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Minitron Filament Display bi-directional 0.36"
3015F 0-9 L/H d.pt.
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LIQUID CRYSTAL DISPLAY complete with socket and removable reflective backing. Ref AN4132R 13mm character height. Can be directly driven by National Semiconductors Alarm Clock chip MM5316. £13.99 ●

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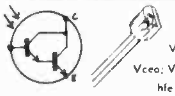

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Vceo; Vcbo 25v; Vebo 8v
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hfe 2500; Ic 250 mA **35p.**

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enables
LIT707 0.3" 90p ● LIT747 0.6" £1.99 ●

I.C. SOCKETS

	Dual-in-line							TO5	
Pins	8	14	16	24	28	36	40	8	10
● Price	13p	15p	15p	26p	30p	39p	44p	31p	35p

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Litronix Double Digit Displays 0.5"; Common Anode + 2 R/H D.P.'s
DL721 gives ± 1.9
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Suitable for Clocks; Instruments; T.V. Channel Indicator
Our Price £4.75 each. ●

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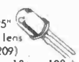

	0.125" dia. lens (TIL209) 1+	10+	100+	0.16" dia. lens 1+	10+	100+	0.2" dia. lens (MLED 650) 1+	10+	100+
Red	16p	15p	13p ●	27p	24p	22p ●	18p	16p	14p ●
Green	27p	24p	22p ●	33p	30p	27p ●	30p	27p	25p ●
Orange	27p	24p	22p ●	33p	30p	27p ●	30p	27p	25p ●
Yellow	34p	31p	29p ●	35p	32p	29p ●	35p	33p	30p ●

Low Cost Red GaAsP Motorola MLED 500 in a TO92 package. 15p ●

NEW Opto-isolators ILI (4N25 or TIL116 6 pin industry standard package 2.5KV isolation £1.00 ●

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1. Orders valued at £5 or more will be post free.
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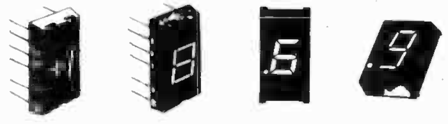

		COMMON ANODE R/H Dec. Pt.	COMMON ANODE L/H Dec. Pt.	COMMON ANODE - 1	COMMON CATHODE R/H Dec. Pt.	Our Price
0.3"	RED	DL707R	DL707	DL701	DL704	£1.82 ●
	GREEN	MAN51	MAN52	MAN53	MAN54	£1.82 ●
	RED	MAN71	MAN72	MAN73	MAN74	£1.82 ●
	YELLOW	MAN81	MAN82	MAN83	MAN84	£1.82 ●
	ORANGE	MAN3610	MAN3620	MAN3630	MAN3640	£1.82 ●
	GREEN	XAN51	XAN52	-	XAN54	£1.49 ●
	RED	XAN71	XAN72	-	XAN74	£1.49 ●
	YELLOW	XAN81	XAN82	-	XAN84	£1.49 ●
0.4"	GREEN	MAN4510	MAN4520	MAN4530	MAN4540	£2.32 ●
	RED	MAN4710	MAN4720	MAN4730	MAN4740	£2.32 ●
	YELLOW	MAN4810	MAN4820	MAN4830	MAN4840	£2.32 ●
	ORANGE	MAN4610	MAN4620	MAN4630	MAN4640	£2.32 ●
		C.A L/H Dec Pt.	C.A - 1	C.C. L/H Dec Pt	C.C. - 1	
0.6"	RED	DL747	DL746	DL750	DL749	£2.42 ●

NOTE. MAN4000 series pinouts are 14 pin dil the same as MAN50;70 & 80 series.

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PRACTICAL
ELECTRONICS
VOLUME 11 No. 9 SEPTEMBER 1975

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

FREE ENTRY COMPETITION

Our October issue will be published on Friday, September 12, 1975

(for details of contents see page 720)

SAXON

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35W RMS 25–50V
7 transistors, 7 diodes

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- ★ 4–16 ohms
- ★ Simple wiring
- ★ Short and open circuit proof
- ★ Continuously rated
- ★ Top-grade components

120 watt module complete with built-in supply—extra heavy duty £24·75 Carr. 60p

THE SA100 MODULE

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UNSTABILISED—READY WIRED AND FUSED

PU45	Suits 2 SA35 or 1 SA50 (4 ohm)	£6·50	Carriage 50p
PU70	Suits 2 SA50 or 2 SA100 (8 ohm)	£9·50	Carriage 60p

STABILISED

PS45	Suits 2 SA35 or 2 SA50 (4 ohm)	£5·50	Carriage free
MT45	Transformer for above	£3·90	Carriage 50p
PS70	Suits 2 SA100	£6·50	Carriage free
MT70	Transformer for above	£5·50	Carriage 60p

N.B. PS70 is not suitable for the SA50

Mk II STEREO DISCO MIXER £29·50
Carr. 50p

This well tried Pre-Amp mixes two decks, handles any ceramic cartridge, and features mic over-ride plus separate full range bass and treble controls on both mic and deck inputs. Ample headphone power is available for P.F.L. May be used for mono and is mains operated. Fitted with sturdy screening case. Controls: Mic vol, bass, treble. Left/Right fade, deck volume, bass, treble, h/phone select, vol, Mains. Size 17½in × 3in × 4in deep.

DISCO MODULE £12·50 Carr. 50p

Thousands sold of this extremely popular mono Pre-Amp. A mic input may be fitted using the VA30 (see below). Low consumption from a 9V battery. Features the same high standards of reproduction as the Stereo version. Controls: H/phone select, vol, Left deck vol, Right deck vol, bass, treble, master vol. Size 12¾in × 3in × 2in deep.

3-CHANNEL SOUND-LITE £24·75 Carr. 50p

Only SAXON can supply such incredible value for money. This unit features 3kW power handling, full-wave control, bass, middle, treble AND master controls. Twin loudspeaker jacks for "through" connections. Uses coloured reflector lamps and panel mount next to either of the above. Size 12in × 3in × 2½in deep. Professional standards at a price you can afford!

SINGLE CHANNEL VERSION £7·90 Carr. free
High sensitivity, compact, handles 1kW. Full wave operation

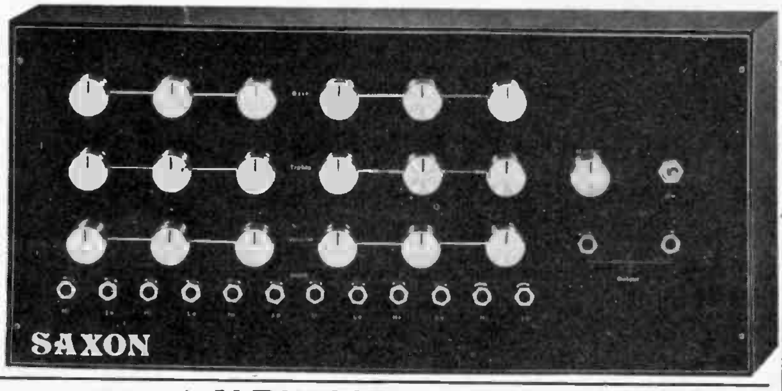
Add 8% VAT to all orders

MULTI-PURPOSE MIXERS

M4HL **£25·00** Carr. 60p
M6HL **£35·00** Carr. 60p

Featuring multiples of our VA30 module, the M4HL and M6HL fulfil the requirements of all clubs, groups, etc. where a high quality mixer is required. Each channel has one high and one low impedance input, plus volume, treble and bass controls. Input impedances may, if required, be easily changed. The M4HL has four channels, and one output, and the M6HL six channels (12 inputs) and a master control and two outputs. Either unit may be used free-standing or panel mounted. These mixers will feed all types of amplifier. Recommended for their versatility and high performance, and excellent value for money.

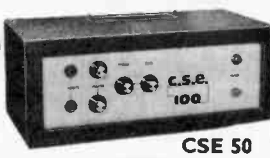
VA30 CHANNEL MODULE £3·90 Carr. free
This is the basic channel module in the above mixers and may also be used for extra inputs on either the mono or stereo mixers. Fitted with volume, bass and treble controls, requires just a jack and supply (9–100V)



SAXON CSE 100

COMPLETE AMPLIFIER
£39·90
Carr. 60p

100W of speech and music—Two separately controlled inputs. Wide range bass and treble controls. Sturdy and attractive vynide case. Twin outputs. Ideal for groups, discos, etc. Fully tested and guaranteed. 50W version identical in appearance.



CSE 50
£33·00 Carr. 60p

NEW!!
SAXON MULTIMIX 100 £57 CARR. £1·00

100W RMS **SLIDER** controls **PLUS** master slider.
Wide range bass and treble controls—fantastic value.
Ideal for complete Disco's, Groups, Clubs, etc.

SAXON MULTIMIX 50 EXACTLY AS ABOVE BUT 50W RMS **£45**

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RT-VC*

NEW!

VISCOUNT IV STEREO SYSTEM

System 1a. £65.00

The new 20+20 watt Stereo Amplifier incorporating the latest silicon transistor solid state circuitry, the RT-VC VISCOUNT IV gives you a powerful 20 watts RMS per channel into 8 ohms. Superb teak-finished cabinet, with anodised fascia to harmonise with any decor. Polished trim and knobs.

The VISCOUNT IV has a comprehensive range of controls – volume, bass, treble, balance, mono/stereo, mode selector, and scratch filter.

Front panel socket for stereo headphones. And a host of sockets at the rear – for left and right speakers, tape recorder, auxiliary, tuner, disc and microphone.

SPECIFICATION: 20 watts RMS per channel 40 watts peak. Suitable 8-15 ohms speakers. Total distortion @ 10 watts better than 0.2%. Six switched inputs: 1. Magnetic P.U. – 3 millivolts @ 47 K ohms (R.I.A.A.); 2. Crystal/ceramic P.U. – 50 millivolts @ 50 K ohms (R.I.A.A.); 3, 4, 6. Tape Tuner/Aux. – 140 millivolts @ 50 K ohms (flat frequency response); 5. Microphone – 3 millivolts @ 50 K ohms (flat frequency response).

CONTROLS: Push button ON/OFF, stereo/mono, scratch filter. 6 position rotary selector. Individual rotary controls for treble, bass, balance and volume. Headphone socket, tape out socket. Aux. mains output. **Frequency response:** 25 Hz to 25 KHz @ full rated output. **Signal to noise ratio:** better than –50 dB on all inputs. **Tone control range:** Bass ±15 dB @ 50 Hz; Treble ±12 dB @ 10 KHz. **Power requirements:** 200-250V A.C. mains @ 60 watts. **Approx. size:** 15¼" × 3" × 10".

MP60 type deck with magnetic cartridge, de luxe plinth and cover.

Two Duo Type IIa matched speakers – Enclosure size approx. 19½" × 10¼" × 7¾" in simulated teak. Drive unit 13" × 8" with 3" tweeter. 15 watts handling. 30 watts peak.

Complete System with these speakers £69.00 +£6.50 p & p.

System 2. £81.00

Viscount IV amplifier (As System 1a)
MP60 type deck (As System 1a)
Two Duo Type III matched speakers – Enclosure size approx. 27" × 13" × 11½". Finished in teak simulate. Drive units 13" × 8" bass driver, and two 3" (approx.) tweeters. 20 watts RMS. 8 ohms frequency range – 20 Hz to 18,000 Hz.
Complete System with these speakers £85.00 +£7.60 p & p.

PRICES: SYSTEM 1a

Viscount IV R103 amplifier	£25.00+£1.90 p & p.
2 Duo Type IIa speakers	£30.00+£6.50 p & p.
MP60 type deck with Mag. cartridge de luxe plinth and cover	£20.00+£3.30 p & p.
Total if purchased separately:	**£75.00**
Available complete for only:	**£65.00** +£6.50 p & p.

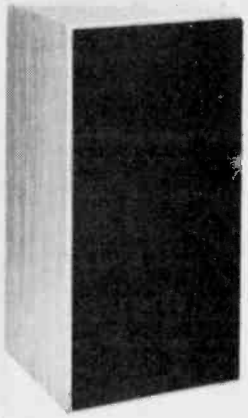
PRICES: SYSTEM 2

Viscount IV R103 amplifier	£25.00+£1.90 p & p.
2 Duo Type III speakers	£46.00+£7.50 p & p.
MP60 type deck with Mag. cartridge de luxe plinth and cover	£20.00+£3.30 p & p.
Total if purchased separately:	**£91.00**
Available complete for only	**£81.00** +£7.60 p & p.

20x20 SYSTEM

Scotland and the Orkneys P & P Surcharge
System 1a £1.75 System 2 £3.50

EMI SPEAKERS AT FANTASTIC REDUCTIONS



LE-4 SPEAKERS

Superb performance and beautifully finished in selected teak veneers. A professional standard four-way speaker system giving 25 watts RMS power handling. Bass unit is 14"×9" with 8"×5" unit for mid-range and twin 3" high frequency units to give monitor type quality and performance.

Specification – Size 33"×14"×16" approx. Impedance 8 ohms. Power handling 25W RMS. (Peak 50 watts.) Frequency range 35 Hz–20 KHz.

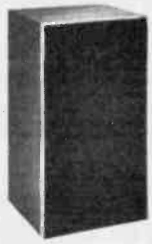
Our Price £34.00 each
(normally £66.00)+£5.80 p & p.
Scotland and the Orkneys
P & P Surcharge £3.50

EASY TO BUILD SPEAKER KITS

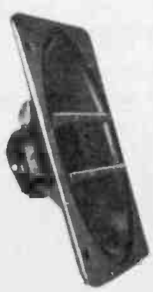
These superb simulated teak-finished speaker kits have been specially designed by RT-VC for the cost-conscious hi-fi enthusiast who wants top quality speakers but doesn't want to spend the earth. Built to EMI's exacting specification, these new RT-VC speaker kits (350 type kit) incorporate 13" × 8" woofer, 3¼" tweeter and matching crossover.

Easily put together with just a few basic tools.

Specification (each speaker): Impedance 8 ohms. Power handling 15 watts RMS (30 watts peak). Response 20–20,000 Hz. Size 20" × 11" × 9½" approx. Comparable built units (EMI LE3) sold elsewhere for over £45 pair.



£22.00 pair complete
+£5.20 p & p. Complete with crossover Components and circuit diagram



EMI 350 KIT

System consists of a 13" × 8" approx. woofer with a 3" tweeter, crossover components and circuit diagram. Frequency response: 20 Hz to 20 KHz. Power handling 15 watts RMS into 8 ohms. (Peak 30 watts.)

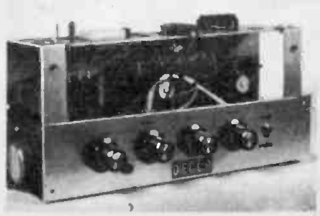
£6.50 +£1.20 p & p.

Complete with crossover Components and circuit diagram

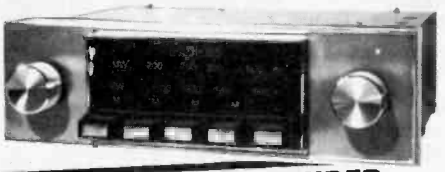
DECCA STEREO AMPLIFIER CHASSIS

Specification: 4+4 watts into 8 ohms. Input Sensitivity 4mV into 47K (for magnetic cartridges). AC Mains only 240V. Controls – volume, bass, treble, on/off, mono/stereo switch. Chassis size 11"×5½"×3¼" approx.

£6.90 +£1.20 p & p.



PUSH BUTTON CAR RADIO KIT—THE TOURIST TT*



NO SOLDERING REQUIRED

NOW BUILD YOUR OWN PUSH BUTTON CAR RADIO

Easy to assemble construction kit comprising fully completed and tested printed circuit board on which no soldering is required. All connections are simple push fit type making for easy assembly. Fine tuning push button mechanism is fully built and tested to mate with printed circuit board.

TECHNICAL SPECIFICATION: (1) Output 4 watts RMS output. For 12 volt operation on negative or positive earth. (2) Integrated circuit output stage, pre-built three stage IF Module. Controls volume manual tuning and live push buttons for station selection, illuminated tuning scale covering full, medium and long wave bands. Size chassis 7" wide 2" high and 4¾" deep approx. **£9.50** +£1.05 p & p. Speaker including baffle and fixing strip £2.00 +45p p & p. Car Aerial Recommended — fully retractable £1.60+40p p & p.

The Tourist I Kit For the experienced constructor. If you can solder on a printed circuit board you can build this model. Same technical specification as Tourist TT. **Price £8.20** +£1.05 p & p.

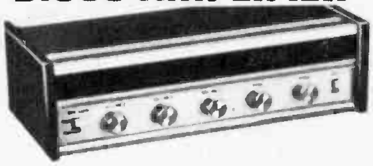
*STEREO 21 QUALITY SOUND FOR LESS THAN £24.00

Stereo 21, easy to assemble audio system kit. No soldering required.
The unit is finished in white P.V.C. and the acrylic top presents an unusually interesting variation on the modern deck plinth.
Includes — BSR 3 speed deck, automatic, manual facilities together with stereo cartridge.
Two speakers with cabinets.
Amplifier module. Ready built with control panel, speaker leads and full, easy to follow assembly instructions.
Specifications — For the technically minded:
Input sensitivity 600mV. Aux. input sensitivity 120mV. Power output 2.7 watts per channel. Output impedance 8—15 ohms. Stereo headphone socket with automatic speaker cutout. Provision for auxiliary inputs — radio, tape, etc., and outputs for taping discs.
Overall Dimensions. Speakers approx 15½"×8"×4". Complete deck and cover in closed position approx. 15½"×12"×6".

Complete only £23.20 +£3.00 p & p.

Extras if required. Optional Diamond Styli £1.60.
Specially selected pair of stereo headphones with individual level controls and padded earpieces to give optimum performance £5.80.

*DISCO AMPLIFIER

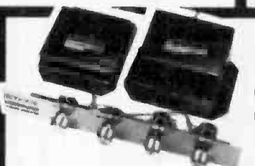


Reliant Mk IV Mono Amplifier, ideal for the small disco or house parties. Output 20 watts RMS into 8 ohms (suitable for 15 ohms).
Inputs *4 electrically mixed inputs. *3 individual mixing controls. *Separate bass and treble controls common to all 4 inputs. *Mixer employing F.E.T. (Field Effect Transistors). *Solid State circuitry. *Attractive styling.
INPUT SENSITIVITIES — Input — 1). Crystal mic. guitar or moving coil mic. 2 and 10mV. (Selector switch for desired sensitivity.) — Inputs — 2). 3), 4). Medium output equipment — ceramic cartridge, tuner, tape recorder, organs, etc. — all 250mV sensitivity. AC Mains, 240V operation. Size approx: 12½"×6"×3½". **£20.00** +£1.35 p & p.

*8 TRACK HOME CARTRIDGE PLAYER

Elegant self selector push button player for use with your stereo system. Compatible with Viscount IV system, Unisound module and the Stereo 21. Technical specification Mains input, 240V, Output sensitivity 125mV. Comparable unit sold elsewhere at £24.00 approx. Yours for only

£16.20 +£1.70 p & p.



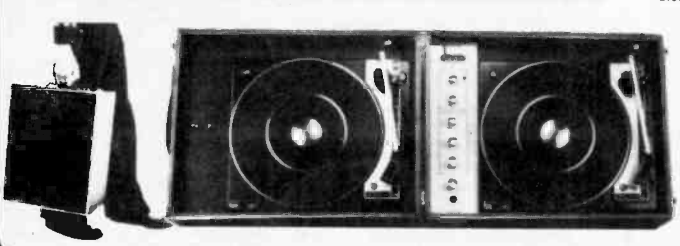
BUILD YOUR OWN STEREO AMPLIFIER*

For the man who wants to design his own stereo — here's your chance to start, with Unisound — pre-amp, power amplifier and control panel. No soldering — just simply screw together. 4 watts per channel into 8 ohms. Inputs: 120mV (for ceramic cartridge). The heart of Unisound is high efficiency I.C. monolithic power chips which ensure very low distortion over the audio spectrum. 240V. AC only.

