PRACTICAL

ELECTRONICS

OCTOBER 1977

40p

DIGITAL MULTIMETER

Also in this issue...

SUSTAIN UNIT FOR ELECTRIC GUITARS

U.K. RETURN OF POST MAIL ORDER SERVICE *also* WORLDWIDE EXPORT SERVICE

R.C.S. 10 WATT AMPLIFIER KIT

This kit is suitable for record players, tape play back, guitars, electronic instruments or small P.A. systems. Two versions are available. The mono kit uses 13 semiconductors. The stereo kit uses 22 semiconductors. Both kits have printed front panel and volume, bass and treble controls. Spec. 10W output into 8 ohms, 7W into 15 ohms. Response 20c/s to 30kc/s, input 100M.V. high imp. Size $9\frac{1}{2} \times 3 \times 2$in. A/C mains operated.

Mono kit **£11·25** Stereo kit **£18** post 45p

Easy to build. Full instructions supplied.

ELAC 10 inch £4·50

Ribbed cone. Large ceramic magnet. 50–16,000 c/s. Bass resonance 55 c/s. 10W. 15 ohm impedance.

ELAC 9×5in HI-FI SPEAKER TYPE 59RM £3·45 Post 35p

This famous unit now available. 10W, 8 ohm.

ELAC HI-FI SPEAKER 8in TWIN CONE

Dual cone plastic roll surround. Large ceramic magnet. 50-16,000 c/s. Bass resonance 40 c/s. 8 ohm impedance. 15 watts. RMS. **£5·95** Post 35p

MAINS TRANSFORMERS

ALL POST 50p each

250–0–250V 70mA, 6·3, 2A	£2·95
250–0–250 80mA, 6·3V 3·5A, 6·3V 1A or 5V 2A	£4·60
350–0–350 80mA, 6·3V 3·5A, 6·3V 1A or 5V 2A	£5·80
300–0–300 120mA 2 × 6·3V 2A C.T., 6·3V 2A	£8·50
220V 45mA, 6·3V 2A	£1·75
HEATER TRANS. 6·3V 3A, £1·45. ½ amp.	95p
GENERAL PURPOSE LOW VOLTAGE. Tapped outputs at 2A 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30V	£5·30
1A, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£5·30
2A, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£8·50
3A, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£11·00
5A, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£14·50

5, 8, 10, 16V ½A £2. 12V 100mA £1. 12V 300mA £1. 12V 750mA £1. 40V 2A tapped 10V or 30V £2·95. 20V 3A £2. 40V 2A £2·95. 30V 5A + 34V 2A ct. £3·75. 2 × 18V 6A £11.
20–0–20V 1A £2·95. 30V 1½A £2·75 20V 1A £2·20.
60V, 40V, 20V or 20–0–20V, 1A £3·50.
AUTO TRANSFORMERS. 115V to 230V or 230V to 115V 150W £5; 250W £6; 400W £7; 500W £8.
CHARGER TRANSFORMERS. Input 200/250V for 6 or 12V 1½A £2·75; 4A £4·60.
FULL WAVE BRIDGE CHARGER RECTIFIERS: 6 or 12V outputs 1½A 40p; 2A 55p; 4A 85p.

GOODMAN'S COMPACT 12in BASS WOOFER

Standard 12in diameter fixing with cut sides $10\frac{1}{2}$in square. 14,000 gauss magnet. 30 watt r.m.s. 4 ohm impedance. Bass resonance: 30 c.p.s. Frequency response: 30–8,000 c.p.s. £10·95 each. Post £1·00.

PERIOD LOUDSPEAKER CABINETS

Two styles available, Regency and Queen Anne. Size approximately 34 × 19 × 16in. These cabinets are slightly soiled and are priced from £10 each. Callers only.

BARGAIN 3+3W STEREO AMPLIFIER. 10 Transistor Push-Pull Ready built with volume, treble and bass controls. 240V operated. **£10·95**

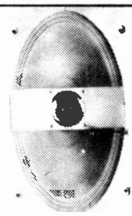
HEATING ELEMENTS WAFER THIN

Size $10\frac{1}{2} \times 8\frac{1}{2} \times \frac{1}{16}$in. Operating voltage 200/250V a.c. 250W approx. Suitable for Heating Pads, Food Warmers, Convector Heaters, etc. Must be clamped between two sheets of metal or asbestos.

ONLY **40p** EACH (FOUR FOR £1·50)

ALL POST PAID—Discounts for quantity.

E.M.I. $13\frac{1}{2} \times 8$in SPEAKER SALE!



With tweeter. And crossover. 10W. State 3 or 8 ohm. As illustrated. **£7·95** Post 45p

15W model £10·50 8 ohms. Post 65p

20W model £11·50 4 or 8 or 15 ohms. Post 65p

TEAK VENEER HI-FI SPEAKER CABINETS

MODEL "A". 20 × 13 × 12in. For 12in. dia. or 10in. speaker. Illustrated. **£14·50** Post £1·60

MODEL "B". BOOKSHELF For 13 × 8in. or 8in. speaker. **£8·50** Post £1

R.C.S. BOOKSHELF SPEAKERS Size 14 × 9 × 6in. approx. Response 50 to 14,000 cps 6 watt rms 8 ohms. **£16 pair** Post £1·30

ACOUSTIC WADDING 18in. wide, 20p ft.

KUBA-KOPENHAGEN STEREO

TUNER-AMPLIFIER CHASSIS AM-FM 5+5 WATT

This Continental 4-band radiogram chassis uses first class quality components throughout. Features: Large facia panel with 7 push buttons for medium, long, short, VHF-FM, AFC, phono, mains on-off. 4-rotary controls, tuning, volume, tone, balance. Facia size $17 \times 4\frac{1}{2}$in. Chassis size $17 \times 4\frac{1}{2} \times 5\frac{1}{2}$in. DIN-connector sockets for tape record/playback, loudspeakers, phono pick-up, external FM-AM aerials. Automatic stereo beacon light. Built-in ferrite rod aerial for medium/longwave. a.c. 240V mains. Circuit supplied. **£33·50** Post £1·50

BAKER MAJOR 12 INCH £15

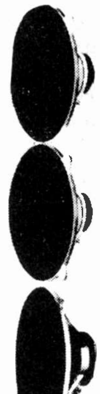
Post £1·00

30–14,500 c/s. 12in double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s. Rated 25W.
NOTE: 4 or 8 or 16 ohms available.

Module kit, 30–17,000 c/s with tweeter, crossover, baffle, $19 \times 12\frac{1}{2}$in, instructions. As illustrated. **£19**

Please state 4 or 8 or 16 ohms. Post £1·60

"BIG SOUND" BAKER SPEAKERS



Robustly constructed to stand up to long periods of electronic power. As used by leading groups and discos. Useful response 30–13,000 c/s. Bass Resonance 55 c/s.

GROUP "25" 12in 30W 4, 8 or 16 ohms. **£12** Post £1

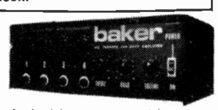
GROUP "35" 12in 40W 4, 8 or 16 ohms. **£14** Post £1

GROUP 50/12in 60W 8 or 16 ohns with aluminium presence dome. **£21** Post £1·60

GROUP 50/15in 15in 75W 8 or 16 ohms **£26** Post £1·60

Disco, Group + PA Cabinets in stock. Send for Leaflet. Cabinet Fittings, Handles, Corners, Feet, Covering Material all in stock.

BAKER 150 WATT ALL PURPOSE TRANSISTOR AMPLIFIER



Ideal for Groups, Disco, P.A. and Musical Instruments. 4 inputs speech and music. 4 way mixing. Output 4/8/16 ohm. a.c. Mains Separate treble and bass controls. **£72** Carr. £1·50

NEW "DISCO 100 WATT" £52

ALL TRANSISTOR AMPLIFIER CHASSIS Carr. £1

2 inputs. 4 outputs separate volume treble and bass controls. Ideal disco or slave amplifier chassis.
BLACK CARRYING CABINET AVAILABLE £9.

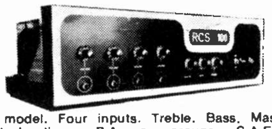
PW SOUND TO LIGHT DISPLAY

Complete kit of parts with R.C.S. printed circuit. Three 1,000W channels. As featured in Practical Wireless. CABINET extra £3. **£14·00**

GOODMANS CONE TWEETER

18,000 c/s. 25W 8 ohm. Price **£3·25**
E.M.I. 5in. mid range 25W £4·95.
E.M.I. 13 × 8in. 25W Bass Unit £10·50

R.C.S. 100 WATT VALVE AMPLIFIER CHASSIS



Professional model. Four inputs. Treble. Bass. Master Volume Controls. Ideal disco, P.A. or groups. S.A.E. for details. 5 speaker outputs 3 or 8 or 15 ohm. 100V line to order. Suitable carrying case £16·50. **£85** plus £2·50 carr.

LOW VOLTAGE ELECTROLYTICS

1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V 10p. 500mF 12V 15p; 25V 20p; 50V 30p. 1000mF 12V 17p; 25V 35p; 50V 47p; 100V 70p. 2000mF 6V 25p; 25V 42p; 50V 57p. 2500mF 50V 62p; 3000mF 25V 47p; 50V 65p. 3900mF 100V £1·60. 4700mF 63V £1·20. 5000mF 6V 25p; 12V 42p; 25V 75p; 35V 85p; 5600mF 76V £1·60.

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS

All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer. Input 200/240V a.c. Output voltages available 6 or 7·5 or 9 or 12V d.c. up to 100mA or less. Size $3 \times 2\frac{1}{2} \times 1\frac{1}{4}$in. Please state voltage required. **£2·95** Post 45p

R.C.S. POWER PACK KIT

12V, 750mA. Complete with printed circuit board and assembly instructions. **£3·35**
12V 300mA KIT, £3·15. 9V 1 amp KIT, £3·35. Post 30p

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER—BRITISH MADE £1·45

Ideal for Mike, Tape, P.U., Guitar. Battery 9–12V or H.T. line 200–300V d.c. operation. Size $1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{2}$in. 25 c/s to 25 kc/s. 26 dB gain. For valve or transistor equipment. Instructions supplied.

ELECTRO MAGNETIC PENDULUM MECHANISM 95p Post 30p

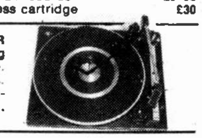
1·5V d.c. operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or for metronome, strobe, etc.

BSR HI-FI AUTOCHANGER

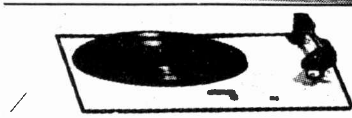
Plays 12in, 10in or 7in records Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee. a.c. 200/250V. Size $13\frac{1}{2} \times 11\frac{1}{4}$in. Above motor board $3\frac{1}{4}$in. Below motor board $2\frac{1}{2}$in. With STEREO/MONO CARTRIDGE. **£11·95** All Post 75p

Single Player version £13·50.	
BSR P128 with Magnetic Cartridge	£24·50
GARRARD MINICHANGER plays all records	£9·95
BSR P163 BELT DRIVE DECK, less cartridge	£30

BSR DE LUXE AUTOCHANGER



Features balanced arm. Cueing device, stylus pressure gauge. 3 speed plays all size records. Fitted with stereo ceramic cartridge. Size: 13 × 12in. £17·50. Post £1.



R.C.S. DISCO DECK SINGLE RECORD PLAYER

Fitted with auto stop, stereo/cartridge. Baseplate. Size $11 \times 8\frac{1}{2}$in. Turntable. Size 7in diameter. a.c. mains. 220/250V. 3 speeds plays all size records. **£6·95** Post 45p
Two for £13. Post 75p.

HEAVY METAL PLINTHS

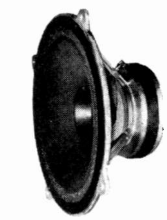
With P.V.C. Cover. Cut out for most B.S.R. or Garrard decks. Silver grey finish. **£6·50**
Model "A". Size $12\frac{1}{2} \times 14\frac{1}{2} \times 7\frac{1}{2}$in.
Model "B". Size $16 \times 13\frac{1}{2} \times 7$in. £7·50. Post £1·30
Extra Large Plinth and Cover. For transcription decks. Size $20 \times 17\frac{1}{2} \times 9$in. uncut board. Callers only £18·50.

TINTED PLASTIC COVERS ONLY

Sizes: "A"—$14\frac{1}{2} \times 12\frac{1}{2} \times 4\frac{1}{2}$in, £3. "B"—$20\frac{1}{2} \times 12\frac{1}{2} \times 4\frac{1}{2}$in, £3·75. "C"—$17\frac{1}{2} \times 13\frac{1}{2} \times 3\frac{1}{2}$in, £3·75. "D"—$16\frac{1}{2} \times 14 \times 4$in, £4. "E"—$19 \times 14\frac{1}{2} \times 4\frac{1}{2}$in, £4. $15 \times 13\frac{1}{2} \times 3$in, £3·50. Ideal for record decks, tape decks, etc. Post 75p.

BAKER HI-FI SPEAKERS

HIGH QUALITY—BRITISH MADE



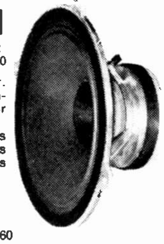
SUPERB £22
12in 25 watt Post £1·60

Quality loudspeaker, low cone resonance ensures clear reproduction of the deepest bass. Special copper drive and concentric tweeter cone. Full range reproduction with remarkable efficiency in the upper register.

Bass Resonance	25 c/s
Flux Density	16,500 gauss
Useful response	20–17,000 c/s

8 or 16 ohms models.

AUDITORIUM £21
12in 35 watt Post £1·60



A full range reproducer for high power. Electric Guitars, public address, multi-speaker systems, electric organs. Ideal for Hi-Fi and Discotheques.

Bass Resonance	35 c/s
Flux Density	15,000 gauss
Useful response	25–16,000 c/s

8 or 16 ohms models.

AUDITORIUM £26
15in 45 watt Post £1·60

BLANK ALUMINIUM CHASSIS, 18 s.w.g. $2\frac{1}{2}$in sides. 6 × 4in, 70p; 8 × 6in, 90p; 10 × 7in, £1·15; 14 × 9in, £1·50; 16 × 6in, £1·45; 12 × 3in, 87p; 16 × 10in, £1·70; 12 × 8in, £1·35.
ALUMINIUM PANELS, 18 s.w.g. 6 × 4in, 15p; 8 × 6in, 25p; 10 × 7in, 30p; 12 × 5in, 30p; 12 × 8in, 40p; 16 × 6in, 45p; 14 × 9in, 50p; 12 × 12in, 55p; 16 × 10in, 75p.
ALUMINIUM ANGLE BRACKET, $6 \times \frac{3}{4} \times \frac{3}{4}$in. 15p.
ALUMINIUM BOXES, MANY SIZES IN STOCK.

THE "INSTANT" BULK TAPE ERASER & HEAD DEMAGNETISER.

Suitable for cassettes, and all sizes of tape reels. a.c. mains 200/240V. Leaflet S.A.E. **£4·95** Post 40p

RADIO COMPONENT SPECIALISTS 337 WHITEHORSE ROAD, CROYDON, U.K. Tel. 01-684 1665

Minimum post 30p. Access and Barclaycard. Same day despatch. Radio Books and Components Lists 20p. Open 9—6 Wed. 9—1 Sat. 9—5 (Closed for lunch 1.15—2.30)

PRACTICAL
ELECTRONICS

VOLUME 14 No. 2 OCTOBER 1977

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

Our November issue will be on sale Friday, 7 October, 1977
(for details of contents and special 8 page supplement see page 119)

GREENWELD

443 Millbrook Road Southampton
SO1 OHX Tel: (0703) 772501

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

★ ***SAVE ON TIME—No delays in waiting for parts to come or shops to open!***

★ ***SAVE ON MONEY—Bulk buying means lowest prices—just compare with others!***

★ ***HAVE THE RIGHT PART—No guesswork or substitution necessary!***

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

K001 50V ceramic plate capacitors, 5%. 10 of each value 22pF to 1000pF. Total 210, **£3·35**

K002 Extended range, 22pF to 0·1µF. 330 values **£4·90**

K003 Polyester capacitors, 10 each of these values: 0·01, 0·015, 0·022, 0·033, 0·047, 0·068, 0·1, 0·15, 0·22, 0·33, 0·47µF. 110 altogether for **£4·75**

K004 Mylar capacitors, min 100V type. 10 each all values from 1000pF to 10,000pF. Total 130 for **£4·45**

K005 Polystyrene capacitors, 10 each value from 10pF to 10,000pF, E12 series 5% 160V. Total 370 for **£12·30**

K006 Tantalum bead capacitors. 10 each of the following: 0·1, 0·15, 0·22, 0·33, 0·47, 0·68, 1, 2·2, 3·3, 4·7, 6·8, all 35V; 10/25 15/16 22/16 33/10 47/6 100/3. Total 170 tants for **£14·20**

K007 Electrolytic capacitors 25V working, small physical size. 10 each of these popular values: 1, 2·2, 4·7, 10, 22, 47, 100µF. Total 70 for **£3·50**

K008 Extended range, as above, also including 220, 470 and 1000µF. Total 100 for **£5·90**

K021 Miniature carbon film 5% resistors, CR25 or similar. 10 of each value from 10R to 1M, E12 series. Total 610 resistors, **£6·00**

K022 Extended range, total 850 resistors from 1R to 10M **£8·30**

K041 Zener diodes, 400mW 5%. BZY88 etc. 10 of each value from 27V to 36V, E24 series. Total 280 for **£15·30**

K042 As above but 5 of each value **£8·70**

PC ETCHING KIT MK III

Now contains 200 sq. ins. copper clad board, 1lb. Ferric Chloride, DALO etch-resist pen, abrasive cleaner, two miniature drill bits, etching dish and instructions, **£4·15.**

FERRIC CHLORIDE

Anhydrous technical quality in 1lb double sealed packs. 1lb **£1·00**; 3lb **£2·18**; 10lb **£5·60**; 100 lb **£39·00.**

MOTORS

240V ac 60 rpm. High torque, drive to 6mm shaft 20mm long. Size 70mm dia × 55mm **£2·20.**

LED DIGIT DRIVER

ITT type 7105. 16 pin DIL package. Supplied with data sheet. 8 for £1.

VERO OFFCUTS

Pack A, All 0·1"
Pack B, All 0·15"
Pack C, Mixed
Pack D, All 0·1" plain

Each pack contains 7 or 8 pieces with a total area of 100 sq in. Each pack is **£1·30.** Also available by weight, 1lb **£3·45**, 10lb **£28.** We are also VERO wholesalers—Trade price list on request from Bone Fide Companies.

VEROCASES

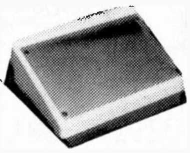
Plastic top and bottom, ally panels front and back.

Type		
1410	205 × 140 × 40mm	£3·70
1411	205 × 140 × 75mm	£4·17
1412	205 × 140 × 110mm	£5·20
1237	154 × 85 × 40mm	£2·83
1238	154 × 85 × 60mm	£3·05
1239	154 × 85 × 80mm	£3·75

PLASTIC BOXES

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 version.

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	£2·10
T-DEC Breadboard	£3·75

1977 CATALOGUE NOW AVAILABLE—MUCH BIGGER AND BETTER, WITH DISCOUNT VOUCHERS. ONLY 30p plus 15p POST.

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.

LEKTROPAKS

17 TURNHAM GREEN TERRACE, CHISWICK, LONDON W.4
Tel. 01-994 2784

★ LARGE RANGE OF COMPONENTS NOW STOCKED. SEND LARGE S.A.E. FOR FREE LISTS.

★ OCTOBER OFFER—25% OFF ALL SEMICONDUCTOR SALES FOR PERSONAL CALLERS BRINGING THIS ADVERT.

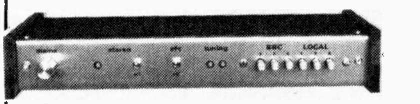
★ WALK-ROUND SELF-SERVICE SHOP NOW OPEN MON-SAT 9.30-5.30.

★ MANY SURPLUS COMPONENT BARGAINS FOR PERSONAL CALLERS.

★ RESISTORS, CAPACITORS, TRANSISTORS, DIODES, TRIACS, DIACS, ICs, POTS, ALI BOXES, VERO, COPPER CLAD BOARD, CABLE, AUDIO CONNECTORS, SPEAKERS, MICROPHONES, P.A. TRANSFORMERS, KNOBS, ETC, ETC.

Designer approved

ORION STEREO TUNER



Complete set of semiconductors	£4·99
Mullard LP1186 tuner head	£9·60
High quality glass fibre P.C.B.	£2·45

ORION STEREO AMPLIFIER

Complete set of semiconductors	£9·40
High quality glass fibre P.C.B.	£2·99

Both the above PCBs are printed with component locations

PE DIGITAL VOLTMETER

ZNA116 *£6·00 with circuits and data

Complete set of all semiconductors for the P.E. DVM including I.C.'s, transistors, diodes, displays, regulator, etc.	£20·50*
Set of two professional grade glass fibre P.C.B.'s printed with component locations	£3·40*
Complete set of resistors, incl. attenuator resistors	£1·00*
Complete set of capacitors incl. 2200µF power supply	£1·60*

ZN424 £1, ZN423* £1, ZN7447* £1·75, 78MO5 regulator* 85p.
SEVEN SEGMENT DISPLAYS: DL701* (+/−1) £1·75, DL707* (0–9) £1·75.
TEXAS I.C. SOCKETS: 14 pin 25p*, 16 pin 30p*, 24 pin 45p low profile.

FERRANTI SEMICONDUCTORS—WE ARE THE EXPERTS!

BZV zeners	10p	BFS98	14p	ZTX107	11p	ZTX239	18p	MOTOROLA	
All types		MS4A*	£1·35	ZTX108	9p	ZTX320	18p	BD699*	£1·14
BC415P	17p	ZS170	13p	ZTX109	11p	ZTX384	17p	BD700*	£1·28
BFS60	15p	ZS178	54p	ZTX212	15p	ZTX450	18p	MC1310P	£1·80
BFS61	15p	ZS271*	23p	ZTX213	15p	ZTX550	18p	MC1357PQ	£1·65
BFS97	15p	ZTXA20	10p	ZTX214	17p	ZTX4403	18p	SN76660N	75p

We can supply any FERRANTI semiconductor device. S.A.E. for quotation.
ZN1034E* £1·80, ZN1040E* universal count/display i.c., with data £7·50

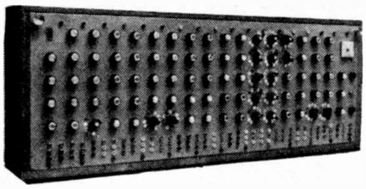
PE TV SOUND SEPARATOR

Complete set of semiconductors £2·30, High quality glass fibre p.c.b. £1
POSTAGE AND PACKING 15p per order. Orders over £5 post free. All devices are top grade, brand new and to full manufacturer's spec. We do not sell seconds or rejects. Send S.A.E. for our data sheet and price list.
Prices do not include VAT—add 8% to items marked*, and 12½% to all others

DAVIAN ELECTRONICS (MAIL ORDER, CALLERS BY APPOINTMENT)

13 Deepdale Avenue, Royton, Oldham OL2 6XD

KITS FOR SYNTHESISERS, SOUND EFFECTS



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

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

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

PHONOSONICS

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

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

Set of basic component kits	from £64·25
Set of printed circuit boards	£9·71

P.E. SYNTHESISER (P.E. Feb. 73 to Feb. 74)
The well acclaimed and highly versatile large-scale mains-operated Sound Synthesiser complete with keyboard circuits. Other circuits in our lists may be used with the Synthesiser to good advantage, notably, P.E. Minisonic, Phasing Unit, Wind and Rain, Rhythm Generator, Sound Bender, Voltage Controlled Filter, Guitar Effects Pedal and Overdrive, Fuzz, Tremolo and Wah-Wah units.
The Main Synthesiser: PSU, 2 linear VCOs, 2 ramp generators, 2 input amps, sample hold, noise generator, reverb amp, ring modulator, peak level circuit, envelope shaper, voltage controlled amp. Full details in lists.

Set of basic component kits	£83·03
Set of printed circuit boards	£11·45

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

Set of basic component kits	£48·18
Set of printed circuit boards	£7·66

GUITAR EFFECTS PEDAL (P.E. July 75)
Modulates the attack, decay and filter characteristics of an audio signal not only from a guitar but from any audio source, producing 8 different switchable effects that can be further modified by manual controls. Possibly the most interesting of all the low-priced sound effects units in our range. Circuit does not duplicate effects from the Guitar Overdrive Unit.

Component set with special foot operated switches	£7·59
Alternative component set with panel mounting switches	£4·96
Printed circuit board	£1·43

SOUND BENDER (P.E. May 74)
A multi-purpose sound controller, the functions of which include envelope shaper, tremolo, voice-operated fader, automatic fader and frequency-doubler.

Component set for above functions (excl. SWs)	£7·84
Printed circuit board	£1·81

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

Component set (incl. PCB)	£2·88

PHASING UNIT (P.E. Sept. 73)
A simple but effective manually controlled unit for introducing the "phasing" sound into live or recorded music.

Component set (incl. PCB)	£2·87

PHASING CONTROL UNIT (P.E. Oct. 74)
For use with the above Phasing Unit to automatically control the rate of phasing.

Component set (incl. PCB)	£4·48

SOPHISTICATED PHASING AND VIBRATO UNIT
A slightly modified version of the circuit published in "Elektor", December 1976, and includes manual and automatic control over the rate of phasing and vibrato.

Component set	£17·69
Printed circuit board	£2·33

WAH-WAH UNIT (P.E. Apr. 76)
The Wah-Wah effect produced by this unit can be controlled manually or by the integral automatic controller.

Component set (incl. PCB)	£3·55

AUTOWAH UNIT (P.E. Mar. 77)
Automatically produces Wah-pedal and Swell-pedal sounds each time a new note is played.

Component set, PCB, special foot switches	£7·27
Component set and PCB, with panel switches	£4·83

P.E. JOANNA (P.E. May/Sept. 75)
A five-octave electronic piano that has switchable alternative voicing of Honky-Tonk piano, ordinary piano, harpsichord, or a mixture of any of the three, together with facilities including fast and slow tremolo, loud and soft pedal switching, and sustain pedal switching. The power amplifier typically delivers 24 watts into 8 ohms. The PCBs have been redesigned by ourselves making improved use of the space available.
Main power supply, tone generator, 61 envelope shapers, voicing and pre-amp circuits.

Set of basic component kits for above	£75·29
Set of printed circuit boards for above	£20·35
Power amplifier	£15·97
Printed circuit board for power amp	95p

RHYTHM GENERATOR (P.E. Mar./Apr. 774)
Programmable for 64,000 rhythm patterns from 8 effects circuits (high and low, bongos, bass and snare drums, long and short brushes, blocks and soft cymbal), and with variable time signatures and rhythm rates. Really fascinating and useful.

Tempo, timing and logic circuits	£12·70
PCB for above circuits (double-sided)	£3·33
Component set for all 8 effects circuits	£13·99
PCB for all 8 effects	£3·70
Simple mixer (our design) incl. PCB	£3·95
Alternative mixer with external volume controls (incl. PCB)	£11·17
Power supply for T, T and L, and effects (incl. PCB)	£8·45

(See our list for Power Supplies for Mixers)

RHYTHM GENERATOR—NEW CONTROL UNIT
Using an M252 Rhythm Generator integrated circuit this control unit is for use in place of the above Tempo, Timing and Logic control. It provides 15 different and readily selectable rhythm patterns such as Waltz, Tango, March, Foxtrot, etc.

Component set (incl. PCB but excl. sw's)	£12·90
Power supply (incl. PCB)	£12·00

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

WIND AND RAIN UNIT
A manually controlled unit for producing the above-named sounds.

Component set (incl. PCB)	£3·72

GUITAR OVERDRIVE UNIT (P.E. Aug. 76)
Sophisticated, versatile Fuzz unit, including variable and switchable controls affecting the fuzz quality whilst retaining the attack and decay, and also providing filtering. Does not duplicate the effects from the Guitar Effects Pedal and can be used with it and with other electronic instruments.

Component set using dual slider pot	£6·86
Component set using dual rotary pot	£6·20
Printed circuit board	£1·62

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

Component set (incl. PCB)	£2·03

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

Component set (incl. PCB)	£3·64

TREBLE BOOST UNIT (P.E. Apr. 76)
Gives a much shriller quality to audio signals fed through it. The depth of boost is manually adjustable.

Component set (incl. PCB)	£2·40

P.E. TUNING FORK (P.E. Nov. 75)
Produces 84 switch-selected frequency-accurate tones. A LED monitor clearly displays all beat note adjustments. Ideal for tuning acoustic and electronic musical instruments alike.

Main component set (incl. PCB)	£15·59
Power supply set (incl. PCB)	£7·03

P.E. SYNCHRONOME (P.E. Mar. 76)
An accented-beat electronic metronome, providing duple, triple and quadruple times with full control over the beat rate. Can also be used as a simple drum-beat rhythm generator. Includes power supply.

Component set (incl. loudspeaker)	£11·62
Printed circuit board	£2·04

VOLTAGE CONTROLLED FILTER (P.E. Oct. 74)
An independently designed VCF that can be used with the P.E. Synthesiser.

Component set	£3·80
Printed circuit board	£1·38

ENVELOPE SHAPER WITHOUT VCA (P.E. Oct. 75)
Provides full manual control over attack, decay, sustain and release functions, and is for use with an existing voltage controlled amplifier.

Component set (incl. PCB)	£4·66

ENVELOPE SHAPER WITH VCA (P.E. Apr. 76)
This unit has its own voltage controlled amplifier and has full manual control over attack, decay, sustain and release functions.

Component set (incl. PCB)	£6·68

TRANSIENT GENERATOR (P.E. Apr. 77)
An envelope shaper, without VCA, having the usual attack, decay, sustain and release functions, and in addition it also provides a "Repeat Effect" enabling a synthesiser to be programmed to imitate such instruments as a mandolin or banjo.

Component set	£4·52
Printed circuit board	£1·82

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

Component set (incl. PCB but excl. sw's)	£8·19

VOLTAGE CONTROLLED FILTER (P.E. Dec. 74)
Part of the P.E. Minisonic now released as an independent kit for use with other synthesisers.

Component set (incl. PCB) (Order as Kit 65-1)	£8·22

RING MODULATOR (P.E. Jan. 75)
Part of the P.E. Minisonic now released as an independent kit for use with other synthesisers.

Component set (incl. PCB) (Order as Kit 59-1)	£5·50

NOISE GENERATOR (P.E. Jan. 75)
Part of the P.E. Minisonic now released as an independent kit for use with other synthesisers.

Component set (incl. PCB) (Order as Kit 60-1)	£3·35

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

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

Component set (incl. PCB)	£3·78

VOICE OPERATED FADER (P.E. Dec. 73)
For automatically reducing music volume during "talk-over"—particularly useful for Disco work or for home-movie shows.

Component set (incl. PCB)	£3·97

DYNAMIC RANGE LIMITER (P.E. Apr. 77)
Automatically controls sound output to within a preset level.

Component set (incl. PCB)	£4·58

POST AND HANDLING
U.K. orders—under £15 add 25p plus VAT, over £15 add 50p plus VAT. Keyboards £1·50 plus VAT.
Optional insurance for compensation against loss or damage in post, add 35p in addition to above post and handling.
Eire, C.I., B.F.P.O., and other countries are subject to Export postage rates.

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

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

PHONOSONICS · DEPT. PE59 · 22 HIGH STREET · SIDCUP · KENT DA14 6EH

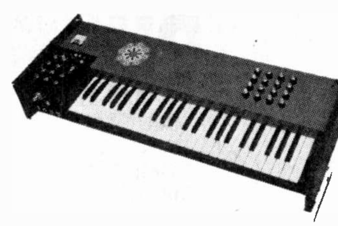
MAIL ORDER AND C.W.O. ONLY
SORRY BUT NO CALLERS PLEASE

AND OTHER PROJECTS

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

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

OVERSEAS enquiries for list: Europe—send 20p; other countries—send 40p.



KEYBOARDS AND CONTACTS
Kimber-Allen Keyboards as required for many published circuits, including the **P.E. Joanna, P.E. Minisonic,** and **P.E. 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!

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

ORGAN CONVERSION KIT
Converts the P.E. Joanna electronic piano to also provide most of the facilities offered by the above electronic organ.
Basic component set and PCB **£12·34**

SYNTHESISER TUNING INDICATOR (P.E. July 77)
A simple 4-octave frequency comparator for use with synthesisers and other instruments where the full versatility of the P.E. Tuning Fork is not required.
Component and PCB (but excl sw.) **£7·45**

GUITAR FREQUENCY DOUBLER (P.E. Aug. 77)
A modified and extended version of the circuit published. Details in list.

TAPE NOISE LIMITER
Very effective circuit for reducing the hiss found in most tape recordings. All kits include PCBs
Standard tolerance set of components **£2·96**
Superior tolerance set of components **£3·76**
Regulated power supply (will drive 2 sets) **£4·69**

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 enterprisiing 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
CA3046	90p
MC3340	150p
SG3402N	262p

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PHONOSONICS

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£4·60
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Engineer
Student

These courses were written so that you could teach yourself the theory and application of digital logic. Learning by self instruction has the advantages of being quicker and more thorough than classroom learning. You work at your own speed and must respond by answering questions on each new piece of information before proceeding to the next.

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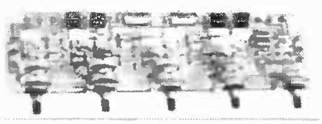
PRE AMPLIFIERS

Designed for use with TUAC power amplifier modules.

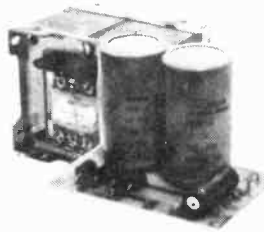


VA08
Vol. Treb. Mid. and Bass controls. HI. IMP. FET. I/P suitable Mid. Guitar, Radio Crystal/Ceramic P.U. Sensitivity 4mV. Treble + 35dB at 16kHz. Mid + 20 –15dB at 1kHz. Bass + 20 – 10dB at 40Hz. **£9.00**

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**

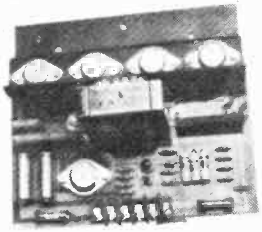
POWER SUPPLIES



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

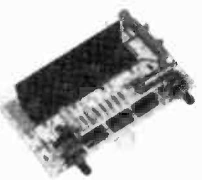
TL100
- 100 watt R.M.S. continuous sine wave output
- 2 R.C.A. 150 watt 15 amp transistors

£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

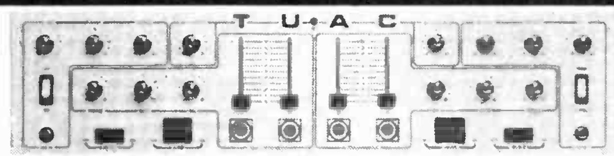
4 CHANNEL SOUND TO LIGHT SEQUENCE CHASER - 4LSMI



- 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

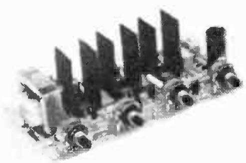
With touch sensitive switching and auto fade

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.

