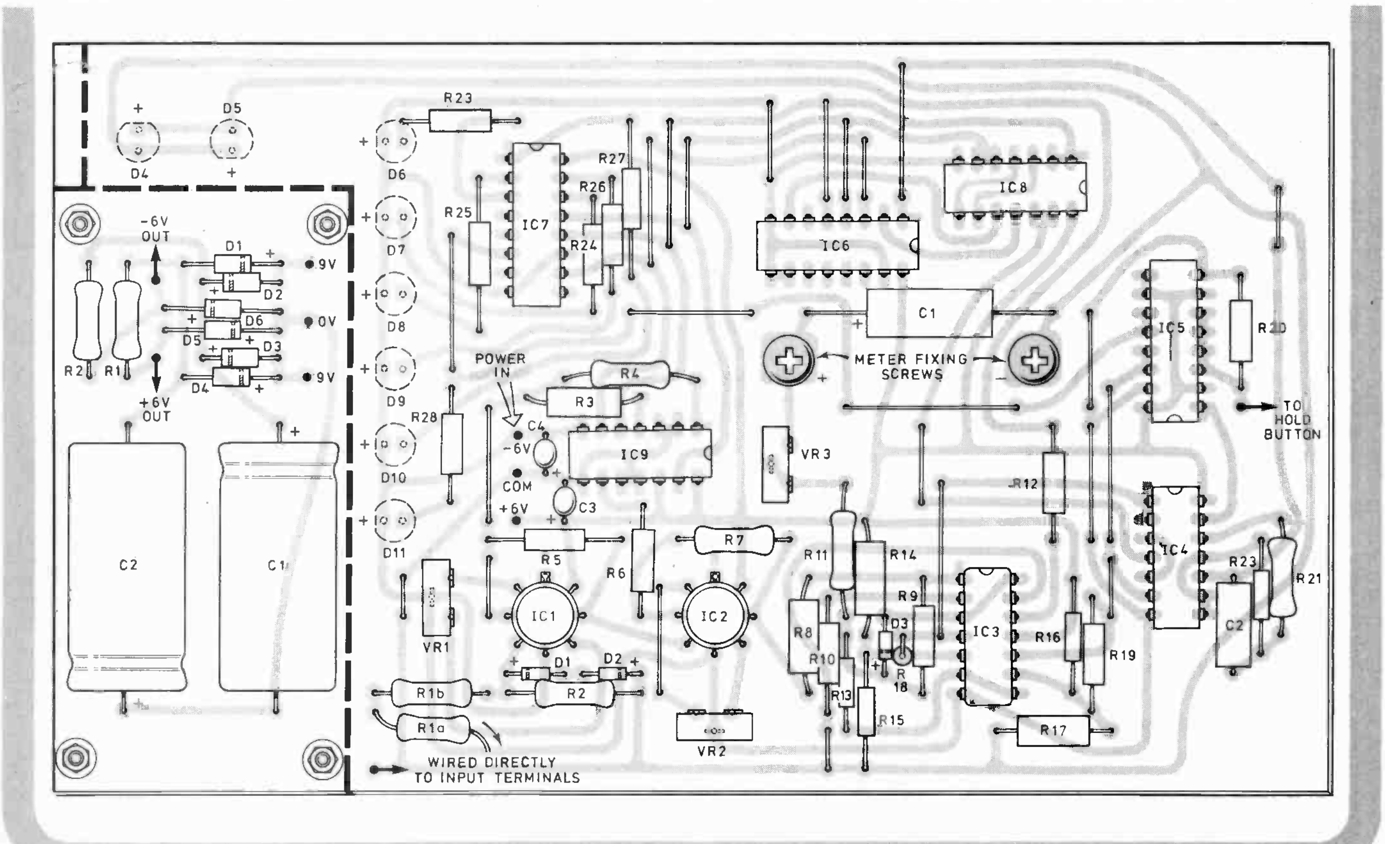


Fig. 4. Printed circuit board layout (full size). The power supply board is included on the same layout so that both can be etched simultaneously. The power supply area would still need to be cut out even if batteries are to be used. Note the shape of the p.c.b. in the photographs

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	9·1MΩ + 620kΩ in series
R2	300kΩ
R3	820Ω*
R4	10kΩ*
R5	100kΩ
R6	10kΩ*
R7	27kΩ
R8	1kΩ*
R9	1kΩ
R10	470Ω
R11	56kΩ
R12	680Ω
R13	47kΩ
R14	30kΩ
R15	27kΩ
R16	47kΩ
R17	6·2kΩ
R18, R19	1MΩ (2 off)
R20	100kΩ
R21	82kΩ
R22	39kΩ
R23–28	1·2kΩ (6 off)

All resistors are ¼W 5% carbon.
*Resistors to be selected on test, see text.

Potentiometers
VR1–VR3 10kΩ vertical preset (sub min)

Capacitors

C1	1000pF polyester
C2	22µF 25V
C3, C4	10µF 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	µA741T
IC3	RC4136D
IC4	CD4001
IC5	CD4048
IC6	CD4518
IC7	CD4028
IC8	CD4001
IC9	CD4066

Miscellaneous
S1 Single pole, push-to-make
Case 110mm × 188mm × 60mm
M1 50µA 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 ¼W carbon (2 off)

Capacitors
C1, C2 1000µF 25V (2 off)
C3, C4 10µF 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

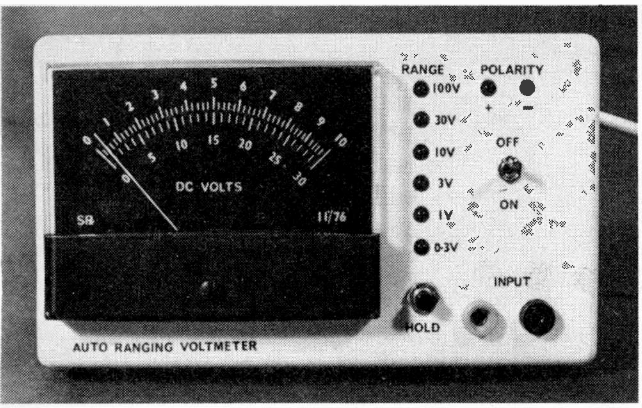
If the recommended p.c.b. design is used, the CA3140T type should be ordered for IC1 (T stands for 8-lead TO5 package).

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.



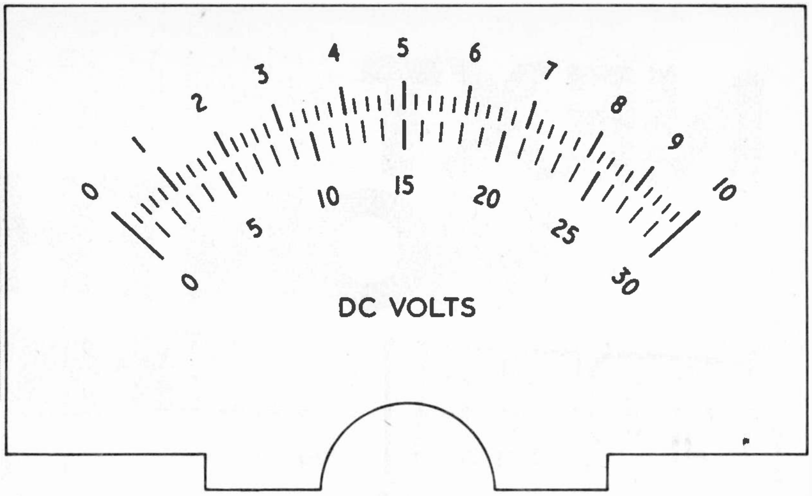


Fig. 6. Meter scale required by the Auto-Ranging D.C. Voltmeter

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 ×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 ×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 ×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

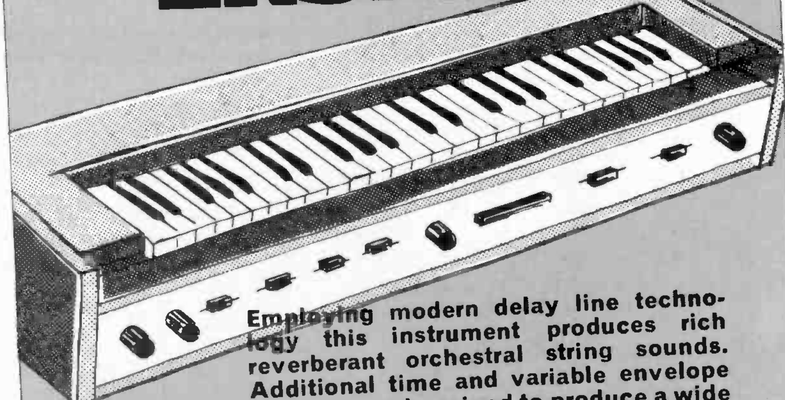
The author would like to thank Mr. D. Bowers for his helpful comments and suggestions during this project. ★

NEXT MONTH...

FREE! COVER-MOUNTED GIFT matrix marker

...a useful tool for constructors

PE STRING ENSEMBLE

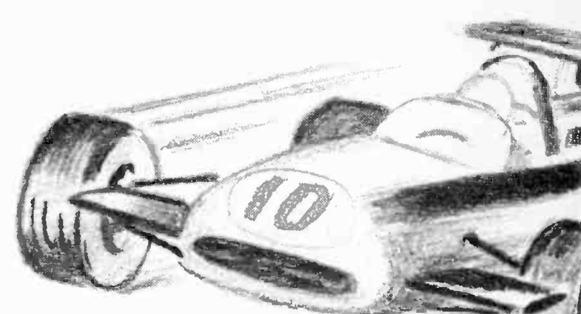


Employing modern delay line technology this instrument produces rich reverberant orchestral string sounds. Additional time and variable envelope controls can be mixed to produce a wide spectrum of sound. Features include:

* 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 Introkit which featured the SC/MP microprocessor. The Introkit 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 microcomputer 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!

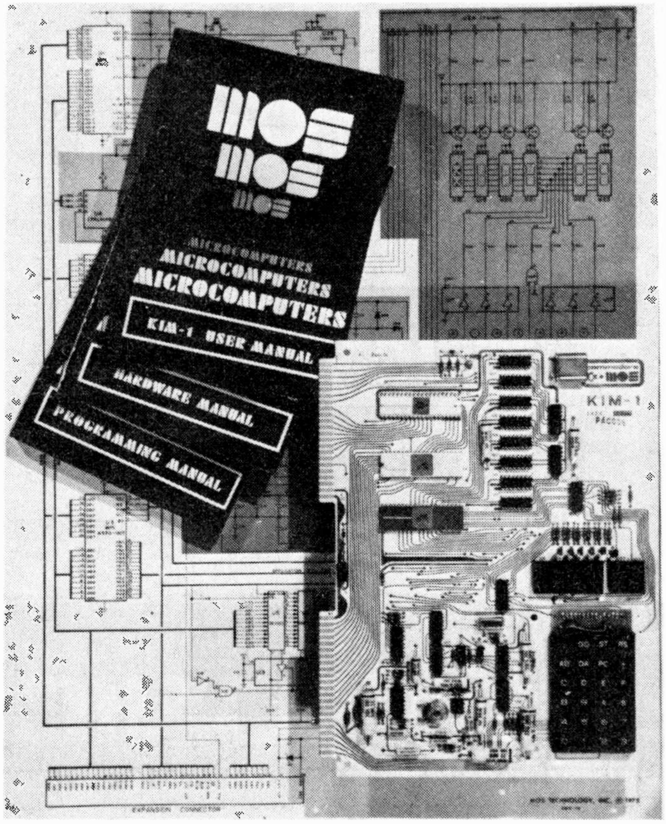
With a full 1k of user RAM available from the start, a KIM-1 owner is unlikely to feel cramped for space for quite a while, especially since programs can be stored on, and retrieved from, conventional cassette tapes with the simple addition to the system of a low cost audio cassette recorder. As a user 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.

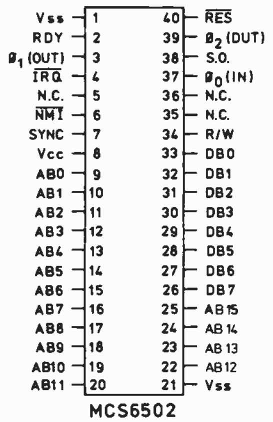
The 6502 microprocessor and associated circuits require only a single 5 volt supply which can be easily put together using a fixed voltage LM309K regulator. When a cassette recorder is used, an additional low current 12 volt supply is required to power the interface circuitry.

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





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 instruction 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.