Also available with 2 speakers (7" x 4") £10+£1.75 p & p. £8.95 +£1.05 p & p.

PORTABLE DISCO CONSOLE*

INCORPORATES: Pre-Amp with full mixing facilities, including switched input for mic with volume control, switched input for auxiliary with volume control, bass and treble controls, volume control and blend control for turntables. Two B.S.R. MP60 type single play professional series decks, fitted with crystal cartridges.



TECHNICAL SPECIFICATION:
Pre-amp — Output — 200mV. Auxiliary inputs — 200mV and 750mV into 1 meg. Mic input — 6mV into 100K. 240 volt operation. **Turntables capacity** — 7", 10" or 12" records. **Rumble, wow and flutter** Rumble Better than —35dB. Wow Better than 0.2%. Flutter Better than 0.06% (Gaumont kalee meter).
Finish — Satin black mainplate with black turntable mat inlaid with brushed aluminium trim. Tonearm and controls in black and brushed aluminium.

Console size —
Unit Closed — 17¾"×13¾"×8¾" (app.)
Unit Open — 35¾"×13¾"×4¾" (app.)
This disco console is ideally matched for the Reliant IV and Disco 50 or any other quality amplifier.
The unit is finished in black PVC with contrasting simulated teak edging, diamond spun control knobs with matching control panel.

Yours for only
£49.00 +£6.50 p & p.

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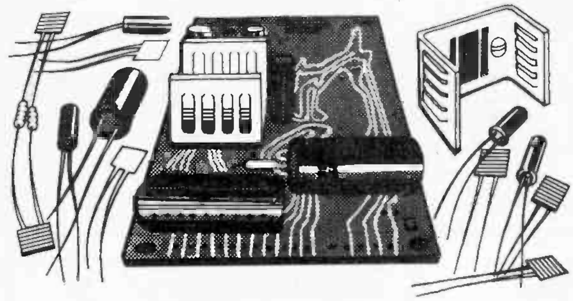
Sinclair IC20



The watts...

The Sinclair IC20 is a revolutionary new 20 watts stereo amplifier kit.

It incorporates state-of-the-art integrated circuits – two monolithic silicon chips each containing the equivalent of over 20 transistors! These deliver 10 W per channel into 4Ω speakers.

And the IC20 has integral short-circuit protection and thermal cut-out – it's virtually indestructible. Use it for converting your mono record player to stereo... for upgrading your existing stereo... or for improving your car radio/tape player.

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Black plastic knobs, ¾in dia., ¼in spindle, 4 for 50p.
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TYPE 72703, 400V at 10mA + 200V at 5mA + 6·3V at 400mA, £1·25.
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Heatsinks (Approx. 3in × 4in × 2in high), 12 fins (drilled for 1 × TO3 transistor) brand new, 45p each.

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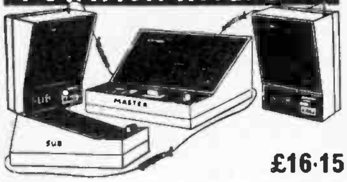

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Solve your communication problems with this **4-Station Transistor Intercom** system (**1 master and 3 Subs**), in robust plastic cabinets for desk or wall mounting Call/talk/listen from **Master** to **Subs** and **Subs** to **Master**. Ideally suitable for Business, Surgery, Schools, Hospitals, Office and Home. Operates on one 9V battery. On/off switch. Volume control. Complete with 3 connecting wires each 66ft and other accessories. P. & P. 65p.

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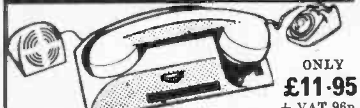

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0–12–15–20–24–30V 2A, £4·20; 4A, £6.
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MAINS TRANSFORMERS
Prim. 200/240V a.c. TX6 sec., 425–0–425V 500 MA, 6·3V CT 6A, 6·3V CT 6A, 0–5–6·3V 3A £18·75; TX1 425–0–425V 250 MA, 6·3V CT 4A, 6·3V CT 4A, 0–5–6·3V 3A, £11·25; MT3 Prim. 0–110–240V, sec., 250V 100 MA, 6·3V 2A, E/S, £3·75.

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Covering valve amplifiers of 30W to 400W 35p.

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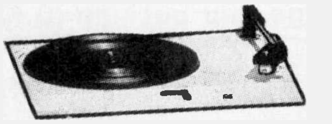

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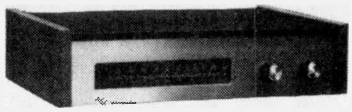
BRITISH MADE



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32/500V	50p	8 + 8/450V	22p	16 + 16 + 16/275V	45p
25/25V	10p	8 + 16/450V	25p	32 + 32 + 32/350V	65p
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Primary 0-110-240V. Secondary 0-240V 3 amps 720 watts. Insulated terminals. Varnish impregnated. Fully enclosed in steel case with fixing feet. Famous make (Value £19) OUR PRICE **£13·50** Carr. 95p
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With tweeter and crossover. 10 watt. State 3 or 8 or 15 ohm. As illustrated. **£5·25** Post 35p

With flared tweeter cone and ceramic magnet. 10 watt. Bass res. 45-60 c/s. Flux 10,000 gauss. State 3 or 8 or 15 ohm. Post 25p **£3·45**
13 × 8in Bass unit 20 watt rubber cone surround £6·60

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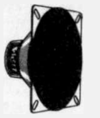
Teakwood strips mounted on cloth backing, easily glued on to baffle to modernise cabinets. Size 18¼ in × 10¼in. **75p** Or size 10¼in × 7¼in. **45p**

GOODMANS 6½in. HI-FI SPEAKER

8 ohm. 10W. Large ceramic magnet. Special Rubber cone surround. Frequency response. Twin cone. 30-12,000 c/s. Ideal P.A. Columns. Hi-Fi Enclosure Systems, etc. **£4·60**

ELAC CONE TWEETER



The moving coil diaphragm gives a good radiation pattern to the higher frequencies and a smooth extension of total response from 1,000 c/s to 18,000 c/s. Size 3½ × 3½ × 2in deep. Rating 10W. 3 ohm.
Crossover £1·85 **£2·20** Post 30p.

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8 ohm 15 watt. Rubber surround. Heavy ceramic magnet. Bass resonance 35 cps. Frequency response 30-8,000 cps. Ideal bass unit for Hi-Fi system. **£5·75**

SPECIAL OFFER LOUDSPEAKERS

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8 ohm. 2½in; 2¾in; 5in × 3in; 3in; 4in; 5in; 6 × 4in.
15 ohm. 3½in; 5in; 6 × 4in; 5 × 3in; 7 × 4in; 8 × 5in.
25 ohm. 2½in; 5 × 3in; 5in; 6 × 4in; 7 × 4in.
35 ohm. 3in; 5in. 64 ohm 2½in.
80 ohm. 2½in; 2¾in. 120 ohm 3in. **£1·25** EACH

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2 stage triode pentode valve. 3 watts output. Volume on/off and tone controls. Printed circuit A.C. mains complete and tested. **£4·50** Post 35p
Complete with speaker.

COAXIAL PLUG 10p. PANEL SOCKETS 10p. LINE 18 OUTLET BOXES, SURFACE MOUNTING 50p.
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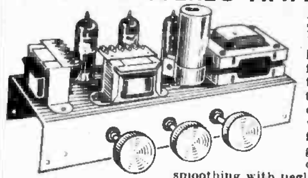
SUPERSOUND 13 HI-FI MONO AMPLIFIER

A superb solid state audio amplifier. Brand new components throughout. 5 Silicon transistors plus 2 power out-put transistors in push-pull. Full wave rectification. Output approx. 13 watts r.m.s. into 8 ohms. Frequency response 12Hz. 30KHz ±3db. Fully integrated pre-amplifier stage with separate Volume, Bass boost and Treble cut controls. Suitable for 8-15 ohm speakers. Input for ceramic or crystal cartridge. Sensitivity approx. 40mV for full output. Supplied ready built and tested, with knobs, escutcheon panel, input and output plugs. Overall size 3" high × 6" wide × 7½" deep. AC 200/250V. PRICE £15·00. P. & P. 65p.

DE LUXE STEREO AMPLIFIER



A.C. mains 200-240 v. Using heavy duty fully isolated mains transformer with full wave rectification giving adequate smoothing with negligible hum. Valve line-up:–2 × ECL86 Triode Pentodes. 1 × EZ80 as rectifier. Two dual potentiometers are provided for bass and treble control, giving bass and treble boost and cut. A dual volume control is used. Balance of the left and right hand channels can be adjusted by means of a separate 'Balance' control fitted at the rear of the chassis. Input sensitivity is approximately 300m/v for full peak output of 4 watts per channel (8 watts mono), into 3 ohm speakers. Full negative feedback in a carefully calculated circuit, allows high volume levels to be used with negligible distortion. Supplied complete with knobs, chassis size 11"w × 4"d. Overall height including valves 5". Ready built and tested to a high standard. £12·50. P. & P. 85p.

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Pri. 200/240v. Sec. 10–0–10 at 2 amp. £2·20. P. & P. 40p.

3 VOLT RELAY. 100 m/A single pole normally closed. 2 for 60p. P. & P. 15p.

GENERAL PURPOSE HIGH STABILITY TRANSISTOR PRE-AMPLIFIER

For P.U. Tape, Mike, Guitar, etc. and suitable for use with valve or transistor equipment. 9-18v. battery or from H.T line 200/300v. Frequency response 15Hz—25KHz. Gain 26dB. Solid encapsulation size 1¾" × 1¼" × ¾". Brand new complete with instructions. Price £1·36. P. & P. 15p.

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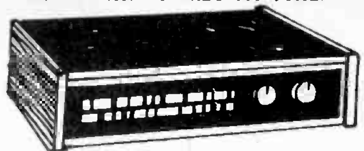
8 pole 3 way 2 bank low loss Yaxley type switches 1¼" sections. Standard spindle. 2 switches 75p + 15p P. & P.

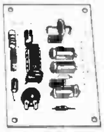
HARVERSONIC MAINS OPERATED SOLID STATE STEREO FM TUNER



Enjoy Fabulous Stereo Radio at this Low Introductory Price!

Designed and styled to match our 10 + 10 amplifier but will suit any other standard stereo amplifier. The design incorporates the very latest circuitry techniques with high-grain, low noise IF stages. Automatic frequency control to "lock on" station and prevent drift. IC stereo decoder for maximum stereo separation. L.E.D. for stereo beacon indicator. Nominal output of tuner 100mV. Approximate size 12½in wide × 8in deep by 2¾in high. Supplied ready built, fully tested and fully guaranteed (not available in kit form).
Price £27·50. Post and Packing £1·00.

STEREO-DECODER SIZE 2" × 3" × ½"



Ready built. Pre-aligned and tested. Sens. 20-560mV for 9-16V neg. earth operation. Can be fitted to almost any FM VHF radio or tuner. Stereo beacon light can be fitted if required. Full details and instructions (inclusive of hints and tips) supplied. £6·25 plus 15p P. & P. Stereo beacon light if required 45p extra.

LATEST HI SENSITIVITY UNI-DIRECTIONAL SLIM-LINE CONDENSER MICROPHONE as used by many professionals. Very low acoustic feedback. Available Hi impedance or low impedance. State which required. £16·25. P. & P. 25p.

LATEST ACOS GP91/1SC mono compatible cartridge with t/o stylus for LP/EP/78. Universal mounting bracket. £1·75. P. & P. 15p.

CERAMIC STEREO CARTRIDGE. Universal mounting brackets and turnover stylus. 70mV per channel output. ONLY £2·06. P. & P. 15p.

SONOTONE 9TAHC COMPATIBLE STEREO CARTRIDGE T/O stylus Diamond Stereo LP and Sapphire 78. ONLY £2·62. P. & P. 10p. Also available fitted with twin Diamond T/O stylus for Stereo LP. £3·18. P. & P. 15p.

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LATEST T/O MONO COMPATIBLE CARTRIDGE for playing EP/LP/78 mono or stereo records on mono equipment. Only £1·75. P. & P. 15p.

QUALITY RECORD PLAYER AMPLIFIER MK. II A top quality record player amplifier employing heavy duty double wound mains transformer, ECC83, EL84, and rectifier. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in wide × 3in deep × 6in high. Ready built and tested. PRICE £6·50. P. & P. 75p.
ALSO AVAILABLE mounted on board with output transformer and speaker. PRICE £7·75. P. & P. 75p.

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Beautifully made simulated teak finish enclosure now with most attractive slatted front. Size 16½" high × 10¼" wide × 9" deep (approx.). Fitted with E.M.I. Ceramic Magnet 13" × 8" bass unit, H.F. tweeter unit and crossover. AVAILABLE IN NOMINAL 4 ohm, 8 ohm or 16 ohm impedance (state which).
OUR PRICE £11·25 each. Carr. £1·25
Cabinet Available Separately £6·25. Carr. £1·10.
Also available in 8 ohms with EMI 13" × 8" base speaker with parasitic tweeter £10·00. Carr. £1·25.

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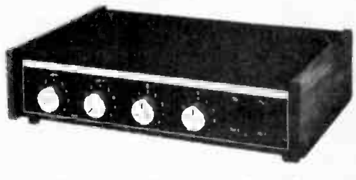
HARVERSONIC SUPER SOUND 10 + 10 STEREO AMPLIFIER KIT

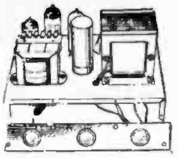


A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors including Silicon Transistors in the first five stages on each channel resulting in even lower noise level with improved sensitivity. Integrated pre-amp with Bass, Treble and two Volume Controls. Suitable for use with Ceramic or Crystal cartridges. Very simple to modify to suit magnetic cartridge—instructions included. Output stage for any speakers from 8 to 15 ohms. Compact design, all parts supplied including drilled metal work, high quality ready drilled printed circuit board with component identification clearly marked, smart brushed anodised aluminium front panel with matching knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief specifications: Power output: 14 watts r.m.s. per channel into 5 ohms. Frequency response ±3dB 12–30,000 Hz Sensitivity: better than 80mV into 1MΩ. Full power bandwidth: ±3dB 12–15,000 Hz. Bass, boost approx. to ±12dB. Treble cut approx. to —16dB. Negative feedback 18dB over main amp. Power requirements 35v. at 1·0 amp.
Overall Size 12"w. × 8"d. × 2¼"h.
Fully detailed 7 page construction manual and parts list free with kit or send 25p plus large S.A.E.

AMPLIFIER KIT	£15·00	P. & P. 50p
(Magnetic input components 33p extra)		
POWER PACK KIT	£5·35	P. & P. 55p
CABINET	£5·35	P. & P. 55p

(Post Free if all units purchased at same time)
Full after sales service
Also available ready built and tested £32·50. Post Free.
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.

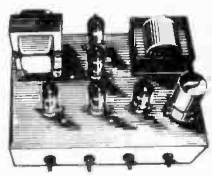
3-VALVE AUDIO AMPLIFIER HA34 MK II.



Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7½"w. × 4"d. × 4¾"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 £7·75. P. & P. 70p.

HSL "FOUR" AMPLIFIER KIT. Similar in appearance to HA34 above but employs entirely different and advanced circuitry. Complete set of parts, etc. £6·50. P. & P. 70p.

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 3–15 Ω speaker and 2 independent volume controls, and separate base and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EF86 and EZ80 rectifier. Simple instruction booklet 25p × SAE (Free with parts). All parts sold separately. ONLY £12·00, P. & P. £1·00. Also available ready built and tested £16·50. P. & P. £1·00.

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Adjustable headband with comfortable flexifoam ear-muffs. Wired and fitted with standard stereo ¼in jack plug. Frequency response 30–15,000Hz. Matching impedance 8–16 ohms. Easily converted for Mono. PRICE £4·05. P. & P. 25p.

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AC126	0·18
AC127	0·19
AC128	0·19
AC132	0·15
AC134	0·15
AC137	0·15
AC141	0·19
AC141K	0·30
AC142	0·19
AC142K	0·26
AC151	0·16
AC154	0·20
AC155	0·20
AC156	0·20
AC157	0·25
AC165	0·20
AC166	0·20
AC167	0·20
AC168	0·25
AC169	0·15
AC176	0·20
AC177	0·25
AC178	0·29
AC179	0·29
AC180	0·20
AC180K	0·30
AC181	0·20
AC181K	0·30
AC187	0·23
AC187K	0·23
AC188	0·22
AC188K	0·23
ACY17	0·26
ACY18	0·20
ACY19	0·20
ACY20	0·20
ACY21	0·20
ACY22	0·17
ACY27	0·19
ACY28	0·19
ACY29	0·36
ACY30	0·29
ACY31	0·29
ACY34	0·21
BC173	0·15
BC174	0·15
BC175	0·22
BC177	0·19
BC178	0·19
BC179	0·19
BC180	0·25
BC181	0·25
BC182	0·15
BC182L	0·15
BC183	0·15
BC183L	0·15
BC184	0·20
BC184L	0·20
BC186	0·29
BC187	0·29
BC207	0·11
BC208	0·11
BC209	0·12
BC212L	0·13
BC213L	0·13
BC214L	0·17
BC225	0·26
BC226	0·36
BC301	0·28
BC302	0·25
BC303	0·31
BC304	0·37
BC440	0·31
BC460	0·37
BCY30	0·25
BCY31	0·27
BCY32	0·31
BCY33	0·22
BCY34	0·26
BCY70	0·15
BCY71	0·20
BCY72	0·15
BCZ10	0·20
BCZ11	0·26
BCZ12	0·26
BD115	0·63
BD116	0·81
BD121	0·61
BD123	0·67
BD124	0·70
BD131	0·51
BD132	0·61
BD133	0·67
BD135	0·41
BFY53	0·18
BSX19	0·16
BSX20	0·16
BSY25	0·16
BSY26	0·16
BSY27	0·16
BSY28	0·16
BSY29	0·16
BSY38	0·19
BSY39	0·19

Type	Price
BSY40	0·29
BSY41	0·29
BSY95	0·13
BSY95A	0·13
BU105	£2·04
C111E	0·51
C400	0·31
C407	0·26
C424	0·26
C425	0·51
C426	0·36
C428	0·20
C441	0·31
C442	0·31
C444	0·36
C450	0·22
MAT100	0·19
MAT101	0·20
MAT120	0·19
MAT121	0·20
MJE521	0·56
MJE2955	0·88
MJE3055	0·57
MJE3440	0·51
MPF102	0·43
MPF104	0·38
MPF105	0·38
OC19	0·36
OC20	0·65
OC22	0·47
OC23	0·49
OC24	0·57
OC25	0·39
OC26	0·30
OC28	0·51
OC29	0·51
OC35	0·43
OC36	0·51
OC41	0·20
OC42	0·25
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ACY35	0·21
ACY36	0·29
ACY40	0·18
ACY41	0·19
ACY44	0·36
AD130	0·39
AD140	0·49
AD142	0·49
AD143	0·39
AD149	0·51
AD161	0·36
AD162	0·36
AD161 & AD162(MP)	0·69
ADT140	0·51
AF114	0·25
AF115	0·25
AF116	0·25
AF117	0·25

