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JULY 1972

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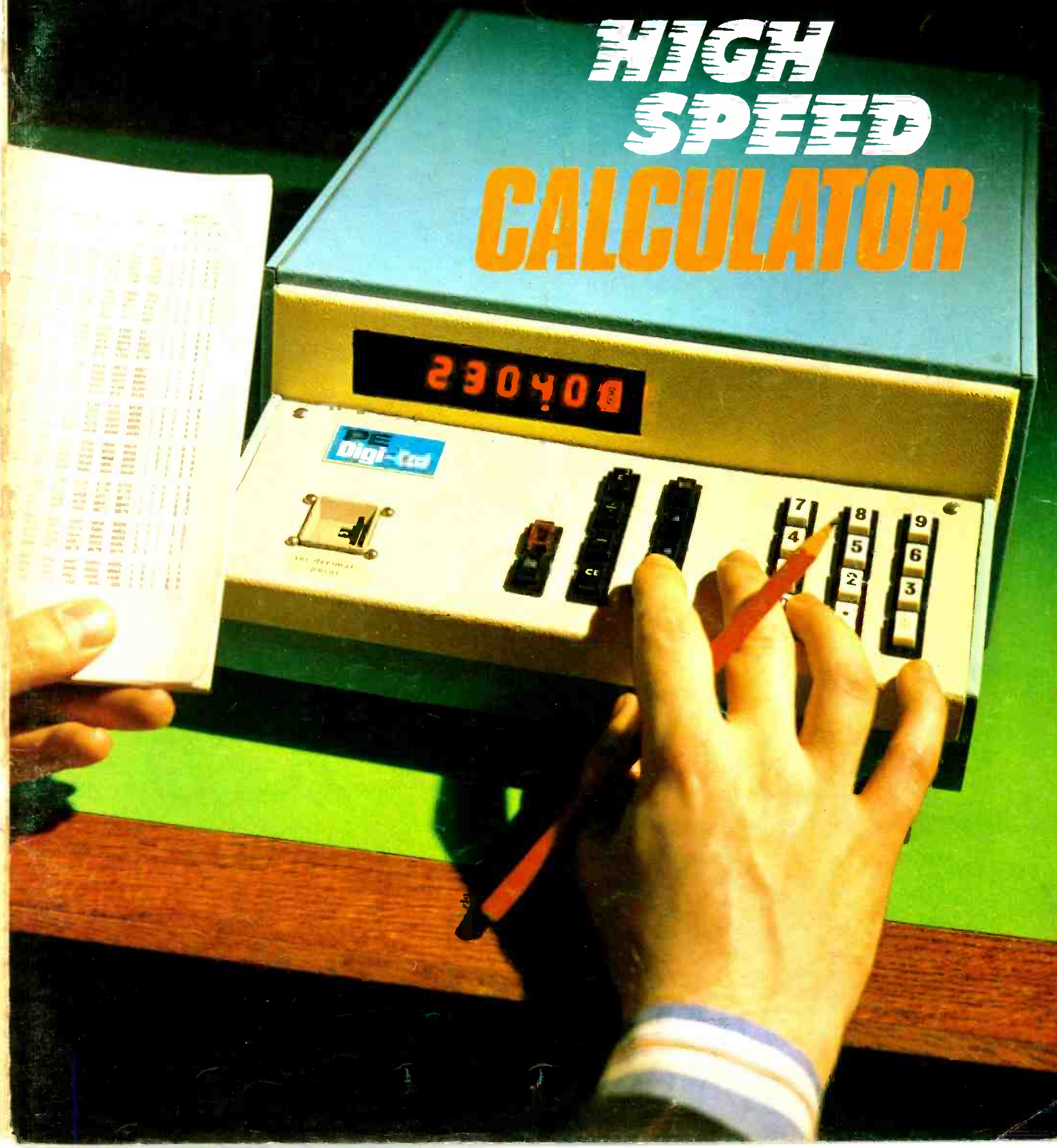

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100V	0·68μF	15p
250V	0·01μF	5p
250V	0·015μF	5p
250V	0·022μF	5p
250V	0·033μF	6p
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25V	100μF	9p
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NKT224	21p	19p
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NKT243	51p	44p
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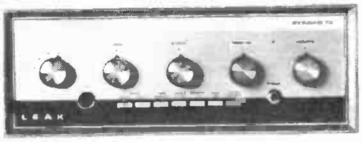

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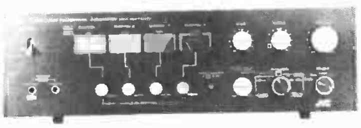

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Stereo car Player

Accepts all standard pre-recorded 8 track stereo cartridges. Features include automatic head cleaner, channel select and channel repeat push buttons, slider type volume and tone controls, channel balance. Output 5 watts per channel, frequency response 50Hz-10kHz. Output imp. 4 ohms, size 4¾(W) × 1 11/16(H) × 6¼(D) in. Operates on 12V DC negative earth. Beautifully styled with black ivory and chrome trim.

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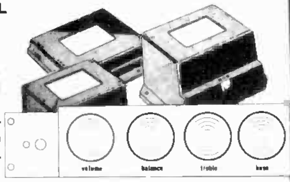

CONTROL Fitted with bass, treble, vol. and balance controls. All wires fitted for connecting. Size 9in x 1¾in x 1in. **£2·25.**

EP-9001 PRE-AMP. Input imp. PU 2.2M, tuner 1M. Sensitivity PU 320mV, tuner 140mV. Treble and bass control range −14dB to +14dB Treble at 16KHz, bass at 60Hz. Size 4in x 5in x 1in. **£2·40.**

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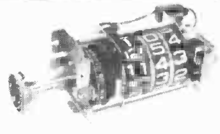

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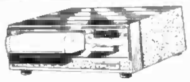
BSR TD8S



8 TRACK STEREO CARTRIDGE PLAYER

The unit is switched on and off by the insertion of the cartridge; The TD8S is suitable for use with most modern stereo amplifiers and delivers a pre-amp output of 125mW. Power requirements: 210/250V AC, 50Hz. Frequency response: 50Hz-10KHz. 4 pole dynamically balanced synchronous motor maintains unwavering speed accuracy - independent of mains fluctuations. Compact in size the TD8S is housed in black and woodgrain plastic cabinet. Size: 8¼(W) x 3¾(H) x 10¼ (D) in.

C & P 35p

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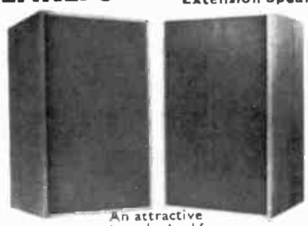
Bookshelf Extension Speakers



An attractive bookshelf speaker system with teak veneer finish. Imp. 8 ohms. Max. Power 12W. Size 14½ (H) x 9 (W) x 7¼ (D) in.

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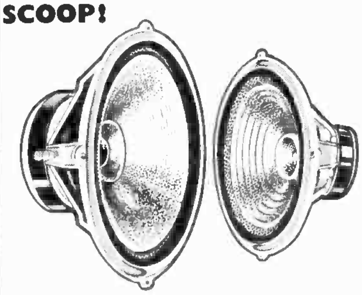

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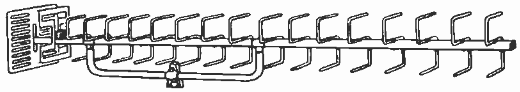

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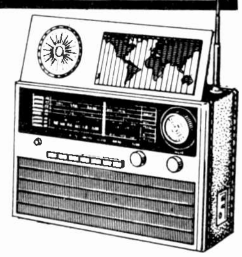

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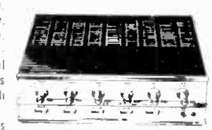
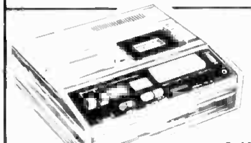


Specifications: 25 watts rms per channel into 8 ohms. Inputs Magnetic, Tuner, Tape/Aux, Tape play. Frequency response 20-20,000 Hz (± 1db). Size 333mm × 102mm × 285mm. Normal Price £33·60. **ROC PRICE £26·40**

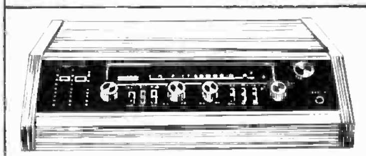
A-5000 60-WATT SOLID STATE STEREO AMPLIFIER
With the A-5000, you're in the big-sound class – 30 watts rms per channel into 8 ohms! The circuit is all-silicon-transistor, giving you top quality sound and a mere 0·2% distortion at 25 watts output. And optimum stereo input balance is derived from the use of an IC (integrated circuit). There's no need to worry about overload or short-circuiting the output – the A-5000 has built-in protection. Specifications: 30 watts rms per channel into 8 ohms. Frequency response 15-40,000 Hz (± 2db) Inputs Magnetic, Tuner, Tape/Aux, Tape Play. Normal Price £43·40. **ROC PRICE £34·00**

R-200 20-WATT AM/FM/MPX STEREO TUNER AMPLIFIER What more could a hi-fi enthusiast want! The R-200 gives you top quality reproduction of both AM and FM programmes, including all the stereo broadcasts now available on FM. And you have built-in facilities for recording your favourite programmes on an external tape recorder. The front panel is carefully designed, with the latest slider controls for bass, treble, volume and balance. Alongside the dial are a meter for accurate tuning and a stereo indicator lamp that automatically lights up when you're tuned in to a stereo signal. Dozens of other brilliant facilities including main and remote speaker terminals.
Specifications: 10 watts rms per channel into 8 ohms. Frequency response: 25-40,000 Hz (± 2db) Inputs: Magnetic, Ceramic, Tape, Aux, Tape Play. Size: 398mm × 267mm × 106mm. Normal Price £50·00. **ROC PRICE £42·00**

R-150 12-WATT AM/FM/MPX STEREO TUNER AMPLIFIER You couldn't get better value for money in Stereo Tuner Amplifiers anywhere! Just look at all the facilities the R-150 gives you – bass, treble, balance, volume, switchable AFC for drift-less reception on FM, socket for headphones on the front panel. A tuning meter. Stereo indicator. Tape output, so that you can record your favourite programmes. To name but a few. AM section covers the medium waveband – 535-1605 kHz, and the FM band 88-108 MHz.
Specifications: 6 watts rms per channel into 8 ohms. Frequency response 40-20,000 Hz (± 2db) Inputs Magnetic, Ceramic, Aux. Size: 107mm × 385mm × 263mm. Normal Price £38·30. **ROC PRICE £29·90**



D-400B STEREO CASSETTE DECK Precision engineered for trouble-free performance, this Stereo Cassette Deck has a fantastic range of facilities, making it a real value-for-money unit. Left and right level meters for recording, the latest slider controls for record level, switchable playback noise filter, aux/mic switch, mic input sockets, piano-key controls for record, rewind, play, fast-forward, and stop/eject. Index counter with reset button.
Specifications: Frequency response: 35-12,000 Hz. Wow and flutter less than 0·25%. Inputs: Mike, Aux, Din Socket. Size: 345mm × 300mm × 100mm. Normal Price £39·50. **ROC PRICE £34·00**



MR-15 AM/FM/MPX STEREO TUNER AMPLIFIER Here's a beautifully styled AM/FM Stereo Tuner Amplifier. Featuring FET (Field Effect Transistor) front end FM tuner and dual-channel IC equalizer for perfect balance, the MR-15 incorporates professional style vertical sliding controls for bass and treble. All the input/output facilities you need. Covers FM 88-108 MHz. AM 535-1605 kHz. Output 16 watts rms per channel into 8 ohms. Inputs Magnetic, Tape, Aux, Tape Play. Size 467mm × 458mm × 130mm. Normal Price £67·60. **ROC PRICE £54·00**

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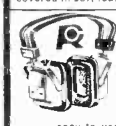
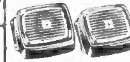
R.328 STEREO HEADPHONE If you're starting in hi-fi, and you discover the need for a pair of really good stereo head-phones, The R.328 is ideal, at a price you can afford. They have padded ear cushions, a 6-foot cord and jack plug. Frequency range 30-15,000 Hz. Impedance 8 ohms per channel.
ROC PRICE £2·95

R.186 STEREO HEADPHONE JUNCTION BOX If you want easy, fingertip control of headphones *and* loudspeakers, here's the ideal solution to the problem. All you do is connect it to your speakers and amplifier, plug in your headphones – and you're ready to take over! At the flick of a slide switch, you can have headphones alone, or speakers alone, or both together. Input suitable for use with amplifiers rated up to 20 watts. Size: 2⅖" × 3$\frac{1}{32}$" × 1$\frac{7}{64}$".
ROC PRICE £1·50

EAGLE SE-30 STEREO HEADPHONE This model is for the more discriminating listener. For a start the frequency range extends from 30 to 16,000 Hz. And you can adjust the volume of each earpiece independently. There's also a mono/stereo switch. For maximum comfort, the ear cushions are covered in soft leathers. **ROC PRICE £7·05**



TEC HR-007 HEADPHONE RADIO When you want to listen to the radio all by yourself. Then this will solve the problem. Separate volume and tuning controls with easy-to-use knobs. Frequency range is 535 to 1605 kHz medium wave band. Maximum output is 300 mW.
Normal Price £9·45 **ROC PRICE £5·80**

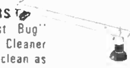


R.151 STEREO CAR SPEAKERS Smart black, tough, plastic cases, each containing a high flux 110mm diameter speaker unit. Just what you need to go with the CS.8 Cartridge Player or any other car stereo system. Fitted with over three yards of connecting cable. Dimensions: 6$\frac{1}{16}$" × 5$\frac{33}{64}$" × 3$\frac{1}{32}$". Impedance: 8 ohms per speaker. Rating: 5 watts max per speaker. **ROC PRICE £3·72**

EAGLE 8-TRACK CAR STEREO PLAYER, CS.8 Drive to the sound of music – with this fabulous 8-Track Cartridge Player. It gives you superb tone and power to fill the car with stereo sound. Ideal for use with R.151 or R.152 speakers. Complete with all mounting accessories. For negative earth electrical systems only. Output: 2·5 watts per channel. Frequency range: 70-10,000 Hz. Wow and flutter: less than 0·3%. Tape speed: 3·5 cm/sec. Channel selector: automatic with manual over-ride. Mounting dimensions: 5$\frac{33}{64}$" × 5$\frac{1}{2}$" × 2$\frac{1}{16}$". **ROC PRICE £27·20**

R.152 STEREO CAR SPEAKERS These sloping front speakers match the CS.8 Cartridge Player or any other car stereo system. Fitted with high flux 110mm diameter speaker unit, and over three yards of connecting cable. Dimensions: 6$\frac{1}{16}$" × 6$\frac{1}{2}$" × 3⅞". Impedance: 8 ohms per speaker. Rating: 5 watts max. per speaker.
ROC PRICE £4·96

EAGLE LC.05 STEREO MAGNETIC CARTRIDGE For fabulous reproduction at a very low price, you'll find it hard to beat. 0·7 mil diamond stylus. Output: 6mV per channel. Frequency range: 30-18,000 Hz. Channel balance: ±1·5dB. Channel separation: 20dB. Recommended stylus pressure: 2-4 grams. Compliance: 9 × 10-6 cm/dyne. **ROC PRICE £4·75**



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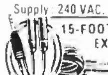
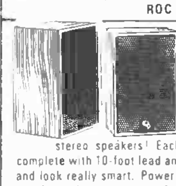
EAGLE LC.07 STEREO MOVING-MAGNET CARTRIDGE Here's your opportunity to own a transcription cartridge for the price of a ceramic! Is specially designed to match top quality tone arms, and to get the very best from your hi-fi amplifier. 0·7 mil diamond stylus. Output: 7mV per channel. Frequency range: 20-21,000 Hz. Channel balance: ±1dB. Channel separation: 28dB. Compliance: 12 × 10-6 cm/dyne.
ROC PRICE £6·37



15-FOOT STEREO HEADPHONE EXTENSION CORD R.362 Fitted with heavy duty 3-circuit stereo plug at one end and a matching stereo socket at the other. **ROC PRICE £1·30**

STEREO HEADPHONE "Y" ADAPTOR R.361 Enables you to use two sets of stereo headphones from a single socket. Fitted with male plug and two female sockets. **ROC PRICE £1·30**



R.088 MATCHED STEREO LOUD-SPEAKERS Here's real value in stereo speakers! Each unit comes complete with 10-foot lead and phono plug, and look really smart. Power handling per speaker: 4 watts rms, 8 watts peak. Frequency range: 40-16,000 Hz. Flux density: 8,500 gauss. Impedance: 8 ohms. Dimensions: 9" high, 5¼" wide, 4¾" deep. Finish: oiled walnut.
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Total	£59·00	

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SYSTEM 2

Viscount III R101 amplifier	£22·00	+90p p&p
2 x Duo Type III speakers	£32·00	£3 p&p
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This is real value for money! We have designed 2 systems and the heart of them all is the Viscount III amplifier. A unit of great eye appeal with teak finished cabinet. FET's (Field effect transistors) are incorporated on the input stages, just like the top priced units. FET's give you more of the signal you want and almost none of the hiss you don't. Both units have output sockets for headphones and tape recorder. Filters and tone controls give a wide range of bass and treble adjustment.

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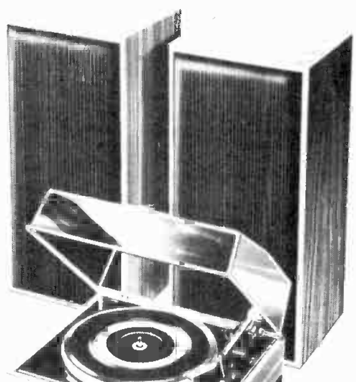
SPECIFICATION. 14 watts per channel into 3-4 ohms (suitable 3-15 ohms). Total distortion at 10W, at 1 kHz, 0·1%. P.U.1 (for ceramic cartridges): 150mV into 3 Meg. P.U.2 (for magnetic cartridges). 4 mV at 1 kHz into 47 K equalised within ±1 dB R.I.A.A. Radio: 150 mV into 220K. (Sensitivities given at full power). Tape out facilities; headphone socket, power out 250 mW per channel. Tone controls and filter characteristics. Bass: +12 dB to −17 dB at 60 Hz. Bass filter: 6 dB per octave cut. Treble control: treble +12 dB to −12 dB at 15 kHz. Treble filter: 12 dB per octave. Signal to noise ratio: (all controls at max) P.U.1 and radio −65 dB. P.U.2: −58 dB. Crosstalk better than −35 dB on all inputs. Overload characteristics better than 26 dB on all inputs. Size: Approx. 13¼in × 9in × 3¾in.

SPEAKERS Duo Type II. Size: Approx. 17in × 10¾in × 6¾in. Drive unit: 13in × 8in with parasitic tweeter. Max. power 10 watts, 8 ohms. Simulated teak cabinet. **£14 pair** + £2 p&p.

Duo Type III. Size: Approx. 23½in × 11½in × 9½in. Drive unit: 13½in × 8¼in with H.F. speaker. Max. power, 20 watts at 3 ohms. Freq. range: 20 Hz to 20 kHz. Teak veneer cabinet. **£32 pair** + £3 p&p.



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ACY17	0·20	2G303	0·13
AF239	0·30	2N711	0·50
AF186	0·20	2N1302-3	0·15
AF139	0·30	2N1304-5	0·17
BC154	0·20	2N1306-7	0·20
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BSY27	0·13	OC26	0·25
BSY28	0·13	OC28	0·30
BSY29	0·13	OC35	0·25
BSY9SA	0·10	OC36	0·37
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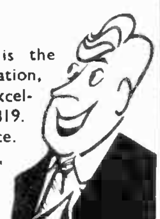

This field effect transistor is the 2N3823 in a plastic encapsulation, coded as 3823E. It is also an excellent replacement for the 2N3819. Data sheet supplied with device. 1-10 **30p** each, 10-50 **25p** each, 50+**20p** each.

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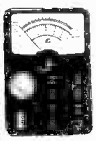

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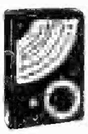

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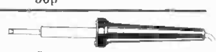
Features large easy-to-read meter, wide choice of ranges. With test leads, batteries and manual. Size: 4¼in × 3¼in × 1in. **Ranges:** D.C. voltages: 0-5-25-50-250-500-2,500V. A.C. voltages: 0-10-50-100-500-1,000V. D.C. current: 0-50μA-2·5mA-250mA. Resistance: 0-6,000 ohms, 0-6 meg ohms (300 ohms and 30 kohms at centre scale). Capacity: 10uf to ·001uf, ·001uf to ·1uf. Decibels: −20 to +22dB. **£4·90.** P. & P. 25p

MODEL CT620 MULTITESTER
Ranges: D.C. voltages: 0, 5, 25, 100, 500/1,000V (20,000 ohms/V). A.C. voltages: 0, 5, 25, 100, 500, 1,000V (10,000 ohms/V). D.C. current: 0, 50μA, 0mA, 5mA, 50mA, 500mA. Resistance: 0, 6kΩ, 600kΩ, 6MΩ, 60MΩ. Decibels: −20 to +62dB in 5 ranges. **£5·62.** P. & P. 25p

"WELLER EXPERT" SOLDER GUN
Saves time and simplifies soldering in the home and service dept. Two position trigger gives instant dual heat 100/140 watt. 240 volt A.C. **£3·95** P. & P. 50p



"Weller Marksman" Soldering Iron
Lightweight, ³⁄₁₆in pencil bit, 25 watt. 240 volt A.C. **£1·50** P. & P. 16p

VERITAS V-313 TAPE HEAD DEFLUXER

A must for all tape users! Tape heads become permanently magnetized with constant use; this leads to background noise that prevents perfect recordings. Simply applied to recording head the V313 leaves head free of magnetism. Cleans any tape head in seconds. **£1·72.** P. & P. 15p

PREMIER HI-FI OFFERS!

Rogers Ravensbrook 11 Stereo Amplifier teak	£38·50
Rogers Ravensbourne Stereo Amplifier teak	£49·00
Metrosound ST20E Stereo Amplifier teak	£25·50
Goldring GL72 less cartridge	£22·00
Garrard SP25 111 with Goldring G800 cartridge	£15·00

Garrard SP25 Mk. III Single Record Player. Fitted Goldring G800 Magnetic Stereo Cartridge. Complete in Teak Plinth with Cover.

Total list Price over £34.

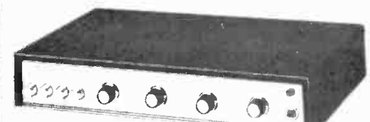
PREMIER PRICE £18·50 P. & P. 50p

GARRARD AP76 WITH G800, READY WIRED TO 5-PIN DIN IN PLINTH WITH COVER	£29·50
Garrard AP76 less cartridge	£18·80
GARRARD 401 TRANSCRIPTION UNIT	£27·40
Garrard 2025 T/C with Stereo Ceramic Cartridge	£8·50
Garrard 2025 T/C with Stereo Ceramic Cartridge ready wired in teak plinth with cover	£12·45

Carriage and Insurance 60p extra any item.

CARTRIDGE BARGAINS!
GOLDRING G800H £5·00; G800 £5·50; G800E £9·50.
SHURE M3D £4·00, M44E £5·75; M55E £6·50; M75EII £10·90.

PREMIER 800 STEREO AMPLIFIER



(As used in System "ONE" above)

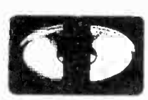
A truly high quality stereo amplifier—compare the specification, compare the price. Output: 5 watts per channel. Frequency response: 30–20,000Hz ± 2db. Distortion: 1%. Output Impedance 8 ohms nom. Inputs equalised to R.I.A.A. Magnetic 4mV. Ceramic 100mV. Tuner 100mV. Tape 100mV. Tape out 150mV. Din sockets for inputs and outputs. Controls: Bass, Treble, Volume, Balance, Selector. Mono/Stereo switch. Stereo Headphone socket. Attractive slim line design black leatherette cabinet with aluminium front panel. Size 12¼in × 6¾in × 2¾in **ONLY £15·00** Carr. 50p

Mk. II Version available with Teak Finish Cabinet. **£16·25.** Carr. 50p.

HI-FI STEREO HEADPHONES
Designed to the highest possible standard. Fitted 2¼in speaker units with soft padded ear muffs. Adjustable headband. 8 ohm impedance. Complete with 6ft lead and stereo jack plug. **£2·47** P. & P. 25p

STEREO STETHOSCOPE SET Low imp. **£1·25.** P. & P. 10p
MONO STETHOSCOPE SET Low imp. **52p.** P. & P. 10p

E.M.I. 13×8in. HI-FI SPEAKERS



Fitted two 2½in tweeters and crossover network. Available with 8 or 15 ohm impedance. Handling capacity 10W. Brand new. **£3·47** P. & P. 50p

VERITAS V-49 MIXER

Battery operated 4-channel audio mixer providing four separate inputs. Size 6in × 3in × 2in suitable for crystal microphone, low impedance microphone with transformer, radio, tape, etc. Max. input 1·5V, max. output 2·5V, gain 6dB. Standard jack plug socket inputs, phonoplugs output. Attractive teak wood grain finish case.
Mono Model £3 **Stereo Model £3·47** P. & P. 15p

TAPE CASSETTES

C60	(60 min.)	29p	3 for 81p
C90	(90 min.)	40p	3 for £1·11
C120	(120 min.)	52p	3 for £1·40

P. & P. 10p

FREE Cassette Head Cleaner with every 10 cassettes

"VERITONE" RECORDING TAPE

SPECIALLY MANUFACTURED IN U.S.A. FROM EXTRA STRONG PRE-STRETCHED MATERIAL. THE QUALITY IS UNEQUALLED.
TENSILISED to ensure the most permanent base. Highly resistant to breakage, moisture, heat, cold or humidity. High polished splice free finish. Smooth output throughout the entire audio range. Double wrapped—attractively boxed.

LP3	3"	250'	P.V.C.	28p
TT3	3"	450'	POLYESTER	37p
DT3	3½"	600'	POLYESTER	57p
SP5	5"	600'	P.V.C.	42p
LP5	5"	900'	ACETATE	50p
DT5	5"	1200'	POLYESTER	75p
LP6	5¾"	1200'	ACETATE	75p
DT6	5¾"	1800'	POLYESTER	£1·12
TT6	5¾"	2400'	POLYESTER	£1·87
SP7	7"	1200'	P.V.C.	62p
LP7	7"	1800'	ACETATE	75p
DT7	7"	2400'	POLYESTER	£1·25
TT7	7"	3600'	POLYESTER	£2·50

TAPE SPOOLS 3" 5p, 5", 5¾", 7" 9p.
Post and Packing 3" 5p, 5", 5¾" 8p, 7" 10p. (3 reels and over Post Free.)

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The largest selection

NEW LOW PRICE TESTED S.C.R.'s

PIV	1A TO-5	3A TO-66	7A TO-66	10A	16A TO-48	30A TO-48
	£p	£p	£p	£p	£p	£p
50	0·23	0·25	0·47	0·50	0·53	1·15
100	0·25	0·33	0·53	0·58	0·63	1·40
200	0·35	0·37	0·57	0·61	0·75	1·60
400	0·43	0·47	0·67	0·75	0·93	1·75
600	0·53	0·57	0·77	0·97	1·25	—
800	0·63	0·70	0·90	1·20	1·50	4·00

SIL. RECTS. TESTED

PIV	300mA	750mA	1A	1·5A	3A	10A	30A
	£p	£p	£p	£p	£p	£p	£p
50	0·04	0·05	0·05	0·07	0·14	0·21	0·47
100	0·04	0·06	0·05	0·13	0·16	0·23	0·75
200	0·05	0·09	0·06	0·14	0·20	0·24	1·00
400	0·06	0·13	0·07	0·20	0·27	0·37	1·25
600	0·07	0·16	0·10	0·23	0·34	0·45	1·85
800	0·10	0·17	0·13	0·25	0·37	0·55	2·00
1000	0·11	0·25	0·15	0·30	0·46	0·63	2·50
1200	—	0·33	—	0·33	0·57	0·75	

TRIACS

VBOM	2A TO-1	6A TO-66	10A TO-88
	£p	£p	£p
100	30	50	76
200	50	60	90
400	70	75	1·10

FULL RANGE OF ZENER DIODES VOLTAGE RANGE 2-33V. 400mW (DO-7 Case) 13p ea. 1½W (Top-Hat) 18p ea. 10W (SO-10 Stud) 25p ea. All fully tested 5% tol. and marked. State voltage required.

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FOR USE WITH TRIACS
BR100 D32 .. 37p each

10amp POTTED BRIDGE RECTIFIERS on heat sink. 100 PIV. 90p each.

UNIJUNCTION

UT46. Eqvt. 2N2646, Eqvt. TIS43. BEN3000 **27p** each, 25-99 **25p** 100 UP **20p**.

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MIXED ELECTRONIC COMPONENTS Exceptionally good value

Resistors, capacitors, pots, electrolytics and coils plus many other useful items. Approximately 3lbs in weight. Price incl. P. & P. **£1·50 only**

Plus your satisfaction or money back guarantee.

NPN SILICON PLANAR BC107/108, **10p** each; 50-99, **9p**; 100 up, **8p** each; 1,000 off, **7p** each. Fully tested and coded TO-18 case.

FREE

One 50p Pak of your own choice free with orders valued £4 or over.

SPECIAL OFFER
2N2926 (Y) (O). 10 for **50p**. 25 for £1. 20,000 TO CLEAR.

CADMIUM CELLS

ORP12 **43p**
ORP60, ORP61 **40p** each

GENERAL PURPOSE NPN SILICON SWITCHING TRANS. TO-18 SIM. TO 2N706/8, BSY27/28 95A. All usable devices no open or short circuits. ALSO AVAILABLE in PNP Sim. to 2N2906, BCY70. When ordering please state preference NPN or PNP.

		£p
20	For	0·50
50	For	1·00
100	For	1·75
500	For	7·50
1000	For	13·00

PHOTO TRANS.

OCP71 Type. **43p**

BRAND NEW TEXAS GERM. TRANSISTORS Coded and Guaranteed

Pak No.			EQVT
T1	8	2G371B	OC71
T2	8	D1374	OC75
T3	8	D1216	OC81D
T4	8	2G381T	OC81
T5	8	2G382T	OC82
T6	8	2G344B	OC44
T7	8	2G345B	OC45
T8	8	2G378	OC78
T9	8	2G399A	2N1302
T10	8	2G417	AF117

All **50p** each pak

2N2060 NPN SIL. DUAL TRANS. CODE D1699 TEXAS. Our price **25p** each.

120 VCB NIXIE DRIVER TRANSISTOR. Sim. BSX21 & C407, 2N1893 FULLY TESTED AND CODED ND120. 1-24 **17p** each. TO-5 N.P.N. 25 up **15p** each.

SIL. G.P. DIODES £p

300mW	30 ..	0·50
40PIV (Min.)	100 ..	1·50
Sub-Min.	500 ..	5·00
Full Tested	1,000 ..	9·00

Ideal for Organ Builders.

Sil. trans. suitable for P.E. Organ. Metal TO-18 Eqvt. ZTX300 **5p** each. Any Qty.

D13D1 Silicon Unilateral switch 50p each.
A Silicon Planar, monolithic integrated circuit having thyristor electrical characteristics, but with an anode gate and a built-in "Zener" diode between gate and cathode. Full data and application circuits available on request.

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PLASTIC ENCAPSULATED 2 AMP BRIDGE RECTS.

Each
50V RMS **32p**
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Size 15mm × 6mm

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Unequalled Value and Quality
NEW BI-PAK UNTESTED SEMICONDUCTORS

Satisfaction GUARANTEED in Every Pak, or money back.

Pak No.		£p
U1	120 Glass sub-min. general purpose germanium diodes	0·50
U2	60 Mixed germanium transistors AF/RF	0·50
U3	75 Germanium gold bonded diodes sim. OA5, OA47	0·50
U4	40 Germanium transistors like OC81, AC128	0·50
U5	60 200mA sub-min. Sil. diodes	0·50
U6	30 Silicon planar transistors NPN sim. BSY95A, 2N706	0·50
U7	16 Silicon rectifiers Top-Hat 750mA up to 1,000V	0·50
U8	50 Sil. planar diodes 250mA, OA/200/202	0·50
U9	20 Mixed volts 1 watt Zener diodes	0·50
U11	25 PNP silicon planar transistors TO-5 sim. 2N1132	0·50
U13	30 PNP-NPN sil. transistors OC200 & 28104	0·50
U14	150 Mixed silicon and germanium diodes	0·50
U15	25 NPN Silicon planar transistors TO-5 sim. 2N697	0·50
U16	10 3-Amp silicon rectifiers stud type up to 1000 PIV	0·50
U17	30 Germanium PNP AF transistors TO-5 like ACY 17-22	0·50
U18	8 6-Amp silicon rectifiers BYZ13 type up to 600 PIV	0·50
U19	25 Silicon NPN transistors like BC108	0·50
U20	12 1·5-Amp silicon rectifiers Top-Hat up to 1,000 PIV	0·50
U21	30 A.F. germanium alloy transistors 2G300 series & OC71	0·50
U23	30 Madt's like MAT series PNP transistors	0·50
U24	20 Germanium 1-Amp rectifiers GJM up to 300 PIV	0·50
U25	25 300Mc/s NPN silicon transistors 2N708, BSY27	0·50
U26	30 Fast switching silicon diodes like IN914 micro-min	0·50
U29	10 1-Amp SCR's TO-5 can up to 600 PIV CRS1/25-600	1·00
U31	20 Sil. Planar NPN trans. low noise amp 2N3707	0·50
U32	25 Zener diodes 400mW D07 case mixed volts, 3-18	0·50
U33	15 Plastic case 1 amp silicon rectifiers IN4000 series	0·50
U34	30 Sil. PNP alloy trans. TO-5 BCY26, 28302/4	0·50
U35	25 Sil. planar trans. PNP TO-18 2N2906	0·50
U36	25 Sil. planar NPN trans. TO-5 BFY50/51/52	0·50
U37	30 Sil. alloy trans. SO-2 PNP, OC200 2S322	0·50
U38	20 Fast switching sil. trans. NPN, 400Mc/s 2N3011	0·50
U39	30 RF germ. PNP trans. 2N1303/5 TO-5	0·50
U40	10 Dual trans. 6 lead TO-5 2N2060	0·50
U41	25 RF germ. trans. TO-1 OC45 NKT72	0·50
U42	10 VHF germ. PNP trans. TO-1 NKT667 AF117	0·50
U43	25 Sil. trans. plastic TO-18 A.F. BC113/114	0·50
U44	20 Sil. trans. plastic TO-5 BC115/116	0·50
U45	7 3A SCR's TO-66 up to 600 Piv	1·00

Code Nos. mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked.

POWER TRANSISTOR BONANZA!

GENERAL PURPOSE GERM. PNP
Coded GP100. BRAND NEW TO-3 CASE. POSS. REPLACE.:—OC25-28-29-30-35-36, NKT 401-403-404-405-406-430-451-452-453, T13027-3028, 2N250A, 2N456A-457A-458A, 2N511 A & B, 2G220-222, ETC. VCBO 80V VCEO 50V IC 10A PT. 30 WATTS Hfe 30-170.

PRICE	1-24	25-99	100 up
	43p each	40p each	36p each

AD161 *NPN*
AD162 *NPN*
M/P COMP GERM TRANS. OUR LOWEST PRICE OF 55p *PER PAIR*

SILICON High Voltage 250V NPN TO-3 case. G.P. Switching & Amplifier Applications. Brand new Coded R 2400 VCBO 250/VCEO 100/IC 6A/30 Watts. HFE type 20/fT 5MHZ.

OUR PRICE EACH:	1-24	25-99	100 up
	50p	45p	40p

2N3055
115 WATT SIL POWER NPN
50p EACH

SILICON 50 WATTS MATCHED NPN/PNP BIP 19 NPN TO-3 Plastic. BIP 20 PNP. Brand new. VCBO 100/VCEO 50/IC 10A. HFE type 100/ft 3mHZ.

OUR PRICE PER PAIR:	1-24	25-99	100
	prs.	prs.	prs.
	60p	55p	50p

EX-STOCK TYPE EACH AS PRICED

OC20	50p	OC28	40p	AD149	43p	BD131	70p	BD139	75p
OC22	30p	OC29	40p	AL102	85p	BD132	80p	BD140	85p
OC23	33p	OC35	33p	AL103	85p	BD135	70p	BD155	75p
OC24	45p	OC36	40p	BD121	60p	DB136	80p	BU105	£3
OC25	25p	AD140	40p	BD123	75p	BD137	70p	2N3054	45p
OC26	25p	AD142	40p	BD124	70p	BD138	80p		

RTL MICROLOGIC CIRCUITS

	Price each 1-24	25-99	100 up
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uL900 Buffer	35p	33p	27p
uL914 Dual 2i/p gate	35p	33p	27p
uL923 J-K flip-flop	50p	47p	45p

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TWO Ranges PROFESSIONAL and NEW LOW COST.