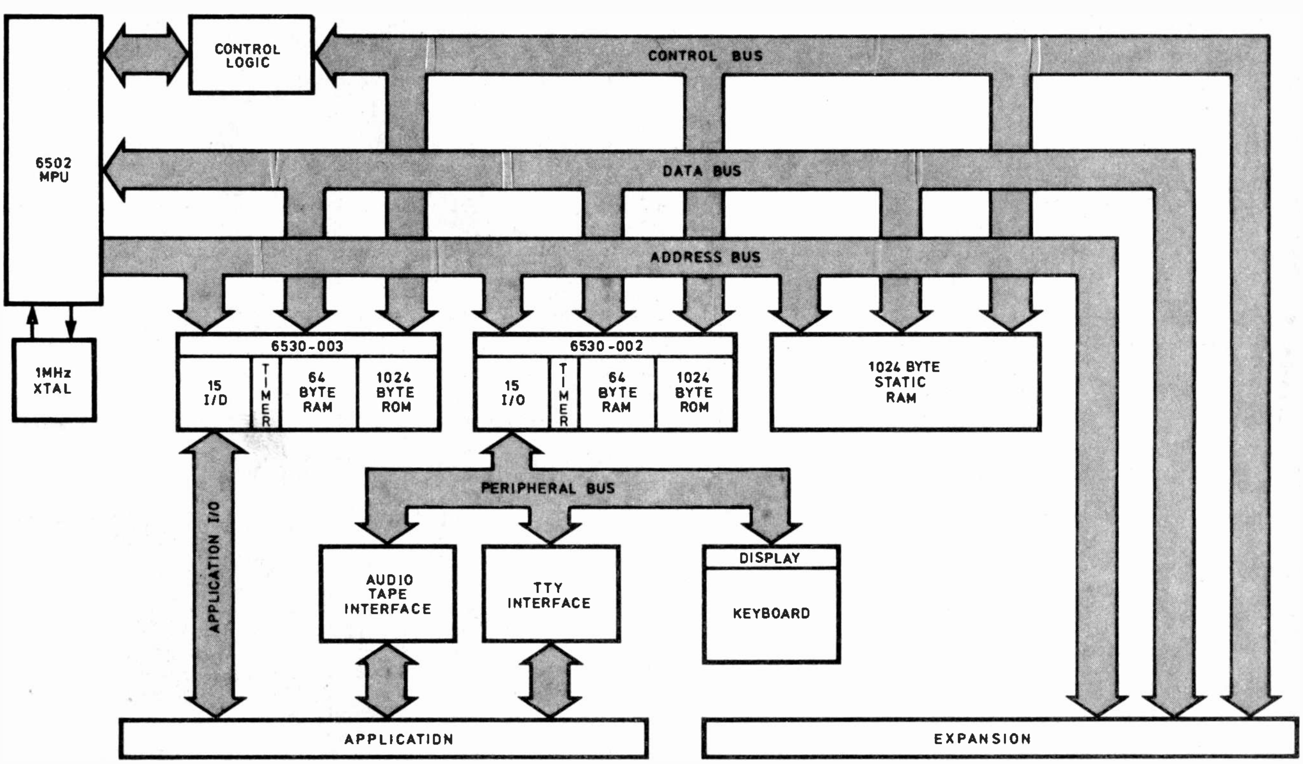
User program storage on the KIM-1 board is provided by eight 1024 by 1 bit 2102 type NMOS RAM chips, although as you will have gathered from the description of the MCS6530 chip, a further 128 words *is* available if required. The basic address range of KIM-1 is 8k words, with the MCS6530 ROM, RAM I/O 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

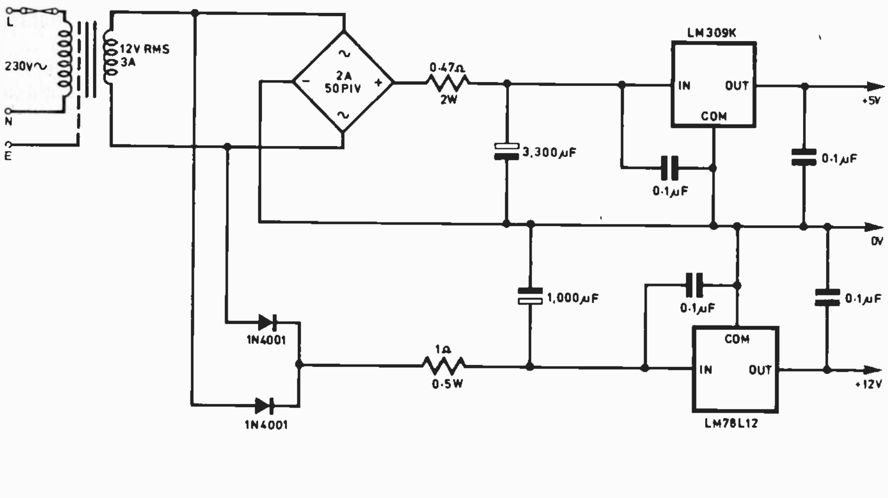
The KIM-1 monitor program controls the storage and retrieval of data on the cassette, and when recording a program a checksum is added in at the end so that verification is possible during replay into KIM-1 RAM. Each program must be given a unique "name" before recording takes place, and this "name" (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
AND	"AND" Memory with Accumulator
ASL	Shift Left One Bit (Memory or Accumulator)
BCC	Branch on Carry Clear
BCS	Branch on Carry Set
BEQ	Branch on Result Zero
BIT	Test Bits in Memory with Accumulator
BMI	Branch on Result Minus
BNE	Branch on Result not Zero
BPL	Branch on Result Plus
BRK	Force Break
BVC	Branch on Overflow Clear
BVS	Branch on Overflow Set
CLC	Clear Carry Flag
CLD	Clear Decimal Mode
CLI	Clear Interrupt Disable Bit
CLV	Clear Overflow Flag
CMP	Compare Memory and Accumulator
CPX	Compare Memory and Index X
CPY	Compare Memory and Index Y
DEC	Decrement Memory by One
DEX	Decrement Index X by One
DEY	Decrement Index Y by One
EØR	"Exclusive-or" Memory with Accumulator
INC	Increment Memory by One
INX	Increment X by One
INY	Increment Y by One
JMP	Jump to New Location
JSR	Jump to New Location Saving Return Address
LDA	Load Accumulator with Memory
LDX	Load Index X with Memory
LDY	Load Index Y with Memory
LSR	Shift One Bit Right (Memory or Accumulator)
NØP	No Operation
ØRA	"OR" Memory with Accumulator
PHA	Push Accumulator on Stack
PHP	Push Processor Status on Stack
PLA	Pull Accumulator from Stack
PLP	Pull Processor Status from Stack
RØL	Rotate One Bit Left (Memory or Accumulator)
RØR	Rotate One Bit Right (Memory or Accumulator)
RTI	Return From Interrupt
RTS	Return From Subroutine
SBC	Subtract Memory from Accumulator with Borrow
SEC	Set Carry Flag
SED	Set Decimal Mode
SEI	Set Interrupt Disable Status
STA	Store Accumulator in Memory
STX	Store Index X in Memory
STY	Store Index Y in Memory
TAX	Transfer Accumulator to Index X
TAY	Transfer Accumulator to Index Y
TSX	Transfer Stack Pointer to Index X
TXA	Transfer Index X to Accumulator
TXS	Transfer Index X to Stack Pointer
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 13 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.

Semiconductor UPDATE...

FEATURING: NE580 MC14500B 1N5283—1N5314

R.W. Coles

BAR DRIVER

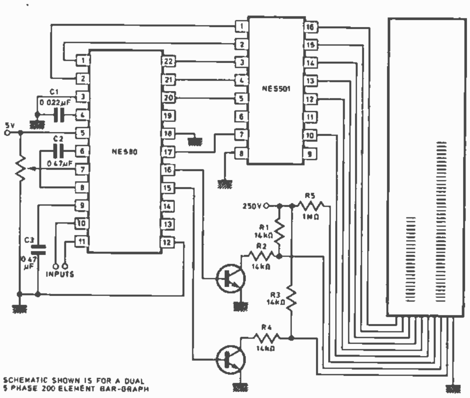
Sometimes a digital display can actually be inferior to more traditional analogue displays such as the moving coil meter. This is particularly true where useful information can be gleaned from the rate of change of a reading, or where a simple comparision is required between the current reading and some pre-set or variable limit. Needless to say, electronics manufacturers have not just ignored this requirement, and there are a number of alternatives to the moving coil meter presently available.

One of the more attractive of these is the bar graph display, where a column of light of variable length provides an easy to read analogue display. Bar graph displays can be made up with bar type l.e.d.s, but where high definition is required the l.e.d. solution is rather costly and power hungry, and so recourse to gas discharge technology is essential. Burroughs of the U.S.A. make an excellent dual gas discharge bar graph display which has become increasingly popular as an alternative to more conventional analogue readouts, but until now the peripheral drive circuitry to control this useful device had to be built with a collection of TTL and analogue circuits which could fill a fair sized board.

Thanks to Signetics, the Burroughs "Self-Scan" bar graph display is now a lot easier to use because a new i.c., the **NE580** has been introduced which contains 80 per cent of the necessary drive circuitry.

The "Self-Scan" display contains two 201 element bar graphs and is driven in a multiplexed fashion which requires the generation of 200 cathode clock pulses in an interlaced five phase sequence.

The display anodes are switched on at the start of a scan and off when the appropriate display level is reached, and this is accomplished by comparing the signal voltage with a reference voltage ramp. The NE580 contains most of the required external circuitry, including a clock oscillator, sample hold, ramp generator, counter, phase decoder, comparators and anode switches and requires only cathode and anode drivers to complete the system. The NE580 is housed in a 22 pin d.i.l. and runs from a single five volt supply. An example of the chip in action is shown below.



SCHEMATIC SHOWN IS FOR A DUAL 5 PHASE 200 ELEMENT BAR-GRAPH

BIT BY BIT

After the four bit micros came the eight bit micros, and after the eight bit micros came the sixteen bit micros . . . but if you are expecting me to present a sneak preview of a thirty two bit mega-chip . . . forget it!

However, the latest, hottest chip from the microprocessor men is, wait for it, a *one* bit processor called an "Industrial control unit" (i.c.u.) by Motorola, the manufacturers.

The new i.c.u. has been coded **MC14500B,** making it a standard 1400 series buffered CMOS part which will be taking its place alongside the MC14001B quad gate and all the other common-or-garden logic blocks in the family.

If up to now you have been a "doubting Thomas", and still think that micros are a passing fad, the MC14500B is all set to convince you otherwise! This new chip is a real microprocessor all right. It has a sixteen entry instruction set, on a chip clock oscillator, and is designed to be paired up with a ROM or PROM program store, along the same lines as its bigger cousins.

The i.c.u. does differ from other micros in its bit-by-bit logic orientated instruction set, and it is not directly capable of the arithmetic type operations which are the bread and butter of other micros. For many applications, the conventional microprocessors are just too powerful, and so relay systems or printed circuit boards full of random logic are used instead.

The new chip runs from 3V to 18V supplies, and comes in a plastic sixteen pin package. The internal oscillator requires only a single external resistor to set the clock frequency to a value between d.c. and 1Mhz, and system expansion can be carried out using standard CMOS components to provide input parts, output parts, and program counters of any length. With only a sixteen entry instruction set, programming should be child's play, and you can use existing TTL fusible link PROMs or the newer CMOS types to hold the programs once written. I forsee a big future for this unexpected infant!

FET DIODES

We all know that when we require a source of constant voltage the easiest way to provide it is to employ a Zener diode with the required voltage rating. But what about a source of constant current?

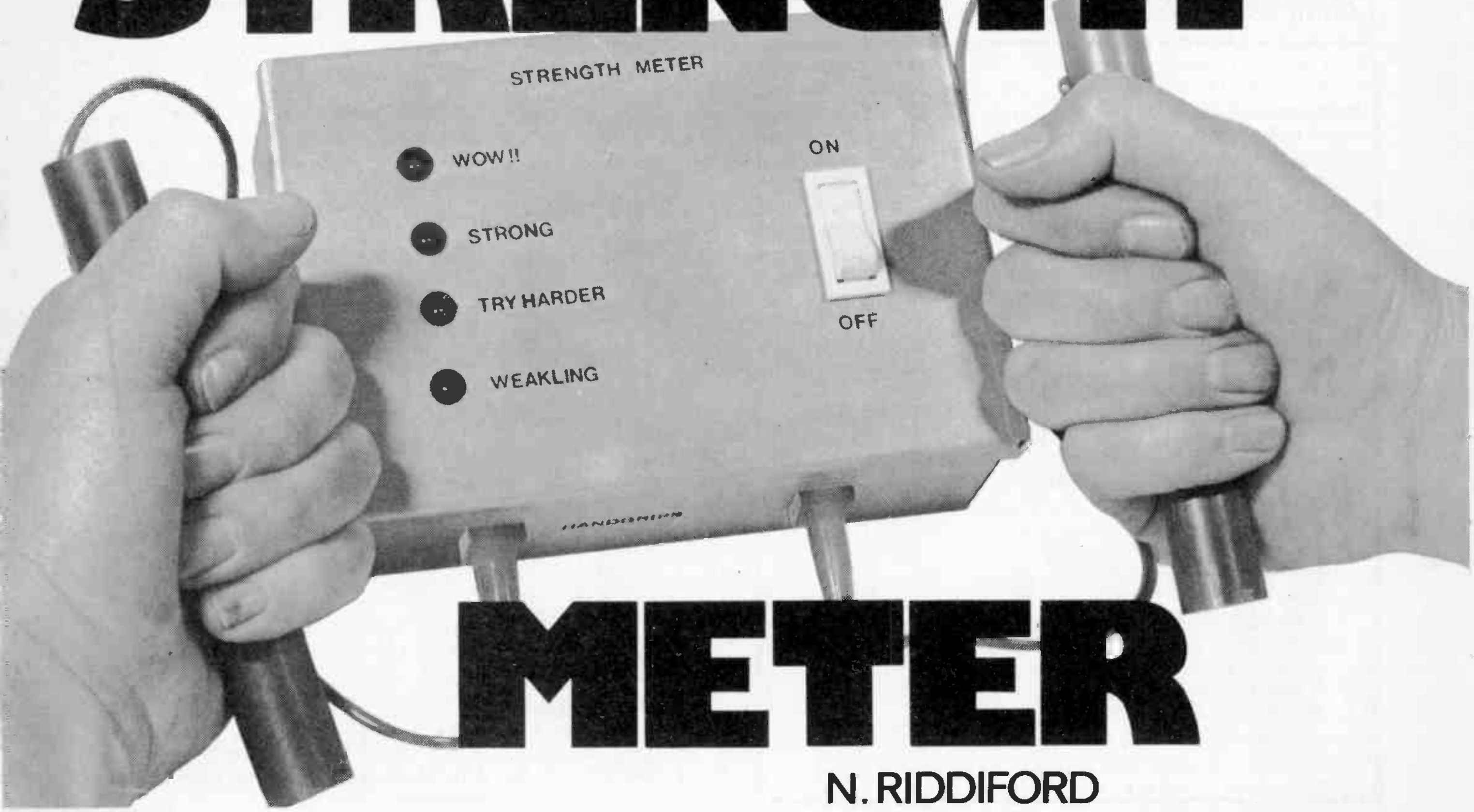
Probably the way most of us tackle this is to use a Zener in conjunction with a transistor and a couple of resistors—but there is a much simpler alternative in the form of the two terminal f.e.t. current regulator diode.

A better way would be to employ one of the Teledyne Crystalonics f.e.t. diodes which are produced in a range which will give accurate current regulation from 220 microamps to 4·7 milliamps.

Thirty two devices are available coded **1N5283** to **1N5314,** and these can be put to good use in a wide range of analogue circuits.