Type	Price
AF118	0·36
AF124	0·31
AF125	0·31
AF126	0·29
AF127	0·29
AF139	0·31
AF178	0·51
AF179	0·51
AF180	0·51
AF181	0·51
AF186	0·51
AF239	0·38
AL102	0·68
AL103	0·68
ASY26	0·26
ASY27	0·31
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BD200	0·98
BD205	0·81
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BDY20	£1·02
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OC171	0·26
OC200	0·26
OC201	0·29
OC202	0·29
OC203	0·26
OC204	0·26
OC205	0·36
OC309	0·41
OCP71	0·44*
ORP12	0·44*
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Type	Price
ORP61	0·41*
P20	0·51*
P346A	0·20
P397	0·43
ST140	0·13
ST141	0·18
TIP29	0·44
TIP30	0·52
TIP31A	0·56
TIP32A	0·68
TIP41A	0·68
TIP42A	0·81
TIS43	0·31*
UT46	0·28*
ZN414	1·11
2G301	0·19
2G302	0·19
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2G304	0·25
2G306	0·41
2G308	0·36
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BC171	0·15

Type	Price
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BF173	0·22
BF176	0·36
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BF178	0·31
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BF257	0·46
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BF273	0·36
BF274	0·36
BFW20	0·61
BFX29	0·28
BFX84	0·22
BFX85	0·31
BFX86	0·22
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BFY50	0·20
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2N5459	0·41
2N6122	0·69
2S301	0·51
2S302A	0·43
2S302	0·43
2S303	0·56
2S304	0·71
2S305	0·80
2S306	0·80
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7401	0·14	0·13	0·12
7402	0·14	0·13	0·12
7403	0·14	0·13	0·12
7404	0·14	0·13	0·12
7405	0·14	0·13	0·12
7406	0·36	0·31	0·29
7407	0·36	0·31	0·29
7408	0·23	0·22	0·21
7409	0·23	0·22	0·21
7410	0·14	0·13	0·12
7411	0·23	0·22	0·21
7412	0·26	0·25	0·24
7413	0·30	0·29	0·28
7416	0·28	0·27	0·26
7417	0·28	0·27	0·26
7420	0·14	0·13	0·12
7422	0·28	0·27	0·26
7423	0·37	0·36	0·35
7425	0·37	0·36	0·35
7426	0·37	0·35	0·33
1427	0·37	0·35	0·33
7428	0·42	0·39	0·37
7430	0·14	0·13	0·12
7432	0·37	0·35	0·33
7433	0·39	0·37	0·35
7437	0·32	0·30	0·28
7438	0·32	0·30	0·28
7440	0·14	0·13	0·12
7441	0·69	0·66	0·59
7442	0·69	0·66	0·59
7443	£1·11	£1·06	£1·02
7444	£1·11	£1·06	£1·02
7445	£1·48	£1·44	£1·39
7446	£1·11	£1·06	£1·02
7447	£1·02	0·99	0·97

Type	Quantities 1	25	100+
7448	£1·02	0·99	0·97
7450	0·14	0·13	0·12
7451	0·14	0·13	0·12
7453	0·14	0·13	0·12
7454	0·14	0·13	0·12
7460	0·14	0·13	0·12
7470	0·30	0·27	0·25
7472	0·30	0·27	0·25
7473	0·38	0·36	0·32
7474	0·38	0·36	0·32
7475	0·56	0·54	0·52
7476	0·41	0·40	0·39
7480	0·56	0·54	0·51
7481	1·02	0·97	0·93
7482	0·83	0·79	0·74
7483	£1·11	£1·06	0·97
7484	0·93	0·90	0·88
7485	£1·48	£1·44	£1·39
7486	0·32	0·31	0·30
7489	£3·70	£3·47	£3·24
7490	0·60	0·58	0·56
7491	£1·02	0·97	0·93
7492	0·69	0·66	0·59
7493	0·69	0·66	0·59
7494	0·79	0·76	0·69
7495	0·79	0·76	0·69
7496	0·89	0·86	0·80
74100	£1·39	£1·34	£1·30
74104	0·56	0·54	0·51
74105	0·56	0·54	0·51
74107	0·41	0·39	0·37
74110	0·56	0·51	0·46
74111	0·83	0·81	0·78
74118	0·93	0·88	0·83
74119	£1·39	£1·30	£1·20
74121	0·46	0·44	0·41

Type	Quantities 1	25	100+
74122	0·65	0·63	0·60
74123	0·69	0·68	0·65
74141	0·79	0·76	0·73
74145	£1·20	£1·16	£1·11
74150	£1·39	£1·30	£1·20
74151	£1·02	0·97	0·93
74153	0·93	0·88	0·83
74154	£1·57	£1·43	£1·48
74155	£1·11	£1·06	£1·02
74156	£1·11	£1·06	£1·02
74157	0·93	0·88	0·83
74160	£1·30	£1·25	£1·20
74161	£1·30	£1·25	£1·20
74162	£1·30	£1·25	£1·20
74163	£1·30	£1·25	£1·20
74164	£1·67	£1·62	£1·55
74165	£1·67	£1·62	£1·55
74166	£1·48	£1·44	£1·39
74174	£1·48	£1·44	£1·39
74175	£1·02	0·97	0·93
74176	£1·16	£1·11	£1·06
74177	£1·16	£1·11	£1·06
74180	£1·16	£1·11	£1·06
74181	£3·66	£3·56	£3·47
74182	£1·16	£1·11	£1·06
74184	£1·67	£1·62	£1·55
74190	£1·81	£1·76	£1·71
74191	£1·81	£1·76	£1·71
74192	£1·81	£1·76	£1·71
74193	£1·81	£1·76	£1·71
74194	£1·20	£1·16	£1·11
74195	£1·02	0·97	0·93
74196	£1·11	£1·06	£1·02
74197	£1·11	£1·06	£1·02
74190	£2·55	£2·50	£2·45
74199	£2·31	£2·21	£2·11

Devices may be mixed to qualify for quantity price. (TTL 74 series only) data is available for the above series of I.C's in booklet form. PRICE 35p.

* D.T.L. 930 SERIES

Type	Quantities 1	25	100+
BP930	0·14	0·13	0·12
BP932	0·15	0·14	0·13
BP933	0·15	0·14	0·13
BP935	0·15	0·14	0·13
BP936	0·15	0·14	0·13
BP944	0·15	0·14	0·13
BP945	0·28	0·26	0·23
BP946	0·14	0·13	0·12
BP948	0·28	0·26	0·23
BP951	0·65	0·60	0·56
BP962	0·14	0·13	0·12
BP9093	0·42	0·40	0·38
BP9094	0·42	0·40	0·38
BP9097	0·42	0·40	0·38
BP9099	0·42	0·40	0·38

* TRIACS

	Case	100V	200V	400V
2 Amp	TO5	0·31	0·51	0·71
6 Amp	TO66	0·51	0·61	0·77
10 Amp	TO48	0·77	0·92	£1·12

* D.I.L. SOCKETS

		1	25	100+
TSO14	14 pin type	0·31	0·28	0·25
TSO16	16 pin type	0·35	0·32	0·30
TSO24	24 pin type	0·69	0·64	0·62
BPS 8	8 pin type (low cost)	0·14	0·12	0·10
BPS14	14 pin type (low cost)	0·15	0·13	0·11
BPS16	16 pin type (low cost)	0·16	0·14	0·12

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72709	0·23	0·21	0·19
72709P	0·19	0·18	0·17
72710	0·32	0·31	0·28
72741	0·28	0·27	0·26
72741C	0·26	0·25	0·24
72741P	0·28	0·27	0·26
72747	0·79	0·74	0·61
72748P	0·35	0·33	0·31
SL201C	0·46	0·42	0·37
SL701C	0·46	0·42	0·37
SL702C	0·46	0·42	0·37
TAA263	0·74	0·65	0·56
TAA293	0·93	0·88	0·83
TAA350A	£1·71	£1·67	£1·57
uA703C	0·26	0·24	0·22
uA709C	0·19	0·18	0·17
uA711C	0·32	0·31	0·28
uA712C	0·32	0·31	0·28
uA723C	0·45	0·43	0·40
76003	£1·39	£1·34	£1·30
76023	£1·39	£1·34	£1·30
76660	0·88	0·86	0·83
LM380	0·93	0·90	0·88
NE555	0·45	0·43	0·40
NE556	0·88	0·86	0·83
TBA800	£1·39	£1·34	£1·30
ZN414	£1·11	—	—

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PIV	300mA (DO 7)	750mA (SO 16)	1 Amp Plastic		1·5Amp (SO 16)	3Amp (SO 10)	10Amp (SO 10)	30Amp (TO 48)
50	0·05	0·06	1N4001	0·05	0·07	0·14	0·19*	0·56*
100	0·05	0·07	1N4002	0·06	0·09	0·16	0·21*	0·69*
200	0·06	0·09	1N4003	0·07	0·12	0·20	0·23*	0·93*
400	0·07	0·14	1N4004	0·08	0·14	0·28	0·35*	£1·25*
600	0·08	0·16	1N4005	0·09	0·16	0·33	0·42*	£1·76*
800	0·11	0·18	1N4006	0·10	0·18	0·35	0·51*	£1·94*
1000	0·13	0·28	1N4007	0·11	0·23	0·44	0·60*	£2·31*
1200	—	0·32			0·28	0·54	0·69*	£2·88*

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Pak No.	Description	Price £p
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U 2	50 Mixed Germanium transistors AF/RF	0·60
U 3	75 Germanium gold bonded sub-min. like OA5, OA47	0·60
U 4	30 Germanium transistors like OC81, AC128	0·60
U 5	60 200mA sub-min. silicon diodes	0·60
U 6	30 Sil. Planar trans. NPN like BSY95A, 2N706	0·60
U 7	16 Sil. rect. TOP-HAT 750mA VLTG. RANGE up to 1000	0·60
U 8	50 Sil. planar diodes DO-7 glass 250mA like OA200/202	0·60
U 9	20 Mixed voltages, 1 Watt Zener Diodes	0·60
U10	20 BAY50 charge storage diodes DO-7 glass	0·60
U11	20 PNP Sil. planar trans. TO-5 like 2N1132, 2N2904	0·60
U13	30 PNP-NPN Sil. transistors OC200 & 28104	0·60
U14	150 Mixed silicon and germanium diodes	0·60
U15	20 NPN Sil. planar trans. TO-5 like 2N696, 2N697	0·60
U16	10 3Amp sil. rectifiers stud type up to 1000 PIV	0·60
U17	30 Germanium PNP AF transistors TO-5 like ACY 17-22	0·60
U18	8 6 Amp sil. rectifiers BYZ13 type up to 600 PIV	0·60
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U35	25 Silicon planar transistors PNP TO-18 2N2906	0·60
U36	20 Silicon planar NPN transistors TO-5 BFY50/51/52	0·60
U37	30 Silicon alloy transistors SO-2 PNP OC200, 82322	0·60
U38	20 Fast switching silicon trans. NPN 400 MHz 2N3011	0·60
U39	30 RF. Ger. PNP transistors 2N1303/5 TO-5	0·60
U40	10 Dual transistors 6 lead TO-5 2N2060	0·60
U43	25 Silicon trans. plastic TO-18 A.F. BC113/114	0·60
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* THYRISTORS

PIV	0·6A TO18	0·8A TO92	1A TO5	3A TO66	5A TO66	5A TO64	7A TO48	10A TO48	16A TO48	30A TO48
10	0·13	0·15	—	—	—	—	—	—	—	—
20	0·15	0·18	—	—	—	—	—	—	—	—
30	0·19	0·22	—	—	—	—	—	—	—	—
50	0·22	0·28	0·20	0·25	0·36	0·36	0·48	0·51	0·54	£1·18
100	0·25	0·30	0·25	0·25	0·48	0·48	0·51	0·57	0·58	£1·43
150	0·31	0·38	—	—	—	—	—	—	—	—
200	0·38	0·44	0·25	0·30	0·50	0·50	0·57	0·62	0·62	£1·63
400	—	—	0·30	0·39	0·55	0·57	0·62	0·71	0·77	£1·79
600	—	—	0·39	0·48	0·69	0·69	0·78	0·99	0·90	—
800	—	—	0·58	0·65	0·81	0·81	0·92	£1·22	£1·39	£4·07

DIODES

Type	Price	Type	Price	Type	Price	Type	Price
AA119	0·08	BY101	0·12	BYZ16	0·41	OA85	0·09
AA120	0·08	BY105	0·18	BYZ17	0·36	OA90	0·07
AA129	0·08	BY114	0·12	BYZ18	0·36	OA91	0·07
AAY30	0·09	BY124	0·12	BYZ19	0·28	OA95	0·07
AAZ13	0·10	BY126	0·15	CG62		OA200	0·07
BA100	0·10	BY127	0·16	(OA91Eq)	0·06	OA202	0·07
BA116	0·21	BY128	0·16	CG651 (OA70-		SD10	0·06
BA126	0·22	BY130	0·17	OA79)	0·07	SD19	0·06
BA148	0·15	BY133	0·21	OA5 Short		1N34	0·07
BA154	0·12	BY164	0·51	Leads	0·21	1N34A	0·07
BA155	0·15	BYX38/300	0·43	OA10	0·14	1N914	0·06
BA156	0·14	BYZ10	0·36	OA47	0·07	1N916	0·06
BA173	0·15	BYZ11	0·31	OA70	0·07	1N4148	0·06
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Q 5	4 OC 75 transistors	0·60
Q 6	5 OC 72 transistors	0·60
Q 7	4 AC 128 transistors PNP high gain	0·60
Q 8	4 AC 126 transistors PNP	0·60
Q 9	7 OC 81 type transistors	0·60
Q10	7 OC 71 type transistors	0·60
Q11	2 AC 127/128 Complementary pairs PNP/NPN	0·60
Q12	3 AF 116 type transistors	0·60
Q13	3 AF 117 type transistors	0·60
Q14	3 OC 171 H.F. type transistors	0·60
Q15	7 2N2926 Sil. Epoxy transistors mixed colours	0·60
Q17	5 NPN 2 × ST.141. & 3 × ST.140	0·60
Q18	4 MADT'S 2 × MAT 100 & 2 × MAT 120	0·60
Q19	3 MADT'S 2 × MAT 101 & 1 × MAT 121	0·60
Q20	4 OC 44 Germanium transistors A.F.	0·60
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Q28	2 Silicon power rectifiers BYZ 13	0·60
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Q31	6 Silicon switch transistors 2N708 NPN	0·60
Q32	3 PNP Sil. trans. 2 × 2N1131, 1 × 2N1132	0·60
Q33	3 Silicon NPN transistors 2N1711	0·60
Q34	7 Sil. NPN trans. 2N2369, 500MHz (code P397)	0·60
Q35	3 Silicon PNP TO-5 2 × 2N2904 & 1 × 2N2095	0·60
Q36	7 2N3646 TO-18 plastic 300 MHz NPN	0·60
Q37	3 2N3053 NPN Silicon transistors	0·60
Q38	5 PNP transistors 3 × 2N3703, 2 × 2N3702	0·60
Q39	5 NPN transistors 3 × 2N3704, 2 × 2N3705	0·60
Q40	5 NPN transistors 3 × 2N3707, 2 × 2N3708	0·60
Q41	3 Plastic NPN TO18 2N3904	0·60
Q43	5 BC 107 NPN transistors	0·60
Q44	5 NPN transistors 3 × BC 108, 2 × BC 109	0·60
Q45	3 BC 113 NPN TO-18 transistors	0·60
Q46	3 BC 115 NPN TO-5 transistors	0·60
Q47	4 NPN high gain transistors 2 × BC 157, 2 × BC 168	0·60
Q48	3 BCY 70 PNP transistors TO-18	0·60
Q49	3 NPN transistors 2 × BFY 51, 1 × BFY 52	0·60
Q50	7 BSY 28 NPN switch transistors TO-18	0·60
Q51	7 BSY 95A NPN transistors 300MHz	0·60
Q52	8 BY 100 type silicon rectifiers	£1·20
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UIC03	= 12 × 7403	0·60	UIC75	= 8 × 7475	0·60
UIC04	= 12 × 7404	0·60	UIC76	= 8 × 7476	0·60
UIC05	= 12 × 7405	0·60	UIC80	= 5 × 7480	0·60
UIC06	= 8 × 7406	0·60	UIC81	= 5 × 7481	0·60
UIC07	= 8 × 7407	0·60	UIC82	= 5 × 7482	0·60
UIC10	= 12 × 7410	0·60	UIC83	= 5 × 7483	0·60
UIC13	= 8 × 7413	0·60	UIC86	= 5 × 7486	0·60
UIC20	= 12 × 7420	0·60	UIC90	= 5 × 7490	0·60
UIC30	= 12 × 7430	0·60	UIC91	= 5 × 7491	0·60
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UIC41	= 5 × 7441	0·60	UIC93	= 5 × 7493	0·60
UIC42	= 5 × 7442	0·60	UIC94	= 5 × 7494	0·60
UIC43	= 5 × 7443	0·60	UIC95	= 5 × 7495	0·60
UIC44	× 5 × 7444	0·60	UIC96	= 5 × 7496	0·60
UIC45	= 5 × 7445	0·60	UIC100	= 5 × 74100	0·60
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UIC47	= 5 × 7447	0·60	UIC141	= 5 × 74141	0·60
UIC48	= 5 × 7448	0·60	UIC151	= 5 × 74151	0·60
UIC50	= 12 × 7450	0·60	UIC154	= 5 × 74154	0·60
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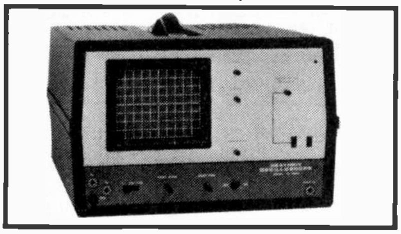

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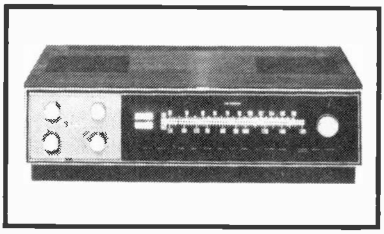

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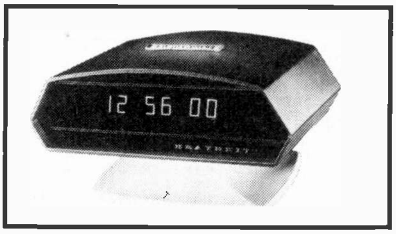

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Because of this technical barrier, it probably remains the popular view that all worthwhile ideas and inventions in the realm of electronics must originate within industry or other professional establishments. This is obviously true of most of the major and more significant developments in the history of applied electronics. Yet the great achievements of organised research and development, whether in private enterprise or public service areas, must not be allowed to overshadow or obliterate the genuine services rendered by private inventors in furthering the wider and often more down-to-earth use of electronic devices, circuits and systems.

One of the strengths of electronics arises from the fact that the subject is no closed shop. Throughout its history electronics has always attracted private experimenters and innovators. The amateurs of the earlier days were comparatively few and many of them showed remarkable devotion as well as rare technical astuteness in pursuing a new and little understood subject, and one that was then hemmed in within narrow confines. With subsequent development and progress, the field opened up increasingly for private endeavour. The coming of solid state devices finally produced the great breakthrough and enabled electronics to become established as the widely based technology of limitless utility it is today.

With this broadening out of the functions of applied electronics the opportunities and scope for the private individual likewise increased enormously. Now that electronics had become a tool of infinite application, the amateur could enter into the innovation area as never before; his awareness of common, or not so common, needs and problems in ordinary life leading to the harnessing of circuits to previously unheard of or undreamt of uses. And the past couple of decades have certainly shown how amateur imagination can play a valuable part in the full cultivation of what is potentially the most useful of all practical sciences.