£129.00

Mono Disco Mixer with autofade **£45.00**

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**

THE PIEZO SUPER HORN

£10.95

- NEEDS NO CROSS-OVER NETWORK
- FREQUENCY RESPONSE 4,000 – 30,000 Hz ± 3dB
- PATENTED MOMENTUM DRIVE PRINCIPLE
- NO VOICE COILS OR MAGNETS
- HIGH INTERNAL IMPEDANCE
- ADAPTS TO ANY SYSTEM
- HIGH ACOUSTIC OUTPUT
- MANY CAN BE CONNECTED IN SERIES TO FORM AN ARRAY – INCREASED OUTPUT
- POWER HANDLING CAPACITY 25 volts RMS – see chart

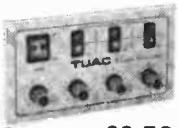
POWER HANDLING GUIDE

System Impedance	Capacity
2 ohms	312 watts
4 ohms	156 watts
8 ohms	78 watts
16 ohms	39 watts

3⅛ × 3⅛ × 2⅞ins

FRONT PANEL FOR LIGHTING EFFECT MODULES

(complete with switches, neons and knobs) as illustrated



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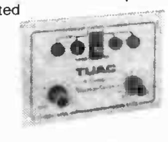

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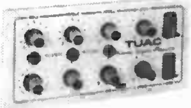

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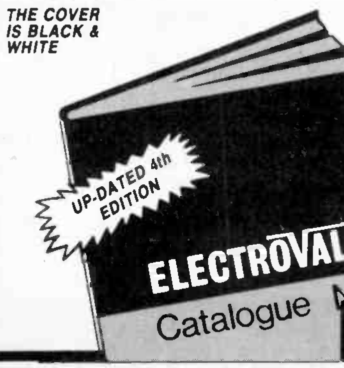

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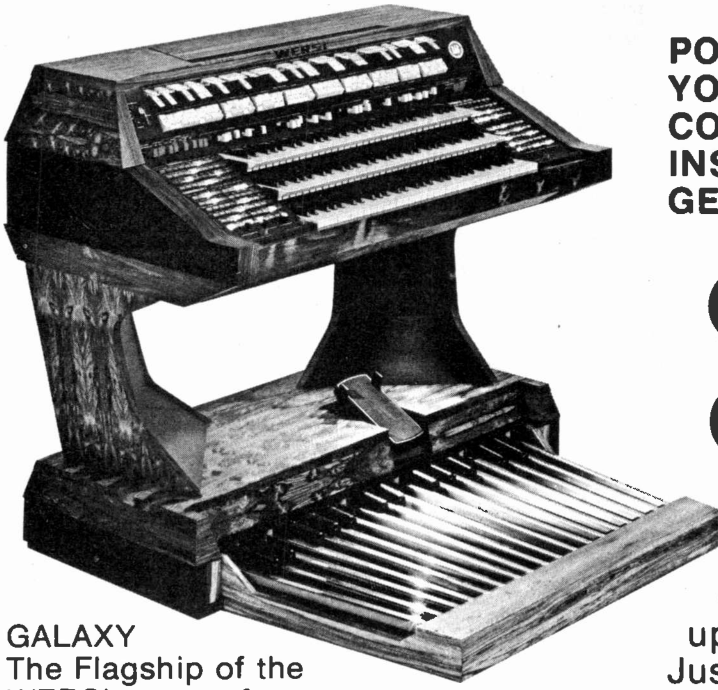

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550mA	613	2A	617	5A	621
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		All 7p each			

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Type	No.	Type	No.	Type	No.
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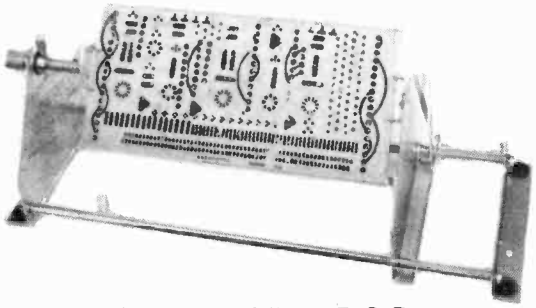

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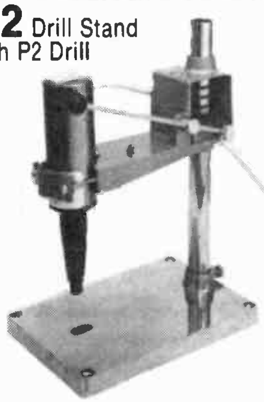

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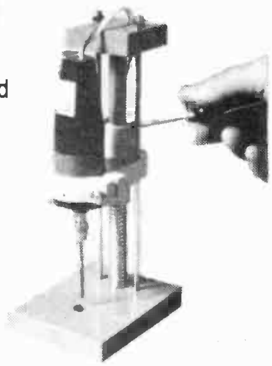

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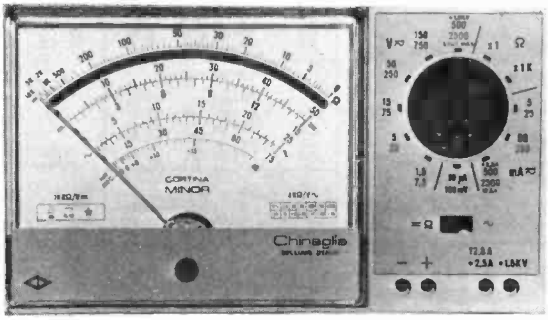

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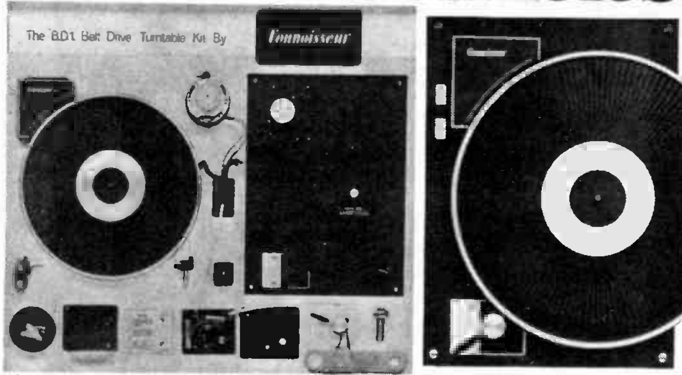

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FULL MEASURE

It is an exceptional hobby where most of the tools and instruments needed for its practice can be made in the normal pursuance of that activity. This ideal state of affairs, representing a big move towards total do-it-yourself, is enjoyed by the electronics enthusiast. From time immemorial the designing and building of test gear has been an essential part of this hobby. One type of instrument invariably excluded on grounds of impracticability has been that indispensable workhorse the multimeter. This was the one vital instrument one *had* to buy.

But eventually the moving-coil instrument lost its monopoly of this area of electrical measurement, with the coming of entirely electronic methods for measuring and displaying those prime quantities: volts, amperes, and ohms. The digital multimeter has now become just another project for the constructor, so extending his area of self-sufficiency even further.

With specially designed i.c.s now available the constructional work is reduced to the minimum and, also of great importance, the performance of the finished instrument can be vouched for.

This month's cover features a Digital Multimeter having useful and valuable features. This multimeter is fully described in our pages and we consider this an excellent example of the kind of high-class instrument the constructor can build for himself today.

Seen against the broader background, this particular project typifies much that is happening in electronics at this time. The constructor's general indebtedness to the i.c. industry is one of the facts of life. What a boon these custom-designed devices have proved to him. And yet this certainly is no one-way traffic. Many original ideas germinating in fertile minds outside the industry find their way back into commercial areas, since they enhance and extend the usefulness of a particular i.c. A very happy situation benefiting, in the long run, all concerned.

FUN AND GAMES

What is the explanation for the popularity of electronic games? Are they one form of escapism from economic blues? There again it might, rather unkindly, be suggested that we are suffering from a plethora of these amusements, simple and harmless in their performance though they be. Certainly the attraction of some electronic games wanes quite quickly. The television game is a particular victim for it is reckoned (by some who should know) to have an active life of only about four weeks before the attraction wears off and the equipment is consigned to the cupboard under the stairs.

Clearly, in the long term, monochrome ping-pong for two cannot hold a luminescent spot to the all-family attractions of *The XYY Man* or *The Black and White Minstrel Show*. Still, technologically speaking, we can count on enterprising designers to continue producing more involved and appealing(?) games for our amusement. It is one very useful and convenient way for i.c. designers to exercise their talents.

Games have a particularly significant place in the field of minicomputers. The personal minicomputer, far more than the television set, has a definite need for "invented" tasks to keep it in full-time employment. How else to justify its existence after one has run through one's personal accounts and income tax records? There is an awful lot of capacity awaiting programming. So why not play games—highly intellectual ones preferably—?

Our new feature *Micro-Bus* will include examples of programs for games—for the very good reason that ". . . the techniques of programming are much the same whether one is writing a game-playing program or a factory process control program . . ." *Micro-Bus* will present other useful information and ideas concerning microprocessors and minicomputers, all having a distinctly practical bearing on the application side of this fast opening-up area of electronics.

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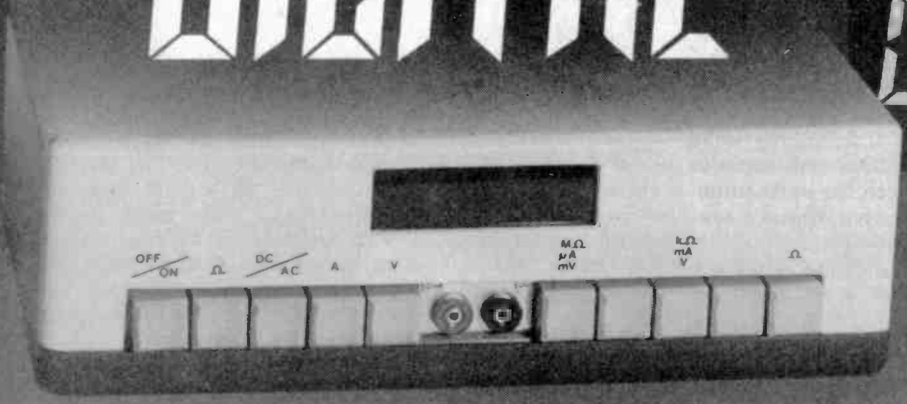
DIGITAL Multimeter



P. BIRNIE

THE construction of a digital voltmeter (DVM) has in the past involved the use of many components, both linear and digital, and with further circuitry to perform other functions, the digital multimeter (DMM) has required still more discrete and integrated devices. This has been a deterrent to the would-be constructor, even with the help of recent digital i.c.s which perform the *system control* of analogue to digital conversion (A to D).

The Siliconix LD130 has brought nearer, the day of the "one chip DVM", because with only the assistance of a BCD to 7 segment/decode driver i.c. and a few other passive components, a 0–999mV DVM can be built.

The LD130, comprising both linear and digital circuitry, could offer an accuracy of ± 1 count when used in this fashion, in addition to automatic polarity with an output for polarity sign indication, and an input impedance of higher than $10^9\Omega$, provide an underrange/overrange output which may be used for auto-ranging, and would operate from ± 5 volt unregulated supplies, consuming only 25mW (the LD130 itself).

The DMM featured in this article *is* such a digital voltmeter, with a few refinements such as an input attenuator network to allow other voltage ranges to be measured, and converters to enable a.c., resistance, and current to be measured also.

LD130 OPERATION

This device has improved upon the Siliconix dual LD110/LD111 A to D system employing the "Quantised Feedback" principle, by incorporating the two functions in a single i.c.

Very basically, quantised feedback is a system whereby the voltage to be measured is integrated to ramp up or down (depending on polarity), and then fed to a voltage comparitor before going to the digital controller. The comparitor reference level is designated "analogue ground", and if its output is positive, set charge packets of opposite sense are delivered to the integrator input until the ramp returns to zero. Consequently the comparitor will then go negative. If the comparitor was initially negative, the reverse happens; but in either case the digital controller counts the number of charge packets required by the feedback path to *zero* the integrator.

The reason for the name "Quantised Feedback" now becomes apparent. There are of course many refinements to this system, and advantages too, and these shall be explained.

Figure 1 shows a block diagram of the LD130, and this can be split into two areas: the logic zone (right), and the analogue zone (left). The logic zone controls the switching into circuit of the various amplifier elements, and also generates the information for interfacing with the three digit multiplexed display. An independent output (pin 5) is multiplexed in conjunction with the digit drive lines, to provide negative sign, overrange, and underrange indication.

If the control logic is the brain of this device, then by the same analogy the analogue section is the limbs; in this case clutching measuring beakers! It should be remembered that everything happens to the beat of pulses generated by the internal oscillator, and squared through a flip-flop. This pulse train is then used to motivate the control logic and is hereafter referred to as the "clock".

During conversion from A to D, which takes 3072 clock cycles, there are two periods: Auto-Zero (AZ), and Measure (M), each occupying 1024 and 2048 clock cycles respectively.

The AZ period is best described first, as the purpose of this is to null offsets within the LD130 linear stages before going ahead with measurement, and as will be seen later, to provide a negative reference voltage to enable inputs of either polarity to be converted

THE A-Z PERIOD

At the start of the Auto-Zero period the non-inverting input of the Input Buffer is grounded, and a few clock cycles later the non-inverting input of the Auto-Zero Buffer is routed to internal resistor R_D. This links the AZ Buffer and integrator together as a closed loop second order system, at which time the up/down (U/D) switch pulses at 50 per cent duty cycle. That is, up to Vref for four cycles and down to analogue ground for four cycles.

It should be noted that the latter, and all other operations work on clock pulse groups of eight, which are called octets. At the outset of the 50 per cent U/D signal, the AZ Buffer, which is monitoring the integrator output, will be theoretically at zero volts; therefore the integrator will only be working on an input switching at 50 per cent duty cycle between ground and Vref (which is 2 volts).

A stepped negative going ramp will be generated at the output of the integrator, which will be repeated at the AZ Buffer output. This, you will see from the diagram, is back at the integrator input! Now that the ramp is under-way; due to the positive reference voltage across R_A, and the increasing negative voltage *now* across R_C, the integrator will begin to produce a gradually more triangular waveform until equilibrium is reached, with the integrator output being a true triangle wave, about a mean negative voltage.

At this point the relationship between the values of R_A and R_C should be considered. Since the value of these two resistors is the same, the integrator output will only hold steady when the current in each is equal and opposite, since this will give an average centre voltage of zero.

Simple figures will show that this is when the AZ Buffer voltage is exactly $-\frac{1}{2}$Vref.

Let the integrator current during U/D high, be I_1, and during U/D low be I_2.

The AZ Buffer output voltage (to be established) = V_{AZ}.
The integrator ceases ramping when $I_1 + I_2 = 0$. (1)

$$I_1 = \frac{V_{ref}}{R_A} + \frac{V_{AZ}}{R_C} \quad (2)$$

$$I_2 = \frac{V_{AZ}}{R_C} \quad (3)$$

Using equation (1), ramping ceases when:

$$\frac{V_{ref}}{R_A} + \frac{V_{AZ}}{R_C} + \frac{V_{AZ}}{R_C} = 0$$

or

$$\frac{V_{ref}}{R_A} = -2\frac{V_{AZ}}{R_C}$$

Since $R_A = R_C$, $V_{AZ} = -\frac{1}{2}$Vref. Vref = 2V, therefore $V_{AZ} = -1$V.

This negative voltage is stored on capacitor C_{AZ}, whilst during the last few cycles of the AZ period, the integrator is returned to zero. The A to D converter will now be ready for the measure (M) period.

THE M PERIOD

Now that internal offsets have been taken care of, and a balanced negative reference voltage (V_{AZ}) has been prepared, the Input Buffer will be switched to monitor V_{IN}, and the loop via the AZ Buffer is broken.

The integrator will now begin to ramp (rate and polarity depending on V_{IN}), and the comparitor will switch accordingly. Charge packets will now be fed back to the integrator input, by control of the U/D switch. This is done in response to the comparitor output, and follows an elementary set of rules.

For a "high" comparitor, the U/D voltage will be *up* for 1 clock cycle, and *down* for 7 (Duty cycle A).

For a "low" comparitor, the U/D voltage will be *up* for 7 clock cycles and *down* for 1 (Duty cycle B).

The comparitor is sampled only during the clock cycle preceding each octet. An up/down BCD counter increments by one count for each U/D "up" charge packet, and decrements

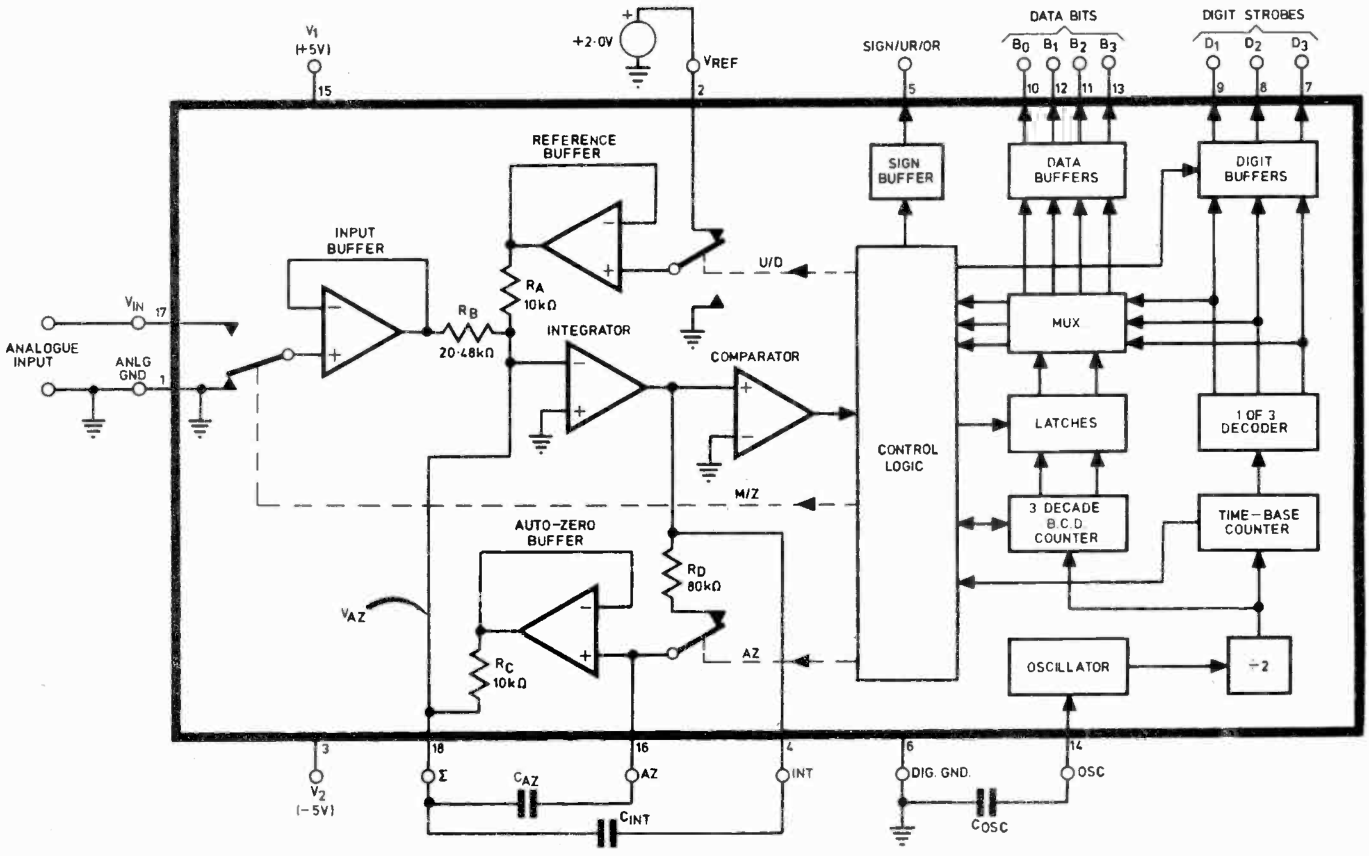


Fig. 1. Internal block diagram of the LD130 DVM chip

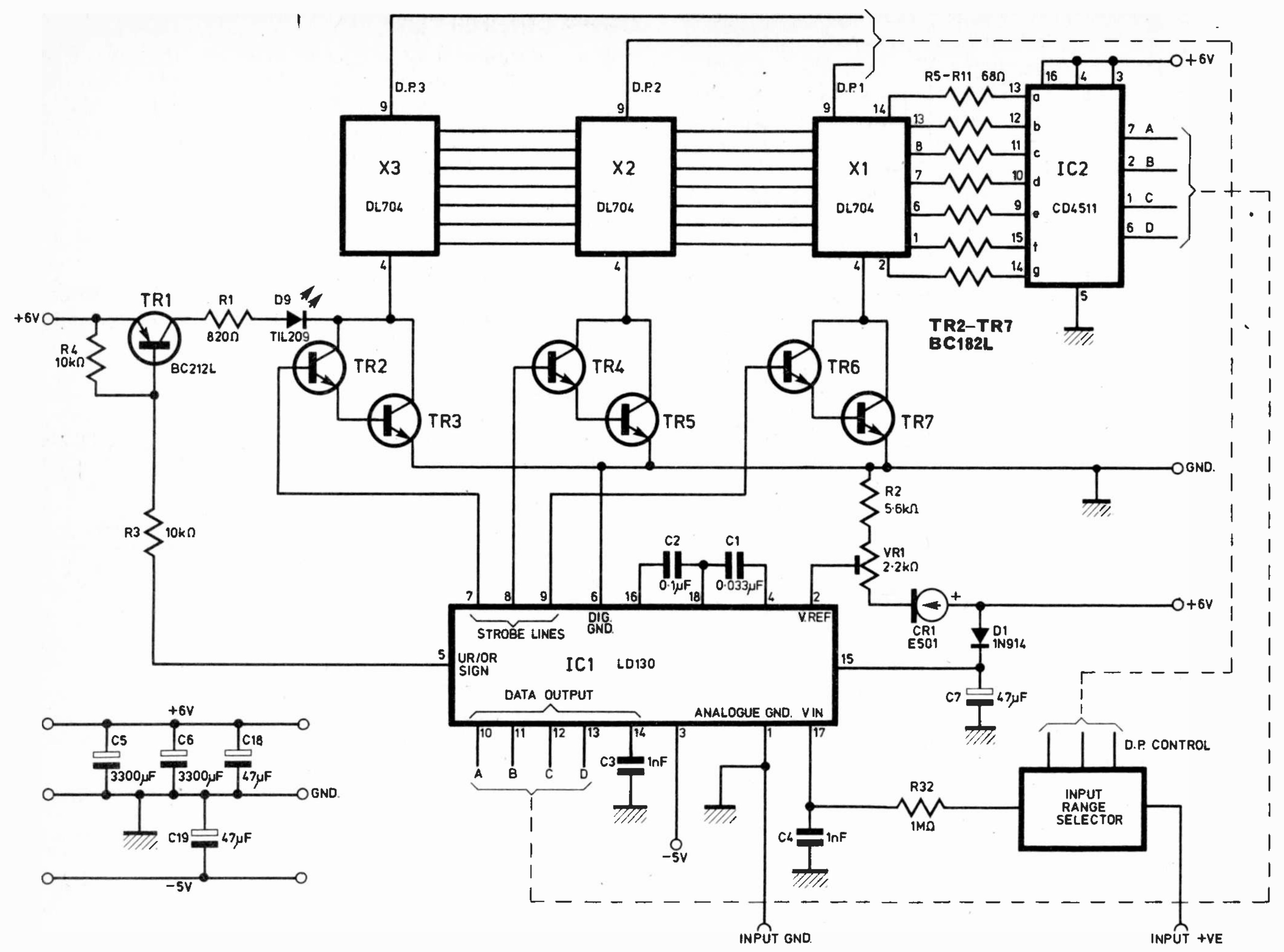


Fig. 2. Circuit diagram of the DMM

for each U/D "down" charge packet, consequently registering a net count of six for each duty cycle. The input polarity is detected by sensing which duty cycle is being employed.

COUNT CORRECTING OVERRIDE

For the most part, the counting is done in groups of six, but an exception to this rule has to be made as a final stage in measurement. Within the first 32 clock cycles of the following AZ period, a little time is stolen to fine tune the counter to the nearest individual count. During this period, known as the "override interval", individual charge packets are fed back to balance the integrator, thus improving the accuracy of the system to ±1 count.

BASIC DVM CIRCUIT

The diagram of Fig. 2 shows the complete circuit of the DMM, which without the Input Range Selector section, leaves what is basically the DVM part of the multimeter.

The components which form the voltage reference for IC1 can be seen connected to pin 2 (R2, VR1, and CR1). The BCD coded output from IC1 is decoded into seven segment drive using a CD4511, CMOS decoder driver with output source capability of 25mA continuous.

Because the IC2 outputs are not current limited, seven 68Ω resistors are used as current limiters.

The seven segment displays have their segment anodes in common, in the conventional multiplexed display manner, and the cathodes are driven by three pairs of transistors connected in "super-alpha" configuration (TR2–TR7). Using BC182L transistors in this way, allows a very small drive current to control the relatively large peak currents required by the displays. This is important to prevent the LD130 from having to source several milliamps current.

A single point source l.e.d., driven from TR1 which is controlled by the "negative sign" output of the LD130 (pin 5), illuminates when the input applied to the DVM is negative.

The input to IC1 goes via a 1MΩ resistor (R32), which provides protection against over-voltage, but because the input impedance of IC1 at V_{IN} is 1,000MΩ, this series resistor has virtually no effect on readings.

A capacitor of 1nF connected between the input pin and ground prevents any noise spikes picked up along the p.c.b. from adversely affecting the readout. In addition, several smoothing capacitors are used (C5, C6, C18 and C19), and these are absolutely essential for correct operation, as are D1 and C7.

INPUT RANGE SELECTOR

The complete input range selection circuitry is shown in Fig. 3. Switches are shown in the non-select (out) position, and the use of press button keys for all ten switches is assumed, although conversion to rotary switches should be fairly straightforward.

The five range selection switches (S6–S10) are mechanically interlocked such that only one can be operated at any given time. The other five switches are partially interlocked.

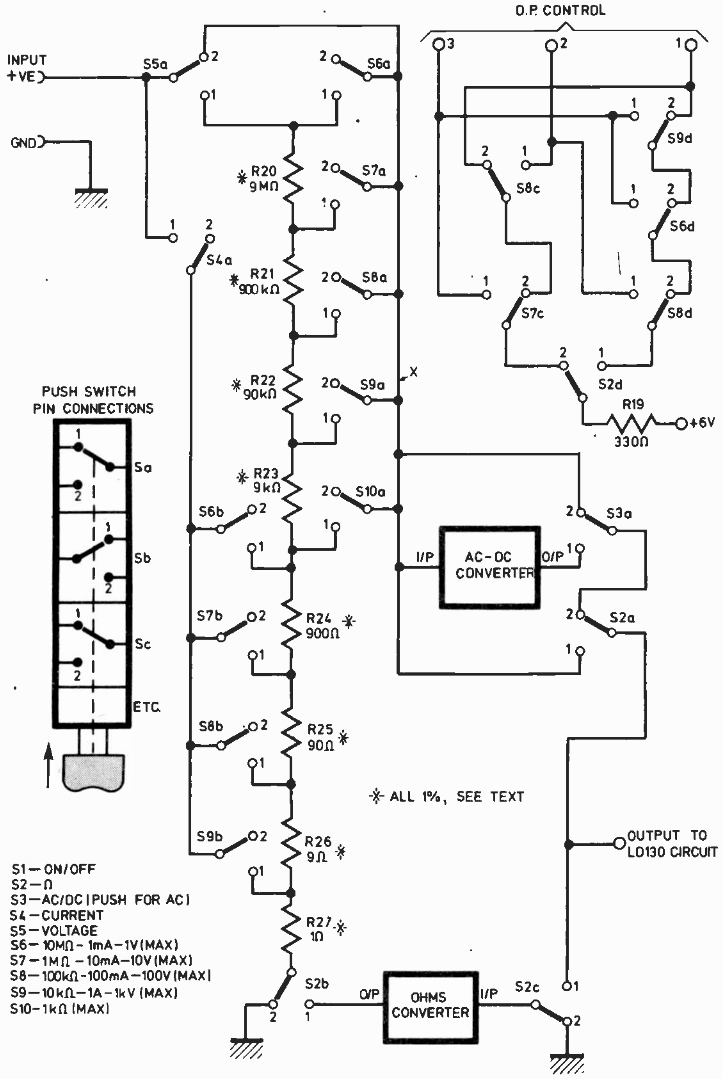


Fig. 3. Input Range Selector

The ON/OFF and AC/DC switches are push-to-select, push-to-cancel, and do not interact with any other switches.

The OHMS, AMPS and VOLTS switches are interlocked such that only one function can be selected at any one time.

A word of warning is needed here, about connection of inputs with the wrong range selected, or illegal button combinations. As with an analogue meter, such actions may cause serious damage to the input circuitry, although the design carefully protects the LD130 itself against applications of up to 1kV on any range, leaving only a few resistors and an operational amplifier to suffer the consequences.

During normal operation, with S5a pressed, the input voltage "sees" R20 to R27 in series, about 10MΩ in all, and dependent on the range selected, a proportion of the input voltage appears at point X. The a.c. to d.c. converter is always operational, and if the AC/DC switch is pushed, then S3a will select the rectified signal rather than the voltage at point X. The pole of S3a is now fed to VIN of the LD130.

On a current input, with S4a operated, the current passes through some or all of resistors R24–R27, depending on the range selected. Point X is now at the voltage generated across the selected shunt resistors, and switch S3a selects either this voltage, or the output of the converter. Again, the pole of S3a now goes to VIN of the LD130.

OHMS CONVERTER

The measurement of resistance relies on the use of the programmable current generator of Fig. 4. At the input terminal, a constant current is produced which is dependent on the value of resistor selected by the range selection switches. This current passes through the positive input terminal of the meter, the unknown resistor, and the negative input terminal to ground. The voltage developed across the resistance by the known current is measured by the DVM section of the instrument.

The range selector switch contacts activate the display decimal point at the correct position for the particular range selected.

DC TO DC CONVERTER

The system requires a negative supply of about 5 volts, and rather than provide a separate supply for the LD130 and two operational amplifiers, the simple d.c. to d.c. converter of Fig. 5 is used.

Transistors TR8 and TR9 form a free running oscillator with the collector of TR9 having a 1mH inductor rather than the usual load resistor. The back e.m.f. from the switch-off current in L1 is coupled by C16 to be shunted by D7. Diode D8 conducts when C16 is pushed negative by induced e.m.f. from L1. This latter conduction is negative with respect to ground, and C17 is charged with this voltage, but regulated to around 5 volts by the Zener diode which is fed back in such a way as to damp down oscillation when it conducts.

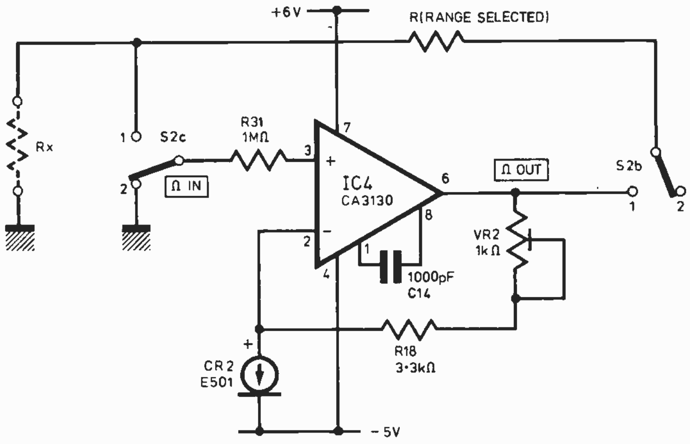


Fig. 4. Ohms Converter

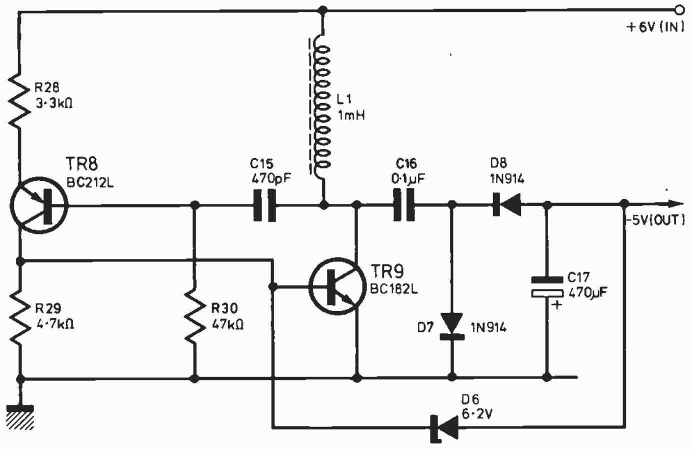


Fig. 5. DC-DC Converter

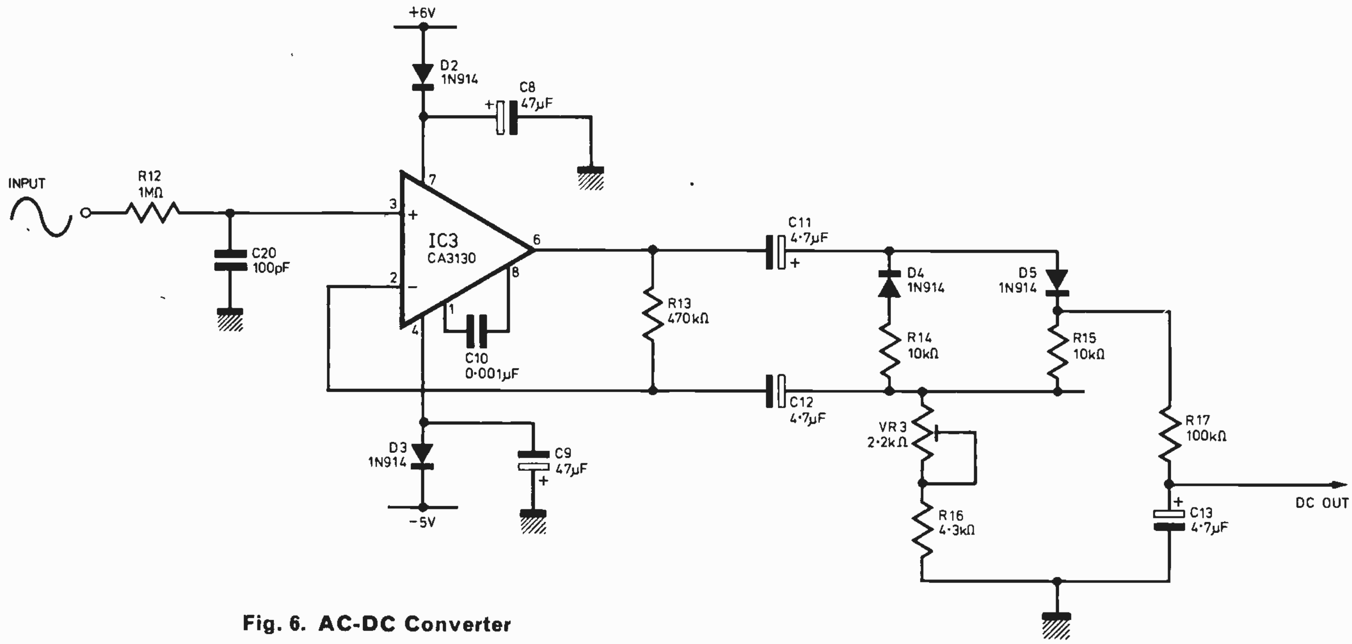


Fig. 6. AC-DC Converter

AC TO DC CONVERTER

This conversion is performed using a straightforward precision rectifier with smoothed output (Fig. 6). The a.c. signal is applied to the input of the CA3130 CMOS operational amplifier, and amplified by a factor of 5. The output, when rectified, is a d.c. voltage of the same value as the r.m.s. voltage of the input waveform. The scale factor is set during calibration by preset VR3.