STRENGTH METER

N. RIDDIFORD



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 of 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

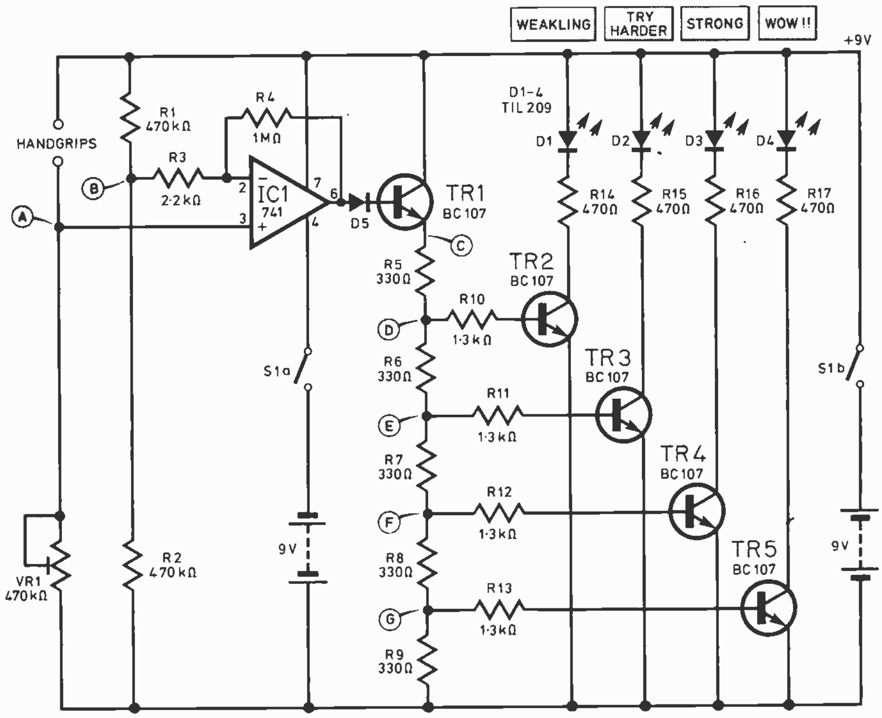


Fig. 1. Complete circuit diagram of Strength Meter. The diode D5 protects TR1 from a negative voltage swing at IC1 output. Although the photographs show a single-pole on/off switch, the arrangement detailed in this circuit diagram is recommended, and uses a two-pole rocker for total switch-off

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 ¼W 5% carbon film

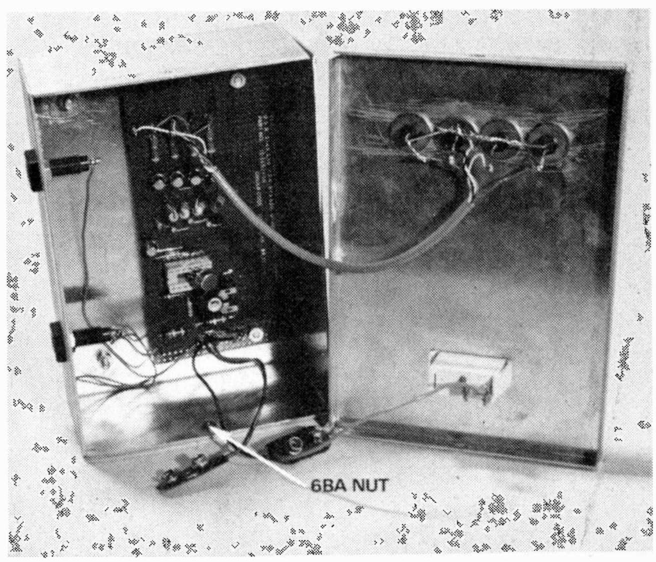
Potentiometers
VR1 470kΩ horizontal preset

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

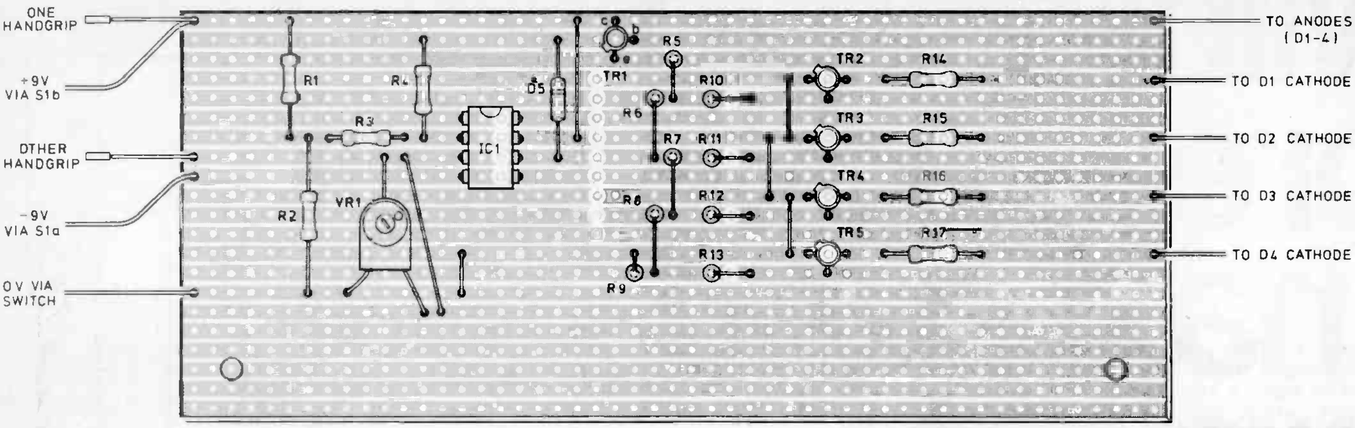
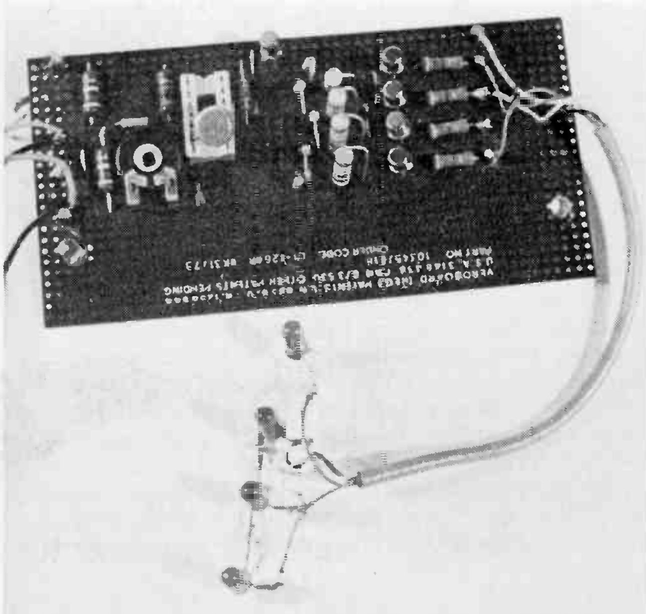
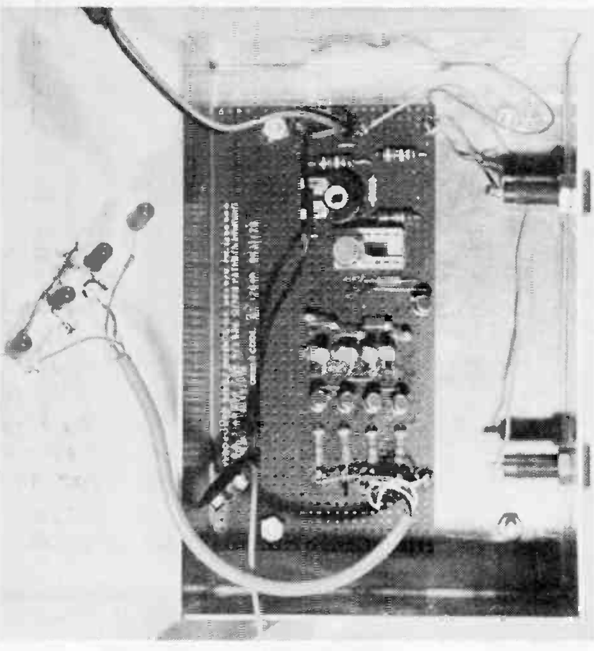


Fig. 2. Stripboard layout. A 14-way i.c. socket may be used for IC1, which can be positioned to allow either 8-pin or 14-pin 741s to be used without stripboard modification. As can be seen in the photographs, this would even allow an 8-lead TO5 type to be used if necessary. Note that R4 is connected to the wrong end of D5 in this diagram





BATTERY RETAINERS

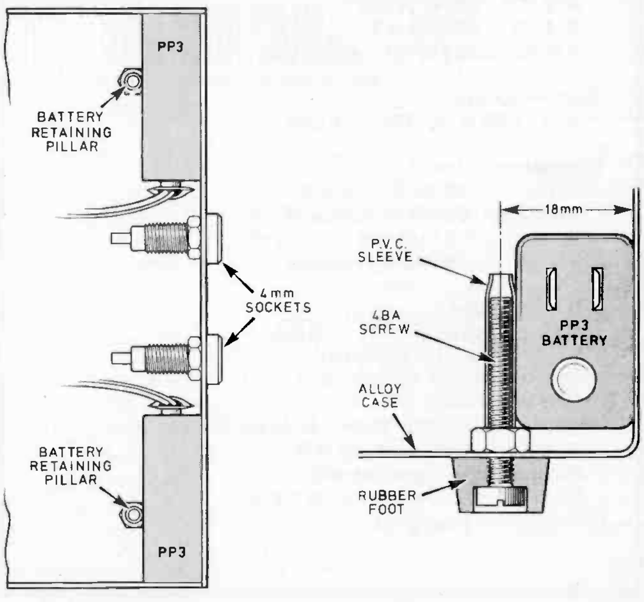
It was felt that a small modification to the prototype featured in the incidental photographs could be made, which would provide a simple but effective means of clamping the PP3 batteries.

If the "rubber feet" screws nearest to the 4mm sockets are positioned 18mm away from *that* inside edge, and are about 25mm long, then they can be used as battery retaining pillars, whereby the PP3s will squeeze between *these* and the side of the case (see Fig. 3). Lengths of p.v.c. sleeving should be slipped over them to improve appearance and protect the batteries from damage. Some sleeving stripped from 3-core mains cable (lightweight type) will do admirably for this!

If this is done, the 4mm terminals will need to be mounted nearer the centre-line of the box (at about 30mm apart) to make room for the PP3 batteries.

continued on page 417

Fig. 3. Using the 4BA "rubber feet" screws to create battery retaining studs. The positions of the rubber feet and 4mm sockets necessary for this facility will be slightly different from those appearing in the photographs

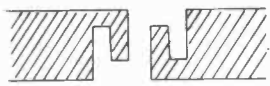


Mini-priced breadboards for maxi-sized projects.

Experimentor* low-cost solderless breadboards are the first in the world specially designed for 0.3" and 0.6" pitch DIP's.

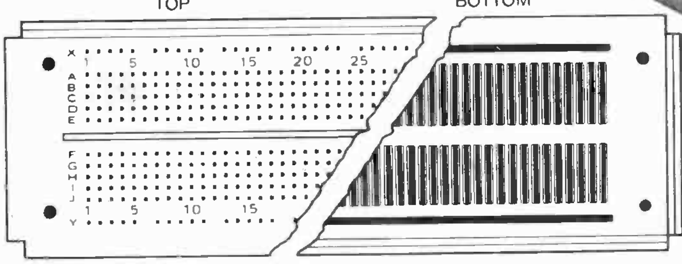
They clip together by an exclusive interlocking system in any configuration, (just like dominoes), so you arrange the breadboards to suit your circuit, not vice-versa.

They are precision moulded from durable, flame-retardant plastic, and feature alphanumeric coding for easy circuit building, and non-corrosive, pre-stressed nickel-silver alloy contacts—reliable for well over 10,000 insertions.



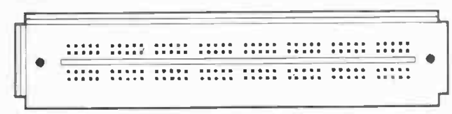
EXCLUSIVE INTERLOCKING SYSTEM.

TOP BOTTOM



Contact resistance is a mere 0.4 mΩ and interterminal capacitance is typically less than 5 pF. The **Experimentor** is usable to over 100 MHz.

Experimentor 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 expands the versatility of the system for the MPU user.

Model	Length"	Width"	Centre channel"	5-way tie points	Bus	Price
EXP300	6.0	2.1	0.3	94(470)	2(80)	£6.77
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.

Experimentor 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.

But however you use them, **Experimentor** breadboards are the quickest and easiest way to build and test circuits.

If you're working on IC's, MPU's, memories, displays or any other circuits, buy the breadboards that are designed for you.

Ring us (01-890 0782) with your Access, Barclaycard or American Express number and your order will be in the post that night.

Alternatively, send a cheque, or postal order (don't send credit cards!) and it still only takes a few days.

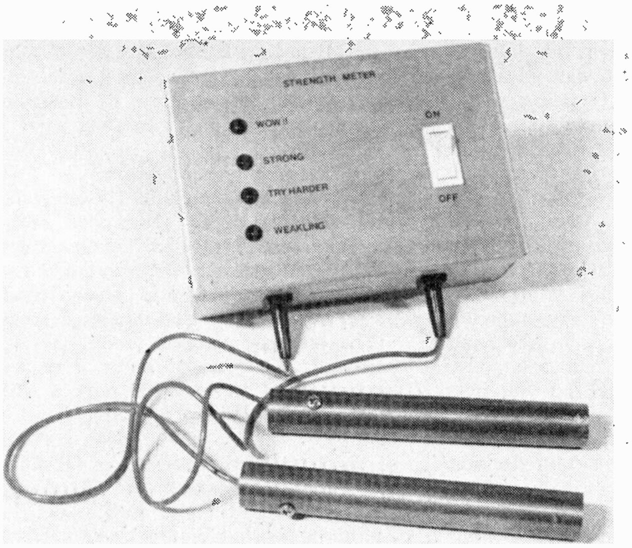
Otherwise ask for our complete catalogue.

CONTINENTAL SPECIALTIES CORPORATION

CSC

CONTINENTAL SPECIALTIES CORPORATION (UK) LTD., SPUR ROAD, NORTH FELTHAM TRADING ESTATE, FELTHAM, MIDDLESEX TW14 0TJ. TELEPHONE: 01-890 0782.

REG IN LONDON: 1303780 VAT NO: 224 8074 71 *TRADE MARK APPLIED FOR ©CSC (UK) LTD 1977. DEALER ENQUIRIES WELCOME. TELEX: 8813669 CSCLTD.



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 ELECTREX, 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 Electricars, 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.

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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 × 76mm × 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.

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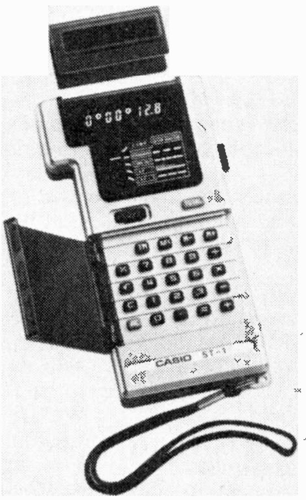


SCRUMPI 2

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.