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TSO16 ,, ,,	35p	32p	30p
Low Cost No.			
BP814	15p	13p	11p
BP816	16p	14p	12p

NEW QUALITY TESTED PAKS

Pak	Description	Price £p
Q1	20 Red spot trans. PNP AF	0·50
Q2	16 White spot R.F. trans. PNP	0·50
Q3	4 OC77 type trans.	0·50
Q4	6 Matched trans. OC44/45/81/81D	0·50
Q5	4 OC75 transistors	0·50
Q6	4 OC72 transistors	0·50
Q7	4 AC128 trans. PNP high gain	0·50
Q8	4 AC126 trans. PNP	0·50
Q9	7 OC81 type trans.	0·50
Q10	7 OC71 type trans.	0·50
Q11	2 AC127/128 comp. pairs PNP/NPN	0·50
Q12	3 AF116 type trans.	0·50
Q13	3 AF117 type trans.	0·50
Q14	3 OC171 H.F. type trans.	0·50
Q15	5 2N2926 sil. epoxy trans.	0·50
Q16	2 GET880 low noise germ. trans.	0·50
Q17	3 NPN 1 ST141 & 2 ST140	0·50
Q18	4 Madt's 2 MAT 100 & 2 MAT 120	0·50
Q19	3 Madt's 2 MAT 101 & 1 MAT 121	0·50
Q20	4 OC44 germ. trans. A.F.	0·50
Q21	3 AC127 NPN germ. trans.	0·50
Q22	20 NKT trans. A.F. R.F. coded	0·50
Q23	10 OA202 sil. diodes sub-min.	0·50
Q24	8 OA81 diodes	0·50
Q25	6 IN914 sil. diodes 75PIV 75mA	0·50
Q26	8 OA95 germ. diodes sub-min. IN69	0·50
Q27	2 10A 600PIV sil. rects. IS45R	0·50
Q28	2 Sil. power rects. BYZ13	0·50
Q29	4 Sil. trans. 2 × 2N696, 1 × 2N697, 1 × 2N698	0·50
Q30	7 Sil. switch trans. 2N706 NPN	0·50
Q31	6 Sil. switch trans. 2N708 NPN	0·50
Q32	3 PNP sil. trans. 2 × 2N1131, 1 × 2N1132	0·50
Q33	3 Sil. NPN trans. 2N1711	0·50
Q34	7 Sil. NPN trans. 2N2369, 500MHZ	0·50
Q35	3 Sil. PNP TO-5 2 × 2N2904 & 1 × 2N2905	0·50
Q36	7 2N3646 TO-18 plastic 300MHz NPN	0·50
Q37	3 2N3053 NPN sil. trans.	0·50
Q38	7 PNP trans. 4×2N3703, 3×2N3702	0·50
Q39	7 NPN trans. 4×2N3704, 3×2N3705	0·50
Q40	7 NPN amp. 4×2N3707, 3×3N3708	0·50
Q41	3 Plastic NPN TO-18 2N3904	0·50
Q42	6 NPN trans. 2N5172	0·50
Q43	7 BC107 NPN trans.	0·50
Q44	7 NPN trans. 4×BC108, 3×BC109	0·50
Q45	3 BC113 NPN TO-18 trans.	0·50
Q46	3 BC115 NPN TO-5 trans.	0·50
Q47	6 NPN high gain 3×BC167, 3×BC168	0·50
Q48	4 BCY70 NPN trans. TO-18	0·50
Q49	4 NPN trans. 2×BFY51, 2×BFY52	0·50
Q50	7 BSY28 NPN switch TO-18	0·50
Q51	7 BSY95A NPN trans. 300MHz	0·50
Q52	8 BY100 type sil. rect.	1·00
Q53	25 Sil. & germ. trans. mixed all marked new	1·50

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Packed with semiconductors and components. 10 boards give a guaranteed 30 trans and 30 diodes. Our price 10 boards, **50p.** Plus 10p P. & P. 100 Boards £3, P. & P. 30p.

SILICON PHOTO TRANSISTOR. TO-18 Lens end. NPN Sim. to BPX 25 and P21. BRAND NEW. Full data available. Fully guaranteed.

Qty.	1-24	25-99	100 up
Price each	45p	40p	35p

FET'S

2N3819 ..	35p	2N5458 ..	50p
2N3820 ..	50p	2N5459 ..	40p
2N3821 ..	35p	BFW10 ..	40p
2N3823 ..	30p	MPF105	40p

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TRANSISTOR EQUIVALENTS BOOK. A complete cross reference and equivalents book for European, American and Japanese Transistors. Exclusive to BI-PAK **90p** each. Red Cover Edition.

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- the lowest prices!

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Check our 74 Series List before you by any I.C's. Our prices are the lowest possible. All devices ex-stock. Full spec. guaranteed.

BI-PAK Order No.	Price and qty. prices 1–24 £p	25–99 £p	100 up £p	BI-PAK Order No.	Price and qty. prices 1–24 £p	25–99 £p	100 up £p
BP00=SN7400	0·15	0·14	0·12	BP86=SN7486	0·32	0·30	0·28
BP01=SN7401	0·15	0·14	0·12	BP90=SN7490	0·67	0·64	0·58
BP02=SN7402	0·15	0·14	0·12	BP91=SN7491AN	0·87	0·84	0·78
BP03=SN7403	0·15	0·14	0·12	BP92=SN7492	0·67	0·64	0·58
BP04=SN7404	0·15	0·14	0·12	BP93=SN7493	0·67	0·64	0·58
BP05=SN7405	0·15	0·14	0·12	BP94=SN7494	0·77	0·74	0·68
BP07=SN7407	0·18	0·17	0·16	BP95=SN7495	0·77	0·74	0·68
BP08=SN7408	0·18	0·17	0·16	BP96=SN7496	0·77	0·74	0·68
BP09=SN7409	0·18	0·17	0·16	BP100=SN74100	1·75	1·65	1·55
BP10=SN7410	0·15	0·14	0·12	BP104=SN74104	0·97	0·94	0·88
BP13=SN7413	0·29	0·26	0·24	BP105=SN74105	0·97	0·94	0·88
BP16=SN7416	0·43	0·40	0·38	BP107=SN74107	0·40	0·38	0·36
BP17=SN7417	0·43	0·40	0·38	BP110=SN74110	0·55	0·53	0·50
BP20=SN7420	0·15	0·14	0·12	BP111=SN74111	1·25	1·15	1·00
BP30=SN7430	0·15	0·14	0·12	BP118=SN74118	1·00	0·95	0·90
BP40=SN7440	0·15	0·14	0·12	BP119=SN74119	1·35	1·25	1·10
BP41=SN7441	0·67	0·64	0·58	BP121=SN74121	0·67	0·64	0·58
BP42=SN7442	0·67	0·64	0·58	BP141 SN74141	0·67	0·64	0·58
BP43=SN7443	1·95	1·85	1·75	BP145=SN74145	1·50	1·40	1·30
BP44=SN7444	1·95	1·85	1·75	BP150=SN74150	1·80	1·70	1·60
BP45=SN7445	1·95	1·85	1·75	BP151=SN74151	1·00	0·95	0·90
BP46=SN7446	0·97	0·94	0·88	BP153=SN74153	1·20	1·10	0·95
BP47=SN7447	0·97	0·94	0·88	BP154=SN74154	1·80	1·70	1·60
BP48=SN7448	0·97	0·94	0·88	BP155=SN74155	1·40	1·30	1·20
BP50=SN7450	0·15	0·14	0·12	BP156=SN74156	1·40	1·30	1·20
BP51=SN7451	0·15	0·14	0·12	BP160=SN74160	1·80	1·70	1·60
BP53=SN7453	0·15	0·14	0·12	BP161=SN74161	1·80	1·70	1·60
BP54=SN7454	0·15	0·14	0·12	BP164=SN74164	2·00	1·90	1·80
BP60=SN7460	0·15	0·14	0·12	BP165=SN74165	2·00	1·90	1·80
BP70=SN7470	0·29	0·26	0·24	BP181=SN74181	2·75	2·60	2·40
BP72=SN7472	0·29	0·26	0·24	BP182=SN74182	0·97	0·94	0·88
BP73=SN7473	0·37	0·35	0·32	BP190=SN74190	3·50	3·25	3·00
BP74=SN7474	0·37	0·35	0·32	BP191=SN74191	3·50	3·25	3·00
BP75=SN7475	0·47	0·45	0·42	BP192=SN74192	2·10	1·95	1·75
BP76=SN7476	0·43	0·40	0·38	BP193=SN74193	2·10	1·95	1·75
BP80=SN7480	0·67	0·64	0·58	BP125=SN74195	1·10	1·05	0·95
BP81=SN7481	0·97	0·94	0·88	BP196=SN74196	1·80	1·70	1·60
BP82=SN7482	0·97	0·94	0·88	BP197=SN74197	1·80	1·70	1·60
BP83=SN7483	1·10	1·05	0·95	BP198=SN74198	5·50	5·00	4·00
				BP199=SN74199	5·50	5·00	4·00

PRICE-MIX. Devices may be mixed to qualify for quantity prices.

PRICES for quantities in excess of 500 pieces mixed, on application.

Owing to the ever increasing range of TTL 74 Series, please check with us for supplies of any devices not listed above, as it is probably now in stock. WARE 3442.

LINEAR I.C's—FULL SPEC.

Type No.	Price 1–24	25–99	100 up
BP 201C—SL201C	63p	58p	45p
BP 701C—SL701C	63p	50p	45p
BP 702C—SL702C	63p	50p	45p
BP 702—72702	53p	45p	40p
BP 709—72709	53p	45p	40p
BP 709P—μA709C	53p	45p	40p
BP 710—72710	53p	45p	40p
BP 711—μA711	58p	50p	45p
BP 741—72741	75p	60p	50p
μA 703C—μA703C	43p	35p	27p
TAA 263—	70p	60p	55p
TAA 293—	90p	75p	70p
TAA 350	170p	158p	150p

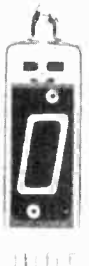
S.G.S. EA 1000 £2·63.

ROCK BOTTOM PRICES LOGIC DTL 930 Series I.C's

Type No.	Price 1–24	25–99	100 up
BP930	12p	11p	10p
BP932	13p	12p	11p
BP933	13p	12p	11p
BP935	13p	12p	11p
BP936	13p	12p	11p
BP944	13p	12p	11p
BP945	25p	24p	22p
BP946	12p	11p	10p
BP948	25p	24p	22p
BP951	65p	60p	55p
BP962	12p	11p	10p
BP9093	40p	38p	35p
BP9094	40p	38p	35p
BP9097	40p	38p	35p
BP9099	40p	38p	35p

Devices may be mixed to qualify for quantity price. Larger quantity prices on application. (DTL 930 Series only.)

NUMERICAL INDICATOR TUBES



MODEL	CD66	GR116	3015F
Anode voltage (Vdc)	170 min	175 min	5 min
Cathode current (mA)	2·3	14	8
Numeral height (mm)	16	13	9
Tube height (mm)	47	32	22
Tube diameter (mm)	19	13	12 wide
I.C. driver rec.	BP41 or 141	BP41 or 141	BP47
Price each	£1·70	£1·55	£1·90

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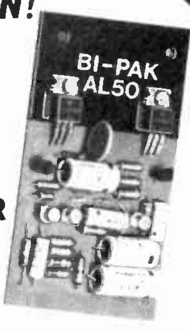

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UIC932	= 12 × μA 932	50p	UIC951	= 5 × μA 951	50p
UIC933	= 12 × μA 933	50p	UIC961	= 12 × μA 961	50p
UIC935	= 12 × μA 935	50p	UIC9093	= 5 × μA 9093	50p
UIC936	= 12 × μA 936	50p	UIC9094	= 5 × μA 9094	50p
UIC944	= 12 × μA 944	50p	UIC9097	= 5 × μA 9097	50p
UIC945	= 8 × μA 945	50p	UIC9099	= 5 × μA 9099	50p
UIC946	= 12 × μA 946	50p	UICX9	25 Assorted 930 Series	£1·50

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UIC01 = 12 × 7401N	50p	UIC47 = 5 × 7447N	50p	UIC82 = 5 × 7482N	50p
UIC02 = 12 × 7402N	50p	UIC48 = 5 × 7448N	50p	UIC83 = 5 × 7483N	50p
UIC03 = 12 × 7303N	50p	UIC50 = 12 × 7450N	50p	UIC86 = 5 × 7486N	50p
UIC04 = 12 × 7404N	50p	UIC51 = 12 × 7451N	50p	UIC90 = 5 × 7490N	50p
UIC05 = 12 × 7405N	50p	UIC53 = 12 × 7453N	50p	UIC91 = 5 × 7491N	50p
UIC10 = 12 × 7410N	50p	UIC54 = 12 × 7454N	50p	UIC92 = 5 × 7492N	50p
UIC13 = 8 × 7413N	50p	UIC60 = 12 × 7460N	50p	UIC93 = 5 × 7493N	50p
UIC20 = 12 × 7420N	50p	UIC70 = 8 × 7470N	50p	UIC94 = 5 × 7494N	50p
UIC40 = 12 × 7440N	50p	UIC72 = 8 × 7472N	50p	UIC95 = 5 × 7495N	50p
UIC41 = 5 × 7441AN	50p	UIC73 = 8 × 7473N	50p	UIC96 = 5 × 7496N	50p
UIC42 = 5 × 7442N	50p	UIC74 = 8 × 7474N	50p	UIC121 = 5 × 74121N	50p
UIC43 = 5 × 7443N	50p	UIC75 = 8 × 7475N	50p	UICX1 = 25 × Asst'd 74's	£1·50
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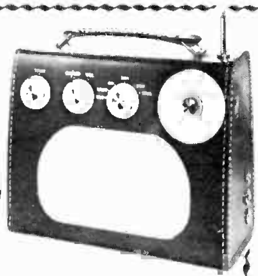

7 TUNABLE WAVEBANDS: MW1, MW2, LW, SW1, SW2, SW3 AND TRAWLER BAND. Built-in ferrite rod aerial for MW and LW. Retractable chrome plated telescopic aerial for short waves. Push-pull output using 600mW transistors. Car aerial and tape record sockets. Selectivity switch. Switched earpiece socket complete with earpiece. 8 transistors plus 3 diodes. 8" × 2½" speaker. Air spaced ganged tuning condenser. Volume/on/off, tuning, wave change and tone controls. Attractive case in rich chestnut shade with gold blocking. Size 9in × 7in × 4in approx. Easy to follow instructions and diagrams. Parts price list and easy build plans 25p (FREE with parts).

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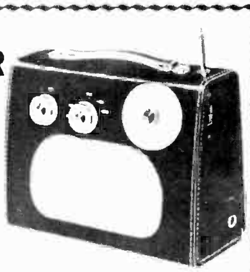

7 TUNABLE WAVEBANDS: MW1, MW2, LW, SW1, SW2, SW3 AND TRAWLER BAND. Extra medium waveband provides easier tuning of Radio Luxembourg, etc. Built-in ferrite rod aerial for MW and LW. Retractable 4 section 24in chrome plated telescopic aerial for SW. Socket for car aerial. Powerful push-pull output. 7 transistors and 2 diodes, including micro-alloy R.F. transistors. 8" × 2½" speaker. Air spaced ganged tuning condenser. Volume/on/off, tuning and wave change controls. Attractive case with carrying handle. Size 9in × 7in × 4in approx. Easy to follow instructions and diagrams. Parts price list and easy build plans 15p (FREE with parts). Earpiece with plug and switched socket for private listening, 30p extra.

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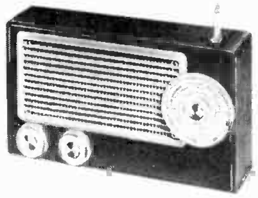
ROAMER SIX



6 TUNABLE WAVEBANDS: MW, LW, SW1, SW2, TRAWLER BAND PLUS AN EXTRA MW BAND FOR EASIER TUNING OF LUXEMBOURG, ETC. Sensitive ferrite rod aerial and telescopic aerial for short waves. 3in speaker. 8 stages—6 transistors and 2 diodes including micro-alloy R.F. transistors, etc. Attractive black case with red grille, dial and black knobs with polished metal inserts. Size 9in × 5½in × 2¾in approx. Easy build plans and parts price list 15p (FREE with parts). Earpiece with plug and switched socket for private listening 30p extra.

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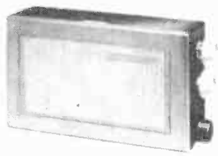
POCKET FIVE



3 TUNABLE WAVEBANDS: MW, LW, TRAWLER BAND WITH EXTENDED MW BAND FOR EASIER TUNING OF LUXEMBOURG, ETC. 7 stages 5 transistors and 2 diodes, supersensitive ferrite rod aerial, fine tone moving coil speaker. Attractive black and gold case. Size 5½in × 1¼in × 3½in. Easy build plans and parts price list 10p (FREE with parts). Earpiece with plug and switched socket for private listening 30p extra.

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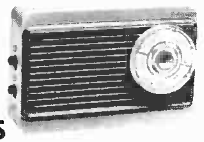
TRANSONA FIVE



5 TRANSISTORS AND 2 DIODES

3 TUNABLE WAVE BANDS: MW, LW AND TRAWLER BAND. 7 stage 5 transistors and 2 diodes, ferrite rod aerial, tuning condenser, volume control, fine tone moving coil speaker. Attractive case with red speaker grille. Size 6½in × 4½in × 1½in. Easy build plans and parts price list 10p (FREE with parts). Earpiece with plug and switched socket for private listening 30p extra.

TOTAL BUILDING COSTS **£2·50** P. P. & INS. 22p (OVERSEAS P. & P. 63p)

TRANS EIGHT

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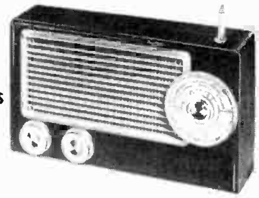

6 TUNABLE WAVEBANDS: MW, LW, SW1, SW2, SW3 AND TRAWLER BAND. Sensitive ferrite rod aerial for MW and LW. Telescopic aerial for short waves. 3in speaker. 8 improved type transistors plus 3 diodes. Attractive case in black with red grille, dial and black knobs with polished metal inserts. Size 9in × 5½in × 2¾in approx. Push-pull output. Battery economiser switch for extended battery life. Ample power to drive a larger speaker. Parts price list and easy build plans 25p (FREE with parts). Earpiece with plug and switched socket for private listening 30p extra.

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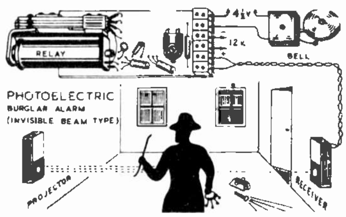

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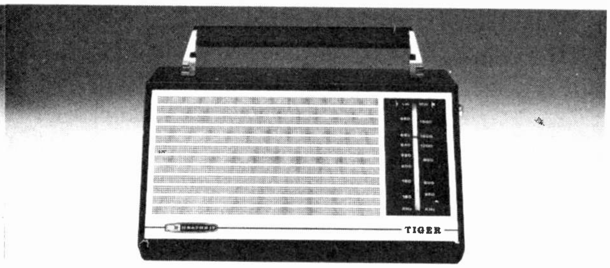

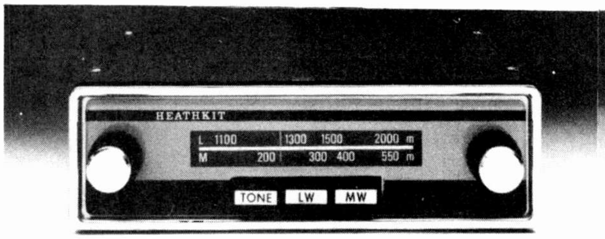

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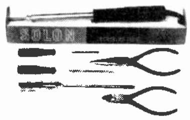

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VOL. 8 No. 7
July 1972

PRACTICAL ELECTRONICS

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Art Editor J. D. POUNTNEY **Technical Illustrators** J. A. HADLEY R. J. GOODMAN
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SYSTEMS ARE GO!

PRIVATE constructors have become accustomed to using integrated circuits, singly or in small quantities, in all manner of circuits. In many instances, though, it could be argued that the use of i.c.s is not really justified—that a few discrete semiconductors could be employed satisfactorily for the same purpose. This will always be a debatable point.

Still it has to be admitted that small projects do not adequately demonstrate the actual or potential capabilities of i.c.s. Their unique features are better exploited when they are used in quantity to make up some extensive and complex system: a system such as would be extravagant in the extreme—if even practicable—were discrete components to be used throughout.

Another expansive era in d.i.y. electronics beckons. Already the imagination and ambition of both designer and constructor have been released from many old inhibitions, imposed by visions of frightening circuit complexity, enormous size of the final assembly, and cost. The sky will be the limit, or nearly so, in the future.

At this juncture it is right to pause and recognise that many constructors are quite happy to indulge in their hobby just to the extent of the more popular and relatively modest projects, whether based on discrete or integrated devices. Such needs will always receive our careful attention and be properly catered for in P.E.

On the other hand, we are sure that amongst our readers there are quite a number who would welcome the opportunity to tackle a project of somewhat larger proportions, from time to time. We hope therefore to present on occasion some special advanced design that offers the constructor a chance to take full advantage of i.c.s and build an item of equipment of a more ambitious nature than hitherto. As a start, we introduce this month the P.E. Digi-Cal—the first high speed calculator designed specially for the constructor.

Small desk calculators are a major growth area in the electronics industry. In this field we witness some most remarkable scaling-down in physical size, due to the adoption of large scale integration techniques. At present l.s.i. is exclusively for equipment manufacturers. Thus the home constructor cannot as yet (if ever) expect to match size for size the smaller of these commercial calculators. This is of course a basic fact that has to be faced in other branches of electronics also.

Yet, when all is considered, this is no very serious limitation. There are countless needs that do not demand an instrument capable of being carried in the vest pocket! Wherever much calculating work is regularly encountered, at home, school, or business, the Digi-Cal will amply pay for the small area of table or desk it occupies.

F.E.B.

THIS MONTH

CONSTRUCTIONAL PROJECTS

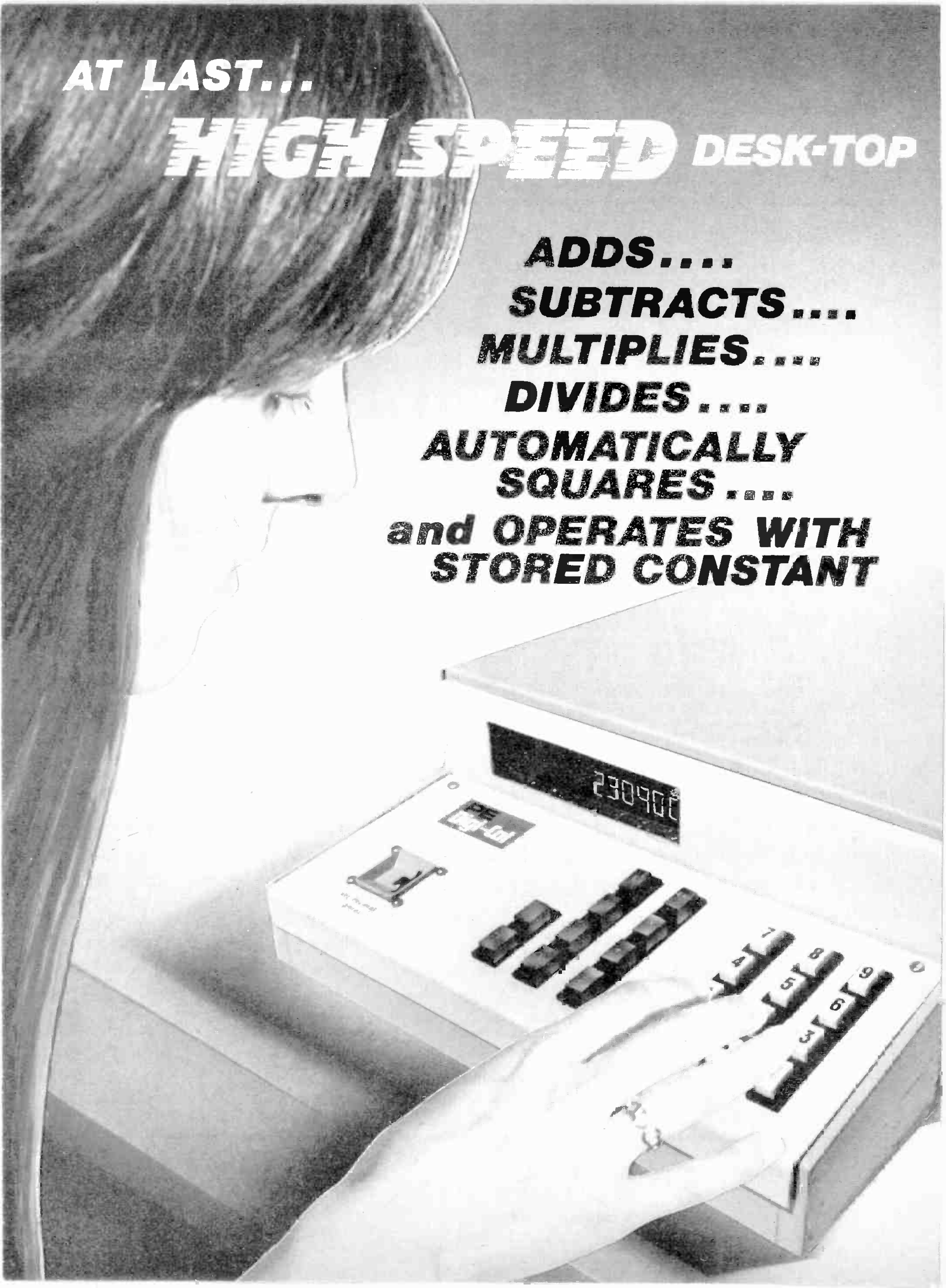
SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our August issue will be published on Friday, July 14

Practical Electronics, Fleetway House, Farringdon St., London. E.C.4. Phone: *Editorial* 01-634 4452; *Advertisements* 01-634 4202

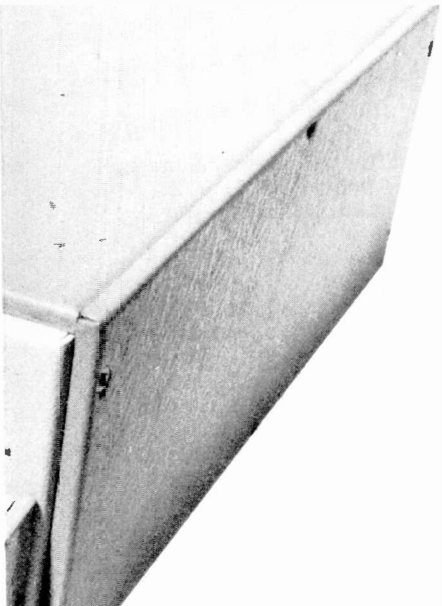


AT LAST...
HIGH SPEED DESK-TOP
ADDS....
SUBTRACTS....
MULTIPLIES....
DIVIDES....
AUTOMATICALLY SQUARES....
and OPERATES WITH STORED CONSTANT

CALCULATOR FOR CONSTRUCTORS

PE

BY R.W.COLES



WE HAVE all become familiar with the host of mechanically operated calculating machines, typified by the supermarket cash-register, which have been with us for many years. The ingenious mechanisms used in these machines can even be coaxed to perform multiplication or division in a simple way, but they are not up to the standard required for general mathematical problems, and have never made much of an inroad into this sphere, where the slide-rule has reigned supreme until very recently.

With the advent of the digital computer employing transistors, and later, integrated circuits, it was soon recognised that it would be possible to build small computers on the lines of mechanical calculators, which would give much simpler operation and a more versatile problem solving capability.

We are now witnessing the heyday of the offspring of the computer/mechanical calculator marriage, and the numbers of small electronic problem solvers becoming available is increasing dramatically every year, bringing big-system electronics to many desk corners.

AMATEUR CONSTRUCTORS

Up to now there has not been an electronic calculator design suitable for amateur constructors, despite the availability of all the necessary integrated circuits. This is mainly due to the fact that the know-how accumulated by the manufacturers of commercial calculators is very jealously guarded, and, to the uninitiated, calculator circuitry does seem quite complex.

Digi-Cal sets out to redress this situation, being designed specifically for home construction and simplified as far as possible without sacrifice of performance. Digi-Cal is a fast flexible tool for performing calculations required in the home, school or laboratory. It can be built using basic techniques and requires no access to expensive test equipment such as oscilloscopes. The prototype was built entirely on the kitchen table!

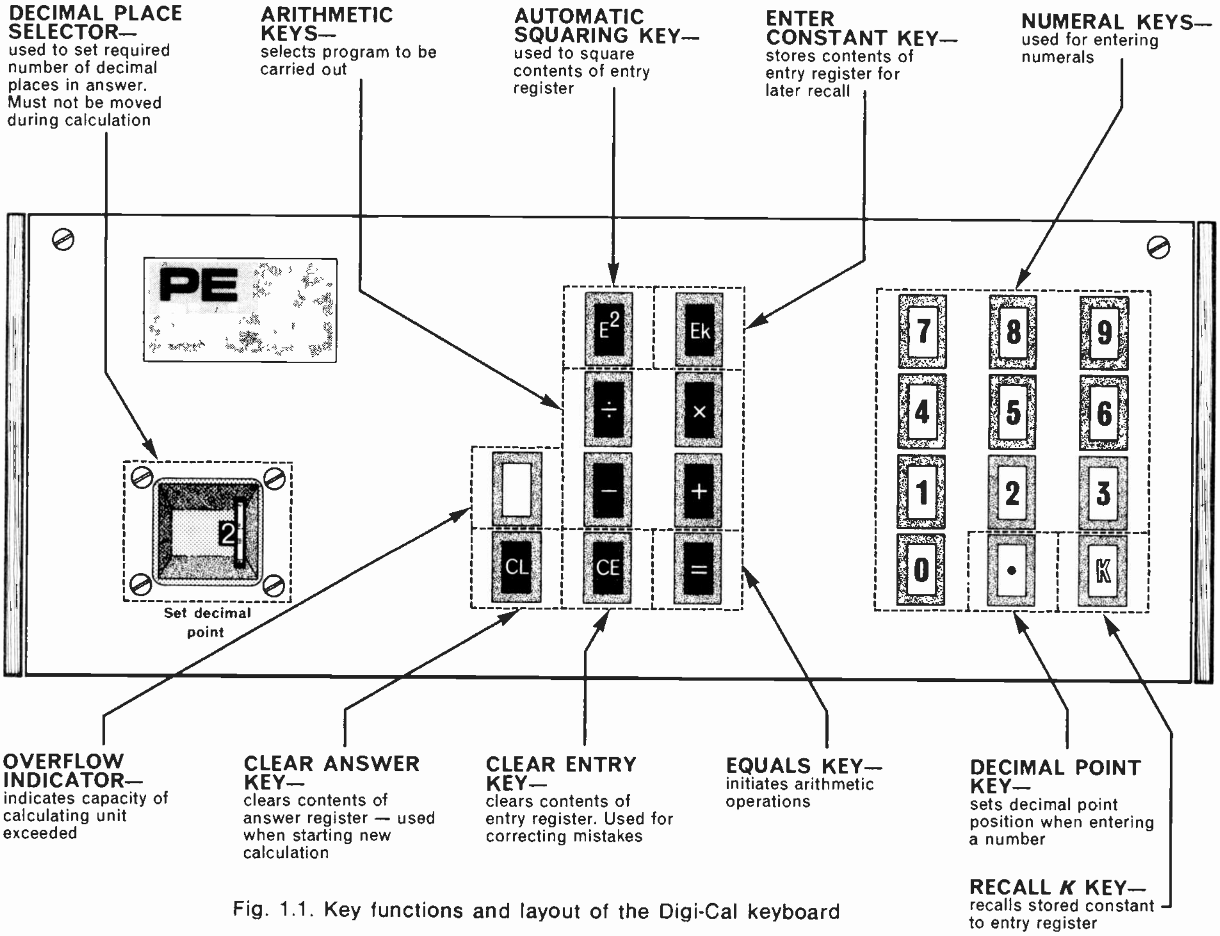


Fig. 1.1. Key functions and layout of the Digi-Cal keyboard

The basic Digi-Cal design has been intended from the outset to be as open-ended as possible to allow for extra features and constructor options. The arithmetic programmes are all easily altered by simply wiring in extra diodes, the constant store and the auto-squaring facility may be omitted and included at a later date, or even omitted altogether, and there are many possible performance improvements for which the design allows without major reconstruction.

All the logic is built on removable cards for easy access, and the complete calculator is housed in a modified "Contil" Mod-2 case with a matching keyboard, making Digi-Cal easily portable.

USING DIGI-CAL

The manipulation of numbers and the initiation of an arithmetic process is carried out using the keyboard, a vital part of any calculator and one which must be carefully thought out both mechanically and electronically. The keyboard is shown in Fig 1.1.

Entries are made by pressing figure keys in the correct sequence, interposing the decimal point where required if necessary. When the first figure key is pressed the display automatically switches from the last anwer to display the new entry, the old answer remaining in store. As subsequent figure keys are pressed they enter from the right taking the decimal point with them, in its correct position, as soon as it is entered. See Figure Entry.

The actual number of figures after the decimal point is immaterial at this point since Digi-Cal positions the numbers automatically before starting a calculation. However, if too many figures are entered, the entry register locks to prevent any further figure inputs, so that if the keyboard is set to give answers to three places, after three places of decimals no further figures can enter the calculator.

With a number entered in the entry register the next step is to select the arithmetic function required, and this is achieved by pressing the appropriate black key. The function entered will remain valid for all subsequent calculations until a different function is required and another key pressed. This means that a whole series of numbers may be added, for example, with only one depression of the add (+) key. Each time a new number is entered the equals key is pressed and the number is automatically added to the previous total.

Pressing the equals key starts the calculation, and when the programme for that function is complete the display switches to the answer register to display the result.

All operations are performed on the previous answer, so when starting with an empty answer register (after it has been cleared by the clear key) the first number entered must be added into it before the calculation proper begins. If a mistake is made when entering figures, the entry register can be cleared with the clear entry (CE) key.

● ENTRIES UP TO SIX DIGITS WITH FLOATING DECIMAL POINT CAN BE MADE, ANSWERS ARE PRODUCED UP TO EIGHT DIGITS LONG WITH THE DECIMAL POINT IN ONE OF FOUR PRESELECTED POSITIONS

● ENTRIES AND ANSWERS ARE DISPLAYED ON EIGHT SEVEN-SEGMENT INDICATORS WITH AN ADVANCED LEADING-EDGE ZERO-SUPPRESSION SYSTEM

● SIMPLE TO USE, PROBLEMS CAN BE ENTERED AS THEY WOULD BE WRITTEN DOWN

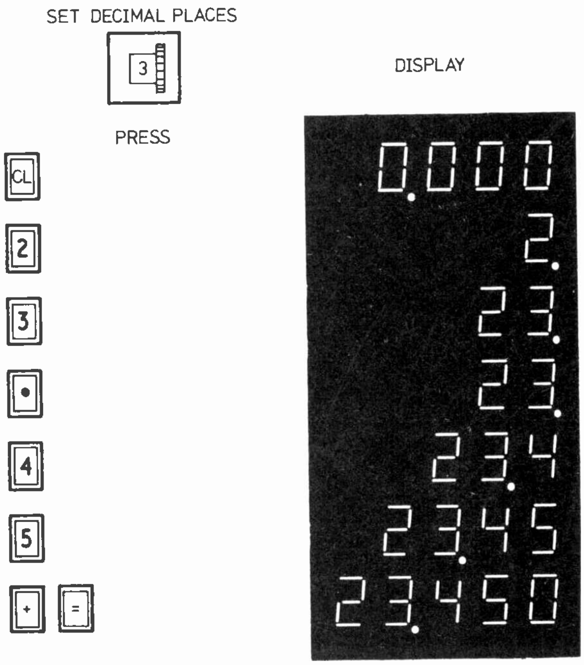
● EMPLOYS READILY AVAILABLE TTL INTEGRATED CIRCUITS THROUGHOUT

OPERATIONS USING A CONSTANT

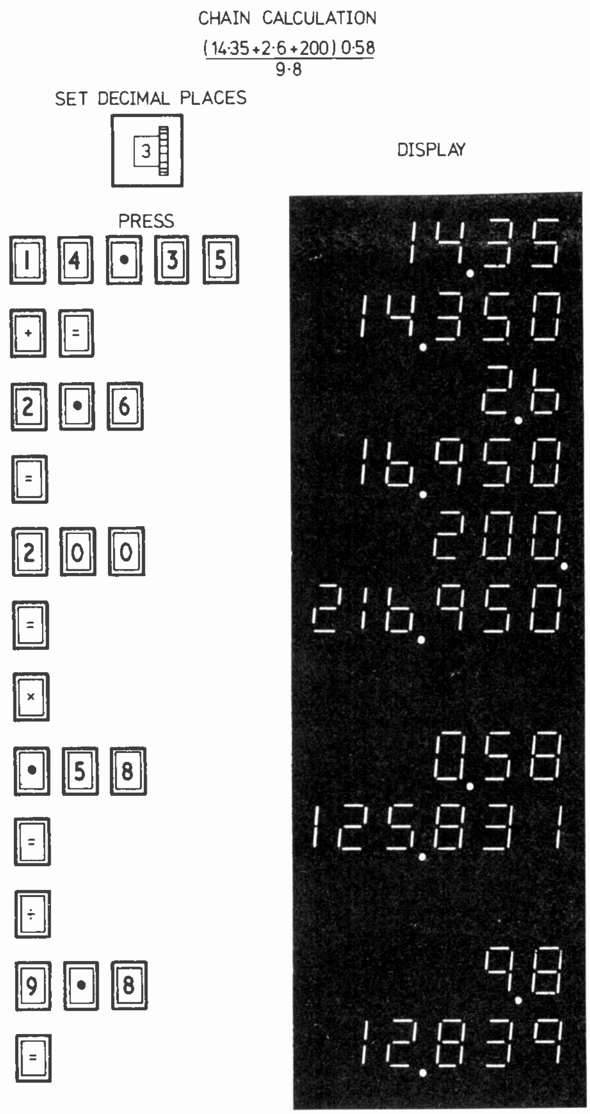
When operation with a constant is required the constant is entered in the entry register in the normal way, except that it must be positioned with the decimal point in the proper place, and then the EK key is pressed to store the constant for future use. When the constant is required the white K key is pressed, which instantly recalls the stored number to the entry register ready for use. The constant remains in store until replaced or the machine switched off.