It should be noted that only sinewave inputs will give a true reading with this circuit.

LAYOUT PHILOSOPHY

The development of any system involving both digital, and sensitive linear circuitry, brings to light problems related to power supply ripple, and noise pick-up at the input wiring.

The pulse currents caused by the multiplexed display (up to 210mA), passing along a p.c.b. track with a resistance of, say, 20mΩ, can cause over 4mV of noise to appear. It would be disastrous if the input earth line shared a current path such as this.

It is for this reason that the LD130 has separate earth lines internally for its analogue and digital sections, and which emerge at different pins. With isolated earths it can therefore be arranged on a p.c.b. for the noisy digital earth to return directly to the supply source, and the input signal earthing to do the same.

The positive supply is provided with 6,600μF of reservoir capacitance to "soak up" much of the peak current requirements of the displays. As will be seen, the p.c.b. layout has two links which are used to connect VIN and analogue ground to the LD130 to keep crosstalk to a minimum.

ASSEMBLY OF CIRCUIT BOARDS

The Main p.c.b. (Fig. 8) is single-sided, and should be of glass-fibre at least one millimetre thick so that it will firmly support the switches without flexing, which might split the tracks. Short mounting spacers may be needed for this p.c.b.

Assembly should be commenced by making up the two switch frames, taking care that the interlock functions operate as desired (so that two conflicting ranges cannot be operated simultaneously). Next, mount them on the p.c.b. as shown in Fig. 8. No screws are used for this, as the many soldered leads will be sufficient. The wire links are then soldered in position, all except the one marked "A". The components can then be mounted, leaving the i.c.s until last, after ensuring that the soldering iron is earthed. The usual precautions for CMOS devices must be taken.

Taking the Display p.c.b. (Fig. 7); again insert the links first, followed by all other components. The seven segment displays are orientated using their decimal points. The polarity of the sign indicator l.e.d. can be checked with a meter, and this component should be stood-off from the board so as to make it sit close to the display window. This board is now put aside while a check on the Main p.c.b. is carried out.

CONVERTER CHECK

The correct operation of the DC-DC Converter on the Main p.c.b. can be checked by connecting a 6 volt battery to the supply and operating the ON/OFF switch. A multimeter connected across C17 should now read approximately 5 volts negative. If this test is satisfactory, switch off the power and connect link "A". Otherwise check the component positions and soldering.

The two sets of holes provided for tying down the inductor core are for a "U" shape copper wire strap, and *not* a continuous loop of wire, since this would cause an effective shorted turn by destroying the flux path in the vicinity.

FINAL ASSEMBLY

An aluminium bracket should be cut out as shown in Fig. 9 and fixed to the Main p.c.b. using two M3 screws. Next the 2mm input sockets are bolted in position, with the positive socket on the left. Two leads connect these sockets to the Main p.c.b., and should be connected up. The Display p.c.b. is now mounted on the bracket using M3 nuts to space them apart.

COMPONENTS . . .

Resistors

R1	820Ω	R22	90kΩ 1% hi-stab ½W*
R2	5·6kΩ ½W m.o.	R23	9kΩ 1% hi-stab ½W*
R3, R4,	10kΩ (2 off)	R24	900Ω 1% hi-stab ½W*
R5–11	68Ω (7 off)	R25	90Ω 1% hi-stab ½W*
R12	1MΩ	R26	9Ω 1% hi-stab ½W*
R13	470kΩ	R27	1Ω 1% high-stab, 1·5W*
R14, R15	10kΩ (2 off)	R28	3·3kΩ
R16	4·3kΩ	R29	4·7kΩ
R17	100kΩ	R30	47kΩ
R18	3·3kΩ	R31, R32	1MΩ (2 off)
R19	330Ω		
R20	9MΩ 1% hi-stab ½W*		
R21	900kΩ 1% hi-stab ½W*		

All ¼W 5% unless otherwise stated
*See Constructor's Note

Potentiometers

VR1 2·2kΩ hor cermet preset
VR2 1kΩ hor cermet preset
VR3 2·2kΩ hor cermet preset

Capacitors

C1	0·033μF polyester
C2, C16	0·1μF polyester (2 off)
C3, C4, C10, C14	0·001μF polystyrene (4 off)
C5, C6	3300μF 6·3V electrolytic (2 off)
C7, C18, C19	47μF 6·3V tantalum bead (3 off)
C8, C9	47μF tantalum bead (2 off)
C11–C13	4·7μF 35V tantalum bead (3 off)
C15	470pF polystyrene
C17	470μF 6·3V electrolytic
C20	100pF polystyrene

Inductors

L1 35 turns of 30 s.w.g. enamelled copper wire, on Mullard FX3312 ferrite toroid

Semiconductors

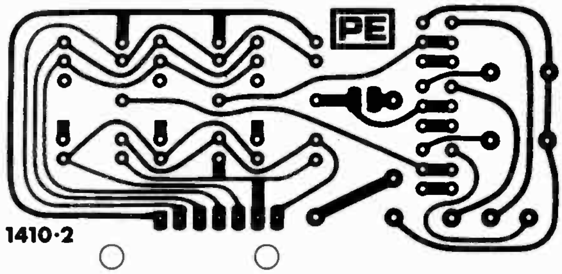
IC1	LD130 Siliconix
IC2	CD4511
IC3, IC4	CA3130T (2 off)
CR1, CR2	E501 Siliconix current regulator (2 off)
TR1, TR8	BC212L (2 off)
TR2–TR7, TR9	BC182L (7 off)
X1–X3	DL704 (3 off)
D1–D5, D7, D8	1N914 (7 off)
D6	6·2V Zener 300mW
D9	TIL209 red

Switches

S1, S3–S5, S10 2 pole c/o push button (5 off) RS type
S2, S6–S9 4 pole c/o (5 off) RS type

Miscellaneous

Mounting frames to take six switches each (2 off)
Square plastic buttons (10 off)
Input sockets 2mm (1 red and 1 black)
Polystyrene case 188 × 110 × 60mm (1 off)
HP7 batteries (4 off) and suitable holder with press stud connector to fit
Main p.c.b. and display p.c.b.
8mm M3 panhead screws for main p.c.b. mounting, and 3mm solderable metal spacers for same (4 off each)
Aluminium for display mounting bracket
6mm M3 panhead screws (2 off)
12mm M3 countersunk screws (2 off).



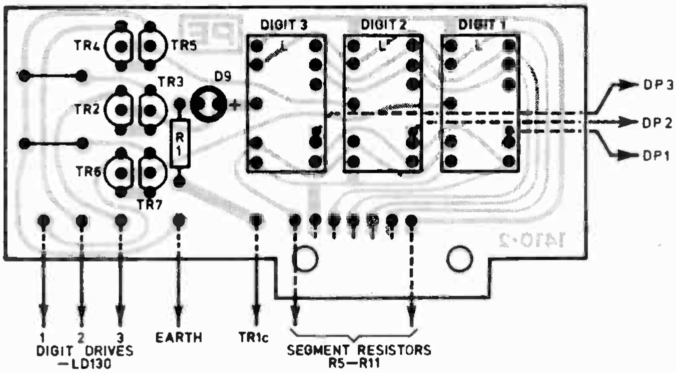


Fig. 7. Display p.c.b. This is mounted on the input socket bracket

M3 nuts (8 off)
Red display filter 60 × 20mm (1 off)
Dry letter transfers and lacquer.
Stick-on cabinet feet
Two 2mm plugs, some flexible wire, and a couple of probe clips will be required for the test leads.
Integrated circuit holders.

CONSTRUCTOR'S NOTE

The Siliconix LD130 and the two E501 current regulators are available from **Semiconductor Specialists (UK) Ltd, Premier House, Fairfield Road, Yiewsley, West Drayton, Middlesex.** The combined cost of the three items is approximately £11·00.

The interlocking switches and associated accessories are available from **Doram Electronics,** and also the Mullard FX3312 toroid, 30 s.w.g. wire, and polystyrene case. The switches *must* be the RS type, which are available via Doram by special order.

*The resistors R20 to R27 are shown in the components list as their *ideal* values. Such a range of close tolerance high-stab resistors may be difficult to obtain through amateur component suppliers with no expensive minimum order charge. However, **Maplin Electronic Supplies** do a sufficiently good range of ½W 1% resistors to provide the following values: R21-910kΩ, R22-91kΩ, R23-9·1kΩ, R24-910Ω, and R25-91Ω.

Accuracy will not be significantly affected by going to the E24 range resistors in multiples of 9·1, or by the extreme upper and lower value resistors reverting to 2% tolerance.

Resistor R27 may be the Maplin 1Ω 3W wirewound resistor at 5% tolerance, if nothing closer can be found.

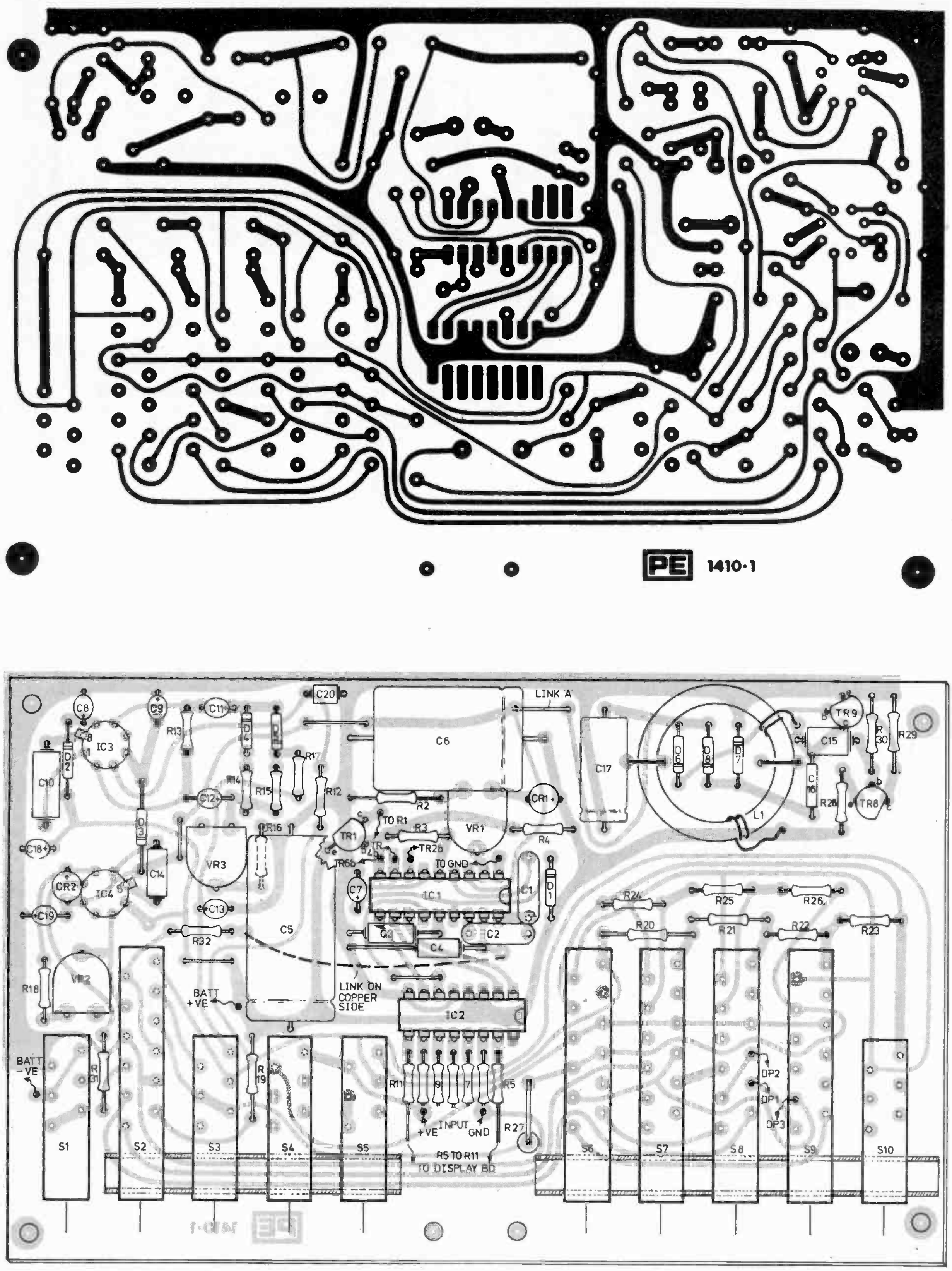
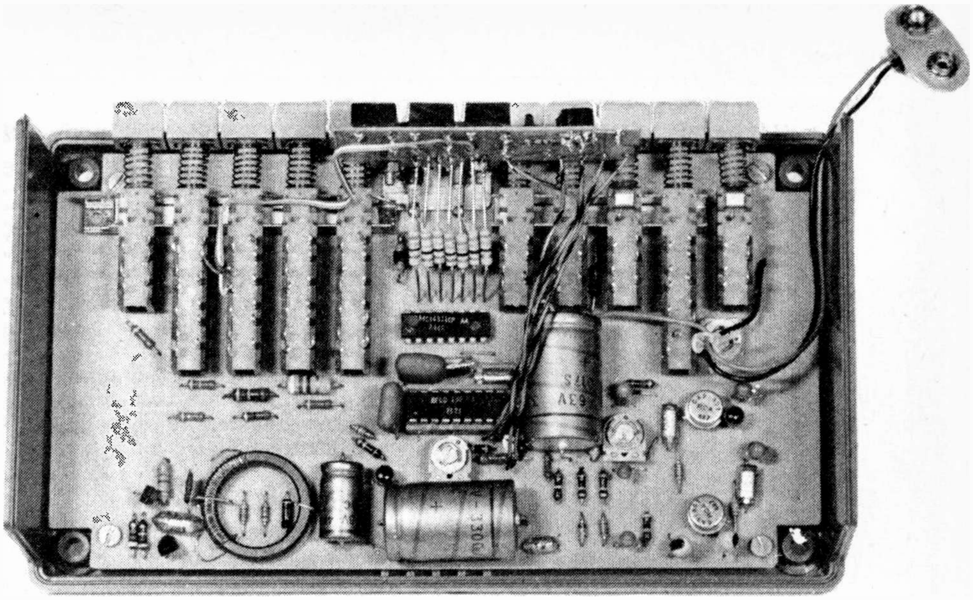


Fig. 8. Main p.c.b. Mounting spacers may be necessary, and may be soldered to the copper cladding



Interior view of the multimeter showing the arrangement of the range switches and segment driver resistors

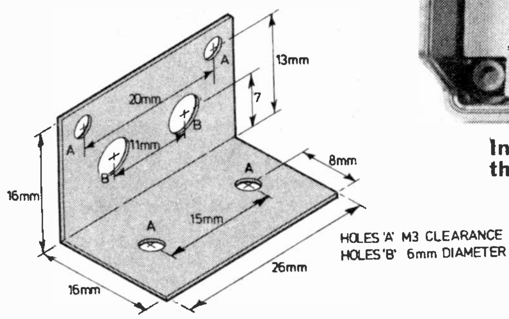


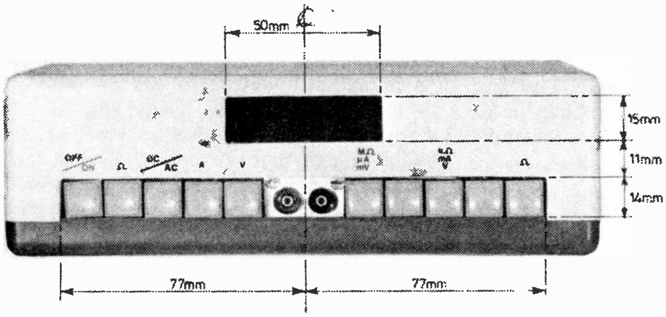
Fig. 9. Dimensions of the aluminium input socket bracket

The segment drive resistors can next be soldered in position between the two p.c.b.s, and all other flying leads, including the decimal point flying leads from S8 and S9. The display window and push button slot should now be cut out to the dimensions shown in the photograph.

The battery holder can be glued to the lid of the box, or if a removable type is used, it can be held in place by a plate and two screws.

TESTING AND CALIBRATION

With a 6 volt supply and the unit switched on, the display should read all zeros when the AC/DC switch is in the DC position (out), and the voltage function is selected. Due to small amounts of crosstalk, the display may occasionally indicate 001, but this is of little significance, as it represents an error of only 0·1 per cent. Should a greater reading than this appear, of a value up to 004 or thereabouts, switch off the power and carefully clean any flux away from the pins of the LD130 using switch cleaner or cellulose paint thinner. This should reduce stray signals to a minimum thereby correcting the display reading.



The voltage reference for the LD130 must now be set, using a known voltage source and adjusting VR1 for the correct display reading. Any source of supply, from a battery to a power supply will suffice, as long as it is known to the accuracy desired from the DMM after calibration. The ideal voltage from which to calibrate is about 0·9V because this range setting will bypass the range selector resistors, and hence you would be calibrating the LD130 DVM chip directly.

Certain combinations of E501 and LD130 may not allow VR1 to give sufficient voltage range to allow the reference to be set, and in this case R2 should be changed until the correct setting can be achieved.

Calibration of the AC-DC Converter is carried out by feeding a known sinewave voltage to the instrument, and adjusting VR3 for a correct reading. The response of the circuit to changes in VR3 is fairly slow, and a few seconds should be left after each alteration to this preset before noting the display.

The Ohms Converter can be set up by connecting a close tolerance resistor to the instrument, selecting OHMS and the appropriate range, and then adjusting VR2 for the correct display reading.

Note that with OHMS selected and no resistor at the input of the instrument, the overrange indication (flashing display) will be active.

OPERATION

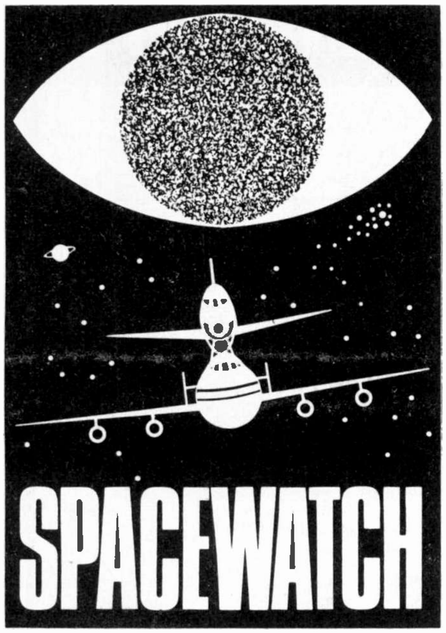
Care is required when using this meter to ensure correct function selection lest the instrument be damaged. This really applies to the function switches for OHMS, AMPS and VOLTS, as the range selection switches will, if wrongly set, cause either no display or the flashing overrange indication.

The AC-DC switch position has no effect on the operation of the OHMS circuitry, although this switch must be in the correct position for current and voltage inputs.

In use, the instrument should be used on the most sensitive range obtainable without overrange indication. ★

ACKNOWLEDGEMENT

The design of this DMM, is in part based on circuits suggested in the Siliconix LSI Design Catalogue.



FRANK W. HYDE

THE VOYAGERS

The two *Voyager* vehicles which will make their way to Jupiter and Saturn are of the *Mariner* class. Included in the programme for the Jupiter and Saturn encounter are detailed surveys of their satellites or moons. Each of the *Voyagers* could fly past four planets and a dozen satellites during the estimated 12 year period of the mission.

From the control centre at the Jet Propulsion Laboratory it will be possible to direct one of the vehicles to Uranus after the Saturn encounter. It could be that the *Voyager* will go on to Neptune for an encounter in 1989.

Some of the broad outlines of this mission have already been noted in a recent *Spacewatch*. Now further details are available as the launch date arrives. When you read this article the first of the vehicles will be on its way for the "launch window", open for 30 days, opened on August 20.

The spacecraft *Voyager 2* will be the first to be sent on its way. It will follow a trajectory which will allow the *Voyager 1* to overtake it and make its encounter some four months ahead of its companion. By the time of the Saturn encounter *Voyager 1* will be nine months ahead of *Voyager 2*.

The trajectories are very carefully planned and are subject to special considerations, particularly those concerned with safety, since the spacecraft will pass through an intense area of radiation when in the vicinity of Jupiter. There are also the possible hazards in the ring area of Saturn. The particle size in the rings themselves and the environment near them is not known though many theories thrive.

Cost and complexity are rivals in these matters since there will be low Sun-Earth-spacecraft angles and this will affect telemetry, command performance and data return. The scientific importance that arises from variations of trajectory in order to do special tasks, as for example taking a look, a close look, at the Saturnian satellite Titan. This is known to have an atmosphere and may well be a priority for close observation.

Also, now that the possibility of a ring system around Uranus has been established, this becomes a must for investigation at close quarters.

LAUNCH SYSTEM

Because the *Titan/Centaur* launch vehicle cannot accelerate the payload of 800kg (1,760lbs) to the energy level required for a ballistic trajectory to Jupiter, an additional upper stage is required. This expendable module will be attached to the bottom of the mission module. This will be the first time that such a module has been used on a planetary spacecraft.

This stage is ignited about 15 seconds after the separation from the *Centaur*. The basic vehicle is a module which weighs 24·5kg (54lb), it is a ten sided framework with ten electronic compartments and has a spherical tank mounted in the centre of the framework. This tank contains the Hydrazine fuel for the thrusters which maintain attitude of the spacecraft.

As the mission is away from the Sun, solar panels for the power supply would not be a suitable system to use. The panels would have to be very large and would have the effect of reducing the effective payload. In place of these panels, isotope thermoelectric units will be used. There are three of these units grouped together on a boom which holds them away from the main body, thus ensuring the least interference with the experimental equipment. The output of the generators is some 430 watts at launch falling to about 380 watts after the Saturn encounter.

On these spacecraft there is a much larger high gain antenna, 3·66 metres in diameter, than has been used before. Communications with the spacecraft will be in the S-band for "up" links, and for the "down" links the X and S-bands will be used. The X-band horn is set in the centre of the main reflector. The S-band feed horns are mounted back to back on the structure of the antenna. One of the special features of this mission is that every 50 million miles these spacecraft will slowly rotate on their axes and optical measurements will be taken in all directions thus making direct calibrations of the instruments.

MISSION PROGRAMME

The spacecraft will commence activity shortly after launch and will observe the Earth and the Moon. The actual imaging of Jupiter will begin on December 1978 when *Voyager 1* will be within 80 days of its encounter position.

Some hours before the closest approach of the spacecraft to Jupiter, it will pass the satellite Amalthea. This satellite is very close to Jupiter and will be within 290,000 miles of the spacecraft. By March 1979 the fly past of the *Voyager 1* will be at a distance of 174,000 miles and at this time the spacecraft will observe the Galilean satellites.

The distance of Io will be about 15,000 miles, Europa will be at a distance of about 465,000 miles and Ganymede and Callisto at a distance of 80,000 miles. When *Voyager 2* is passing Io it will fly through the region of intense magnetic and plasma activity known as the "flux tube".

The *Voyager 1* will cease imaging Jupiter in April 1979 at the time when *Voyager 2* begins its task. At this time *Voyager 2* will also observe four of the satellites.

On July 10 the spacecraft will pass at a distance of 397,000 miles from Jupiter. This distance from the planet has been selected to avoid damage to the spacecraft by the intense radiation in that area. The imaging stage will be terminated in August 1979.

One year later in August 1980 *Voyager 1* will be imaging Saturn. The spacecraft will then be some 62 million miles from the ringed planet. The picture taking will go on until January 1981.

When *Voyager 1* passes Saturn it is estimated that it will be 2,200 miles from the large satellite Titan. This satellite is larger than the Earth and is known to have an atmosphere, making it a focus of special interest for scientists. The other satellites Rhea, Tethys, and Enceladus will be scanned before the spacecraft passes Saturn and its rings.

As this situation will block out the Sun and Earth as seen from the spacecraft, the spacecraft will make occultation measurements. *Voyager 1* will then pass the southern hemisphere of Saturn at about 80,000 miles.

At this time it will be possible for the controller to decide whether *Voyager 2* should be retargeted to Uranus instead of Saturn. The decision need not be made until the spacecraft is within four months of the Saturn encounter. It is a decision which will depend on the possible damage that may have occurred on *Voyager 1* in passing the rings of Saturn. The decision will also depend on the "health" of *Voyager 2* particularly as to whether there is enough attitude control gas available.

The best trajectory would be for a flyby of Saturn at 62,000 miles which would mean that *Voyager 2* passed the visible edge of the outer ring by 23,000 miles. If it is possible to approach Uranus it will be in an ideal position to study the profile of its magnetosphere and any plasma cloud that may exist.

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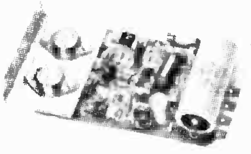

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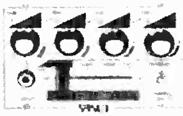

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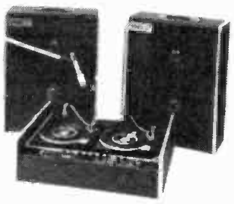

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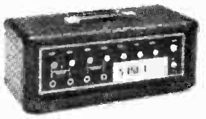

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200V	0·64	0·64	0·75	0·75	0·87	0·87	0·97	1·01	1·17	1·17
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AC176	0·16	BC144	0·30	BCY34	0·55	BF179	0·30	BSX19	0·16	TIP31A	0·54	2N3053	0·20
AC176K	0·32	BC147	0·09*	BCY38	0·50	BF180	0·30	BSX20	0·18	TIP32A	0·64	2N3055	0·50
AC187	0·18	BC148	0·09*	BCY39	1·15	BF181	0·30	BSX21	0·20	TIP41A	0·68	2N3137	1·10
AC187K	0·36	BC149	0·09*	BCY40	0·75	BF182	0·30	BSY52	0·28	TIP42A	0·72	2N3440	0·56
AC188	0·18	BC152	0·25*	BCY42	0·30	BF183	0·30	BSY53	0·39	2N404	0·40	2N3442	1·20
AC188K	0·32	BC153	0·18*	BCY54	1·60	BF184	0·20	BSY54	0·33	2N696	0·20	2N3570	3·60
AD149	0·80	BC157	0·09*	BCY70	0·12	BF185	0·20	BSY55	0·74	2N697	0·20	2N3702	0·10*
AD161	0·35	BC158	0·09*	BCY71	0·18	BF194	0·10*	BSY65	0·30	2N706	0·15	2N3703	0·10*
AD162	0·35	BC159	0·09*	BCY72	0·12	BF196	0·12*	BSY95A	0·16	2N718	0·22	2N3704	0·10*
AF114	0·20	BC160	0·32	BD115	0·55	BF197	0·12*	BU105	1·80*	2N929	0·16	2N3705	0·10*
AF115	0·20	BC161	0·38	BD131	0·36	BF224J	0·18*	BU105/02	1·90*	2N1131	0·15	2N3706	0·10*
AF116	0·20	BC168	0·09*	BD132	0·40	BF244	0·17*	BU108	3·00*	2N1132	0·16	2N3707	0·10*
AF117	0·20	BC169	0·12*	BD135	0·36*	BF257	0·30	BU109	2·50*	2N1302	0·40	2N3708	0·09*
AF118	0·50	BC169C	0·14*	BD136	0·39*	BF258	0·35	BU126	1·60*	2N1303	0·40	2N3709	0·09*
AF124	0·25	BC182	0·11*	BD137	0·40*	BF259	0·48	BU133	1·60*	2N1304	0·45	2N3710	0·10*
AF125	0·25	BC182L	0·12*	BD138	0·48*	BF336	0·35*	BU204	1·60*	2N1305	0·45	2N3711	0·10*
AF126	0·25	BC183	0·10*	BD139	0·58*	BF337	0·32*	BU205	1·90*	2N1306	0·50	2N3715	1·70
AF139	0·35	BC183L	0·10*	BD144	2·20	BF338	0·45*	BU206	2·40*	2N1307	0·50	2N3716	1·80
AF239	0·37	BC184	0·11*	BD157	0·60	BFW30	1·25	BU208	2·60*	2N1308	0·60	2N3771	1·60
AL102	1·45	BC184L	0·12*	BD181	0·86	BFW59	0·30	MJ480	0·80	2N1309	0·60	2N3772	1·90
AL103	1·30	BC186	0·20*	BD182	0·92	BFW60	0·36	MJ481	1·05	2N1711	0·24	2N3773	2·10
AU107	3·30*	BC187	0·24*	BD183	0·97	BFX29	0·26	MJ490	0·90	2N2102	0·44	2N3819	0·28*
AU110	1·75*	BC207B	0·12*	BD184	1·20	BFX30	0·30	MJ491	1·15	2N2217	0·30	2N4347	1·10
AU113	1·60*	BC212	0·11*	BD232	0·60	BFX84	0·23	MJE340	0·40*	2N2369	0·14	2N4348	1·20
BC107	0·09	BC212L	0·12*	BD233	0·48	BFX85	0·25	MJE520	0·45	2N2369A	0·14	2N4870	0·35*
BC107B	0·09	BC213	0·12*	BD237	0·55	BFX86	0·25	MJE521	0·55	2N2483	0·20	2N4871	0·35*
BC108	0·09	BC213L	0·14*	BD238	0·60	BFX87	0·20	OC43	0·95	2N2484	0·16	2N4918	0·60*
BC108B	0·09	BC214	0·14*	BD410	0·60	BFX88	0·20	OC44	0·32	2N2646	0·50	2N4919	0·70*
BC109	0·09	BC214L	0·15*	BDX32	2·30	BFX89	0·90	OC45	0·32	2N2711	0·20	2N4920	0·50*
BC109B	0·09	BC237	0·16*	BDY10	1·50	BFY11	1·10	OC46	0·20	2N2712	0·15	2N4922	0·58*
BC109C	0·15	BC238	0·16*	BDY11	2·00	BFY18	0·50	OC70	0·30	2N2904A	0·20	2N4923	0·46*

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4002BE	0·20
4006BE	0·05
4007BE	0·20
4008BE	0·93
4009BE	0·52
4010BE	0·52
4011BE	0·20
4012BE	0·20
4013BE	0·50
4014BE	1·00
4015BE	0·95
4016BE	0·54
4017BE	1·00
4018BE	1·10
4019BE	0·50
4020BE	1·12
4021BE	1·03
4022BE	0·95
4023BE	0·20
4024BE	0·86
4025BE	0·20
4026BE	1·55
4027BE	0·62
4028BE	0·91
4029BE	1·10
4030BE	0·55
4041BE	0·80
4042BE	0·83
4043BE	1·00
4044BE	0·94
4046BE	1·32
4049BE	0·54
4050BE	0·54
4069BE	0·30
4070BE	0·50

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MICRO-BUS

Compiled by DJD.

This is the first of a new regular feature covering all aspects of microprocessors and minicomputers. 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!

DIGITAL WAVEFORMS

ONE interesting area where micros are being used is in the synthesis of electronic music. The MPU can actually generate any arbitrary waveform. The levels at regular intervals along the wave are coded into 8-bit binary numbers and stored in memory; the program outputs these numbers to a digital-to-analogue converter which converts the 8-bit number to a voltage level proportional to that number.

The D/A converter can be connected to the MPU bus by an 8-bit latch, and one way of forming a latch is from two 74157 quad 2-input data selectors as shown in the circuit diagram, Fig. 1. These devices are already present in the SC/MP kit with keyboard, seven of the latches being used to drive the segment lines of the display. If the eighth unused data selector is connected to DB7 as shown, the eight outputs can also serve to drive the D/A since the display is blank when a program is being executed. The latches can be addressed as any location with AD9 different from AD10; e.g. X'0400 (X' = Hexadecimal).