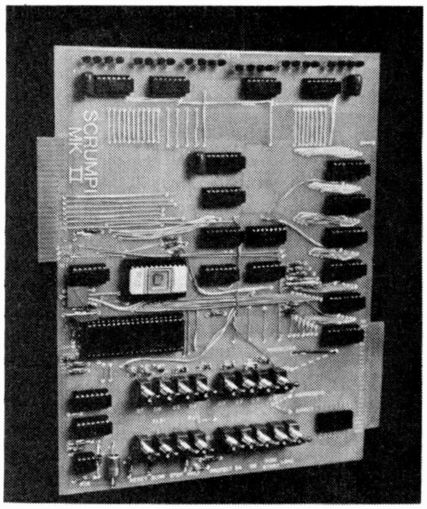
Interfacing facilities on Scrumpi 2 are suitable for either 4-bits or 8-bits and simple VDUs.

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 Ebberns Road, Hemel Hempstead, Herts, HP3 9QR.**



Scrumpi 2 from Bywood

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BC158	.11	BD139	.46	MPSA-06	.22	TIP31C	.64
BC159	.11	BD140	.48	MPSA-13	.24	TIP32A	.65
BC171	.10	BF241	.25	MPSA-56	.22	TIP32B	.61
BC172B	.11	BF258	.24	MPSU-01	.35	TIP32C	.70
BC177	.16	BFX85	.23	MPSU-51	.38	TIP41A	.67
BC182	.11	BFX86	.23	OA47	.08	TIP41B	.70
BC182L	.11	BFX87	.22	OA79	.08	TIP41C	.82
BC183	.11	BFX88	.22	OA81	.08	TIP42A	.75
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1S44	.05	2N3704	.07
1S020	.11	2N3705	.07
1S920	.06	2N3706	.08
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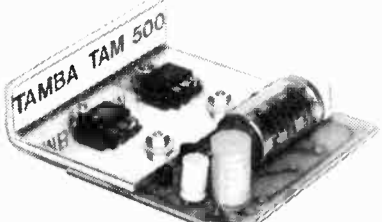

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FRANK W. HYDE

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.

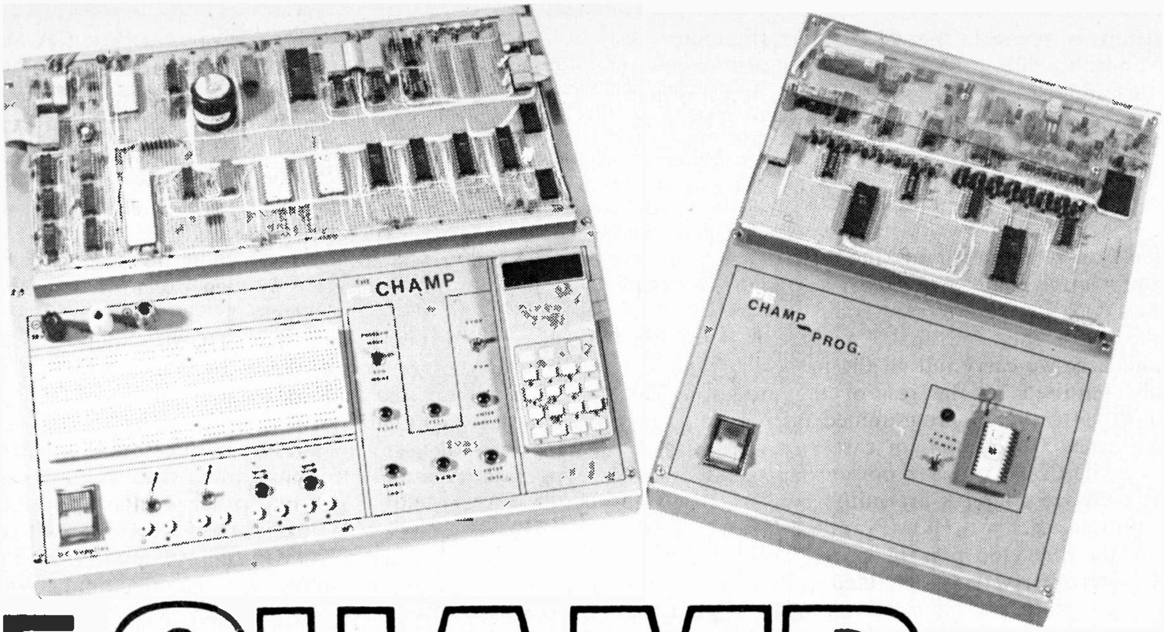
A number of disciplines have been concerned with the possibility of life having begun outside the earth and found its way to the planet. It is so frequent for the work of some individuals and groups to be quoted out of context in support of sensation, yet in the cases now to be detailed there are sensational 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 Wickeamsingh 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 is 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 eraseable 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 1·7μs 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:

(a) Circles represent the beginning and end of events.
(b) Oblong boxes represent actions to be performed.
(c) Diamonds represent decision points with two possible exits.
(d) 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 housekeeping 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.

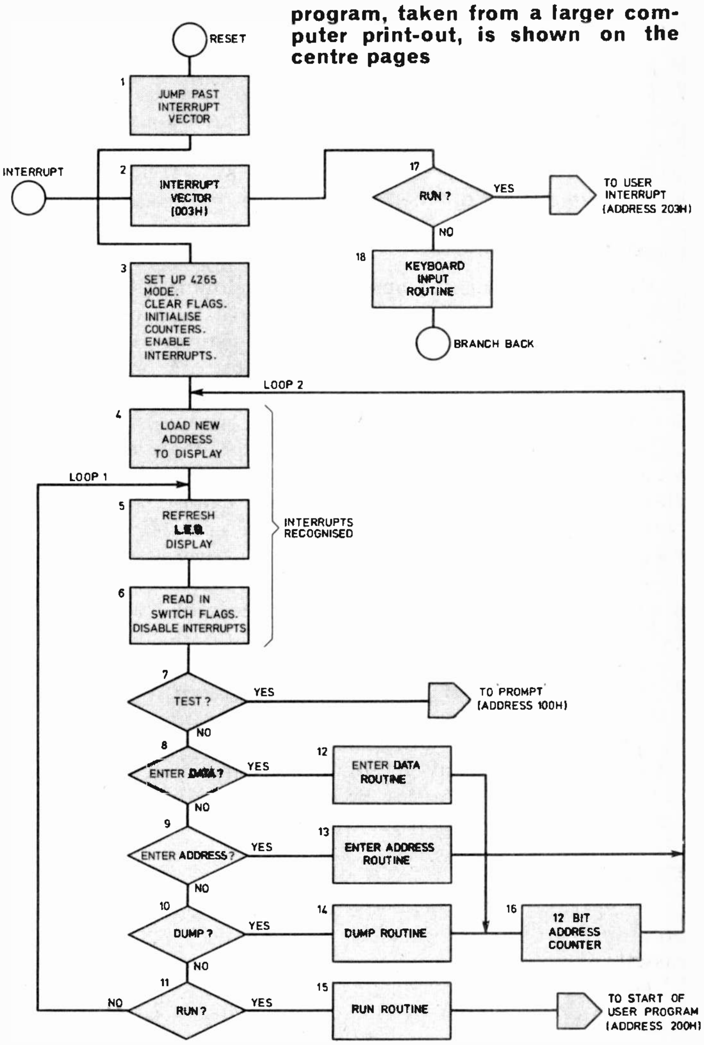
Boxes 8, 9, 10 and 11, check each of the switch flag bits in the accumulator in turn, by shifting them into the carry flip-flop and performing a JCN instruction. If no switches are pressed at box 6 time, then LOOP 1 is completed, and is in fact repeated indefinitely, refreshing the display and checking 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
0046  5097  JMS CLRF;              CLEAR SWITCH FLAGS
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
005C  50CE  JMS LOKY               DISPLAY DUMP BYTE
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        0RG 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 s + 4;              SKIP INTERRUPT
0003  4066  JUN INTER;              INTERRUPT VECTOR
0005  2880  FIM 8, 80H
0007  29    SRC 8
0008  D9    LDM 9
0009  E1    WMP;                    SET UP 4265 MODE
000A  5097  JMS CLRF;               CLEAR SWITCH FLAGS
000C  2428  FIM 4, 28H;             SET MS ADDR. COUNT AND
                                      DDRV COUNT
000E  50A2  LOOP 2: JMS LADR;       LOAD ADDRESS TO DISPLAY
0010  0C    LOOP 1: EIN;            ENABLE INTERRUPTS
0011  50B1  JMS DDRV;               DISPLAY DRIVER
0013  2840  FIM 8, 40H
0015  29    SRC 8
0016  EA    RDR;                    READ IN SWITCHES
0017  0D    DIN;                    DISABLE INTERRUPTS
0018  F6    RAR;                    FIRST FLAG TO CY
0019  111D  JNT SKIP;               JUMP TO CHIP 1 IF TEST SET
001B  4100  JUN 100H
001D  1A32  SKIP: JNC ENTDA;        ENTER DATA?
001F  F6    RAR;                    NEXT FLAG TO CY
0020  1A40  JNC ENTAD;              ENTER ADDRESS
0022  F6    RAR;                    NEXT FLAG TO CY
0023  1A4A  JNC DUMP;               DUMP?
0025  F6    RAR;                    LAST FLAG TO CY
0026  1210  JC LOOP 1;              RUN OR BACK AGAIN
0028  5097  RUN: JMS CLRF
002A  2880  FIM 8, 80H
002C  29    SRC 8
002D  F0    CLB
002E  E5    WR1;                    BLANK DISPLAY
002F  E6    WR2
0030  4200  JUN 200H;               JUMP TO USER PROG IN
                                      CHIP 2
0032  2800  ENTDA: FIM 8, 00H
0034  29    SRC 8
0035  A4    LD 4
0036  E1    WMP;                    SELECT PROGRAM RAM CHIP
0037  23    SRC 2;                  ADDRESS BYTE
0038  AC    LD 0CH
0039  E3    WPM;                    WRITE LEAST SIG NIBBLE
                                      TO RAM
003A  AE    LD 0EH
003B  E3    WPM;                    WRITE MOST SIG NIBBLE
003C  5097  JMS CLRF;               CLEAR SWITCH FLAGS
003E  405E  JUN COUNT;              BUMP ADDRESS COUNT
0040  AD    ENTAD: LD 0DH;          PUT KBD IN COUNTER
0041  B3    XCH 3

008E  BD    THIRD: XCH 0DH;         THIRD IN RD
008F  2A00  FIM 0AH, 00H;           CLEAR KBD CHAR COUNT
0091  50CE  TERM: JMS LOKY;         PUT NEW KBD DIGIT IN 4002
0093  A7    LD 7
0094  F6    RAR;                    RESTORE STATUS
0095  A6    LD 6
0096  02    BBS
0097  2850  CLRF: FIM 8, 50H;       SELECT ROM O.P. PORT 5
0099  29    SRC 8
009A  E2    WRR;                    CLEAR SWITCH FLAGS
009B  2A00  FIM 0AH, 00H;           CLEAR KBD REGISTERS
009D  2C00  FIM 0CH, 00H
009F  2E00  FIM 0EH, 00H
00A1  C0    BBL 0H
00A2  280A  LADR: FIM 8, 0AH;       FETCH 4002 SRC START ADD
00A4  A4    LD 4
00A5  B1    XCH 1
00A6  50DD  JMS HEXL;               CONVERT TO SEVEN SEG
                                      CODE
00A8  A2    LD 2
00A9  B1    XCH 1
00AA  50DD  JMS HEXL;               CONVERT TO SEVEN SEG
                                      CODE
00AC  A3    LD 3
00AD  B1    XCH 1
00AE  50DD  JMS HEXL;               CONVERT TO SEVEN SEG
                                      CODE
00B0  C0    BBL 0H
00B1  27    DDRV: SRC 6;            DISPLAY DRIVER ROUTINE
00B2  E9    RDM;                    LOW FOUR FROM 4002
00B3  2880  FIM 8, 80H
00B5  29    SRC 8;                  LOW FOUR TO 4265 PORT X
00B6  E5    WR1
00B7  67    INC 7;                  BUMP NIBBLE POINTER
00B8  27    SRC 6
00B9  E9    RDM;                    HIGH FOUR FROM 4002
00BA  29    SRC 8
00BB  E6    WR2;                    LOW FOUR TO 4265 PORT Y
00BC  67    INC 7;                  BUMP NIBBLE POINTER
00BD  75C5  ISZ 5, DATO;            INCREMENT SHIFT COUNTER
00BF  DF    LDM 0FH;                FETCH WRM CODE
00C0  E0    WRM;                    BIT SET 4265 Z3 HIGH
00C1  D8    LDM 08H;                PRESET SHIFT COUNTER
00C2  B5    XCH 5
00C3  40C7  JUN PASS
00C5  DE    DATO: LDM 0EH;          FETCH WRM CODE
00C6  E0    WRM;                    BIT SET Z3 LOW
00C7  2880  PASS: FIM 8, 080H;      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:

(a) The assembler program does produce nice neat output listings which are useful for publication purposes.
(b) 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:

(a) ORG and END are pseudo instructions, nothing to do with the 4040 but understood by the assembler.
(b) 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.
(c) Some lines are field separators required by the assembler program.
(d) 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.
(e) 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.