The following examples will show just how simple Digi-Cal is to use and how useful it can be to solve a wide range of problems encountered in all walks of life.

FIGURE ENTRY



EXAMPLE ONE



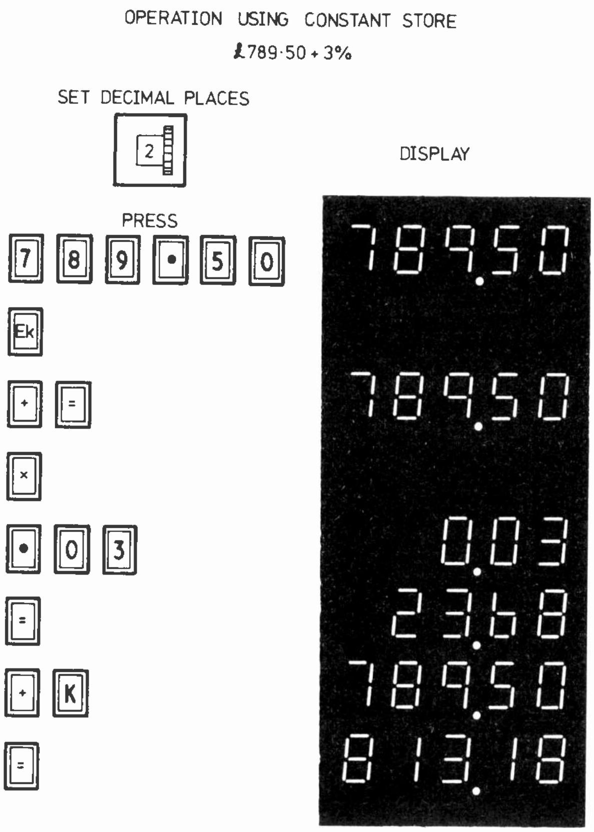
EXAMPLE ONE

This example shows how a simple arithmetical problem can be easily solved using Digi-Cal.

First the number of decimal places required in the answer is set on the decimal place selector. The first number is then entered by pressing the appropriate keys. The add key is then depressed and then the equals key to enter the first number into the calculator. The next number is then entered and added to the previous one by simply pressing the equals key. Similarly with the third number.

We now wish to multiply this total by 0·58 so the multiply key is pressed, 0·58 is entered and the equals key completes the multiplication. The divide key is then pressed, 9·8 is entered and a final press of the equals key completes the calculation.

EXAMPLE TWO



EXAMPLE TWO

This second example illustrates the use of the stored constant. We wish to add 3% of 789·5 to 789·5. The calculation required is thus 789·5 + (0·03 × 789·5). The number 789·5 is used twice, so to facilitate the calculation it is stored so that it will not have to be entered twice.

Of course, since pounds and pence are involved it is natural to set the number of decimal places to 2. The number 789·5 is then entered but the EK key is pressed before the add and equals keys. The multiply key is then depressed and 0·03 is entered. The equals key then gives 3% of 789·5. Pressing the add and the K key followed by the equals key adds the stored number (789·5) to the previous answer to give the final answer.

PRINCIPLES OF OPERATION

Digi-Cal is built entirely of gates and flip-flops, and operates in a similar manner to the large computers which compile gas bills or calculate wage checks. The main difference is that whereas a large business or scientific computer can be programmed and reprogrammed with ease, Digi-Cal and similar calculators are fixed programme machines, the programme being established at the construction stage.

Another basic difference is that while a large computer performs all its calculations in binary arithmetic, Digi-Cal uses a combination of binary and decimal working known as Binary Coded Decimal arithmetic.

In Binary Coded Decimal (B.C.D.) each decimal digit (e.g. a six or a nine) is represented by a separate group of four binary digits (i.e. 0110 and 1001 respectively). Four binary digits have sixteen possible combinations, but to encode decimal data only the first ten of these are utilised, the other six combinations are redundant and represent invalid data if they should occur.

Representing decimal data using these four bit (bit means binary digit) groups is quite different from their representation using straight binary code as can be seen in the following example:

Decimal	362
Straight binary	101101010
B.C.D.	0011 0110 0010

Binary Coded Decimal operation is used in Digi-Cal because it eliminates a good deal of the conversion circuitry which would be required if straight binary code were to be used for the arithmetic operations, since the input and output data must be in decimal to make it simple for the average user.

B.C.D. ARITHMETIC

Adding in straight binary is very simple and follows the following rules:

$$0 + 0 = 0$$
$$1 + 0 = 1$$
$$0 + 1 = 1$$
$$1 + 1 = 0, \text{ carry } 1$$

With B.C.D. working, a complication arises because although the rules given above do apply when adding individual bits within the group of four digits, as soon as the value of those four digits exceeds nine (not fifteen as in straight binary) a carry has to be generated which is added into the next higher group of four B.C.D. digits. To add 16 and 29 together using B.C.D. we proceed thus:

DECIMAL		B.C.D.	
1	6	0001	0110
2	9	0010	1001
1 ◄		1 ◄	
4	5, carry 1	0100	0101, carry 1

In Digi-Cal all arithmetic operations can be broken down to the simple processes described above, and the way that this is achieved in practice can be seen by referring to Fig. 1.2 which is the simplified block diagram of the heart of Digi-Cal.

SYSTEM OPERATION

As each key is pressed the numbers are coded into B.C.D. and then enter the Entry (E) register from the right, one after another. When the required entry has been completed the addition is initiated by pressing the "equals" key which starts the programme sequence.

The Z register is first cleared of any data it may contain and then the entire contents of the E register are transferred in parallel to it (6 × 4, 24 bits). It is at this stage of the sequence that Digi-Cal appears in Fig. 1.2.

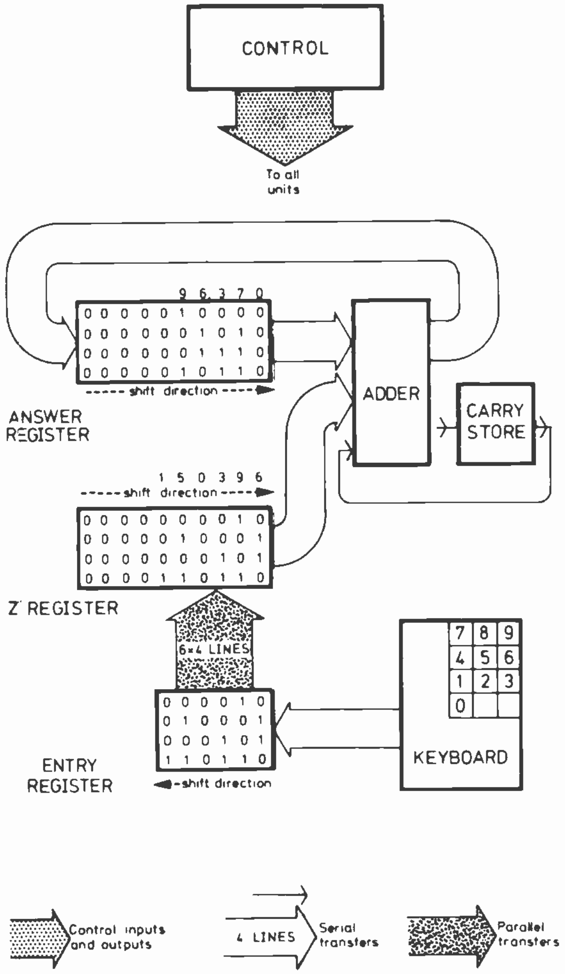


Fig. 1.2. Simplified block diagram of the addition unit

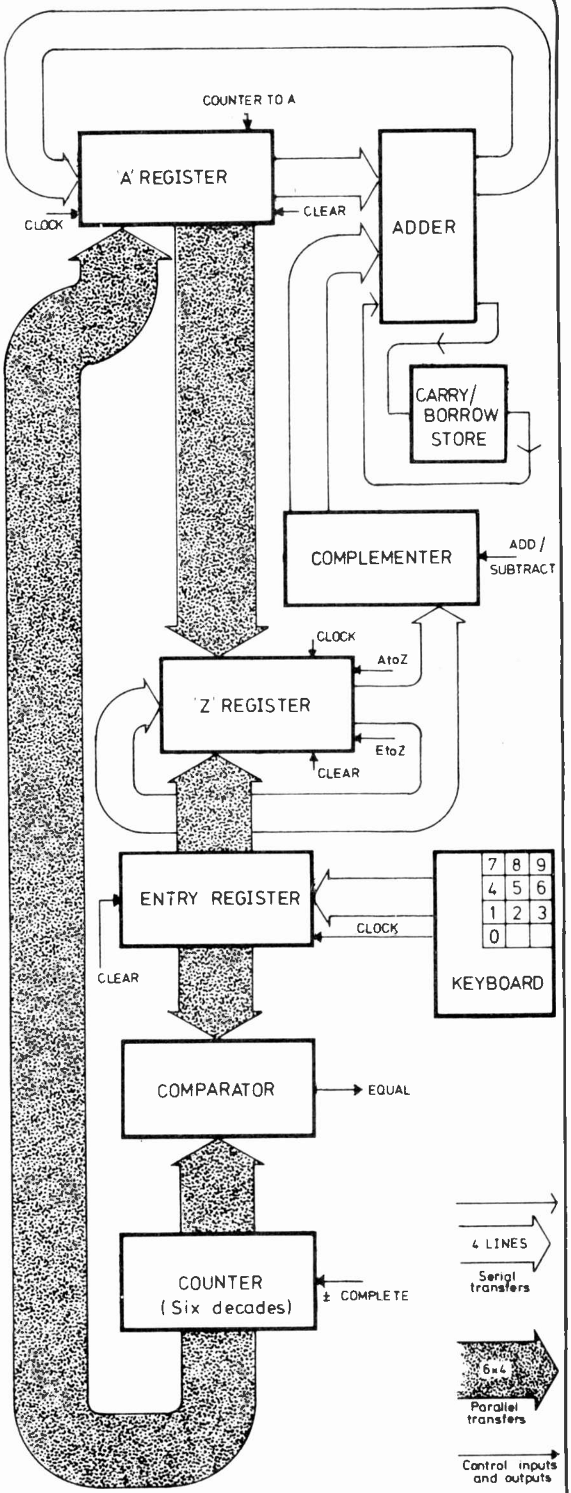


Fig. 1.3. The complete arithmetic unit of Digi-Cal

Both numbers are positioned ready for addition, and to implement this the A register and the Z register are clocked ten times with a burst of ten pulses from the control circuits. Each of the ten pulses presents two new B.C.D. numbers to the adder, which produces a sum and stores a carry if necessary.

When the next pulse arrives the previous answer is shifted into the far end of the A register, so that after the complete addition the first answer is stored in the right-hand location of the A register, and the last answer in the left-hand location, as they should be. In a nutshell then, Digi-Cal carries out parallel B.C.D. but serial decimal addition.

OTHER OPERATIONS

Subtraction is carried out in exactly the same way as addition except that the number to be subtracted is converted to its complement (i.e. each digit subtracted from nine) form before the addition takes place.

Multiplication and division are carried out by performing successive additions and subtractions respectively, and several additions to the basic circuit of Fig. 1.2 are necessary to achieve this. A more complete circuit of the arithmetic section of Digi-Cal is shown in Fig. 1.3. As can be seen, a counter, a comparator and a complementer have been added, along with a number of new interconnections.

MULTIPLICATION

To perform a multiplication the multiplicand is transferred to the Z register from the A register which is then cleared. The multiplier (stored in the E register) is compared with the contents of the counter which is connected to count each complete ten digit addition.

Additions are started by supplying batches of ten clock pulses to the A and Z registers, and this continues until the counter has counted up to the same number as is stored in the E register, whereupon the comparator indicates equality and stops the clock.

The contents of the A register will now be found to be the original contents added to itself the number of times specified by the multiplier, in other words the product of the two numbers.

DIVISION

To perform division, with the dividend in the A register and the divisor in the E register, first the divisor is transferred to the Z register and then the subtractions are started, each one being counted on the counter. When the contents of the A register go negative (determined by the fact that the borrow store is set at the end of a subtraction the clock is stopped and the quotient will be found to be the content of the counter minus 1.

The minus 1 nuisance is neatly disposed of by presetting the counter to 999999 instead of 000000 before counting takes place, the counter therefore automatically counting the number of necessary subtractions minus 1. Finally the quotient stored in the counter is transferred to the A register.

PROGRAMMING AND CONTROL

Up to now the circuits which actually control all the arithmetic and "housekeeping" operations have been ignored, but of course these circuits do have a lot of work to do and are quite extensive.

In Digi-Cal the programme is of the wired diode type, each programme being divided up into a series of time periods (eight steps for add and subtract, and sixteen for multiply and divide). Each programme is enabled when the appropriate arithmetic function is selected, and is started by the equals key.

During any one time step, any of the available programme functions can be performed, depending on whether or not a diode is wired in, and this gives a great deal of flexibility in the finer details of the programme which can be extended or altered at will.

The serial additions or subtractions are carried out at very high speed, the clock frequency being in the region of 1MHz, but the programme steps are performed more slowly, making the programme circuits less critical of wire lengths and board layout. The clock pulses themselves are produced by a board housed in the arithmetic section, this board itself being controlled by the programme.

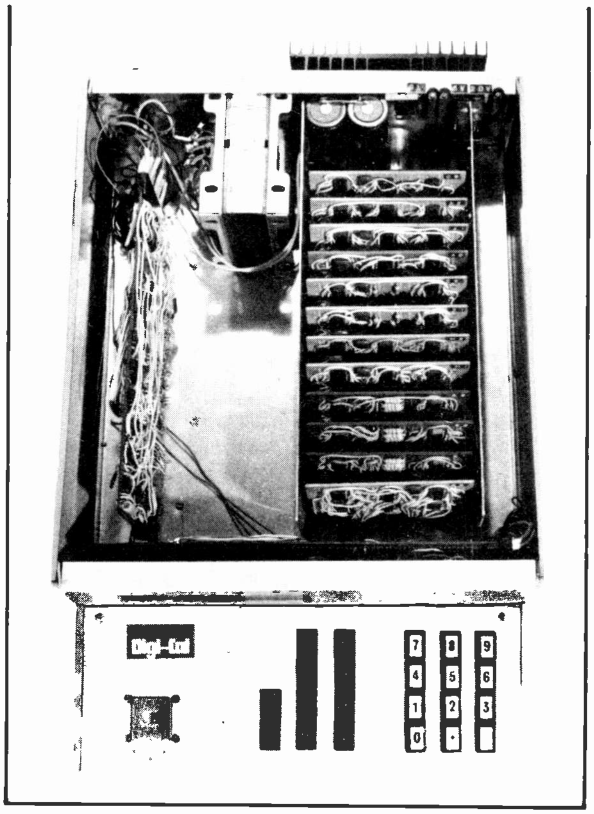
CONSTRUCTION

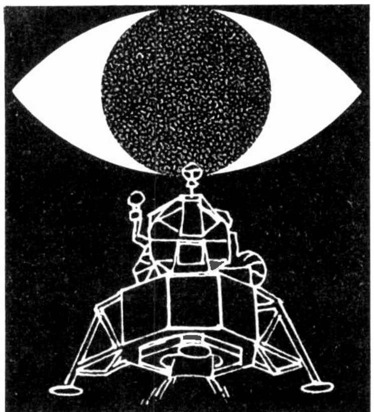
All the logic used in Digi-Cal is housed on removable boards, the critical arithmetic section on Shirehall DL109 cards, and the display, keyboard and programme on Veroboard panels.

The simple power supplies and regulators are built on a home-etched printed circuit board, the output voltages being five volts for the TTL integrated circuits and 20 volts for the seven segment display.

The keyboard modification to the basic "Contil" case is made with an extra Mod-2 front panel and some $\frac{3}{8}$in plywood.

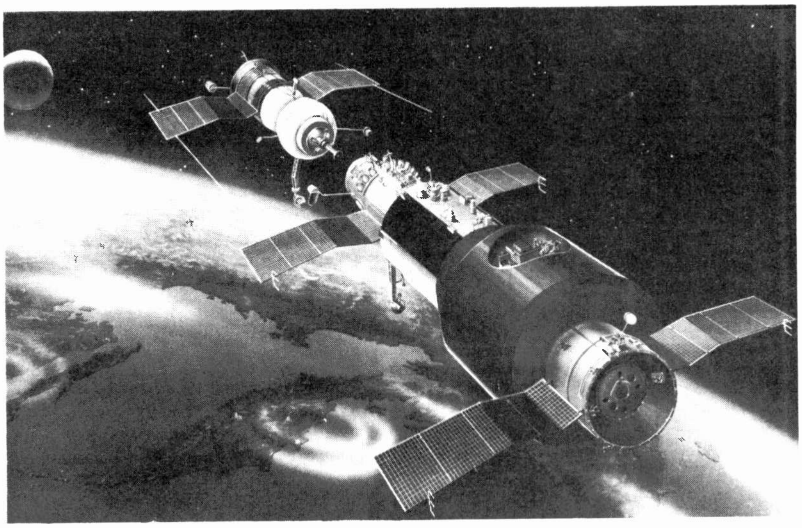
Next month: Construction of main chassis and power supplies, and bulk Component List for the complete project





SPACEWATCH

BY FRANK W. HYDE



Docking of the Soyuz II and the orbiting scientific station Salyut (picture: Novosti)

SALYUT TWO

The Soviet Union are moving forward with their programme for a successor to the *Soyuz II* and it is expected that a new space laboratory will be launched this year.

It would seem that the design of the new vehicle is more sophisticated and advanced than the American counterpart. This has emerged from the special talks that have been taking place regarding the standardising of docking procedures. Indeed, there has been agreement on a plan for an *Apollo* vehicle to carry out a docking experiment with a *Salyut* vehicle by 1975.

The docking device common to both vehicles will be some 3 metres long, 1·5 metres in diameter and weigh about 2,000 kilogrammes.

The procedure to be adopted is that the *Salyut* laboratory will first be launched and stabilised in orbit. A day later the crew will set off in a *Soyuz* vehicle and make their rendezvous. After a lapse of two or three days an *Apollo* vehicle will attempt a docking with the special device. There is therefore the prospect that three Russian and three American astronauts will orbit the earth together for several days.

The details for the programme are not yet finalised but it could be that both teams will leave the station and return to their respective countries.

No information is at the moment available about the vehicle in preparation but presumably it is much the same as the *Soyus-Salyut* combination of 1971. It consisted of three parts, the service module, the work area and module, and the transfer tunnel. It is to the transfer tunnel that the vehicles come to dock. The scientific experiments are also carried out there.

The equipment contained in the tunnel includes temperature control, an environmental control system, a sleeping bag with temperature control, general control panels and other scientific equipment. Mounted on the outside of the vehicle are antennas, ion counters, a beacon light, television camera, spherical tanks with air, the solar panels and a telescope for astrophysical studies.

The working compartment houses the more important equipment. This section is of two diameters, the end nearest the access tunnel being about two metres in diameter which opens into a four metre diameter section. The reserves of food and the life support systems are housed here.

Also contained in the larger area are the cooking facilities, power systems, radio and television telemetry, attitude controls, control panels and work areas. There are also the scientific experiments for biology and medical studies together with photographic apparatus.

These ships are crammed with equipment and in spite of there being some 20 portholes they are mostly occupied by some sensing device or other.

The combination of *Soyuz-Salyut* weighs approximately 20 tons. It is about 22 metres long with a maximum diameter of just over 4 metres.

NEW WORLD METEOROLOGICAL PROGRAMME

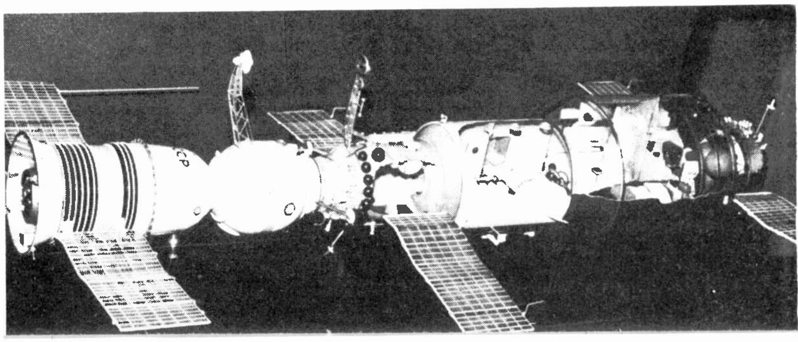
The proposed large scale investigation of the vast energy complexes in certain areas of the world will make use of the techniques of the last decade. The area to be covered is the tropical Atlantic ocean and the adjacent regions of Latin America and Africa. This will enclose a rectangle of more than 260 million square kilometres. This is the tropical region where hurricanes breed.

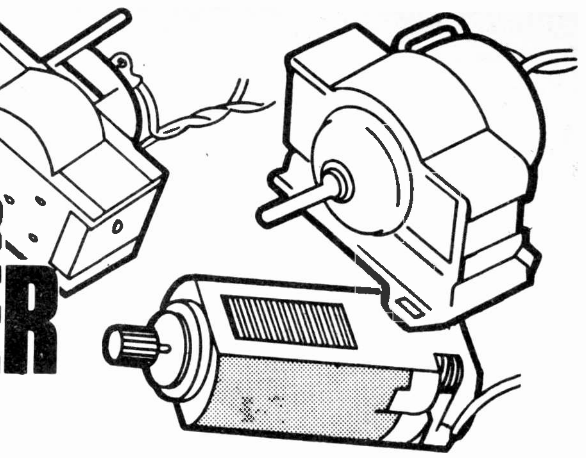
The resources of satellites, ships, balloons, aircraft will be used with the earth stations of the network to feed computers with continuous data. It is hoped that some better understanding of the area will be acquired.

Recent satellite pictures have shown formations which need study for they seem to indicate the manner in which these great turbulences are formed. The sun sucking vast quantities of water into the atmosphere helps to provide the driving force which controls the world wide weather.

A smaller area of something of the order of one million square kilometres near Dakar will also be subject to an intense observation.

Model showing the Soyuz II linked up with Salyut (picture: Novosti)





MINI MOTOR POWER BOOSTER

By C. F. FLETCHER

Over the past few years, toy and working-model manufacturers have made increasing use of the miniature permanent magnet motors originating in the Far East. These "minimotors" are also generally available for model makers and come in two or three frame sizes.

Almost all of them are designed to work from a 1·5 or 3 volt batery and draw around 0·5 ampere when stalled. Looking at these ingeniously made motors one may think of many things to do with them, but not until one has tried something in particular do their shortcomings come to light.

SHORTCOMINGS

The author came face to face with some of these shortcomings when attempting to construct a rotatable indoor television aerial. The motive power to rotate the Yagi array was to be derived from an old electric toy crane drive which used a minimotor with a reduction gear train.

Applying 1·5 volts to this motor caused it to run at a high speed when lightly loaded but it stalled when faced with turning the aerial via a belt drive. Applying 3 volts produced a very good windmill, but very little hope of stopping the aerial in any desired direction.

Something had to be done to reduce the speed of the motor on one hand whilst retaining the high torque provided by the 3 volt supply. Before going on to describe the booster which was designed to do the job, it is worthwhile to consider just why the little motor behaved as it did.

D.C. PERMANENT MAGNET MOTORS

Electromagnetic motors function because of the interaction of two magnetic fields. In the case of a permanent magnet motor, one field is provided by the permanent magnet and the other by the current flowing in the armature windings. The geometry of the motor is such that the force developed between the two magnetic fields drives the armature around and produces the desired rotating action.

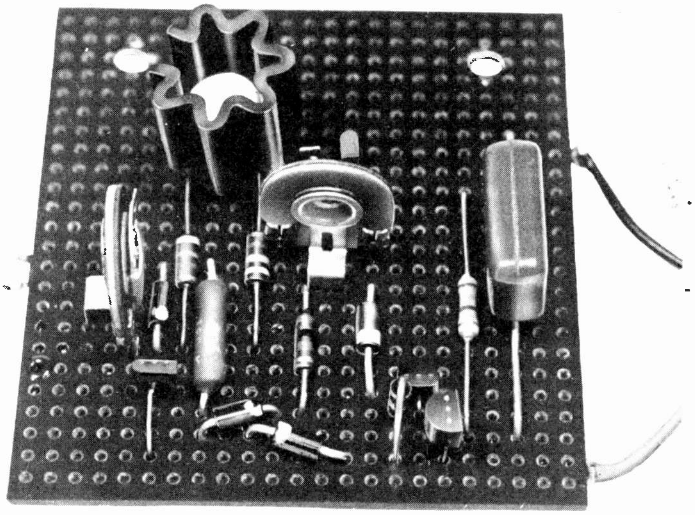
All very well, but how fast will the motor turn and how much torque (twisting force) will it produce?

To understand this, one needs to consider what happens inside the motor when a battery is connected to the armature. A circuit is made from battery positive, through one of the brushes to the armature windings, then returning to battery negative via the other brush.

The circuit has resistance and so initially a current flows given by

$$I = \frac{\text{Battery volts}}{\text{Total circuit resistance}}$$

Remember the armature has not yet moved, and so the starting torque is determined by the size of the standstill current which in turn depends upon the circuit resistance and the volts applied.



A photograph of the upper side of the Veroboard panel showing the heatsink mounted on TR4

BACK E.M.F.

Once the motor begins to turn, however, the picture changes, for the movement of the armature windings through the permanent magnetic field causes a voltage to be induced in the armature in opposition to the battery voltage.

The effective voltage is now the difference between these two and the motor reaches a steady speed when the voltage difference drives a current through the armature resistance just big enough to produce the load torque required. No-load requires a small torque, a small current, and a small voltage difference, therefore a high speed is to be expected.

Applying a load slows the armature, increases the voltage difference and causes a bigger current to flow to meet the load. The speed/load characteristic of such a machine is a steadily drooping curve as shown by Fig. 1. Since the minimotors under consideration have a large resistance for their voltage, a sharply drooping load curve results.

Pushing up the applied volts certainly increases the maximum torque but it also makes the no-load speed very high. If the load varies, large variations in the speed must be expected. Thus we have arrived at the inherent disadvantage of these motors: poor speed control and limited starting torque.

ONE SOLUTION

As the armature generated voltage is directly related to armature speed (being zero at standstill), if one could separate this voltage from the armature resistance drop and measure it, one would have a direct means of measuring the speed of the motor.

Knowing the motor speed, a circuit can be designed to constantly monitor it and vary the armature current to keep it steady. Such a "closed loop" system can provide good speed control together with good torque. In fact, by using a supply voltage well in excess of the motor's rated armature voltage, a maximum torque several times normal maximum can be produced.

The circuit to be described uses the well known Wheatstone Bridge measuring system but it has been specially adapted to work from only 4·5 volts and control low voltage motors.

WHEATSTONE BRIDGE

As mentioned earlier, the booster is based upon a Wheatstone Bridge balancing circuit, see Fig. 2. The motor is connected between terminals Y and Z and is represented by R_a, the armature resistance, and E_a, the armature e.m.f.

The bridge function is to separate E_a from the armature resistance drop $I_a \times R_a$. Remember, what appears between terminals Y and Z is $E_a + (I_a \times R_a)$. Applying the Wheatstone principle, if R_3/R_2 is made equal to R_1/R_a then there will be no voltage between X and Y due to the current I.

However, when E_a appears due to the armature rotation, this is not balanced out by the bridge and a proportion of it can be measured between X and Y. Since this voltage is directly proportional to E_a, it is also directly proportional to the motor speed.

THE BOOSTER CIRCUIT

Fig. 3 shows the complete circuit diagram of the Minimotor Power Booster.

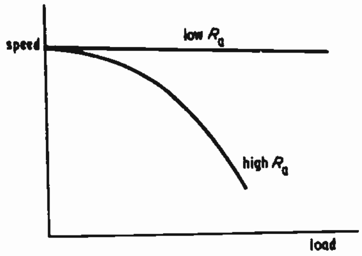


Fig. 1. The speed/load characteristic of a permanent magnet motor

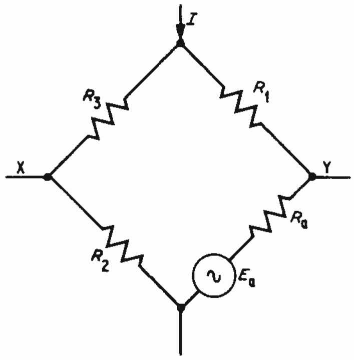


Fig. 2. The Wheatstone Bridge method of measuring the armature e.m.f.

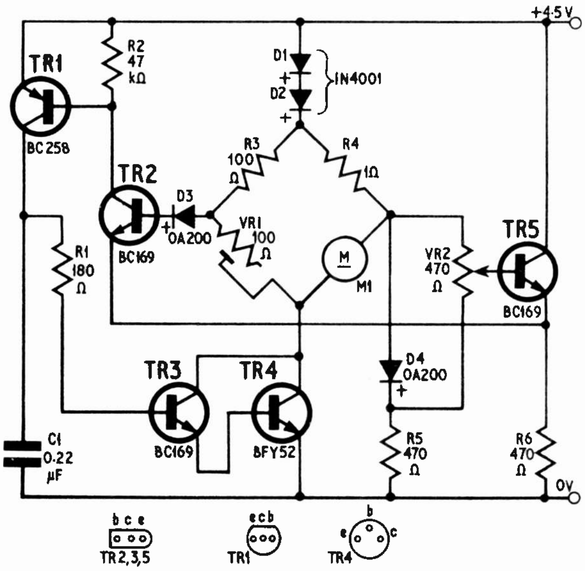


Fig. 3. The complete circuit of the minimotor power booster

COMPONENTS . . .

Resistors
R1 180Ω
R2 47kΩ
R3 100Ω
R4 1Ω 1W
R5 470Ω
R6 470Ω
All ±10%, ¼W carbon unless otherwise stated

Potentiometers
VR1 100Ω skeleton preset
VR2 470Ω skeleton preset or potentiometer (see text)

Capacitor
C1 0·22μF

Transistors
TR1 BC258 *or* 2N4289 *or* OC202
TR2, TR3, TR5 BC169 *or* 2N4291 (3 off)
TR4 BFY52 *or* 2N3054

Diodes
D1, D2 1N4001 or any 25 p.i.v. 1A diode (2 off)
D3, D4 OA200 or any small silicon signal diode (2 off)

Motor
M1 Any small 1·5 or 3 volt permanent magnet motor (see text)

Miscellaneous
TO5 heatsink for TR4
Veroboard 0·1in matrix, 2·4in × 2·4in

Current flowing through diode D4 produces approximately 0·6 volts across it which is largely independent of the current. This voltage is used as a reference voltage and part of it is picked off VR2 and applied to TR5 base.

TR5 and TR2 form a voltage comparator which detects any difference between E_a and the reference voltage picked off VR2. If E_a is lower than the reference, current flows in TR2 and is amplified by transistors TR3, 4 and 1. These latter three transistors provide a large current gain and full load motor current can thereby be produced in TR4 with only a small offset between E_a and the reference.

By this action the motor e.m.f. E_a and hence the speed is tied closely to the wanted speed set on VR2.

SPEED CONTROL

The motor used by the author was a 1·5 volt type. If a 3 volt motor is to be controlled, two diodes in series should replace D4 if full speed is required. Again, in the author's model, speed was to be preset. If the constructor requires a variable speed drive, VR2 is simply changed to a normal potentiometer and mounted conveniently.

The supply voltage is not important provided that it is 4·5 volts or more. Be cautious however not to use too high a voltage, because TR4 will have to dissipate more heat as the supply voltage is increased. Mounting TR4 on a substantial heat sink is a worthwhile precaution for a general purpose booster.

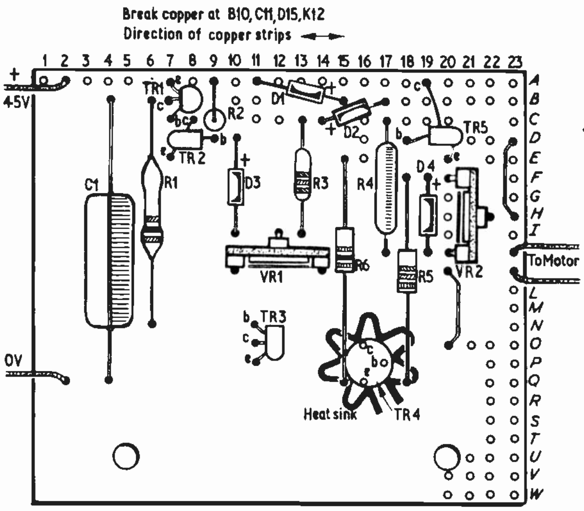


Fig. 4. The layout of the components on the Veroboard panel

For applications where motor current exceeds 1A, use transistor type 2N3054 for TR4.

Diodes D1 and D2 ensure that the comparator has sufficient voltage under all conditions and they pass the full motor current. D3 guarantees the motor will run to standstill when the reference voltage is zero. No special precautions are necessary in construction although short wiring is always to be recommended in high gain amplifiers.

Fig. 4 shows the layout of the components on the Veroboard panel. The preset potentiometer VR2 may be replaced by a potentiometer if variable speed control is required, as mentioned earlier.

CAUTION

Finally a little word of caution. Whereas no damage will be done to the motor, which is made to produce more than its normal power for short periods, sustained overloads will cause overheating and maybe damage. As a general guide, if the motor does not become hot on continuous load or spark excessively at the brushes, it is unlikely to be damaged. ★

DIGITAL ELECTRONIC ORGAN SYSTEMS

BY ALAN DOUGLAS

THE electronic organ has passed through more design stages than any other instrument. Many of these were arbitrary since the results are subjective and the requirements of tonal synthesis were not properly understood. With the exception of electro-mechanical generators, all methods used discrete components until the advent of integrated circuits. Printed circuit boards further extend the opportunities for compactness and the last hurdle has now been overcome—the generation of all frequencies from one master oscillator.

This technique enables an organ to be tuned by one control and, since the methods used to derive the required frequency scaling consist of gates, bistables and multivibrators, it becomes possible to vary the tuning within the octave to suit different temperaments—mean tone, just intonation, Werckmeister's, equal temperament, etc. The tuning accuracy is much greater and by employing sufficient binary digits, both this and tonal synthesis can be extended beyond the limits attainable with conventional techniques.

At the outset it must be understood that these advantages are only possible because of micro-circuit techniques.

In this article we shall look at digital methods of complete frequency generation from a single oscillator, tonal synthesis and keying control.

SINGLE OSCILLATOR SCALING SYSTEM

The problem of full frequency generation from a single tone source is to find a way to divide the master oscillator frequency by the intervals of a tonal scaling system. The most usual case is that of equal temperament, in which the frequency ratios of any two adjacent notes are in the relationship $1 : \sqrt[12]{2}$, or 1·05946. It is at once obvious that this could not be obtained by a bistable system, it is an irrational number and must be only an approximation. But how good must the approximation be?

One way of solving it is to divide the master oscillator frequency by 196 and then multiply by 185, which is a close approximation to the required value. Any standard organ would be based on C for the top note. Therefore all lower C's can be derived directly from this by bistable division, leaving 11 circuits for the remaining notes of the top octave. Fig. 1 shows the master oscillator entering a divide by 196 multivibrator. As is well known, RC multivibrators readily lock onto an injected frequency even if their free-running frequency is slightly different.