It is therefore highly gratifying whenever industry shows that it recognises the value of the vast "Think Tank" that amateurs collectively can provide. Practical Electronics is especially delighted that one of Britain's top electronics firms, The Plessey Co. Ltd., has now joined with this magazine in sponsoring a unique kind of competition intended to tap this "Think Tank". Our readers are not likely to be short of ideas, and we look forward to a bumper crop of novel suggestions for useful and viable applications of a given circuit. Substantial rewards are waiting to be won, which should help to stir the imagination.

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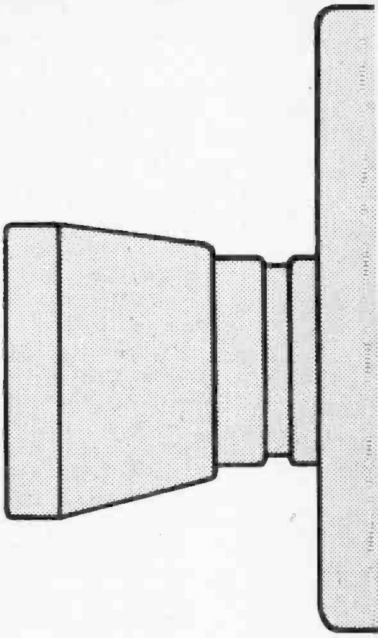
TIME LAPSE PHOTOGRAPHY



By D.J. BONFIELD

FOR many years, time lapse photography has been an invaluable aid to the scientist, but to the ordinary photographer armed with a cine camera, it can open up a whole new field of beautiful and often strange effects. For example, a green rose bud may be transformed into a magnificent deep red rose in a matter of seconds, while at the other end of the scale, a forest of mustard and cress may appear as if by magic to rise from a seething mass of seeds.

But time lapse photography is by no means confined to plant life. Sunrises and sunsets provide good subjects, and even mould growing on a slice of damp bread can be quite fascinating!

BASIC PRINCIPLES

Any cine camera with the facility for exposing a single frame of the film with each operation of the shutter release, can be used in conjunction with the unit to be described, to effectively compress events lasting hours or even days into a few seconds on film.

The usual way to produce this effect is to reduce the speed of the film while in the camera, and project it back at normal speed. Consider the common 8mm cine camera, which usually runs at a speed of about 16 frames per second. If we wanted to compress 24 hours of filming into 15 seconds, we would want to take a total of 16 × 15 = 240 frames in 24 hours, which is one frame every 6 minutes.

To meet such requirements, the Time Lapse Controller was designed to provide a reliable automatic method of operating the camera at pre-set intervals. Many subjects to be photographed will require artificial lighting, and since leaving photoflood lights on continuously is wasteful, the facility has been incorporated in the unit to electronically switch up to 1kW of lighting throughout the period of each exposure.

The unit is connected to the camera via a cable release, and the time between successive exposures can be varied continuously over the range 10 seconds to 48 minutes.

CIRCUIT DESCRIPTION

The complete circuit of the Time Lapse Controller is shown in Fig. 1. The requirements for this circuit are that during each cycle it should first switch on the lighting, and then allow approximately three seconds for the lights to reach their full intensity, after which a solenoid is to be operated for about a second to release the camera shutter, followed a second or so later by the lights switching off.

555 TIMER

The basic timing element of the circuit is the NE555V integrated circuit, IC1, which is used in an astable mode. The mark-to-space ratio of the

Title photographs by David & Katie Urry (Bruce Coleman Ltd) squarewave output can be varied considerably by the two controls S1 and VR1; one cycle is shown in Fig. 2.

When the output of IC1 is low, TR2 is driven to saturation, switching on the indicator l.e.d. D5 and the triac CSR1. This in turn switches on the photoflood lighting. (A triac conducts with either a positive or negative gate signal regardless of the voltage polarity across its MT1 and MT2 terminals.) The indicator l.e.d. is useful as it shows when the solenoid is about to operate when no lighting is plugged into the unit. Thus the lights are on for about 5 seconds, determined by the pre-set potentiometer VR3, during each cycle.

DELAY

TR3 is an inverting buffer stage. As soon as the collector voltage rises, C3 begins to charge up through R22 and VR4. Due to the voltage drop across the silicon diode D6, TR4 does not begin to conduct until the voltage across C3 exceeds about 1 volt.

The Schmitt trigger input to the monostable IC2 is used so that the voltage at TR4 emitter has to reach a certain threshold voltage before the monostable is triggered. Thus the purpose of C3, D6, TR4, and associated resistors, is to delay by about 3 seconds the triggering of the monostable, once the lighting has been switched on.

Once triggered, the monostable remains in its unstable state for about a second, determined by C4 and VR5. During this period TR5 is saturated, turning on the triac CSR2, which operates the mains solenoid.

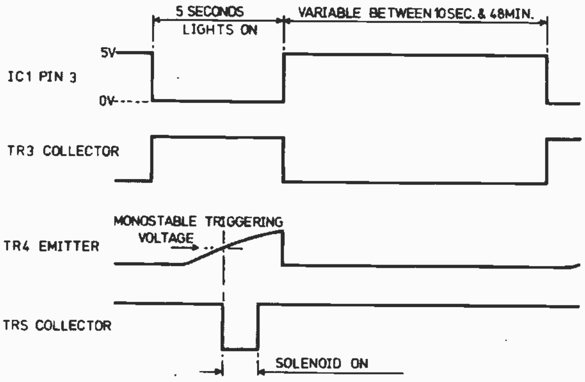


Fig. 2. Waveforms for one cycle of operation

The solenoid actuates the camera shutter via a cable release. Shortly afterwards the output of IC1 goes high, switching off the lights and completing the cycle.

POWER SUPPLY

TR1 and associated components, operating in an emitter-follower arrangement, form a simple stabilised power supply, giving approximately 5 volts from a 9-0-9 volt 100mA miniature transformer. The l.e.d. D4 is the mains-on indicator.

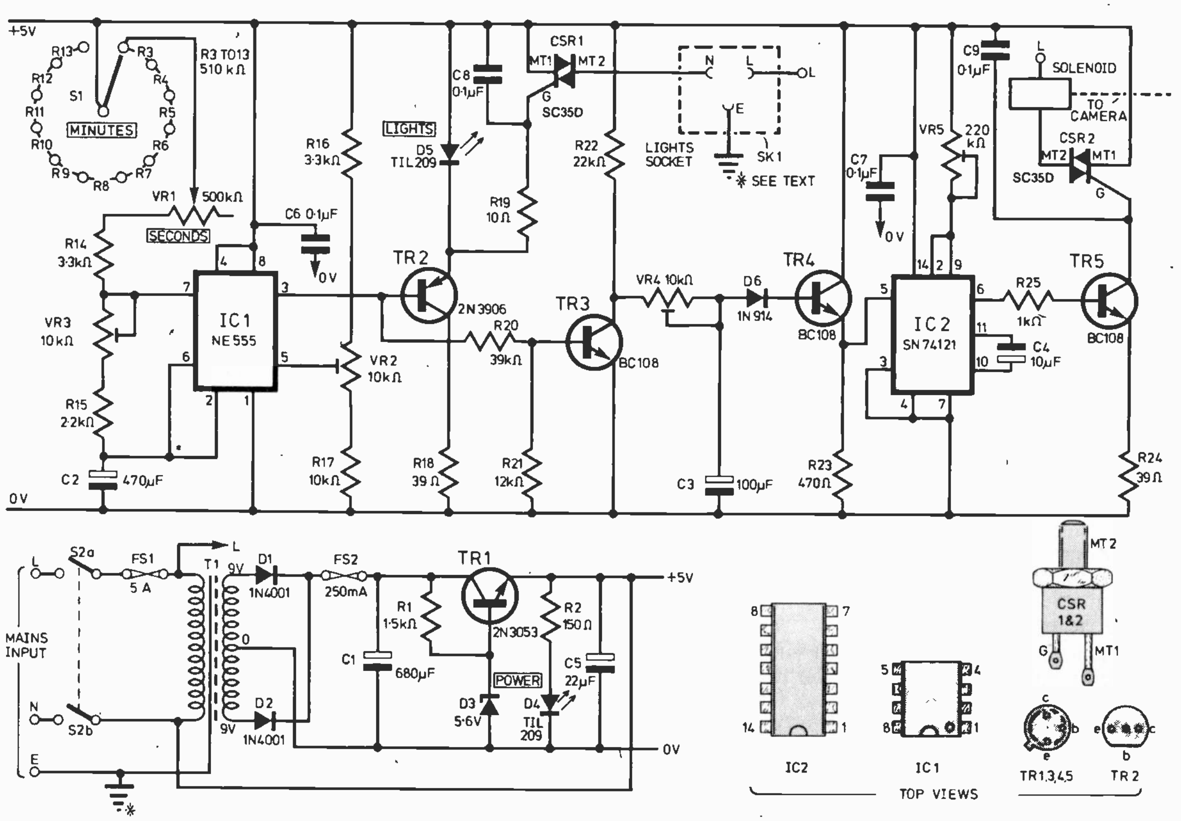
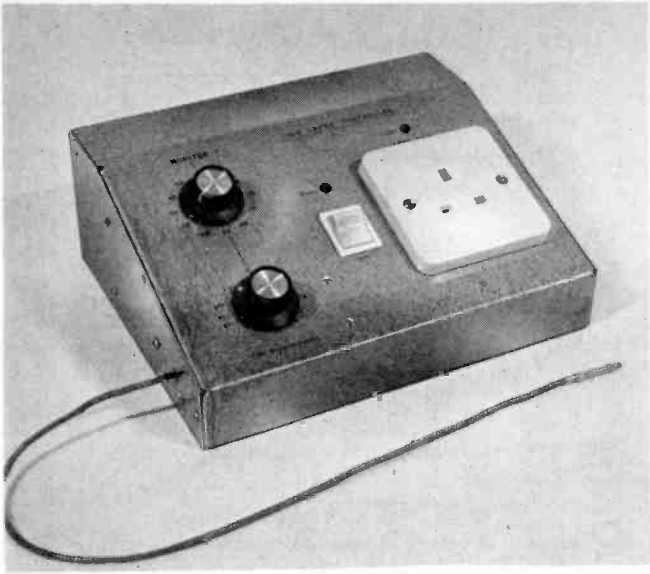


Fig. 1. Circuit diagram of Time Lapse Controller



Front panel arrangement of the time lapse controller

The circuit takes its maximum current of about 180mA when both triacs are conducting. With both triacs off, the quiescent current is in the region of 50mA.

COMPONENTS

The triac CSR1 controlling the lights is rated at 6A, r.m.s., at ±400V at 75 degree C, so it is capable of switching about 1·4 kilowatt of lighting at mains voltage. It would probably be wise to consider one kilowatt the maximum, since no heat sink is used. When switching on one kilowatt for 5 seconds in every 10, the triac does not get sufficiently hot to warrant the use of a heat sink.

It should perhaps be emphasised that good quality components should be used for the timing capacitors, in particular C2. The higher the leakage current of this capacitor, the less accurate will be the timing on the higher ranges of S1, rather defeating the object of using 2 per cent tolerance resistors.

CONSTRUCTION

The majority of the components are mounted on one printed circuit board measuring 7in × 3in (178 × 76mm), shown full size in Fig. 3, and the component layout is shown in Fig. 4.

The author advises the use of sockets for the i.c.s if only to provide a simple method of testing other 555's and 74121's!

The usual care must of course be taken with the orientation of the semiconductors and capacitors. A TO5 cooling clip is essential for TR1.

TRIAC MOUNTING

The triacs are mounted through ¼in holes drilled in the circuit board. The cases of the triacs will be live when the unit is in operation, so it is essential to ensure that there is adequate space between adjacent components, tracks on the board, and the case.

Fairly thick wire is used to join the main terminal 1 (MT1) of CSR1 to MT1 of CSR2, and a further short length of wire to join these MT1's to the + 5 volt track on the circuit board.

COMPONENTS . . .

Resistors

R1	1·5kΩ
R2	150Ω
R3–R13	510kΩ2%
R14	3·3kΩ
R15	2·2kΩ
R16	3·3kΩ
R17	10kΩ
R18	39Ω ½W
R19	10Ω
R20	39kΩ
R21	12kΩ
R22	22kΩ
R23	470Ω
R24	39Ω
R25	1kΩ

All ¼ watt 5% carbon unless otherwise stated.

Potentiometers

VR1 500kΩ lin.
VR2–4 10kΩ S/Min. Horiz. Preset
VR5 220kΩ S/Min. Horiz. Preset

Capacitors

C1 680μF 16V elect.
C2 470μF 6·3V elect.
C3 100μF 10V elect.
C4 10μF 10V elect.
C5 22μF 16V elect.
C6–9 0·1μF 16V polyester.

Semiconductors

TR1 2N3053
TR2 2N3906
TR3–5 BC108
IC1 NE555V
IC2 SN74121
D1–2 1N4001
D3 5·6V 400mW Zener
D4–5 TIL209 l.e.d. + clip
D6 1N914
CSR1 SC35D 3A 400V triac (Henry's Radio)
CSR2 SC40D 6A 400V triac (Henry's Radio)

Switches

S1 1-pole 12-way rotary
S2 Double-pole on/off rocker switch (5A min.)

Solenoid

Westool type MM6, mains operated solenoid. (From Electro-Tech Components Ltd., 315/317, Edgware Rd., London W2)

Case

Instrument case size 235mm × 190mm × 90mm type U. (From H. L. Smith & Co. Ltd., 287/289 Edgware Rd., London W2 1BE)

Transformer

T1 Miniature mains transformer. 9–0–9V 100mA

Miscellaneous

I.C. sockets; T05 cooling clip; two 20mm fuse holders; 5A fuse; 250mA fuse; 13A flush wall mounting socket; Bulgin mains connector (plug & socket); two knobs, cable release; p.c. board; aluminium for brackets; s.r.b.p. board and hardware for mounting solenoid.

CIRCUIT BOARD DETAILS

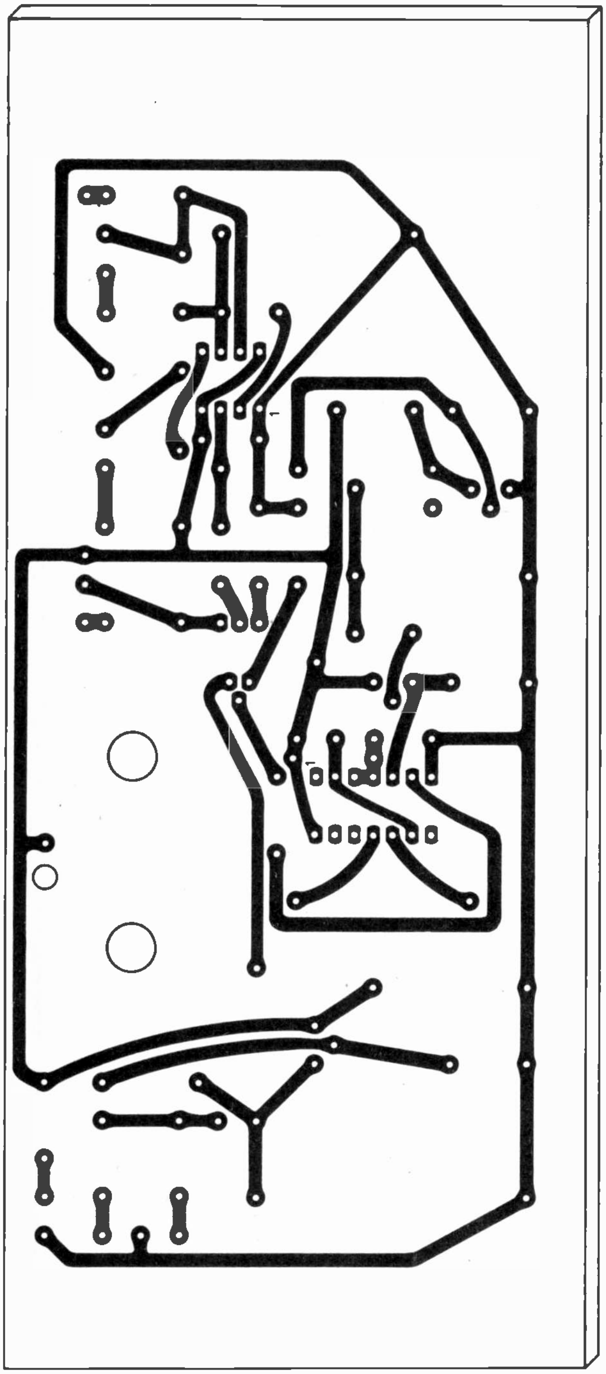


Fig. 3. Printed circuit board master

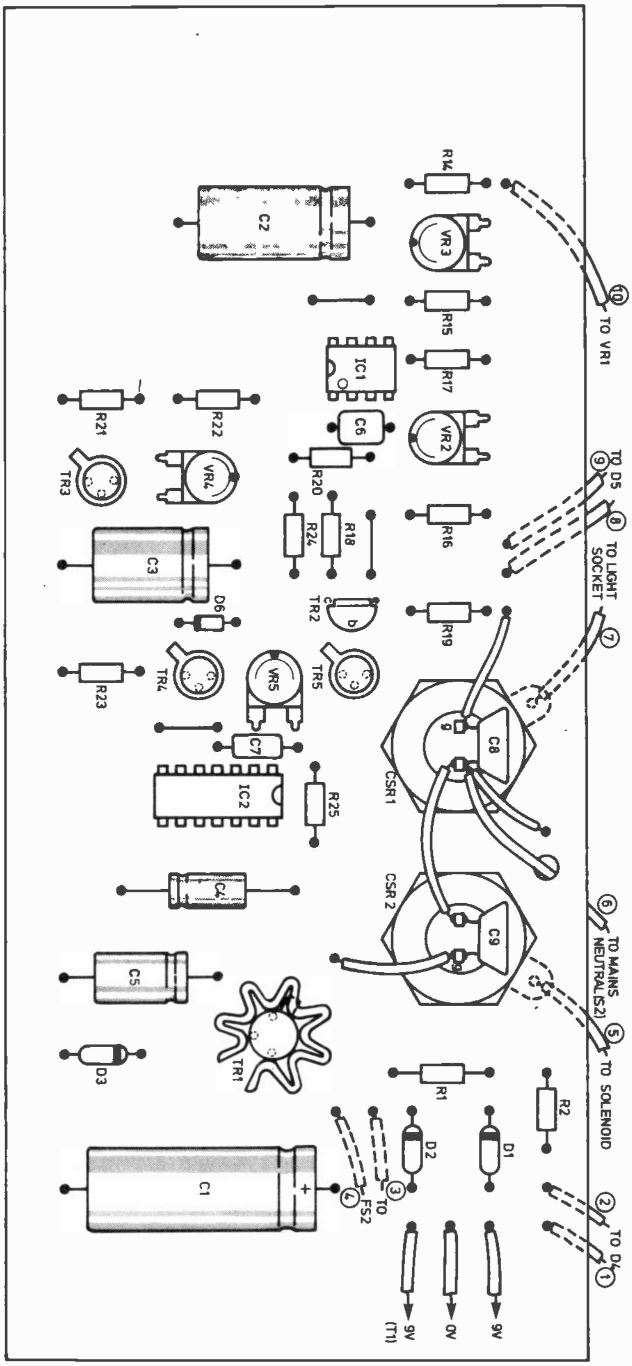
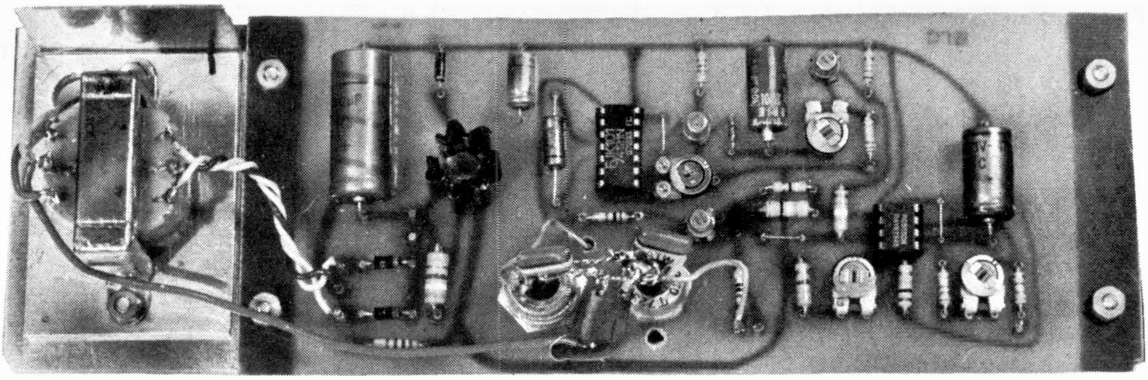


Fig. 4. Component layout



Components mounted on the printed circuit board and positioning of the transformer on the L-shaped heatsink

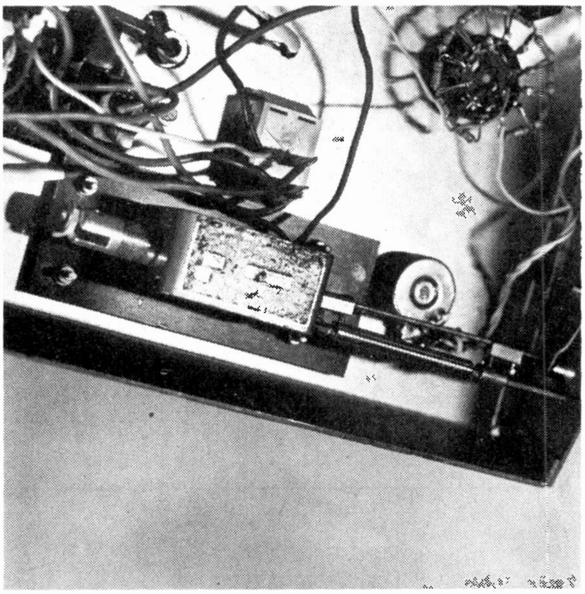
CASE

The whole unit is housed in a 9¼ × 7½ × 3½in (235 × 190 × 89mm) aluminium case with a sloping front panel and an attractive hammered silver finish. Fig. 5 shows the layout inside the case. The front panel can be finished off with Letraset and protected by a coating of clear lacquer to give a professional appearance.