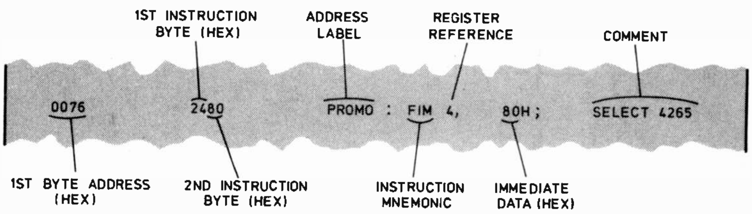


Fig. 6.3. One assembler output line and what it means

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,

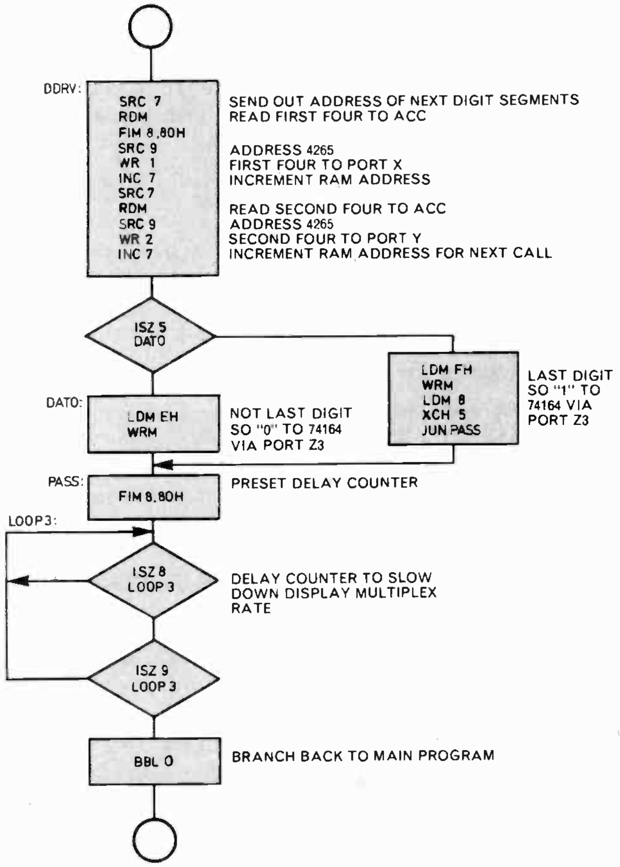


Fig. 6.5. Display driver subroutine. Refer to box 5 in CHOMP main flow chart, and address 00B1H on CHOMP program listing

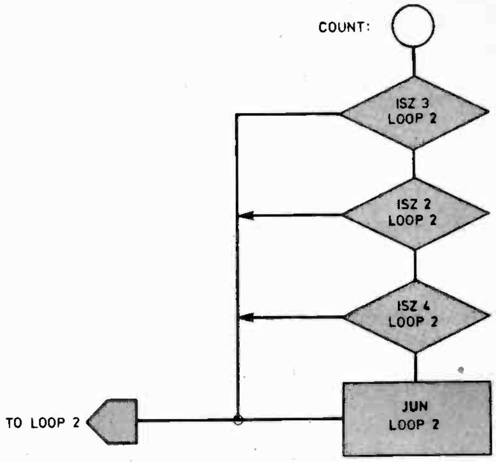


Fig. 6.4. Twelve bit address counter flow chart. Refer to box 16 in CHOMP main flow chart, and address 005EH. The CHAMP address counter should not be confused with the 4040 address counter

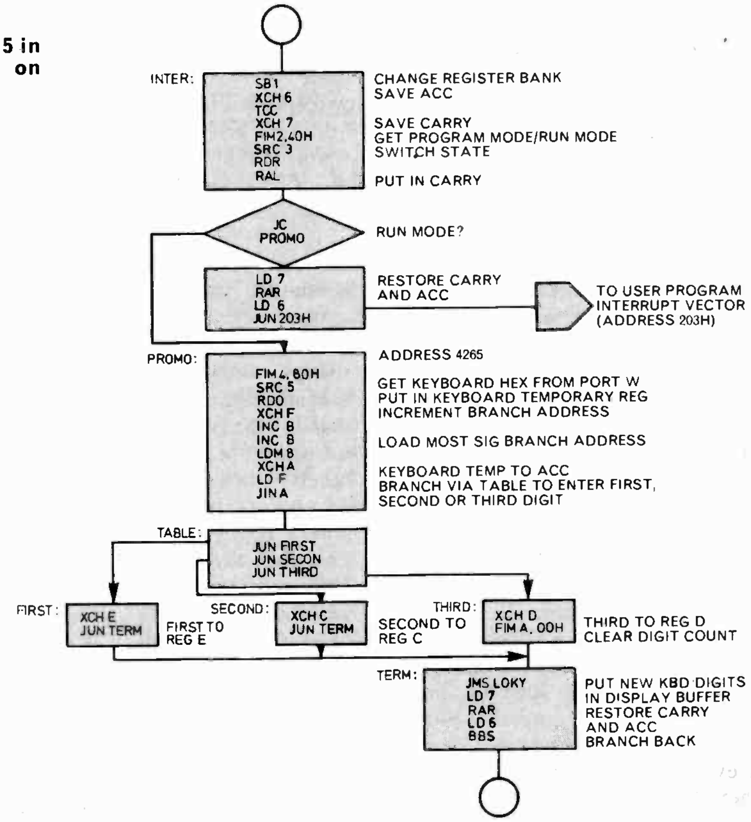


Fig. 6.6. Interrupt routine. Refer to boxes 17 and 18 in CHOMP main flow chart, and address 066H in CHOMP program listing

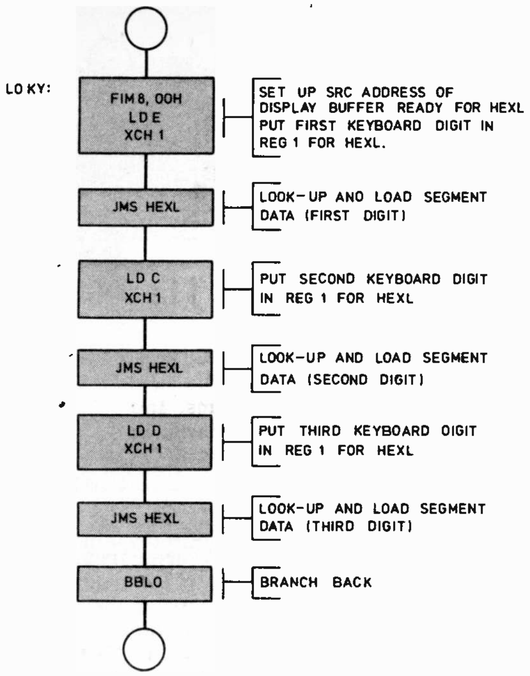


Fig. 6.7. Load keyboard subroutine. Refer to address 00CEH in CHOMP program

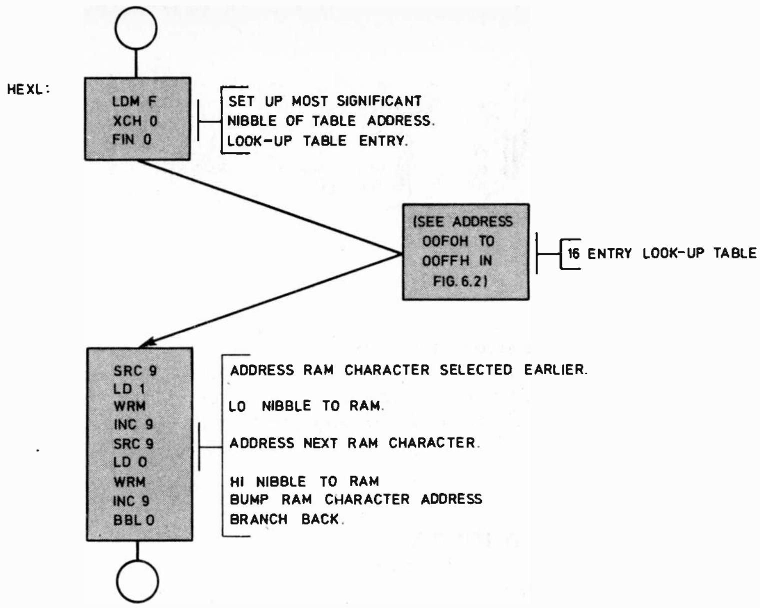


Fig. 6.8. Seven segment from hex look-up subroutine. Refer to address 00DDH in CHOMP program

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/$\overline{W}$ low when each digit is valid. There are some test instructions, such as TX=O, and these cause the $\overline{BR}$ 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/$\overline{W}$ and $\overline{BR}$ 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

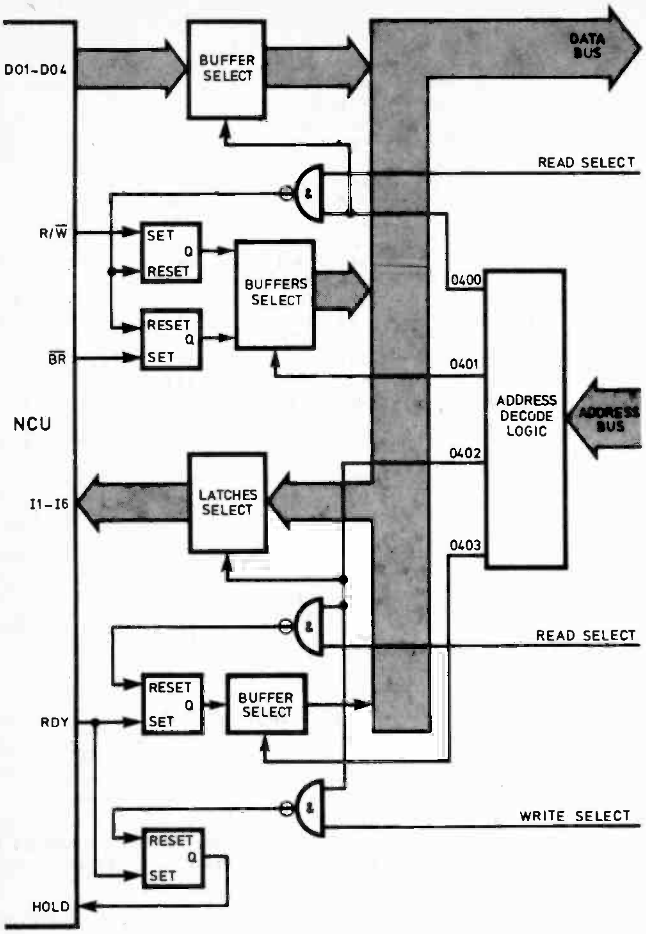
The complete interface circuit is shown in Fig. 2. The NCU is a PMOS device requiring a 9V supply (at 20mA) and to make it compatible with the microprocessor system supplies of +5V and −4V are used. The PIA side A inputs PA0-PA7 and CA2 presents one TTL load, and so pull-down resistors to the −4V rail are needed on the DO1–DO4 outputs, and $\overline{BR}$ needs a buffer transistor. The CA1 and CB1 inputs are high impedance so a pull-down resistor to 0V is needed on the R/$\overline{W}$ 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_6I_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*	SF1	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.



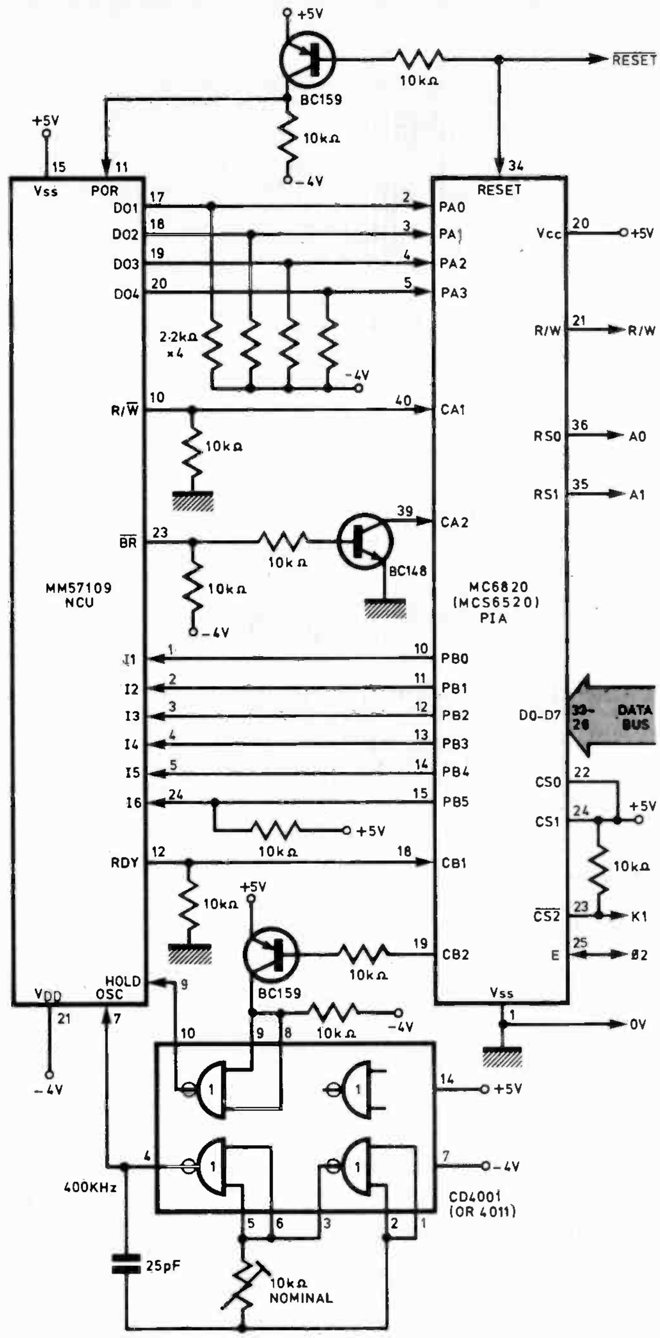


Fig. 1. Block diagram showing the logic needed to interface the Number Cruncher Unit with a micro as described. This logic is all provided in the PIA

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

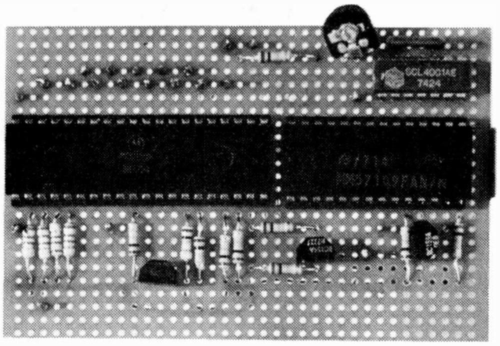
drivers are needed, and a CMOS inverter re-inverts HOLD to active high. Two other gates in the CMOS package form a simple 400kHz oscillator to drive the OSC input. Finally, a resistor is required from I6 to +5V as shown. The circuit was constructed on a plain matrix board using wire-threading (see Fig. 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/$\overline{W}$ has gone low, bit 7 will be set and a branch to the label $\overline{RW}$ is called for. If $\overline{BR}$ has gone low bit 6 will be set and a branch to $\overline{BR}$ 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.