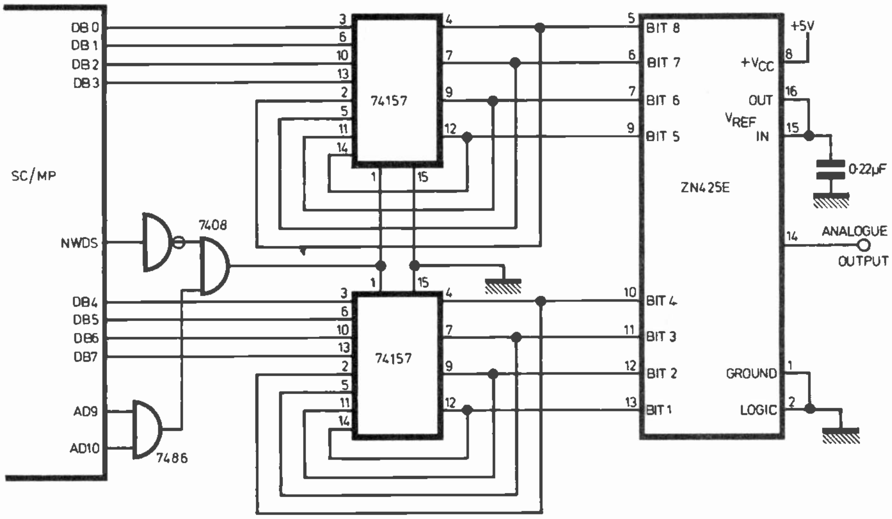

Fig. 1. Circuit showing a latch formed from a pair of 74157 quad 2-input data selectors

A program to test the circuit is given in Fig. 2, and this outputs the 36 values stored at X'OF50 repeatedly to the D/A to give a digital approximation to a sine-wave. The values in locations X'OFF7 to X'OFFC are loaded into the pointer registers by the monitor program; in systems without such a monitor, code to load these registers will have to be appended to the program.

```
                    .TITLE  SINE-WAVE
              ;FOR SC/MP INTROKIT OR KEYBOARD KIT

                    .=0F30
0F30 C4DB     OUTPUT: LDI     BEGIN-LAST        ;PROGRAM START
0F32 01       NEXT:   XAE                       ;LOAD E WITH -37
0F33 C180             LD      -128(1)           ;LOAD FROM P1+E
0F35 CA00             ST      (2)               ;STORE TO DAC
0F37 40               LDE
0F38 F401             ADI     1                 ;FOR NEXT POINT
0F3A 98F4             JZ      OUTPUT            ;LAST POINT?
0F3C 90F4             JMP     NEXT              ;NO

              ;LOCATIONS TO SET POINTERS
                    .=0FF7
0FF7 0F2F             .DBYTE  OUTPUT-1          ;PC FOR INTROKIT
0FF9 0F74             .DBYTE  LAST              ;P1 -> END
0FFB 040F             .DBYTE  040F              ;P2 -> DAC

              ;POINTS FOR SINE-WAVE
                    .=0F50
0F50 80       BEGIN:  .BYTE   080,096,0AC,0C0,0D2,0E2,0EF,0F8,0FE
0F59 FF               .BYTE   0FF,0FE,0F8,0EF,0E2,0D2,0C0,0AC,096
0F62 80               .BYTE   080,06A,054,040,02E,01E,011,008,002
0F6B 00               .BYTE   000,002,008,011,01E,02E,040,054,06A
                    .=LAST

     0000             .END
```

Fig. 2. Program for SC/MP to give a digital approximation to a sine wave

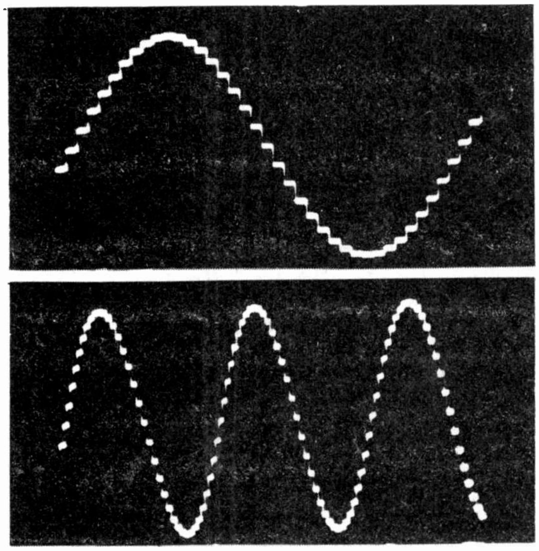

Fig. 3. Oscilloscope traces of sine wave produced from program in Fig. 2

The resulting waveform is shown in the oscilloscope traces, Fig. 3. The measured first-harmonic distortion was about 0·3 per cent, which is what you would expect since 8 bits gives you 256 levels—the maximum deviation from a true sine-wave is 1/256.

Although a sine-wave was chosen for this demonstration, any waveform can be generated with its accuracy determined by the number of sample points and the number of bits, and the frequency can be made continuously variable by feeding a variable-frequency oscillator to the interrupt input SENSE-A and modifying the program to output the data on interrupts.

To take the idea a step further an electronic organ or synthesiser could contain "templates" in read-only memory for the waveforms of notes of different instruments. These would then be used by the MPU to generate the different voices of the instrument.

THE EURO-MICRO

The Ferranti F100-L is a unique microprocessor in two respects. Firstly it has been developed and designed entirely in Europe. Secondly it uses the bipolar CDI technology rather than the more usual NMOS giving it a speed of around 10MHz, at least twice that of other MPUs, and a typical instruction time of 4μsec.

It can address up to 32K 16-bit words, and it communicates with the memory and peripherals by a 16-bit bus and 5 control lines. The decoding into address and data lines is performed by special interface sets which will cater for a variety of possible requirements.

The instruction set has a pleasing orderliness about it and all the instructions can use the four addressing modes: direct, immediate indirect, immediate data and pointer indirect. With direct addressing any location within the first 2K of memory can be specified in a single-word instruction; alternatively immediate indirect addressing allows one to specify the full 15-bit address in the next word.

Immediate data addressing supplies the operand in the second word. Finally pointer indirect addressing takes the contents of a pointer to be the required address. There are no pointer registers on the CPU chip; instead any of locations 1 to 255 can be specified as pointers, with the option of auto-increment or decrement. Thus up to 255 separate stacks can be maintained in memory.

As well as the usual instructions to add/subtract memory into the accumulator there are add/subtract accumulator into memory instructions, making it possible to replace: load X, add Y, store to Y, by the shorter: load X, add to Y.

Although there are no multiply or divide instructions, an additional single-chip unit, the F101-L, will provide these functions with execution times of less than 15μsec.

The arithmetic and logical functions act on the accumulator and memory, but the shifts and a variety of bit-test, set, and clear instructions operate on any of the accumulator, condition register, or memory. A single instruction provides a jump if a defined bit in a word is set (or clear) and then clears (or sets) it; this would be invaluable for controlling lock-outs in timesharing or multi-processor systems.

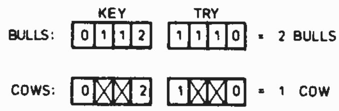

Fig. 4. The eight consecutive locations for Bulls and Cows game

The prospective computer-builder reading this may be disheartened to learn that production devices will not become available until October, when the prices will be £55·00 for the processor and £25·40 for the interface set (1 off). However, you can already set about designing your system with the help of the Hardware and System Manual, available for £7·50.

BULLS AND COWS GAME

The techniques of programming are much the same whether one is writing a game-playing program or a factory process-control program, and whereas the first is of almost universal interest, the second would probably only inspire a very restricted brand of programmer. For this reason game programs will frequently be featured in *Micro-Bus* while at the same time admitting that microprocessors have more serious applications.

One absorbing game which lends itself to being programmed is the traditional pencil-and-paper guessing game variously referred to as "Bulls and Cows" or "Moo", and recently made popular as "Mastermind". For those not already familiar with it, a brief description of one form of the game follows:

The two players first each think of a code consisting of four digits, each digit being one of the eight octal digits 0–7. The players then take turns in trying to determine the other player's code by making a guess of a number. The guesser is told the number of "bulls", i.e. digits correct and in the right position (bulls-eyes), and the number of "cows", i.e. digits correct but in the wrong position. This information guides the player towards deducing the code. For example, if the code is "3455", to the guess "4653" the reply is 1 bull, 2 cows. The first player to guess the other's code wins.

A program has been written for the 6800 in which the human player and the microprocessor alternately try to guess each other's code. It centres around the two subroutines which count the numbers of bulls and cows between two numbers, and listings for these in assembler are given below, Fig. 5.

The two numbers to be compared, referred to as KEY and TRY in the program, are stored unpacked (one octal digit per word) in the eight consecutive locations starting at 0000; see Fig. 4. Subroutine BULLS is called first and makes four comparisons between corresponding pairs of digits, returning with the number of matches in the B accumulator (2 bulls in the case shown). It complements matching digits so that they will not be counted as cows. Subroutine COWS then compares each digit in TRY not complemented with the four digits in KEY again returning with the number of matches in B (1 cow in this case). XREG is a double-byte variable used to store the X register.

The machine's strategy is at every stage of the game to make a guess chosen at random from the class of numbers consistent with the replies made to its previous guesses. The program usually wins unless its human opponent uses careful logical thinking, and the result is a highly entertaining game; readers with micro-computer systems are urged to program it.

Alternatively the program "Bulls and Cows" is available from PRACTICAL ELECTRONICS in a form suitable for running on a Motorola D2 kit and using ½K of memory. A listing and Kansas-City format cassette containing the program will be supplied on receipt of £2·50.

```
                    NAM     BULL
               *
               ****VARIABLES****
               *
0000 0004      KEY     RMB     4
0004 0006      TRY     RMB     6
000A 0002      XREG    RMB     2
               *
               ****SUBROUTINE TO FIND BULLS****
               *
000C 5F        BULLS   CLR B
000D CE 0000           LDX     £KEY
0010 A6 00     BUL2    LDA A   X
0012 A1 04             CMP A   4,X
0014 26 05             BNE     NOBUL
0016 5C                INC B
0017 63 00             COM     X
0019 63 04             CDM     4,X
001B 08        NOBUL   INX
001C 8C 0004           CPX     £KEY+4
001F 26 EF             BNE     BUL2
0021 39                RTS
               *
               ****SUBROUTINE TO FIND COWS****
               *
0022 5F        COWS    CLR B
0023 CE 0000           LDX     £KEY
0026 DF 0A             STX     XREG
0028 A6 04     COW2    LDA A   4,X
002A 2B 12             BMI     NOGOOD
002C CE 0000           LDX     £KEY
002F A1 00     TES2    CMP A   X
0031 26 05             BNE     NOCOW
0033 5C                INC B
0034 63 00             COM     X
0036 20 06             BRA     NOGOOD
0038 08        NOCOW   INX
0039 8C 0004           CPX     £KEY+4
003C 26 F1             BNE     TES2
003E DE 0A     NOGOOD  LDX     XREG
0040 08                INX
0041 DF 0A             STX     XREG
0043 8C 0004           CPX     £KEY+4
0046 26 E0             BNE     COW2
0048 39                RTS
               *
                       END
```

Fig. 5. Program for "Bulls and Cows"

The next Micro-Bus will be in the December issue, and we hope to feature circuits and programs submitted by readers. If you have any interesting and original contribution, send it to: Micro-Bus, Practical Electronics, Fleetway House, Farringdon Street, London, EC4.

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2N698	0·62	2N3705	0·15	40362	0·55	BC161	0·35	BD132	0·54	BFX88	0·30
2N699	0·55	2N3706	0·16	40363	1·30	BC167	0·12	BD135	0·37	BFX89	1·25
2N706	0·28	2N3707	0·18	40406	0·60	BC168	0·12	BD136	0·37	BFY50	0·25
2N706A	0·28	2N3708	0·13	40407	0·52	BC169	0·12	BD137	0·38	BFY51	0·25
2N708	0·28	2N3709	0·15	40408	0·75	BC170	0·18	BD138	0·38	BFY52	0·30
2N709	0·50	2N3710	0·16	40409	0·75	BC171	0·16	BD139	0·40	BFY53	0·34
2N718	0·27	2N3711	0·16	40410	0·75	BC172	0·14	BD140	0·40	BFY90	1·20
2N718A	0·50	2N3712	1·20	40411	2·85	BC177	0·20	BD239	0·40	BRY39	0·50
2N720A	0·80	2N3713	2·30	40594	0·80	BC178	0·20	BD240	0·45	BSX20	0·33
2N914	0·35	2N3714	2·45	40595	0·90	BC179	0·23	BD241	0·45	BSX21	0·32
2N916	0·30	2N3715	2·55	40673	0·75	BC182	0·11	BD242	0·50	BU105	1·40
2N918	0·38	2N3716	3·00	AC126	0·45	BC182L	0·11	BD243	0·60	BU205	2·20
2N929	0·25	2N3771	1·95	AC127	0·45	BC183	0·11	BD244	0·65	MEO402	0·20
2N930	0·26	2N3772	2·00	AC128	0·45	BC183L	0·14	BD245	0·65	MEO404	0·15
2N1131	0·30	2N3773	2·90	AC151V	0·40	BC184	0·12	BD246	0·66	MEO412	0·20
2N1132	0·37	2N3789	2·90	AC152V	0·50	BC184L	0·16	BD529	0·45	ME4102	0·10
2N1613	0·30	2N3790	3·10	AC153	0·55	BC207	0·16	BD530	0·50	ME4104	0·10
2N1711	0·30	2N3791	3·10	AC153K	0·55	BC208	0·16	BDY20	1·00	MJ481	1·55
2N1893	0·38	2N3792	3·50	AC176	0·50	BC212	0·14	BF115	0·38	MJ490	1·35
2N2102	0·98	2N3794	0·20	AC176K	0·65	BC212L	0·17	BF121	0·55	MJ491	1·85
2N2218	0·33	2N3819	0·36	AC187K	0·60	BC213	0·14	BF123	0·55	MJ2955	1·25
2N2218A	0·37	2N3820	0·38	AC188K	0·60	BC213L	0·16	BF152	0·25	MJE340	0·58
2N2219	0·35	2N3823	0·80	AD161	1·00	BC214	0·16	BF153	0·25	MJE370	0·58
2N2219A	0·36	2N3904	0·21	AD162	1·00	BC214L	0·17	BF154	0·25	MJE371	0·60
2N2220	0·35	2N3906	0·22	AF106	0·55	BC237	0·14	BF159	0·35	MJE520	0·45
2N2221	0·25	2N4036	0·67	AF109	0·75	BC238	0·12	BF160	0·30	MJE521	0·65
2N2221A	0·26	2N4037	0·55	AF124	0·65	BC239	0·15	BF161	0·60	MJE2955	1·50
2N2222	0·25	2N4058	0·20	AF125	0·65	BC251	0·16	BF166	0·40	MJE3055	0·95
2N2222A	0·25	2N4059	0·15	AF126	0·65	BC253	0·22	BF167	0·35	MP8111	0·35
2N2368	0·25	2N4060	0·20	AF139	0·69	BC257A	0·17	BF173	0·35	MP8112	0·40
2N2369	0·25	2N4061	0·17	AF186	0·50	BC258A	0·17	BF177	0·25	MP8113	0·45
2N2369A	0·25	2N4062	0·18	AF200	1·20	BC259B	0·18	BF178	0·25	MPP102	0·30
2N2646	0·75	2N4126	0·17	AF239	0·65	BC261A	0·24	BF179	0·30	MPSA05	0·25
2N2647	1·40	2N4289	0·20	AF240	1·14	BC262B	0·24	BF180	0·35	MPSA06	0·25
2N2904	0·36	2N4919	0·65	AF279	0·80	BC263C	0·30	BF181	0·35	MPSA12	0·40
2N2904A	0·37	2N4920	0·75	AF280	0·85	BC300	0·40	BF182	0·35	MPSA55	0·25
2N2905	0·37	2N4921	0·50	BC107	0·15	BC301	0·40	BF183	0·40	MPSA56	0·25
2N2905A	0·38	2N4922	0·55	BC108	0·15	BC303	0·50	BF184	0·38	MPSU05	0·50
2N2906	0·28	2N4923	0·70	BC109	0·15	BC307	0·15	BF185	0·35	MPSU06	0·56
2N2906A	0·25	2N5190	0·60	BC113	0·20	BC308	0·15	BF194	0·15	MPSU55	0·55
2N2907	0·25	2N5191	0·70	BC115	0·20	BC309C	0·15	BF195	0·15	MPSU56	0·60
2N2907A	0·25	2N5192	0·75	BC116	0·19	BC317	0·14	BF196	0·15	TIP29A	0·45
2N2924	0·15	2N5195	0·90	BC116A	0·20	BC318	0·13	BF197	0·17	TIP29C	0·60
2N2925	0·17	2N5245	0·34	BC117	0·22	BC327	0·20	BF198	0·18	TIP30A	0·49
2N3019	0·55	2N5294	0·40	BC118	0·20	BC328	0·19	BF200	0·35	TIP30C	0·65
2N3053	0·26	2N5295	0·40	BC119	0·30	BC337	0·19	BF225J	0·25	TIP31A	0·50
2N3054	0·60	2N5296	0·40	BC121	0·45	BC338	0·21	BF244	0·35	TIP31C	0·66
2N3055	0·70	2N5298	0·40	BC132	0·30	BC547	0·12	BF245	0·40	TIP32A	0·55
2N3390	0·20	2N5447	0·15	BC134	0·20	BC548	0·12	BF246	0·75	TIP32C	0·75
2N3391	0·20	2N5448	0·15	BC135	0·20	BC549	0·13	BF254	0·24	TIP33A	0·80
2N3391A	0·20	2N5449	0·19	BC136	0·19	BCY30	1·00	BF255	0·24	TIP33C	1·10
2N3392	0·16	2N5457	0·32	BC137	0·20	BCY31	1·00	BF257	0·37	TIP34A	0·90
2N3393	0·15	2N5458	0·33	BC140	0·35	BCY32	1·00	BF258	0·45	TIP34C	1·20
2N3394	0·15	2N5459	0·29	BC141	0·40	BCY33	1·00	BF259	0·49	TIP35A	2·50
2N3439	0·88	2N5484	0·34	BC142	0·30	BCY34	1·00	BF459	0·50	TIP36A	2·80
2N3440	0·64	2N5486	0·38	BC143	0·30	BCY38	2·00	BFR39	0·28	TIP41A	0·70
2N3441	0·81	2N6027	0·60	BC147	0·12	BCY42	0·60	BFS21A	2·60	TIP41C	0·90
2N3442	1·35	2N6101	0·45	BC148	0·12	BCY58	0·25	BFS28	1·38	TIP42A	0·80
2N3638	0·16	2N6107	0·42	BC149	0·14	BCY59	0·25	BFS61	0·30	TIP42C	1·00
2N3638A	0·16	2N6109	0·50	BC153	0·27	BCY70	0·25	BFS98	0·30	TIP2955	0·65
2N3639	0·30	2N6121	0·38	BC154	0·27	BCY71	0·26	BFX29	0·35	TIP3055	0·55
2N3641	0·20	2N6122	0·41	BC157	0·14	BCY72	0·24	BFX30	0·35	TIS43	0·43
2N3702	0·13	2N6123	0·43	BC158	0·14	BD115	0·80	BFX84	0·35		

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CA3028A	1·01	LM3301N	0·85	TAA661A	1·50
CA3030	1·35	LM3302N	1·40	TAA661B	1·50
CA3030A	2·00	LM3401	0·70	TAA700	3·91
CA3045	1·40	LM3900	0·75	TAA930A	1·30
CA3046	0·89	LM3905	1·60	TAA930B	1·30
CA3048	2·23	LM3909	0·68	TAD100	1·95
CA3049	1·80	MC1035	1·75	TBA120	0·75
CA3050	2·42	MC1303	1·03	TBA400	2·00
CA3052	1·62	MC1304	1·40	TBA500	2·21
CA3080	0·75	MC1305	1·40	TBA500Q	2·30
CA3080A	1·88	MC1310	1·91	TBA510	2·21
CA3086	0·80	MC1327	1·54	TBA510Q	2·30
CA3088	1·70	MC1330	1·00	TBA520	2·21
CA3089	2·52	MC1350	0·90	TBA520Q	2·30
CA3090	4·00	MC1351	1·20	TBA530	1·98
CA3130	0·98	MC1352	1·10	TBA530Q	2·07
LM301A	0·67	MC1458	1·91	TBA540	2·21
LM301N	0·40	NE555	0·40	TBA540Q	2·30
LM304	2·45	NE556	1·10	TBA550	3·13
LM307N	0·65	NE565	1·30	TBA550Q	3·22
LM308C	1·82	NE566	1·65	TBA560Q	3·22
LM308N	0·85	NE567	1·80	TBA570	1·29
LM309K	1·85	SAS560	2·50	TBA570Q	1·38
LM317K	3·00	SAS570	2·50	TBA641B	2·70
LM318N	2·26	S042P	1·25	TBA651	2·20
LM323K	6·46	76001N	1·30	TBA700	1·52
LM339N	1·40	76003N	2·20	TBA700Q	1·61
LM348N	1·50	76008K	1·50	TBA720Q	2·30
LM360N	2·75	76013N	1·50	TBA750	1·98
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LM371N	1·70	76018K	1·50	TBA800	1·25
LM372N	1·70	76023N	1·45	TBA810	1·25
LM373N	2·80	76023ND	1·26	TBA820	1·25
LM374N	3·10	76033N	2·20	TBA920	2·90
LM377N	1·75	76110N	1·18	TBA920Q	2·99
LM378N	2·25	76115N	1·51	TBA940	1·62
LM379S	3·95	76116N	1·66	TCA160C	1·85
LM380-8	0·90	76131N	1·20	TCA160B	1·61
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LM381N	1·60	76228N	1·41	TCA290A	3·13
LM382N	1·25	76530N	0·75	TCA420A	1·84
LM384N	1·45	76532N	1·40	TCA730	3·22
LM386N	0·80	76533N	1·20	TCA740	2·76
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LM709N	0·45	76570N	1·68		
LM710C	0·60	76620N	0·90		
LM710N	0·60	76650N	1·10		
LM723C	0·85	76660N	0·60		
LM723N	0·75	76666N	0·92		
LM741C	0·65	TAA320A	1·00		
LM741N	0·40	TAA350A	2·48		
LM741-8	0·40	TAA521	1·00		
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AA119	0·14	BA202	0·09	OA90	0·08	IN4007	0·12
AA129	0·09	BAX13	0·07	OA91	0·08	IN4148	0·07
AAZ17	0·18	BAX16	0·10	OA95	0·10	IN4150	0·19
BA100	0·18	BB103	0·30	OA200	0·10	IN5400	0·14
BA102	0·18	BB104	0·40	OA202	0·14	IN5401	0·16½
BA144	0·12	BY126	0·29	IN914	0·07	IN5402	0·17½
BA145	0·18	BY127	0·36	IN916	0·07	IN5404	0·18½
BA154	0·10	BY182	1·50	IN4001	0·06	IN5406	0·22½
BA155	0·12	BY206	0·20	IN4002	0·07	IN5407	0·27
BA156	0·15	BY207	0·22	IN4003	0·08	IN5408	0·40
BA157	0·29	BYX10	0·27	IN4004	0·09	IS44	0·07

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7402	0·16	7414	1·80	7441	1·03	7472	0·34	7490	0·61	74121	0·49	74162	1·41				
7403	0·16	7416	0·50	7442	0·78	7473	0·43	7491	0·98	74122	0·45	74163	1·41				
7404	0·26	7417	0·50	7445	1·35	7474	0·43	7492	0·61	74123	0·58	74164	1·23				
7405	0·26	7420	0·21	7446	1·23	7475	0·58	7493	0·61	74141	1·03	74165	1·23	74182	1·08		
7406	0·60	7423	0·39	7447	1·10	7476	0·51	7494	0·74	74145	1·06	74167	3·70	74184	2·46	74192	1·62
7407	0·60	7425	0·39	7448	1·10	7480	0·45	7495	0·78	74151	1·11	74174	1·52	74185	2·46	74193	1·62
7408	0·24	7427	0·39	7450	0·21	7481	1·10	7496	1·03	74153	1·11	74175	1·35	74188	2·46	74196	1·17
7409	0·24	7430	0·21	7451	0·21	7482	0·67	7497	4·60	74154	1·85	74176	1·23	74189	3·99	74197	1·17
7410	0·20	7432	0·35	7453	0·21	7483	1·33	74100	1·15	74155	1·11	74180	1·77	74190	1·91	74198	2·93
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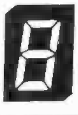

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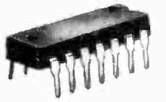

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CD4002	0·24	CD4020	1·27	CD4043	1·15	CD4063	1·25	CD4085	0·81	74LS08	0·24	74LS157	1·17
CD4006	1·34	CD4021	1·15	CD4044	1·06	CD4066	0·80	CD4086	0·81	74LS10	0·24	74LS160	1·40
CD4007	0·24	CD4022	1·10	CD4045	1·59	CD4067	4·25	CD4089	1·77	74LS13	0·65	74LS161	1·50
CD4008	1·10	CD4023	0·24	CD4046	1·52	CD4068	0·25	CD4093	0·91	74LS32	0·25	74LS162	1·50
CD4009	0·64	CD4024	0·84	CD4047	1·15	CD4069	0·25	CD4094	2·13	74LS42	1·01	74LS162	1·50
CD4010	0·64	CD4025	0·24	CD4049	0·64	CD4070	0·66	CD4095	1·19	74LS74	0·48	74LS163	1·50
CD4011	0·24	CD4027	0·64	CD4050	0·64	CD4071	0·25	CD4096	1·19	74LS75	0·60	74LS164	1·52
CD4012	0·24	CD4028	1·02	CD4051	1·06	CD4072	0·25	CD4510	2·00	74LS76	0·40	74LS173	2·35
CD4013	0·60	CD4029	1·30	CD4052	1·06	CD4073	0·25	CD4511	2·30	74LS85	1·45	74LS174	1·20
CD4014	1·15	CD4030	0·64	CD4053	1·06	CD4075	0·25	CD4516	2·00	74LS86	0·48	74LS175	1·20
CD4015	1·15	CD4031	2·53	CD4054	1·32	CD4076	1·17	CD4518	2·00	74LS90	1·00		
CD4016	0·64	CD4035	1·34	CD4055	1·50	CD4077	0·66	CD4520	2·00	74LS92	0·90		
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74LS

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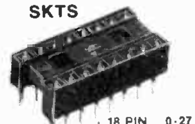
74C04	0·26	74C90	0·91
74C08	0·26	74C107	1·30
74C10	0·26	74C151	2·62
74C20	0·26	74C157	2·35
74C30	0·26	74C160	1·18
74C32	0·26	74C161	1·18
74C42	0·92	74C162	1·18
74C48	2·30	74C163	1·18
74C73	0·58	74C164	1·04
74C74	0·59	74C173	0·95
74C76	0·58	74C174	0·95

LOW PROFILE SKTS



		18 PIN	0·27
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14 PIN	0·16	28 PIN	0·45
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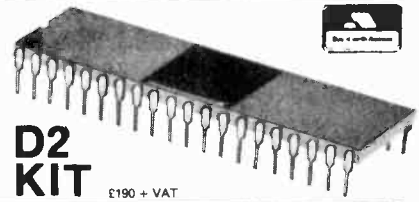

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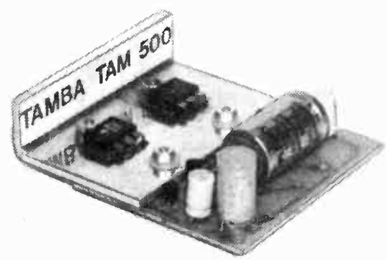

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A plastic box with moulded extrusion rails for PC or Chassis panels with metal front plate fitted with four screws (all supplied). Size (internal) 81mm × 51mm × 28mm. Our Price **50p** + 8%.

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No disco should be without our new effects projector, we believe that this is the most versatile machine for projecting coloured images to supplement your music. Spec.: Volts—220/240, a.c., 50 Hz, Lamp—A1/167 150W, Standard Lens—60mm. A sturdy metal construction and takes a range of lenses and accessories. Comes complete with 6in wheel and ready to use. A bargain at £30 + £1·25 P. & P. + 8% VAT.

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Switched 3, 4½, 6, 7½, 9 and 12V at 500 mA. With on/off switch and pilot light.
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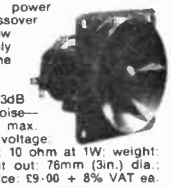

New high quality high power tweeter, no form of crossover network is required as low frequency voltages simply have no effect on the tweeter. Specification—Frequency response: 3·8kHz to 28kHz ±3dB (input 4V r.m.s. pink noise—output 105dB): max. continuous r.m.s. input voltage 25V; min. series resistor: 10 ohm at 1W; weight: 63gm (2·25oz); panel cut out: 76mm (3in.) dia.; size: 85 × 85 × 75mm. Price: £9·00 + 8% VAT ea.

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A mains suppressor designed to reduce unwanted mains interference caused by fridges, boilers, etc. Best results are obtained by plugging the item causing the interference directly into the suppressor, which is fitted with a 3-pin 13A mains socket. The suppressor is housed in a black plastic box with silver front panel and measures approx. 116 × 77 × 54mm. The unit comes fitted with 1·5m of 3-core cable and has a max. current loading of 3A. Price: £9·00 + 8% VAT.

ACCESS AND BARCLAYCARD ACCEPTED
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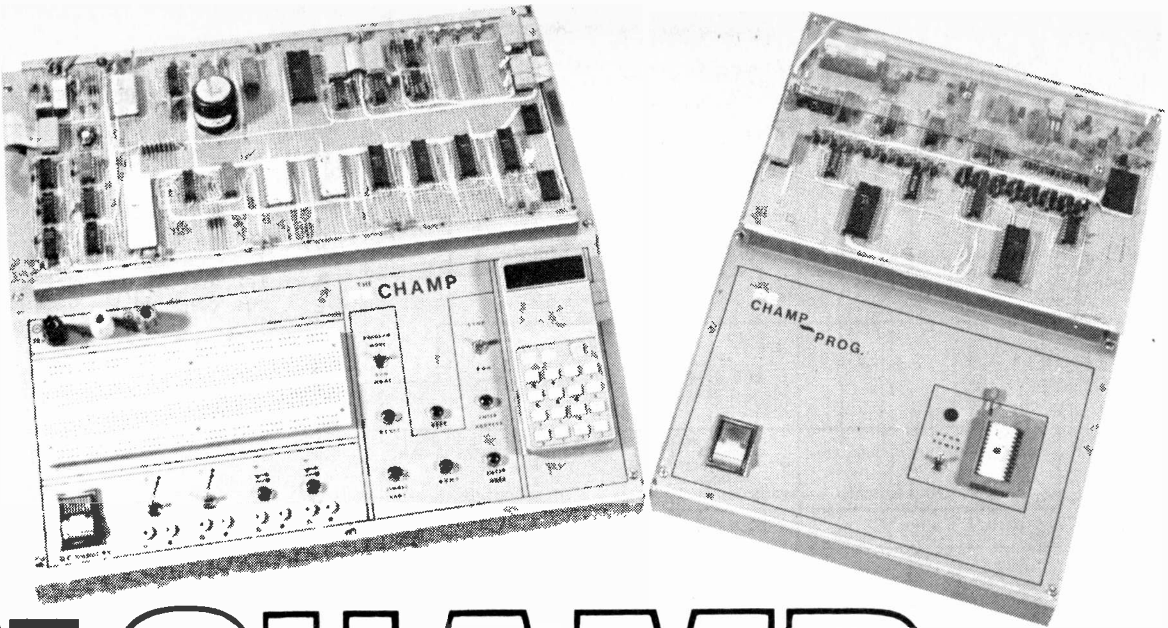
VAT—All prices are excluding VAT. Please add to each item the VAT rate indicated.



PE CHAMP PART TWO

R.W. COLES
B. CULLEN

Last month we examined the CHAMP "family" concept of combining a microprocessor unit (CHAMP itself), PROM programmer (CHAMP-PROG), and a PROM eraser (CHAMP-UV) to produce a self-sufficient and capable development system.

This month we shall start to look in detail at the circuitry on the CHAMP microprocessor board, and at the 4040 MPU chip around which the system is constructed.

MAIN BOARD

The main objective of the CHAMP design was to produce a *complete* microprocessor system at the lowest possible cost, and in keeping with this objective no expensive plug-in cards and edge connectors are used at all. Major circuitry is mounted on a single piece of 0·1in matrix Veroboard which, in fact, is a much more convenient packaging solution than more expensive plug-in cards anyway!

Connections to the board are made via 16-way d.i.l. plugs and sockets, and in the basic system, only two of these are occupied with the others available for system expansion and debugging purposes. Power is coupled to the board via three hardwired leads terminated in wander plugs. These can be plugged into sockets on the power supply itself, or, when the board is in its vertical position, into sockets adjacent to the breadboard.

CONSTRUCTOR'S NOTE

A kit comprising the main i.c.s for CHAMP:

4040	4289	2 off 5101-8
4201A	1 off 4702A	Plus
4265	3205	4040 XTAL
1 off 4002-1		

is available from Rapid Recall Ltd., Dep. N, 9 Betterton Street, Drury Lane, London WC2H 9BS at the special price of £49·68 including post, packing and VAT

The board can be removed rapidly when necessary by simply uncoupling the connectors mentioned above and then sliding it sideways out of the self adhesive card guides in which it rests. Under the board, on the plinth, is another card guide which can be used to support the board in the vertical position with all connections remade, on those occasions where access to *both* sides of the board is required.

The board itself measures 305 × 159mm and carries 25 integrated circuits including PMOS, CMOS and TTL devices.

4040 MPU CHIP

At the heart of the board is of course the 4040 microprocessor chip. The 4040 is a development of the Intel 4004, which had the honour of being the first microprocessor ever produced. As mentioned last month, CHAMP is downwards compatible with the 4004 chips, allowing the development of very low cost dedicated systems when the more sophisticated features of the 4040 are not required.

The 4004 chip is housed in a 16-pin package whereas of course the 4040 uses the larger 24-pin version; both chips are made using the well tried PMOS technology and need 15 volt supplies. In CHAMP, supplies of −5V and −10V are used so that interface to TTL and CMOS can be simply achieved without recourse to level translation.

The 4040 and 4004 are "four-bit" microprocessors, which means that their arithmetic units operate on "words" of four binary bits, and that transfer of data within a 4040 or 4004 system is carried out four bits at a time. This does *not* of course mean that arithmetic resolution is limited to four bits: *any* arithmetic resolution can be achieved by simply cascading four-bit operations. "Natural" 4040 arithmetic resolutions are in fact 64 bits binary or 16 digits decimal, as we shall see when we consider the arrangement of data memory.