INTERIOR LAYOUT

The circuit board is fixed vertically at the deep end of the case, with the components facing the ventilation slot. The C2 end of the board is attached to the side of the case by a ½ × ½ × 3in (12 × 12 × 76mm) long "L" shaped bracket made from a piece of aluminium sheeting. The opposite end is held by a ½ × 2½ × 3in (12 × 63 × 76mm) long "L" shaped bracket. This second bracket provides a convenient position on which to mount the transformer. In the prototype a small plate of aluminium with a flange was sandwiched between the transformer and bracket to help dissipate any heat produced by the transformer.

Close-up view of the solenoid



EARTHING

It must be emphasised that although the case is earthed, neither the positive nor the negative supply lines are connected to earth, but the positive supply line *is* connected to mains neutral.

COMPONENT POSITIONING

The resistors R3 to R13 are mounted directly on the single-pole 12-way rotary switch S1. The two light emitting diodes are held in clips mounted in holes in the positions shown in Fig. 5. The mains on-off switch S2 is a double-pole rocker type rated at 5A or more. A Bulgin mains connector (chassis mounting plug and line socket) was used to give the unit a neater overall appearance. This can be mounted on one side of the cas together with the two 20mm fuse holders.

WIRING

Insulated wire capable of carrying 5A must be used to connect the MT1's of the triacs to mains neutral via the switch S2. A standard 13A flush wall mounting socket is mounted on the front panel, into which the lighting can be plugged as required. 5A wire must again be used to connect MT2 of the triac CSR1 to the terminal marked neutral on this socket, and again from the terminal marked live on the socket to the mains live.

THE SOLENOID ASSEMBLY

The solenoid recommended for this project has a pull of 3lb, which should be sufficient for even the most stubborn shutter release.

Fig. 6 shows the method used to connect the solenoid to the cable release. It is important to be able to adjust the probe depth setting so that the camera operates smoothly, and is not damaged by the probe depth being too great. This aim is not too difficult to achieve with the specified solenoid, making use of the 4BA tapped holes in the base and end of the solenoid housing.

PLATFORM

First a platform is made out of a piece of s.r.b.p. or Perspex, approximately 4½ × 1¾in (115 × 45mm). Two slots about ¾in (19mm) long have now to be made in it to correspond with the two tapped holes in the solenoid base. The slots are best made by drilling a series of ⅛in holes and then filing down the jagged edges. The solenoid can then be attached to the

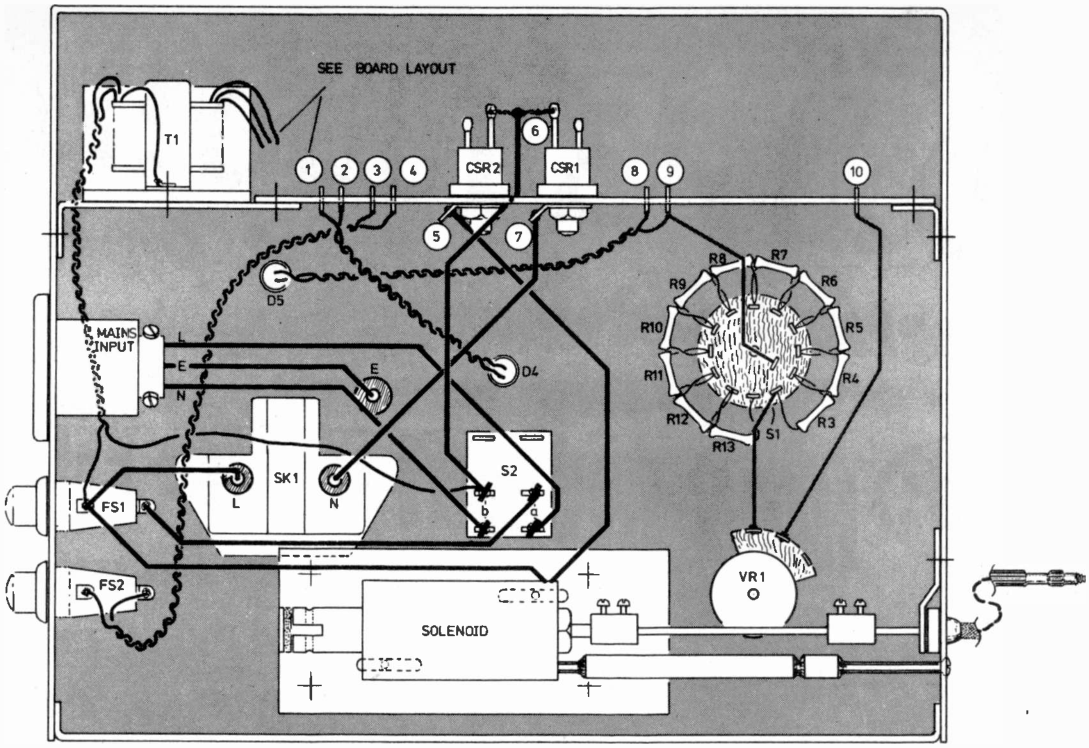


Fig. 5. Interior layout and interwiring details

platform by two short 4BA bolts. These bolts should not be screwed in all the way but be just loose enough to allow the solenoid to move reasonably smoothly up and down the slots.

Before the unit is put into operation, it will be necessary to glue the ends of the bolt shanks into the tapped holes with a strong adhesive such as Araldite, otherwise they may tend to shake loose due to the 50Hz vibration of the solenoid. The platform can now be mounted at each corner on a short pillar or a couple of nuts, in the position shown by Fig. 5.

The solenoid is moved along the platform slots by a short length of 4BA studding, one end of which is screwed through a tapped hole at the end of the solenoid. A 4BA bolt is pushed through a hole in the side of the case in line with the studding, to which it is attached by means of a 4BA tapped pillar or a spacer filled with plenty of Araldite. Thus by turning the head of the bolt, the solenoid can be moved towards or away from the side of the case.

CABLE RELEASE

The next step is the cable release, which should be as long as possible; 20in should be considered the minimum. The button at the top of the cable release shaft has to be removed, with some cable releases it simply screws off, with others it will have to be sawn off.

A suitably sized hole is drilled in the side of the case in line with the solenoid plunger, so that the collar of the cable release fits snugly into it. The gap between the solenoid and cable release is best bridged with a thin metal rod. Some type of connectors are required to join the cable release to the rod to the solenoid. Parts from a dismantled terminal block provide a good solution, but probably Araldite will again be required to stop them working loose.

SETTING UP

Before switching on, the mains wiring must be carefully checked to ensure that the live and neutral have not become interchanged. A neutral wire should lead to the triacs, and a live wire to the solenoid and the lights socket.

If all is well, set all preset potentiometers to approximately their mid-positions. Set S1 to position 1, and set VR1 to minimum resistance. Replace FS1 by a 1A fuse for the initial testing, and plug a low wattage lamp such as a table lamp into the lights socket.

Check that the +5V or 0V supplies are not connected to earth, and ensure that the case is earthed.

Remembering that the cases of the triacs will be live, switch on. Within about 15 seconds, the table lamp should come on for several seconds together with the lights indicator, l.e.d. D5. Sometime during the period that the lamp is on, the solenoid should be actuated for about a second. This cycle should be repeated at approximately 10 second intervals.

PRESETS

Preset VR3 can now be adjusted until the period during which the lights are on in each cycle lasts 5 seconds. Now adjust VR4 to produce a delay of

continued on page 719

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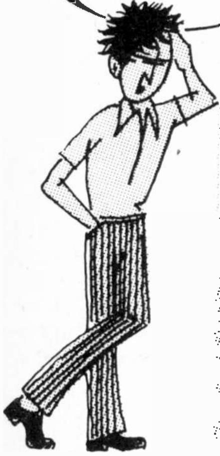

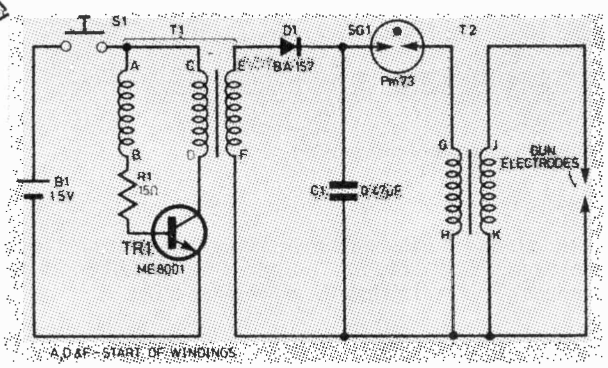

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When you saw the Portable Gas Ignitor in the July issue of *Practical Electronics* did you immediately think of other applications for this particular circuit? Can you suggest any ways in which the device could be put to other uses in industry or in the home? If so, here's an opportunity to put your ideas to good advantage. And if you missed the July issue, not to worry—the circuit and the essentials of its operation are given on this page.

In association with the Plessey Company, we present this fascinating challenge and offer prizes totalling over £500 in value for really practicable and ingenious ideas. And a chance, possibly, to see your idea in production! So get that grey matter plus your know-now of electronics working, and meet our challenge right away!

HOW TO ENTER

The contest is for practical applications of the Portable Gas Ignitor Circuit—either utilising the original circuitry or including design modifications to increase its scope.

To remind you, the operation of the Ignitor is:

The application of a high voltage across a pair of electrodes produces an electric field in the gas between them, this leads to ionisation and breakdown of the gas producing a spark across the gap. When the circuit of the ignitor is completed current flows from a battery into a transistor oscillator circuit and the resultant pulses of energy charge a capacitor to approximately 300 volts The capacitor is then discharged by an electronic switch into the primary of an H.T. transformer which produces the necessary voltage to cause the sparks at the electrode. The design enables a steady stream of sparks at 10,000 V to be generated with complete safety and employing only a single 1·5V dry cell as the power source.

Entries must be written/drawn clearly on one side of plain paper with the entrant's full name and address at the top of every sheet. Each entry to comprise:

(a) a brief summary of the idea (about 25 words)

(b) any such further lucid description, drawings, sketches or circuit diagrams you consider the judges may need to form the best appraisal of your idea. DO NOT send actual models.

Each entry must have a properly completed entry coupon firmly affixed to the BACK of the summary.

SECOND CHANCE!

Another free entry coupon will appear in the October issue of Practical Electronics.

The closing date is Monday October 13, 1975, to allow plenty of time for you to obtain the second entry coupon from our next issue and post two different ideas in one envelope if you wish.

RULES AND CONDITIONS

There is no entry fee nor limit to the number of entries a reader may submit but each entry must be accompanied by a proper printed entry coupon, cut from PRACTICAL ELECTRONICS, and must bear the entrant's own full name and address. Entries will also be accepted from groups—in which case the entry coupon must be completed by one of the group and the names and addresses of all the other members listed on a separate piece of paper affixed, with the entry coupon, to the back of the summary.

All accepted entries will be examined by a panel of expert judges, including Plessey engineers and the Editor of *Practical Electronics*, and asssesed on (a) originality of the idea, (b) technical merit, (c) practicability, (d) economic viability, (e) market potential. The prizes will be awarded for the best entries in order of merit. No entrant may win more than one award. In the event of the same idea being submitted by two or more entrants, presentation of the entry (clarity, best expression, etc) will decide such winner(s) or winning order.

In the event that the judges consider there are not enough entries of a sufficiently high standard, the Editor reserves the right not to award any prize(s) at his discretion.

Entries arriving after closing date will not be considered, nor will any received that are illegible, not wholly understandable, are not accompanied by a properly completed entry coupon or in any other way do not comply exactly with the instructions and rules.

No responsibility can be accepted for entries lost or delayed in the post or otherwise; proof of posting will not be accepted as proof of receipt. No entries can be returned.

Copyright of all entries shall become the property of IPC Magazines Ltd., publishers of *Practical Electronics*. Ideas submitted may be used or adapted by the competition sponsors for production or other commercial use. Where appropriate, additional payment will be automatically negotiated with the entrant. Entries will not be published prior to evaluation in order to comply with legal safeguards.

Decisions of the judges, and of the Editor in all other matters affecting the competition, will be final and legally binding. No correspondence will be entered into nor interviews granted.

Winners will be notified by post and brief details of winning entries published later in *Practical Electronics*. The Editor reserves the right to amend and/or re-draw any sketches or diagrams of prizewinning entries for publication purposes.

The contest is open to all readers in Great Britain, Northern Ireland, Eire, Channel Isles and Isle of Man except employees of IPC Magazines Ltd., the Printers of Practical Electronics, and the Plessey Co. Ltd. and its subsidiary companies; and the families of all such employees.

Post your entry in a sealed envelope to: Ignitor Application Contest, PRACTICAL ELECTRONICS, 136 LONG ACRE, LONDON, WC2E 9QP, to arrive not later than October 13, 1975 the closing date.

FREE ENTRY COUPON

NAME (Mr/Mrs/Miss) ....
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I certify that

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*** (b) this entry is made on behalf of the group members listed, and is our own original idea not copied from any other source.**

(c) this idea has not been published—or offered for publication elsewhere.

I/We agree to abide by the rules and conditions, and to accept the published result as final and legally binding.

SIGNED ....

TIME LAPSE PHOTOGRAPHY

continued from page 717

3 seconds between the lights coming on and the solenoid starting to operate. Next adjust VR5 so that the solenoid operates for a period of one second, leaving one second between the solenoid switching off and the lighting switching off. Thus the camera shutter will be actuated only after the lighting has had time to reach its full intensity.

Now turn S1 to position 2, and with VR1 at minimum resistance, adjust VR2 until the time between subsequent cycles is exactly 4 minutes and 10 seconds. S1 will then be calibrated in 4 minute steps, and VR1 will be variable over the range 10 seconds to 4 minutes.

When the calibration has been completed, the 5A fuse FS1 can be replaced, and the unit tested with larger loads up to a maximum of one kilowatt.

CONNECTING UNIT TO CAMERA

Turn the probe depth setting screw on the side of the case anticlockwise to push the solenoid to the far end of the slots, and connect the cable release to the camera. Now slowly screw up the probe depth setting screw, with the solenoid operating, until the setting is just sufficient to operate the camera shutter. Take care not to have the setting too deep or damage may be caused to the camera mechanism.

THE UNIT IN OPERATION

If H hours of filming is to be compressed into s seconds of projection time, then the time between frames required is:

$$\frac{60 \times H}{P \times s} \text{ minutes}$$

where P is the speed of the film when projected (i.e. 16 or 18 frames per second).

If the filming is to continue throughout the day and night, the light falling on the subject from the photoflood lighting must be of far greater intensity than any daylight that may reach the subject. Otherwise the exposure of the finished film will be inconsistent. Artificial light film should of course be used.

Now with a certain amount of patience (since it takes a very long time to expose a 50 foot length of film, taking each frame separately!) you will be able to produce some fine examples of time lapse photography. ★

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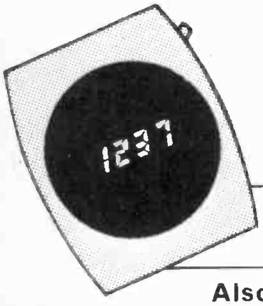

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BY FRANK W. HYDE

RIFT ON MARS

The huge Coprates canyon on Mars has puzzled planetary scientists ever since the composite picture of the red planet was made from the many pictures sent back by *Mariner 9*. The canyon is some 2,700km in length, 150km wide, 6km deep and stretches from the Tharsis plateau toward the east.

Recently two papers have dealt with the subject in a new way. These appeared in "Earth and Planetary Science Letters".

One of the papers by D. McAdoo and J. Burns, suggests that the cause of the great rent on the surface of the planet is the result of tensions resulting from the outer shell movement. They indicate that in their opinion the stresses were caused when the planet tried to adjust itself to accommodate with the changing position of the poles. The change that is meant here is the wandering position of the poles.

This changing of position would require that the planet's shape also changed as the outer layers sought to adjust the curvature required by the spin on the polar axis. It is this adjustment that could have resulted in the creation of the canyon.

McAdoo and Burns claim that the canyon's proximity to the equator, it's shape, particularly the s-shape, and the east to west alignment all point to "membrane" stresses. This is to some extent supported by other configurations such as the quasi-circular formations in the polar regions.

An alternative view is taken by V. E. Courtillet and C. J. Allegre of the Institute de Physique du Globe and M. Mattauer of the Laboratoiire de Géologie Structurale.

They suggest that at the western end of the canyon there may be a junction of three tectonic plates. A "triple junction" as it is known. One of the plates would be the area of the Tharsis plateau with its numerous volcanoes. Another could be in an area north of the rift and the third could be south between Coprates and the region of Pheonicus Lacus. This is a situation where the transform fault would be similar to the Aden Rift on the Earth.

There will be considerable controversy in this matter in the future for now that two positive suggestions have been made sides will be taken. Certainly there is food for thought in this matter of Mars, for there is a marked difference between its two hemispheres.

The division in this case, however, is not north and south of the equator but along a line at an angle of 50 degrees to the equator. One hemisphere is heavily cratered, the other is only lightly sprinkled but contains the volcanoes. There is a great contrast between them and this has led to speculation as to the nature of the present state of the evolution of the planet. It is possible, some planetologists say, that Mars could be at a stage where there is one large continent and one ocean basin.