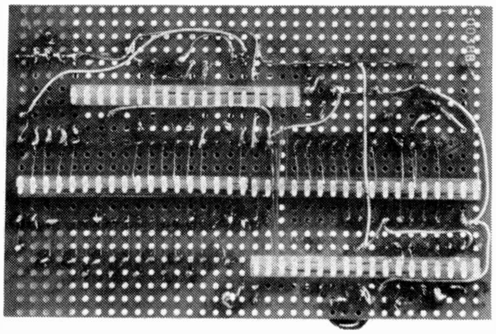


Fig. 3. The Number Cruncher Unit and interface circuits described in this article. Top and underside view

```
                ;       NUMBER-CRUNCHER (MM57109)
                ;       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  B4 00             LDY 0,X         LOAD INSTRUCTION
0222  E8                INX             POINT TO NEXT
0223  8C 02 04          STY BREG        SEND TO NCU
0226  C0 0F             CPY £$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

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/$\overline{W}$, and $\overline{BR}$ 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 × Sine
      Sine = Sine + Delta × 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 multiplication and effectively fixes Delta as 1/256."

The period of the sine wave produced is about 2π/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

RHYTHM GENERATOR

PART 2

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.

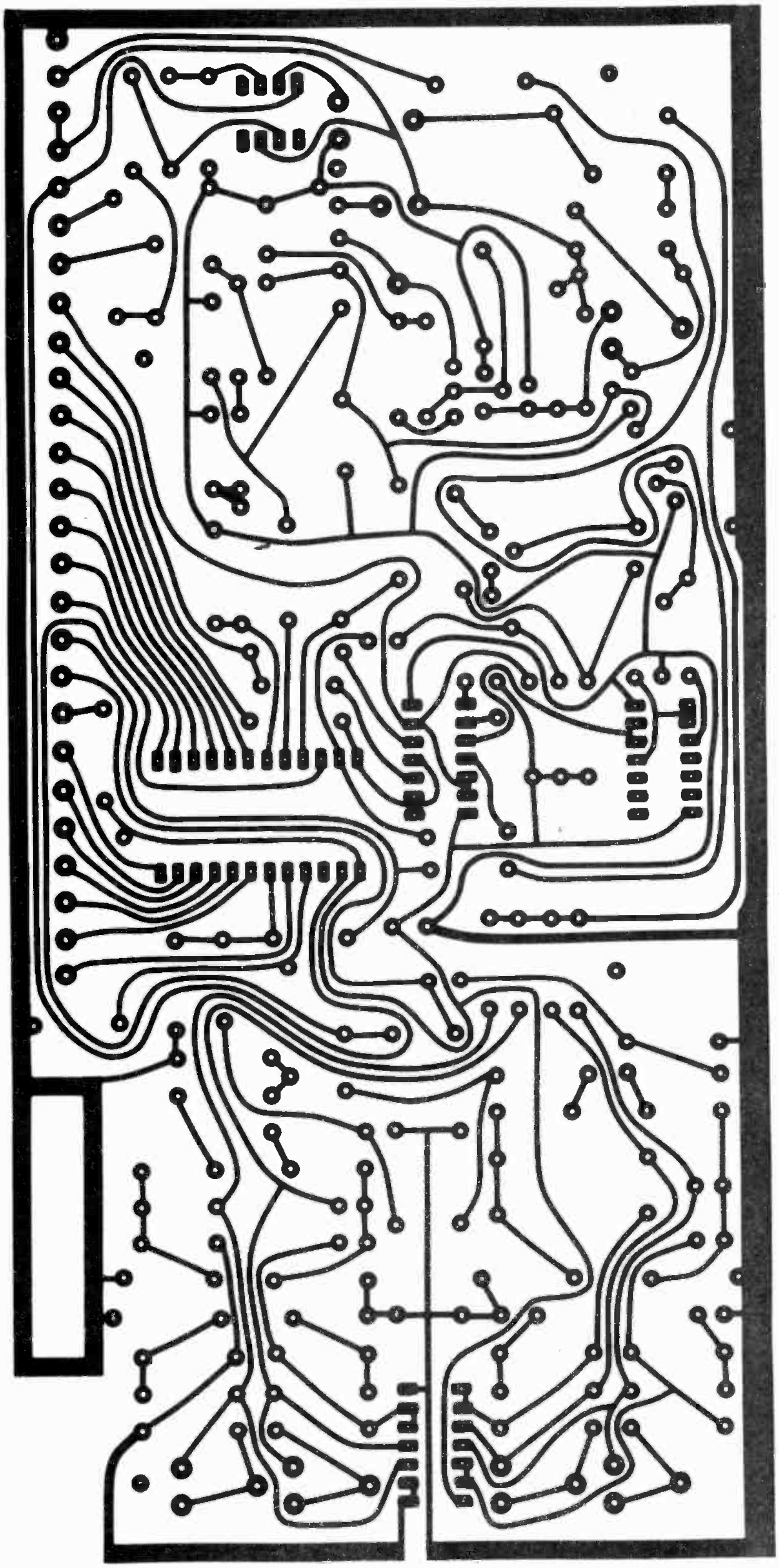
Another point to remember is that they should not be inserted or removed from their sockets while the power is switched on.

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 $\frac{1}{2}$in before fitting to the panel. The three knobs used have a very fine taper on the internal $\frac{1}{4}$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.



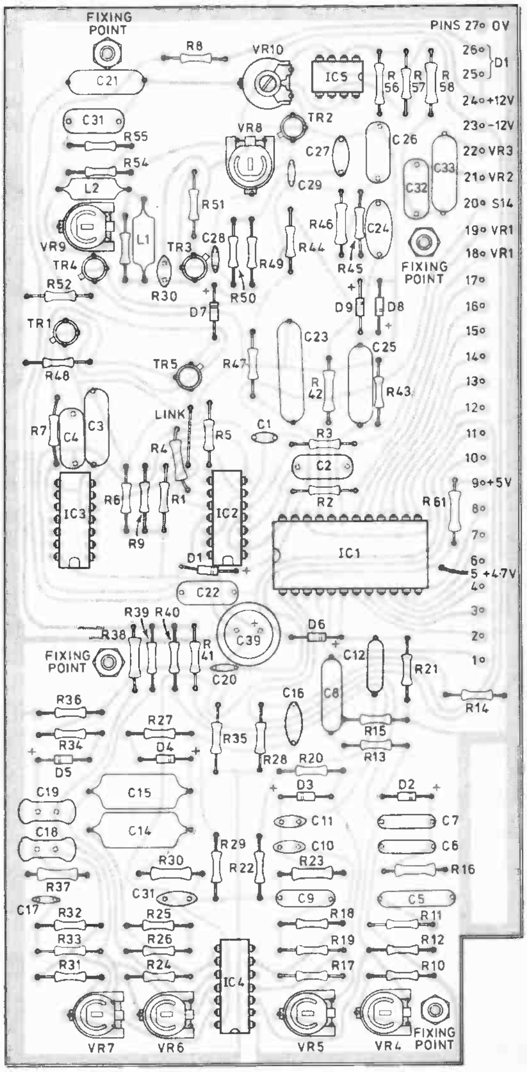


Fig. 11. Component layout on main board

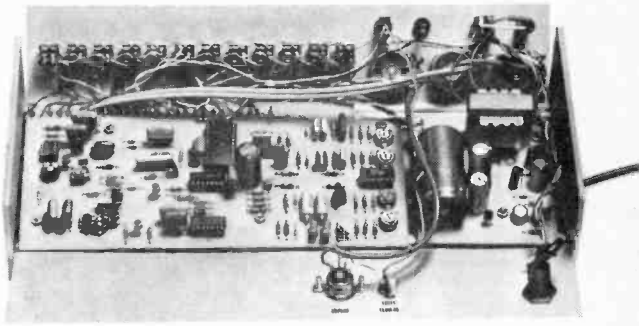


Fig. 10. Printed circuit layout of main board

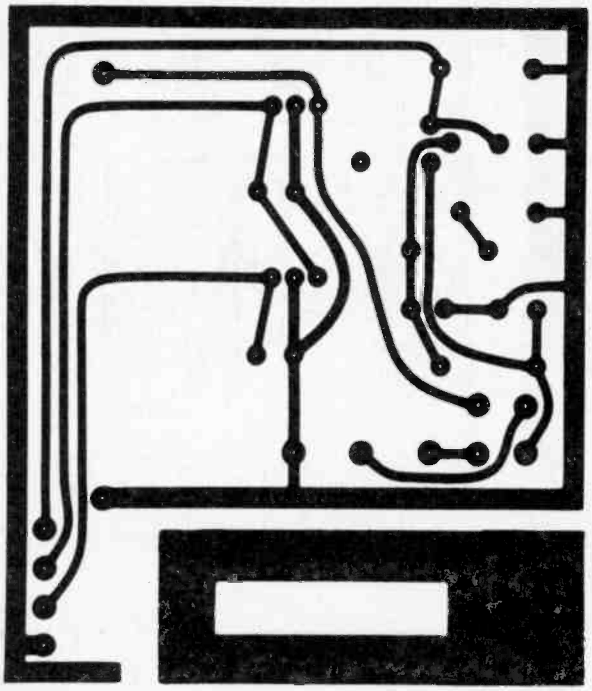


Fig. 12. Power supply board etching details

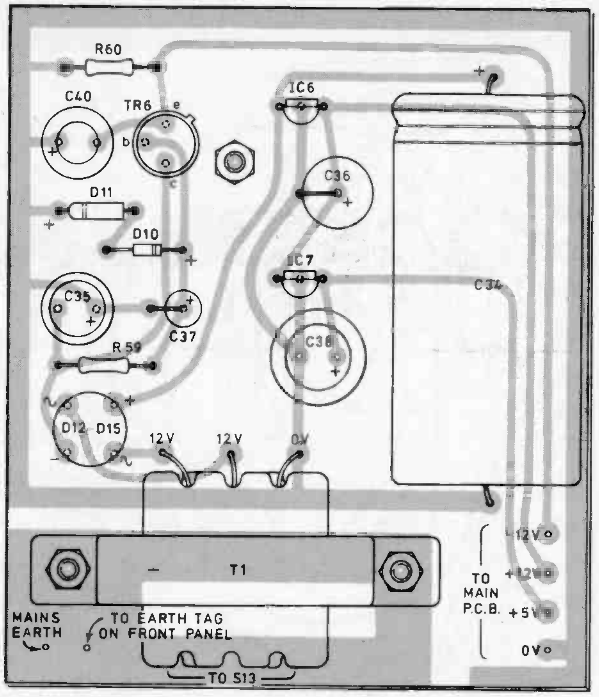
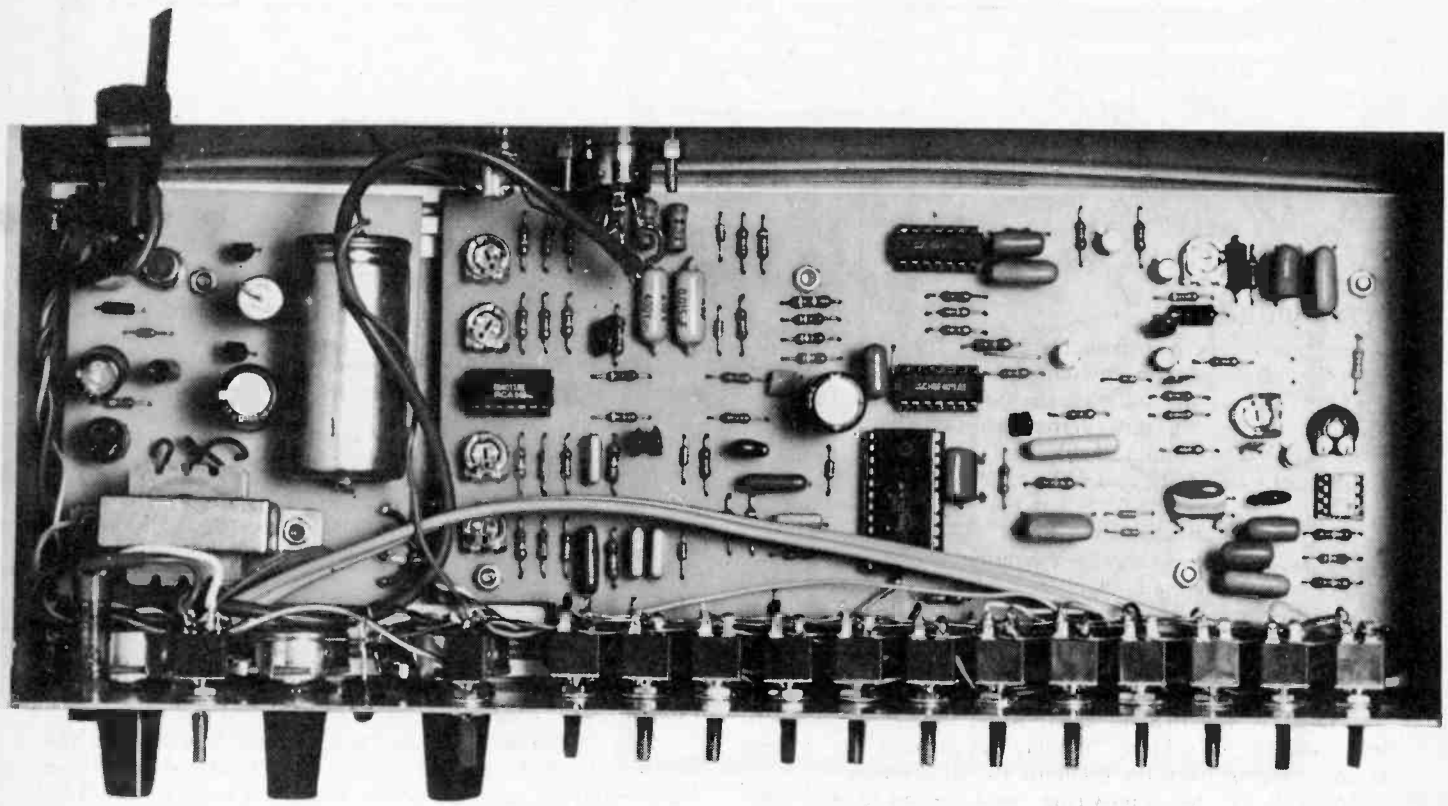


Fig. 13. Component layout of power supply board



Plan view of Generator interior

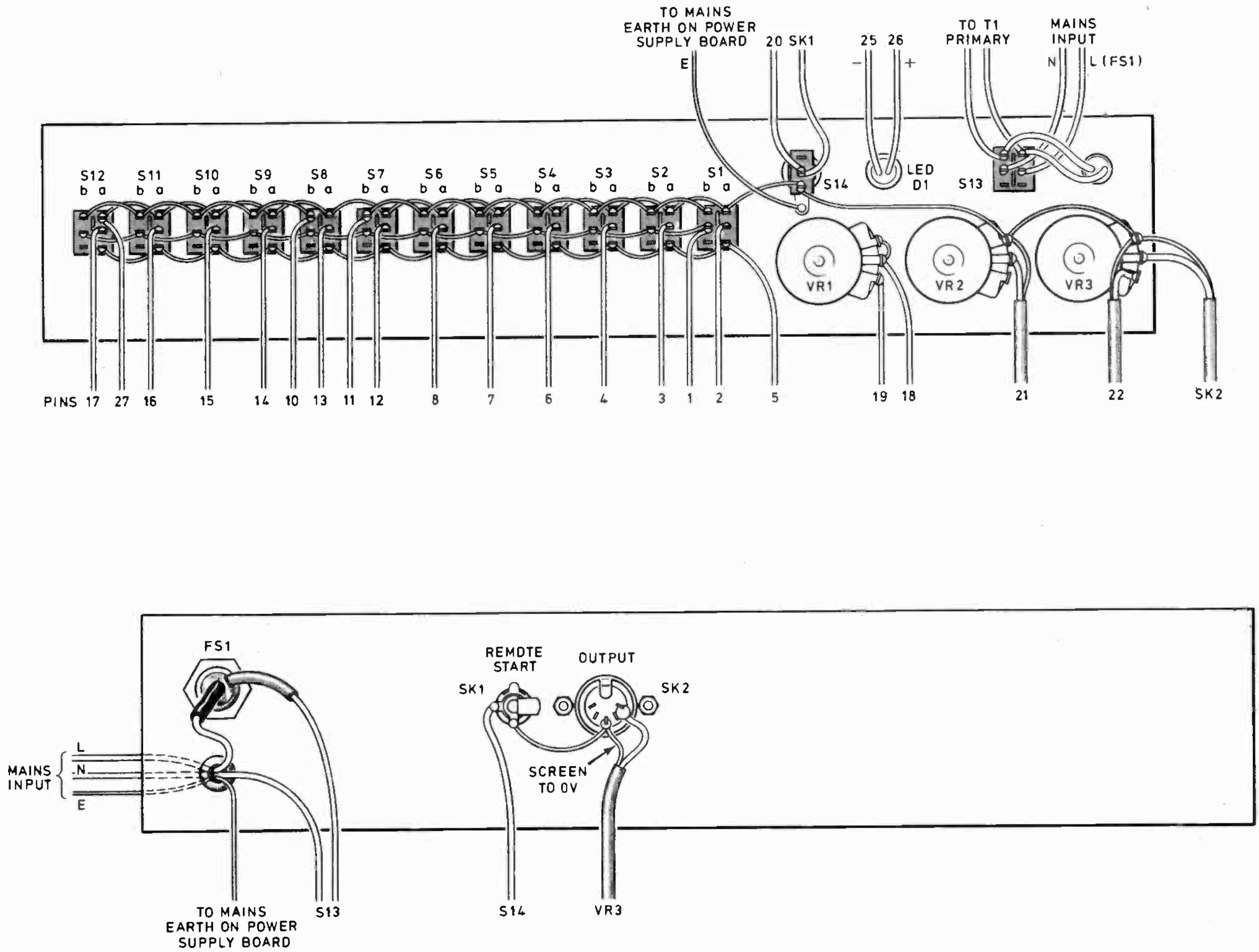


Fig. 15. Back panel wiring

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.

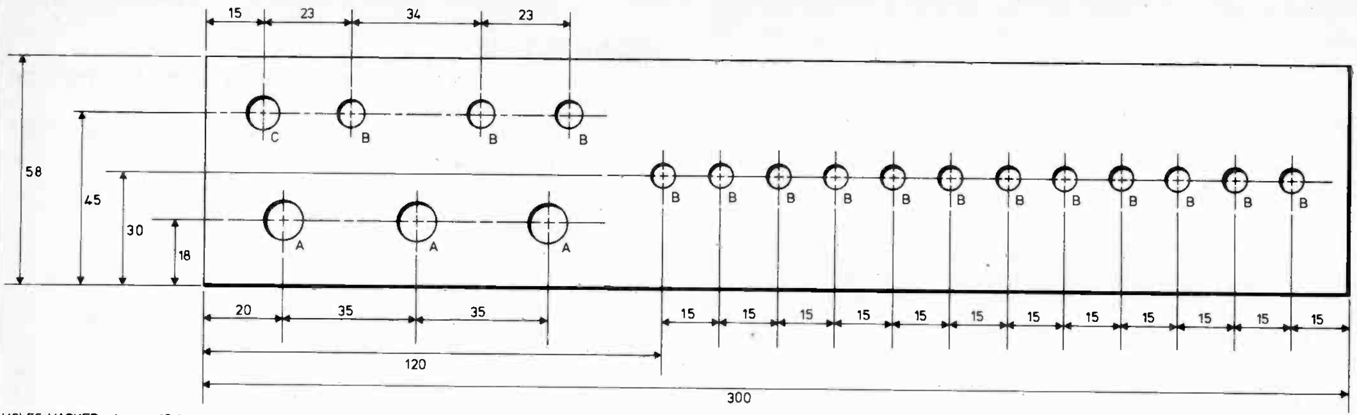
The row of Veropins should be nearest the front panel and two gaps of 30mm each should be left between the p.c.b. and front and back panel. If this gap is not left all the wires will be too short when the assembly is fitted into the case framework.

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.

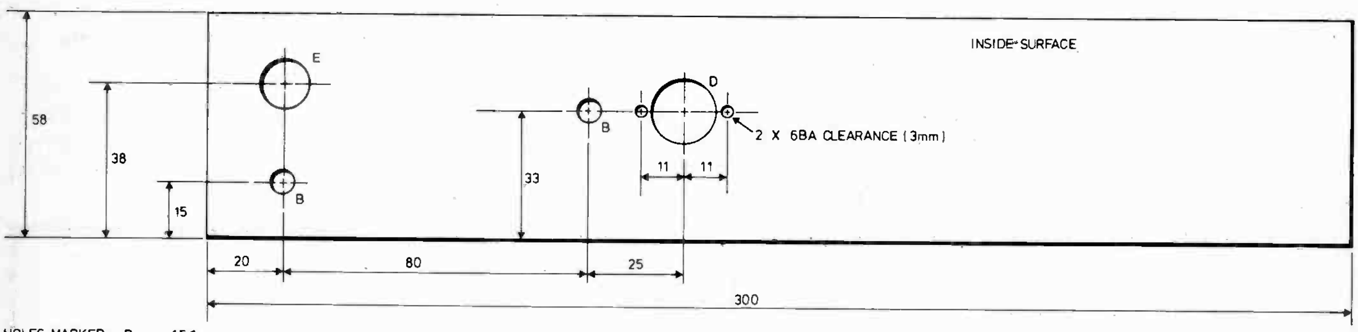
It is advisable to scrape away a small section of the anodised finish on the internal surfaces of the four aluminium extrusions and the front and back panels. This should be done to ensure a good earth contact throughout the case, as unfortunately the anodised surfaces act as an insulator.



HOLES MARKED A = 10φ
B = 6φ
C = 8φ
D = 15φ
E = 12·5φ

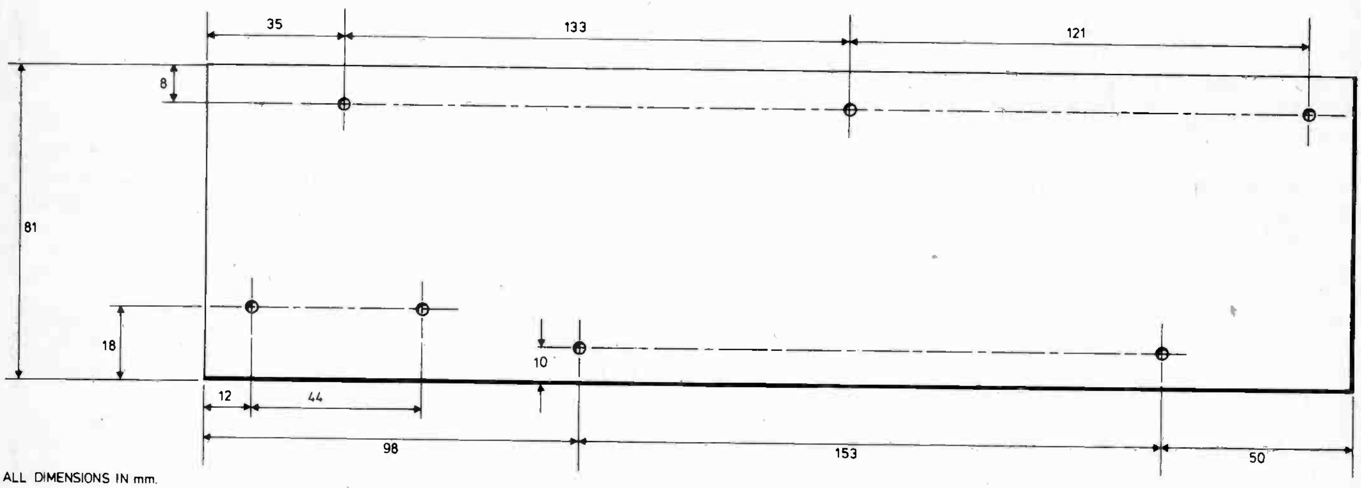
ALL DIMENSIONS IN mm

Fig. 16. Front panel showing dimensions and drilling details



HOLES MARKED D = 15φ
E = 12·5φ
ALL DIMENSIONS IN mm.

Fig. 17. Back panel



ALL DIMENSIONS IN mm.
ALL HOLES 6BA CLEAR

Fig. 18. Base panel

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 ± 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	Start	Stop/Start Switch
S3 to S14	Bossa Nova on	"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.