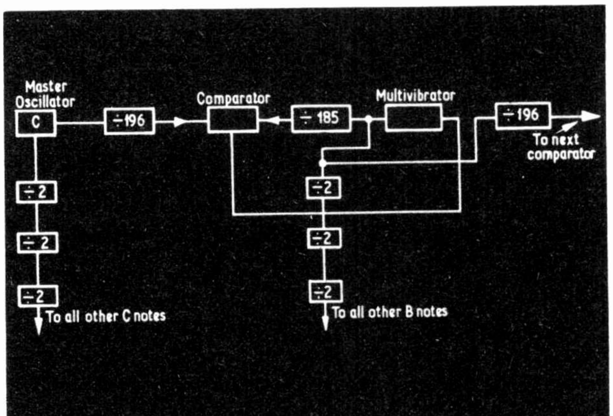


Fig. 1. Method of frequency division from a single oscillator

The output from this circuit now enters a frequency comparator circuit and compares with a divide by 185 multivibrator; the resultant frequency is now B in the equal tempered scale, from which all lower B notes are derived by bistable division in the normal way. Should the division ratios tend to drift, the comparator device holds them to the accuracy required. So to cover the range of notes, there must be a chain of multivibrators and bistables.

TONAL SYNTHESIS

In this, the N. E. Rockwell system, the highest required frequency is set by the demanded accuracy of tonal synthesis. This will be appreciated from Fig. 2 which shows the sampling of an imaginary waveform. Here, the process is additive and the closer the sampling points, the greater the realism.

It has been established that 48 such points will give the maximum realism, this corresponding to 48 harmonics in a normal complex wave system, which is hardly ever attained—certainly not over the whole compass. If 48 points are to be used, then the top frequency must be that of the highest note times 48, for example, top C 4ft = 4,186Hz, therefore 48 × 4,186 = 200,928Hz.

Although it is at once obvious that we can thus provide top C 2ft (8,372Hz and above), there would not be the same number of sampling points; and this is rational, since most of these would be far above audibility, although it is known that beats between audible and inaudible frequencies do occur and do modify high pitched tones to some extent.

DIGITAL CONVERSION

So far we have provided an array of frequency sources, but these can be used to cover full tonal synthesis by digital conversion. Looking again at Fig. 2, we see that sampling points are represented by digital representation of level in the form of 8 bit words to which are assigned binary code numbers.

sustained part of the signal (i.e. as long as the key is held down) and a somewhat similar decay so that the sound does not stop abruptly.

The shift registers are operated from the ring counters which assign the chosen frequencies to the diode matrix gates, and are so arranged that each count shifts a digital word one position to the right; this corresponds to an amplitude division by two, hence by using any desired number of register stages, the amplitude is decreased in steps to zero level. Although this decay is in step form, the ear hears them only as a smooth release of the tone, as seen in Fig. 3.

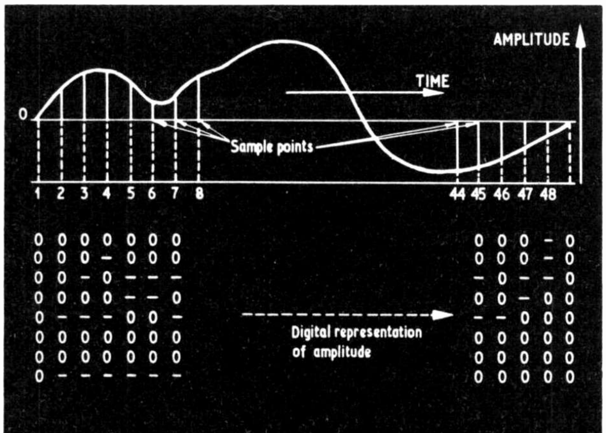


Fig. 2. 48 point sampling process in digital notation

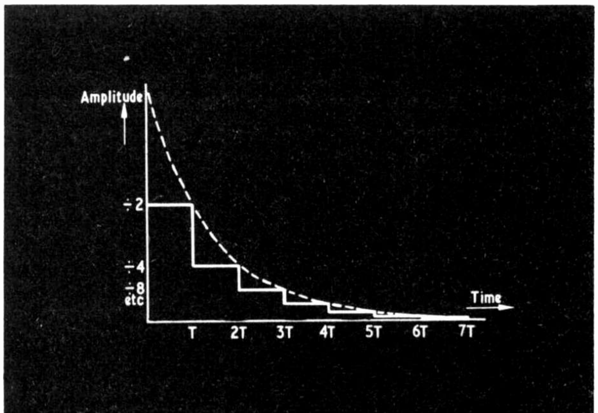


Fig. 3. Showing decay curve as result of shift register operation. Attack curve is the inverse of this

If a C_1 key is depressed, the frequency synthesiser will energise a ring counter which will repeatedly produce an output of $C_1 \times 48$ into a diode storage matrix where all the amplitude increments are stored in binary form. If all are connected for this note, 6 bit signals corresponding to the stored digital words will appear at the output at a rate of $48 \times C_1$ words per second, thus the sampling rate is the same but the actual frequency will vary according to the key selected. The number of diodes connected will be controlled by the stops, which operate gates connecting the composite frequency outputs to the keying system.

KEYING CONTROL

In conventional keying, attack, hold and decay are usually provided by rather crude RC time constant circuits, unless the organ if of the free-phase type with independent oscillators where these attributes can be individually determined for each note. However, it is generally conceded that if the rate of attack is equal to the duration of about 7 periods of the frequency in question, the audible effect is like that of an 8ft organ pipe.

In the digital system a one-shot multivibrator having a period of 7 cycles is used in conjunction with a shift register to provide a series of logarithmic steps simulating the rise in sound level, the

CONVERSION

Subsequent to the control of the required number of notes played (e.g. a chord), a summing amplifier adds all the signals from the decay circuits and since they are still in digital form, they must be turned into an audio signal by a digital to analogue converter. The input to this consists solely of step functions, which will have a high-frequency component; this may be left in to simulate wind noise which of course is a component of all organ flue pipes, and without which true synthesis is not possible.

Many modifications to the basic principles outlined are possible as, for example, exhibited in the N. E. Rockwell organ system which is used in the Allen organ.

PHILIPS SYSTEM

The next system to be looked at is the one devised by N.V. Philips, of Eindhoven, Holland. This is a digital organ generator which produces frequencies by a subtractive method—rejecting a certain number of pulses from a series of pulses.

The number to be rejected will be $2^{1/12}$ times the number of input pulses. Twelve such circuits will then form a tempered octave, but because of the irrational divisor the output pulses will be spaced

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AC115	23p	AF117	17p	BC142	45p	BCY33	17p	BF274	30p	MAT100	15p	ST140	12p
AC125	17p	AF118	30p	BC143	40p	BCY34	20p	BF308	35p	MAT101	17p	ST141	17p
AC126	17p	AF124	21p	BC145	45p	BCY70	17p	BF309	37p	MAT120	15p	TIS43	40p
AC127	17p	AF125	20p	BC147	17p	BCY71	30p	BF316	75p	MAT121	17p	UT46	27p
AC128	17p	AF126	20p	BC148	12p	BCY72	15p	BFW10	55p	MPF102	43p	V405A	25p
AC141K	17p	AF127	20p	BC149	17p	BCZ11	20p	BFX29	27p	MPF105	43p	V410A	45p
AC142K	17p	AF139	33p	BC150	17p	BD121	85p	BFX84	20p	OC19	30p	2G301	19p
AC151	15p	AF178	50p	BC151	20p	BD123	85p	BFX85	27p	OC20	50p	2G302	19p
AC154	15p	AF179	50p	BC152	17p	BD124	75p	BFX86	22p	OC22	30p	2G303	19p
AC155	17p	AF180	50p	BC153	27p	BD131	80p	BFX87	25p	OC23	33p	2G304	20p
AC156	17p	AF191	50p	BC154	30p	BD132	80p	BFX88	22p	OC24	45p	2G306	35p
AC157	17p	AF186	45p	BC157	20p	BDY20	£1	BFY50	20p	OC25	25p	2G308	35p
AC165	17p	AF239	37p	BC158	17p	BF115	22p	BFY51	20p	OC26	25p	2G309	35p
AC166	17p	AFZ11	37p	BC159	20p	BF117	45p	BFY52	20p	OC28	40p	2G339	17p
AC167	20p	AFZ12	45p	BC167	13p	BF118	60p	BFY53	17p	OC29	40p	2G339A	15p
AC168	20p	AL102	85p	BC168	13p	BF119	70p	BSX19	15p	OC35	33p	2G344	15p
AC169	14p	AL103	85p	BC169	13p	BF152	35p	BSX20	15p	OC36	40p	2G345	15p
AC176	23p	ASY26	25p	BC170	12p	BF153	35p	BSY25	15p	OC41	20p	2G371	13p
AC177	20p	ASY27	30p	BC171	13p	BF154	35p	BSY26	15p	OC42	22p	2G371B	10p
AC187	30p	ASY28	25p	BC172	13p	BF157	45p	BSY27	15p	OC44	15p	2G374	17p
AC188	30p	ASY29	25p	BC173	13p	BF158	25p	BSY28	15p	OC45	12p	2G377	27p
ACY17	25p	ASY50	25p	BC174	13p	BF159	30p	BSY29	15p	OC70	15p	2G378	15p
ACY18	20p	ASY51	25p	BC175	22p	BF160	30p	BSY38	15p	OC71	9p	2G382	15p
ACY19	22p	ASY52	25p	BC177	17p	BF162	30p	BSY39	15p	OC72	12p	2G401	30p
ACY20	20p	ASY54	25p	BC178	17p	BF163	35p	BSY40	30p	OC74	12p	2G414	30p
ACY21	20p	ASY55	25p	BC179	17p	BF164	35p	BSY41	35p	OC75	15p	2G417	25p
ACY22	19p	ASY56	25p	BC180	20p	BF165	35p	BSY95	12p	OC76	15p	2N388	30p
ACY27	18p	ASY57	25p	BC181	22p	BF167	22p	BSY95A	12p	OC77	25p	2N388A	50p
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ACY29	30p	ASY58	25p	BC182L	10p	BF176	35p	C111E	60p	OC81D	15p	2N404A	30p
ACY30	25p	ASZ21	40p	BC183	10p	BF177	35p	C400	30p	OC82	15p	2N524	55p
ACY31	25p	BC107	10p	BC183L	10p	BF178	45p	C407	25p	OC82D	15p	2N527	60p
ACY34	18p	BC108	10p	BC184	13p	BF179	50p	C424	17p	OC83	20p	2N696	12p
ACY35	18p	BC109	11p	BC184L	13p	BF180	30p	C425	40p	OC84	20p	2N697	15p
ACY36	30p	BC113	25p	BC186	27p	BF181	30p	C426	30p	OC139	15p	2N698	24p
ACY40	15p	BC114	30p	BC187	27p	BF182	30p	C428	20p	OC140	17p	2N699	55p
ACY41	18p	BC115	30p	BC207	11p	BF183	30p	C441	27p	OC170	15p	2N706	7p
ACY44	35p	BC116	35p	BC209	11p	BF184	25p	C442	35p	OC171	15p	2N706A	8p
AD140	40p	BC117	35p	BC209	11p	BF185	30p	C444	37p	OC200	25p	2N708	12p
AD142	40p	BC118	25p	BC212L	11p	BF188	30p	C450	17p	OC201	27p	1N709	45p
AD149	43p	BC119	45p	BC213L	11p	BF194	23p	C720	12p	OC202	27p	2N711	40p
AD161	35p	BC125	35p	BC213L	11p	BF195	24p	C722	25p	OC203	25p	2N717	42p
AD162	35p	BC126	35p	BC214L	12p	BF196	30p	C740	25p	OC204	25p	2N718	24p
AD161/		BC132	25p	BC225	25p	BF197	35p	C742	17p	OC205	35p	2N718A	50p
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2N918	30p	2N2714	25p	2N3704	15p
2N929	22p	2N2904	25p	2N3705	12p
2N930	25p	2N2904A	30p	2N3706	12p
2N1131	20p	2N2905	25p	2N3707	13p
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2N1711	20p	2N2926(Y)	11p	2N4058	15p
2N1889	35p	2N2926		2N4059	10p
2N1890	45p	(O)	10p	2N4060	12p
2N1893	37p	2N3010	80p	2N4061	12p
2N2160	60p	2N3011	20p	2N4062	12p
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2N2148	60p	2N3054	50p	2N5459	43p
2N2192	30p	2N3055	63p	2S034	75p
2N2193	30p	2N3391	17p	2S301	50p
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BY100	15p	BYZ17	35p	OA95	7p
BY101	12p	BYZ18	30p	OA200	6p
BY105	15p	BYZ19	25p	OA202	7p
BY114	12p	OA5	17p	SO10	4p
BY126	15p	OA10	22p	SO19	4p
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BC132	20p
BC134	20p
BC137	30p
BC142	35p
BC143	40p
BC144	35p
BC145	30p
BC147	9p
BC148	9p
BC149	9p
BC153	30p
BC154	35p
BC182L	9p
BC183L	9p
BC184L	9p
BC212L	12p
BC213L	12p
BC214L	12p
BCY70	18p
BCY71	20p
BCY72	17p
BF152	25p
BF153	25p
BF158	25p
BF159	35p
BF177	25p
BF178	30p
BF179C	35p
BFX86	25p
BFX87	27p
BFX88	25p
BFY34	30p
BFY50	19p
BFY51	19p
BFY52	19p
ME0404-1	10p
ME0404-2	10p
ME1001	10p
ME1002	11p
ME2001	10p
ME3001	20p
ME3002	25p
ME4001	10p
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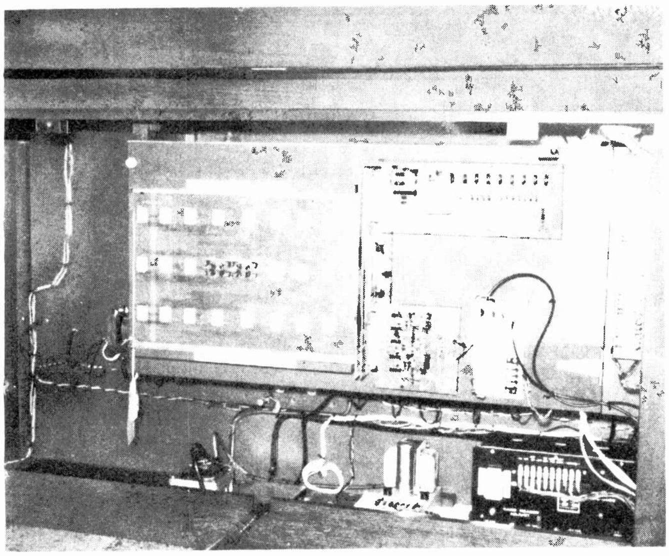
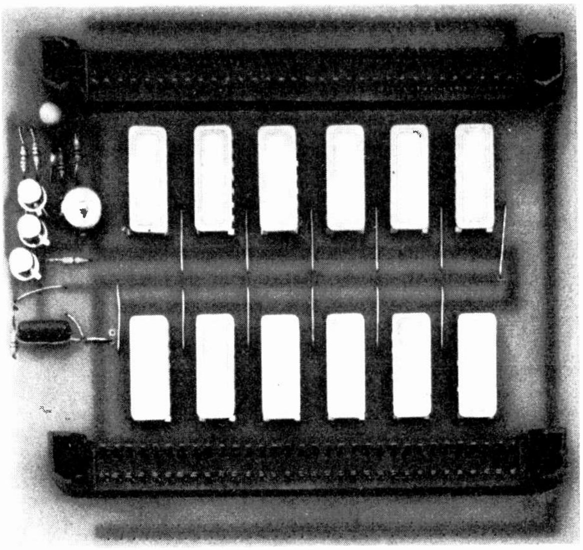


Photograph of the Allen console which uses the Rockwell organ system. This measures about 4½ft in length



Philips' digital organ generator

Table 1.

RATIOS OF FREQUENCIES WITHIN THE OCTAVE

Note	Decimal	Binary
C′	2·0000	10·0000000000
B	1·8878	1·1110001101
A	1·7818	1·1100100001
A	1·6816	1·1010111010
G	1·5874	1·1001011010
G	1·4983	1·0111111110
F	1·4142	1·0110101000
F	1·3348	1·0101010111
E	1·2599	1·0100001010
D	1·1892	1·0011000010
D	1·1225	1·0001111101
C	1·0595	1·0000111101
C	1·0000	1·0000000000

irregularly, making the resultant tones sound harsh. To remedy this, the frequency is made very much higher than the desired values, and the output frequencies are divided by the same factor before using them for tone forming. Since the required frequencies will be related to the equal tempered scale, they must be derived digitally.

We have just seen one approach, and other investigators have tried to obtain the exact intervals by successive division by large integers between 200 and 300. But in this case, the required number of pulses is obtained by adding trains of pulses at different repetition rates.

BINARY DIVISION

In Table 1 we see the binary notation corresponding to one octave. The master frequency is 10 and the half frequency is 1; all notes within the octave must be given by a binary number between 1 and 10. Pulse trains obtained by halving the master oscillator frequency (suitably reduced by division) correspond successively with the binary numbers 0·1, 0·01, 0·001, etc. and provide the material for making up the binary numbers between 1 and 10 with the required accuracy (no deviation greater than 0·05 per cent = 1/2,000 = $1/2^{11}$, hence 11 binary numbers). If the frequency 1 is note C, then A is formed by adding the following pulse trains:

1
0·1
0·001
0·00001
0·000001
0·0000001
0·000000001
———————
1·101011101

Other notes can be formed in a similar way, but it has been found easier to form the note by subtraction from the binary 10 of the primary frequency. The A just mentioned is equal to 1·1010111010 which is equal to 10–0·0101000110. ★

This month's cover picture was photographed in the "Bird's Nest" pub in the Kings Road, Chelsea, London.

INGENUITY UNLIMITED

A selection of readers' suggested circuits. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.
This is YOUR page and any idea published will be awarded payment according to its merits.

LOGIC PROBE

As the number of constructional projects employing i.c.s is increasing, this simple logic probe may prove invaluable to fault finding in such circuits. It consists of a 932 (or 944) DTL i.c. and a 6V 0 06A lamp, see Fig. 1.

As only half of the i.c. is used it is possible to salvage a partially functional device which would otherwise have little value in circuit construction.

The probe, Fig. 2, can be constructed on a ball-point pen barrel. In operation the lamp will light when a "1" logic level is detected, and will be extinguished when a "0" level is detected. If a continuously pulsed input is applied the lamp will glow dimly.

Any of the inputs may be used as shown, except for inputs 4 and 11 which require a silicon diode in series with the probe lead.

A. Meldrum,
Fife,
Scotland.

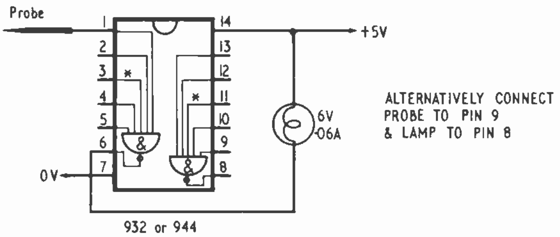


Fig. 1. Circuit details of the logic probe

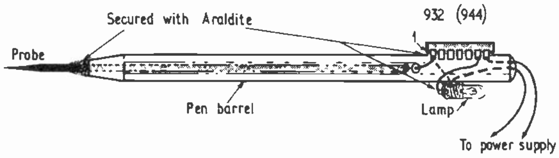


Fig. 2. Constructional details of the probe

BATTERY CHARGER PROTECTION

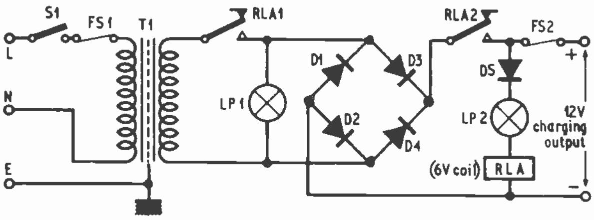


Fig. 1. Battery protection circuit diagram

A battery charger, consisting of nothing more than a transformer and a bridge rectifier, was found to be non-operational and enquiries showed that the output connections had been accidentally reversed.

As explanations about two conducting diodes in series and no current limiting resistance just do not register with everyone, I decided on the modification shown in Fig. 1. I don't say it's completely fool-proof, but it can anticipate most of the common evils perpetrated by the non-technical.

The normal charger transformer and bridge circuit is broken by two relay contacts, one in the a.c. supply to the bridge RLA1 and one in the d.c. output line from the bridge RLA2. The relay coil, diode D5 and lamp LP2 (acting as a ballast resistor) are wired in series and then connected across the output of the charger, see Fig. 1.

If the charger is plugged into the mains with the output leads shorted together nothing happens because the relay contacts have not closed and there is no a.c. supply to the bridge; neither pilot light will light. If next, the charger is connected to the car battery the wrong way round nothing will happen because the diode in series with the relay coil prevents it from energising; neither lamp lighting.

Only by connecting the charger to the battery the right way round will the relay pull-in and the pilot lamp LP2 light to indicate that the battery is connected correctly. Having connected the battery correctly, the relay is energised and allows a.c. to flow to the bridge via RLA1; LP1 will now be illuminated. When both lamps LP2 and LP1 are illuminated it indicates that the charger is functioning correctly.

The relay used can be any type which will pull-in at six volts, and has two "make" contacts capable of handling the output charging current to the battery. Ideally, the relay coil current should be 300mA, or as near to the current required by the pilot bulb LP2 in series with it as possible. Likewise, the diode D5 in series with the lamp is not critical; choose one that has about double the current capacity required, and will stand approximately 50V peak inverse voltage.

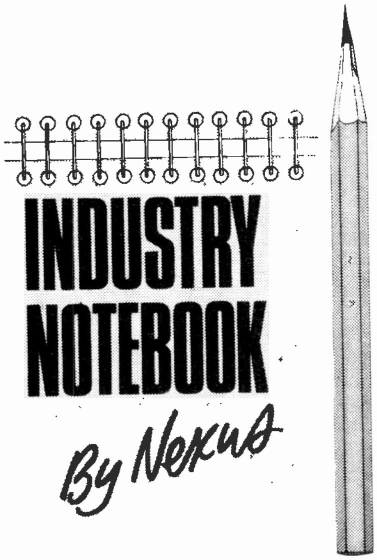
G. Read,
Southampton,
Hants.

OPTIMISM IN THE AIR

ATTENDANCE at the giant IEA exhibition at Olympia was expected to be somewhat down. This will surprise few people, although optimism for the trading future was up, even in the face of all the trouble on the railways and the docks.

As I reported in this column last month, the Paris Components Show, first trade barometer of the year, showed an upward trend in confidence.

After Paris I visited Denmark to get a line on Danish sentiment. Industry leaders I met all admitted that 1971 was a bad year but the universal opinion was that this year will see the turnround.



The Danes are doing well in electronics through being very very good in comparatively narrow sectors of the industry. A country of less than five million people can't be good in every sector and to get to a viable operational size in world markets the Danes have had to go for big exports. The two top instrument companies, Brüel and Kjær, and Radiometer, both export over 95 per cent of their production. Don't underestimate the Danes. They are good engineers in their specialities and know how to sell.

The U.K. is a big investor in Denmark with Rank owning Rank-Arena, the big producers of Danish radio and television, and EMI owning the largest chain of radio retailing outlets. And UK-Danish electronic imports and exports have greatly expanded during the past five years.

Overall, I find my many inputs of information, not only from the U.K. but also from Europe, almost universally optimistic.

BRAVE EXPERIMENT

Seminex, the first seminar and exhibition organised specially for the semiconductor industry was a brave experiment which deserved a better fate than to be hit by the rail dispute which strongly affected attendance. Even though the event must be counted as a qualified success, its organiser, Evan Steadman, is not letting the grass grow under his feet.

As soon as Seminex was over he mailed a questionnaire to all and sundry. He honestly admitted it could have been better. Could he kindly have comments and suggestions?

Evan Steadman is a go-getter not particularly noted for humility. But he is determined to make Seminex an event on the British exhibition calendar and is now planning to take Seminex on tour to the European mainland and, perhaps, even further afield. We wish him well.

COMMUNICATION 72

Another brave experiment, well patronised by the industry, is Communication 72 held at Brighton over the three days June 13-17.

It has the full support of the Electronic Engineering Association and the Department of Trade and Industry in bringing in three trade missions from overseas who are showing the British communication industry in action as well as sitting in at the Brighton seminar and looking at the exhibition. Each mission consists of about 15 senior officials from abroad, all users of radio and data systems. The Conference organisers are IPC Electrical and Electronic Press Ltd.

Communication 72 is yet another example of the trend towards smaller, more specialist exhibitions. But the traditional giant shows are taking a long time to die.

NEW ON THE SCENE

Two businessmen are about to re-emerge with a new commercial image. First, ex-Avo sales director John Minister should make a success of Risso Electronics Ltd, which is just moving off the ground as a new competitor in the busy instrument market.

Risso (what about "The Risso Sign means Happy Metering" for a slogan?) has just won its first major contract from a public corporation for a multi-range meter. The production line is already in action. Risso has also designed a range of panel meters.

Secondly, Keith Harris, ex-marketing director of Keyswitch Relays, comes up as a new force in the relay business. This, I understand, will be a marketing operation of a nature as yet undisclosed but while being reticent about his new business venture he is nevertheless full of confidence for the future.

THE TAKEOVER TRAIL

One of the fascinations of the industry is its dynamism, not only in technology but also in its business structure. After every big merger there is a spawning of little companies. Lots of people don't like working for the big corporations and, more often than not, after a big merger there is an inevitable "shake out" of what is loosely termed middle management, men who are willing and in some cases anxious to strike out on their own.

But it works the other way, too, with plenty of smallish companies seeking the shelter (with a cash handout) of a larger grouping. And, of course, a move in this direction can make a lot of sense, especially if the product lines are complementary.

The group to watch for real finesse in acquiring complementary companies is Racal whose chairman and managing director, Ernie Harrison, has a keen nose for this sort of thing.

Mum's the word during negotiations but yet another company, whose name may be announced before this column is printed, is about to join the Racal Group. It will be the third Racal acquisition in less than twelve months and my guess is that it won't be the last this year.

INSTRUMENT'S TRAVAIL

The UK has no instrument company in the world class and by this I mean companies like Hewlett-Packard or Tektronix. Many leaders in the industry regret this, especially as instrument sales have been stagnant now for three or four years.

The solution would be in regrouping into larger units but though there have been discussions on the possibility, no common ground of agreement has been found.

The differences have centred on who is to be the nucleus company. There are plenty of possibles but while all are prepared to be the nucleus, none are willing to be the satellites. And can you really blame them?

Meantime, one British instrument company at least is marketing, under its own brand, instruments made in Japan and Sweden to name but two countries who are getting a share of the British market which rightly should go to our own manufacturing units.

It's time these differences were resolved.

More on LOGICAL RADIO CONTROL

The short series of articles *Logical Radio Control* published earlier this year (reprints and back numbers are not available) has provoked much correspondence, some of which has been published in *Readout*. Some of the more general questions with the author's replies are given here together with further details on the Decoder module.

SYNC PULSE GENERATOR

Does one need to use the F9601 retriggerable monostable? Can an alternative circuit be used and could a substitute be found from the Texas SN74 range?

Many alternative forms of sync generator are possible, some being quite economic. Having regard to the convenience of fitting only *one* i.c., its reliability and the question of noise immunity, the retriggerable monostable technique is recommended.

Excessive noise, for example, interference from a servo-motor, must not be allowed to give spurious sync pulses leading to complete breakdown of control.

If the specified i.c. cannot be obtained conveniently the SGS type T118D1 can be used. This is a direct replacement type and is available from Quarndron Electronics (Semiconductors) Ltd., Slack Lane, Derby DE3 3ED, price £2·70.

The Texas SN74122 may be used by comparing the manufacturers' information and changing connections accordingly. This unit is priced £1·44.

INTERFACE UNITS

Can the Coder 2B output be used to switch the modulator of a transmitter and if not can you suggest a circuit?

In general the output voltage of an integrated circuit unit is either a minimum of 2·4V in the high or logical "1" state or is a maximum of 0·4V (typically 0·2V) in the low or logical "0" state.

The most convenient and definite interface stage is one using a silicon *npn* transistor (e.g. 2N3704); this is held in the "off" condition by a logical "0" output of 0·4V, which is less than the "turn on" voltage V_{be} of 0·6V. In the logical "1" state the transistor is turned on and an additional resistor R1, as shown in Fig. 1 (of value greater than 500Ω, to prevent overloading the i.c.) is used to supply adequate bias current to bottom or saturate the transistor.

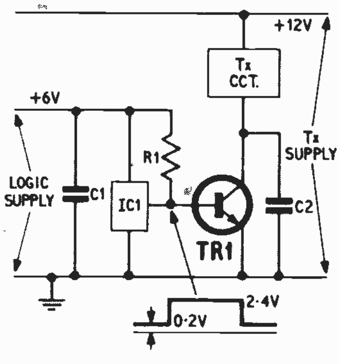
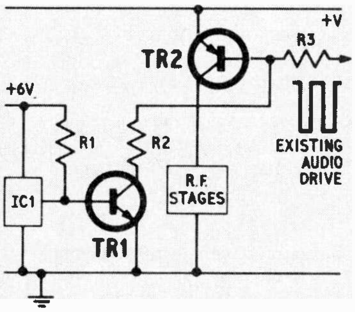
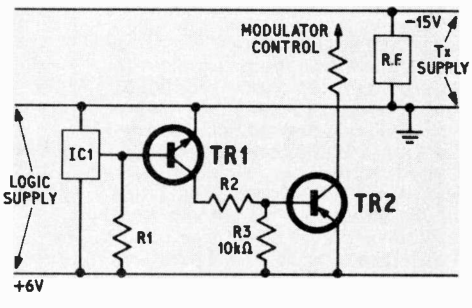


Fig. 1



(a)

Fig. 2



(b)

Fig. 2

In the case of a transmitter with a positive supply (with respect to earth) the units are connected as shown in Fig. 1.

In the "off" state the collector of TR1 rises to the voltage of the transmitter supply (say +12V) and when "on" or bottomed is at approximately +0·2V. Therefore, TR1 acts as a supply switch, with a loss of 0·2V and may be used to control either the r.f. output stage or preferably, the modulating transistor or stages, avoiding difficulties of r.f. decoupling and pulse shaping.

The selection of TR1 (Fig. 1) ensures that:

(a) The maximum current rating (800mA for 2N3704) is not exceeded by the load of the controlled stage, including the charging current of the electrolytic capacitors used for decoupling.

interfacing, necessitating only that an inversion, using one transistor or a gate, is used in the receiver, so that zero modulation corresponding to a coder pulse, produces a positive going input to the decoder.

The value of resistor R2 is chosen to bottom TR2. If TR2 has a nominal "gain" of say 50 and normally passes 50mA to the load, a base current of approximately 2mA is necessary to ensure bottoming.

For a 12V supply

$$R_2 = 12 - (V_{ce(TR1)} + V_{be(TR2)}) \times \frac{1{,}000}{2} \text{ ohms}$$

$$= 12 - (0{\cdot}7 + 0{\cdot}3) \times \frac{1{,}000}{2} \text{ ohms}$$

$$\simeq \frac{11{,}000}{2} \simeq 5{,}500 \text{ ohms}$$

or to the nearest preferred value — 5·1kΩ.

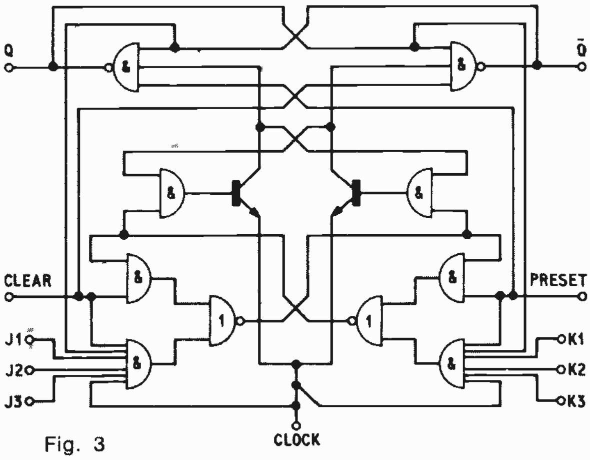


Fig. 3

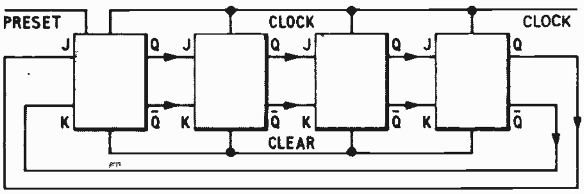


Fig. 4

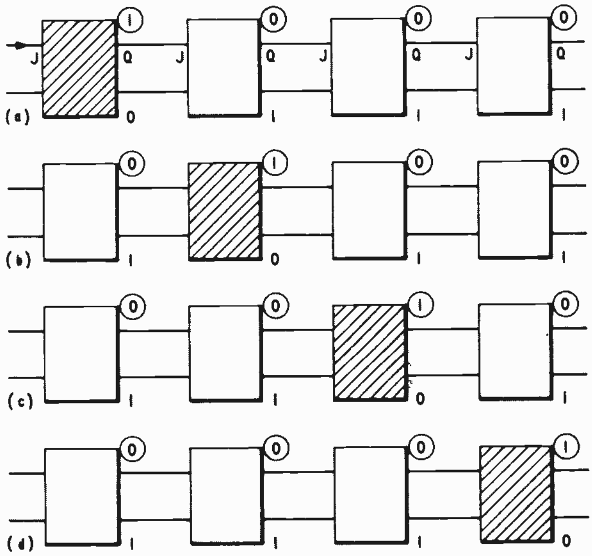


Fig. 5

(b) The maximum collector open circuit voltage (V_{co} = 50V for 2N3704) is not exceeded bearing in mind that an undecoupled inductive load, such as the r.f. "tank" coil, produces collector voltages several times that of the supply.

R.F. decoupling capacitors (0·1 to 0·01μF) should be fitted where shown at C1, C2.

In cases where the transmitter uses a negative supply the circuit shown in Fig. 2b should be used. Here TR1 (*npn*) is turned on by a logic "1" as before, providing a bias current via R2 to saturate TR2 (*pnp*) which should be selected as before, to perform the required switching action, bearing in mind that the effective supply to TR2 is the transmitter supply voltage plus the logic supply.

USUAL DESIGN

A usual design for simple transmitters is shown in Fig. 2a where the r.f. output *npn* transistor is in series with a *pnp* switching transistor driven from an audio multivibrator circuit. In this case the action of TR1, when cut off, is to allow modulation, but when "on," TR2 is bottomed giving full unmodulated r.f. output. This is a convenient method of

DECODER

Do the Decoder outputs go high after *the pulses and remain high until the next clear pulse?*

For purposes of illustration only Fig. 3 shows the internal functions of an SN7472 JK master-slave flip-flop. The units used in the article are the dual

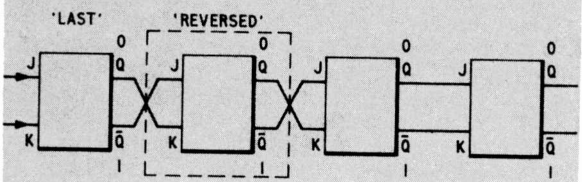


Fig. 6

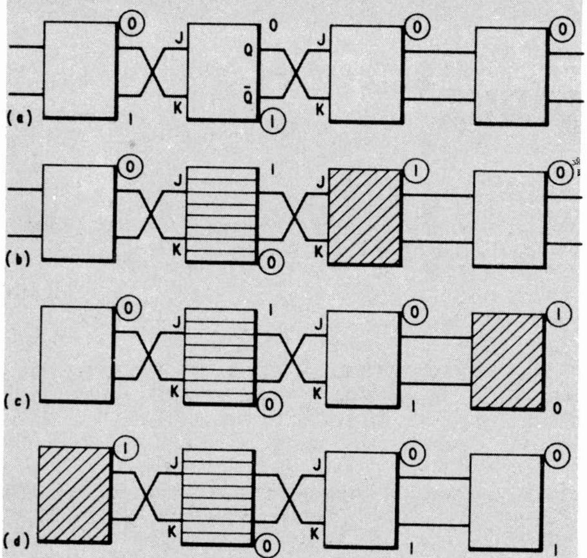


Fig. 7

version of this unit, i.e. two inside one integrated circuit package, and the preset input is not available.

Though apparently very complicated, they are simple to use necessitating only a knowledge of this simplified truth table:

Before Clock inputs J	K	After Clock pulse Q output
0	1	0
1	0	1

The $\bar{Q}$ output is the inverse of the Q output and the sequence of operation is

1. Isolate slave from master;
2. Enter AND gate information to master;
3. Disable AND gate inputs;
4. Transfer information from master to slave.

Also, preset (which sets Q to 1) and the clear (which sets $\bar{Q}$ to 1) inputs operate on negative-going signals.

FLIP-FLOP RING

Consider a "ring" of any number of such flip-flops connected as shown in Fig. 4 with each Q output connected to the next J input and $\bar{Q}$ output to K inputs.