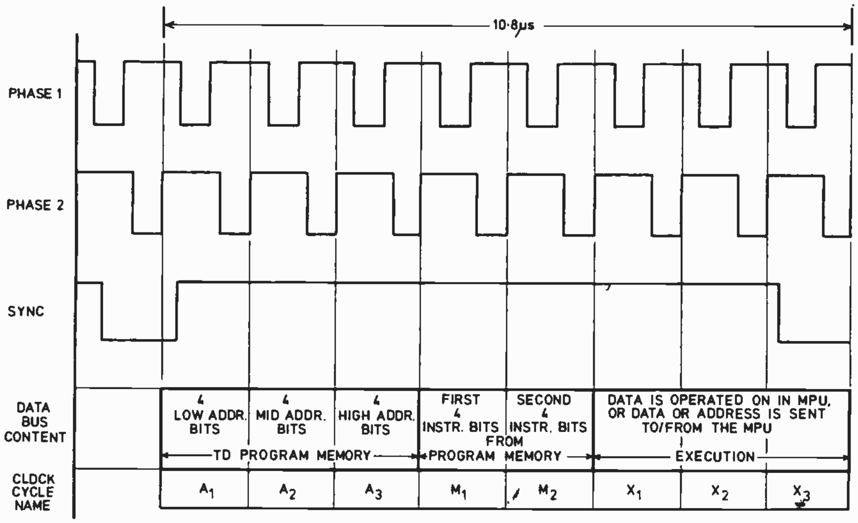


Fig. 2.1. System timing and data bus contents for the 4040

COMPONENTS . . .

CHAMP BOARD

Resistors

4 off	47Ω	R1–3, R40
2 off	100Ω	R33, 59
8 off	150Ω	R51–58
1 off	270Ω	R32
17 off	1kΩ	R6, R8–13, R15, 17, 26, 31, 34, R35–38, R60
13 off	5·1kΩ	R14, R18–25, R45–48
9 off	10kΩ	R4, 7, 16, 39, R41–44, R49
4 off	12kΩ	R27–30
1 off	47kΩ	R50
1 off	1MΩ	R5

All 2% ⅛W carbon film

Capacitors

2 off	33pF	Sub-min ceramic	C4, 5
7 off	10nF	Ceramic disc 18V	C6–11, C14
1 off	0·1μF	Ceramic disc 18V	C12
3 off	0·22μF	Polyester	C1, 2, 13
1 off	1μF	Tantalum bead 35V	C3
1 off	4·7μF	Tantalum bead 35V	C15

Transistors

5 off BC108 TR1–5

Diodes

1 off	BYZ88C3V9 Zener, 3·9V 400mW	D13
14 off	OA47	D1–12, D19–20
6 off	1N4148	D14–18, D21

Integrated Circuits

1 off 3205	IC17
2 off 4002	IC4, 5
1 off 4040	IC2
1 off 4201	IC1
1 off 4265	IC6
1 off 4289	IC15
2 off 4702A	IC18, 19
4 off 5101	IC20–23
3 off 74L00*	IC3, 10, 24
1 off 74L02*	IC25
3 off 74L74*	IC11–13
1 off 74123	IC9
1 off 74125	IC14
1 off 74157	IC16
2 off 75491	IC7, 8

*See Text

Miscellaneous

B1 Nickel Cadmium stack, 4·8V 225mAh
XL1 Crystal 5·185MHz
8 off 16-pin d.i.l. low profile sockets, SK1–8
500 off Soldercon sockets
Veroboard VB124 179 × 454mm

4040 INSTRUCTIONS

Although the 4040 is a "four-bit" device, its instruction set is based on an eight-bit word length which means that program memory (which is separate to data memory) is organised as consecutive locations each containing *eight* bits. A popular name for an eight-bit word is "byte", and a four-bit word is often called a "nibble" (for obvious reasons!). From now on we will be using these terms when appropriate.

The 4040 has a total of 60 separate instructions, some of which are 16 bits long and require two consecutive bytes in program memory.

For dedicated applications, program memory would normally consist of ROMS or PROMS, but because CHAMP is a development system, an area of RAM program memory is also provided, for user programs, and this makes it important for us to differentiate between program and data RAM which are of course used for different purposes. The 4040 uses a 12-bit address counter which allows up to 4096 bytes of program memory to be directly addressed, although only 1024 locations are actually used in the CHAMP system as it stands, 512 bytes being assigned to PROM and 512 bytes to RAM. The CHOMP system firmware occupies 256 bytes only; when the PROMPT programmer firmware is added however, the full 512 bytes of PROM are utilised.

USER'S MANUAL

It is important that any intending CHAMP constructor should obtain a copy of the "Intel MCS-40 User's Manual" preferably of the March 1976 or later edition. This is provided free when a chip set is purchased, and is a mine of information on 4040 operation, programming, and interfacing, and contains data sheets on systems components like RAMS and PROMS.

The description of 4040 operation provided here is necessarily limited by space considerations, and most CHAMP users will soon find themselves wanting to know more! The User's Manual provides all the answers to technical questions and includes many programming and applications examples to whet one's appetite!

4040 OPERATION

The 4040 uses the dynamic mode of operation which means that it must be continuously clocked to ensure proper data retention. The necessary 2-phase clock is best provided by the Intel 4201 clock generator which is produced especially for this purpose, since in addition to containing the clock circuitry this device provides the power-on reset logic and the single step logic which forms an essential part of any development system. The basic clock frequency is determined with the aid of a crystal, and is normally set, as in CHAMP, to 5·185MHz to give the data sheet instruction cycle time of 10·8 microseconds. The basic clock frequency is divided in the 4201 to give two 740kHz non-overlapping pulse trains which are used to drive the MPU chip clock inputs.

Inside the 4040 this clock frequency is further divided into "instruction cycles" which each consist of eight clock periods. The instruction cycle is really the shortest interval which can be isolated in an operational system. When the SINGLE SHOT mode is used it initiates either one or two of these instruction cycles depending on whether a one- or two-byte instruction is involved. The 4040 signals the start of a *new* instruction cycle with a pulse output on its SYNC pin, and this signal is wired to all the other devices which interface directly with the 4040 bus so that they can keep in step with processor timing.

The 4040 uses a four-bit data bus (D_0 D_1 D_2 D_3) to communicate with its associated flock of program memory, data memory, and input/output ports. In fact this so called data bus is really a combined data and address bus, since there is no separate address bus as in most other microprocessors.

Now, if you have followed me so far, you may be wondering how on earth the 4040 manages, during the execution of a single instruction, to send *out* 12-bit addresses, *retrieve* 8-bit instructions, and *shift* 4-bit data nibbles around when all it has to do it with is a single four-bit bus! The answer, of course, is provided by time multiplexing, and now we can begin to see why one instruction cycle consists of eight clock cycles.

DATA BUS CONTENTS

Immediately after the 4040 SYNC pulse, the low order four bits of a program memory address are sent out on the data bus followed one clock cycle later by the middle four bits, and then the high order four bits, after this back to the 4040 come the first four bits of the instruction, followed by the second four bits. This leaves three clock cycles out of the eight for the execution phase of the instruction, when the accumulator contents and data RAM addresses are able to use the bus as required by the particular instruction which was fetched.

The use of a time multiplexed bus of this type drastically reduces the number of interconnections required (at least 20 wires would be required by a non multiplexed bus) but it does impose a time penalty. It is our contention that for home built systems this is a trade-off worth making, after all, even with a 10·8 microsecond instruction cycle, 92,592 single-byte instructions can be carried out in one second! System timing and data bus contents are summed up in Fig. 2.1.

ADDRESSING DATA MEMORY

The data memory used with a 4040 system is of a special type, organised in a unique way. The chips used are coded 4002 and they contain, in a 16-pin package, four RAM registers and a four-bit output port. Each register consists of 20 separately addressable locations of four bits, subdivided into 16 main memory locations and 4 status characters (Fig. 2.2).

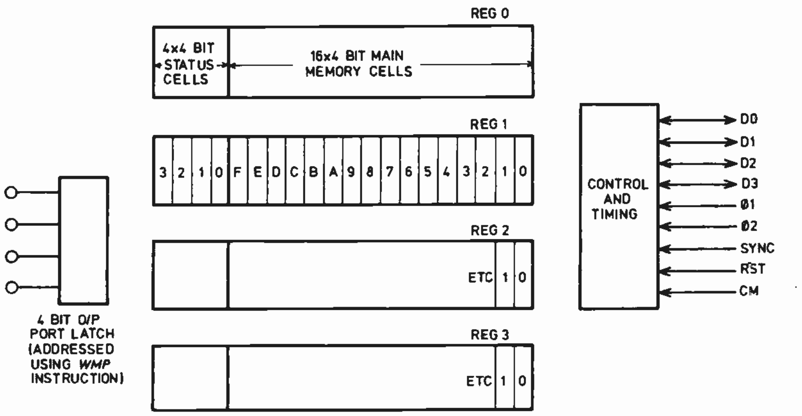


Fig. 2.2. Organisation of 4040 system data memory

This memory organisation was originally intended for the convenient storage of 16-digit binary coded decimal floating point numbers, the status characters being intended for storage of the mantissa sign, two-digit exponent, and exponent sign. Despite this design intention, the 4002 structure is quite suitable for all other likely uses and can readily be used for the storage of binary arithmetic operands, status flags, counters, and what-you-will. The status characters are directly addressable within a register and are therefore useful as "overspill" registers to take the load off the internal 4040 register array when space is limited.

Addressing a particular 4002 location is achieved with the aid of an instruction called *SRC* (Send Register Control) which causes the eight-bit address of a RAM location to be sent out on the 4040 data bus in two consecutive nibbles. The 4002 contains all the necessary demultiplexing circuitry to unscramble and latch this address.

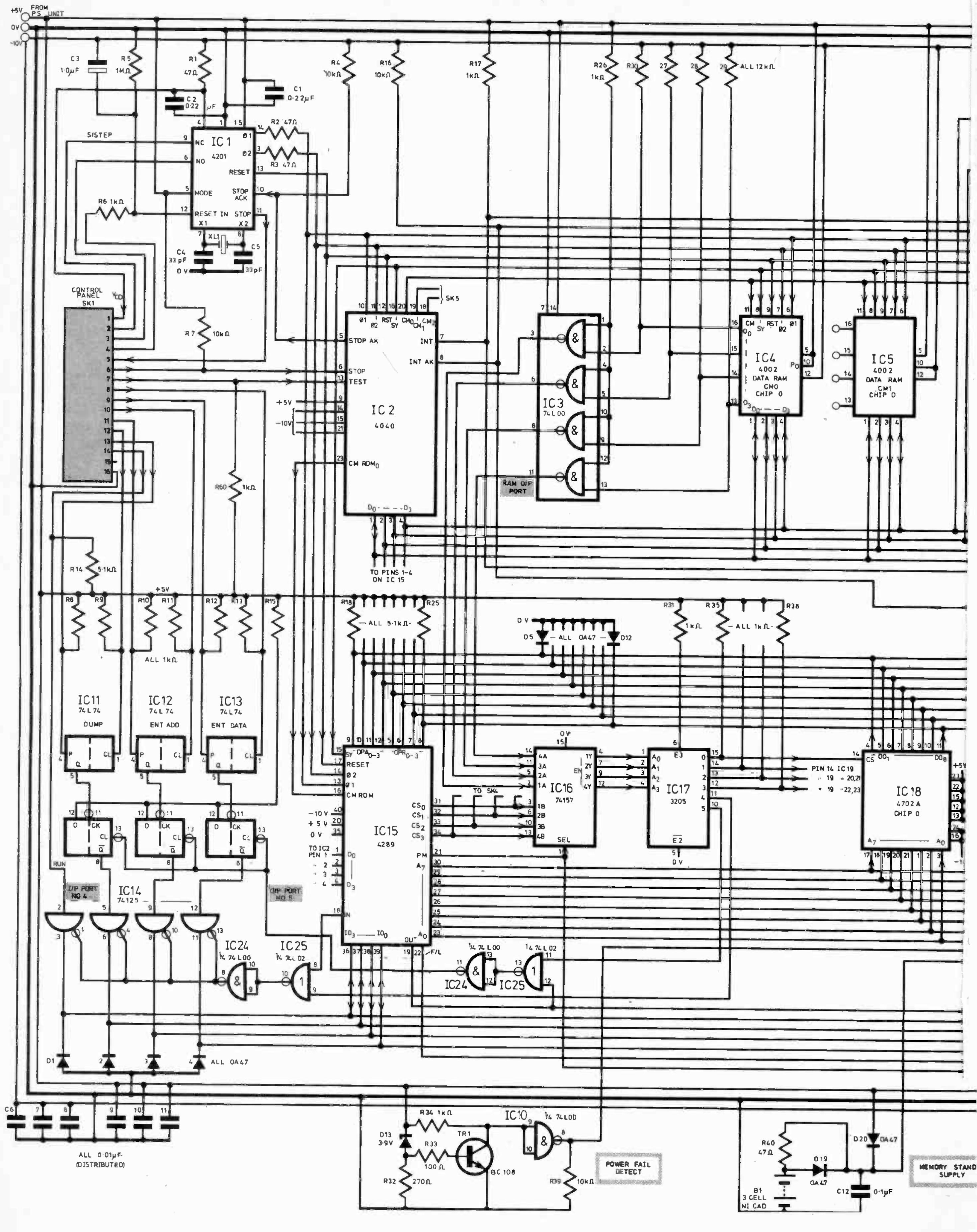
ADDRESSING PROGRAM MEMORY

The CHAMP system uses standard 4702A EPROM chips and 5101 256 × 4 RAM chips to form the program array, but these chips have no internal facilities for demultiplexing the 4040 bus. To provide the necessary multiplexing and demultiplexing functions, another member of the 4040 family, the 4289 memory interface chip, is used. The 4289 "unscrambles" the 4040 bus to give twelve parallel address outputs, and also "scrambles" the eight-bit instruction words *from* the program memory so that they can be sent back to the MPU chip over the bus.

The combination of 4289 and standard memory components is therefore equivalent to the 4308 mask-programmed ROMS which *do* contain 4040 bus interface logic but which are of course unsuitable for use with a development system because they cannot be reprogrammed. The 4308 parts also contain a number of input/output ports which can be accessed using the *RDR* and *WRR* instructions, after selection with an appropriate *SRC*. To duplicate this function the 4289 provides a four-bit bidirectional I/O bus which interfaces with up to 16 input and 16 output ports built with TTL or CMOS logic.

INPUT/OUTPUT

In the CHAMP system this "ROM I/O" facility is used only by the CHOMP firmware for control functions and for writing programs into program RAM. CHAMP *users* would normally concern themselves only with the data RAM based I/O provided by the 4265 programmable general purpose I/O chip.



+5V FROM P.S. UNIT
0V
-10V
C3 1·0μF
R5 1MΩ
R1 47Ω
C2 0·22μF
C1 0·22μF
R4 10kΩ
R16 10kΩ
R17 1kΩ
R26 1kΩ
R30
27
28
29
ALL 12kΩ
S/STEP
IC1 4201
R2 47Ω
R3 47Ω
R6 1kΩ
XL1
C4 33pF
C5 33pF
CONTROL PANEL SK1
SK5
R7 10kΩ
IC2 4040
TO PINS 1-4 ON IC15
IC3 74L00
RAM O/P PORT
IC4 4002 DATA RAM CM0 CHIP 0
IC5 4002 DATA RAM CM1 CHIP 0
R60 1kΩ
R14 5·1kΩ
ALL 1kΩ
ALL 5·1kΩ
ALL OA47
ALL 1kΩ
IC11 74L74 DUMP
IC12 74L74 ENT ADD
IC13 74L74 ENT DATA
IC15 4289
IC16 74157
IC17 3205
IC18 4702A CHIP 0
TO SK4
PIN 14 IC19
RUN
O/P PORT NO 4
O/P PORT NO 5
IC14 74125
IC24 ¼ 74L00
IC25 ¼ 74L02
D1
ALL OA47
C6
ALL 0·01μF (DISTRIBUTED)
D13 3·9V
R34 1kΩ
R33 100Ω
R32 270Ω
TR1 BC108
IC10 ¼ 74L00
R39 10kΩ
POWER FAIL DETECT
R40 47Ω
D19 OA47
D20 OA47
B1 3 CELL NI CAD
C12 0·1μF
MEMORY STAND SUPPLY

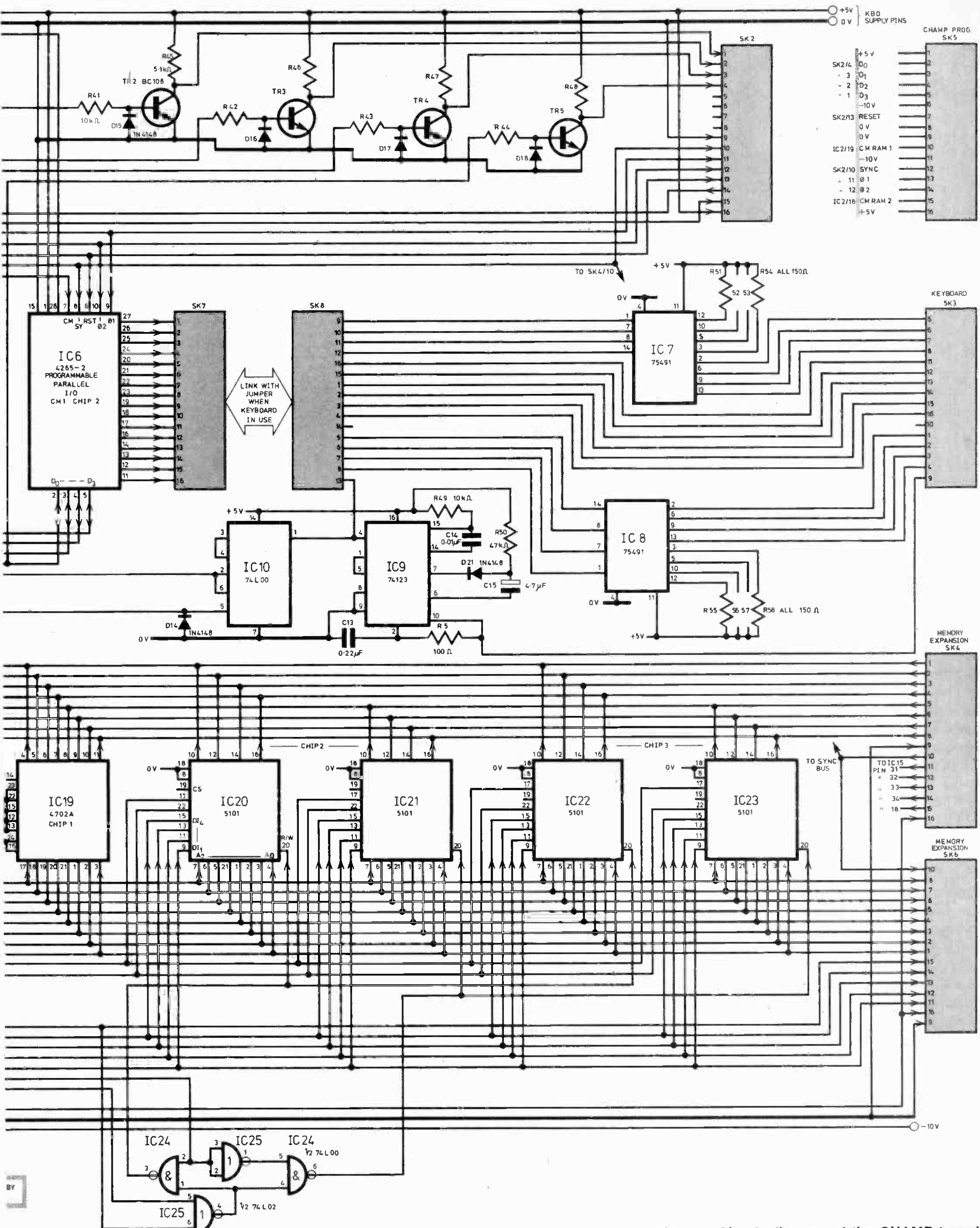
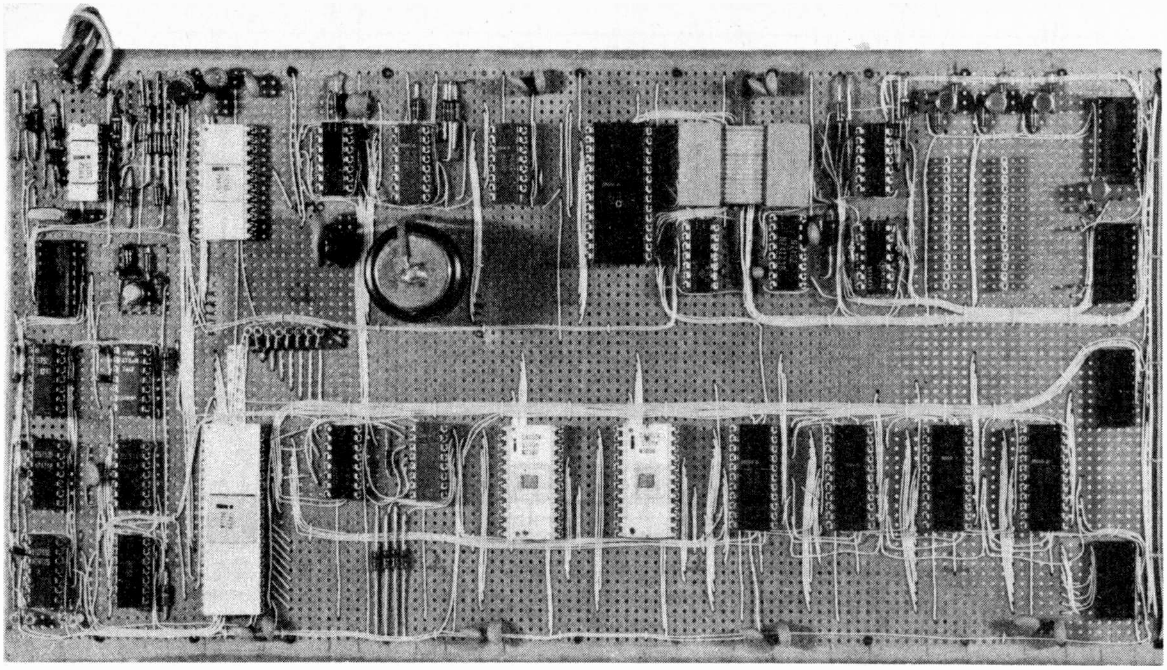


Fig. 2.3. Circuit diagram of the CHAMP board



Bird's-eye view of the CHAMP board

The 4265 is a powerful addition to the 4040 family which can live at the end of the 4040 bus and yet provide 16 input/output lines which may be configured *using software* into any one of 14 separate operating modes. The 4040 system can directly address up to four 4265 chips, and one is provided on the CHAMP main board. If CHAMP-PROG is added, then a further two 4265s come with it, their ability to talk directly to the 4040 bus being demonstrated by the fact that only a single 16-way flat cable is needed to pass all programming data and power supplies between the two units!

The 4265s occupy address space normally used by 4002 data RAM chips, and are in fact addressed and accessed in the same way, using the same instructions. The mode of operation for each 4265 is programmed during system initialisation by means of the *WMP* instruction, subsequent data transfers being made by use of the *WR0* to *WR3*, *RD0* to *RD3*, *WRM*, *RDM*, *ADM* or *SBM* instructions.

The CHAMP "on board" 4265 is put into mode 9 during initialisation and used as the keyboard/display interface during program load and debug. When a user program is run, however, the same 4265 can be reprogrammed to a *different* mode, with connections to user circuitry made via the 16-way d.i.l. socket provided for this purpose. Needless to say, this is a very useful and powerful facility! The 4265 chips even have a mode which allows them to be used as a data memory interface for use with standard memory chips like the 2111. This is very useful where a lot of data RAM is required because a 4265 and four 2111 chips provide 1024 four-bit nibbles in a much more compact form than the 16 4002 chips otherwise required. It is only fair to point out, however, that *most* 4040 applications do not need that much data RAM!

INTERRUPTS

The 4040 has a single-level interrupt which can be extended externally to any number of lines. CHAMP uses the interrupt facility for keyboard entries, although user programs can reallocate the interrupt to another source or sources as required, multiple interrupts being resolved by using an input port to "poll" all possible sources.

The 4040 has an internal seven-level hardware address register stack which is used to save the current address value when an interrupt occurs. This stack is also used for saving subroutine return addresses.

PUTTING THE PIECES TOGETHER

In Fig. 2.3 we show the overall circuit of the CHAMP board and you should now be able to pick out the main system components like the 4201 clock generator, the 4002 data RAM, the 4289 program memory interface, the 4702A and 5101 program memory chips, the 4265 programmable I/O and of course the 4040 MPU chip itself. You will also see that scattered among these major systems components there are a number of TTL gates and flip-flops and of course a variety of discrete components, which together form an essential part of the CHAMP microprocessor circuit. Next month we shall be examining the operation of this circuitry in detail, but meanwhile a word about interfacing is necessary.

TTL COMPATIBLE

CHAMP brings together on one board PMOS system chips, CMOS memory chips and TTL gates and flip-flops, all of which differ in their interface requirements. Most 4040 system parts have a variety of options available via their supply pins so that their output drive levels may be programmed to be compatible with all the logic families likely to be encountered.

In CHAMP, TTL interfacing has been chosen since this is practical and uncomplicated and is also suitable for use with 5 volt CMOS. For complete details of the interface considerations involved, refer to chapter three of the user handbook where the 4040, 4289, 4265, and the 4002 are dealt with.

In general it is best to use *low power* TTL in an MCS40 system since it is both sufficiently fast and easy to drive, although certain 4289 and 4265 outputs *are* capable of driving standard TTL loads if necessary. In CHAMP, low power TTL is recommended, although it is only *essential* in the IC3 position.

NEXT MONTH: CHAMP Development System circuit description

Semiconductor UPDATE...

FEATURING: SC/MP-II MC4000 B-Series

R. W. Coles

REVAMPED SC/MP

The SC/MP microprocessor chip from National is a good compromise between price and performance, and has now become very popular with hobbyists both here and in the USA.

It's not just the basic price of an MPU chip which determines the overall cost of a working system of course, the numbers and types of any necessary supporting i.c.s will usually be more important, and it is on this count that the SC/MP chip beats the more sophisticated opposition represented by the Intel 8080A and the Motorola 6800.

The SC/MP has an on-chip clock oscillator which will run with just an *RC* timing network if required, and this alone can save the significant cost of a crystal and the clock generator chip (or chips) often required. It also has CMOS or TTL compatible outputs too, and the use of memory mapped input/output removes the need for the more capable but rather expensive, programmable interface chips, allowing a functional system to be built with just an MPU chip and a handful of standard logic.

To improve this image of capable economy, the SC/MP needs a low cost plastics package and the advantage of operation from readily available five volt logic power supplies, but with the PMOS process technology this has not been possible. Both these assets *could* have been gained by switching to NMOS technology but until now this switch has been avoided because PMOS has been cheaper and more readily produced.

Now National have relented and introduced **SC/MP-II** which *does* live in a plastics package and *does* run from a single 5V supply. SC/MP-II retains all the original SC/MP-I features and an identical instruction set, but now an advanced silicon gate *n*-channel ion implant process is used for chip manufacture.

In most cases the new chip can be directly substituted for the old with just a change of chip supply voltage, and I believe that a low cost conversion set is to be offered to the many users of the popular Introkit.—Well done National!

BE BUFFERED

You may have decided that 4000 series CMOS logic, with its wide supply voltage range, low power operation, and high noise immunity is the best thing since sliced bread. Or, you may be a TTL man!

No matter what your feelings about CMOS, you should take a new look at this popular but sometimes controversial family now that B-series devices are becoming freely available.

The B in B-series CMOS stands for "buffered" because each ouptut is isolated from its associated inputs by a separate buffer stage so that output drive is independent of the number of driven inputs. This is a big improvement over standard 4000 series devices, which have a poor output drive capability which can sometimes only be improved by paralleling gate *inputs!*

The B-series CMOS will drive without compromise a couple of low power TTL loads or a single low power Schottky load over the full temperature range. A big improvement, but that's not all. The B-series devices have been improved in other respects, and now feature improved noise margins, reliable high voltage operation, improved static charge protection and a guaranteed fanout to over 50 fellow CMOS inputs.

Motorola already offer about 100 suffix B types with such favourites as the 14011, the 14016 and 14013 now freely available in this new style as the **14011B**, **14016B** and the **14013B**. Certain B series devices are complete redesigns of existing 4000 series parts and these offer performance advantages in other areas.

Take the **MC14538B** dual monostable for example. This is a plug-in replacement for the older MC14528 dual mono with improvements like high precision pulse timing, reduced temperature dependence, and a new timing equation. This device should bring CMOS mono performance closer to that of the excellent workhorse, the TTL 74123, and put an end to the difficulties sometimes encountered with the 14528.

POINTS ARISING

P.E. MINISONIC 2
("Sound Design"—A P.E. Publication)

On the component layout drawing. Fig. 21, page 24, the diode D5/2 in the Envelope Shaper should have its polarity reversed.

Readers intending to make their own printed circuit boards for this project can obtain a clean copy of the track layout master from the Editorial Office, free of charge. Please send a large stamped addressed envelope.

LINEAR OHMMETER *(September 1977)*

In Fig. 3, page 47, VR2 wiper should connect to IC3 pin 4. In the second paragraph under the side heading "Setting Up", 0·6μA should read 0·6mA.

FREQUENCY COUNTER/TIMER *(September 1977)*

Referring to Fig. 8, the unmarked pad on pin 11 of IC17 should be numbered: 37. In Fig. 4, capacitor C6 goes to ground and *not* +5V.

GUITAR SUSTAIN UNIT

D. GIBBS & I. SHAW

EVERY guitarist must be familiar with the sound of a sustain unit. It enables the length of a note to be greatly extended—indefinitely if necessary with acoustic feedback to help. A sustain unit for an electric guitar works by maintaining a constant output level as the actual output signal from the guitar dies away.

ALTERNATIVES

The simplest way to achieve sustain is to use a high gain amplifier and then clip the output in a similar way to a fuzz unit. The clipped output is then filtered to remove harsh sounding high order harmonics and give a more musical sound (Fig. 1).

The second, and more sophisticated method is to automatically increase the gain of a v.c.a. (voltage controlled amplifier) as the output signal from the guitar dies away (Fig. 2).

Using this method preserves the original sound of the guitar without distortion. It also enables full chords to be played unlike the first method—which causes such severe intermodulation distortion that care has to be taken to avoid playing even two notes simultaneously.

The circuit described here uses the second method with all its advantages. Obviously the circuit cannot amplify a signal which is infinitely small and the maximum gain has to be a compromise between a long sustain and excessive noise and hum pickup as the gain increases to maximum at very low signal levels.

FULL ATTACK

To maintain the guitar's natural attack the initial transient is allowed to pass through the unit without compression, but the circuit then maintains a virtually constant output level down to 0·5mV input, when the output dies away.

INVESTIGATIONS

There are two problems in designing a v.c.a. type sustain unit—firstly to design a v.c.a. system with a sufficiently fast response to follow the envelope of the output waveform from a guitar without causing any significant waveform distortion, and secondly to achieve an acceptable noise performance.

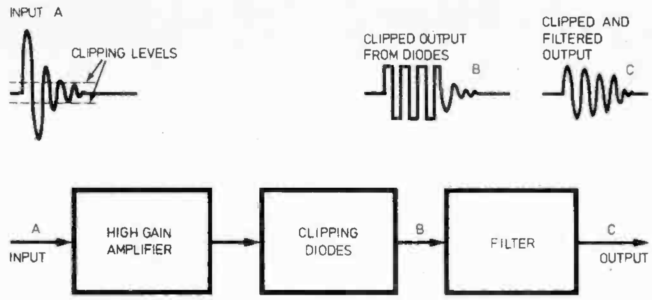


Fig. 1. Clipping type sustain unit

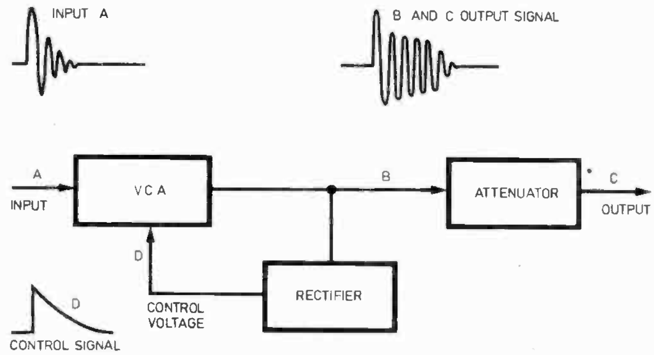


Fig. 2. Block layout for producing a non-distorting sustain unit using a voltage controlled amplifier

Various methods of controlling the amplifier gain were tried out in several experimental prototypes, using f.e.t.s and biased diodes, but all suffered from either poor transient response or unacceptable distortion. Eventually the answer was found in a combination of an l.e.d. and a cadmium sulphide photoresistor (l.d.r.). As the current through the l.e.d. is increased its brightness increases—causing the resistance of the photoresistor to fall and hence reducing the gain of the amplifier. This arrangement also has other

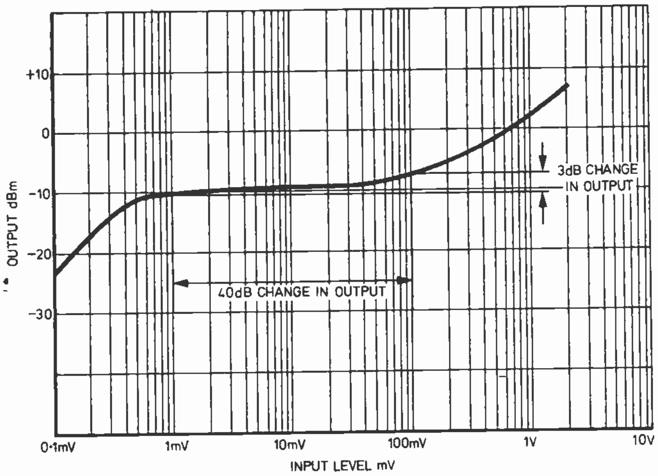


Fig. 3. Output response for different input levels

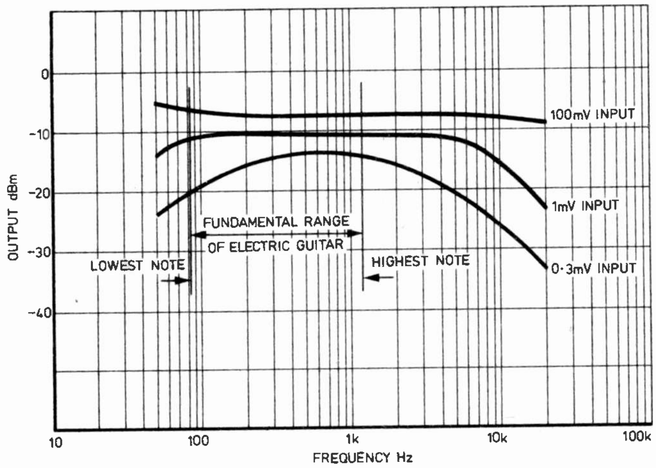


Fig. 4. Frequency response of sustain unit showing how bandwidth changes with input

useful characteristics. The photoresistor responds rapidly at high signal levels but much more slowly at low levels—this effectively gives the system a variable time constant and reduces distortion at low levels, as the note is dying away. Also as the negative feedback provided by the photoresistor is reduced so the bandwidth of the amplifier is reduced too. This helps to reduce noise and hum at low levels and at the same time it gives increased emphasis to the higher harmonics in the guitar output to compensate for the falling harmonic content in the note as it dies away.