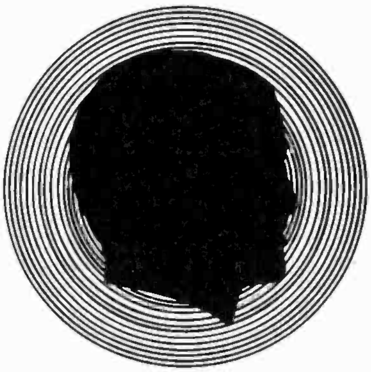
FINAL SETTING UP

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—25kΩ logarithmic, C31—0·1μF polyrad and IC1—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

A TELEPHONE MEMORY

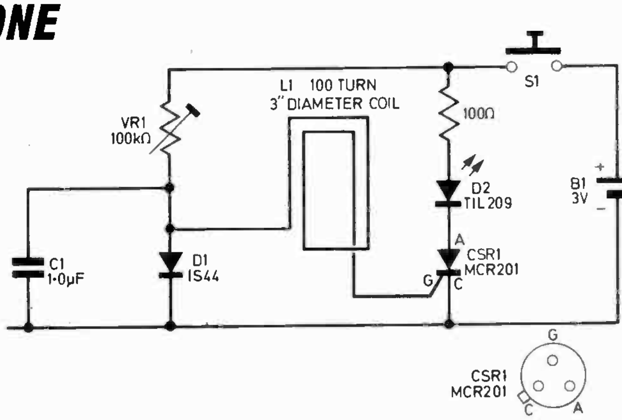


Fig. 1

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.

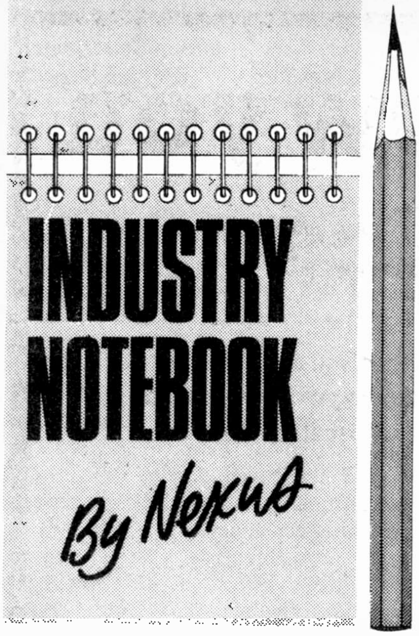
In Fig. 1 a 100-turn 3in. diameter coil of 30 s.w.g. enamelled copper wire is positioned on the underside of the telephone in a position (approximately dead centre where the bell magnetic field can be picked up. Voltage induced in the coil appears across the gate/cathode of thyristor MCR201 which is 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 60μA 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



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 shipborne 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 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

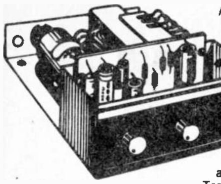
It's still action all the way in the Racal Electronics Group with expansion at home and overseas. Dana Laboratories in Irvine, California is the latest acquisition together with the Dana sales affiliates in the UK and France. The Dana range of digital instruments is now added to the complementary range 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.

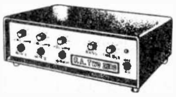
SUPERSOUND 13 HI-FI MONO AMPLIFIER



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 ± 3db. 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 cartridge. Sensitivity approx 40mV for full output. Supplied ready built and tested, with knobs, escutcheon panel, input and output plugs. Overall size 3in high × 6in wide × 7½in deep. AC 200/250V.

PRICE £15·00 P. & P. £1·20.

HARVERSONIC MODEL P.A. TWO ZERO



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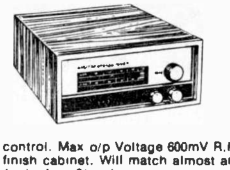

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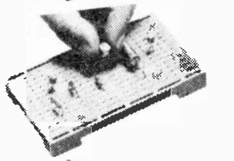

T-DEC

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.
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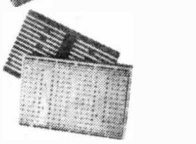
PRICE £4.30 inc. VAT.



µ-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.
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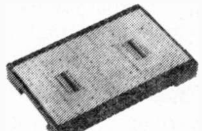
PRICE £4.31 inc. VAT.



µ-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.
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7445	49p*	74193	50p*
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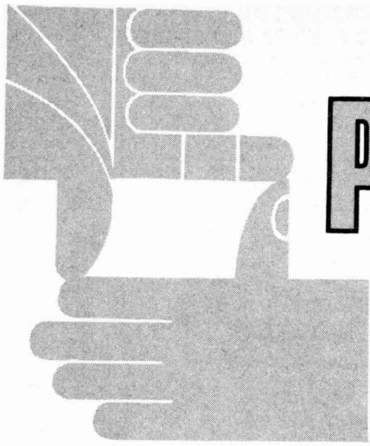


PATENTS REVIEW...

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.

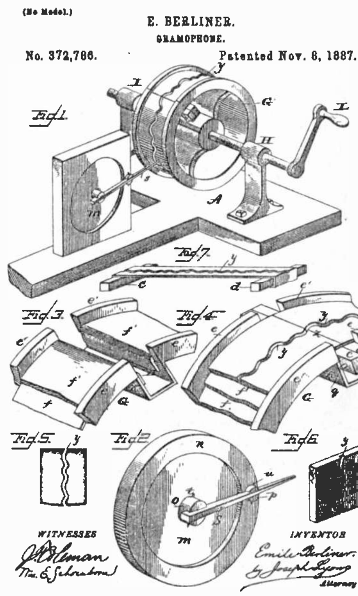
In July 1877, Edison filed a British Patent (BP 2927/1877) for a scheme to make a permanent record of a telegraph message by making impressions in paper on a disc or cylinder backing. In the same month, Edison patented (BP 2909/1877) a microphone system which enabled the human voice to be transmitted 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.