When power is applied the units may take up any random position but a subsequent clear pulse will set Q outputs to 0 and all $\bar{Q}$ outputs to 1. Any subsequent clock pulse will not change the situation since each J input "sees" a "0" from the Q output of the preceeding stage and similarly the K input is a "1."

From the truth table the output cannot change: if however a preset pulse is applied to only one unit making its Q output a "1" as shown in Fig. 5 a subsequent clock pulse will cause the next flip-flop to change state since its "J" input sees a "1." The flip-flop that was preset will also change back to a Q = 0 output since its J input "sees" a "0."

Further clock pulses will cause successive flip-flops to change state and back again so that the "1" (shown shaded) moves round the ring of Q outputs.

The Q = 1 or high output of an individual flip-flop can be identified therefore with a particular clock pulse and only when, say, number 3 clock pulse is present, will the corresponding number 3 flip-flop output be high.

As mentioned in the article, the flip-flop output is high for the duration of the clock pulse and for the brief and defined period of inter-clock pulse "gap" of $\frac{1}{3}$ to $\frac{1}{2}$ millisecond. The flip-flop output is integrated to give a d.c. level dependent upon the duration of the pulse; the small additional "gap" period is included in this, appearing as a small constant d.c. level off-set by initial adjustment of the servo. Any small time-by-time variation of the inter-clock pulse gap (say 5% of 0·5ms) is insignificant with respect to the cycle time of about 25ms.

REVERSED OUTPUT

To avoid the necessity of providing a preset pulse, after the clear and prior to the train of clock pulses (particularly since low-cost i.c.s with multiple flip-flops such as the SN7473 do not have a preset input) the ring of flip-flops is arranged as shown in Fig. 6 with the input and output connections of one flip-flop reversed.

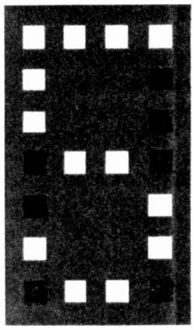
Since the "J" input of the following unit now sees a "1" from the $\bar{Q}$ output, it changes state on the first clock pulse. The "reversed" flip-flop also changes state since its J input sees a 1 from the $\bar{Q}$ output of the "last" flip-flop.

Further clock pulses cause the "1" to move round the ring of Q outputs as before (shown in Fig. 7). Subsequent to the "last" flip-flop changing state, the "reversed" flip-flop will change back to the initial condition.

The "reversed" flip-flop is used therefore to store the necessary "1." The normal flip-flop Q outputs correspond to the clock pulse-channel outputs as before except that the $\bar{Q}$ output of the "reversed" flip-flop can be used as explained in the article, using gates, to provide a channel output.

In the wiring pattern in Fig. 20 (January 72 issue) a double reversal appears in error. To correct this the connections to pins 8 and 9 of IC2 (at the bottom centre) should be reversed. ★

ALPHA NUMERIC DISPLAYS

Part 

By R.W. Coles

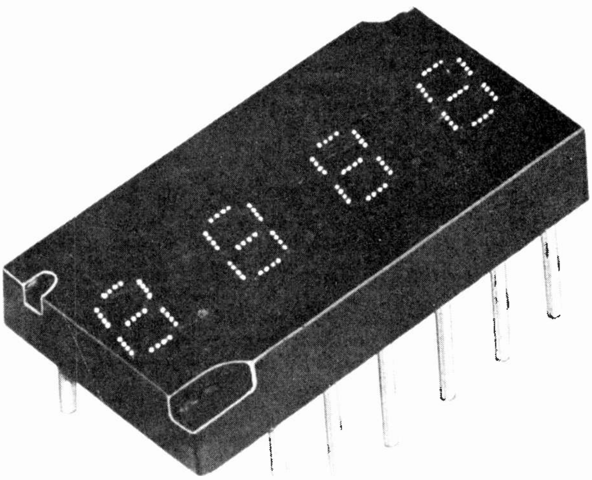
Light Emitting Diode Displays

THE ALPHA-NUMERIC display devices considered so far in this series (gas discharge and filament types), have utilised basic principles which have been known for many years and which have been employed for other purposes before their incorporation in display systems.

This month is concerned with the brand new technology of solid state semiconductor light emitters and the incorporation of this technology into readout devices.

SEMICONDUCTOR LIGHT EMISSION

Silicon and germanium are well known as semiconductors, but they are by no means the only substances which bear this label, and it was while investigating the properties of some of the more exotic members of the family that it was discovered that certain semiconductors have the property of emitting radiation when a current flows through them.



Each segment in this device is made up of four light emitting diodes (Guest International)

The first practical device to result from this research was the gallium arsenide (GaAs) diode, which, when forward biased, emitted infra-red radiation.

This type of device found many uses in speech-link and beam-breaking equipment, and has been featured several times in this magazine.

The radiation from L.E.D.s is monochromatic, that is, it has a single frequency or colour, and, since it is in the infra-red range, the radiation from a GaAs diode is not visible to the naked eye and is therefore unsuitable for display purposes.

Further research produced a diode using gallium arsenide phosphide (GaAsP) which emitted light in the red portion of the visible spectrum, making it ideal for incorporation in readout devices, and it is diodes of this type which will be dealt with in this article.

A very informative account of the exact mechanism involve in L.E.D. structures was contained in the article on *Electroluminescence* in the December 1971 issue, and it is beyond the scope of this article to delve any further into this aspect of the subject.

DECREASING PRICES

The fact that L.E.D.s are made in the same way as other semiconductor devices such as transistors and integrated circuits means that they are set fair for mass production by basically standard methods, and already the explosion of these new indicators into the display market is beginning.

Prices, which were prohibitively high only a couple of years ago, are now dropping rapidly in the same way that i.c. prices did, and within a year or two there is little doubt that L.E.D. indicators will have the lion's share of the display market.

CONSTRUCTION OF L.E.D. DISPLAYS

Alpha-numeric readouts using L.E.D.s employ numbers of square or oblong emitting areas arranged either as a "dot matrix" or a "bar matrix." They are normally laid out on a single slice of semiconductor material, the whole chip being enclosed in a package like an integrated circuit, except that the packaging compound is transparent rather than opaque.

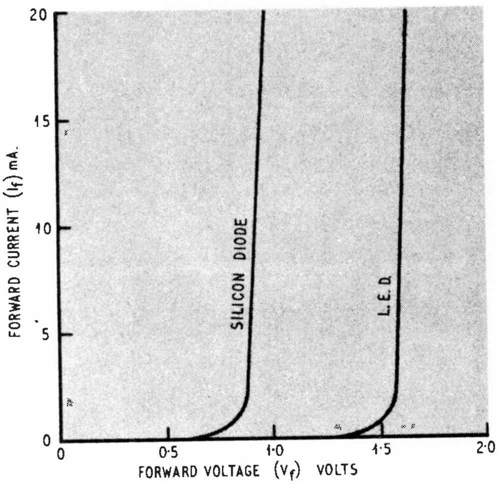


Fig. 5.1. Forward characteristic of a typical L.E.D. compared with a silicon diode

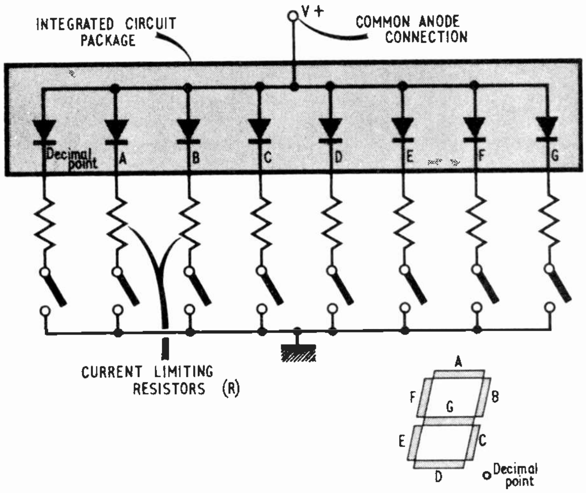


Fig. 5.2. Basic circuit arrangement for a seven-segment L.E.D. indicator. The switches shown would normally be replaced by the output stage of an i.c. decoder/driver

Because L.E.D. readouts are made by manufacturers specialising in other semiconductor devices it is a logical step to include some or all of the decoding and driving electronics for the display inside the same package as the L.E.D.s in the form of an i.c. chip. This is a possibility not open to other display technologies, and it is a very important advantage which, no doubt, will eventually be exploited to the full.

Perhaps the most striking advantage of these new devices is their small size, character height commonly being in the region of only ¼in, making it possible to enclose up to six separate digits in a single dual-in-line package, for example.

Other advantages include very long life; freedom from catastrophic failure; compatibility with all types of drive circuitry; and most important, the ability to be run from a wide variety of supply voltages from 2V upwards.

DRAWBACKS

Of course, there are a few drawbacks, the small physical size quoted above as an advantage can be a disadvantage for displays which are to be read from more than a few feet away. Large L.E.D. arrays are not practical in integrated form due to the large area of semiconductor which would be necessary, and these devices are not likely to be competitive when character height exceeds ½in.

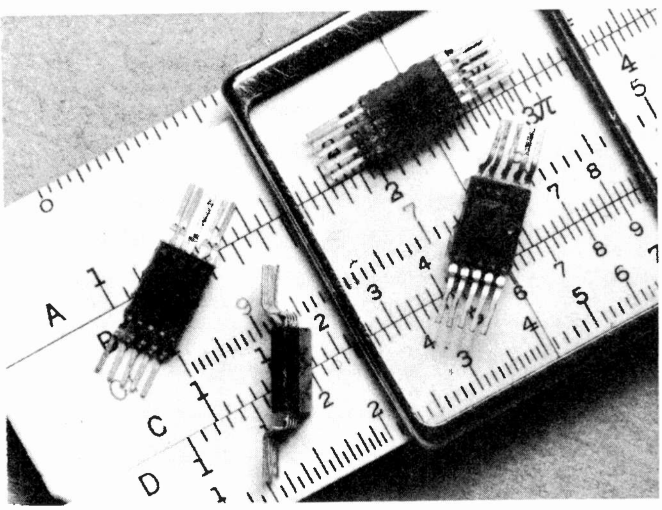
The monochromatic red colour, whilst ideal for calculators and measuring instruments is undesirable in such applications as film annotation where certain emulsions have a blind spot in this region of the spectrum. It is worth mentioning that this colour problem has been overcome by using a different semiconductor, and both green and amber displays have been produced in the laboratory, but as yet the price of these devices is higher than equivalent red light types.

DEVICE CHARACTERISTICS

A single L.E.D. behaves in a similar way to the silicon and germanium components which have become so familiar.

Its forward characteristic is shown in the graph of Fig. 5.1, where it is compared with that of a silicon diode. As can be seen, the only difference is in the voltage at which it begins to conduct, being typically 1·6V for an L.E.D. as against 0·8V for a silicon device.

In a practical display a single L.E.D. is used for each bar or dot of the matrix, though in the larger seven-bar types it is necessary to use two (or sometimes more) L.E.D.s in series for each bar which



These L.E.D. indicators from Mullard (type 185CQY) show an alternative method of packaging to the normal D.I.P. type gives an apparent doubling of the forward voltage necessary for conduction to typically 3·2V.

To drive an L.E.D. display it is only necessary to insert a resistor in series with each separate element to limit the current to the desired value (usually between 5 and 10mA). The circuit arrangement for a single digit using a seven segment device is shown in Fig. 5.2. In practice the switches shown would be replaced with the output drivers of a seven segment decoder such as the SN7447 discussed last month.

LIMITING RESISTOR

The value of the resistor required can be worked out very easily by working out the voltage across it and dividing it by the required current. The voltage across the resistor is equal to the supply voltage minus both the voltage across the L.E.D. (1·6 or 3·2V as discussed earlier), and any saturation voltage of the switch (around 0·2V for the SN447 i.c.).

For example, if the desired current is 5mA and each bar of the display consists of a single diode, with an available supply voltage of 5V the value of R is found as follows:—

$$R = \frac{V_{CC} - V_{LED} - V_{CE(Sat)}}{I_{LED}}$$

$$= \frac{5{\cdot}0 - 1{\cdot}6 - 0{\cdot}2}{5} \text{ kilohms (where } I_{LED} \text{ is in mA)}$$

$$= \frac{3{\cdot}2}{5} \text{ kilohms}$$

Thus R = 640 ohms (620 ohms preferred value could be used).

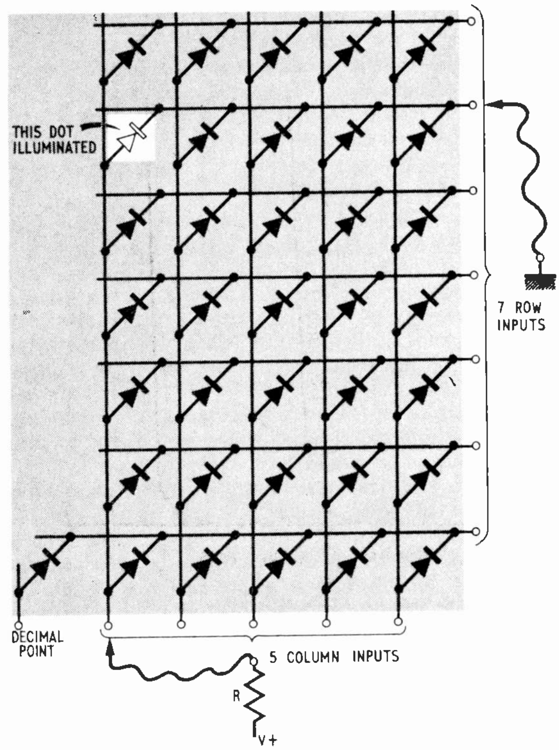


Fig. 5.4. The internal circuit of an L.E.D. indicator using a 5 × 7 matrix of diodes. The external components show how a particular diode is illuminated though the switching in a real system would be done electronically

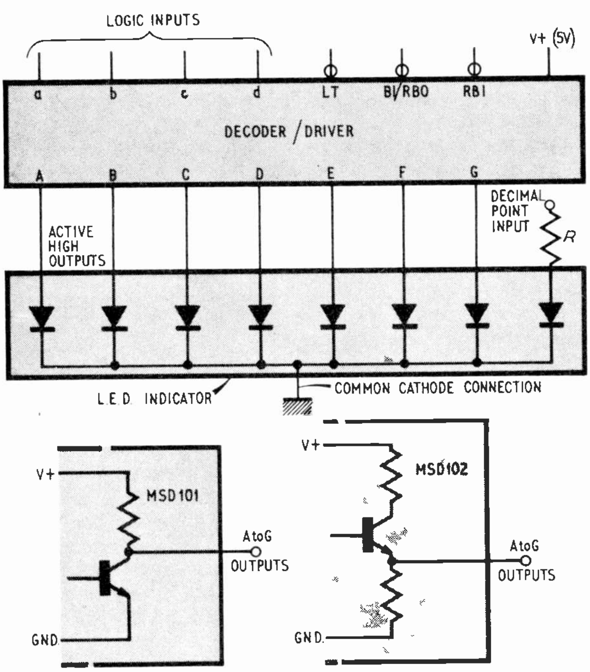


Fig. 5.3. Circuit arrangement for a common cathode type L.E.D. indicator. Also shown are the output stages of two types of driver i.c.s, the Monsanto MSD101 and MSD102

COMMON CATHODE

The seven bar indicator just considered had a common connection to all seven diode anodes, the single pin used to carry this common lead being connected externally to the positive supply. It is equally possible to have a common cathode connection which is taken to the negative supply, an arrangement which is suited to a new generation of decoder/drivers which have emitter follower outputs and resistors included in the package, see Fig. 5.3.

DIODE ACTION

The fact that an L.E.D. is not just a light source but also a semiconductor diode can be used to great advantage where time sharing of a display is necessary, since the diode action can be used as part of the logic of the driving circuitry.

This feature is especially useful in the dot matrix L.E.D. indicators which employ a 5 × 7 array of separate emitters with only five plus seven separate connections, five column wires and seven row wires (Fig. 5.4).

This type of indicator can display all letters and symbols as well as the numerals and in a practical system each dot of the matrix is controlled by a complex decoder called a "Read Only Memory" or R.O.M. The elements of the matrix are addressed either a row at a time or a column at a time, at a rate fast enough to eliminate flicker, a particular L.E.D. being "ON" if both its row connection and its column connection are switched on simultaneously.

The same system could be used with filament lamps, but a moment's reflection reveals that each lamp in the matrix would require a diode in series with it to isolate it from the other lamps; with L.E.D.s the diode is inherent in their construction, resulting in a very simple array.

IMPROVED FORMAT

The seven segment format is very easy to fabricate using L.E.D. technology but it does offer rather stylised numerals which can be ambiguous under difficult reading conditions. The reason for this possible ambiguity is the lack of redundancy in the simple format, all the bars used for a particular figure being absolutely vital for accurate interpretation.

A classic example of this lack of redundancy causing trouble can be envisaged when, for example the readout of a digital-voltmeter has an indicated reading in which the last digit is alternating rapidly between a four and a five, due perhaps to noise on the signal.

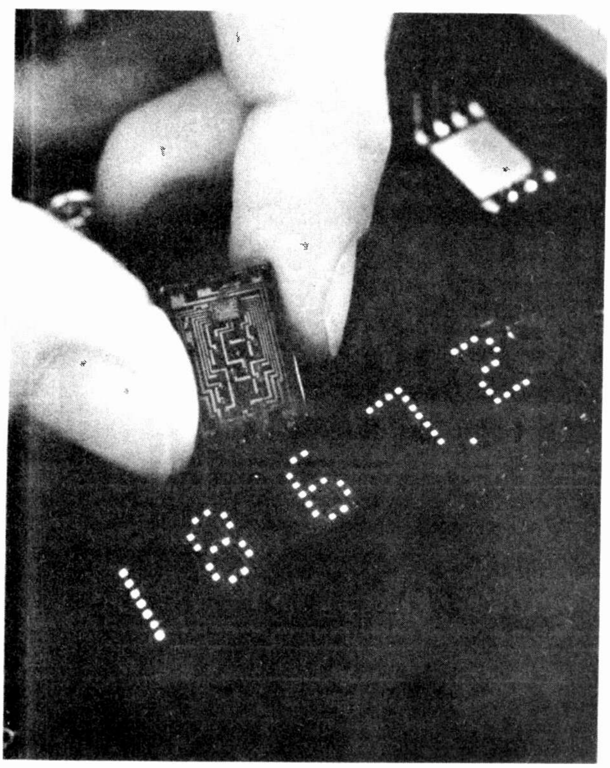
With discrete character displays (e.g. cold cathode tubes) this alternation can be easily detected and an accurate reading deduced, but with the seven segment indicator the four and five can be integrated by the observer's eyes to give an apparent reading of nine, which is too far from the correct reading for comfort.

Even worse errors can be produced if for any reason one of the bars of the format becomes permanently illuminated or extinguished, as the result of a fault.

The dot matrix format on the other hand has a great deal of redundancy built in, and even with several dots out of action a readable display is still possible. Unfortunately dot marix displays are both expensive and unnecessarily difficult to drive when only a numerical readout is required. As an answer to this problem a new format has been used in the Hewlett Packard HP 5082-7300 series of indicators, which is really a compromise between a dot and a bar matrix.

As can be seen in Fig. 5.5 the display is still based on a "square 8" format, but in this indicator each bar is made up of dots which can be separately illuminated to give a highly readable and pleasing display with the minimum of complexity. These indicators are unique in also having the decoder/driver i.c. chip inside the package, only four line B.C.D. inputs being presented to the indicator from the external circuitry.

The actual decoder used in the package will of course be more complicated than a simple seven segment type, but even so the savings involved compared with a 5 × 7 matrix full alpha-numeric indicator are considerable.



This photograph shows the large size and good readability of the Hewlett-Packard HP5082-7300 series indicators

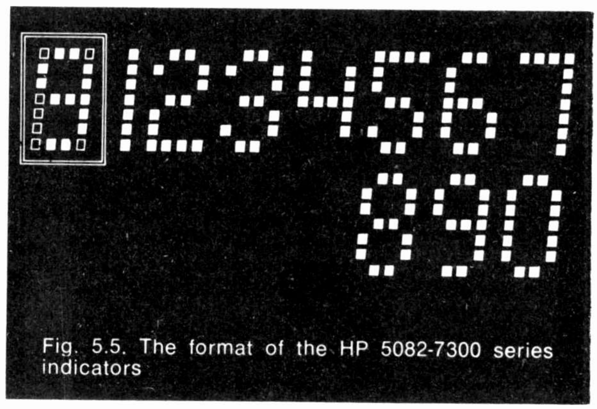


Fig. 5.5. The format of the HP 5082-7300 series indicators

PRACTICAL DEVICES

The H.P. 5082-730 series of indicators cost in the region of £8 at the moment, which is rather too expensive for amateur use, and this price barrier is also present with the 5 × 7 alpha-numerics which are currently priced at about £10 each (without decoder). This does not mean that L.E.D. displays are completely excluded from amateur projects because several types of seven segment L.E.D. devices are available at much lower unit cost, and the slight extra cost of even these examples over, say, an incandescent device, can sometimes be justified by the better performance of the L.E.D. types.

Some examples of L.E.D. indicators suitable for amateur use are shown in the photographs.

Next month: Practical display systems using L.E.D. indicators.

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.

RHYTHM BOXES

A custom designed MOS nitride integrated circuit has been designed by **SGS/ATES** for use in rhythm boxes in electronic organs.

The design was developed especially for Eminent and Solina of Holland, makers of high class organs. The research department of Eminent and a professional drummer looked after the musical part. For the electronic part the Eminent engineers worked closely with the SGS MOS design team in Italy.

The resulting rhythm boxes are sold under the trade name "Rithmix" either as built-in optional accessories or as independent units.

The MOS rhythm generator consists of eight different pattern configurations selectable externally by simple pushbuttons. Each pattern can trigger the reproduction of the sounds of up to 12 different percussion instruments.

The sounds which they generate form an accompaniment for the organist, providing him with such rhythms as march, swing, rock, slow rock, cha-cha-cha, samba, bossa nova, or with a combination of these. A counter, integrated in the device, driven by an external adjustable oscillator, can sequentially scan the selected pattern to generate the various rhythms.

Although the idea of rhythm accompaniment is not new, the novelty of the current product lies in the use of the most advanced semiconductor technology, which, while it offers improved and more complete musical simulations, also reduces costs and the overall size of the unit.

The range of rhythm boxes available includes, in addition to the simple foot-operated start-stop types, a version presenting an even more far reaching innovation whereby the speed of the rhythm automatically follows the speed of the player.

PIEZO ELECTRIC LIGHT

Some time ago we published a report from Europe in which the reporter mentioned a mains operated gas lighter installed in most kitchens in France. This report created a considerable amount of interest and we are still receiving letters a year later.

Ideal for the Home, Industry and Camping, we have now received details of a new piezo gas igniter from Germany which is guaranteed for ten years, does not use any flints, requires no battery and is not mains operated.

Called the Junkers Piezo Gas Igniter, the "gun" works on the principle that if a sudden force is applied at the interfaces of various crystals, an electric charge is formed. This charge is sufficient to ignite all fuel gases, including natural gas.

When the spring loaded trigger is pulled it releases an impact pin which deforms the piezo crystal and causes a voltage discharge of approximately 20kV to appear at the end of the "gun barrel". The end of the "barrel" can be likened to the car spark plug and the voltage appearing at the centre electrode jumps the gap to the barrel wall. It is this 20kV spark, having a pulse duration of only 50 microseconds, that ignites the gas.

The price of the Junkers Gas Igniter seems to depend where the purchase is made, and varies from £2 to £2·40 each. The one we tried was obtained from **Servitronix Ltd.,** 572 Kingston Road, Raynes Park, SW20 8DR; price £2·25.

No more worries about whether the matches have been left where young children can get at them and cause havoc?

OPEN TO THE CONSTRUCTOR

The do-it-yourself electronic enthusiast and the small user of electronic components can now take advantage of the large range of components stocked by **GSPK (Sales) Ltd.,** which have only until now, been available to the trade.

They have now issued a new catalogue containing a full range of components available through mail order or from their premises at Harrogate. The price of the catalogue is 10p to cover postage.

Copies of the catalogue can be obtained from GSPK (Sales) Ltd., Hookstone Park, Harrogate, Yorkshire HG2 7BU.

DISPLAY MODULES

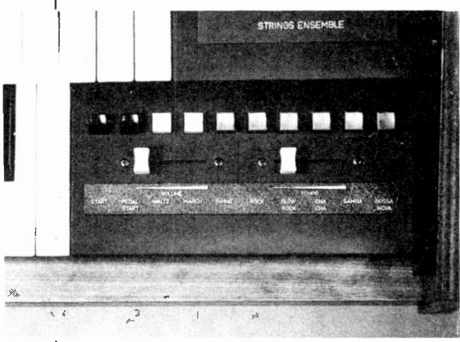
The Codicount range of counting, storage and digital display modules from **Contraves Ltd.,** has been produced to meet the broad requirements of general purpose counting.

The range is claimed to provide designers of control consoles and panels with a "building brick" system which relieves them of logic design responsibility, facilitates rapid updating during development and does not require rack mounted hardware.

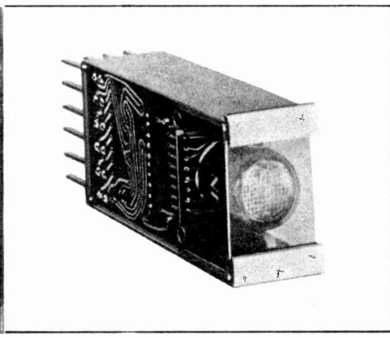
The system provides ten variations and is TTL compatible. Employing i.c.s, the modules have good frequency response, high reliability and freedom from noise problems, the +5V logic supply terminal on each module being decoupled from line noise by a tantalum capacitor.

The supply voltages required for the Logic System is +5V at 21mA to 105mA and +250V at 2·2mA for the readout display.

Further details of the Codicount range of counting, storing and display modules can be obtained from Contraves Industrial Products Ltd., Time House, Station Approach, Ruislip, Middlesex HA4 8LH.



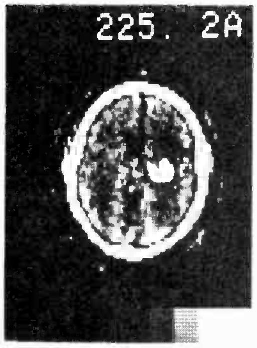
Rhythm unit designed by SGS/ATES



Codicount storing and display module

Junkers Piezo Gas Igniter

Haematoma associated with tumour



Haematoma

Primary intracerebral haemorrhage

Primary intracerebral haemorrhage taken at 1 cm higher on same patient

These four photographs show the capability of the new system. They help the diagnostician identify conditions impossible to see using conventional techniques

Computerised X-ray System Improves Pictures of Brain

DIAGNOSIS of brain disease is one of the most challenging aspects of medicine, so this new system from EMI, which makes possible study of brain tissue in detail never before attainable, must be regarded as a major step forward.

This British breakthrough makes use of a computer in processing data from a highly sensitive X-ray machine, and follows three years of research and development by EMI together with specialists from the Department of Health and Social Security.

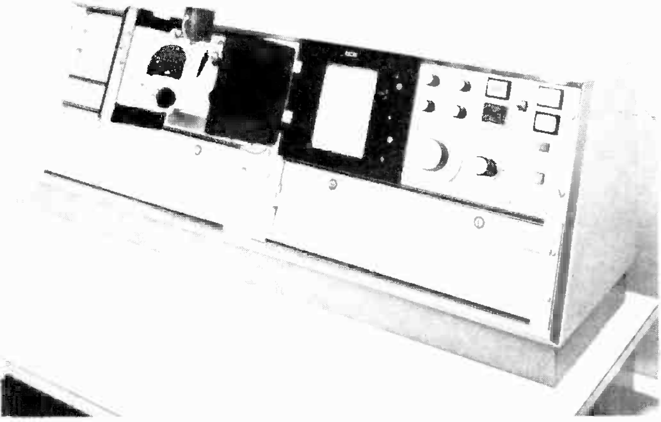
The system, known as Computerised Transverse Axial Tomography, uses an X-ray machine which rotates around the head of the patient taking over 56,000 readings from a narrow beam of X-rays passing through the head in a single plane. These readings are stored by the computer which then solves 28,000 simultaneous equations to build up a 160 × 160 matrix picture. For general clinical work an 80 × 80 matrix has proved adequate.

The system may be used for investigating a wide range of conditions such as tumours, cysts and haemorrhages. It is claimed to be 100 times more sensitive than conventional X-ray techniques.

The equipment can be handled by one operator with only a modicum of medical knowledge and can screen up to four patients an hour. This speed together with the lack of discomfort to the patient makes the system ideal for use on outpatients who would normally take up valuable hospital beds and staff.

The limitations of conventional X-ray techniques are due primarily to low sensitivity which means that a feature has to be comparatively thick or dense to register on the photograph at all. The fact that X-ray plates record three-dimensional information on a two-dimensional surface also causes difficulties.

The unit as it is used. The cathode ray tube viewing unit and computer are located nearby



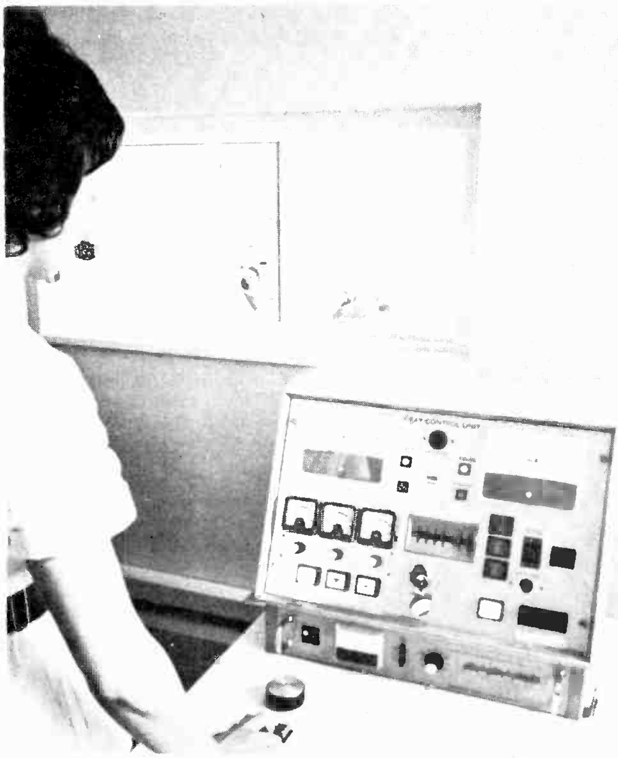
The results from the X-ray equipment are produced as a detailed picture on this cathode ray tube viewing unit

Studies of conventional X-ray techniques have shown that only one hundredth of the information potentially available from the radiation of X-rays is actually realised on the photographic plate.

The difficulties mentioned above are compounded in brain examination since the dense bone tissue of the skull completely surrounds the soft tissue of the brain so that variations in bone thickness completely obliterates details of the brain tissue.

This patented equipment has been under evaluation at Atkinson Morley Hospital, Wimbledon during the last six months. The Department of Health and Social Security is considering installing two of these machines at other hospitals in the near future.

This is the control unit of the installation at the Atkinson Morley Hospital



NEWS BRIEFS

The Open University

A NEW development in the Open University's activities is the provision of Post Experience Courses. These courses are designed for people in all kinds of employment who would benefit from further education or training but who cannot be released from work to take conventional courses.

As with undergraduate courses, tuition will be through correspondence material, supplemented by television and radio programmes, use of computer terminals, home experiment kits, tutorials, and summer schools. Courses will generally run for one year or less, and start January 1973.

Open University certificates will be awarded on completion of the courses.

The first five courses are: Biological Bases of Behaviour, Computing and Computers, Electromagnetics and Electronics, Reading Development, and Reformation Studies.

Electromagnetics and electronics

The aim of the course is to provide a good understanding of the scientific bases of electronic circuit design. It is intended for people in industry, government establishments, hospitals, etc., who find they have a need for electronics, even if they do not intend to proceed to higher level courses. Little prior knowledge of electronics or electromagnetics is required, but the course does assume a background of scientific or technical education beyond GCE "O" level.

A good deal of electronic experimentation at home will be involved, centred round a cathode ray oscilloscope, a signal generator and other apparatus and components loaned to students.

Copies of the Post Experience Courses prospectus and application forms may be obtained from The Post-Experience Student Office, The Open University, P.O. Box 76, Bletchley, Bucks.

New Course for Teachers

A NEW main course in engineering science and technology is planned by Edge Hill College of Education, St. Helens Road, Ormskirk, Lancs. Entitled Science and People, this course is aimed at providing intending teachers with a knowledge of the principles and practice of modern technology.

It is hoped it will also appeal to suitably qualified men and women in industry who wish to enter the teaching profession.

The three year course commences in September, 1972 and leads to the Certificate of Education. Details of admission procedure are available from the Admissions Secretary.

British Amateur Electronics Club

THE seventh annual B.A.E.C. exhibition will be held on July 22 to July 29 next at the Shelter in the centre of the Esplanade, Penarth, Glamorgan at 7 p.m. every night. This year the club is exhibiting various projects made by members which should make this exhibition more interesting than before.

Gerry Brown . . .

ON THE FRINGE

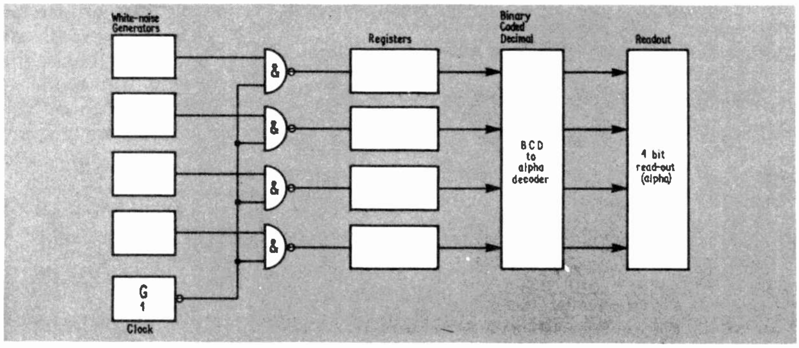


Fig. 1

ART—IN A WORD

Difficult though it may be to accept, we are probably all sensation seekers of one kind or another. In the old times people were wont to get their kicks from the consultation of oracles and inspection within the depths of such things as crystal balls or tea leaves. To some degree, anyway, the random nature of such aids almost certainly held the most valid reason for their success; indeed, this is likely to be the secret of their attraction even now.

However, today we witness the availability of more varied and "way-out" sensations plus an attendant increase in would-be participants to appreciate them. Remember the demand, a couple of years ago, for those quaint little blocks of glass-like plastics containing a number of (seemingly, lit-from-the-air) randomly flashing neon lamps? And how about those ever popular collections of Victoriana composed of countless bits of glass suspended from the ceiling and gently tinkling a coolness into the still air of a hot summer evening?

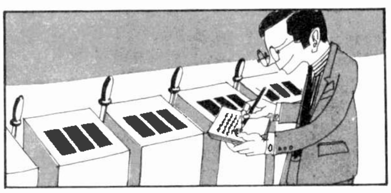
Undoubtedly, the ready-made interest factor is that unpredictable ingredient inherent in randomly produced material or events, one, in fact, which is currently providing the basis for many new art-forms.

One area, in particular, specialises in the production of "unique" forms of both music and prose, relying on computer programs to mould random material according to formalised laws for the specific discipline. This is a field of programming I must confess to indulging in myself, and one which it is tempting to replicate, in part at least, in the form of real-time hardware.

In case you have a yen to build something of this nature, Fig. 1., shows just the "bare bones" of a scheme designed to generate random words. It doesn't, of course, include (as a program might do) rules for ordering the occurrence of consonants or vowels, and, indeed, harsh economy dictates a total word length of only four letters.

The hardware model suggested employs one white-noise generator per letter channel which is periodically gated, by a clock pulse, into a register having a maximum count of 26 for the letters of the alphabet. The count: i.e., letter, held in each register, following a clock-pulse, is decoded into a form suitable for driving a 16-segment filament type readout and subsequently displayed.

This, possibly crass, waste of electronics may not be your particular idea of a "hang-up," but then it *is* fairly innocuous and (if you take the trouble to jot down every word) might just write you a sonnet or two!



PICTURE IF YOU WILL

On a different tack, but interesting none-the-less, is a clever new device just given birth by some workers in Albuquerque, U.S.A. It constitutes an unusual way of storing images, and functions in a fashion similar to that of liquid crystal devices employing the nematic phase.

The main difference is that it doesn't use liquid crystals. The prototype device consists of a thin slice of electro-optic ceramic plate coated (on one side) with a photo-conductive film with the two sandwiched between a couple of transparent electrodes.

Prior to use, the device must be initially exposed to light (from the film side) while a potential is applied between the electrodes. If, following this, the image from a photographic negative is projected on to the film side, and the voltage applied once again, a latent image will be stored by the ceramic.