Low noise is an essential requirement in a sustain unit as the gain can increase by 500 times from the start to the end of a note. This design uses a specially selected ZTX384 type transistor in the first stage, operated at a low collector current to obtain as good a noise performance as possible.

CIRCUIT DESCRIPTION

In Fig. 5 TR1 and TR4 form a two stage amplifier with an open loop gain of around 1000. Negative feedback is provided by the l.d.r. to control the gain and d.c. feedback to stabilize the operating point by R8. This circuit arrangement was chosen because it has very good stability and will operate over a wide range of battery voltage—from 10V for a fresh battery down to 6V for a worn out one. The average current drain is only about 2mA, in the interests of a long battery life.

Normally there would be a resistor from the collector of TR4 to the negative rail, but in this design the resistor has been replaced with a constant current source comprising TR2 and TR3. This increases the gain of the amplifier and enables a very large output voltage swing to be obtained. The circuit will give an output of at least 2 volts r.m.s. without distortion, which enables the high amplitude transients at the start of a note to pass through the amplifier with minimum distortion. Commercial sustain units often use two batteries to achieve similar performance.

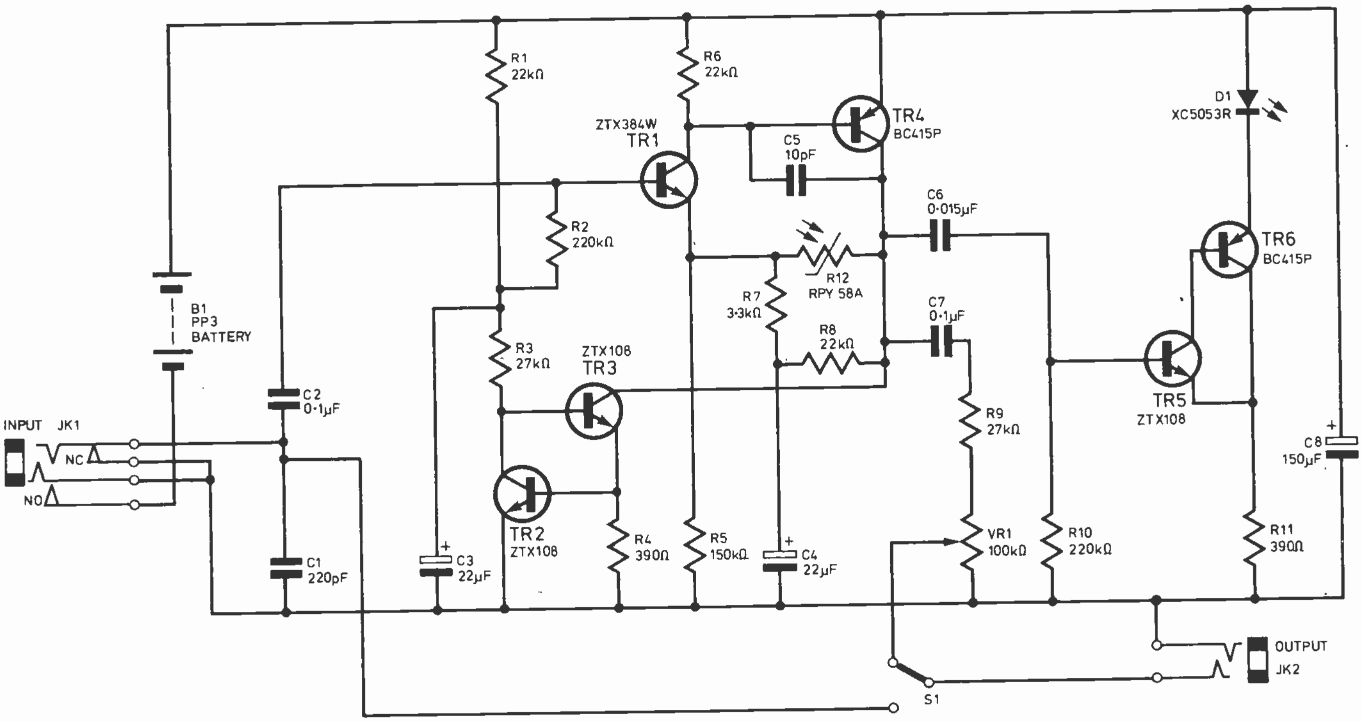


Fig. 5. Circuit diagram of sustain unit

GUITAR SUSTAIN

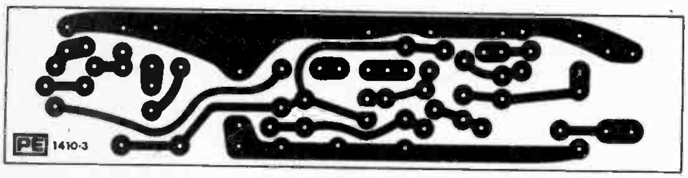
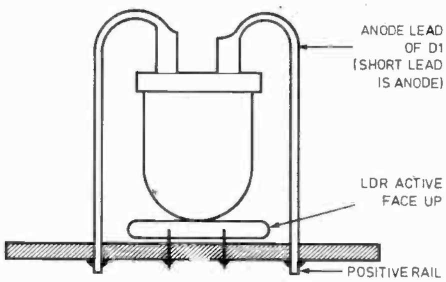


Fig. 6. Printed circuit board (full size)



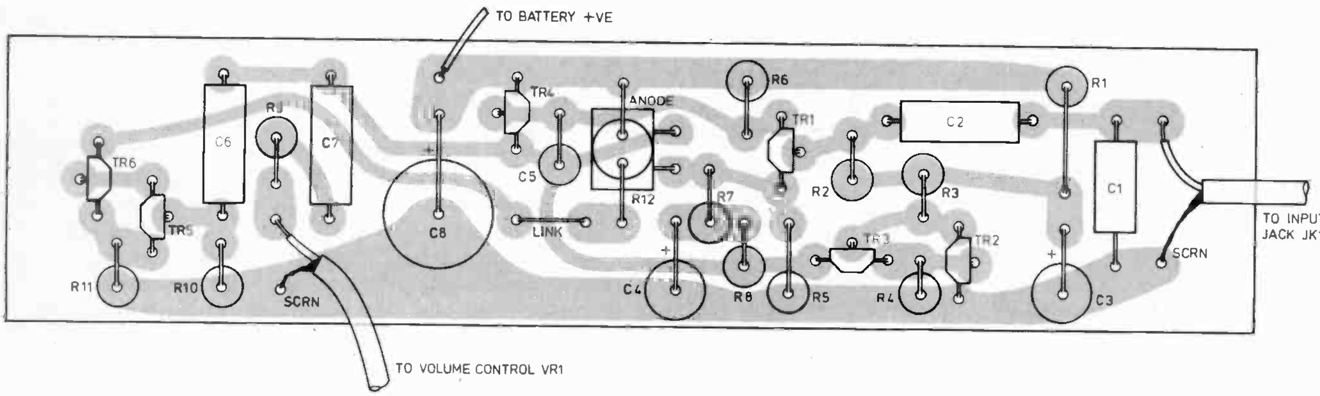


Fig. 7. Component layout and mounting details for D1 and R12 shown above

COMPONENTS . . .

Resistors

R1	22kΩ	R7	3·3kΩ
R2	220kΩ	R8	22kΩ
R3	27kΩ	R9	27kΩ
R4	390Ω	R10	220kΩ
R5	150kΩ	R11	390Ω
R6	22kΩ		

All resistors $\frac{1}{3}$ Watt 5 per cent carbon film

Potentiometer

VR1 100kΩ single gang log law potentiometer

Capacitors

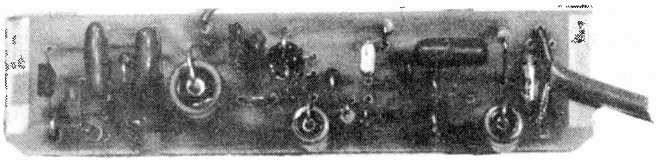
C1 220pF 63V polystyrene
C2 0·1μF 250V Mullard C280 polyester
C3 22μF 25V electrolytic or tantalum
C4 22μF 25V electrolytic or tantalum
C5 10pF ceramic or polystyrene
C6 0·015μF 250V Mullard C280 polyester
C7 0·1μF 250V Mullard C280 polyester
C8 150μF 16V electrolytic

Semiconductors

R12 RPY58A Mullard
D1 XC5053R Xciton
TR1 ZTX384W
TR2 ZTX108 Ferranti
TR3 ZTX108 Ferranti
TR4 BC415P Ferranti
TR5 ZTX108 Ferranti
TR6 BC415P Ferranti
All semiconductors can be obtained from Davian Electronics

Miscellaneous

JK1 Jack socket, front contact normally open
rear contact normally closed
JK2 Standard jack socket, non switching
S1 Arrow D.P.D.T. push to make/push to break footswitch (Davian)
Case ITT Diecast box type 46R.CS00.043.A00
Printed circuit—Davian Electronics
Control knob, PP3 battery, battery clip, connecting wire, rubber feet, small piece of foam rubber



TR5 and TR6 operate as a half wave rectifier, the compound Darlington arrangement providing a very high input impedance so as not to load the output of the amplifier. The operation is as follows.

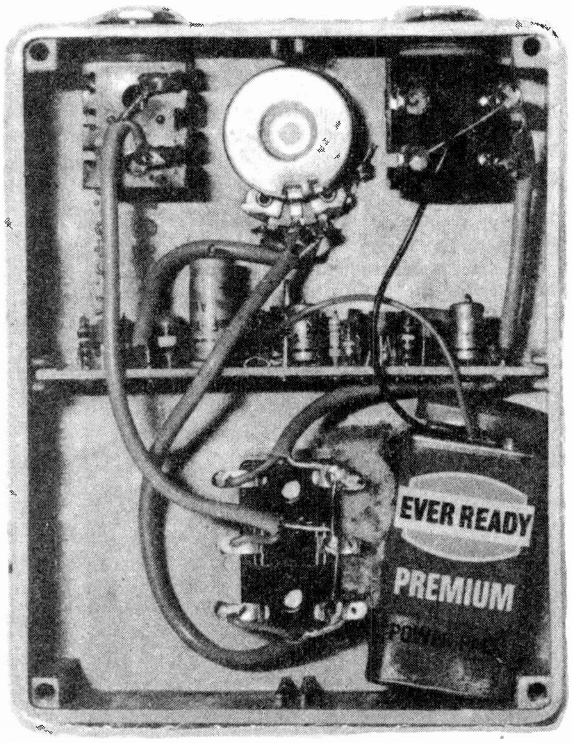
When a note is played this passes through the amplifier and turns on TR5 and TR6. This causes the l.e.d. D1 to light up, which reduces the resistance of the l.d.r. and hence the gain of the amplifier to provide an output signal just sufficient to keep TR5 and TR6 turned on. All this occurs in the first few cycles of the note.

As the input signal dies away the signal at the base of TR5 tries to fall. This reduces the current through the l.e.d., increasing the gain of the amplifier to maintain constant output. When the input falls below about 0·5mV, D1 is extinguished and the gain of the amplifier cannot be increased any further. The output then falls with the input.

MECHANICAL CONSTRUCTION

The unit is constructed in an ITT diecast box, which provides an enclosure rugged enough to be stood on, dropped or generally kicked around.

After drilling the case should be cleaned thoroughly and sprayed with paint. Gold was used on the prototype and gives a very attractive finish. The unit can then be lettered with Letraset or some similar product and finished off with a thin coat of protective clear lacquer.



To prevent the unit sliding around on the floor it is a good idea to fix two small rubber feet to the rear of the case lid. This also tips the box forward at a convenient angle for foot operation. Finally glue a small piece of foam rubber inside the lid to hold the battery in place.

ELECTRICAL CONSTRUCTION

Most of the components are mounted on a small printed circuit board which fits into the slots in the box. There is not a great deal of room to spare and miniature components should be used.

The printed circuit board pattern and layout are shown in Fig. 6 and should be largely self explanatory. The only point to note is that R12 is mounted flat on the printed circuit board with the active face pointing upwards (the opposite side to that which the wires are connected to). The l.e.d. is then mounted facing down towards the l.d.r. with the leads bent double. Take care when bending the l.e.d. leads as they tend to be rather brittle. The l.d.r. should be soldered in place as quickly as possible with a clean iron. It is rather sensitive to heat and the wires tend to fall off if it is overheated! The anode of the l.e.d. is the shorter of its two leads and this should be connected to the positive rail.

Mount the two jack sockets, the output potentiometer and the footswitch in the diecast box. Note that the push button switch must have a push to make/push to break action. The tags on the footswitch must be bent sideways so as they lie flat—otherwise they will short out to the lid of the box.

The negative rail of the circuit is earthed to the diecast box by means of a wire soldered to the case of the output potentiometer. One of the metal tabs securing the cover of the pot can be bent up and used as a solder tag if desired.

Miniature screened cable must be used for the input and output and the leads to the footswitch as any stray coupling between input and output can cause the circuit to oscillate. Note that the input jack socket JK1 has a front contact (nearest the nut) which is normally open. The battery negative is wired to this contact (see photo) which makes when the input jack is inserted to switch the unit on.

USING THE SUSTAIN UNIT

For best results the unit should be operated with as much input as possible, therefore the volume control on the guitar should be set at or near maximum. The output control on the sustain unit should be set to give the same output level as with the unit switched out.

It is possible with the high gain involved for magnetic or mechanical feedback to occur between non-humbucking pickups and the loudspeakers and care must be taken to avoid this by reducing the volume control on the guitar or by moving further away from the loudspeakers. On the other hand acoustic feedback can be used advantageously to sustain the note for as long as desired, but a certain amount of playing technique is involved as the sound system may have a peak at some frequency other than the note being played, and this may cause other strings to be excited if they are not damped.

One final point. The unit will not work if any external light is allowed to fall on the l.d.r. The diecast box is excellent in this respect since it has a lip around the lid which provides a very effective light seal. Needless to say, a makeshift box which is not light proof, or failure to use a box at all, will prevent the circuit from giving any noticeable sustain effect.

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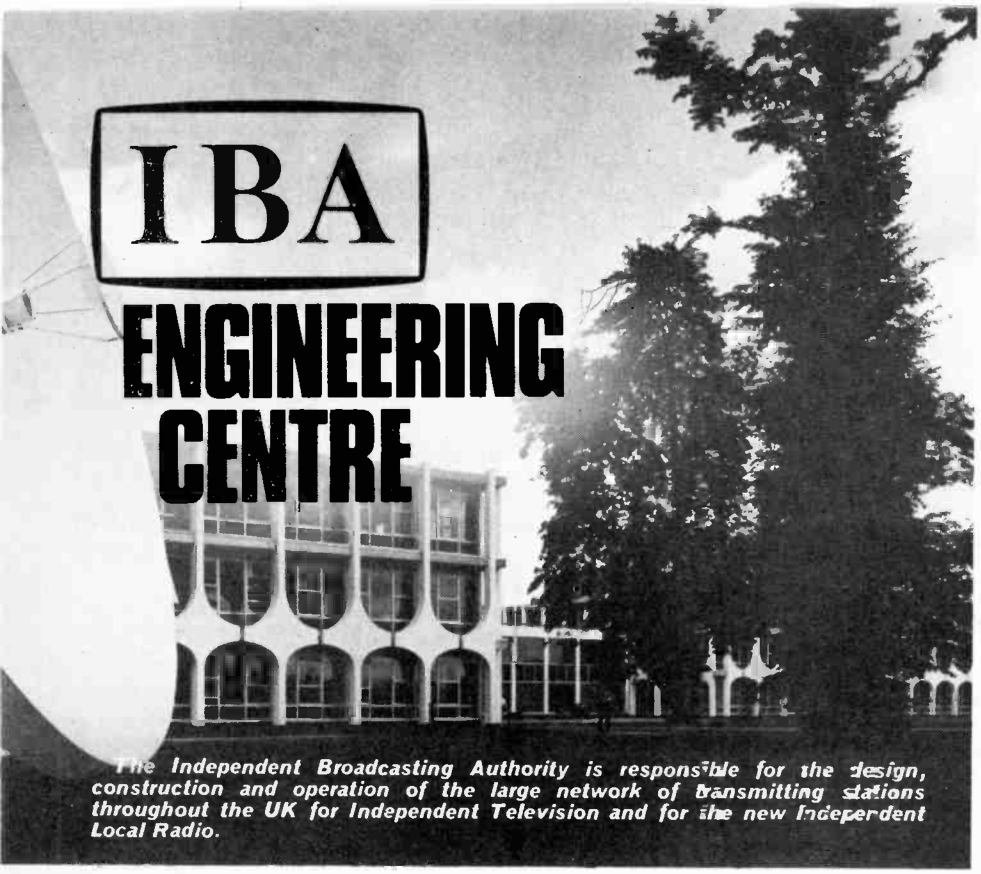


IBA ENGINEERING CENTRE

The Independent Broadcasting Authority is responsible for the design, construction and operation of the large network of transmitting stations throughout the UK for Independent Television and for the new Independent Local Radio.

SOME aspects of the Independent Broadcasting Authority's current engineering developments were revealed during a series of open days held at the IBA Engineering Centre, Crawley Court, near Winchester, in July.

Crawley Court is a purpose-built Broadcast Engineering and Administration Headquarters situated in idyllic surroundings in a well-wooded park. This modern building has an elegance not always synonymous with precast concrete structures; it well simulates the quiet atmosphere of a venerable college, yet it has the practical advantages of a well-planned functional layout within.

RESEARCH AND DEVELOPMENT

Of the 400 persons employed here about 40 are research engineers who, with an additional 50-strong technical services team, work in the Experimental and Development Department's Laboratory. This is divided into three sections: Automation and Control, Radio Frequency, and Video/Colour. Examples of important work in progress in all these sections were shown and demonstrated to visitors. A summary account of some of these activities is given below.

ORACLE JUNIOR

A service with information generated by computer was devised by IBA engineers and first demonstrated in 1973. This first "Oracle" system allowed up to 50 pages with text in only one colour. The present system is more attractive and flexible, with up to 800 pages, colour and other features, including a digital clock accurate to 20msec.

(The generic title "Teletext" is now often used, but the name Oracle remains for the ITV service.)

Current development includes work on a small Oracle system based on a microprocessor, for origination and demonstration purposes. It operates at 64 kilobauds and provides up to 60 pages. A semiconductor memory is used. The keyboard (part of a VDU) provides insert/delete facilities. Apart from its use in broadcasting organisations, it was suggested that this small Oracle system has commercial possibilities for hotels, holiday camps, etc., allowing local information to be inserted as an alternative to nationally transmitted information.

MEASUREMENT OF DATA SIGNALS

Satisfactory Oracle (Teletext) reception requires the receiver to be able to distinguish between 1 and 0, despite multi-path propagation distortion or "ghosting". The measurement of data signals requires different methods to those employed for normal transmissions. Teletext decoder manufacturers have little means of checking the performance of receivers their instruments will be used with, and to solve this problem a signal generator has been developed as a design aid for decoder makers.

This signal generator provides pulse and bar test pattern, and facilities for carrying out the different methods for measuring Teletext signals. It is understood that a standard for such measurements will be produced in the future.

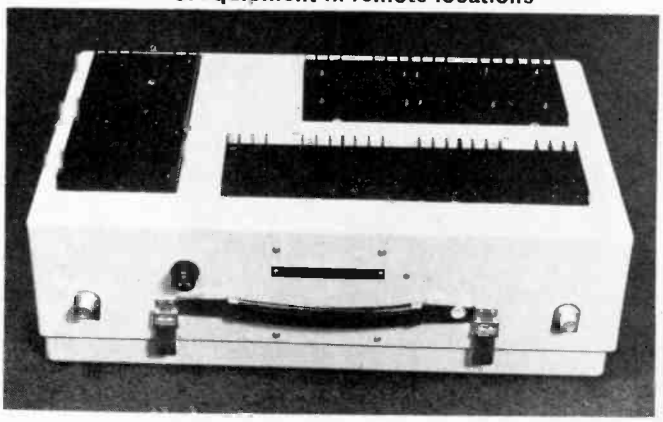
STEERABLE ADAPTIVE AERIAL

Receivers used as part of a broadcast link are likely to suffer from co-channel interference (CCI), resulting in severe patterning from other stations, if a conventional aerial is used.

The provision of colour TV to the Channel Islands proved to be particularly difficult since reception from the nearest mainland station in Devon was subjected to considerable co-channel interference from other UK and European transmitters.

After initial investigations an experimental 8-element Adaptive Aerial System was built at Crawley Court. The final system built during the beginning

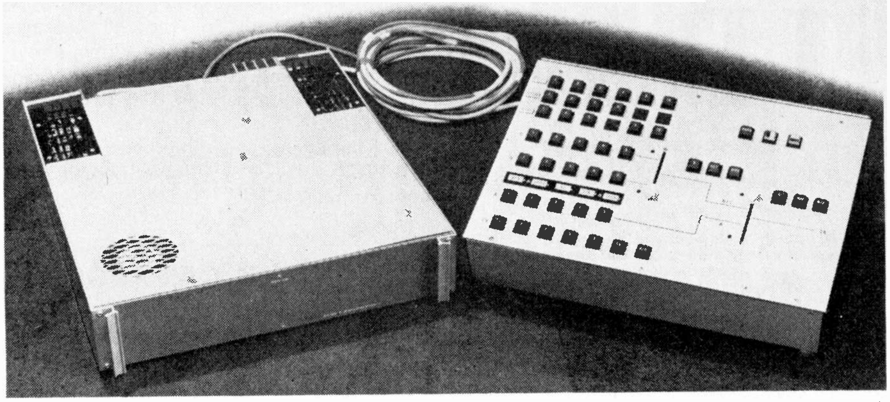
This 2W u.h.f. transposer has been designed by IBA development engineers as part of a feasibility study into low-power, low-cost stations for small communities. Maintenance is on a pre-aligned module basis to minimise the need for test equipment in remote locations



of 1977 at Alderney, CI, incorporates a 16 × 4 dipole array.

The Adaptive Aerial is essentially a phased array in which the amplitude and phase of the outputs of the individual elements are adjusted before combining in such a way as to produce an aerial pattern which has nulls in the directions of the interfering sources.

It is expected that simpler versions of this aerial system will be used for rebroadcast reception at other sites in the UK where the increasing number of transmitters will require aerial systems with the ability to null CCI by up to 50dB.



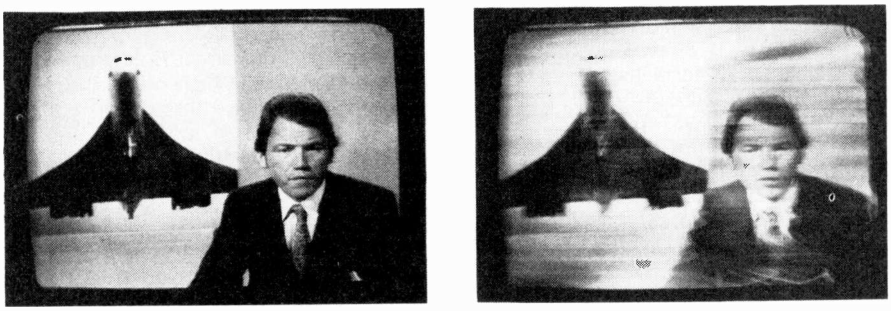
Experimental digital vision mixer developed by the IBA. Input and output signals are coded in linear PCM, at a sampling rate of $2f_{sc}$. The mixer offers additive mixing and split-screen wipe facilities

ADAPTIVE FILTER

Another method for overcoming CCI is the Adaptive Filter. This is a comb filter with adjustable notches which can track the frequencies of the CCI beats. This device is seen as complementary to the Adaptive Aerial, in improving the technical quality of signals.

LOW-COST U.H.F. TRANSPOSER

To bring u.h.f. television to small viewer areas, IBA engineers have designed a low-cost 2 watt transposer. This receives a broadcast and retransmits the programme on another channel. The transposer is small and portable, of suitcase construction and designed with ease of on-site servicing in mind.



These off-air pictures show the effect of SABRE on CCI which is only 20dB below the wanted signal

INDEPENDENT LOCAL RADIO

Since the advent of Independent Radio in 1972, IBA has had an interest in sound radio. More recently, Crawley Court has become involved in a study of "surround sound" or quadraphony. The establishment of standards for broadcasting is important, for those adopted are likely to stand for 20–40 years.

The current investigations are concerned with both subjective and technical problems of this subject and IBA engineers have now come to the conclusion that a "2½-channel" type of system best meets these two difficult requirements, and they consider there is much in favour of a system combining features of Matrix H and 45J.

Engineers are able to listen to various types of programme material encoded in QS, SQ, UMX, Matrix H and 45J.

THE ALL-DIGITAL STUDIO OF THE FUTURE

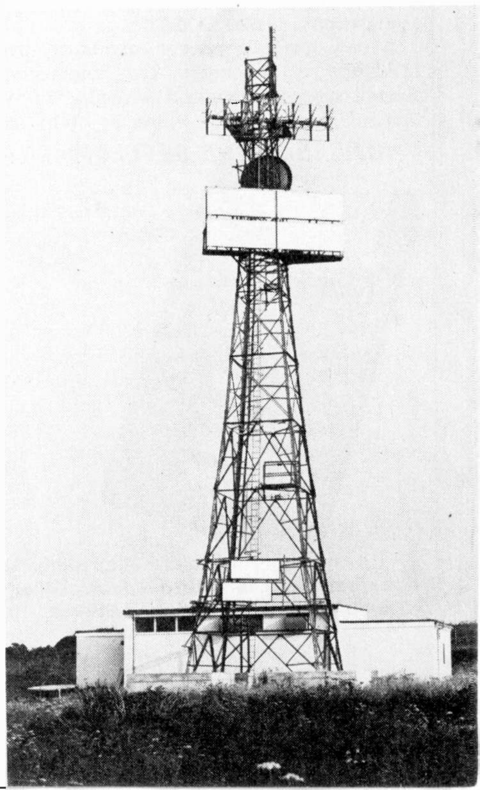
As part of a long-term study of digital techniques for television the IBA has developed in experimental form the major component parts needed for an all-digital television studio. All major studio vision operations, excluding picture origination, are carried out using digital video signal processing, including digital vision coding and decoding, vision mixing and switching, video tape recording and the generation of a colour-bar test signal.

The development of an operational digital studio depends on overcoming the problems of recording digital signals on magnetic tape without requiring extremely high-speed tape transport.

The experimental digital recording system developed by the IBA applied to a standard broadcast analogue machine is capable of producing excellent half-width colour pictures with a tape consumption half that of conventional (15in/sec) analogue machines. This is believed to be significantly in advance of any digital system yet demonstrated, anywhere in the world. Further development is required to produce a full-width picture machine suitable for operational use.

It is claimed, however, that the experimental half-width system conclusively demonstrates the feasibility and potential advantages of digital video recording.

The Alderney Steerable Adaptive Broadcast Reception Equipment (SABRE) aerial—the first successful u.h.f. adaptive aerial system for television. The aerial array, behind the four fibreglass panels, receives signals over an 80 mile sea-path from the IBA transmitter at Stockland Hill, Devon. From this installation on Alderney, the signals are microwaved to Jersey for transmission to Channel Television viewers



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.

PRINTING CALCULATORS

Into the very competitive market of small calculators, **Hewlett-Packard Ltd.** has just launched its first pocket-sized printing calculator. The new HP-10 is a general purpose, pre-programmed "adding machine type" instrument with all proven functions, plus a printer for "hard copy" readout.

Intended for executives and professionals in their business and personal applications, the HP-10 features a 10 digit l.e.d. display, a quiet thermal printer, keys to allow the user to add, subtract or recall data from memory, a data storage accumulator, and automatic decimal point positioning for pounds and pence calculations. This calculator weighs 12 ounces, measures 3·4 × 6·5 × 1·6in and costs £125.

Three other new calculators for specialist applications have also been announced by Hewlett-Packard.

Full financial evaluation capabilities with mathematical and statistical functions are embodied in the HP-92 Investor, a portable printing model designed for professional investment analysts, stockbrokers, bankers and other finance executives. The HP-92 has a powerful set of pre-programmed functions to suit these applications. Price £475.

A new scientific pocket calculator, the HP-29C, is intended for engineers, scientists, technicians and students. Fully merged programming allows as many as four keystrokes to be combined into a single step of memory. Programming is further simplified by the 30 storage registers. CMOS memory chips allow programmes and data to be retained in memory for long periods after switch off. Price £149.

A handheld printing version, the HP-19C, will be available shortly, at approximately £260.

The first pocket printout calculator, type HP-10, from Hewlett-Packard

ORGAN KIT CATALOGUE

An exciting new catalogue featuring musical instruments, effects units and amplification systems from **Wersi Electronic** has just arrived. Wersi, a well-known company in Europe, predominantly specialise in electronic organ kits for the do-it-yourselfer. Conceived eight years ago, Wersi has grown considerably. One can only assume that this is as a result of the technical excellence and quality of the products, this is certainly reflected in the detailed, full colour, 104 page catalogue.

The fact that the eight organs available—from smallest spinet to the largest console—have a professional specification would indicate that they are not cheap. For example, at the low end the fully assembled and tested Wersi Orion W1T retails at £4,594 with VAT to add! At the top end the three manual Galaxis W4 is a heady £18,239. However, since the range is available in kit form these figures can be dramatically reduced—£1,913 for the Orion W1T and £5,957 for the Galaxis.

The organisation of the Wersi kit concept is based on the constructor's requirement to play either entertainment music or more ambitious works. Usually, these ambits are regulated by keyboard size, either 49 or 61 notes.

As an example, to assemble a full blown entertainment organ such as the Orion W1T, a dozen kit packs would be required. These packs are made up of the p.c.b.s, components, wiring harnesses and other piece parts to make up the various organ sub-assemblies, each being labelled for contents.

To mastermind the assembly of a pack an illustrated manual is included with step-by-step instructions and check list so that project realisation can be achieved with maximum continuity.

To defer the cost of a full specification instrument, it is possible to make up a basic organ from any one of the Wersi range and then add to it—money permitting.

To achieve this, kit packs are organised in so-called "option levels" of purchase. Option Level 1 for the Orion W1T would cost you £906, consist of 5 kit packs and provide you with an 8 octave multiple wave master generator and dividers, manuals, electronic keyer circuits, drawbars, special effects and cabinet. From this you have a playable instrument. The second option of 4 kit packs would cost another £426 but would provide pedals, fixed stops, rotating and string choir sounds and other effects.

The final option of 3 kit packs provides piano voices, a 24 rhythms unit, auto-accompaniment and registration memories. This for an extra £581, but now the instrument is truly complete.

Other instruments, besides organs, in the Wersi catalogue include rhythm units, electronic pianos, string orchestras, PA systems, mixers and rotating sound systems.

Handling Wersi kit sales is **Aura Sounds, Dept. P.E., Copthorne Bank, Crawley, West Sussex.** Anyone wishing to hear or view instruments or equipment should first ring Mr Griffiths (0342-713338) for an appointment.

The catalogue price is £2 which is redeemable on purchases.

Another new Catalogue/Order Form worth investigating is the one just released by a new company known as **Ace Mailtronix Ltd.**

This company, specialising in mail order, lists approximately 500 of the more popular components that the home constructor might require at one time or another. The catalogue is layed out more in the form of an order sheet/s with spaces for inserting quantities required and component costings. This means that the purchaser simply indicates his/her requirements, adds up totals, attaches the relevant sum and posts the order.

It is claimed that delivery is ex-stock, that is to say every order is despatched on the day it arrives at their office. Prices are guaranteed and fixed throughout a preset period of validity of an order form, the form being updated and automatically replaced with each order received.

All products are guaranteed for twelve months from date of purchase since they are all *bona fide* new products. Items carried include transistors, diodes, i.c.s, resistors, capacitors, switches, lamps, plugs and sockets and technical books.

Copies of the catalogue/order form are available from **Ace Mailtronix Ltd., Dept. P.E., Tootal Street, Wakefield, West Yorkshire, WF1 5JR.**

MPU LECTURES ON RECORD

In the May '77 issue we reported the success of a microprocessor forum jointly organised by National Semiconductor (UK) Ltd., A. Marshall (London) Ltd., and ourselves. In fact the venture was so oversubscribed a second forum had to be staged.

Fortunately, for anyone who might have missed this baptism in microprocessor technology, the edited lectures have been committed to tape by a team called **Specialist Productions.** The result is in effect an audio-visual "teach yourself" course as the C60 and C90 cassettes are backed by a 72 page booklet which is keyed to the lectures.

The course components are available from **A. Marshall (London) Ltd.** (see advertisement in this issue) price £9·95 which includes VAT and postage.

NEXT MONTH

Extra 8 Page Supplement...

Thought-Provoking

IC Specials

An 8-page supplement describing a range of selected integrated circuits, having some particular emphasis in consumer applications. Areas of application include Electronic Musical Instruments, Motor Vehicles, Domestic Control Systems, TV Games, etc. A certain source of inspiration for experimenters and constructors alike

TUNE-PROGRAMMABLE SEQUENCER...

This unit will enable a synthesiser, e.g. PE MINISONIC, to automatically play a pre-programmed tune consisting of up to 32 pitches in a 128-note-long sequence from a single RAM. The note length and the rhythmic pattern can be made variable.