NEW COMET

The period of the first comet discovered by Dr R. West and then by Dr Ikemura of Tokio and Dr L. Kahoutek of Hamburg, is now known to have a period of six years. It is a twelfth magnitude object.

The details of its period has been calculated by Dr R. G. Marsden who says that the comet was at a perihelion on February 26 and was 218 million kilometres from the Earth. It passed within 1·5 million kilometres of Jupiter in March 1972 which probably captured it into near solar orbit at that time. It is now named West-Kohoutek-Ikemura in the catalogues.

BIOLOGICAL LINKS WITH SPACE

From the USSR comes some interesting data about the effects of supernovae on the flora of the Earth. A botanist from Leningrad, Nikolai Lovelius of the Institute of Botany, USSR Academy of Sciences, has demonstrated these effects by using the stump of an 807 years old Juniper tree. The stump came from the slopes of Zerevshan in the Pamir-Altai range of mountains in Turkestan.

This is an area where living organisms are responsive to the slightest changes in the medium.

Lovelius carefully analysed the volume and distribution of the annular rings and discovered that there were three occasions during the lifetime of the tree when its growth was slowed down. An examination of the cosmic explosions revealed that the time of the tree's slow growth periods coincided with major cosmic events.

The first was at the time of the Tycho Brahe supernova (1572), the second at the time of the Kepler supernova (1604) and that of the third at the time of Cassiopea-A (1700). The growth of the tree was noticeably slower in the first few years after the events. This continued for 15 years before full recovery was reached.

Lovelius does not offer any particular explanation of this new link between outer space and the Earth, but no doubt there are other trees of great age which could be used for study.

VENUS PROBE

The automatic interplanetary space station *Venus-9* was launched from the USSR in June. The main aim of this mission is the further exploration of its environment.

The spacecraft will, during its flight along an Earth-Venus trajectory, carry out research into the physical characteristics of the interplantary space including the magnetic fields, solar wind and the ultraviolet radiation.

The *Venus-9* is a new type of spacecraft developed for the exploration of the planet. It was injected into an interplanetary orbit from an intermediate Earth orbit. The spacecraft is due to be within the vicinity of the planet in October next.

The flight is being directed from the long range communication centre of the USSR. Many new and novel features are on this vehicle and represent the best of Soviet technology since the launch of the first probe to Venus by the USSR in February 1961.

Venus approaches closer to the Earth than any other planet but this distance constantly varies which complicates launching. It is interesting to make a comparison about the accuracy required, which may be compared to using a rifle to hit a coin at a distance of one kilometre. Although the distance between the Earth and Venus varies between 118 and 85 million kilometres, *Venus-9* will have covered around 370 million kilometres by the time of approach.

COSMOS SATELLITES

Two more Earth satellites have been launched by the Soviet Union, *Cosmos 741* and *Cosmos 742*. The orbital elements are:

Cosmos 741

Revolution period: 89 minutes
Apogee: 246km
Perigee: 210km
Orbit inclination: 81.4 degrees

Cosmos 742

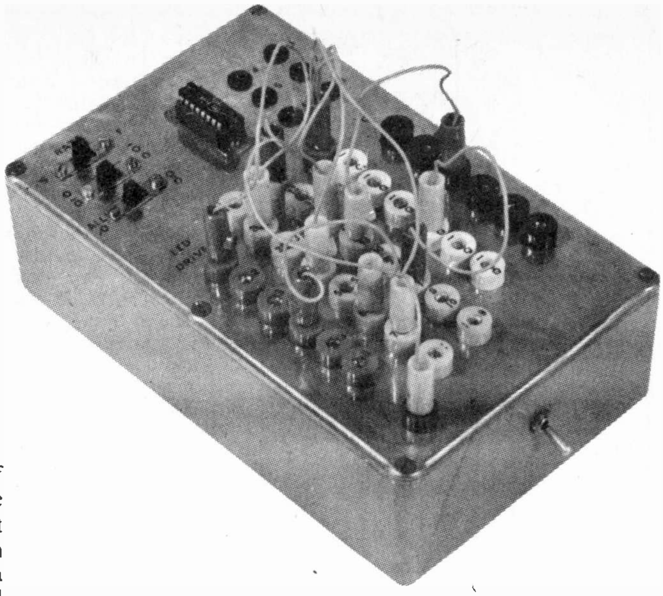
Revolution period: 89.8 minutes
Apogee: 375km
Perigee: 189km
Orbit inclination: 62.8 degrees

They were launched on May 29 and June 3 respectively.

Cosmos 741 carries a transmitter operating on 19.99MHz in addition to the special equipment for space measurements. A feature on this satellite is a radio system for accurately determining the orbital elements.

DIGITAL I.C. TESTER

By W.H. DAVIES



IT IS reasonable to assume that many readers of this magazine possess a transistor tester of one type or another and those who do will readily agree that the expense incurred to effect construction has been repaid ten-fold. Primarily, these testers provided a facility for checking packs of untested and unmarked transistors available from component suppliers at reasonable cost and matching pairs of transistors by comparison of h_{fe} measurements.

They also provide a confidence check procedure whereby a transistor can be tested prior to soldering in circuit.

Recent trends in constructional projects indicate the increasing use of logic integrated circuits and a need has arisen for a similar device on which the constructor can test a wide variety of the current range of i.c.s.

The unit described here does this. It provides a means of testing 14 and 16 pin dual-in-line TTL and DTL types, and light emitting diodes (l.e.d.s) provide a visual indication of the logic states. It is constructed in a box, either metal or plastic, the dimensions of which are determined by the physical size of the switches and associated sockets employed, and whether or not the tester is to be powered by internal batteries or from an external source.

It should be noted, however, that the changeover switches used need not be toggle types as small slider switches are available at low cost and these have an acceptable degree of efficiency. Patch cords are used to obtain the necessary combinations required to permit versatility of operation.

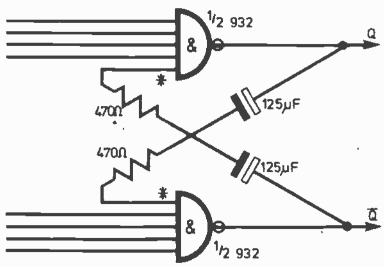


Fig. 1. This basic oscillator circuit can provide two differing frequencies dependent on the values of the two identical capacitors

COMPONENTS . . .

Resistors
R1 470Ω
R2 470Ω
R3 to R8 330Ω 6 off.
All $\frac{1}{8}$W 2%

Capacitors
C1, C4 250μF, 10V
C2, C3 125μF 10V

Integrated Circuits
IC1 BP932
IC2 BP936

Diodes
D1 to D6 TIL209 *or* HP5082

Switches
S1, S2, S3 DPDT slider or toggle, 3 off
S4 SPCO on/off switch

Miscellaneous
Sockets SK1 to SK36, 2mm, 36 off. Plugs to suit. Batteries and holder, 4 off U11 or similar. Case, die-cast or plastic, $7\frac{1}{2} \times 4\frac{3}{4} \times 2$in in model. $3\frac{1}{2} \times 2$in Veroboard 0·1in matrix, pins, nuts, bolts, spacers, wire, solder, etc.

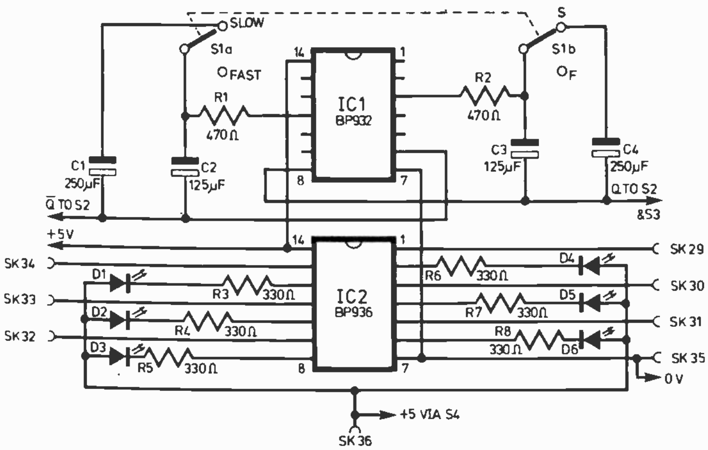
THE OSCILLATOR

With the exception of a regulated 5V d.c. power supply source, a pre-requisite for the tester is an oscillator capable of providing the necessary Q and $\overline{Q}$ square wave logic. This is achieved by employing a standard multivibrator circuit derived from a DTL 930 series BP932 dual 4-input NAND gate, using the expanders with external *R* and *C* components as shown at Fig. 1.

The frequency (*F*) of such a multivibrator is given by the formula:

$$F \simeq \frac{160}{C}$$

where *F* is expressed in hertz and *C* in micro-farads.



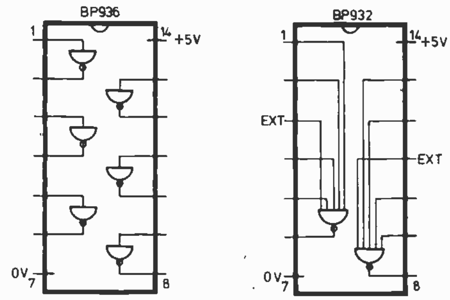


Fig. 2. Circuit diagrams of the oscillator and l.e.d. drive

The oscillator, as constructed, provides a choice of fast (F) or slow (S) modes of operation by switching into circuit one of two values of C, 125μF or 250μF. The values are chosen so that the two frequencies are 1·28Hz and 0·43Hz respectively. In addition, the Q and Q̄ outputs are switchable so that the available logic may be Q and Q̄ as indicated by the socket labelling on the front panel, reversed Q for Q̄, or all one (Q or Q̄).

The general circuit diagram for the prototype board is shown in Fig. 2. The switch wiring for the Q—Q̄ changeover is shown in Fig. 3.

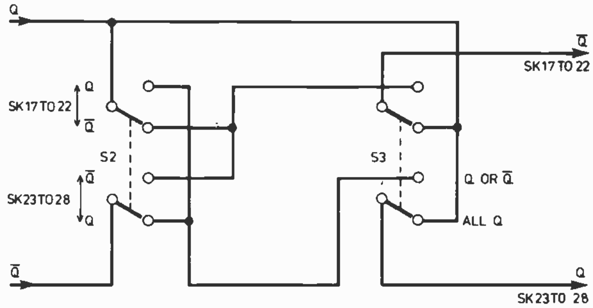


Fig. 3. The Q and Q̄ output switching for the various combinations of Q and Q̄ required

L.E.D. DRIVE

A BP936 hex inverter with a 330Ω load in series with the output of each gate supplies sufficient drive for the l.e.d.s. Gate inputs are via the l.e.d. drive sockets on the front panel. In Fig. 2 the l.e.d.s are shown as on the board with the i.c.s but in fact they, and switch S1, are mounted on the instrument front panel.

CONSTRUCTION

The oscillator and l.e.d. drive assembly is mounted on one piece of Veroboard measuring 3½in by 2in, with the copper strips running widthwise as in Fig. 4.

Vero pins are used at the various interconnecting points to the front panel and batteries. These provide sufficient anchorage for interconnection wiring and soldering. For the prototype unit the author dismantled an old multisocket connector and used the individual socket elements as female connectors to the Vero pins; this made interconnecting relatively easy.

The switch connections and front panel layout are given at Fig. 5 which shows the wiring diagram for the reverse side of the front panel and the suggested location for the various sockets. The positioning of the oscillator and l.e.d. drive assembly and the battery holder are shown in the accompanying photographs.

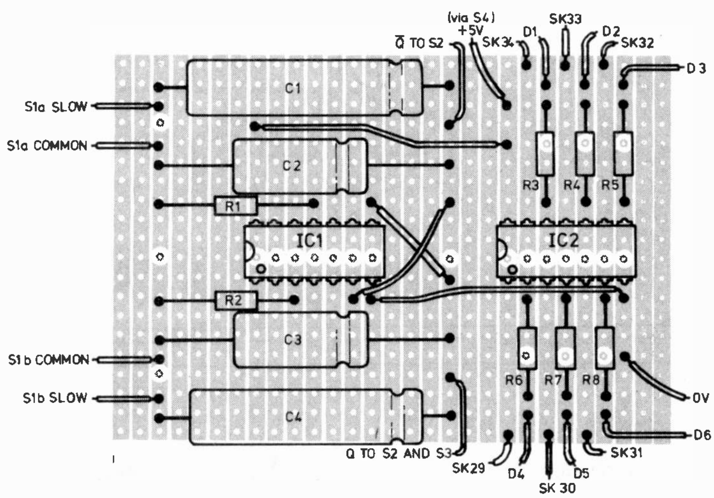


Fig. 4. Component layout and Veroboard cutting details for the oscillator and l.e.d. drive circuitry

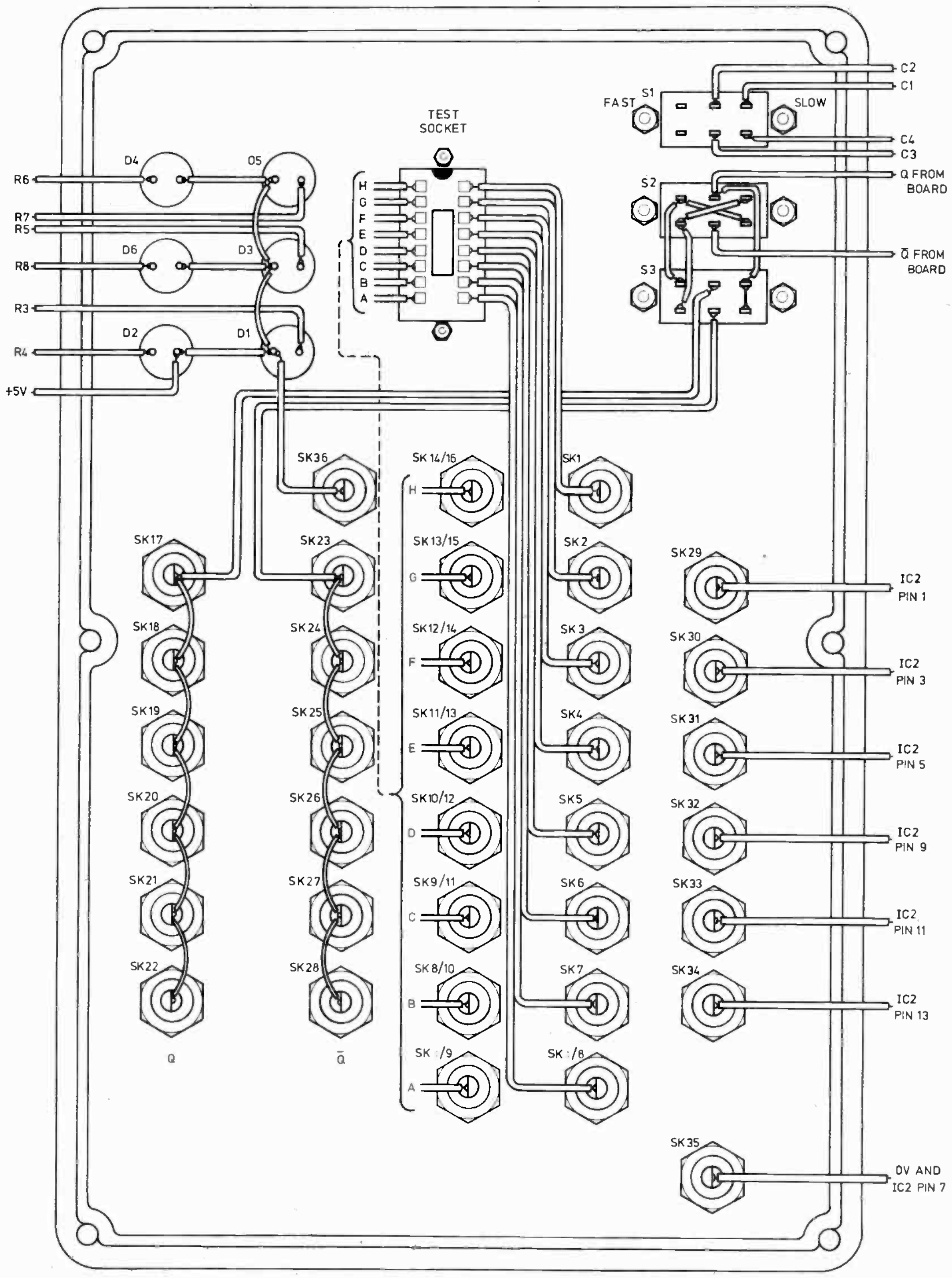
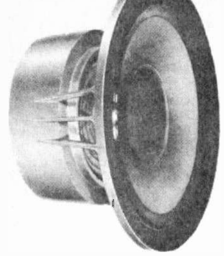


Fig. 5. General layout and wiring of the front panel viewed from the rear showing both switch connections and the wiring of the i.c. test socket patch sockets SK1 to SK14/16



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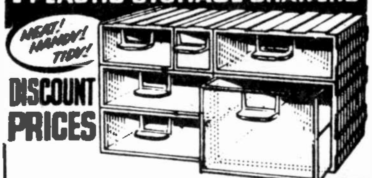

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PATCH CORDS

A minimum of 18 patch cords is desirable but not essential. However, at least two of these should be of the triple cord variety, i.e. three cords each having an individual banana plug at one end, but terminated into a common banana plug at the other.

OPERATION

Numbering the l.e.d. inputs 1 to 6 on the front panel from top to bottom, D4 becomes 1, D5 is 2, D6 is 3 and so on.

On completion of the unit it is suggested that the Q and $\overline{Q}$ sockets be tested for correct logic by patching these sockets direct to the l.e.d. drive socket. If the oscillator is functioning correctly the l.e.d.s will follow the logic and flash on and off.

With the patch cords still in this position proceed to test the FAST and SLOW modes of operation by operating the RATE switch. Then check the logic reversal facility by operating the Q—$\overline{Q}$ changeover switch.

Finally check the ALL Q facility by operating Q/$\overline{Q}$—ALL Q switch. If the unit is functioning correctly we may now proceed to the next stage, that of checking known i.c.s and some examples are given.

7404 HEX INVERTER

To test a 7404 TTL hex inverter, patch socket SK14/16 to 5V, SK36, SK7 to 0V SK35, socket SK1 to a Q socket, socket SK2 to l.e.d. drive SK29, and l.e.d. drive SK30 to a $\overline{Q}$ socket. Now insert the 7404 into the holder ensuring that it is correctly positioned for 14 pin d.i.l. operation and switch on power supply.

Light emitting diodes D4 and D5 should now flash on and off simultaneously, indicating that the inverter gate is functioning correctly. Repeat the procedure for the remaining five gates, bearing in mind that gate inputs are via sockets SK3, 5, 9, 11 and 13 and gate outputs via sockets SK4, 6, 8, 10 and 12 respectively.

7490 DECADE DIVIDER

Patch socket SK5 to the +5V socket SK36, and socket SK10 to the 0V socket SK35 using a triple lead patch cord. Connect the remaining two leads of this patch cord—one to socket SK2 and one to socket SK6.