This image can be subsequently reproduced simply by illuminating the device from the film side; the electrodes at such times must not be energised, otherwise the image could be erased. Actual erasure takes place by re-exposing to light while the voltage is applied, and in this way continues countless images can be stored again and again.

The principle Cerampic, as the device is called, employs for its operation is one which relies upon the formation of ferro-magnetic domains having different orientations within the ceramic plate.

Variation in the orientation constitutes the difference in the areas of contrast in the stored image. This, seemingly, controls the amount of light scattering produced by the material; thus, bright parts of the image seem to be formed by domain orientations aligned with the direction of incident light, while darker areas are produced by alignments which scatter more of the light away.

Since this remarkable material can be switched on and off at fairly high rates, it would appear, like liquid crystals, to be a serious contender in the race to produce picture-frame television. Even if it never gets that far, it is sure to provide sufficiently good resolution for such things as document transmission and copying by wire.

NO SHHH . . . . .!!

In the last *On the Fringe* under the heading "Occultaphonics" I mentioned a device which could be put together to produce white-noise. Unfortunately, the circuit, shown in the accompanying figure at that time, did not include a Zener diode. This component, vital to the operation of the device, is now shown in Fig. 2.

Some Zeners are a bit reluctant to generate electrical "hash," so you may well need to try a few before finding the ideal.

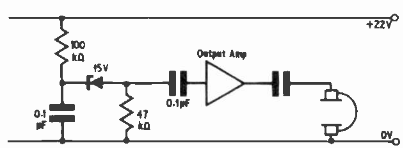


Fig. 2

CALLERCORD

There are times when it is Impossible to answer a call at the door. The "Callercord" will answer callers and record messages on magnetic tape.

BY J. BECKER

THERE are times when it is inconvenient or impossible to answer a call at the front door. You could be in the bath, taking a nap, or out shopping with no one else around to answer the door. The Callercord has been designed to help alleviate the frustrations caused to you or the caller in these and other situations by enabling you to leave a recorded message which is automatically played back to the callers each time the door bell is rung. Having repeated its message, the machine then records any message which they may have for you. The Callercord could be of particular use to small shopkeepers who could use it to take messages or orders while the shop is closed, as for example during lunch hours or on early closing days.

The Callercord uses two tape recorders, but in conjunction with just one recorder, it can easily provide other services, such as repeatable information or commentary at any place where it is not necessarily desirable to have the information constantly repeating itself and where it need only be available at the touch of a switch.

Again using one tape recorder, preferably a larger one than those used in the Callercord, and with slight modification to the sensing device, the machine can even be used as a baby-soother, sensing when the baby wakes and playing soothing music or mother's voice.

Without any tape recorders at all, the main control circuit can be used on its own to control a variety of functions for which automatic sequential timing is required, such as remote control of photographic lighting, cameras and enlargers. The individual sub-units of the control can also be duplicated to control an electric train or model car.

DESIGN CONSIDERATIONS

The basic design considerations are for the Callercord to sense when the door bell is being rung, play back a pre-recorded message (PBM), then record a message from the caller (RCM), and finally switch off the recorders.

There are several ways of achieving all these functions and the first consideration is the method to be used for record and playback. It is possible to use an automatic record player for PBM, but unless the message stays unchanged, the cost and inconvenience of having discs cut rules out this method. It is also feasible to use magnetic disc recorders but these are hard to come by.

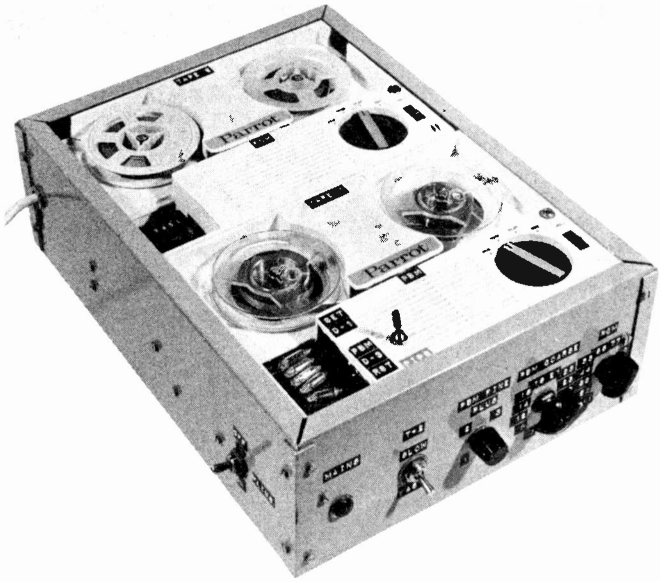
Another method, and one which at first sight appears attractive, is to use a stereo tape recorder, but the problem here, as will be seen later, is that of repeatedly playing the PBM. Cassette recorders were seriously thought about for a while, but the cheapest that could be found was about £13. It was decided that two cheap tape recorders were the best answer, and a search was started to find the cheapest ones possible. A number were found, and the make finally chosen was the Japanese "Parrot Bookcorder". The quality of sound on these might not suit some hi-fi enthusiasts, but in this instance, sound quality was considered to be unimportant, and these machines have proved to be satisfactory for the job.

BLOCK DIAGRAM

Sensing of the door bell ringing could be achieved by placing a microphone so that it picks up the bell, and then passes this signal as a start pulse to the control circuit. In this machine a similar effect is achieved by breaking connection with the input part of the control circuit when the bell switch is used. To keep the number of wires from the door to a minimum, the connection between the input control and the door is made using the same wires that feed the external speaker. This can be seen in the block diagram of Fig. 1.

The bell switch S1 is a push to make and break type with one side in series with the speaker leads. When connection with the control circuit input is broken, it passes a pulse through to a bistable gating circuit. This only allows one pulse through and then closes to prevent further pulses from disrupting the rest of the circuit, and will not open again until the control circuit has completed its cycle.

As the gate closes, a pulse initiates a delay (Delay 1) before anything else happens, so that there is time for someone to answer the door personally if they wish to do so. At the end of the delay, two relays are operated. Relay RLA switches the external speaker LS1 out of circuit with the control input and across to relay RLB which switches the speaker leads into circuit with the PBM recorder (Tape Recorder 1) and also causes it to play back its pre-recorded message.



AUTOMATIC REWIND

There is a choice of ways to make the PBM recorder play back the same message each time it is needed. It is of course possible to record the same message over and over again onto a whole spool of tape, but the prospect of doing this each time the message has to be changed is a little daunting, and there is also the problem of the control circuit selecting the right moment at which to switch on the RCM recorder (Tape Recorder 2). Another method is to use an endless loop of tape, switching over to the RCM recorder at a point determined either by time or by a physical method such as using a contact switch or a photoelectric sensor. The endless loop system was in fact experimented with, but was eventually rejected because of the problem of ensuring reliable loop transport plus the fact that the "Parrot" has a spool drive which would need adapting to pull the tape across the heads.

The method finally chosen uses a spool of tape which is rewound automatically after playing the message, thus allowing for repetition and length variation as required. Automatic rewinding initially presented another problem, for the "Parrot" has a

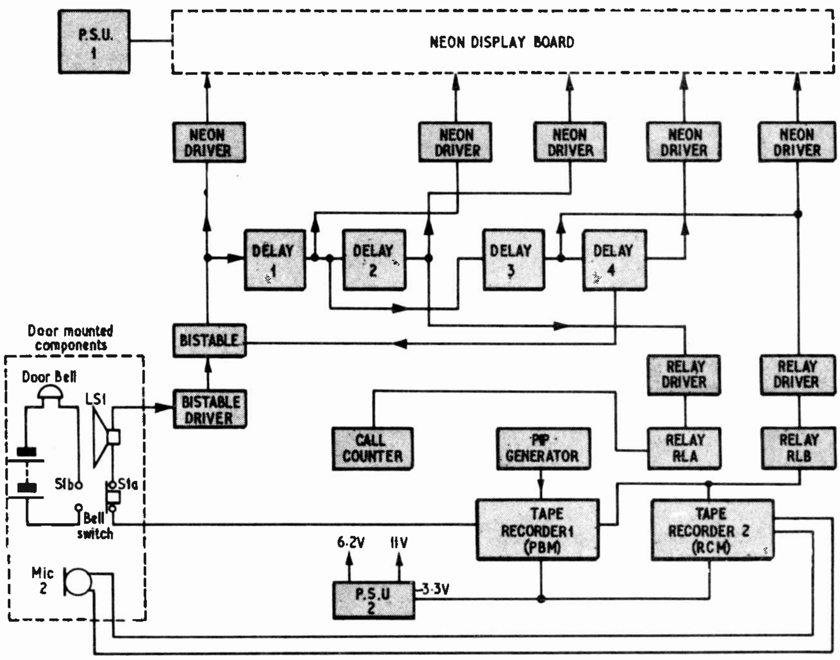


Fig. 1. Block diagram of Callercord

COMPONENTS . . .

Resistors

R1	47kΩ	R46	8·2kΩ
R2	4·7kΩ	R47	8·2kΩ
R3	4·7kΩ	R48	8·2kΩ
R4	3·3kΩ	R49	8·2kΩ
R5	8·2kΩ	R50	8·2kΩ
R6	8·2kΩ	R51	2·2kΩ
R7	3·3kΩ	R52	10kΩ
R8	4·7kΩ	R53	220Ω
R9	10kΩ	R54	47kΩ
R10	1kΩ	R55	1kΩ
R11	1kΩ	R56	10kΩ
R12	10kΩ	R57	10kΩ
R13	18kΩ	R58	1kΩ
R14	2·2kΩ	R59	1kΩ
R15	10kΩ	R60	18kΩ
R16	220Ω	R61	10kΩ
R17	10kΩ	R62	2·2kΩ
R18	18kΩ	R63	10kΩ
R19	120kΩ	R64	220Ω
R20	1kΩ	R65	68kΩ
R21	22kΩ	R66	1kΩ
R22	22kΩ	R67	18kΩ
R23	22kΩ	R68	10kΩ
R24	22kΩ	R69	120kΩ
R25	22kΩ	R70	220kΩ
R26	22kΩ	R71	680Ω 1W
R27	22kΩ	R72	5·6kΩ
R28	10kΩ	R73	270Ω
R29	1kΩ	R74	470Ω
R30	1kΩ	R75	68Ω 1W
R31	2·2kΩ	R76	12Ω 2½W
R32	10kΩ	R77	33Ω 1W
R33	220Ω	R78	33Ω 1W
R34	47kΩ	R79	120kΩ
R35	1kΩ	R80	22Ω 1W
R36	18kΩ	R81	4·7kΩ
R37	10kΩ	R82	220kΩ
R38	10kΩ	R83	220kΩ
R39	10kΩ	R84	4·7kΩ
R40	1kΩ	R85	4·7kΩ
R41	1kΩ	R86	27kΩ
R42	8·2kΩ	R87	27kΩ
R43	8·2kΩ	R88	10kΩ
R44	8·2kΩ	R89	22Ω
R45	8·2kΩ	R90	4·7kΩ

All ±10%, ¼W carbon

Capacitors

C1	0·1µF
C2	0·01µF
C3	0·01µF
C4	47µF elect 6V
C5	0·01µF
C6	470µF elect 6V
C7	0·01
C8	320µF elect 6V
C9	0·01µF
C10	10µF elect 6V
C11	0·01µF
C12	32µF elect 450V
C13	32µF elect 450V
C14	2,000µF elect 25V
C15	470µF elect 6V
C16	100µF elect 12V
C17	470µF elect 6V
C18	470µF elect 6V
C19	470µF elect 6V
C20	470µF elect 6V
C21	0·68µF
C22	0·68µF
C23	0·01µF
C24	0·01µF
C25	0·01µF

Potentiometers

VR1	10kΩ carbon linear
VR2	2·5kΩ carbon linear

Transistors

TR1	BC109	TR14	BC109
TR2	BC109	TR15	BC109
TR3	BC109	TR16	BC109
TR4	BC109	TR17	2N2102
TR5	2N2102	TR18	BC109
TR6	BC109	TR19	BC109
TR7	BC109	TR20	BC109
TR8	2N2102	TR21	BC109
TR9	BC109	TR22	2N2102
TR10	BC109	TR23	BC109
TR11	BC109	TR24	BC109
TR12	2N2102	TR25	2N3055
TR13	BC109	TR26–TR30	BC109 (5 off)

Diodes

D1–D6	IN914 (6 off)
D7–D8	OA91 (2 off)
D9	BY100
D10–D13	BYX22/200 (4 off)
D14	BZX61/C6V2
D15	BZY88/C6V2
D16	OA91
D17	BZX61/C5V6
D18–D20	IN914 (3 off)
D21–D22	BZY88/C3V3
D23–D25	OA91 (3 off)

Relays

RLA/RLB 6–12V, 185 ohms, 4 sets of change-over contacts, type PC4 (2 off)

Transformer

T1 230V Primary, 6·3V + 6·3V secondary. Hygrade Filament transformer

Solenoid

X1 12V Solenoid, thrust type operation

Counter

X2 12V, four figure electromagnetic counter

Switches

S1	Press to make and break
S2	Single pole 8-way rotary switch
S3	Single pole 10-way rotary switch
S4	D.P.D.T. mains toggle
S5	S.P.S.T. toggle
S6	S.P.S.T. toggle

Miscellaneous

LP1–LP5 Miniature 90V neons (5 off)
LP6 Mains indicator neon
"Parrot" Book-Corder tape recorders (2 off)
4¾in × 3½in, 0·1in matrix Veroboards (2 off)
4¾in × 3½in, 0·15in matrix Veroboard (1 off)
FS1-250mA antisurge fuse
Universal chassis 13in × 10in × 4in
½in × ½in angle aluminium, 13in long (2 off)
8-way edge connector sockets and plugs (5 off)
Octal plug and socket

mechanical rewind control. This works by rocking a double-ended motor on a pivot, one spindle driving forwards, and after rocking over, the other driving backwards. By slightly modifying the motor bracket and attaching a solenoid, automatic wind and rewind were easily achieved.

With the solenoid switched on, Recorder 1 drives forward, and backward when off. The supply line is switched over to relay RLB from RLA and is the power line to activate the solenoid. Thus when relay RLA is on, RLB has control of the direction of Recorder 1. To prevent the tape message being heard in reverse, RLB also switches off the loudspeaker during rewind.

The point at which Recordèr 1 switches into reverse is determined by another delay circuit (Delay 3) preset by an external switch to suit the length of message and initiated by the ending of Delay 1. At the end of Delay 3, RLB is turned off, so switching Recorder 1 to rewind, and Recorder 2 to record the incoming message, and at the same time switching off the external speaker.

ADDITIONAL DELAYS

Ideally the machine should sense the right moment at which to switch off Recorder 2. This could be done by sensing the pause after the caller has finished speaking, but it could be subject to error, either because of the caller hesitating too long between sentences, or because of possible noises from the street. Consequently, switching off is achieved by again using an externally preset time delay (Delay 2) which is usually preset to give about 40 seconds of recording time, though it can be set to give other times if necessary. For the sake of con-

CALLERCORD CONTROL CIRCUIT

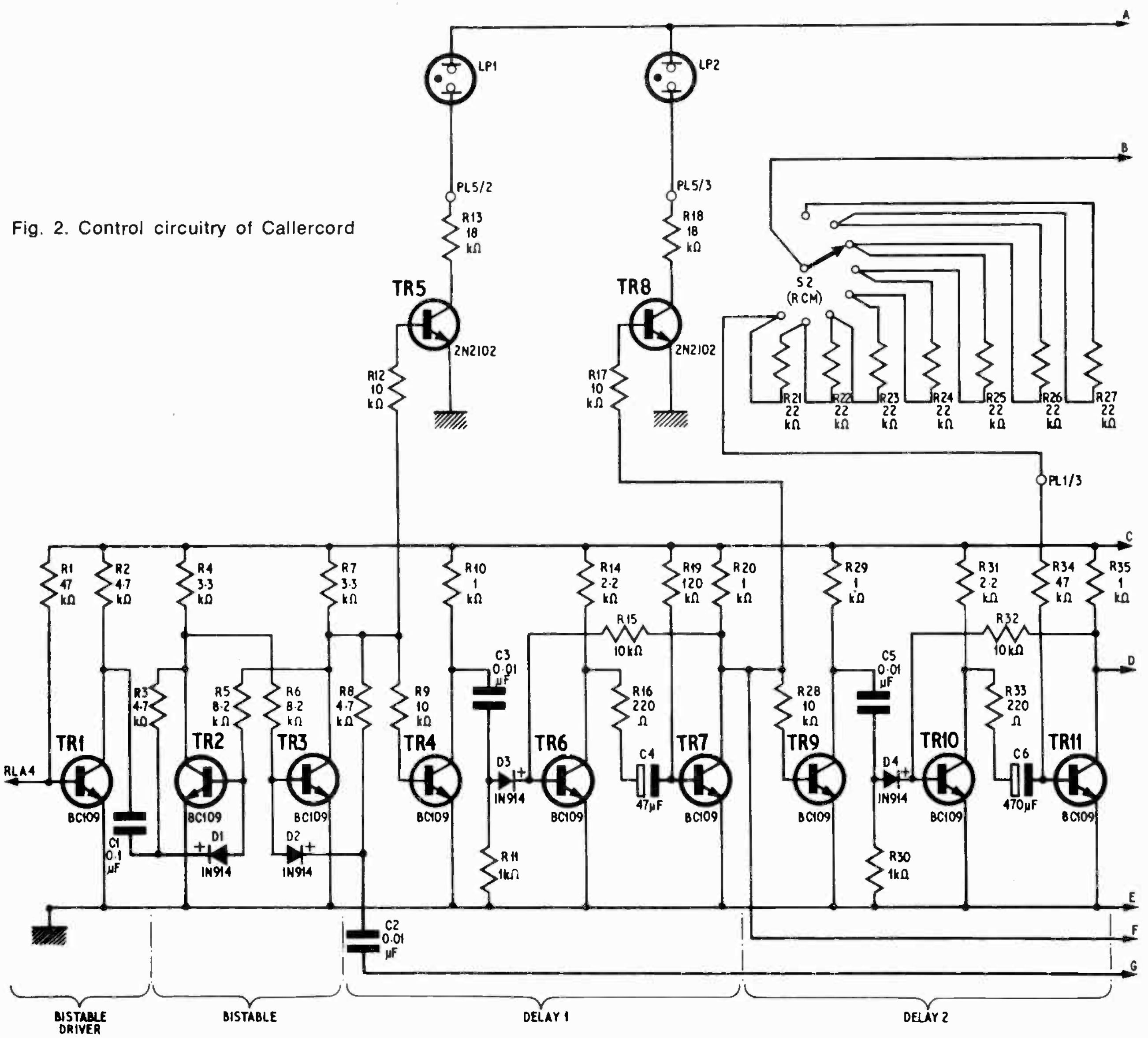


Fig. 2. Control circuitry of Callercord

venience this delay is also started by the ending of Delay 1.

At the end of Delay 2, several things happen. Relay RLA is switched off, so switching off the power to the recorders and solenoid. Although Recorder 1 has by this time rewound the tape, it still has its motor on. While the motor is unable to turn and is drawing maximum current, it will come to no harm during the short time that this condition prevails. Relay changeover also means that the speaker leads are also switched back into circuit with the control input, and the call counter, which clocks up incoming calls, is disconnected.

The ending of Delay 3 initiates a fourth delay circuit (Delay 4) which allows a short pause and then sends the open signal to the gate. The cycle is now complete, and the circuit is ready to receive the next caller.

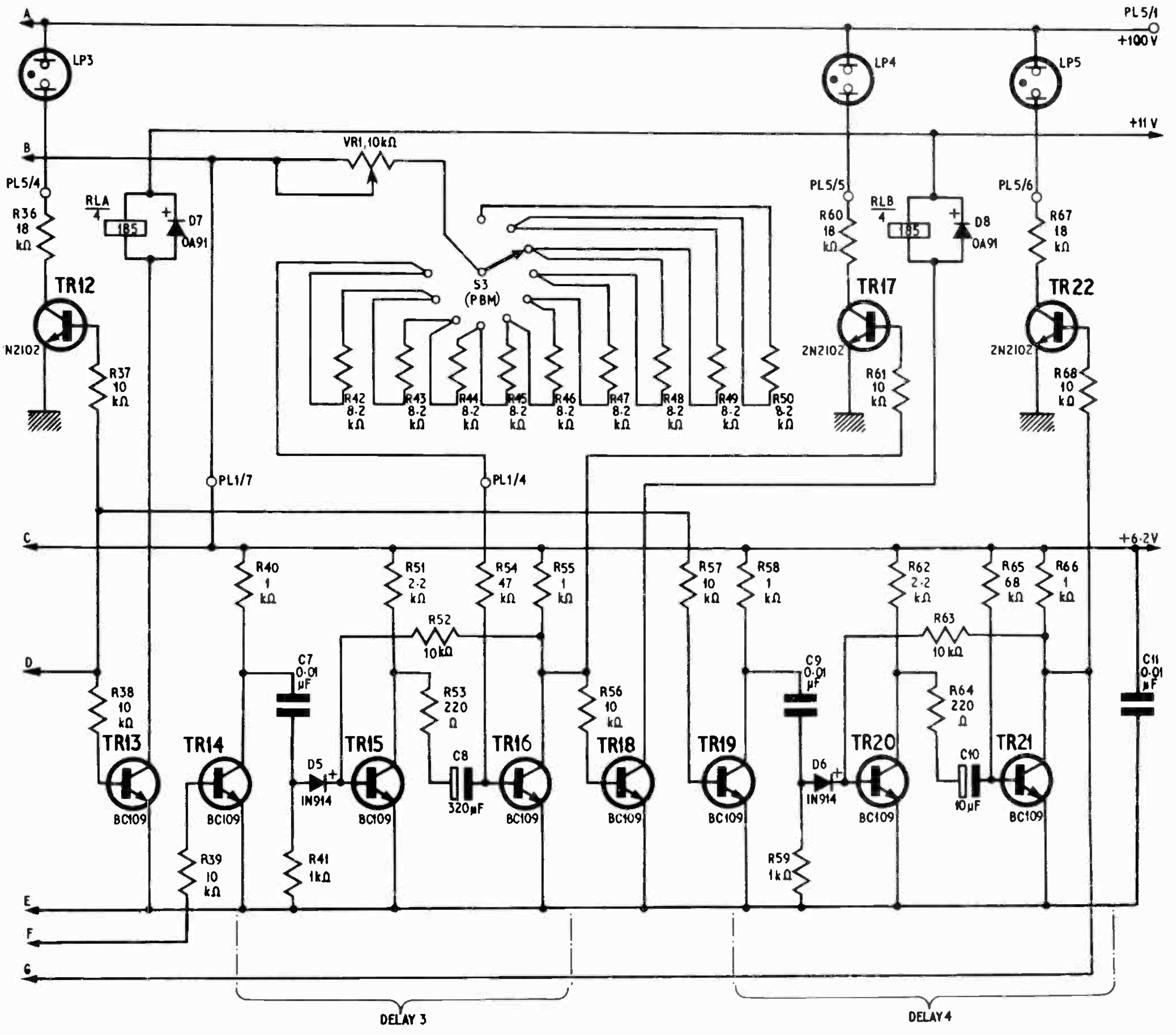
NEON INDICATORS

All of the various processes in the control chain are indicated by five neon lamps. Besides providing a visual check-out for correct functioning of the stages, they facilitate delay time settings.

CONTROL CIRCUIT ACTION

The start pulse is derived in a very simple manner as seen in the control circuit of Fig. 2. The base of TR1 is taken to earth via the leads of the external speaker, so holding TR1 off. In series with the speaker is placed a switch which is normally closed. The same press switch has two normally off contacts which are in series with the door bell. On pressing the switch, the bell is rung and the base of TR1 is disconnected from earth.

When this happens, the base of TR1 is made positive through R1 and a negative going collector



voltage is passed as a pulse via C1 to the bistable circuit, so triggering it into its opposite state. The negative going voltage change of TR3 is inverted by TR4 and this drives the monostable circuit (Delay 1) into its quasistable state with TR7 collector negative going. The voltage change is inverted by TR9 and is passed as a pulse to trigger the monostable, Delay 2. The transistor TR13 then conducts thus turning on relay RLA.

The voltage change of TR7 is also inverted by TR14 and passed as a pulse to trigger Delay 3 monostable, so turning on relay RLB. When TR16 reverts to its stable state, TR18 ceases to conduct; this relay switches off. When TR11 reverts to its stable state, TR13 ceases to conduct, turning off relay RLA. This second voltage change of TR11 is inverted by TR19 and triggers Delay 4

As TR21 stabilises, it passes a pulse to TR3 reverting the bistable gate to its original state. The control circuit is then receptive to the next start pulse.

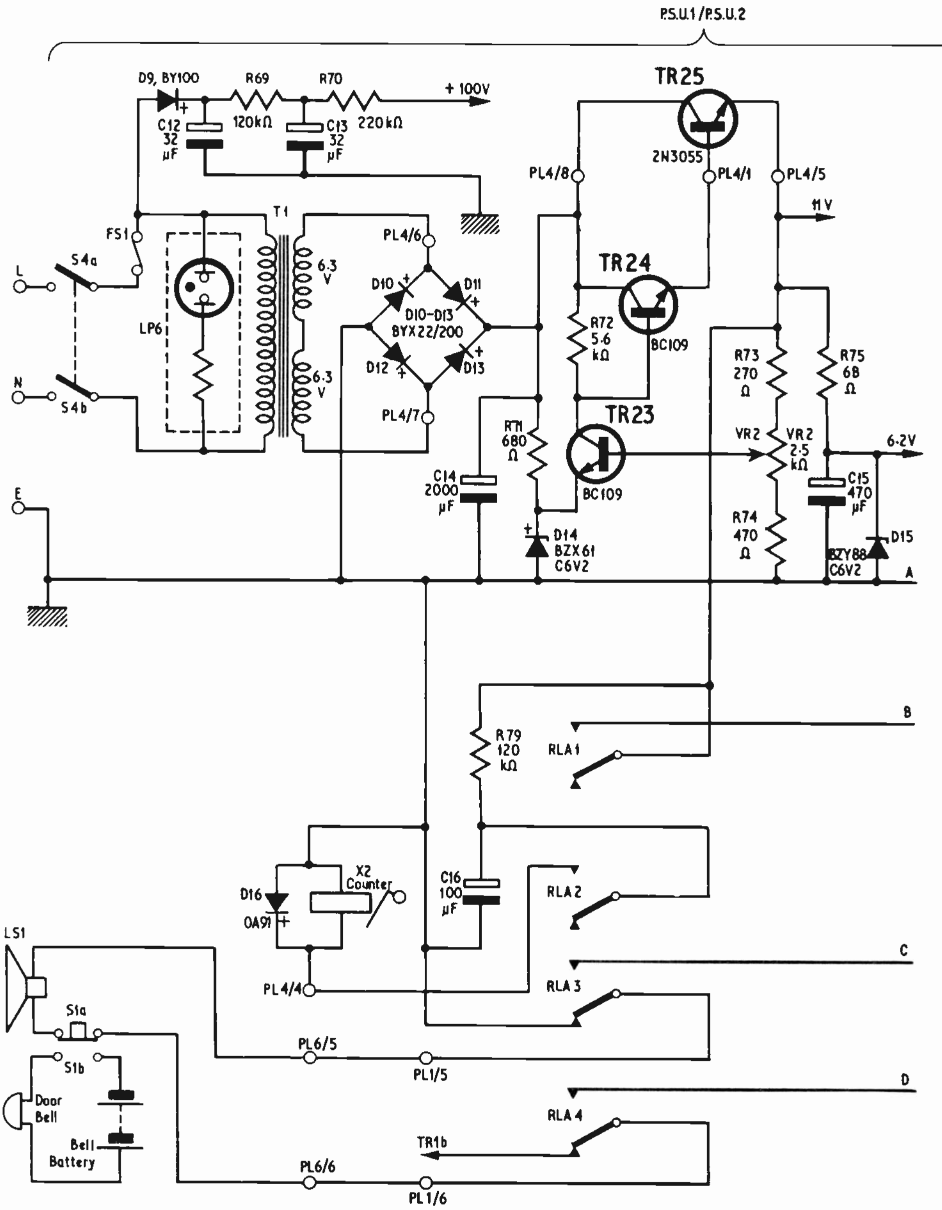
VARYING THE DELAY TIME

The switching time of the delay circuits 2 and 3, may be changed by controlling the charge rate of the respective timing capacitor by switching in resistors. With Delay 3 fine control is achieved by using a variable resistor in series with the switch S3.

PULSE SUPPRESSION

The diodes that are used with the relays, solenoid, and recorder motors are vital to the smooth functioning of the control circuits, for at the moment of switching off a coil, a back e.m.f. is developed which by feeding back along the power line could influence

CALLERCORD POWER SUPPLIES



other circuits, and in the case of the monostables and bistable, could be large enough to trigger them into their opposite states.

POWER SUPPLIES

The main power supply (Fig. 3) has the transformer secondary windings connected to give 12·6V a.c. which is rectified and smoothed, and the resulting d.c. supplies the stabilising circuit which has its output voltage set at 11V. The 11V supplies the relays, solenoid and counter, and is also sub-divided and dropped to give 6·2V for the transistor circuits, −3·3V for the tape amplifiers, −3·3V for the motor of Recorder 1, and as a convenience, a switchable −1½V/−4V to allow Recorder 2 to move slowly for recording, and fast for rewinding.

Something not foreseen was the fact that the nominal rectified voltage of about 18V with no load, drops down to about 13·5V under full load. This is due mainly to distortions occurring in the a.c. waveform from the transformer secondary windings, and partly due to the impedance of the transformer and rectifiers. As the stabilising circuit needs a voltage drop of at least 2V across it to give adequate stabilising, the output voltage has been set at 11V to allow for the full load condition. If a 15V transformer had been available, then the stabilised voltage would have been set at 12V. However, this is not an important point as the solenoid does not need to have an accurately controlled supply, and the 11V fed to the 12V relays is still within their operating range of 8V to 17V.

Next month: Full constructional details for the Callercord.

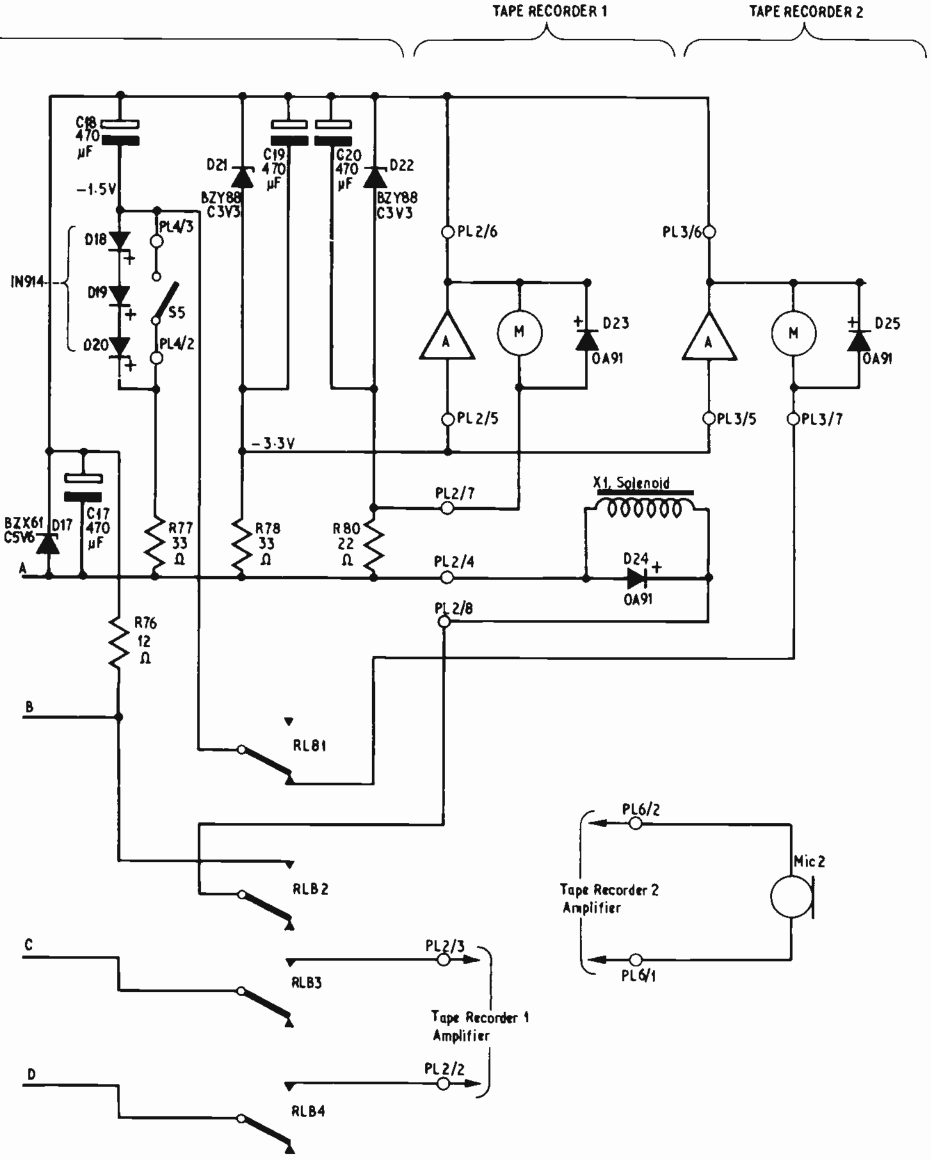


Fig. 3. Power supplies and relay contact inter-wiring

PATENTS REVIEW...

IMPROVING POWER AMPLIFIERS

TRANSISTOR power amplifiers for broadcast transmitters normally use output stages with a pair of transistors working in "push-pull". The transistors can be biased into class A, AB or B and the type of bandwidth required is usually 1·5MHz to 30MHz.

In British Patent 1 257 550 the Marconi Company Ltd. explain how the design requirements for a transformer to couple balanced transistors to an unbalanced aerial are mutually conflicting. Some factors dictate a large transformer with a large number of turns while other factors dictate a small transformer with a small number of turns.

The Marconi patent is directed to a transmitter power amplifier with an auto-transformer having a centre tapped primary winding. The output transistors are connected in push-pull to feed the centre tap and in addition a conventional transformer is used, the secondary winding of the auto-transformer being connected to the primary of this conventional transformer and the output taken from its secondary.

By using an auto-transformer a much lower leakage inductance may be achieved than with a conventional transformer for the same power handling requirements. Closer matching of the output impedance of the transistors may also be obtained. The use of a conventional transformer provides the necessary function of impedance transference and conversion from a balanced to an unbalanced load.

Fig. 1a shows such a circuit compared with its equivalent in Fig. 1b. The power transistors TR1 and TR2 feed the centre-tapped auto-transformer T1 which in turn feeds the conventional transformer T2 coupled to the aerial. The capacitances of C2, C3 and C4 are, in part, formed by stray capacitances and in part by capacitors.

As the equivalent circuit Fig. 1b shows (L1, 2 and L3, 4 being the leakage inductances of the auto-transformer and the conventional transformer respectively), the arrangement functions as a low-pass filter with a top cut-off equivalent to the highest frequency transmitted. The capacitances and inductances require careful selection but the overall advantages can be low leakage despite high power handling and good conversion from balanced to unbalanced load. There will also be tight coupling between the push and pull sides of the windings and isolation of the load from the transistor supply voltage.

BP 1 257 550

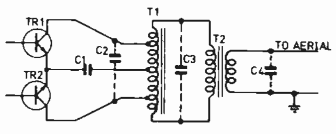


Fig. 1a

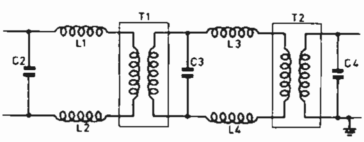


Fig. 1b

NEON NOVELTY

PLANS for an attractive recreational device of the type that is sometimes written off as "a gift for someone who has everything" are to be found in British Patent 1 257 288, in the name of Roger Saunders.

The idea is to envelope neon lamps in a block of transparent plastics with the circuitry for periodically illuminating them in a block of opaque plastics. See Fig. 1.

It is perhaps not generally recognised that if sufficient neon lamps are flashed in a complicated sequence, the psychological effect can be that the flashing is non-periodic and non-repetitive. By hiding the circuitry and batteries in opaque plastics, the layman is even more confused.

Saunders illustrates eight neon lamps and four cells buried in acrylics. In the simple circuit diagram given (see Fig. 2), the neons are shown all paralleled across the battery of cells. Each neon is bridged by a capacitor and the pairs of paralleled neons and capacitors are each in series with a resistor. The neons can be divided into groups and, for instance, in one group be connected across capacitors of one value (0·22μF) and in the other group be connected across capacitors of another value (0·47μF). In each of these two groups different value resistors are used (e.g. 5·6, 7·5, 8·2 and 10 megohms).

Where the triggering voltage of the neons is 86 volts the inventor suggests a battery voltage of 90 volts. Battery life may well be several years with the low current requirements of the neons.