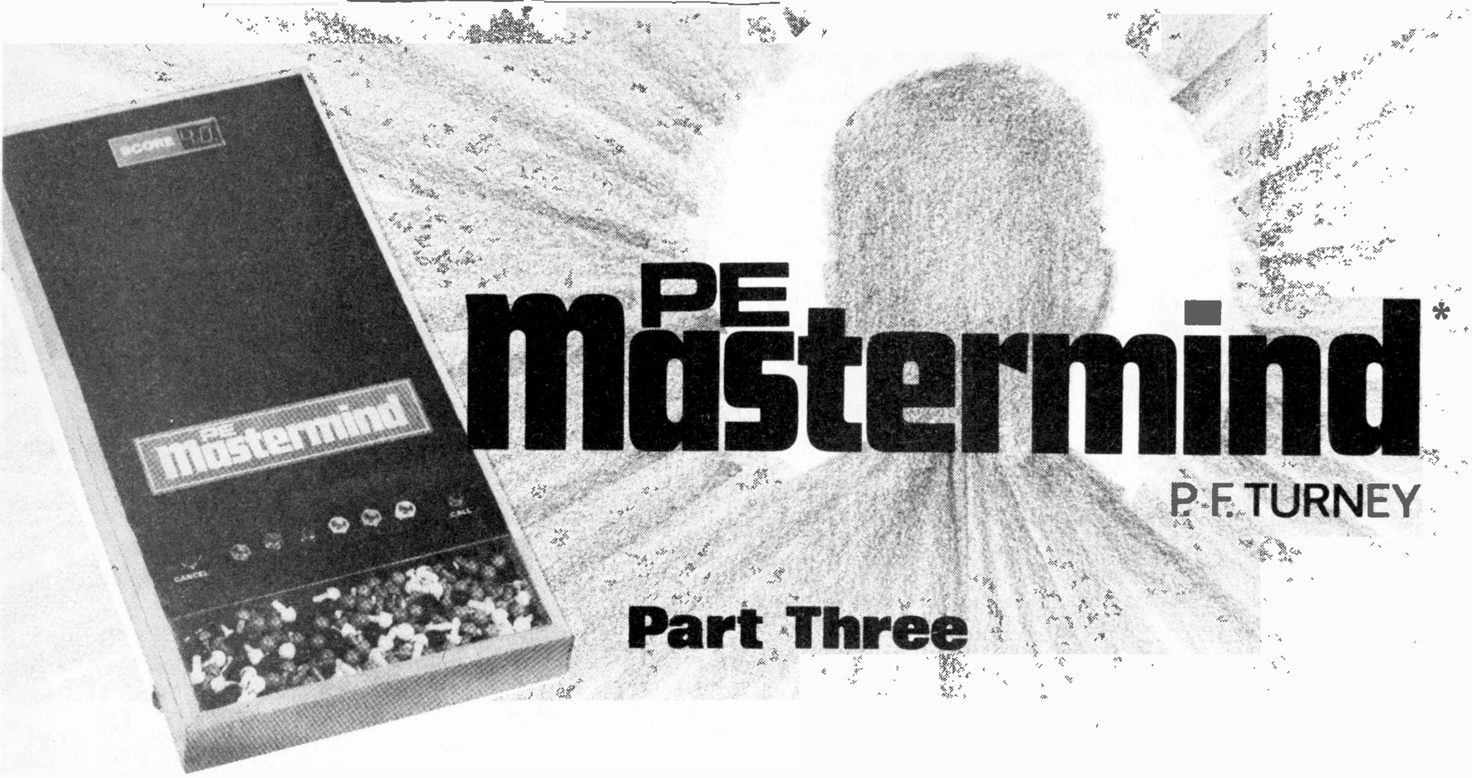
DIGITAL REACTION TIMER

Displays digitally a subject's reaction time on a scale of 1-9. The time scaling is arbitrary

PRACTICAL

ELECTRONICS

OUR NOVEMBER ISSUE WILL BE ON SALE FRIDAY, OCTOBER 7, 1977



PE Mastermind*

P. F. TURNEY

Part Three

THIS month will see the description of the control circuits and an introduction to the scoring logic, where we deal with the formation of the results for the number of the players' coloured pegs correct for both colour and position (the "P" results).

THE ENTRY COUNTER

Each single deduction comprises four entries which are counted by the "entry counter" within the machine. A shift register, type SN7496N (IC20), is used to perform this function producing four output signals, K, L, M and N.

The 7496 is a five bit shift register, although for this counter only the first four bits are required. The circuit diagram is shown in Fig. 3.1.

The depression of one of the clear buttons, S7 or S8, will clear the register, setting all outputs to logical zero and making the serial input, pin 9, logical 1 via the NOR gate IC12c. When the first colour is entered into the machine the Z signal clocks the counter and the first output, K, goes high and the serial input low. The second entry simply steps the logical 1 from position K to position L and so on.

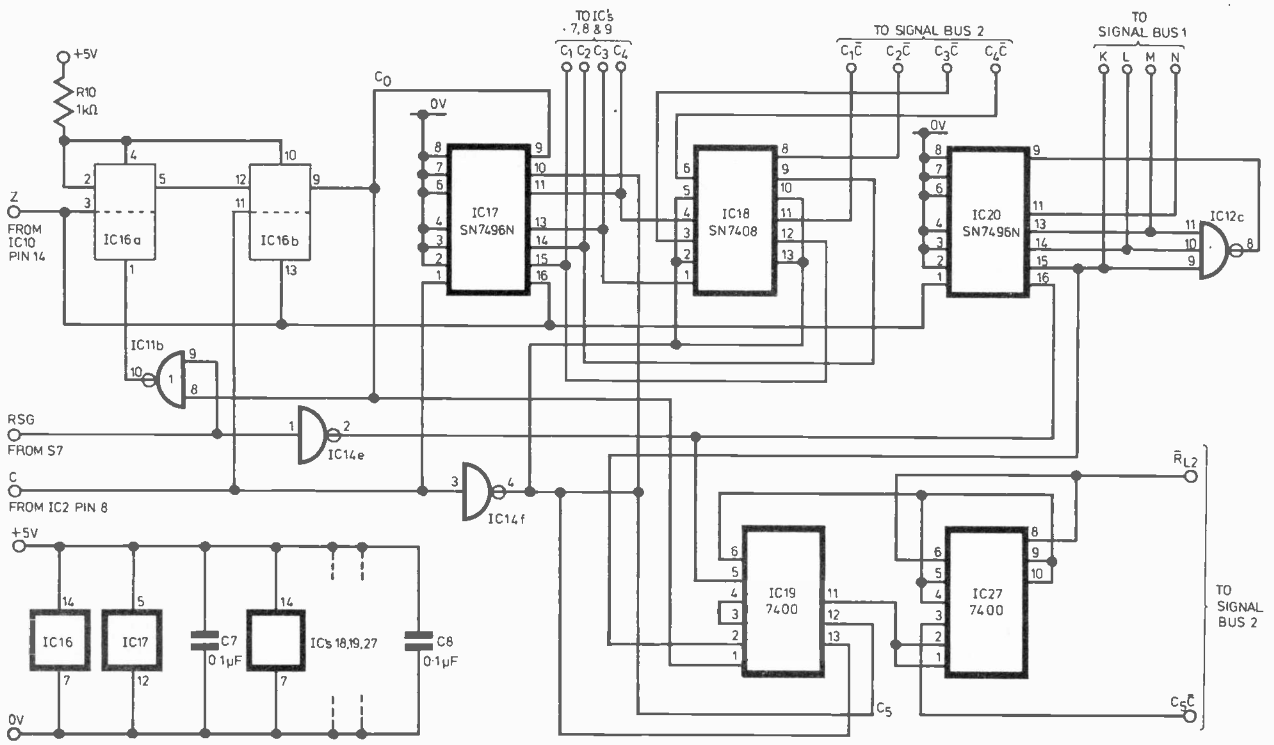


Fig. 3.1. Control logic circuitry

On the fourth entry output N is high and will remain as such until the next deduction is commenced, the first entry of which will set K high again. The counter is therefore a simple ring counter, so called because a single 1 circulates around through all outputs in succession.

COMPARISONS COUNTER

The main function of the comparisons counter is to provide the signals C_1–C_4. These signals are generated each time an entry is made so that the code on lines RST is compared with each X code in turn. The results of these comparisons appear on the E lines and it is the function of the scoring logic to interpret these and produce from them the correct scores for display to the player.

In addition to these four signals, the counter generates C_0, the pre-clear pulse, and C_5 which performs computational duties in the scoring logic.

A shift register is used, the six bits being obtained from one half of a type SN7474N (IC16b) dual flip-flop (C_0), and an SN7496N five bit shift register, IC17 (C_1–C_5). The whole counter is enabled by the Z signal, connected to its clear inputs, pin 13 of IC16b and pin 16 of IC17. Note that all the flip-flops are cleared by logical zeros.

When an entry is made the Z signal is generated and is used to clock flip flop IC16a sending its output, pin 5, to logical 1. This output is connected to pin 12, of IC16b, the first stage of the register, whose output, pin 9, will go high when it is clocked by the master clock, forming the signal C_0. However, C_0 will promptly clear IC16a, via IC11b, so that pin 12 of IC16b is from then on 0. A single string of 1s therefore appears on the outputs C_0–C_5, as shown in the timing diagram of Fig. 3.2.

SERVICE SIGNALS

The various service signals required are produced by IC19 and 27. $\overline{KC_0}$, IC19 pin 3, is the pre-clear signal, serving to clear the scoring logic of the results of a previous

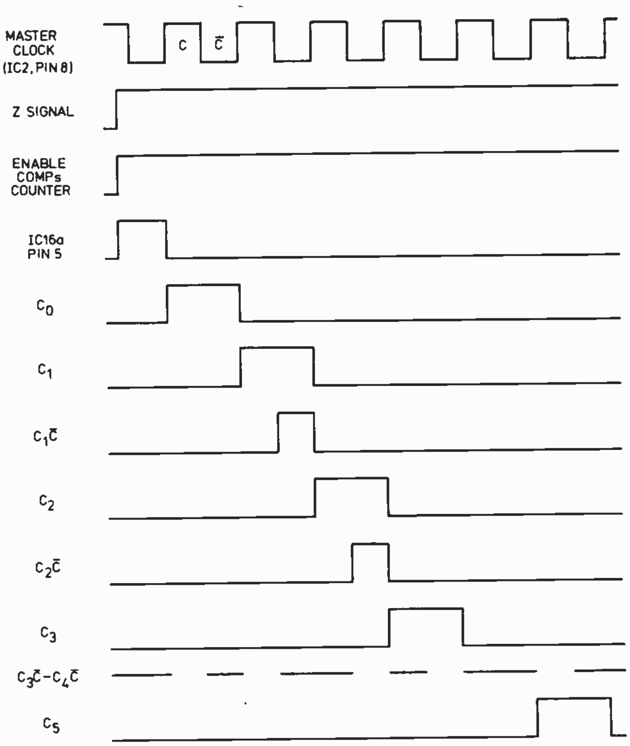


Fig. 3.2. Timing diagram for the comparisons counter

COMPONENTS . . .

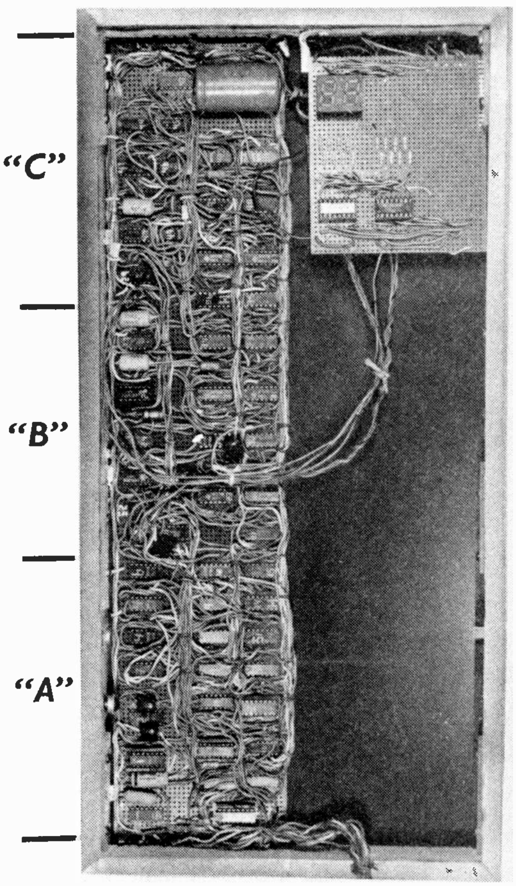
Integrated Circuits

IC16	SN7474N
IC17	7496
IC18	7408
IC19	7400
IC20	7496
IC21	7408
IC22–23	7473 (2 off)
IC24	7408
IC25	7486
IC26/28	7482 (2 off)
IC27	7400
IC27	7400
IC30	7454

Resistors
R10 1kΩ

Capacitors
C7–C10 0·1μF 10V ceramic (4 off)

Miscellaneous
6 Veropins, wire, etc.



Main board assembly order

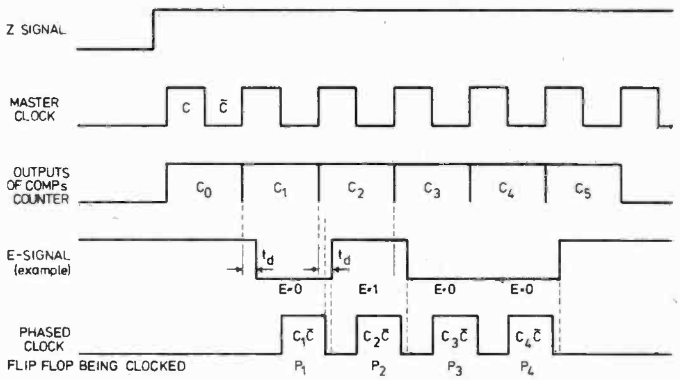


Fig. 3.3. Illustrating the clock phasing

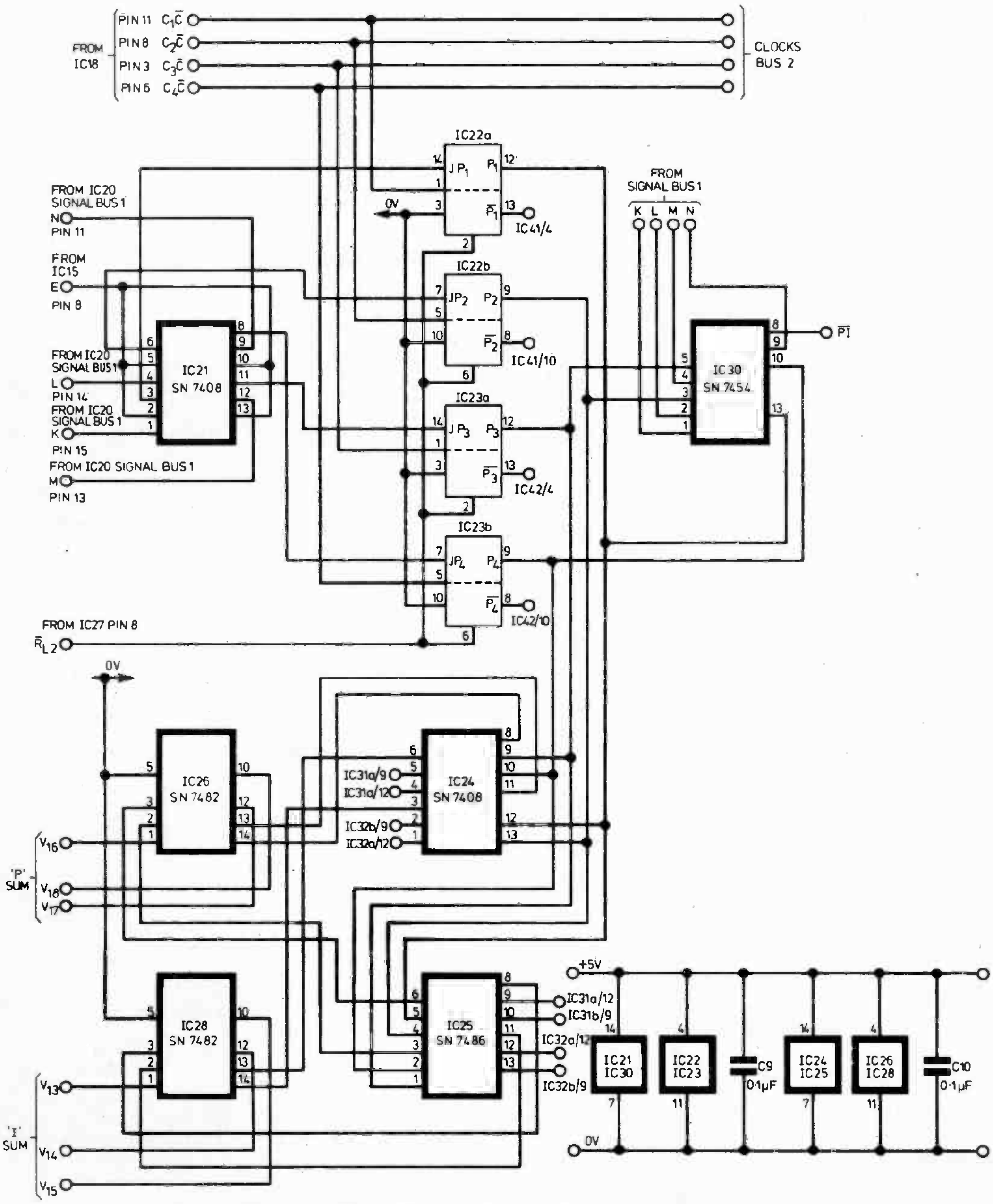


Fig. 3.4. The "P" flip flops and associated logic

deduction, thus obviating the need to manually clear the logic after each deduction. This is combined with the external clear signal, RSG, to form:

$$\overline{R_{L2}} = \overline{KC_0 + RSG}$$

which is the equation for the unconditional reset of the logic.

A single SN7400N NAND gate has a maximum permitted fan-out of ten, but since R_{L2} will be applied to more than this number of inputs two 7400 gates are used in parallel to provide a fan-out capacity of twenty inputs.

INTRODUCTION TO THE SCORING LOGIC

As hinted earlier, the function of the scoring logic is to interpret the results of the comparisons, appearing on the E lines, in relation to the timing signals produced by the entry and comparison counters. We now consider how the "P" results are derived from this information.

If the first entry made by a player is equal to the first code, X1, within the generator, then this particular entry is obviously correct for both colour and position. Similarly if the player's second entry is equal to the second code, X2, then this too is correct for colour and position, and so on.

Since C_1 from the comparisons counter calls the first X code, X1, for comparison, and since the player's first entry is recognised by the fact that signal K from the entry counter will be high, then a flip flop clocked during C_1 and presented with data KE will set if the entry is correct for position and colour. A second flip flop clocked during C_2 and presented with input LE will record the second "P" result, and similarly for the third and fourth entries.

THE "P" FLIP FLOPS

These four flip flops are called the "P" flip flops and are shown in Fig. 3.4 as IC22 and 23.

The "K" inputs to these are not required, and are therefore grounded. The equations for the "J" inputs are $J_{P1}=KE$, $J_{P2}=LE$, $J_{P3}=ME$ and $J_{P4}=NE$, these functions being implemented using the AND gate of IC21.

An example illustrating the action of these flip flops is shown in Table 3.1.

CLOCK PHASING

Flip flop P_1 is not clocked directly by C_1, nor is P_2 by C_2, etc. The reasons for this stem from the existence of time delays in the gates of the data selector and the comparator, which if not considered would lead to errors in the functioning of the system. The signal $C_1\overline{C}$ is therefore used to clock P_1, being related to C_1 as shown in Fig. 3.2. Fig. 3.3 is an example showing just how this derived or "phased" signal overcomes the time delay problem. As shown in the diagram $E=1$ during C_2, so that P_2 would set if L were present. If C_2 had been used for the clocking, then the $E=0$ overlapping from the C_1 interval would be responsible for setting P_2 to 0, producing an error in operation. The phased clock ensures that the data input to the flip flop is absolutely stable for the entire duration of the clocking period ($C_2\overline{C}$ in this case).

Notice that when no entry has been made $E=1$. This is of little consequence, however, since E will remain high until an untrue comparison is made.

IC18 produces the phased clocking signals, this being an SN7408 AND package.

"P" INDICATOR LINE

Consider the combination of X codes and first entry shown in Table 3.2. We see that entry one is "P" correct. However, it is also correct for colour and incorrect for position ("I" correct) with two of the remaining X codes, X2 and X3. The correct score for this entry is just one black key peg, so that the comparisons with X2 and X3 must be disregarded. A strobe signal, to be called PI, is therefore formed to indicate to subsequent logic that the first entry is "P" correct, and as such the comparisons made between it and X2 and X3 may be disregarded. Clearly the function $PI=KP_1$ will serve here for the first entry, so that for all four entries the function is

$$PI = KP_1 + LP_2 + MP_3 + NP_4.$$

IC30 produce the inverse of this, $\overline{PI}$, shown in Fig. 3.4.

RESULT ADDERS

The number of "P" flip flops which are set indicates the "P" result and this number is formed by an adder. The circuit is shown in Fig. 3.4, and ICs 24 and 25 take the four "P" outputs and produce from them two individual two bit sums,

Table 3.1

Entries	X Codes			
	Red 000 X1	Green 001 X2	Black 010 X3	Yellow 011 X4
Red	$K=1$, $C_1=1$, $E=1$, $PI=1$	$K=1$, $C_2=1$, $E=0$	$K=1$, $C_3=1$, $E=0$	$K=1$, $C_4=1$, $E=0$
White	$L=1$, $C_1=1$, $E=0$	$L=1$, $C_2=1$, $E=0$, $P_2=0$	$L=1$, $C_3=1$, $E=0$	$L=1$, $C_4=1$, $E=0$
Black	$M=1$, $C_1=1$, $E=0$	$M=1$, $C_2=1$, $E=0$	$M=1$, $C_3=1$, $E=1$, $P_3=1$	$M=1$, $C_4=1$, $E=0$
Yellow	$N=1$, $C_1=1$, $E=0$	$N=1$, $C_2=1$, $E=0$	$N=1$, $C_3=1$, $E=0$	$N=1$, $C_4=1$, $E=1$, $P_4=1$

P_1, P_3 and P_4 are set indicating that three colours are correct for position

Table 3.2

Entries	X Codes			
	Red X1	Red X2	Red X3	Blue X4
Red	$K=1$, $C_1=1$, $E=1$, $P_1=1$	$K=1$, $C_2=1$, $E=1$, $PI=1$	$K=1$, $C_3=1$, $E=1$, $PI=1$	$K=1$, $C_4=1$, $E=0$, $PI=1$
Green	$L=1$, $C_1=1$, $E=0$, $PI=0$	$L=1$, $C_2=1$, $E=0$, $P_2=0$	$L=1$, $C_3=1$, $E=0$, $PI=0$	$L=1$, $C_4=1$, $E=0$, $PI=0$

P_1 is set, so that the score at this stage is one black key peg

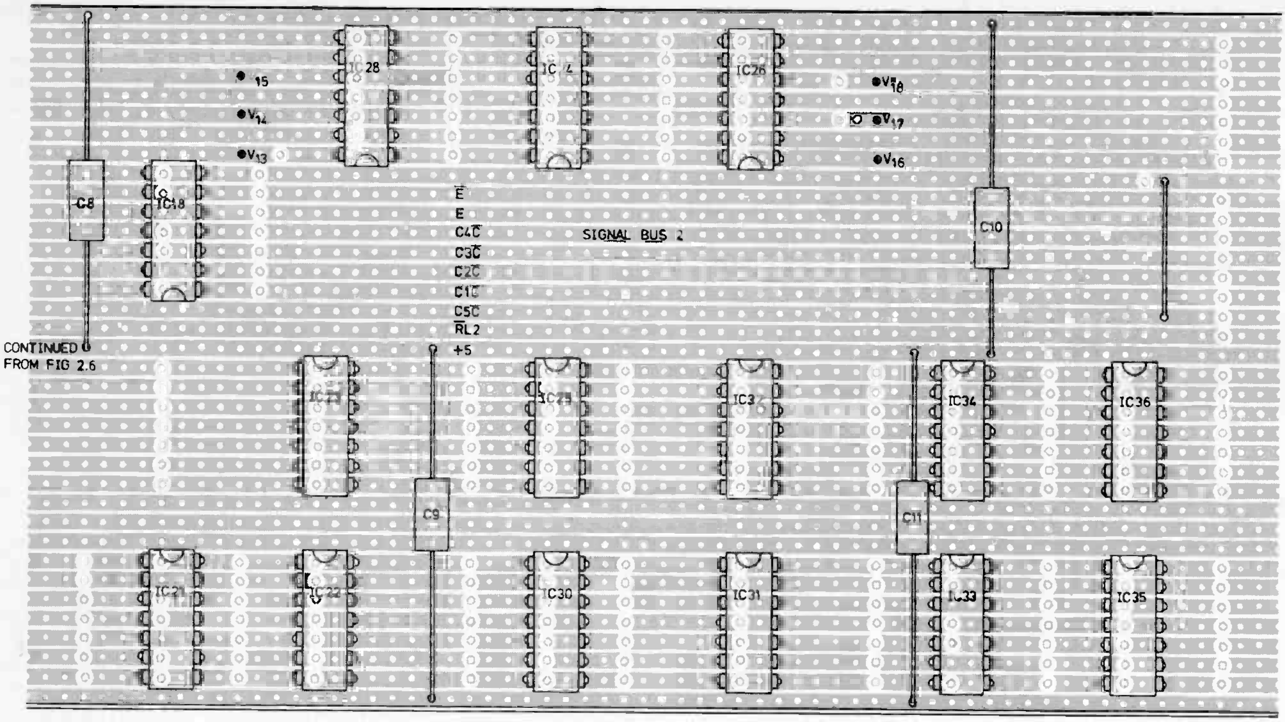


Fig. 3.5. Prototype components layout for the middle third of the main board (section B in photograph). To assemble this constructors should work from the circuit diagrams

which are subsequently added together by IC26, a type SN7482N adder package.

The mode of operation is as follows. The AND gate whose output is pin 11 of IC24 and the EXCLUSIVE OR gate whose output is pin 6 of IC25 together form one of the two bit adders, producing the binary sum P_1QP_2. IC24, pin 8, and IC25, pin 3, produce the second two bit sum P_3+P_4. These sums are then added together by IC26, producing the three bit sum $P_1+P_2+P_3+P_4$. An identical adder serves for the "I" results; this is also shown in Fig. 3.4.

CONSTRUCTION

The main board positions of the i.c.s are shown in Fig. 3.5, and with reference to the circuit diagrams of Figs. 3.1 and 3.4 the wiring is very straightforward and is carried out using single cored wire on the blank side of the board.

The timing, reset and equality signals are connected to a large number of i.c.s, some of which have yet to be described. It is for this reason that the most important of these are wired to a signal bus, organised as in Fig. 3.5. The connections to the i.c.s from this bus may then be made using wires of a recognisable colour particular to each different signal.

The six outputs from the "P" and "I" adders are taken to six Veropins, as shown in Fig. 3.5, ready for connection to the display board later.

TEST SCHEDULE

The timing circuits are to be tested first as these are required in order to test the rest of this month's construction.

(a) *The Entry Counter*

This is readily checked as follows. Press either S7 or S8 and using a logic probe or a voltmeter (d.c.) verify that all outputs of IC20 are at logical 0. Then using the colour entry buttons, check that the counter operates. (Note that a logical 0 will be in the region of 0·5V and a logical 1 approximately 3·5V.)

(b) *The Comparisons Counter*

An almost static test may be performed on this by slowing down the master clock, IC2, to a frequency below 1Hz. This is achieved by placing a large electrolytic capacitor (approximately 4,700μF) temporarily in parallel with C_3 of IC2. This clock will now be slow enough to enable the counter to be monitored using a d.c. voltmeter and Fig. 3.2 verified.

With the master clock operating so slowly it will be necessary to hold an entry button depressed for about ten seconds in order to give all the signals from this counter a chance to appear.

Verify that $\overline{R}_{L2}$ goes low whenever a first entry or one of S7 or S8 is activated.

(c) *The Flip Flops*

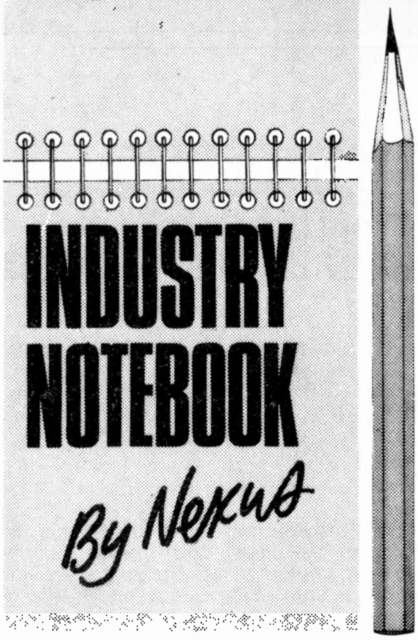
Still keeping the clock running slowly, monitor and record the four X codes in ICs 3–6. Now, after clearing with S8, enter the first of these codes using the colour entry buttons, holding the button down until P_1 sets. Enter the three remaining codes, after which all flip flops should be set. The output of the "P" adder, IC26, should be 100 (4) on pins 10, 12 and 1 respectively, indicating that the entries were all correct for position.

Variation may be introduced by entering four colours, only two of which are correct for position, so that IC26 gives 010, etc.

In all these cases the $\overline{PI}$ signal, IC30 pin 8, should go low, whenever an entry correct for colour and position is made, following the setting of the respective "P" flip flop.

If these tests are successful restore the master clock to full speed and play a crude version of the game! Note that with the clock frequency of approximately 22kHz the machine takes only 6/22000 sec. to produce signals C_0–C_5, so that even the shortest manual press on an entry button will allow plenty of time!

NEXT MONTH: Scoring logic continued.



EMPLOYMENT

Engineers' salaries have been creeping up during the year. Far more jobs are being advertised with salaries up to £5,000 with the occasional breakthrough to £6,000 or even more in special cases. But there are still far too many home-based jobs round the £3,000 mark which, at today's income levels, is almost an insult to qualified engineers.

If you can put up with the climate the best financial openings are still in the Middle East where senior people can earn over £10,000 tax free and technician engineers £7,500 tax free plus a whole range of fringe benefits. Scanning through the classified columns the demand for engineers looks as high as ever it has been, but employers are clearly being selective.

How salary rates for engineers will fare during the next few months of free-for-all wage bargaining is anyone's guess but my own view is that engineers will fall back again relative to manual workers who are looking for a norm of £5,000 in those industries where militancy is rampant.

PRIVATE SECTOR LAGS

It will be interesting, too, to see whether private sector employees will recover their position relative to those in the public sector. The last IEE salary survey showed that qualified electronic engineers in the public sector were ahead by about £1,000 a year. And according to the Society of Electronic and Radio Technicians, technician engineers in the nationalised industries were £300 a year better off than their colleagues in the private sector.

It seems odd that while concern is being expressed that fewer and fewer of our young are showing interest in the engineering professions that the IEE, whose membership has increased at an average of 650 over the past few years has, for the past two years enjoyed a gratifying increase. Last year it shot up by 2,000 and this year it was 1,200. Total membership is now about 70,000.

This year the IEE's Career Consultancy Service is available to all members. The Service is to run on a pilot scale for two years. If successful and there is a genuine need it will be expanded.

WHAT'S GOOD FOR GEC . . .

To paraphrase the old tag about General Motors we might say what's good for GEC is good for Britain. Sir Arnold Weinstock has done it again. Turnover for the first time has topped £2,000 million and pre-tax profits are up. Export orders nearly doubled to £936 million and GEC has a healthy cash balance in the bank of nearly £500 million.

To keep the pot boiling GEC has started a management game in which all the companies in the group are invited to enter teams. The game starts in September and runs through to next April. HQ of the game is GEC's management college at Dunchurch and each team's management decisions will be processed by GEC Midlands Computer Services Ltd. The idea is to get everyone in the group motivated towards business and what it's all about. Not every employee can directly participate but it is hoped that all will follow the fortunes of their own team.

THE TIDDLER

Compared with GEC, Racal is a comparative tiddler, but their annual report shows another year of dramatic growth. In 1972 turnover was £21 million with just over £3 million pre-tax profit. The 1977 figures are £122 million and £32 million. The forecast for 1977/78 is for a turnover of £200 million. The company was formed in 1950 with a capital of £100.

Hard on the heels of Racal's acquisition of Milgo in the United States, Racal recently purchased Hellerman Cassettes Ltd from the Bowthorpe-Hellerman Group. Purchase price was £825,000 and the acquisition puts Racal-Zonal, the magnetic tape company, firmly in the cassette market.

Don't be surprised if other acquisitions by Racal are announced soon. Plessey, tipped as a possible, is defensive. Chairman Sir John Clark points out that Plessey is doing very nicely, thank you, with sales and profits both up and a record £600 million order book. While Sir John has been adamant that Plessey has not been talking to the National Enterprise Board, he is coy on the subject of discussions with other private enterprise companies.

CB RADIO

The lobby for Citizens Band two-way radio has been as active as ever. The prize for industry is said to be a home market in the UK of £100 million and the creation of 5,000 jobs. The penalty could be unholy pollution of the frequency spectrum. The entrepreneurs are looking enviously at the United States where over 20 million CB radios have been sold and they are looking for a similar bonanza in Europe. Even in the UK, cramped for space and not exactly overflowing with spare cash in the citizens' pockets, exponents of CB are suggesting that UK sales could top a million units a year within two years of the service being sanctioned.

Heady figures, indeed. But it has already been pointed out that there is no guarantee that the sets would be made in UK. The Japanese are already old in the tooth at supplying the American market in which they are the dominating force with over 100 companies in the business. But, says the UK CB lobby, our sets will not be cheap junk on 27MHz. We are aiming at 230MHz with 44 channels and the sets will cost between £100 and £200 each.

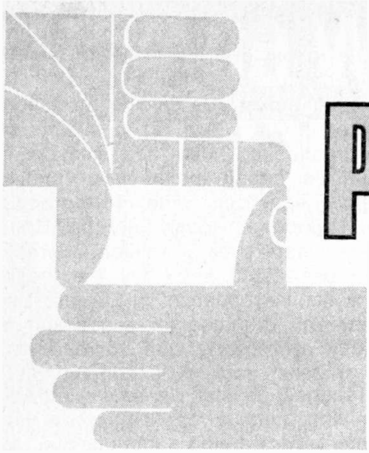
Anyone with an atom on sense knows that the Japanese can and will supply the market whatever the technical specification. In principle, there is no reason why the UK should be denied CB radio. But its possible benefits to the UK electronics industry or to the citizen user needs more consideration than the bandying about of hypothetical statistics.

MPU INSTRUMENTS

Dr Colin Gaskell, technical manager of Marconi Instruments, warns of gimmickry in the use of microprocessors in instruments. He said at an SERT symposium at Keele University that few instruments are as yet making effective use of them. But he added that commercial security could well be keeping some exciting applications under wraps for the time being. He also warned that MPU technology is moving so fast that those now being used in some instruments may well be obsolete quickly and a buyer may have trouble in getting replacements if they fail in service.