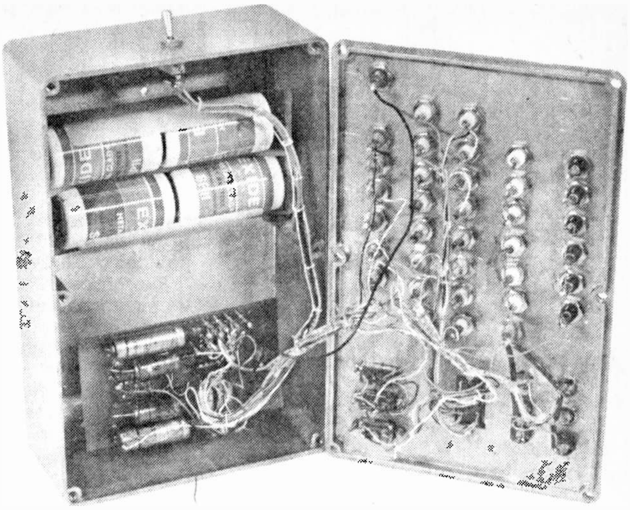
Patch socket SK14 to a Q socket and socket SK12 to socket SK1. Patch socket SK11 to l.e.d. drive SK29, and l.e.d. drive SK30 to a Q socket.

Insert the 7490 ensuring that it is correctly positioned. Switch on power supply.

Diode D4 should light once for every ten pulses of diode D5 indicating that the correct frequency division has taken place.

7413 DUAL 4-INPUT NAND (SCHMITT TRIGGER)

Patch socket SK14/16 to the 5V socket SK36. Patch socket SK7 to the 0V socket SK35. Patch SK1, 2, 4 and 5 to a Q socket and socket SK6 to l.e.d. drive SK29.



Patch l.e.d. drive SK30 to a $\overline{Q}$ socket, and insert the 7413 ensuring that it is correctly positioned. Switch on power supply.

Diodes D4 and D5 should now flash on and off simultaneously indicating that the first 4-input NAND gate is functioning correctly. Repeat the procedure for the second gate substituting socket numbers SK9, 10, 12 and 13 for sockets SK1, 2, 4 and 5, and SK8 for SK6.

7492 DIVIDE-BY-TWELVE

Patch SK5 to the 5V socket SK36. Patch socket SK10 to the 0V socket SK35 using a triple lead patch cord. Connect one of the remaining two leads to socket SK6.

Patch socket SK1 to socket SK12 and l.e.d. drive SK29 to a Q socket. Patch socket SK8 to l.e.d. drive SK30, connect socket SK14 to a Q socket and insert the 7492.

Switch on the power supply and diode D5 will illuminate after six pulses of D4 and remain lit for the next six pulses, indicating that the correct frequency division has taken place.

Sufficient examples have now been given for the constructor to familiarise himself with the capability and operation of the tester and no difficulty should be experienced when testing other devices provided pin connection data and truth tables are available. Some devices such as retriggerable monostables may, in some circumstances, need two external components in the form of an *R* and *C*, but these may easily be connected into circuit for test purposes by wedging the ends of the components into the appropriate sockets with the aid of the banana plugs.

MATERIALS

The two DTL i.c.s BP932 and BP936 used in the oscillator and l.e.d. drive assembly are obtainable from Messrs BI-PAK, or A. W. Marshall and Sons. The case is a normal die-cast box housing all components and the i.c. socket is a normal 16-pin holder with a bezel made up to suit. Of course it may be adhered to the case with Araldite or the like.

★

SEMICONDUCTOR UPDATE...

By R. W. COLES

LONG TIME, SMALL C

Last month I reported on the ZN1040E count and display circuit, an exciting example of the Ferranti C.D.I. process which is now being used in a number of interesting standard circuits, complementing the custom designs which the process has been associated with in the past. Another example of the power of standard C.D.I. circuits is provided by the new **ZN1034E** precision timer, which fills a big gap in the range of timing circuitry available to the circuit designer.

Until this new i.c. came along, the standard way of producing a time delay was to use a monostable circuit of some kind, a prime example being the popular and useful 555 chip which has appeared in many amateur designs.

Timers such as the 555 are limited in the length of time delay attainable by the practical limitations of the large *C* and *R* components required for long time periods. In the case of the 555 for example, the maximum delay that can be realistically achieved is about ten minutes.

To produce longer delays, some form of counter circuit has to be added which will require resetting circuitry, and can consume considerable power, two reasons why this is a messy solution not suited to simple constructions which need a long delay.

The ZN1034E is the simple answer for producing long delays because it contains in one 14-pin d.i.l. package, a very stable oscillator and a 12-stage binary counter which gives a division of 4095. The time period required is set with the usual *C* and *R* components external to the chip, but now the calculated time constant (*C* times *R*) can be multiplied by 4095 to derive the overall time delay produced. As a striking example, a resistor of 1 megohm and a capacitor of 1μF will give a delay well in excess of one hour, the exact value being trimmable by means of a calibration resistance which could be a pot.

The chip can be operated from a standard TTL 5V supply, or, by using the internal regulator circuit, a supply of from 6 to 450V can be employed. Typical consumption is a miserly 5mA which makes battery operation quite feasible, and I think this is a device that we will be seeing more of in these pages.

A TASTE OF TOMORROW

An indication of just how much sophisticated electronics will soon be affecting our day-to-day lives is provided by a data sheet on two new devices from Texas Instruments.

Even though we are unlikely to see these components offered for sale to amateurs in the forseeable future, the mind-boggling implications of their eventual widespread use by industry is sufficient justification for their introduction on this page. I am referring to the **TMS1000NC** and the **TMS1200NC** one chip microprocessor, devices which contain a complete digital computer including program store, data store, and a versatile arithmetic unit.

The unique feature of these particular devices is that they can be programmed to suit the user's requirements at the manufacturing stage, so that unlike, for example, the dedicated calculator chips we hear so much about these days, the TMS1000 or 1200 will soon be found in applications as diverse as cash registers, motor vehicles, vending machines, and electric cookers, in addition to the more traditional data-processing areas such as computer terminals and printers.

There are, of course, other chips around which can be used in these types of application, but in general they require a lot of back-up circuitry which means that they are expensive to use and unsuitable for "consumer" goods.

The new Texas devices can stand entirely alone in many circuits, and can be programmed to accept and display data in a wide variety of forms. The chameleon like qualities of these components are provided by the ability to build into the chip 1024 different programme steps which will decide whether it becomes a car nerve centre or a cash register brain, a potentially very cheap way of equipment design.—Roll on 1984! ! !

BRIGHTER THAN BRIGHT

Nobody can deny that l.e.d.s are amongst the most useful devices to appear in recent years, but despite all their advantages, a few problems have remained.

One of the first serious criticisms of these devices was directed against the fact that you could have any colour, so long as it was red; a problem that semiconductor manufacturers have been acutely conscious of, and one which they have overcome by developing exotic new compounds which have added green and yellow light to their repertoire.

Another criticism sometimes levelled at l.e.d.s is that their luminous efficiency is quite low, which means that you don't get much light power for the electric power you drive them with. Of course, this means little when plenty of drive power is available, but in today's energy conscious world, the era of microwatt CMOS logic circuits, the power wasted in displays can be a thorn in the side of the designers of portable equipment.

In the forefront of technology as usual, Hewlett Packard have introduced a new range of "Brighter-Than-Bright" l.e.d.swhich are many times brighter than their predecessors while consuming the same power. The new range is available in the three colours (with no premium to be paid for green or yellow), and two lens styles giving a wide beam (diffused), or a narrow beam (point source).

Hewlett Packard codes for the new discrete l.e.d.s are as follows: **5082-4658** (red), **5082-4558** (yellow), **5082-4958** (green) for the point sources, and **5082-4655** (red), **5082-4555** (yellow), **5082-4955** (green) for the diffused type.

The secret of the new devices is a new construction technique which uses a transparent gallium-phosphide l.e.d. chip backed up by an integral reflector, resulting in all the available light being directed exactly where it is required.

Those who are fed up with peering at their "Dimmer than Dim" calculator displays can take heart from this new technology which promises the chance of a brighter display while retaining long battery life.

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Power Darlingtons are catching on in a big way because they put into a single can the traditionally used "Darlington-pair" circuit with its well known advantages of very high gain (over 1,000) and high power handling capability.

A new range of Darlington devices is announced by Power-Monolithics, who aim to oust the old faithful 2N3055 and 2N3771 transistors from their present position as the almost automatic choice for very high power applications. At the top end of the new range is the **PMD-17K-80** which has a gain of between 800 and 20,000 at 10A, and an 80V breakdown rating. Maximum dissipation is a whopping 225W!

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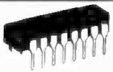
MAN2	Red alpha-numeric .35" 5 x 7 dot matrix 14 pin DIP	£1-21p

TTL



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7401	11	7450	12	74151	60
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7403	11	7453	13	74154	1·05
7404	13	7454	14	74155	95
7405	13	7460	11	74156	71
7406	22	7464	21	74157	71
7407	22	7465	21	74161	95
7408	14	7472	22	74163	1·05
7409	14	7473	26	74164	1·25
7410	11	7474	26	74165	1·25
7411	16	7475	41	74166	1·15
7413	35	7476	26	74173	95
7415	22	7483	70	74175	95
7416	22	7485	80	74176	95
7417	22	7486	24	74177	85
7420	11	7489	1·50	74180	80
7422	22	7490	45	74181	2·50
7423	22	7491	71	74182	80
7425	22	7492	44	74184	1·55
7426	23	7493	44	74185	1·45
7427	22	7494	49	74190	95
7430	12	7495	49	74191	95
7432	22	7496	55	74192	90
7437	25	74100	1·25	74193	85
7438	21	74105	60	74194	95
7440	11	74107	27	74195	80
7441	60	74121	32	74196	1·00
7422	55	74122	50	74197	75
7443	55	74123	55	74198	1·70
7444	60	74125	50	74199	1·70
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74L04	18	74L72	27	74L95	89
74L06	18	74L73	38	74L98	1·53
74L10	16	74L74	38	74L164	1·53
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74H11	16	74H52	18		
74H20	16	74H53	20		

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MM5736	18 pin 6 DIG 4 funct	2·42
MM5738	8 DIG 5 funct K & Mem	2·42
MM5739	9 DIG 4 funct (btry sur)	2·92
MM5311	28 pin BCD 6 dig mux	2·42
MM5312	24 pin 1 pps BCD 4 dig mux	1·94
MM5313	28 pin 1 pps BCD 6 dig mux	2·42
MM5314	24 pin 6 dig mux	2·42
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MAN 1	Red 7 seg. .270"	1·38
MAN 2	Red alpha num .32"	2·72
MAN 4	Red 7 seg. .190"	1·18
MAN 5	Green 7 seg. .270"	1·62
MAN 6	.6" high solid seg.	3·81
MAN 7	Red 7 seg. .270"	74
MAN 8	Yellow 7 seg. .270"	2·17
MAN 64	.4" high solid seg.	2·45
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DL 707	Red 7 seg. .3"	1·18
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319	Hi Speed Dual Comp	DIP	71
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324	Quad Op Amp	DIP	1·07
339	Quad Comparator	DIP	92
340T	Pos Volt Reg (6V-8V-12V-15V-18V-24V)	TO-220	1·07
370	AGC/Squelch AMPL	TO-5 or DIP	65
372	AF-IF Strip detector	DIP	44
373	AM/FM/SSB Strip	DIP	1·78
376	Pos. V Reg	mDIP	33
377	2w Stereo amp	DIP	1·47
380	2w Audio Amp	DIP	81
380-8	.6w Audio amp	mDIP	69
381	Lo Noise Dual preamp	DIP	98
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555	Timer	mDIP	44
560	Phase Locked Loop	DIP	1·94
562	Phase Locked Loop	DIP	1·94
565	Phase Locked Loop	DIP	1·20
566	Function Gen	mDIP	1·20
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739	Dual Hi Perf Op Amp	DIP	65
741	Comp Op AMP	mDIP TO-5	27
747	Dual 741 Op Amp	DIP or TO-5	44
748	Freq Adj 741	mDIP	27
1304	FM Mulpx Stereo Demod	DIP	65
1307	FM Mulpx Stereo Demod	DIP	45
1458	Dual Comp Op Amp	mDIP	38
LH2111	Dual LM 211 V Comp	DIP	1·07
3065	TV-FM Sound System	DIP	38
3075	FM Det-LMTR & Audio preamp	DIP	44
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8 CHANNEL LOGIC TRACE MULTIPLIER

By A.C. Ainslie

THIS second part deals with construction and testing of this versatile oscilloscope adjunct.

CONSTRUCTION

The circuit is built on three p.c.b.s—one for the p.s.u. and one for the D/A converter and the third main board for all the rest.

The print drawings and component layouts are given clearly in the following figures.

The p.c.b.s can all be made using the etchant resist pens now freely available. The larger one is a rather tedious job but can be completed in a few hours if the layout is drawn in carefully and the position of the various chips is marked.

Veroboard or Matrixboard could doubtless be used for this project but would entail some complex cross linking.

The main board has wire links for almost all of the power supply wiring and the parallel inputs to IC1 and IC4 are also formed using cross links.

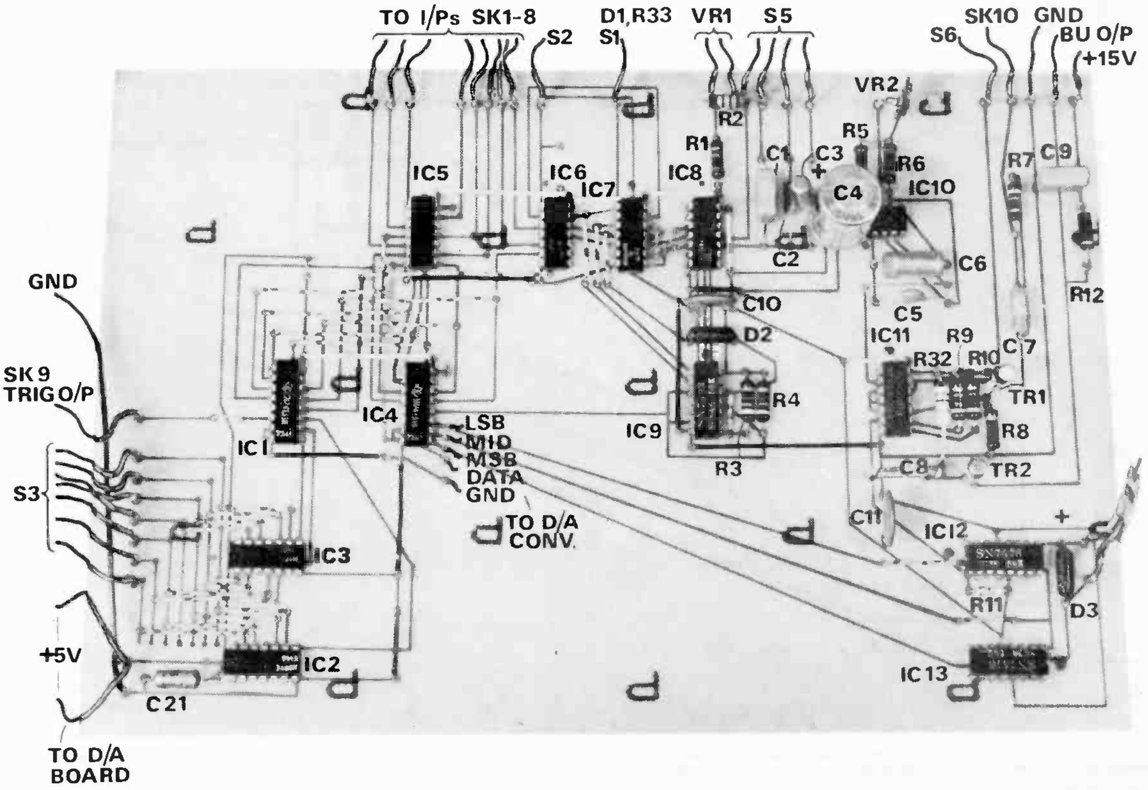
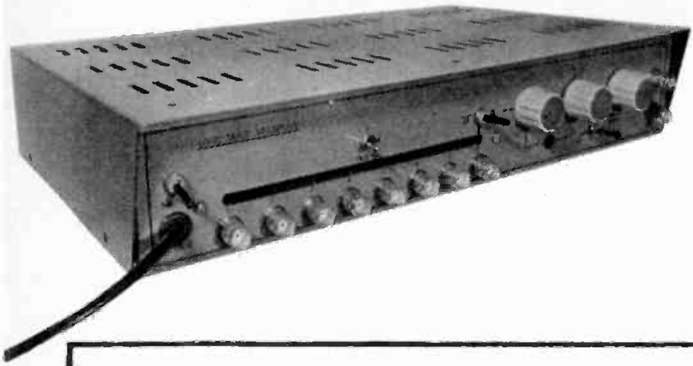


Fig. 6. The main board showing component layout and interconnections to other components and boards



Similarly the wiring for the decimal/binary converter which feeds IC1 is also cross wired. The two inputs to the 74121 involve a crossover but this is made clear on the layout. The only other cross wiring is where necessity demands. Obviously if double sided board could be used this would be a considerable advantage.

Potentiometer VR2 was originally intended to be a back panel preset but a skeleton soldered in position as in Fig. 6 is just as convenient. S1 is ganged with VR1 for convenience of operation.