Certainly not a world-shattering technical breakthrough, but a worthwhile addition to the currently fashionable range of useless but attractive functional objects.

BP 1 257 288

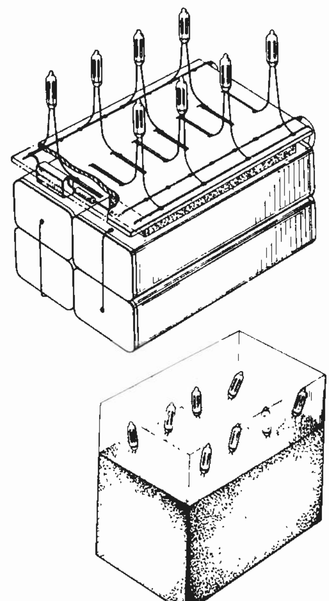


Fig. 1

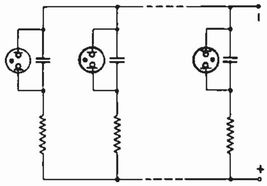
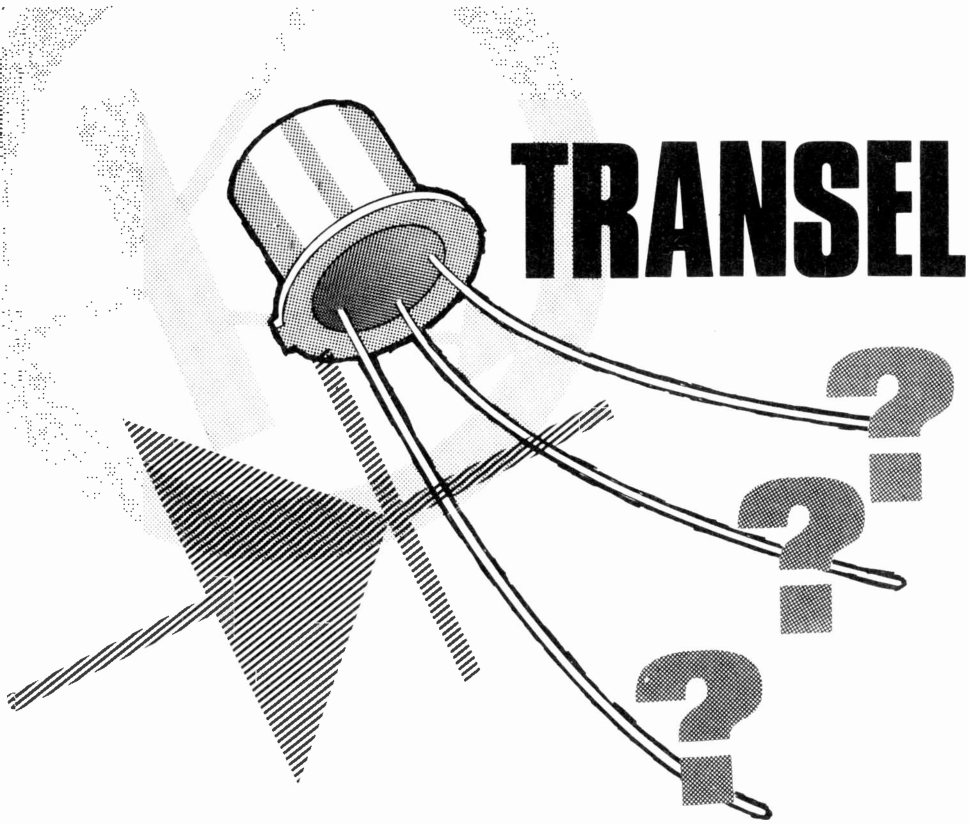


Fig. 2



TRANSELECTOR

LOGIC SEMICONDUCTOR IDENTIFIER

By T. P. SCHOFIELD

PROBABLY one of the cheapest ways for an amateur to obtain transistors is to buy a pack of "unmarked, untested transistors" and test them himself. This is useful for experimental work in which a large number of transistors is required which need not conform to a particular stringent specification.

This automatic transistor selector is designed to test batches of such transistors quickly and simply; it also tests diodes, since an inoperative transistor can frequently be used as an excellent diode.

The device to be tested is plugged into a transistor holder; the selector indicates by lighting lamps whether it is a *pnp, npn,* or a diode with anode at collector socket, or diode with anode at emitter socket. The logic functions required to ascertain these properties are performed by TTL logic i.c.s in the SN74N series.

It seems possible that with additions to its circuitry the selector could perform more complex tests to separate transistors with a particular frequency response or gain.

TESTING PRINCIPLES

The tests applied are shown in Fig. 1, assuming of course that lead connections are established. Transistors are tested by biasing them as shown—in a common-emitter mode logic circuit—and feeding in a test signal. With a *pnp* transistor, if A is at about +4V then C should be driven to about 0V; if A is at about 0V then C should be at about +4V. The same is true of an *npn* transistor in its circuit.

For the diode test, a square wave of alternately 0V and +4V is applied to $\overline{B}$. A diode in the test socket with its anode in the collector terminal, and

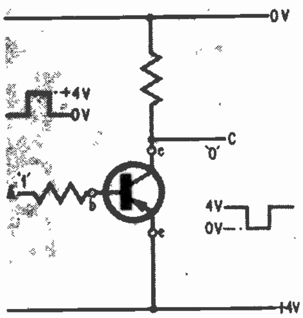


Fig. 1a. A logic "1" to the base and a "0" at collector will indicate a *pnp* transistor when emitter is at +4V

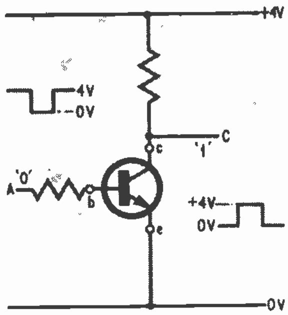


Fig. 1b. A logic "0" to the base and a "1" at collector will indicate an *npn* transistor when emitter is at 0V

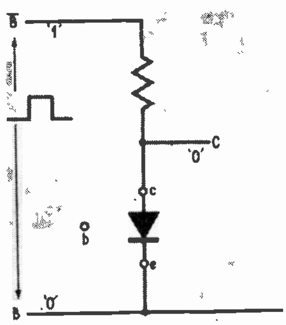


Fig. 1c. Diode polarity (cathode to "e" terminal) when logic 1 fed into $\overline{B}$ line gives 0 at C

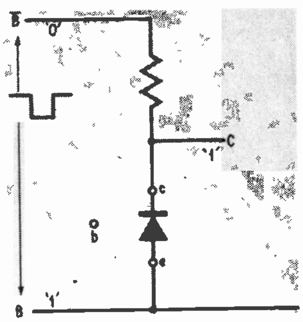
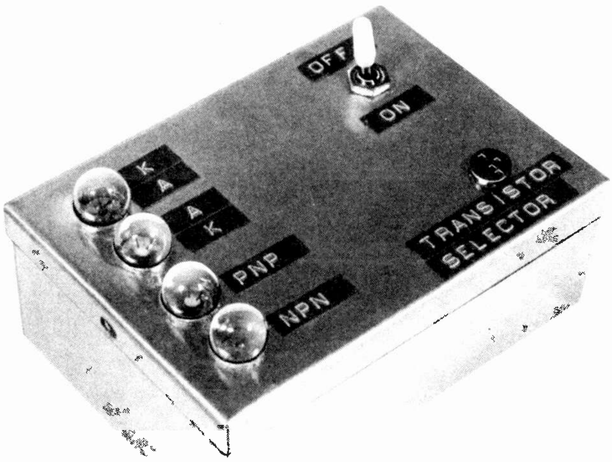


Fig. 1d. Diode polarity (anode to "e" terminal) when logic 0 at $\overline{B}$ gives 1 at C

In both Figs. 1c and 1d, both B and $\overline{B}$ lines are floating



its cathode in the emitter terminal, will conduct only when $\overline{B}$ is positive relative to B and C will be at 0V. A diode the other way round will conduct only when $\overline{B}$ is negative relative to B and C will be at a steady 4V.

WORKING LOGIC CIRCUIT

The complete circuit diagram of the unit is shown in Fig. 2.

The timebase for the test waveform is derived from a Schmitt triggered multivibrator formed by half of IC1. This circuit, a clock pulse generator, is very reliable, simple to construct using only two external components, and produces an output designed to be compatible with TTL circuits and variable from 10MHz down by changing the value of C1. It is possible to use other oscillators, but they must produce a very square wave or the transistor under test may be triggered differently from the remaining logic circuitry, producing a false result.

The output of the clock pulse generator (labelled A in Fig. 2) is fed to one half of an SN7474N—dual edge-triggered type D flip-flop—arranged to divide by two. The true and inverted outputs of this flip-flop, called B and $\overline{B}$ in the diagrams, are used to bias the emitter and collector terminals of the transistor under test. The output of the oscillator is supplied as a test signal to the base of this transistor.

As B changes the transistor is biased as shown in Fig. 1 for testing *pnp* and *npn* transistors and diodes. Thus the waveform appearing at C contains all the necessary information about the device under test. This is amplified by TR1 so that it is acceptable to TTL inputs. The truth table (Table 1) shows what the voltage ($\overline{C}$) at the collector of TR1 should be when different devices are tested. The truth table shows the logic states 0 and 1 representing 0V and +4V respectively.

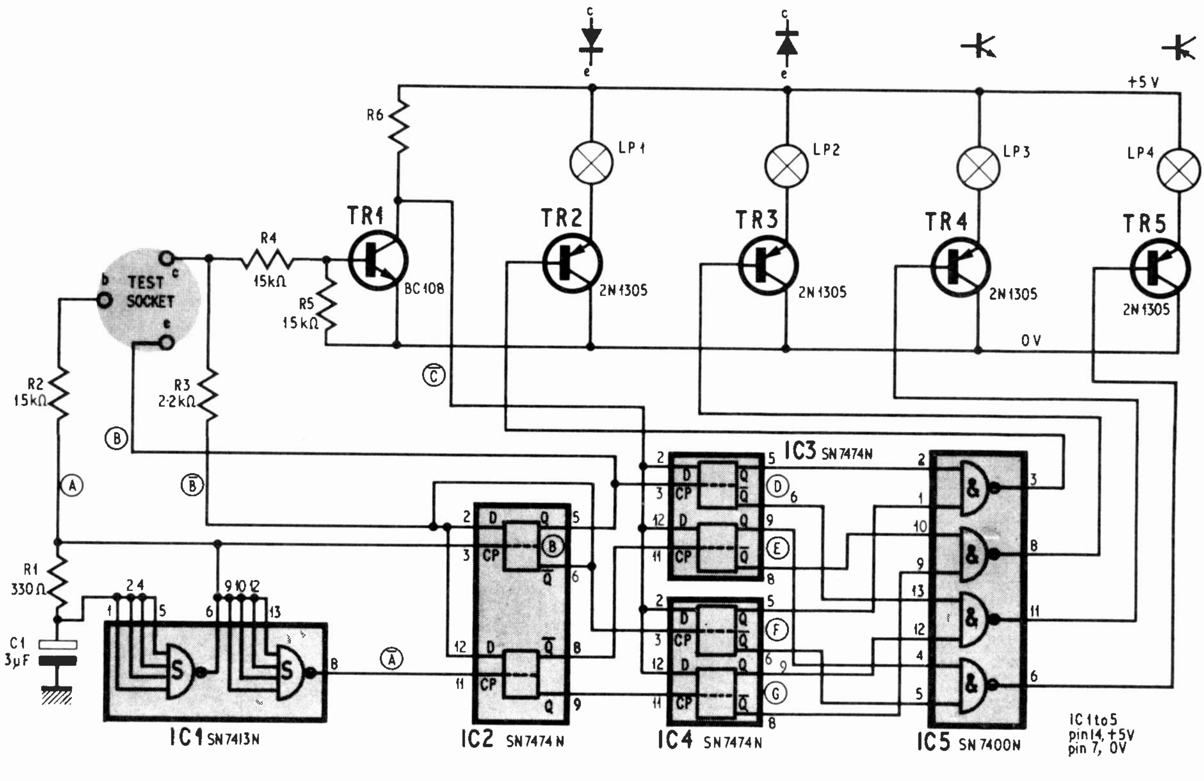


Fig. 2. Circuit diagram of logic transistor and diode identifier

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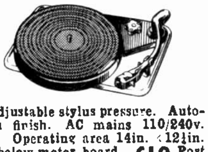

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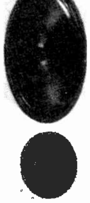

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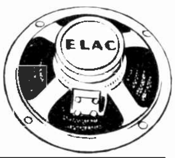

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16/450V	15p	1000/50V	47p	32+32/450V	33p
32/450V	20p	8+8/450V	18p	350+50/325V	50p
25/25V	10p	8+16/450V	20p	32+32+32/350V	43p
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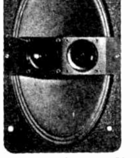

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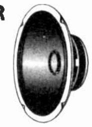

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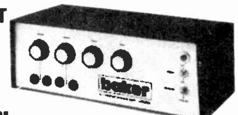

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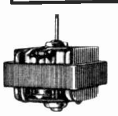

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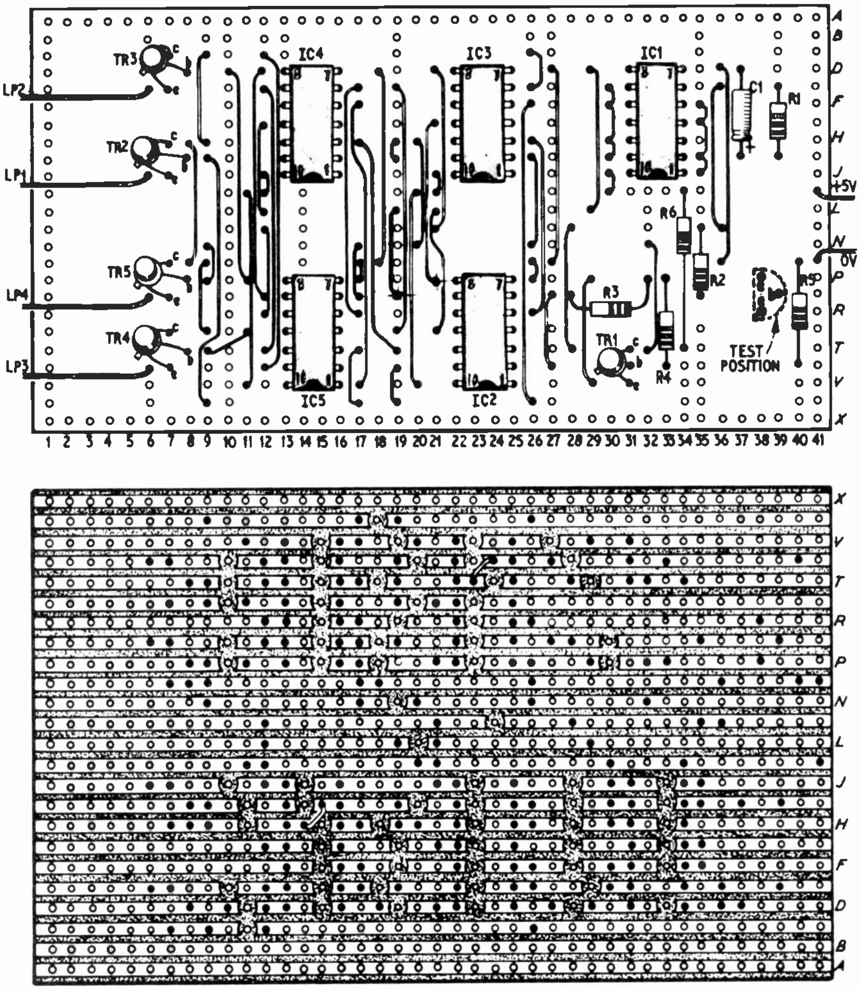


Fig. 3. Suggested circuit layout on Veroboard

COMPONENTS . . .

Resistors
R1 330Ω
R2 15kΩ
R3 2·2kΩ
R4 15kΩ
R5 15kΩ
All ±10%, ¼W carbon

Transistors
TR1 BC108
TR2 to TR5 2N1305 (4 off)

Integrated Circuits
IC1 SN7413N
IC2 to IC4 SN7474N (3 off)
IC5 SN7400N

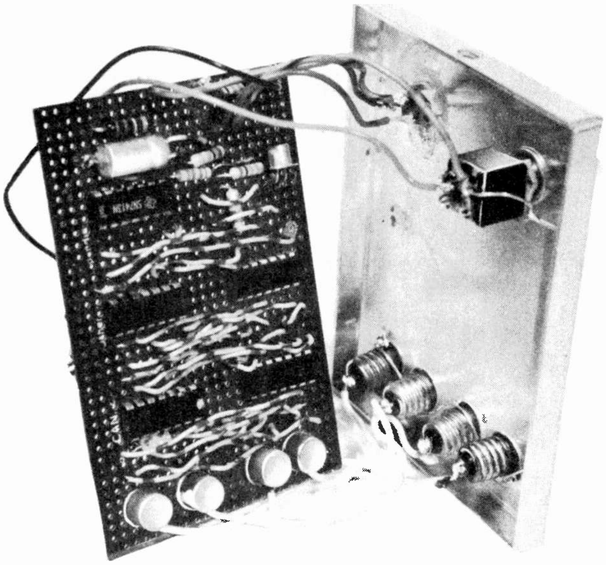
Miscellaneous
C1 3μF elect 10V
LP1 to LP4 6V 40mA
B1 6V battery
Veroboard 0·1in matrix 5in × 2½in

DECODER

The value of $\overline{C}$ for each state of the testing waveforms A and B are stored in the flip-flops D, E, F, G in IC3 and IC4. (The SN7475N quad flip-flop is not suitable as it is not edge-triggered and its clock-inputs are joined in pairs).

When A goes positive, and the value of B changes, either D or F will be clocked; when A goes negative, and the other flip-flop in IC2 follows B, then either E or G will be clocked. This arrangement involves fewer extra i.c.s than one which tries to decode A and B. The inputs of these storage flip-flops are interpreted by ordinary 2-input NAND gates in IC5 according to the truth table. The particular functions chosen make it impossible for the selector to indicate that it is testing a transistor and a diode simultaneously.

The outputs from IC5 operate lamps indicating the sort of device placed in the test socket, through buffer transistors TR2 to TR5. It may well be found that the SN7400N seems able to light the lamps directly, but is not recommended due to the risk of overloading the gates. Two SN7440N circuits, replacing the SN7400N, could pass the current



without harm if preferred, so making the extra buffers unnecessary.

PRACTICAL LAYOUT

The circuit is easily built on a piece of 0·1in matrix Veroboard, as shown in Fig. 3. This diagram shows the complete layout as seen from the top component side. The copper strips should be broken where indicated. Then those wire links which occur under IC2 and IC4 should be made.

The integrated circuits can be soldered to the board at this stage, and also the resistors.

Next all the link connections shown should be made. It is easiest by far to use single-core, plastic sleeved wire for this. Alternatively the connections could be made with 22 s.w.g. tinned copper wire and separate sleeving.

Finally, the connection wires leading to the battery and bulbs and then the transistors can be soldered in. The prototype was not fitted in a box and the bulbs were consequently just soldered onto the wires, but this is of course a personal preference.

The test socket used, fitted directly onto the board as shown in Fig. 3, but it had four sockets and the two corresponding to the base of a transistor were first soldered together. The socket could be fixed on the outside of a case and joined to the appropriate points on the board by three wires if desired.

POWER SUPPLY

A 6 volt battery seems the ideal power source for the transistor selector, but any adequately smoothed supply of 500mA at 5V would be suitable. The unit takes about 60mA quiescent current so the battery should be disconnected by a switch when not in use.

Table 1: TRUTH TABLE OF THE LOGIC DETECTOR

A	$\overline{A}$	B	$\overline{B}$	Entry into flip-flop	State of $\overline{C}$ for Transistor npn	State of $\overline{C}$ for Transistor pnp	State of $\overline{C}$ for Diode Cathode to c	State of $\overline{C}$ for Diode Cathode to e
1	0	0	1	G	1	x	0	1
0	1	0	1	D	0	x	0	1
1	0	1	0	E	x	1	0	1
0	1	1	0	F	x	0	0	1

Note: x indicates insignificant state

It will be noticed that the 6V bulbs are considerably under-run at less than 5V. It was found, however that their indication was still quite clear (since they are always full on or full off) so the provision of 5V bulbs or a separate 6V power supply (which would involve a design change in the output stages) was not thought worthwhile.

TESTING

To test the unit when it is built, the power supply is connected. None of the lamps should stay on (but one might flicker once as the circuits start operating). Check that the appropriate pins of all the i.c.s are connected to the power supply. Place a diode in the test socket; one of the "diode" lamps should light. If it does not, check the operation of the circuit from the multivibrator on. (The multivibrator may be slowed by connecting a much larger capacitor in parallel with C1.) When the selector has been made to operate properly with a diode, a transistor may be tried on it. Short circuits caused by solder runs are the most likely cause of a fault.

Only one light should come on at a time, and it should not flicker. A flickering lamp indicates a poorly decoupled power supply, an exhausted battery or a faulty connection. Two lamps should not normally both light at the same time. If they do the fault is probably in the wiring supplying IC5. If the wrong lamp lights, one of a number of faults may be responsible and the whole circuit should be checked starting with IC1.

It is probably worthwhile trying out this tester on known transistors and diodes to ascertain correct functioning. ★

POINTS ARISING

VERSATILE LIGHT EFFECTS UNIT *(June 1972)*

In Fig. 5 the connections for the base and emitter of TR1 and TR4 should be reversed.

CHARGER POWER UNIT *(June 1972)*

The mains connections shown in Fig. 1 must be strictly adhered to. In Fig. 2, mains line should be the connection to FS1; neutral to S1b. Reversal of these connections could result in live mains potential appearing at SK2.

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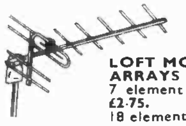

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NEWS BRIEFS

Into the Light

ANOTHER company announces its move into that "most exciting field for the next decade", optical-electronics. FR Electronics of Wimborne, Dorset, was formed in 1963 as a division of Flight Refuelling. First specialising in the manufacture of reed switches, FR Electronics has since expanded its interest in timers, special relays, and a.c. controllers. Now the Company is moving into this newest emerging market with a broad range of opto devices, including visible light sources and infra-red emitters, solid state detectors, optical coupled isolators, and digital readout displays.

In the main, FR Electronics will be marketing devices manufactured by other firms, but they have entered into an agreement with Opto-Electronics of Dallas, Texas, U.S.A. to manufacture this American Company's products under licence.

Computer-Aided Design

THE second conference and exhibition on computer aided design CADEX '72 was held at Southampton University during April. The joint organisers were, as in 1969, The Institution of Electrical Engineers and the Electronics Engineering Association.

Foremost among the exhibitors were Redac Software Ltd, who specialise in design services for the electronics industry. Computer Programmes (Software) are provided for use in customers' computers, bringing a powerful design tool to the aid of any establishment with suitable computer facilities. The programmes cover: *logic simulation*, so that an inter-connected system can be adjusted and modified until satisfactory operation is achieved. *Circuit Analysis*, of large networks. *Circuit Layout* for Printed Circuit Board Design and for micro-electronics. Key feature of this software is its use of interactive graphics to ensure that the optimum results are achieved by the interaction of the designer with the computer via a light pen.

Computer-Aided Design (CAD) is not only a tool for the electronics industry. This was emphasised by the exhibit of DA Computer Services (part of an international engineering organisation involved in the design and construction of industrial installations for manufacturing industries). This firm provides a similar service for mechanical and structural engineers. The design of gear wheels, the layout of pipe systems, calculation of stresses in beams and frames, are some typical examples of the engineering programmes supplied.

Automated draughting systems are an essential part of CAD. Flatbed plotters can draw complex wiring diagrams or P.C.B. artwork masters in minutes, from data stored in a computer. Calcomp Ltd. demonstrated their latest model, the 7800 flatbed system which can ink write on paper or mylar, and scribe or cut on two layer films.

The Ferranti Interactive Freedcraft System produces input data for controlling automatic draughting machines or numerically controlled machine tools. It uses a "digitiser" to convert graphical or pictorial information into digital form for computer input. This operates on an electro-magnetic system of position measurement, offers no drag to manual movements, and gives the operator complete freedom to follow complex curves or irregular shapes smoothly and accurately.

Many CAD users require access to remotely located computers, and so it was no surprise to see the Post Office in attendance. Circuits for computing data transmission are provided by the Post Office and a number of different services are offered, via the public telephone network, the Telex System, or by telegraph private circuits.

Readout—
A SELECTION FROM OUR POSTBAG

Correspondents wishing to have a reply must enclose a stamped addressed envelope. We regret we are unable to guarantee a reply on matters not relating to articles published in the magazine. Technical queries cannot be dealt with on the telephone.

Fit for the mind

Sir,—With reference to Mr D. Bollen's letter on "Brainwave Reinforcement" I find that I must strongly disagree with the points he raised.

Firstly, he declares that Mr Brown's idea does not work. Well, I built the circuit and (although not exactly as described in the article) obtained a reasonable degree of success.

Secondly, Mr Bollen says alpha waves are produced by all normal persons. In fact, approximately 20 per cent of the "normal" persons do not produce alpha waves at all.

And finally he says that the subject must have his eyes closed and his mind blank to produce these waves. If Mr Bollen had watched the BBC programme *Horizon* he would have seen a young boy being taught how to prevent epileptic fits by CONCENTRATING on a row of lights and lighting successive bulbs by alpha wave production.

I hope all the other readers of Mr Bollen's letter have not been discouraged from building Mr Brown's very interesting idea.

K. Reed,
Northumberland.

Matter of opinion

Sir,—On reading my May issue of P.E. I was very interested in the book review of "Guide to Printed Circuits" by G. J. King.

I am in complete disagreement with your reviewer's findings.

I have read every one of Mr King's books both published under his name and his Nom-de-plume and I thought that this book was his best practical book by far. The information on printed circuit substitutes was alone worth the cost of the book. The description of soldering and de-soldering methods was practical and informative.

Your reviewer forgot that a soldering iron is the basic tool of the enthusiastic amateur and the better the tools we have the better the finished job contrary to the opinions of Mr Lewis, (was it not) I consider that this is a *must* for the serious constructor and is a worth while contribution to the literature of the subject.

I have no connection with Mr King and I have never met or seen him.

D Fisher,
Middlesex

Required by law

Sir,—Having been a caravanner for some 20 years, I was particularly horrified to read Mr L. Musworth's suggestion in the *Ingenuity Unlimited* pages of your April edition of P.E.

The heavy duty flasher units that one buys for use on caravans and trailers have an extra terminal, which is connected to an extra warning lamp, which, when mounted within view of the towing vehicle's driver, flashes *only* when the load of a third (trailer flashing indicator) lamp is connected in parallel to the lamps of the towing vehicle.

This warning lamp *or* an audible system is required by law, and must indicate that the filament of the trailer's flasher is not open-circuit. It is not enough to know that volts are being sent to it, by connecting an indicator lamp in parallel with the trailer flasher filament.

The other drawback with the circuit is that the vehicle's flasher unit is used in series with the front and rear flasher lights, which are returned to earth at the respective sockets. This then would necessitate connecting an extra "live" lead from the fuse box (at the front of most vehicles), to an auxiliary set of relay contacts.

This circuit is, however, superfluous, as it still breaks the law. I am afraid that all this means that one must buy the correct item—whatever the price!!!

W. A. Rawcliffe,
Teddington.

Carbon leads

Sir,—With reference to the letter from Mr H. D. Briggs, in the May issue of PRACTICAL ELECTRONICS, I am well aware that the majority of modern cars are fitted with carbon string h.t. leads. My own car is fitted with such leads and has run on the "Scorpio" system for over 12,000 miles without any trouble whatsoever. Trouble will only occur if the leads are in poor condition, and if this is the case they should be replaced whatever system used.

I sympathise with his concern for the reliability of car electronics, but he isn't likely to get any useful opinion from a car electrician. Most of these have no knowledge of electronics beyond that required to change a bulb.

D. S. Gibbs.

NOTE: We regret that due to a printer's omission, the formula at the end of Mr G. A. Cozens' letter last month was not complete. The last line should read:

$$R = \frac{R3}{R4} \times R2$$

BACK NUMBERS WANTED

Anyone who can supply the undermentioned are asked to communicate directly with the reader.

We regret that back numbers of Practical Electronics can no longer be supplied. We will try to publish announcements of readers' requirements (without a guaranteed date) free of charge.

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Mr. N. Ley, 78, Limeside Avenue, Rutherglen, Glasgow.

September 1965
Mr. A. Copsey, 1, Ashwood Gardens, Gildersome, Leeds.

April 1966
Mr. R. D. Morrison, Dalkeith, Woodham Road, Woking, Surrey.

March 1972
Mr. D. Lawrence, 8, Stringers Drive, Radborough, Stroud, Glos.

June to August, November and December 1971
Mr. J. B. Corben, 14, Wricklemarsh Road, Blackheath, London, SE3 0NF.

November 1970 to February 1971
Mr. R. A. Scholey, 36, Burlingham Avenue, West Kirby, Wirral, Cheshire, L48 8AP.

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Mr. J. E. Barnett, 18, Swindell Road, Pedmore, Stourbridge, DY9 0TL.

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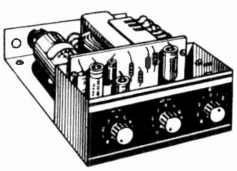

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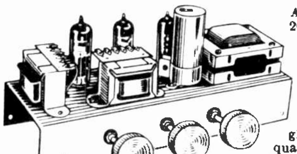

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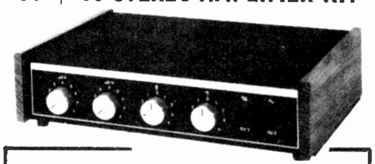

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Fully detailed 7-page construction manual and parts list free with kit or send 18p plus large S.A.E.

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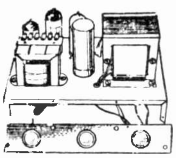
Note: The above amplifier is suitable for feeding two mono sources into inputs (e.g. mike, radio, twin record decks, etc.) and will then provide mixing and fading facilities for medium powered Hi-Fi Discotheque use, etc.

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 7½in w. × 4in. d. × 4¾in. 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 **£4·75**. P. & P. 35p.

HSL "FOUR" AMPLIFIER KIT. Similar in appearance to HA34 above but employs entirely different and advanced circuitry. Complete set of parts, etc. **£3·98**. P. & P. 40p.

HARVERSON'S SUPER MONO AMPLIFIER

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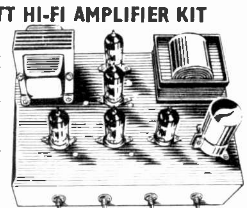
10/14 WATT HI-FI AMPLIFIER KIT



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 13p (Free with parts). **All parts sold separately.** ONLY **£7·97**. P. & P. 55p.

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Project 60 Stereo F.M. Tuner

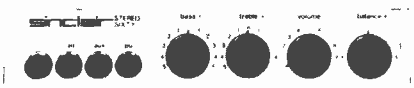
Built and tested. Post free. **£25**

The phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio. Now, Sinclair have applied the principle to an F.M. tuner with fantastically good results. Other original features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stereo decoder and squelch circuit for silent tuning between stations. In terms of a high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically as the tuning control is rotated, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with most other high fidelity systems.

SPECIFICATIONS—Number of transistors: 16 plus 20 in I.C. **Tuning range:** 87.5 to 108 MHz. **Capture ratio:** 1.5dB. **Sensitivity:** $7\mu V$ for lock-in over full deviation. **Squelch level:** $20\mu V$. **Signal to noise ratio:** > 65dB. **Audio frequency response:** 10 Hz – 15 KHz (±1dB). **Total harmonic distortion:** 0.15% for 30% modulation. **Stereo decoder operating level:** $2\mu V$. **Cross talk:** 40dB. **Output voltage:** 2 x 150mV R.M.S. **Operating voltage:** 25-30 VDC. **Indicators:** Stereo on : tuning. **Size:** 93 x 40 x 207mm.

Stereo 60 Pre-amp/control unit

Built, tested and guaranteed. **£9.98**

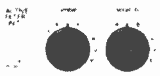


Designed for Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout, achieving a really high signal-to-noise ratio and excellent tracking between channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs.

SPECIFICATIONS—Input sensitivities: Radio – up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A curve ±1dB :20 to 25,000 Hz. Ceramic p.u. – up to 3mV: Aux – up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE + 12 to —12dB at 10 KHz: BASS + 12 to —12dB at 100Hz. **Front panel:** brushed aluminium with black knobs and controls. **Size:** 66 x 40 x 207mm.

A.F.U. High & Low Pass Filter Unit

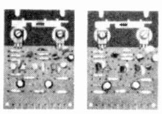
Built tested and guaranteed. **£5.98**



For use between Stereo 60 unit and two Z.30s or Z.50s, and is easily mounted. It is unique in that the cut-off frequencies are continuously variable, and as attenuation in the rejected band is rapid (12dB/octave), there is less loss of the wanted signal than has previously been possible. Amplitude and phase distortion are negligible. The A.F.U. is suitable for use with any other amplifier system. Two filter stages – rumble (high pass) and scratch (low pass). Supply voltage – 15 to 35V. Current – 3mA H.F. cut-off (—3dB) variable from 28KHz to 5KHz. L.F. cut-off (—3dB) variable from 25Hz to 100Hz. Distortion at 1KHz (35V. supply) 0.02% at rated output. **Size:** 66 x 40 x 90 mm.

Z.30 & Z.50 power amplifiers

Built, tested and guaranteed with circuits and instructions manual. **Z.30 £4.48** **Z.50 £5.48**

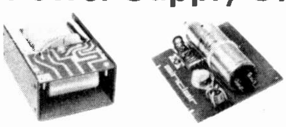


The Z.30 and Z.50 are of advanced design using silicon epitaxial planar transistors to achieve unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0.02% at 15w (8Ω) and all lower outputs. Whether you use Z.30 or Z.50 amplifiers in your Project 60 system will depend on personal preference, but they are the same size and may be used with other units in the Project 60 range equally well.

SPECIFICATIONS *(Z.50 units are interchangeable with Z.30s in all applications).*

Power Outputs
Z.30 15 watts R.M.S. into 8 ohms using 35 volts · 20 watts R.M.S. into 3 ohms using 30 volts.
Z.50 40 watts R.M.S. into 3 ohms using 40 volts: 30 watts R.M.S. into 8 ohms using 50 volts.
Frequency response: 30 to 300,000Hz ±1dB.
Distortion: 0.02% into 8 ohms.
Signal to noise ratio: better than 70dB unweighted.
Input sensitivity: 250mV into 100 Kohms (for 15w into 8Ω)
For speakers from 3 to 15 ohms impedance.
Size: 14 x 80 x 57 mm.

Power Supply Units



Designed special for use with the Project 60 system of your choice. Use PZ.5 for normal Z.30 assemblies and PZ 6 where a stabilised supply is essential.

PZ.5 *30 volts unstabilised* **£4.98**
PZ.6 *35 volts stabilised* **£7.98**
PZ.8 *45 volts stabilised (less mains transformer)* **£7.98**
PZ.8 *mains transformer* **£5.98**

Guarantee

If within 3 months of purchasing Project 60 modules directly from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter. No charge for postage by surface mail. Air-mail charged at cost.