PO SUCCESS

How nice to be able to congratulate the Post Office. I refer to the contract worth £6·75 million for assistance in planning the Libyan trunk telephone cable network. The contract is especially welcome because it is a repeat order from the same customer and ten times the size of the first consultancy order (worth £650,000) announced just over a year ago.



PATENTS REVIEW...

Copies of Patents can be obtained from:
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AUTOMATIC SWITCH-OFF

A system for automatically switching off a radio or TV receiver when transmissions cease has been patented in BP 1 471 585, by Ashok Jain of New Delhi, and Bindu Gandhi of Bombay.

The object is to overcome the disadvantage of simple systems which may shut off the receiver whenever there is a temporary absence of audio or video signal but the transmitter is still on-air, e.g. during extended fadeouts. This is achieved by detecting the presence or absence of i.f. or r.f. signals rather than audio or video.

In the simplest circuit (Fig. 1) a d.c. amplifier receives rectified d.c. consisting of i.f. or r.f. signals from a receiver, and is connected to power source *S* through S1. The output of the amplifier supplies the coil of relay RLA1, the relay contact being closed when the coil is not energised. The receiver is thus normally connected to power source *S* via RLA1.

BP 1 471 585

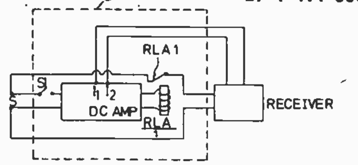


Fig. 1

To provide for automatic shut-down of the receiver when transmissions cease, switch S1 is closed to activate the amplifier. This is biased so that it has no output whilst still receiving r.f. or i.f. from the receiver. Thus, when the supply of i.f. or r.f. ceases, the amplifier powers the relay to open the contact RLA1 and disconnect the receiver.

Clearly the disadvantage of this simple system is that the amplifier continues to draw current after it has switched off the receiver. This disadvantage is overcome in another circuit where the relay is again energised by the amplifier only in the absence of i.f. or r.f., but is a latched relay. Details are also given for a circuit which switches off the d.c. amplifier and receiver from the power source.

TUNING DISPLAY   BP 1 454 060

The Japanese company Matsushita, which makes National Panasonic and Technics equipment, patents (in BP 1 454 060) a novel approach to the digital display of tuning on a radio receiver. The idea behind the invention would also appear to have wider applications, for instance in the display of clock times.

The receiver tuning capacitor is connected by gears to a drum over which runs a continuous loop of opaque paper or photographic film. Thus as the receiver is tuned, the loop advances.

The loop carries a sequence of radio frequencies, encoded as sets of indicia, generally elongated perforations or clear patches of film. To encode three numbers: each set of indicia consists of three columns, and there are seven positions in each column.

A light source is arranged inside the loop and a sensing head lies opposite the light source on the other side of the loop material. The sensing head is laced with the ends of a bundle of optic fibres, the other ends of the fibres being laced into a display panel with three 7-bar numeral windows each in the form of a squared figure-of-eight. In dependence on the indicia positions on the loop, various combinations of the display bars are illuminated by light picked up from the source to form digits between zero and nine. In this way, any 3-digit number can be represented, to denote the frequency of a received broadcast station.

Ideally another light source is arranged opposite a photo cell, with the light path between this source and cell interrupted by a set of control perforations on the loop. The photo cell controls illumination of the main light source by solid-state switching circuitry. This ensures digital display only when the loop is in a position fully suited for display, i.e. when all three digits of a tuning frequency are correctly aligned with the optic fibres.

IN BRIEF

BP 1 471 369—Yazaki Sogyo KK: *Taximeter*. An indication of future development trends for taxicab fare meters. A device similar to a calculator, with a single display and single keyboard panel, integrates control pulses (on engine speed and distance travelled, etc.) and stores them in a memory. The stored information can be called up by the keyboard and each item of data (fee for last fare, total fee for the day, miles travelled without fares) displayed on the readout window as required.

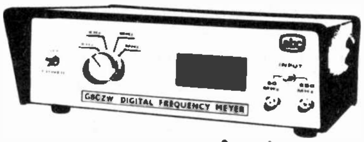
BP 1 471 508—Messrs Leclercq, Poirier & Guichard: *Picture-phone Communication System*. An elaboration of the basic picture telephone concept (with a camera and monitor at each end of the phone line), which enables a person being called to decide whether or not to accept the incoming call.

Pulses characteristic of the incoming call origin trigger a character generator to signal the incoming caller's identity before the called party picks up his telephone to accept the call and energise his camera.

BP 1 466 902—Nissan Motor Co. Ltd.: *Gear Interlocking Device*. This is another electronic system providing electro-mechanical interlock between functions essential to operation of a car (this time a manual gear change lever) and the seat belt latches.

A weight-sensitive switch under the driver and passenger seats is interlocked with switches associated with the seat belts. In a "no go" condition (i.e. driver or passenger sitting without seat belt fastened) solenoids operate to jam the gear lever controls.

G8CZW Digital Frequency Meter



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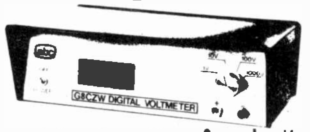

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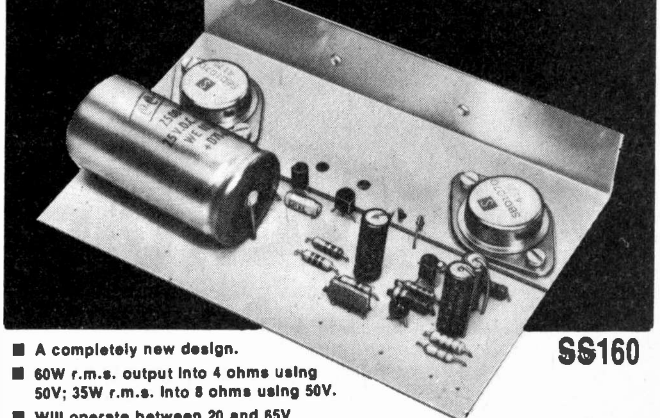

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MULTICHANNEL OVERLOAD PROTECTOR

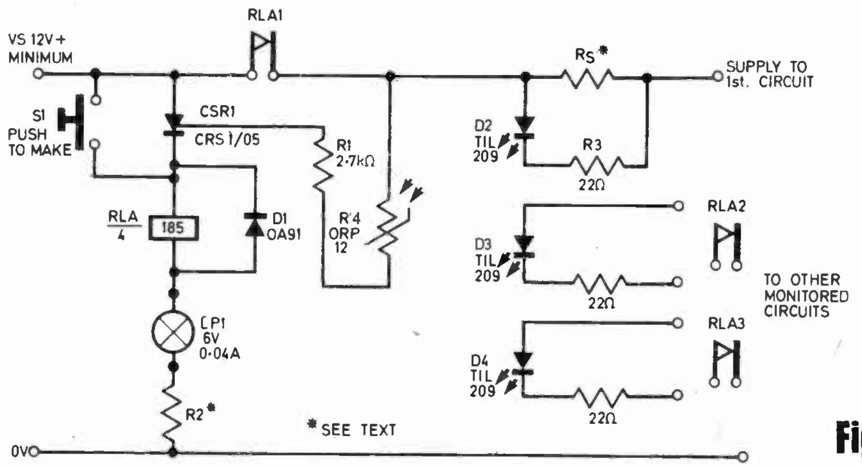


Fig. 1

WHERE it is necessary to supply circuitry with several different voltages at various currents, overload protection can become quite complex. A simple fuse will rarely act quickly enough to protect delicate components.

Conventional electronic protection circuits rely on a voltage developed across a sensing resistor by the error current turning on a transistor or thyristor, the latter turning off or reducing the output of the power supply.

Fig. 1 illustrates a somewhat unconventional approach to overload protection. It is fairly fast-acting, effective from a few milliamps upwards, is easily added to existing circuitry, and provides complete isolation between the different supplies monitored.

When excessive current is drawn by a monitored circuit, the voltage across a sensing resistor, R_S, rises above 2V. This causes a parallel wired l.e.d. to light up, the current through the latter being limited by R3. All l.e.d.s are directed on a light dependent resistor, which triggers a thyristor when illuminated, R1 limiting the thyristor gate current. The s.c.r. drives a relay. Its normally closed contacts (one set for each monitored circuit) open, cutting off all power supplies. A lamp in series with the relay lights up, indicating that the trip has operated. The power supplies remain isolated until reset by S1.

The device may be powered by its own supply, or from one being monitored. R2 is selected to limit the relay/lamp current to a suitable level.

The minimum operating voltage is about 12V, at which level R2 is omitted.

The l.e.d.s. are mounted pointing at R4, and it is essential to exclude extraneous light from this vicinity. The number of channels which can be monitored is limited by the number of l.e.d.s it is possible to direct upon the l.d.r., and the sets of relay contacts.

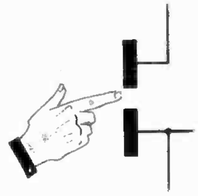
R_S = (2V divided by required max. current) ohms.

Power rating = R_S × (max. current)^2

R_S may be replaced by a fixed and variable resistor, allowing a continuously variable current limit. A wirewound potentiometer of ample rating is essential in this case. A typical set-up would be a 4 ohm 1W resistor and a 250 ohm 1W potentiometer.

B. Woodland,
Harlesden,
London

MAINS TOUCH SWITCH



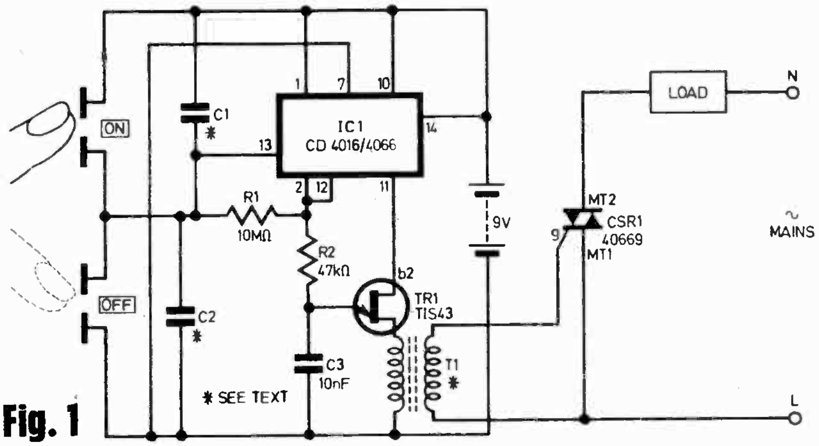
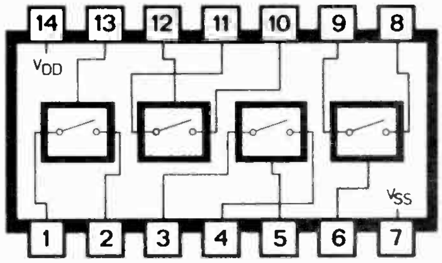


Fig. 1



CD 4016/4066

THE circuit diagram of Fig. 1 is for a touch switch offering the advantages of negligible current consumption, complete mains isolation, high noise immunity, great sensitivity and low cost.

The heart of the circuit is a CD4016 or CD4066 integrated circuit containing four independent CMOS bilateral switches. Only half of the i.c. is used, but the other half could be incorporated into another channel.

One bilateral switch is wired with positive feedback to form the ON/OFF latch. The other is used to drive the unijunction transistor oscillator feeding high frequency pulses via isolating transformer T1 to the gate of the Triac. The transformer used in the prototype was made by winding 50 turns of 30 s.w.g. enamelled copper wire for each winding, on a 25mm length of ferrite rod. The two windings must be well insulated from each other. The capacitors across each touch plate should be between 3·3 and 10nF. Component values are far from critical.

With the 40669 Triac shown, loads of up to 2kW can be handled with an adequate heat sink. Without a heat sink, 250W is the limit. If the Triac will not turn on, more turns may be needed on the secondary winding of T1.

The 9 volt battery shown may be replaced by a small battery eliminator if required. The voltage is not critical and may range between 9 and 15 volts.

S. M. Fifield,
Twickenham.

FLASH TRIGGER

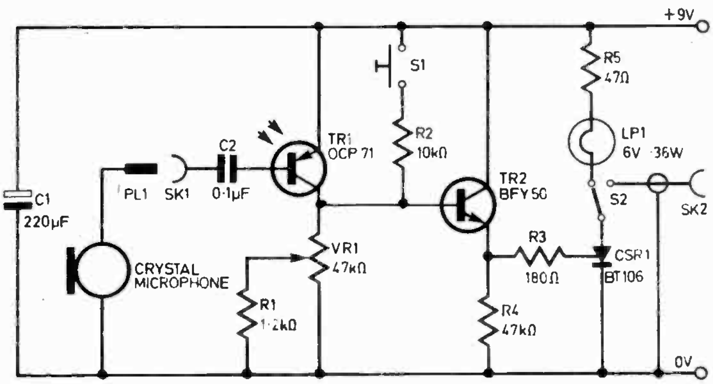


Fig. 1

THE circuit in Fig. 1 is a multi-mode flash trigger which can be operated as a slave flash, sound operated flash, or simply as an independent flash for non-synchronised cameras.

Phototransistor TR1 is an OCP71, which can be switched either by the incident light on its junction, or by a voltage at its base. In either case the collector voltage rises causing TR2 to turn on, whose emitter then rises to almost supply voltage, thus firing CSR1 via R3. The voltage at the base of TR2 can be varied by VR1, and this therefore acts as a sensitivity control. To determine the optimum setting, the unit can be operated with S2 set to turn on LP1 instead of firing the flashgun. Limiting resistor R1 protects TR1 from excessive collector current, and similarly R3 protects the gate of CSR1. Resistor R5 is a voltage dropper to enable a 6V, 60mA bulb to be used for LP1.

When the unit is used in the sound-triggered mode, the crystal microphone will generate sufficient voltage (via C2) to switch TR1 on, without the need for intermediate amplification. Used in the independent mode, S1 acts as the trigger button, by applying bias directly to TR2; this operation of course being irrespective of the sensitivity setting.

It is suggested that the microphone is connected via a phono socket so that it may be unplugged when the unit is being used in the light-triggered slave mode. The output should be connected via a proper flash plug and socket, which will be available from most photographic dealers.

Normally, both electronic and bulb flashguns use the inner terminal of the flash socket as the positive pin, but it may be best to check first using a multimeter.

The sound-triggered flash has many intriguing applications. Photographs may be taken of glass at the instant of shattering, or a champagne cork leaving the bottle, and many other sudden events too quick for the eye to see.

G. Stokes,
Walsall

NEWS BRIEFS

Intelligent Instruments

THE effect of the microprocessor on electronic instruments, both present and future, was one of the principal topics at the recent symposium on Electronic Measurement and Instrumentation, organised by the Society of Electronic and Radio Technicians at Keele University. The event attracted a broad spectrum of instrument manufacturers and users, plus the fine weather which has become almost a tradition for SERT symposiums.

The first benefit of the microprocessor has been the simplification of front panel layouts. Placing of controls is far less subject to mechanical constraints, and scaling factors can be taken care of "behind the panel" without resort to cams, linearising adjustments, etc. Digital readout of output level on a signal generator, for example, can be switched to provide the data in volts, microvolts, dBm, dBV, dBμV or whatever, according to what the test schedule for a particular piece of equipment calls for, with a great reduction in the mental arithmetic required, and in control markings.

The future of the microprocessor, as seen by at least one manufacturer, was the replacement of the presently used minicomputer in a "universal measuring system". Not quite universal; the one restriction is that what you want to measure must be capable of being displayed on the screen of an oscilloscope.

The displayed waveform—be it repetitive or transient—is digitised and stored in memory. Then any desired characteristic of the waveform can be computed, be it frequency, period, amplitude, peak or average power, rise or fall time, etc., and displayed in whatever form and units required. As one speaker remarked, this could make a lot of other instruments obsolete.

In general, it was thought that many instruments of the future would be of the form: analogue to digital converter; digital processor; digital to analogue converter or other output interface; display.

Incidental benefits of using a microprocessor are that it can be used to carry out continuous calibration checks and adjustments, and to diagnose fault conditions, within the instrument, so reducing the m.t.t.r. (mean time to repair). From telling you what repairs are required, the next stage is presumably an instrument that can repair itself!

SERT Microprocessor Symposium

READERS who have a particular concern in the applications of microprocessors will be interested to learn that a residential symposium, entitled "Microprocessor Systems and Software", has been organised by the Society of Electronic and Radio Technicians for the 26 to 29 September, at the University of Kent.

Five technical sessions are being arranged. The first will be an introduction covering the terminology, the ranges of microprocessors available, the principles of a working system and the need for software. The second will be on basic programming techniques and aids including an overview of programming, machine codes, assemblers and loaders, PROM programming, program development aids, system testing and documentation of software.

These will be followed by three other sessions giving examples of working systems in use, the papers here outlining the original requirements and the associated hardware and software solution.

The papers will be presented by experts from research departments in industry and universities, the Post Office, and research associations. There will be discussion sessions, an associated exhibition, and a full social programme.

Further details and registration forms can be obtained from the Secretary, Society of Electronic and Radio Technicians, Faraday House, 8-10 Charing Cross Road, London, WC2H 0HP.

I bought this beautiful little milliamp-meter through the special Bargain List that Home Radio sent me when I bought a copy of their famous Components Catalogue. I reckon I saved a good £1·50 on this one item alone—more than the catalogue itself cost. If I'm not mistaken, you got that natty transformer the same way, so no doubt you're as familiar as I am with the scores of bargains they're offering.

But have you noticed that there are quite a few bargains in the main catalogue itself? That Resistor Pack SP22 for instance—400 preferred value ¼ watt 5% resistors for only £6, beautifully arranged for easy selection. If that's not a bargain, what is? For those readers who have not yet caught on to the advantages of dealing with Home Radio let us explain. It's perfectly simple. Purchase a copy of the Home Radio catalogue, £1·40 including postage and packing or £1 over the counter. It has over 200 pages, listing about 5,000 items, nearly 2,000 of them illustrated. It's a marvellous production. With every catalogue Home Radio give you free an up-to-date Bargain List. You're on to a winner, so why wait? Send the coupon with a cheque or postal order for £1·40 to Home Radio Components, 240 London Road, Mitcham, Surrey.

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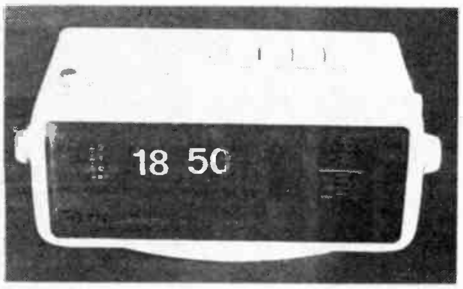

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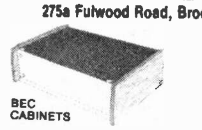

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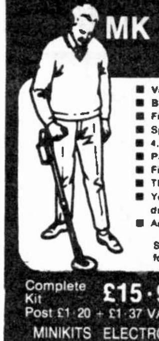

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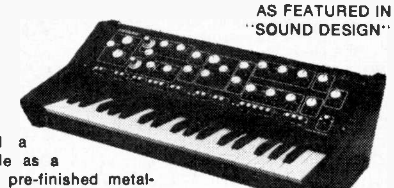

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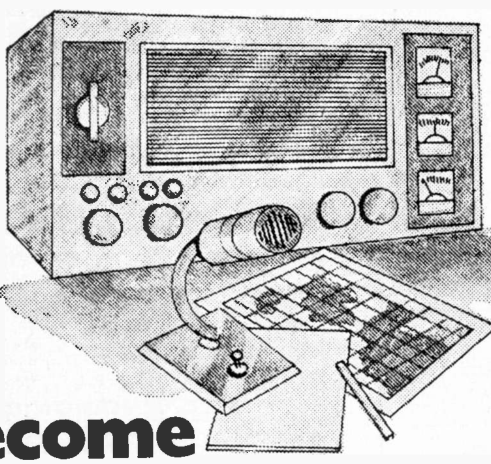

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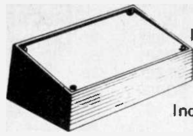

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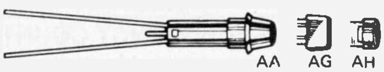

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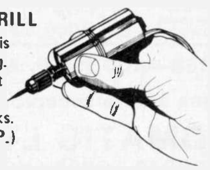

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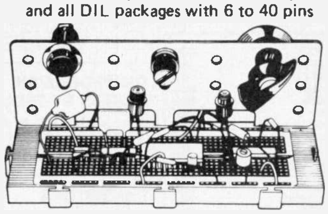

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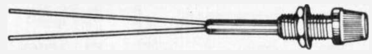

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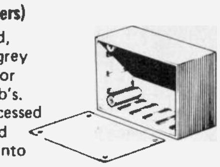

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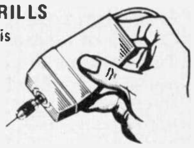

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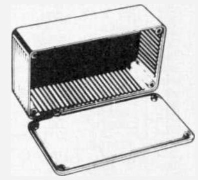

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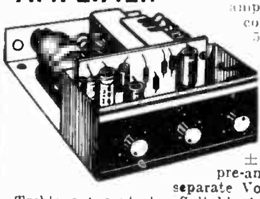
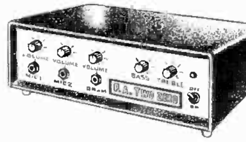


A superb solid state audio amplifier. Brand new components throughout. 5 Silicon transistors plus 2 power out-put transistors in push-pull. Full wave rectification. Output approx. 13 watts r.m.s. into ohms. Frequency response 12Hz. 30KHz ±3db. Fully integrated pre-amplifier stage with separate Volume, 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 3" high × 6" wide × 7½" deep. AC 200/250V. PRICE £13·75. P. & P. £1·20.

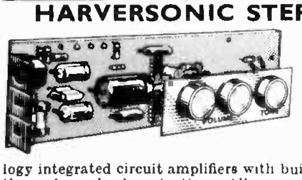
HARVERSONIC MODEL P.A. TWO ZERO



An advanced solid state general purpose mono amplifier suitable for Public Address system, Disco, Guitar, Gram., etc. Featuree 3 individually controlled inputs, each input has a separate 2 stage pre-amp. Input 1 5mv into 47k. Input 2 5mv into 47k. Suitable for use with mic. or guitar, etc. Input 3 100mv into 1 meg. suitable for gram. tuner, or tape, etc. Full mixing facilities with full range bass and treble controls. All inputs plug into standard jack sockets on front panel. Output socket on rear of chassis for an 8 ohm or 16 ohm speaker. Output in excess of 20 watts R.M.S. Very attractively finished purpose built cabinet made from black vinyl covered steel, with a brushed anodised aluminium front escutcheon. For a.c. mains operation 200/240 volts. Size approx. 12½" wide × 5" high × 7½" deep.

Special introductory price **£28** + £2·50 carriage and packing.

HARVERSONIC STEREO 44



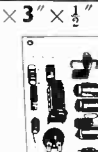
A solid state stereo amplifier chassis, with an output of 3-4 watts per channel into 8 ohm speakers. Using the latest high technology integrated circuit amplifiers with built in short term thermal overload protection. All components including rectifier smoothing capacitor, fuse, tone control, volume controls, 2 pin din speaker sockets and 5 pin din tape rec./play socket are mounted on the printed circuit panel, size approx. 9½" × 2¾" × 1" max. depth. Supplied brand new and tested, with knobs, brushed anodised aluminium 2 way escutcheon (to allow the amplifier to be mounted horizontally or vertically), at only **£9·00 plus 50p P. & P.** Mains transformer with an output of 17V a/c at 500 m/a can be supplied at **£1·50 plus 40p P. & P.** if required. Full connection details supplied.

BRAND NEW MULTI-RATIO MAINS TRANSFORMERS. Giving 13 alternatives. Primary: 0–210–240v. Secondary combinations 0–5–10–15–20–25–30–35–40–60v. half wave at 1 amp. or 10–0–10, 20–0–20, 30–0–30v. at 2 amps full wave. Size 3in. long × 3½in. wide × 3in. deep. Price £2·90. P. & P. £1

MAINS TRANSFORMER. For power supplies.
Pri. 200/240v. Sec. 9–0–9 at 500 mA. £1·50. P. & P. 65p.
Pri. 200/240v. Sec. 12–0–12 at 1 amp. £1·65. P. & P. 65p.
Pri. 200/240v. Sec. 10–0–10 at 2 amp. £2·35. P. & P. 95p.
Pri. 200/240v. Sec. 23v. at 1·5 amp, 6v at ·6 amp, 8v. at 50 mA. £2·00 + 65p P. & P.

ALL PURPOSE POWER SUPPLY UNIT 200/240v. A.C. input. Four switched fully smoothed D.C. outputs giving 6v. and 7½v. and 9v. and 12v. at 1 amp on load. Fitted insulated output terminals and pilot lamp indicator. Hammer finish metal case overall size 6" × 3¼" × 2¾". Ready built and tested. Price £6·75. P. & P. 95p.

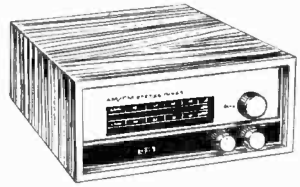
STEREO-DECODER SIZE 2" × 3" × ½"



Ready built. Pre-aligned and tested. Sens. 20-560mV for 9-16V neg. earth operation. Can be fitted to almost any FM VHF radio or tuner. Stereo beacon light can be fitted if required. Full details and instructions (inclusive of hints and tips) supplied. £5·62 plus 20p P. & P. Stereo beacon light if required 40p extra

QUALITY RECORD PLAYER AMPLIFIER MK. II A top quality record player amplifier employing heavy duty double wound mains transformer. ECC83, EL84, and rectifier. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in wide × 3in deep × 6in high. Ready built and tested. PRICE £7·00. P. & P. £1·25.
ALSO AVAILABLE mounted on board with output transformer and speaker. PRICE £8·00. P. & P. £1·30.

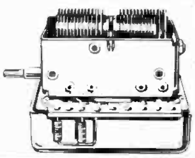
MAINS OPERATED SOLID STATE AM/FM STEREO TUNER



200/240V Mains operated Solid State A/M F/M Stereo Tuner. Covering M.W. A.M. 540-1605 KHZ. VHF/FM 88-108 MHZ. Built-in Ferrite rod aerial for M.W. Full AFC and AGC on AM and FM. Stereo Beacon Lamp Indicator. Built-in Pre-amps with variable output voltage adjustable by pre-set control. Max o/p Voltage 600 m/v RMS into 20K. Simulated teak finish cabinet. Will match almost any amplifier. Size 8½" w. × 4" h. × 9½" d. approx. LIMITED NUMBER ONLY at £28 + £1·50 P. & P.

SPECIAL OFFERS

Mullard LP1159 RF-IF Double Tuned Amplifier Module for nominal 470kHz. Size approx. 2¾" × 1¼" × ¾" 7·6V + earth. Brand new pre-aligned. Full specification and connection details supplied. **£2·25** + P. & P. 20p.



Pye VHF/FM Tuner Head covering 88-108M/Hz. 10·7M/Hz IF output 7-8V + earth. Supplied pre-aligned, with full circuit diagram. Connection details supplied. Beautifully made with precision-geared FM Gang and 323 Pf + 323 Pf AM Tuning Gang only **£3·15** + P. & P. 35p.

PRECISION MADE
Push Button Switch bank. 8 Buttons giving 16 S/P C/O interlocked switches plus 1 Cancel Button Plus 3 d/p c/o. Overall size 5" × 2½" × 1". Supplied complete with chrome finished switch buttons 2 for **£1·50** + 20p, P. & P.

HI-FI LOUDSPEAKER SYSTEM MkII

Beautifully made simulated teak finish enclosure now with most attractive slatted front. Size 16½" high × 10½" wide × 9" deep (approx.). Fitted with E.M.I. Ceramic Magnet 13" × 8" bass unit, H.F. tweeter unit and crossover. AVAILABLE IN NOMINAL 4 ohm, 8 ohm or 16 ohm impedance (state which). Handling power 10 watts R.M.S.

Our Price £12·80 each. Carr. £2·20 each.
Cabinet Available Separately £7·60 each. Carr. £1·60.
Also available in 8 ohms with EMI 13" × 8" bass speaker with parasitic tweeter **£11·10** each. Carr. £2·20.

LOUDSPEAKER BARGAINS
5in. 3 ohm **£2·00**, P. & P. 35p. 7 × 4in. 3 ohm **£2·35**, P. & P. 48p. 10 × 6in. 3 or 15 ohm **£3·20**. P. & P. 75p. 8 × 5in. 3 ohm with high flux magnet **£3·00**, P. & P. 60p. Tweeter. Approx. 3½". Available 3 or 8 or 15 ohms, **£2·00** + 30p P. & P.

SPECIAL OFFER. 6½" long throw, roll surround, ceramic magnet 8 ohm 10 watt speaker chassis. **Specially suitable for Hi Fi. £3·95** + 75p P. & P.

2" PLASTIC CONE HF TWEETER 4 ohm, **£3·50** per matched pair + 50p P. & P.

HIGH POWER HI-FI 8 ohm Dome Tweeter. 1" voice coil. Magnet size 3" dia. Suitable for use in up to 50 watt systems. **£4·50** each + 60p P. & P.

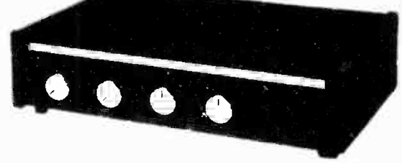
VYNAIR & REXINE SPEAKERS & CABINET FABRICS app. 54 in. wide. Our price £1·50 yd. length. P. & P. 50p per yd. (min. 1 yd.). S.A.E. for samples.

"POLY PLANAR" WAFER-TYPE, WIDE RANGE ELECTRO-DYNAMIC SPEAKER
Size 11¾" × 14¾" × 1⅞" deep. Weight 19oz. Power handling 20W r.m.s. (40W peak). Impedance 8 ohm only. Response 40Hz–20kHz. Can be mounted on ceilings, walls, etc. and used with or without baffle. Send S.A.E. for details. Only £8·40 each. P. & P. 90p for one, £1·10 for two.
Now also available in either 8" round version or 4½" × 8½" rectangular, 10 watt RMS 60Hz-20kHz. £5·25 + P. & P. (one 65p, two 75p).

SONOTONE 9TAHC COMPATIBLE STEREO CARTRIDGE
T/O stylus Diamond Stereo LP and Sapphire 78.
ONLY £2·36. P. & P. 10p. Also available fitted with twin Diamond T/O stylus for Stereo LP. **£2·86.** P. & P. 18p.
LATEST CRYSTAL T/O STEREO/COMPATIBLE CARTRIDGE for EP/LP/Stereo 78. **£1·80.** P. & P. 18p.
LATEST T/O MONO COMPATIBLE CARTRIDGE for playing EP/LP/78 mono or stereo records on mono equipment. Only £1·58. P. & P. 18p.

SEND SAE WITH ALL ENQUIRIES. FOR PERSONAL CALLERS ONLY: WE CAN NOW OFFER A FULL REPAIR SERVICE ON ALL HI-FI EQUIPMENT, DISCO, CASSETTES, CAR RADIO, ETC

HARVERSONIC SUPER SOUND 10 + 10 STEREO AMPLIFIER KIT



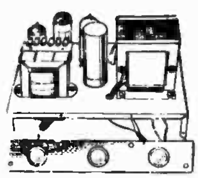
A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors including Silicon Transistors in the first five stages on each channel resulting in even lower noise level with improved sensitivity. Integrated pre-amp with Bass, Treble and two Volume Controls. Suitable for use with Ceramic or Crystal cartridges. Very simple to modify to suit magnetic cartridge—instructions included. Output stage for any speakers from 8 to 15 ohms. Compact design, all parts supplied including drilled metal work, high quality ready drilled printed circuit board with component identification clearly marked, smart brushed anodised aluminium front panel with matching knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief specifications: Power output: 14 watts r.m.s. per channel into 5 ohms. Frequency response ±3dB 12–30,000 Hz Sensitivity: better than 80mV into 1MΩ. Full power bandwidth: ±3dB 12–15,000 Hz. Bass, boost approx. to ±12dB. Treble cut approx. to −16dB. Negative feedback 18dB over main amp. Power requirements 35v. at 1·0 amp.
Overall Size 12"w. × 8"d. × 2¾"h.
Fully detailed 7 page construction manual and parts list free with kit or send 25p plus large S.A.E.

AMPLIFIER KIT	**£13·50**	P. & P. 80p
(Magnetic input components 33p extra)		
POWER PACK KIT	**£5·50**	P. & P. 95p
CABINET	**£5·50**	P. & P. 95p

Special offer—only £23·75 if all 3 units ordered at one time plus £1·25 P. & P.

Full after sales service
Also available ready built and tested £31·25. P. & P. £1·50.

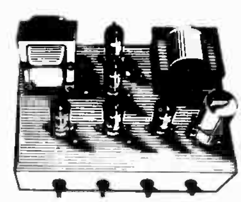
3-VALVE AUDIO AMPLIFIER HA34 MK II.



Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7½"w. × 4"d. × 4½"h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker. Separate volume control and now with improved wide range tone controls giving bass and treble lift and cut. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls. Complete with knobs, valves, etc., wired and tested for only **£8·20.** P. & P. £1·40.

HSL "FOUR" AMPLIFIER KIT. Similar in appearance to HA34 above but employs entirely different and advanced circuitry. Complete set of parts, etc. **£7·60.** P. & P. £1·40.

10/14 WATT HI-FI AMPLIFIER KIT



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3–15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and EZ80 rectifier. Simple instruction booklet 25p × SAE (Free with parts). All parts sold separately. **ONLY £12·00.** P. & P. £1·40. Also available ready built and tested **£16·50.** P. & P. £1·40.

SPECIAL LINES

OFFERED SUBJECT TO STOCK AVAILABILITY

Limited number of British Manufacturer's Surplus professional 100 watt RMS Slave amplifiers. Special features: 2 separate power modules, 1 for Bass response, and 1 for mid. range/tweeter. 5 stage LED display for power o/p indication. A/c mains i/p switchable for 110 or 240V. Can easily be converted to stereo.

AVAILABLE TO PERSONAL CALLERS ONLY—PLEASE PHONE TO CONFIRM AVAILABILITY.
Brand new and tested only £33·75.

OUR PRICES INCLUDE VAT AT CURRENT RATES

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Closed Wednesday.
Prices and specifications correct at time of press. Subject to alteration without notice

HARVERSON SURPLUS CO. LTD.

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