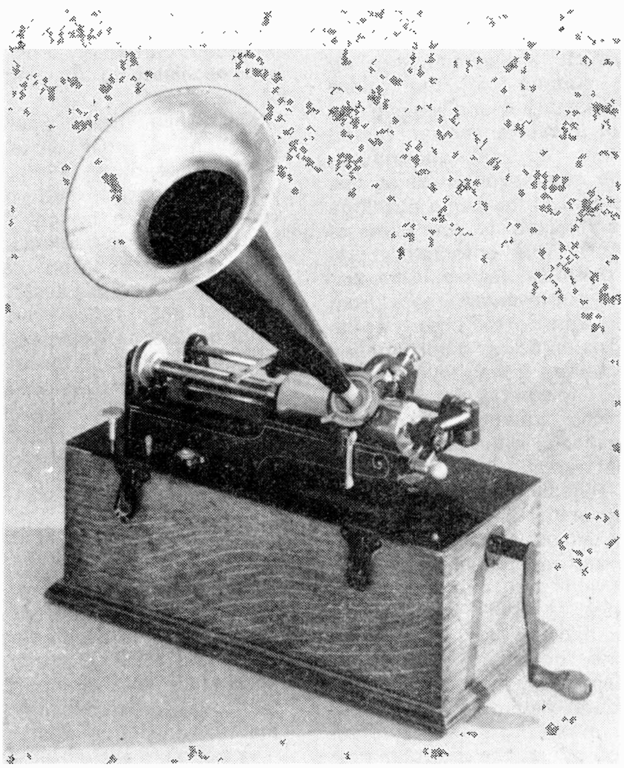
LATERAL CUT

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 vacuous 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.

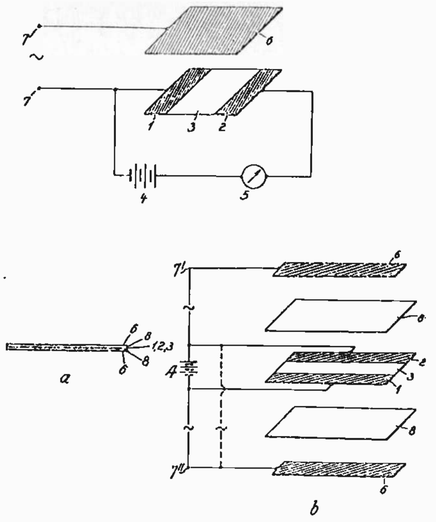
Modern multi-channel discs of discrete multiplex type (as marketed by JVC for the CD-4 system) find their origin there and in a 1946 invention made by EMI engineer William Livy (BP 612 163). The system relied on a recorded carrier to lock a demodulation oscillator to the rotational speed of the record.

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 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.

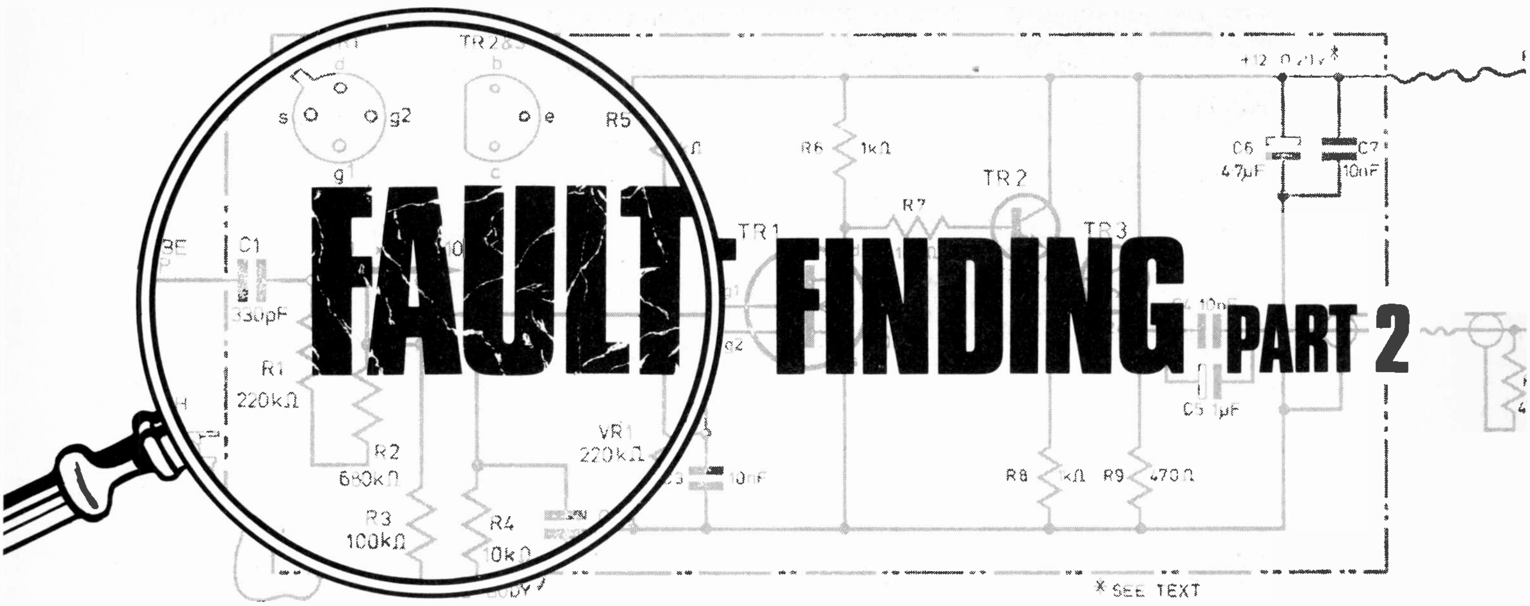


Paul Voigt patent illustration of 1924

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.



FAULT FINDING PART 2

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

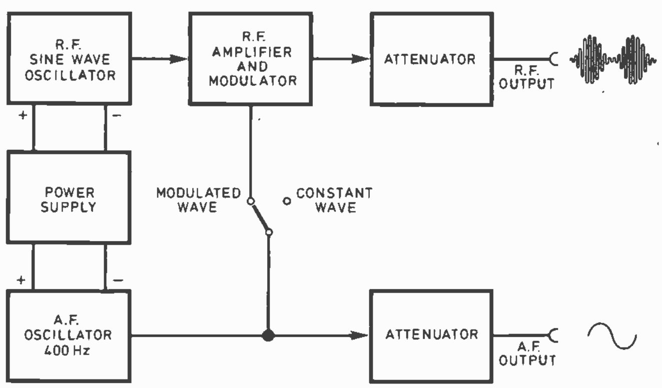


Fig. 2.1. Block diagram of r.f. generator

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)

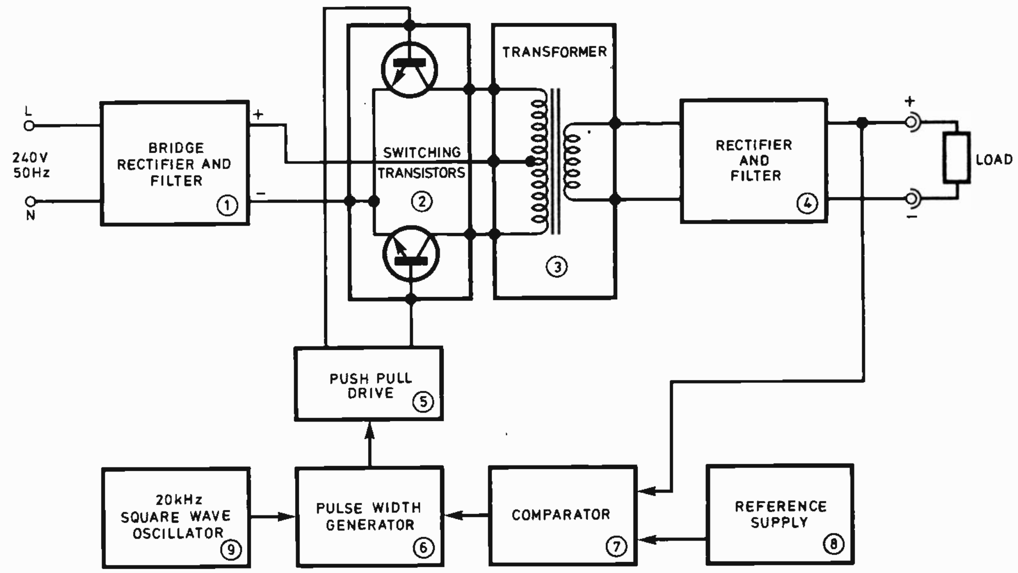


Fig. 2.2. Block diagram of switched mode power unit

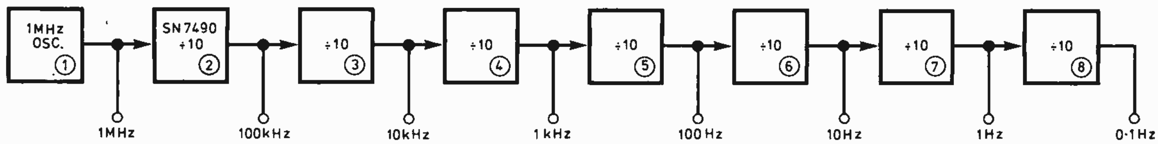


Fig. 2.3. Frequency divider chain

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 unstabilised 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 feed back 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.

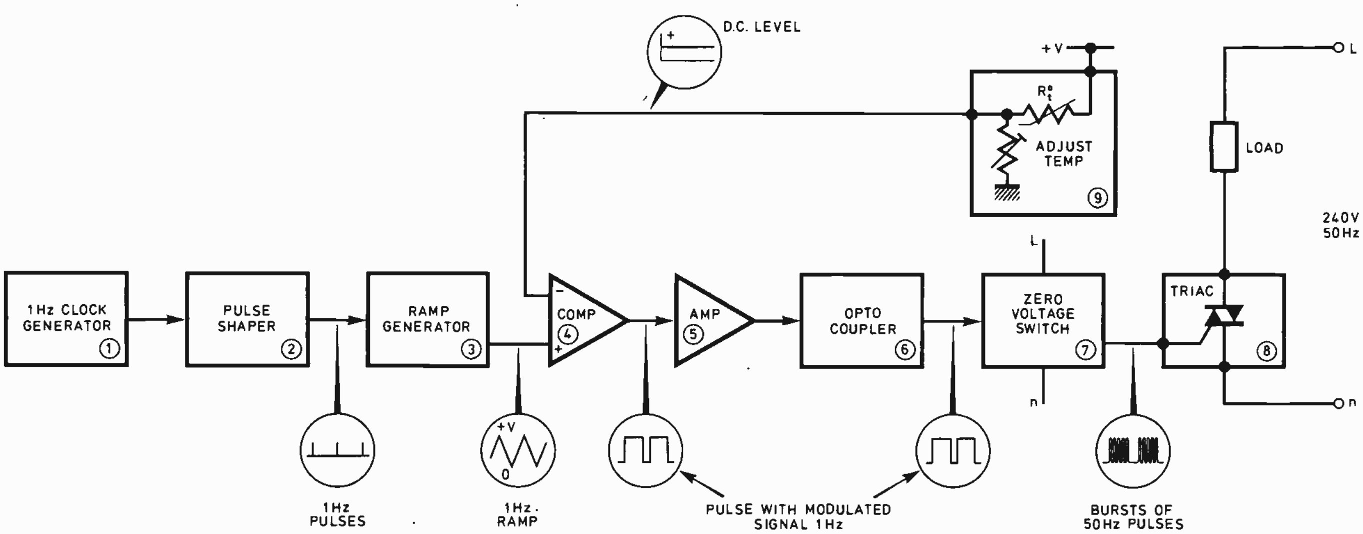


Fig. 2.4. Block diagram of temperature controller

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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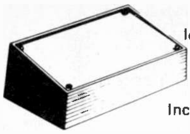

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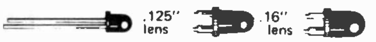

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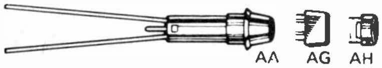

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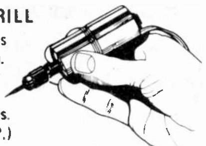

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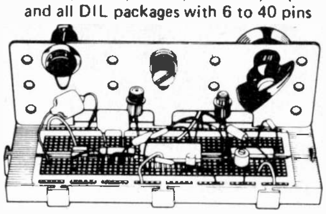

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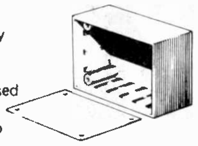

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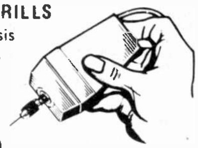

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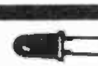

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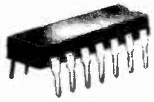

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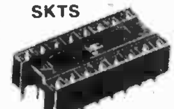

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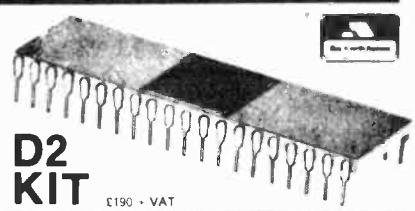

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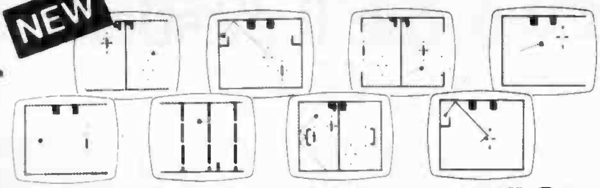

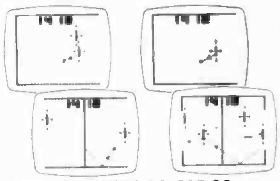

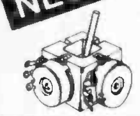

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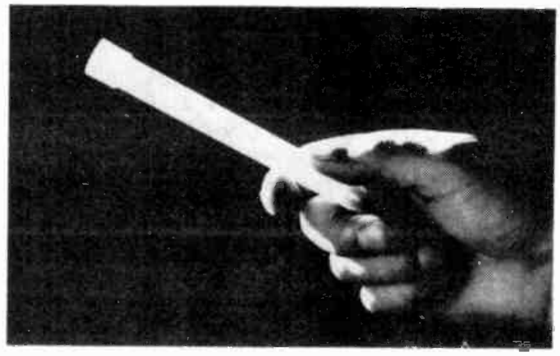

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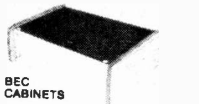

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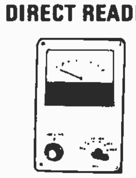

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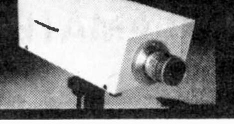

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