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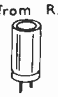

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CA3018A	1·10	0·99	CA3056	1·20	1·07
CA3019	0·84	0·75	CA3056A	3·19	2·85
CA3020	1·26	1·13	CA3059	1·65	1·46
CA3020A	1·60	1·43	CA3060	4·91	4·37
CA3021	1·56	1·39	CA3062	2·55	2·27
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CA3022	1·30	1·16	CA3065	1·20	1·07
CA3023	1·26	1·13	CA3066	2·11	1·88
CA3026	1·00	0·90	CA3067	2·18	1·94
CA3026PRE	1·00	0·90	CA3068	2·43	2·16
			CA3070	1·70	1·51
CA3028A	0·74	0·65	CA3071	1·62	1·44
CA3028B	1·05	0·94	CA3072	1·66	1·48
CA3029	0·67	0·77	CA3075	1·13	1·00
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2N2217	27½p
2N2218	23p
2N2219	23p
2N2220	25p
2N2221	25p
2N2222	30p
2N2287	£1·07½
2N2297	30p
2N2368	17½p
2N2369	17½p
2N2369A	17½p
2N2410	42½p
2N2483	27½p
2N2484	32½p
2N2539	22½p
2N2540	22½p
2N2613	35p
2N2614	30p
2N2646	52½p
2N2696	32½p
2N2711	25p
2N2712	25p
2N2713	27½p
2N2714	30p
2N2865	62½p
2N2904	30p
2N2904A	32½p
2N2905	37½p
2N2905A	40p
2N2906	25p
2N2906A	27½p
2N2907	30p
2N2923	15p
2N2924	15p
2N2925	15p
2N2926	
.. Green	14p
.. Yellow	12½p
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2N3011	30p
2N3014	32½p
2N3053	18p
2N3054	46p
2N3055	62p
2N3133	30p
2N3134	30p
2N3135	25p
2N3136	25p
2N3390	25p
2N3391	20p
2N3391A	30p
2N3392	17½p
2N3393	15p
2N3394	15p
2N3402	22½p
2N3403	22½p
2N3404	32½p

2N3405	45p
2N3414	22½p
2N3415	22½p
2N3416	37½p
2N3417	37½p
2N3570	£1·25
2N3572	97½p
2N3605	27½p
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2N3607	22½p
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2N3706	9p
2N3707	11p
2N3708	7p
2N3709	9p
2N3710	9p
2N3711	12p
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2N3791	£2·06
2N3819	35p
2N3823	97½p
2N3854	27½p
2N3854A	27½p
2N3855	27½p
2N3855A	30p
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2N3900A	40p
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2N3905	37½p
2N3906	37½p
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2N4059	10p
2N4060	12½p
2N4061	12½p
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2N4244	47½p
2N4285	17½p
2N4286	17½p
2N4287	17½p
2N4288	17½p
2N4289	17½p
2N4290	17½p
2N4291	17½p
2N4292	12½p
2N4303	47½p
2N5027	52½p
2N5028	57½p
2N5029	47½p
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2N5175	52½p
2N5176	45p
2N5232A	30p
2N5245	45p
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2N5249	67½p
2N5265	£3·25
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2N5267	£2·62½
2N5305	37½p
2N5306	40p
2N5307	37½p
2N5308	37½p
2N5309	62½p
2N5310	42½p
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2N5355	27½p
2N5356	32½p
2N5365	47½p
2N5366	32½p
2N5367	57½p
2N5457	37½p
2S005	75p
2S020	£2
2S102	50p
2S103	25p
2S104	25p
2S501	32½p
2S502	35p
2S503	27½p
3N128	70p
3N139	£1·27½
3N140	77½p
3N141	72½p
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3N143	67½p
3N152	87½p
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40050	55p
40244	22½p
40251	87½p
40309	32½p
40310	45p

40311	35p
40312	47½p
40314	37½p
40320	47½p
40323	32½p
40324	47½p
40326	37½p
40329	30p
40344	27½p
40347	57½p
40348	52½p
40360	42½p
40361	47½p
40362	57½p
40370	32½p
40406	57½p
40407	40p
40408	52½p
40410	62½p
40467A	57½p
40468A	35p
40600	57½p
40673	85p
AC107	30p
AC126	20p
AC127	25p
AC128	20p
AC154	22½p
AC176	25p
AC187	62½p
AC188	37½p
ACY17	27½p
ACY18	25p
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ACY20	25p
ACY21	25p
ACY22	20p
ACY28	20p
ACY40	20p
ACY41	25p
ACY44	40p
AD140	52½p
AD149	57½p
AD150	62½p
AD161	87½p
AD162	37½p
AF106	42½p
AF114	25p
AF115	25p
AF116	25p
AF117	25p
AF118	62½p
AF119	20p
AF124	22½p
AF125	20p
AF126	20p
AF127	17½p
AF139	37½p
AF178	42½p
AF179	72½p
AF180	52½p
AF181	42½p
AF239	42½p
AF279	47½p
AF280	62½p
AFZ11	32½p
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ASY27	37½p
ASY28	27½p
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BC107	10p
BC108	10p
BC109	10p
BC113	15p
BC115	15p
BC116A	15p
BC118	10p
BC121	20p
BC122	20p
BC125	20p
BC126	20p
BC140	37½p
BC147	10p
BC148	10p
BC149	12p
BC152	17½p
BC157	20p
BC158	11p
BC159	12p
BC160	62½p
BC167	11p
BC168B	10p
BC168C	11p
BC169B	11p
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BC171	15p

BC172	15p
BC175	22½p
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BC183	9p
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BC212L	13p
BCY30	27½p
BCY31	30p
BCY32	50p
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BCY43	15p
BCY54	32½p
BCY58	22½p
BCY59	22½p
BCY60	97½p
BCY70	20p
BCY71	25p
BCY72	17½p
BCZ10	27½p
BCZ11	42½p
BD116	£1·12½
BD121	65p
BD123	82½p
BD124	60p
BD131	75p
BD132	85p
BDY10	£1·37½
BDY11	£1·62½
BDY17	£1·50
BDY18	£1·75
BDY19	£1·97½
BDY20	£1·12½
BDY38	97½p
BDY60	£1·25
BDY61	£1·25
BDY62	£1
BF115	25p
BF117	47½p
BF163	37½p
BF167	18p
BF173	19p
BF177	30p
BF178	30p
BF179	30p
BF180	35p
BF181	32½p
BF184	25p
BF185	42½p
BF194	17½p
BF195	15p
BF196	42½p
BF197	42½p
BF198	42½p
BF200	52½p
BF224	14p
BF225	19p
BF237	23p
BF238	23p
BF244	23p
BFW58	27½p
BFW59	25p
BFW60	25p
BFW61	47½p
BFX12	22½p
BFX13	22½p
BFX29	30p
BFX30	30p
BFX43	37½p
BFX44	37½p
BFX68	67½p
BFX84	25p
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BFX86	25p
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BFX89	62½p
BFX93A	70p
BFY10	32½p
BFY11	42½p
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BFY24	45p
BFY25	25p
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BFY29	50p
BFY30	50p
BFY41	50p
BFY43	62½p
BFY50	23p
BFY51	20p
BFY52	23p
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BFY75	30p
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BPX25	£1·85
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BRY39	47½p
BSW41	42½p

BSW70	27½p
BSX19	17½p
BSX20	17½p
BSX21	37½p
BSX26	45p
BSX27	47½p
BSX28	32½p
BSX60	82½p
BSX61	62½p
BSX76	22½p
BSX77	27½p
BSX78	27½p
BSX78	27½p
BSY10	27½p
BSY11	27½p
BSY24	15p
BSY25	15p
BSY26	17½p
BSY27	17½p
BSY28	17½p
BSY29	17½p
BSY32	25p
BSY36	25p
BSY37	25p
BSY38	22½p
BSY39	22½p
BSY51	32½p
BSY52	32½p
BSY53	37½p
BSY54	40p
BSY56	90p
BSY78	47½p
BSY79	45p
BSY82	52½p
BSY90	57½p
BSY95A	12½p
C111	75p
C424	27½p
C425	55p
C426	40p
C428	37½p
C744	30p
D13T1	62½p
D16P1	37½p
D16P2	40p
D16P3	37½p
D16P4	40p
D40N1	75p
GET102	30p
GET113	20p
GET114	20p
GET118	20p
GET119	20p
GET120	52½p
GET873	12½p
GET880	30p
GET887	20p
GET889	22½p
GET890	22½p
GET896	22½p
GET897	22½p
GET898	22½p
MJ400	£1·07½
MJ420	£1·12½
MJ421	£1·12½
MJ430	£1·02½
MJ440	95p
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MJ481	£1·25
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MJ491	£1·37½
MJ1800	£2·17½
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NKT128	27½p
NKT135	27½p
NKT137	32½p
NKT210	30p
NKT211	30p
NKT212	30p
NKT213	30p
NKT214	22½p
NKT215	22½p
NKT216	37½p
NKT217	42½p
NKT219	30p
NKT223	27½p
NKT224	25p
NKT225	22½p
NKT229	30p
NKT237	35p

NKT238	25p
NKT240	27½p
NKT241	27½p
NKT242	20p
NKT243	62½p
NKT244	17½p
NKT245	20p
NKT261	20p
NKT262	30p
NKT264	20p
NKT271	20p
NKT272	20p
NKT274	20p
NKT275	20p
NKT281	27½p
NKT401	87½p
NKT402	90p
NKT403	75p
NKT404	62½p
NKT405	75p
NKT406	62½p
NKT451	62½p
NKT452	62½p
NKT453	47½p
NKT603F	32½p
NKT613F	32½p
NKT674F	30p
NKT677F	30p
NKT713	25p
NKT781	30p
NKT10419	30p
NKT10439	37½p
NKT10519	32½p
NKT20329	47½p
NKT20339	37½p
NKT80111	77½p
NTK80112	97½p
NKT80113	£1·12½
NKT80211	92½p
NKT80212	92½p
NKT80213	92½p
NKT80214	92½p
NKT80215	92½p
NKT80216	92½p
OC20	75p
OC22	50p
OC23	60p
OC24	60p
OC25	50p
OC26	27½p
OC28	62½p
OC29	62½p
OC35	50p
OC36	62½p
OC41	22½p
OC42	25p
OC44	20p
OC45	12½p
OC46	15p
OC70	15p
OC71	12½p
OC72	12½p
OC74	32½p
OC75	22½p
OC76	22½p
OC77	30p
OC81	20p
OC81D	22½p
OC83	25p
OC84	25p
OC139	32½p
OC140	32½p
OC170	30p
OC171	30p
OC200	40p
OC201	60p
OC202	75p
OC203	42½p
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P346A	22½p
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TIS34	62½p
TIS43	40p
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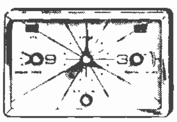
15 AMP ELECTRICAL PROGRAMMER



Learn in your sleep. Have radio playing and kettle boiling as you awake, switch on lights to ward off intruders, have warm house to come home to. All these and many other things you can do if you invest in an electrical programmer clock by famous maker with 15 amp on/off switch. Switch on time can be set anywhere to stay on up to 6 hours. Independent 60 minute memory jogger. A beautiful unit. Price **£1·95** + 20p p. & p. or with glass front chrome bezel 75p. extra.

TREASURE TRACER MARK II

Complete Kit (except wooden battens) to make the metal detector similar to the circuit in Practical Wireless August issue. **£2·95** plus 20p post and insurance.

QUICK CUPPA

Mini Immersion Heater, 350W, 200/240V. Boils full cup in about two minutes. Use any socket or lamp holder. Have at bedside for tea, baby's food, etc. **£1·25**, post and insurance 14p. 12V car model also available same price. Jug heater **£1·50** plus p. & p. 14p.

SNAP ACTION SLIDE SWITCH

Rated 5a. 240v. Made by Arrow. Type fitted in the handles of electric drills, vacuums, etc. **5p** each, 10 for **45p**.

NUMICATOR TUBES

For digital, instruments counters, timers, clocks, etc. Hi-vac XN. 3, Price **£1 45** each. 10 for **£13**.

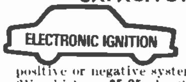
12 WAY SUB-MINIATURE MULTI-CORE CABLE

7·0076 copper cores each core P.V.C. insulated and of different colour. P.V.C. covered overall and approx. 3/16in. thick. Price **20p** per yard.

LIGHT CELL

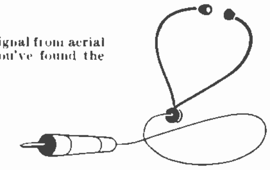
Almost zero resistant in sunlight increases to 10 K Ohms in dark or dull light, epoxy resin sealed. Size approx. 1in. dia. by ¼in. thick. Rated at 500 MW, wire ended. **43p** with circuit. Also ORP 12 light cell **45p**.

CAPACITOR DISCHARGE CAR IGNITION



This system which has proved to be amazingly efficient. We offer a kit of parts as PW circuit **£5·95** + 20p. De-luxe model with prepared circuit boards **£6·95**. When ordering please state whether for positive or negative systems. Also available, ready made ignition systems for 6V vehicles. **£5·25** plus 20p.

RADIO STETHOSCOPE



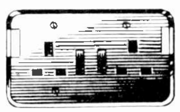
Easiest way to fault find—traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece. **£2**—twin stethoset instead of earpiece **75p** extra—post and ins. 20p.

STANDARD WAFER SWITCHES

Standard size 1¼ wafer—silver-plated 5-amp contact standard ¼" spindle 2" long—with locking washer and nut.

No. of Poles	2 way	3 way	4 way	5 way	6 way	8 way	9 way	10 way	12 way
1 pole	40p	40p	40p	40p	40p	40p	40p	40p	40p
2 poles	40p	40p	40p	40p	40p	40p	40p	70p	70p
3 poles	40p	40p	40p	40p	70p	70p	70p	95p	95p
4 poles	40p	40p	40p	70p	70p	70p	70p	£1·20	£1·20
5 poles	40p	40p	70p	70p	95p	95p	95p	£1·45	£1·45
6 poles	40p	70p	70p	70p	95p	95p	95p	£1·70	£1·70
7 poles	70p	70p	70p	95p	£1·20	£1·20	£1·20	£1·95	£1·95
8 poles	70p	70p	70p	95p	£1·20	£1·20	£1·20	£2·20	£2·20
9 poles	70p	70p	95p	95p	£1·45	£1·45	£1·45	£2·45	£2·45
10 poles	70p	70p	95p	£1·20	£1·45	£1·45	£1·45	£2·70	£2·70
11 poles	70p	95p	95p	£1·20	£1·70	£1·70	£1·70	£2·85	£2·95
12 poles	70p	95p	95p	£1·20	£1·70	£1·70	£1·70	£3·20	£3·20

THIS MONTH'S SNIP
13 AMP TWIN GANG SOCKETS



Offered at less than wholesale price your opportunity to replace those dangerous adaptors—brown bakelite flush mounting standard fitting. Unswitched **20p** each, separately switched **30p** each. Separately switched and with neon on/off indicators **45p** each. Less 10% ten or more + 20p postage if order under £5.

THYRISTOR LIGHT DIMMER

For any lamp up to 1kW. Mounted on switch plate to fit in place of standard switch. Virtually no radio interference. Price **£2·50**, plus 20p post and insurance.

MULLARD AUDIO AMPLIFIER MODULE

Uses 4 transistors, and has an output of 500mW into ohms speakers. Input suitable for crystal mic. or pick-up. 9V battery operated. Size 2in long × 1¼in wide × 1in high. SPECIAL SNIP PRICE **60p** each. 10 for **£5**.

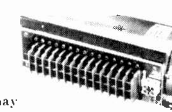
HORSTMANN "TIME & SET" SWITCH

(A 30 Amp Switch.) Just the thing if you want to come home to a warm house without it costing you a fortune. You can delay the switch on time of your electric fires, etc., up to 14 hours from setting time or you can use the switch to give a boost on period of up to 3 hours. Equally suitable to control processing. Regular price probably around £5. Special snip price **£1·50**. Post and ins. **23p**.

MOTORISED COMPRESSORS

Ex mains operated frig. units. There should be plenty of applications for these and we invite customers' suggestions. Our price is **£3 each**—carriage, etc., 50p. These are complete with starting relay and are sold as being in good order but untested.

HONEYWELL PROGRAMMER



This is a drum type timing device, the drum being calibrated in equal divisions for switch setting purposes with trips which are infinitely adjustable for position. They are also arranged to allow 2 operations per switch per rotation. There are 15 changeover micro switches each of 10 amp type operated by the trips thus 15 circuits may be changed per revolution. Drive motor is mains operated 5 revs per min. Some of the many uses of this timer are Machinery control, Boiler firing, Dispensing and Vending machines, Display lighting animated and signs, Signalling, etc. Price from makers probably over £10 each. Special snip price **£5·75** plus 25p post and insurance. Don't miss this terrific bargain.

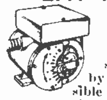
INTEGRATED CIRCUIT BARGAIN

A parcel of integrated circuits made by the famous Plessey Company. A once-in-a-lifetime offer of Micro electronic devices well below cost of manufacture. The parcel contains 5 IC's all new and perfect, first-grade device, definitely not sub-standard or seconds. 4 of the ICs are single silicon chip GP amplifiers. The 5th is a monolithic NPN matched pair. Regular price of parcel well over **£5**. Full circuit details of the IC's are included and in addition you will receive a list of many different IC's available at bargain prices 25p upwards with circuits and technical data of each. Complete parcel only **£1** post paid. *DON'T MISS THIS TERRIFIC BARGAIN.*

BATTERY CONDITION TESTER

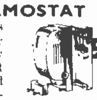
Made by Mallory but suitable for all batteries made by Ever Ready and others, most of which are zinc carbon types but also mercury manganese—nicad—silver oxide and alkaline batteries may be tested. The tester puts a dummy load on the battery and the meter scale indicates the condition depending upon which section the pointer rests. The section reads "replace" "weak" or "good". The tester is complete in its case, size 3½in × 6¼in × 2in with leads and prods. Price **£1·75** plus 20p postage.

ZPM—MODULATION MOTOR



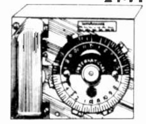
Could also be used to open ventilators, doors, valve, damper, etc., particularly suitable for remote control. Made by Satchwell. Essentially a reversible geared motor fitted with internal limit switches to stop it at the end of its travel. Size approx. 6in × 6in × 5½in and weighing approx. 10lb. This is extremely powerful and would lift a heavy door or open a long line of ventilators. To operate this motor you put the 50 cycle supply through a change over switch. For instance a thermostat with changeover contacts could automatically regulate the temperature in a growing house, chicken hatchery etc. An indicator on the motor gradnated 0–10 shows the state of open or close. Also internally fitted is a variable resistor, wires from this to a volt meter would give a remote indication of the open or close position. A very expensive motor if bought direct from Satchwell, our price complete with step down Transformer is **£15**.

CHANGE-OVER THERMOSTAT



Satchwell type QX. This is ideal for working with the Satchwell ZPM. Extremely accurate in operation. Neat modern design in gold finished metal case with external temperature setter. These are set for the range 10°–25°C but the setting is adjustable by an internal screw to make it suitable for other temperature ranges. This is an expensive Thermostat. Our price however is only **£4·50**.

24-HOUR TIME SWITCH



Made by Smiths, these are ac mains operated, NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. 2 completely adjustable time periods per 24 hours, 5 amp changeover contacts will switch circuit on or off during these periods. **£2·50**, post and ins. 23p. Additional time contacts **50p** pair.

EDUCATIONAL KITS
all with pictorial instructions

THIS BALANCE KIT FREE

Eagle educational kits. Japanese made these are excellent value for money. We do not expect to be able to repeat this offer once stocks are sold. Brief description of each kit is given below and with 3 kits or more we give FREE an accurate 11 piece balance kit Price of kits **40p** each post paid. Special price for all 7 kits **£2·50** with free balance kit.

KA2 Lens kit. Eleven parts, including candle, one concave lens, one convex lens, stage and slit frame, etc. Watch light rays bend as they pass through different lenses.

KA3 Water Pump Kit. Thirteen parts. Top of pump is transparent so that operating parts may be observed. Small parts are brightly coloured to be seen easily while working. Three types of pump may be made: Lift pump, Force Pump and Force Pump with reservoir and nozzle.

KA4 Buzzer Kit. Eleven parts. Transparent covers allow the operation of buzzer to be seen. Illustrates and teaches how electromagnetism with an automatic switch results in an operating buzzer.

KA6—3-Pole Motor Kit. Twenty-four parts, including enamel wire, armature and pole piece, etc. Motor operates from 1½V battery. Illustrates and teaches how electro-magnetism operates a motor.

KA7 Electro-Magnet Kit. Fifteen parts, includes compass. Makes two electro-magnets, one with one layer of wire and one with several layers of wire. Picks up tacks, nails and any small metal parts showing how magnetism works.

KA8 Current and Resistance Kit. Twenty-nine parts, including bench and light bulb. Conduct interesting and educational projects to learn the application of "OHMS LAW" and see the difference in current and resistance with different types and lengths of wire.

KA9 Bell Kit. Eight parts, including bell and push button switch. Build a complete electric bell and see how the hammer is triggered to make the bell ring.

PULSE GENERATORS

Sectronic, made by Smiths. Operated by single 1·5V battery or transformer and rectifier. Two models, one gives 10 pulses per second the other gives 8. In plastic enclosures, size approx. 2in × 1¾in × 1¼in deep. Price **£2** each 10 for **£18**.

MAINS TRANSFORMER SNIPS

Mains Transformer. Primary 240V tapped 220V. Secondary 20V ½ amp. Price **60p** each or 10 for **£5·40**.

Transformer. Primary 230–240V. Secondary 6·5-0-6·5 1 amp. With fitted primary screen **65p** each or 10 for **£5·85**.

Where postage is not stated then orders over £5 are post free. Below £5 add **20p**. Semi-conductors add 5p post. Over £1 post free. S.A.E. with enquiries please.

J. BULL (ELECTRICAL) LTD.

(Dept. P.E.), 7 Park Street, Croydon CRO IYD

Callers to: 102/3 Tamworth Road, Croydon.

Also see next two pages

SEMI-CONDUCTORS/VALVES
ALL DEVICES BRAND NEW AND FULLY GUARANTEED

Transistors

		2N3415	22p	2N5458	35p	BC114	15p	BFW90	22p	NKT219	30p
		2N3416	37p	2N5459	40p	BC115	15p	BFW91	20p	NKT223	27p
2G301	20p	2N3417	37p	2S102	25p	BC116	15p	BFX12	22p	NKT224	22p
2G302	20p	2N3439	130p	2S103	25p	BC118	15p	BFX13	22p	NKT225	22p
2G303	20p	2N3440	97p	2S104	25p	BC119	30p	BFX29	25p	NKT229	30p
2G306	42p	2N3564	17p	2S301	50p	BC121	20p	BFX30	25p	NKT237	35p
2G308	30p	2N3565	15p	2S302	50p	BC122	20p	BFX37	30p	NKT238	25p
2G309	30p	2N3566	22p	2S303	60p	BC125	15p	BFX44	37p	NKT240	27p
2G371	15p	2N3568	25p	2S304	75p	BC126	20p	BFX68	67p	NKT241	27p
2G374	20p	2N3569	25p	2S501	32p	BC134	12p	BFX84	25p	NKT242	20p
2G381	22p	2N3570	125p	2S502	35p	BC135	12p	BFX85	30p	NKT243	62p
2N388A	49p	2N3572	97p	2S503	27p	BC136	15p	BFX86	25p	NKT244	17p
2N404	20p	2N3605	27p	3N83	40p	BC137	15p	BFX87	25p	NKT245	20p
2N696	15p	2N3606	27p	3N128	70p	BC138	20p	BFX88	20p	NKT261	20p
2N697	15p	2N3607	22p	3N140	77p	BC140	35p	BFX89	62p	NKT262	30p
2N698	25p	2N3638	18p	3N141	72p	BC141	35p	BFX93A	70p	NKT264	20p
2N699	30p	2N3638A	20p	3N142	55p	BC147	10p	BFY11	42p	NKT271	20p
2N706	10p	2N3641	18p	3N143	67p	BC148	10p	BFY18	25p	NKT262	20p
2N706A	12p	2N3642	18p	3N152	87p	BC149	12p	BFY19	25p	NKT274	20p
2N708	15p	2N3643	20p	40050	55p	BC152	17p	BFY21	42p	NKT275	20p
2N709	62p	2N3644	25p	40250	50p	BC153	20p	BFY24	45p	NKT278	25p
2N718	25p	2N3645	25p	40251	32p	BC154	20p	BFY29	40p	NKT281	27p
2N718A	30p	2N3691	15p	40309	32p	BC157	15p	BFY30	40p	NKT401	87p
2N726	30p	2N3692	18p	40310	45p	BC158	11p	BFY41	50p	NKT402	90p
2N727	30p	2N3693	15p	40311	35p	BC159	12p	BFY43	62p	NKT403	75p
2N914	17p	2N3694	18p	40312	47p	BC160	35p	BFY50	20p	NKT404	55p
2N916	17p	2N3702	10p	40314	37p	BC167	11p	BFY51	20p	NKT405	75p
2N918	30p	2N3703	10p	40315	37p	BC168B	10p	BFY52	20p	NKT406	62p
2N929	22p	2N3704	11p	40316	47p	BC168C	11p	BFY53	15p	NKT451	62p
2N930	20p	2N3705	10p	40317	37p	BC169B	11p	BFY56A	57p	NKT452	62p
2N987	40p	2N3706	9p	40319	55p	BC169C	12p	BFY76	42p	NKT453	47p
2N1090	22p	2N3707	11p	40320	47p	BC170	12p	BFY77	57p	NKT713	20p
2N1091	22p	2N3708	7p	40323	32p	BC171	15p	BFY90	65p	NKT717	42p
2N1131	25p	2N3709	9p	40324	47p	BC172	15p	BSX19	17p	NKT734	27p
2N1132	25p	2N3710	9p	40326	37p	BC175	22p	BSX20	15p	NKT736	35p
2N1302	17p	2N3711	12p	40329	30p	BC177	20p	BSX21	20p	NKT773	25p
2N1303	17p	2N3713	187p	40344	27p	BC178	20p	BSX26	45p	NKT781	30p
2N1304	22p	2N3714	200p	40347	57p	BC179	20p	BSX27	47p	OC16	50p
2N1305	22p	2N3715	123p	40348	52p	BC182	10p	BSX28	32p	OC19	37p
2N1306	25p	2N3716	130p	40360	40p	BC182L	10p	BSX60	82p	OC20	75p
2N1307	25p	2N3773	240p	40361	40p	BC183	9p	BSX61	62p	OC22	50p
2N1308	25p	2N3791	206p	40362	50p	BC183L	9p	BSX76	15p	OC23	60p
2N1309	25p	2N3819	34p	40370	32p	BC184	11p	BSX77	20p	OC24	60p
2N1507	17p	2N3820	55p	40406	57p	BC184L	11p	BSX78	25p	OC25	40p
2N1613	20p	2N3823	50p	40407	40p	BC186	25p	BSY24	15p	OC26	25p
2N1631	35p	2N3854	27p	40408	52p	BC187	27p	BSY25	15p	OC28	60p
2N1632	30p	2N3854A	27p	40409	55p	BC212L	12p	BSY26	17p	OC29	60p
2N1637	30p	2N3855	27p	40410	62p	BC213L	12p	BSY27	15p	OC35	50p
2N1638	27p	2N3855A	30p	40412	50p	BC214L	15p	BSY28	17p	OC36	60p
2N1639	27p	2N3856	30p	40467A	57p	BCY10	27p	BSY29	17p	OC41	22p
2N1701	162p	2N3856A	35p	40468A	35p	BCY30	27p	BSY32	25p	OC42	25p
2N1711	24p	2N3858	25p	40528	72p	BCY31	30p	BSY36	25p	OC44	15p
2N1889	32p	2N3858A	30p	40600	57p	BCY32	50p	BSY37	25p	OC45	12p
2N1893	37p	2N3859	27p	40603	50p	BCY33	25p	BSY38	20p	OC46	15p
2N2147	72p	2N3859A	32p	AC107	30p	BCY34	30p	BSY39	22p	OC70	15p
2N2160	57p	2N3860	30p	AC126	20p	BCY38	40p	BSY43	50p	OC71	12p
2N2193	40p	2N3866	150p	AC127	24p	BCY39	60p	BSY51	32p	OC72	12p
2N2193A	42p	2N3877	40p	AC128	20p	BCY40	50p	BSY52	32p	OC73	30p
2N2194	27p	2N3877A	40p	AC151	18p	BCY41	15p	BSY53	37p	OC74	30p
2N2194A	30p	2N3900	37p	AC152	22p	BCY42	15p	BSY54	40p	OC75	22p
2N2217	25p	2N3900A	40p	AC154	22p	BCY43	15p	BSY56	90p	OC76	22p
2N2218	20p	2N3901	97p	AC176	20p	BCY54	32p	BSY79	45p	OC77	30p
2N2219	20p	2N3903	20p	AC187	25p	BCY58	22p	BSY90	57p	OC78	20p
2N2220	25p	2N3904	25p	AC188	25p	BCY59	22p	BSY95A	12p	OC81	20p
2N2221	25p	2N3905	30p	ACY17	27p	BCY60	97p	C424	15p	OC81D	20p
2N2222	20p	2N3906	25p	ACY18	24p	BCY70	15p	C450	15p	OC82	25p
2N2222A	25p	2N4058	12p	ACY19	24p	BCY71	20p	GET102	30p	OC82D	15p
2N2297	30p	2N4059	10p	ACY20	20p	BCY72	15p	GET113	20p	OC83	25p
2N2368	15p	2N4060	12p	ACY21	20p	BCY78	30p	GET114	20p	OC84	25p
2N2369	15p	2N4061	12p	ACY22	10p	BCY79	30p	GET118	20p	OC139	25p
2N2369A	15p	2N4062	12p	ACY28	17p	BCZ10	27p	GET120	25p	OC140	32p
2N2410	42p	2N4244	47p	ACY39	47p	BCZ11	40p	GET873	12p	OC170	25p
2N2483	27p	2N4248	15p	ACY40	20p	BD112	50p	GET880	30p	OC171	30p
2N2484	32p	2N4249	15p	ACY41	15p	BD116	112p	GET887	20p	OC200	40p
2N2539	22p	2N4250	18p	ACY44	25p	BD121	65p	GET889	22p	OC201	60p
2N2540	22p	2N4254	42p	AD140	47p	BD123	80p	GET890	22p	OC202	75p
2N2613	35p	2N4255	42p	AD149	47p	BD124	60p	GET896	22p	OC203	40p
2N2614	30p	2N4284	17p	AD150	62p	BD131	75p	GET897	22p	OC204	40p
2N2646	40p	2N4285	17p	AD161	35p	BD132	80p	GET898	22p	OC205	75p
2N2711	25p	2N4286	17p	AD162	35p	BDY10	125p	MAT100	25p	OC206	95p
2N2712	25p	2N4287	17p	AF109	45p	BDY20	105p	MAT101	25p	OC207	75p
2N2713	27p	2N4288	15p	AF114	25p	BDY61	125p	MAT120	25p	OCP71	42p
2N2714	30p	2N4289	17p	AF115	25p	BDY62	100p	MAT121	25p	ORP12	50p
2N2904	20p	2N4290	12p	AF116	25p	BF115	25p	MJ400	107p	ORP60	40p
2N2904A	25p	2N4291	15p	AF117	20p	BF117	47p	MJ420	80p	ORP61	42p
2N2905	25p	2N4292	15p	AF118	60p	BF152	28p	MJ421	80p	P346A	22p
2N2905A	20p	2N4294	17p	AF121	30p	BF154	20p	MJ430	102p	ST140	15p
2N2906	20p	2N4303	47p	AF124	22p	BF158	15p	MJ440	95p	ST141	20p
2N2906A	25p	2N4964	15p	AF125	19p	BF159	35p	MJ480	97p	TIS34	62p
2N2907	28p	2N4965	18p	AF126	19p	BF163	35p	MJ481	125p	TIS43	40p
2N2923	15p	2N5027	52p	AF127	16p	BF167	18p	MJ490	100p	TIS44	10p
2N2924	15p	2N5028	57p	AF139	28p	BF170	33p	MJ491	137p	TIS45	27p
2N2925	15p	2N5029	47p	AF178	42p	BF173	19p	MJE340	50p	TIS46	11p
2N2926G	10p	2N5030	42p	AF179	45p	BF177	30p	MJE370	80p	TIS47	11p
2N2926O	10p	2N5172	12p	AF180	50p	BF178	25p	MJE371	80p	TIS48	12p
2N2926Y	10p	2N5174	52p	AF181	40p	BF179	30p	MJE520	60p	TIS49	12p
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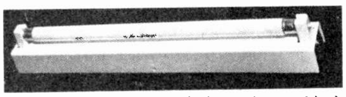

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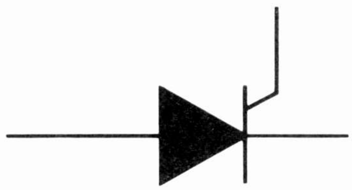

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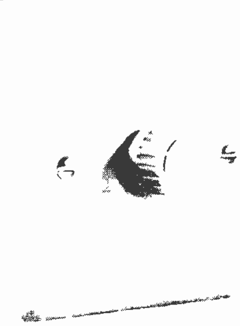

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NKT224	0·22
NKT251	0·24
NKT271	0·25
NKT272	0·25
NKT273	0·15
NKT274	0·20
NKT275	0·25
NKT277	0·20
NKT278	0·25
NKT301	0·40
NKT304	0·75
NKT403	0·75
NKT404	0·55
NKT678	0·30
NKT713	0·25
NKT773	0·25
NKT777	0·38
O78B	0·88
OA5	0·20
OA6	0·12
OA47	0·10
OA70	0·10
OA71	0·10
OA73	0·10
OA74	0·10
OA79	0·10
OA81	0·08
OA85	0·12
OA86	0·15
OA90	0·08
OA91	0·07
OA95	0·07
OA200	0·07
OA202	0·10
OA210	0·25
OA211	0·30
OAZ200	0·55
OAZ201	0·50
OAZ202	0·42
OAZ203	0·42
OAZ204	0·30
OAZ205	0·42
OAZ206	0·42
OAZ207	0·47
OAZ208	0·32
OAZ209	0·32
OAZ210	0·32

	£p
OAZ211	0·32
OAZ222	0·45
OAZ223	0·45
OAZ224	0·45
OAZ241	0·22
OAZ242	0·28
OAZ244	0·22
OAZ246	0·28
OAZ290	0·38
OC16	0·50
OC16T	0·38
OC19	0·37
OC20	0·85
OC22	0·50
OC23	0·60
OC24	0·60
OC25	0·37
OC26	0·25
OC28	0·60
OC29	0·60
OC30	0·40
OC35	0·50
OC36	0·60
OC41	0·25
OC42	0·30
OC43	0·40
OC44	0·17
OC44M	0·17
OC45	0·12
OC45M	0·18
OC46	0·27
OC57	0·60
OC58	0·60
OC59	0·65
OC66	0·50
OC70	0·12
OC71	0·12
OC72	0·20
OC73	0·30
OC74	0·30
OC75	0·25
OC76	0·25
OC77	0·40
OC78	0·20
OC79	0·22
OC81	0·20
OC81D	0·20
OC81M	0·20
OC81DM	0·18
OC81Z	0·40
OC82	0·25
OC82D	0·20
OC83	0·25
OC84	0·25
OC114	0·38
OC122	0·60
OC123	0·65
OC139	0·25
OC140	0·35
OC141	0·60
OC169	0·20
OC170	0·25
OC171	0·30
OC200	0·40
OC201	0·70
OC202	0·80
OC203	0·40
OC204	0·40
OC205	0·75
OC206	0·90
OC207	0·90
OC460	0·20
OC470	0·30
OCP71	0·97
ORP12	0·50
ORP60	0·40
ORP61	0·42
S19T	0·30
SAC40	0·25
SFT308	0·38
ST722	0·38
ST7231	0·63
SX68	0·20
SX631	0·30
SX635	0·40
SX640	0·50
SX641	0·55
SX642	0·60
SX644	0·75
SX645	0·75
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V30/201P	0·75
V60/201	0·50
V60/201P	0·75
XA101	0·10
XA102	0·18
XA151	0·15
XA152	0·15
XA161	0·25
XA162	0·25
XB101	0·48
XB102	0·10
XB103	0·25
XB113	0·12
XB121	0·43
ZR24	0·63

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ZS170	0·10
ZS271	0·18
ZT21	0·95
ZT43	0·25
ZTX107	0·15
ZTX108	0·12
ZTX300	0·12
ZTX304	0·25
ZTX500	0·16
ZTX503	0·17
ZTX531	0·25

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7400	0·20
7401	0·20
7402	0·20
7403	0·20
7404	0·20
7405	0·20
7406	0·30
7407	0·30
7408	0·20
7409	0·45
7410	0·20
7411	0·23
7412	0·42
7413	0·30
7416	0·30
7417	0·30
7420	0·20
7422	0·48
7423	0·48
7425	0·48
7427	0·42
7428	0·50
7430	0·20
7432	0·42
7433	0·70
7437	0·65
7438	0·65
7440	0·20
7441AN	0·75
7442	0·75
7450	0·20
7451	0·20
7453	0·20
7454	0·20
7460	0·20
7470	0·30
7472	0·30
7473	0·40
7474	0·40
7475	0·55
7476	0·45
7480	0·80
7482	0·87
7483	1·00
7484	0·90
7486	0·45
7490	0·75
7491AN	1·00
7492	0·75
7493	0·75
7494	0·80
7495	0·80
7496	1·00
7497	6·25
74100	2·50
74107	0·50
74110	0·80
74111	1·45
74118	1·00
74119	1·90
74121	0·60
74122	1·35
74123	2·70
74141	1·00
74145	1·50
74150	3·35
74151	1·10
74154	2·00
74155	1·55
74156	1·55
74157	1·80
74170	4·10
74174	2·00
74175	1·35
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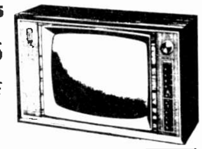

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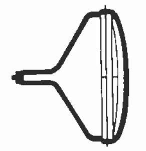

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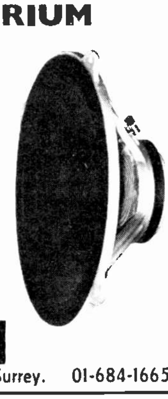

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