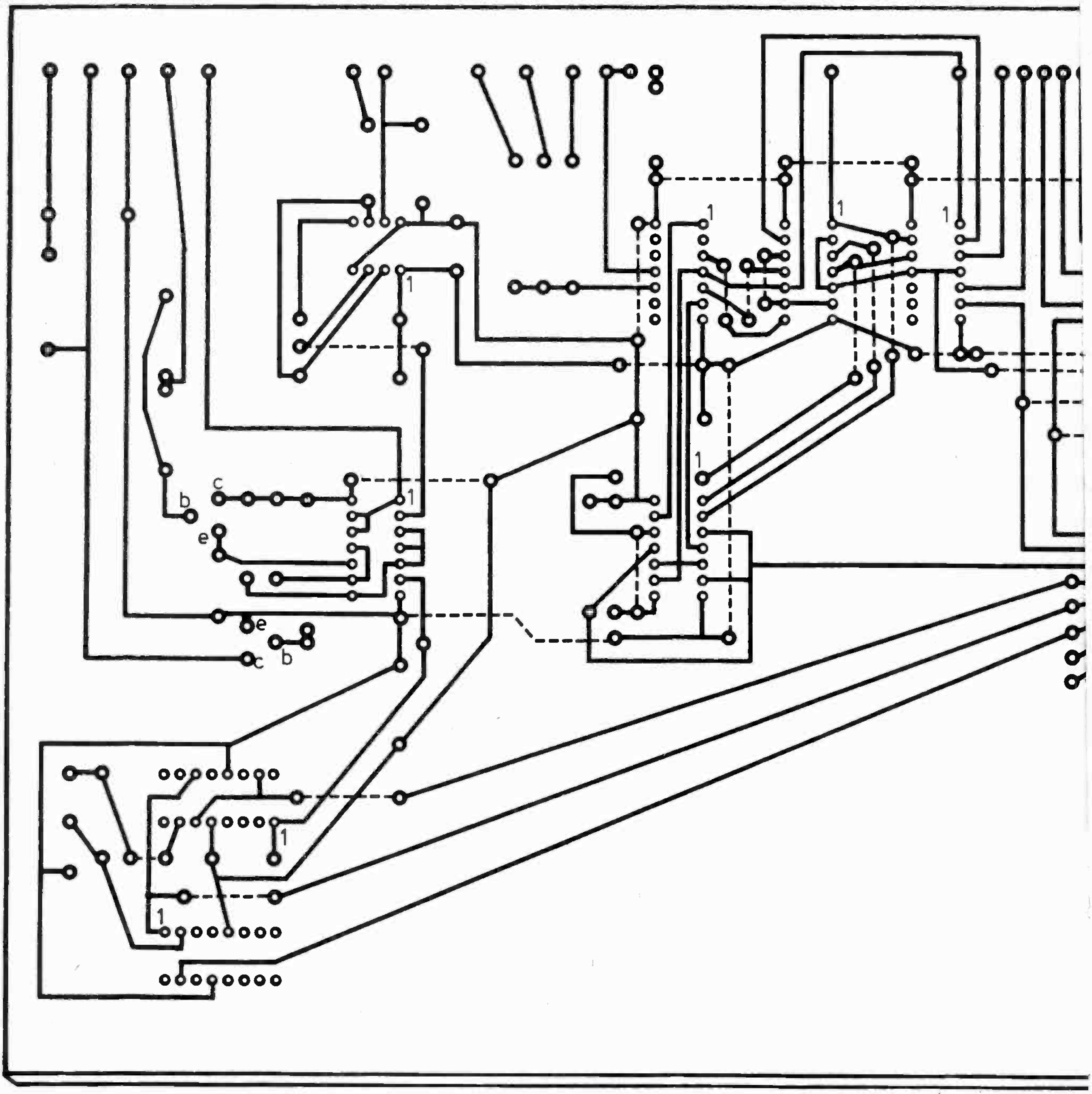
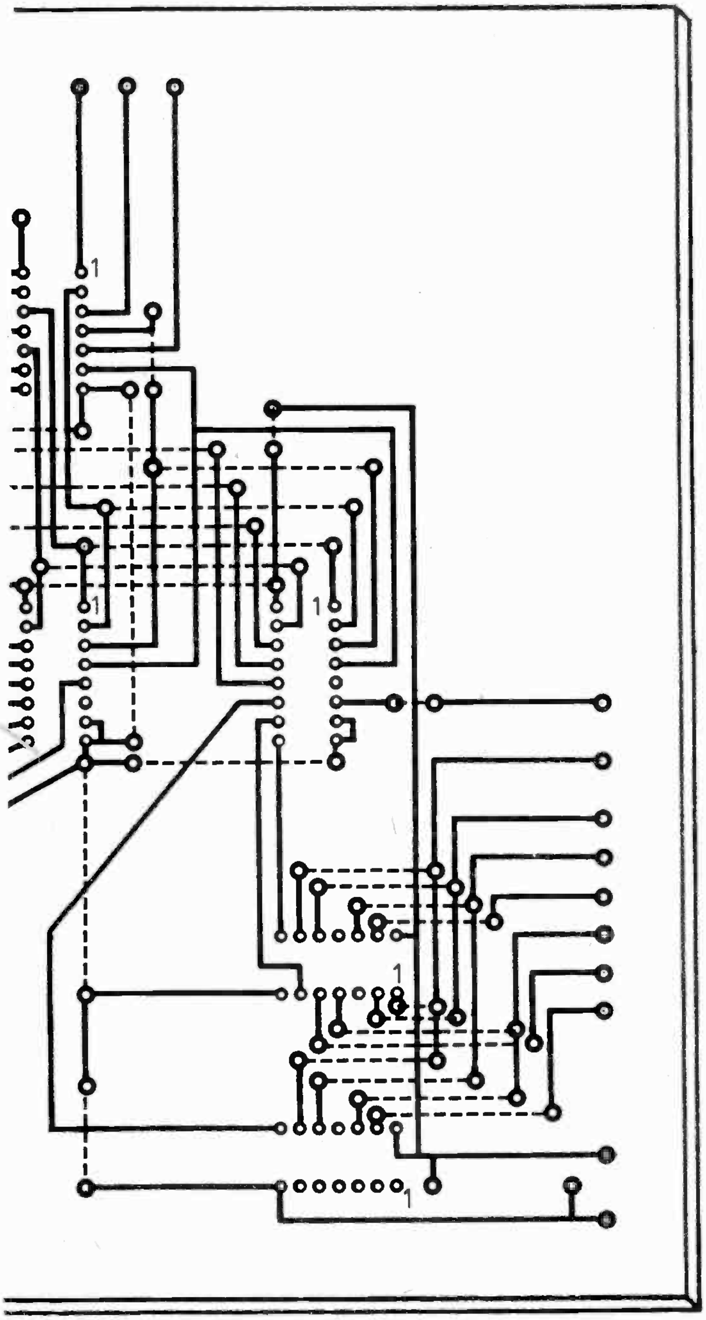


Fig. 7. The printed circuit master for the main board of Fig. 6

Small connecting pins are used for all external connections, including those to the D/A board.

The D/A board is quite simple, there being only one wire link shown in Fig. 8. The earth tracks should be kept as wide as possible. The Gnd. point next to the output is the only connection to the output lead braiding. The D/A board is intended to fit on top of the main p.c.b. in the vacant area. A number of short lengths of single flex twisted together constitute the input and ground connections.



POWER SUPPLY

The power supply board (Fig. 9) is also quite easy to assemble. FS2 is mounted directly onto the board with 1¼in p.c.b. fuse holder. Alternatively, it could be made externally accessible by mounting a fuse holder on the rear panel. However, as the fuse should only blow under fault conditions, this is not really necessary.

The original board was designed so that a separate 24V–0–24V winding could supply a higher voltage to TR2. However, the smoothed 15V line proved adequate and so the points A and B are linked across. Otherwise, should a more vigorous bright-up be found necessary, the link can be removed, a 100μF coupled between A and B and two diodes connected at D and E—driven from a centre tapped winding of up to 30V for a 2N706 bright-up transistor. Higher voltages can be used with other transistors but a Z axis amplifier in the scope would be a better alternative.

TR3 is mounted on a heat sink of about 3 to 4in square. The power dissipated is about 3W and so the device runs well within its rating. IC15 has a relatively easy task and just gets warm. D6 does nothing until the supply tries to exceed 5·1V when it starts conducting, blowing FS2. So under normal conditions D6 should be cold. A warm device would indicate that the 5V line was adjusted to be on the high side.

CABINET

The prototype was built in a commercial cabinet of dimensions about 8 × 2½ × 13in. The layout can be clearly seen from the photographs.

In order to ease selection of the trigger channel in the prototype, eight small filament lamps were wired from +5V to S3. Thus rotating S3 caused the light appropriate to the trigger channel selected to light. The lights were placed above their respective input sockets. L.e.d.s could also be used with a 470Ω in series but they are expensive.

The prototype front panel was lettered with "Letraset" and finished with polyurethane spray. Chassis mounting BNC sockets were used for all the inputs and the "B.U." and "Trig" outputs. These sockets are grounded by the metal work which is grounded to the electronics by a short lead from the power supply ground to a solder tag bolted to the chassis. The ground connection to S3 is made to the same point as are all the other ground connections.

WIRING

There is quite a lot of front panel wiring to complete and this is best done in the form of a harness. The lead to the B.U. socket radiates spikes as does the lead from the scope timebase gate input which is mounted on the back panel. These two leads are therefore run around the perimeter of the instrument, out of harm's way.

The output lead from the D/A is a 36in length of 50Ω cable terminated in a BNC plug to plug directly into the scope Y channel. This lead is grounded only at the point adjacent to the D/A output. Originally a BNC socket was chassis mounted on the front but was susceptible to earth return spikes which blur the display.

D/A BOARD DETAILS

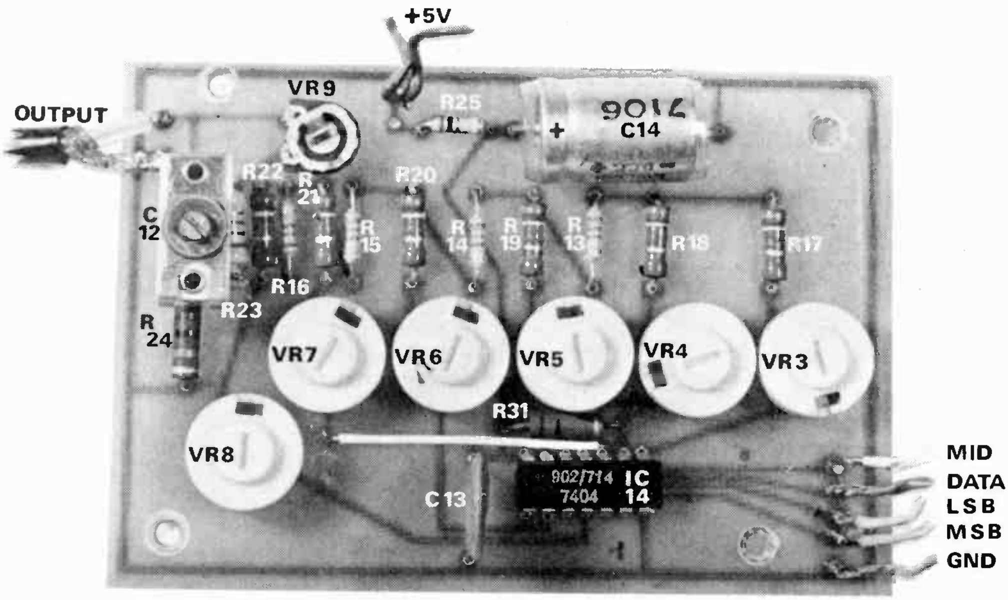
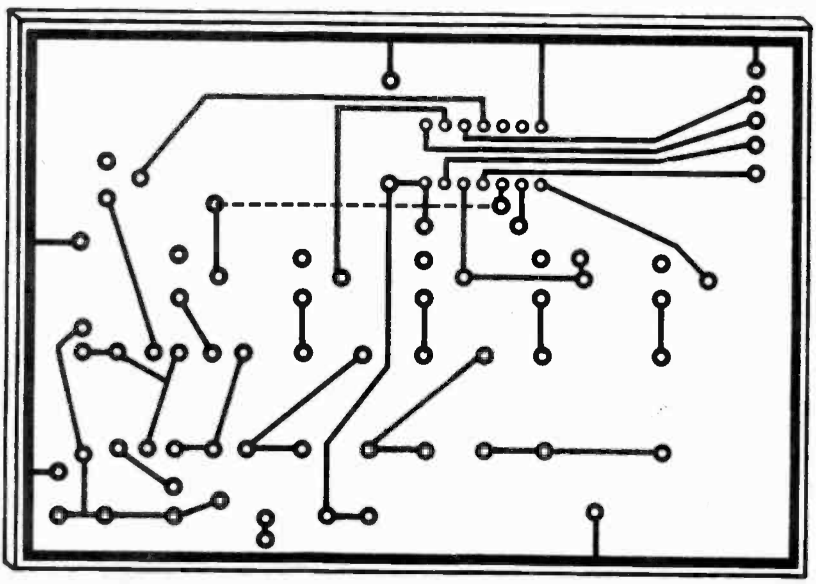


Fig. 8. The D/A board component layout (above) and p.c.b. master (below)



POWER SUPPLY UNIT

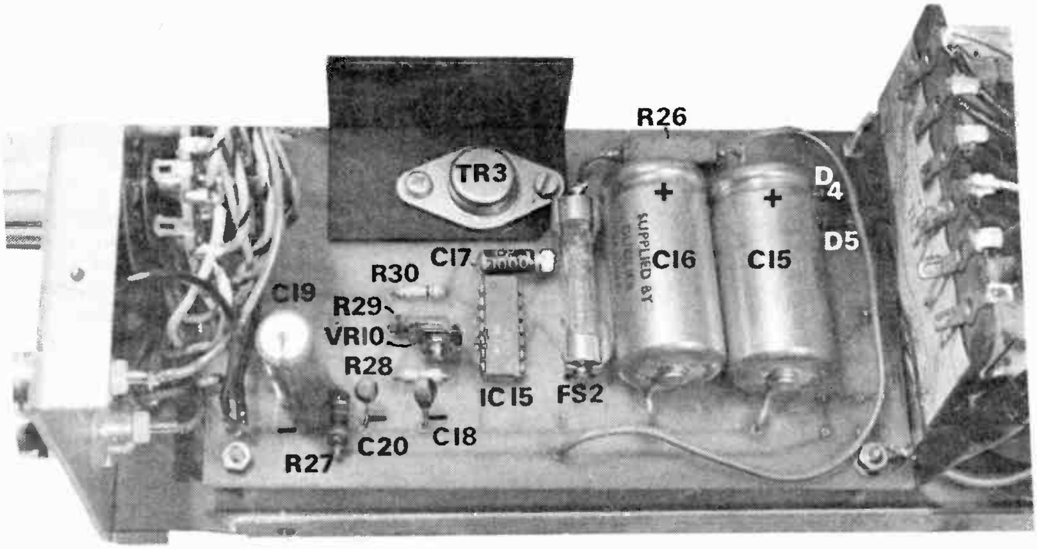
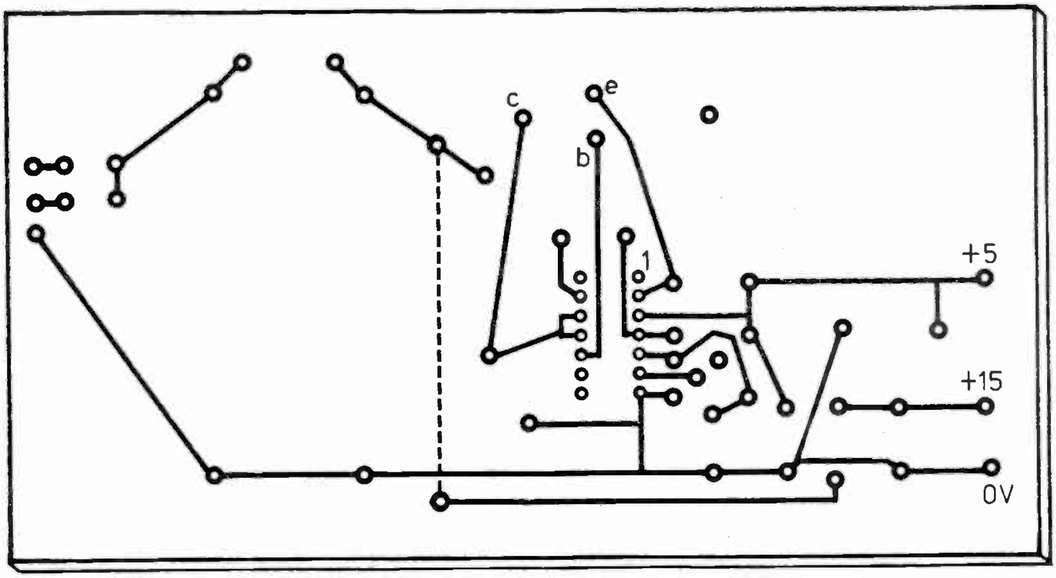


Fig. 9. Power supply layout (above) and associated p.c.b. master below



The p.c.b.s are mounted on ¼in stand-offs so that the metal work forms a reasonable ground plane for the electronics.

TESTING AND SETTING UP

Initially VR10 is set to maximum resistance. The mains is applied and the 5V rail is measured (it is pertinent to replace the logic load by a resistor of 15Ω and 10W rating). Decreasing VR10 should increase the supply towards 5V. With the supply set to precisely 5V, D6 should not get even slightly warm. Setting the supply higher will cause D6 to overheat and probably blow the fuse.

With the logic connected, pin 3 of IC10 should have a roughly square wave of a few tens of kHz. VR2 is decreased until the output wave train starts to jitter. At this point the steps of the staircase will be non uniform.

The correct setting of VR2 is just prior to the onset of jitter.

With S6 set to "CHOP" and S1 open, a staircase should be present at the D/A output if S4 is set to the 8-trace position.

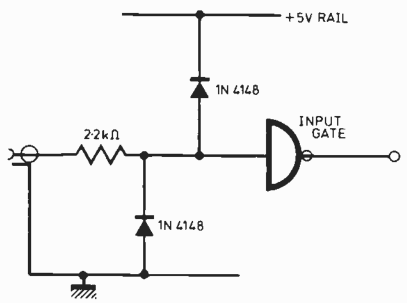


Fig. 10. Input circuit designed to reduce the risk of input overload

LINEARITY

The ladder is now set up to give a linear output. With VR3 and VR6 at mid position, VR7 is adjusted to make the space between traces 2 and 3 the same as between 1 and 2. Similarly VR8 adjusts the spacing of lines 4 and 5. VR9 is now set to give one step per unit with the Y input to the scope set to a convenient step.

Grounding all inputs should cause all the traces to drop by 0·75 units. VR3, VR4 and VR5 are now adjusted to ensure that the ladder is again linear.

With the inputs floating again the other presets can be used to trim up the linearity. The settings are somewhat interdependent but very good linearity can be achieved without much difficulty. C12 adjusts overall sharpness of the step transitions.

Connecting the B.U. lead to the Z axis input should cause the actual transitions on the display to disappear. The properly triggered display should now be a series of short clean horizontal lines.

Applying a logic signal to channel 8 and switching S3 to select CH8 as trigger source should cause the channel 8 signal to appear at "Trig Output", SK9. Connecting this lead to the scope external trigger select should then enable the lower trace to display the CH8 signal, all other seven traces being "high". Reducing the scope sweep speed and switching to "ALT" with the scope sweep gate connected to SK10 should cause the traces to be displayed sequentially, from 1 to 8. Switching S4 should allow 8, 4 or 2 traces to be displayed. Even in the 4 or 2 trace mode, channels 1, 2, 3, etc. can be used as trigger sources.

PULSE STRETCH

The next step is to check the pulse stretch operation. If a 50ns wide pulse is applied to CH8 input with a 1kHz p.r.f. then the pulse will not be visible at 100μs/cm sweep speed. If the trace is low then the applied pulse must be positive going. S2 is therefore left open. S1 is closed and D1 should light. Rotating VR1 in conjunction with S5 should show a positive pulse, of length dependent on the setting of these controls.

A negative going pulse (the trace appears to be high) is stretched with S2 closed and will then appear as a negative going pulse of width determined by VR1/S5.

In operation the unit is very straightforward to use and has proved to be of immense value in fault finding and debugging of logic systems.

The Logic Trace Multiplier is intended for use with TTL systems and must not be used on any other system without providing an interface. To reduce the possibility of damaging the input i.c.s due to input overload the circuit in Fig. 10 may be used, with a slight loss of speed. The components can be conveniently mounted on the BNC sockets. ★

MARKET PLACE

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

SECURITY ALARM

A new modular burglar alarm system suitable for home security protection, which, it is claimed, can be installed anywhere without the need for professional skill is now being marketed by Euroswitch Ltd. The system, called the Euralarm 1, comprises a control box, external bell box, a 6in diameter bell, six magnetically operated reed switches (door contacts), two pressure pads and wire, insulated staples and connector blocks.

The control box, protected by an anti-tamper microswitch, is normally mains operated, but a battery can be placed in the box to give a standby supply if mains failure occurs. The control circuit provides for single and double pole systems, has a facility for testing the alarm circuit and has an open circuit facility which allows the pressure pads to be incorporated. Externally, the control box has a key switch, mains on indicator light, a mains fuse access cap, a push to test switch and a green systems operating light.

The alarm is easily installed by simply placing the units in the required positions and running the wire between contacts, control box and bell. The bell box also has an anti-tamper microswitch fitted.

The Euralarm 1 costs £45 and can be obtained direct from **Euroswitch Ltd., 121 Mildmay Road, London, N.1.**

INSTRUMENT CASES

With economy in mind, West Hyde Developments have just introduced a range of equipment cabinets.

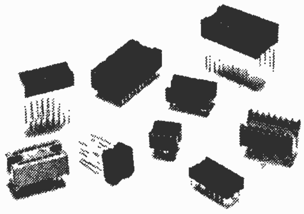
Known as the Contil Swift range these cases feature the use of the strengthening extrusions as semiconductor heat sinks and mounting supports for such components as transformers. By mounting these components directly to the case extrusions, this eliminates the use of mounting brackets and the need for separate heat sinks.

Full particulars of the complete range of Contil Swift cases can be obtained from **West Hyde Developments Ltd., Ryefield Crescent, Northwood Hills, Middlesex, HA6 1NN.**

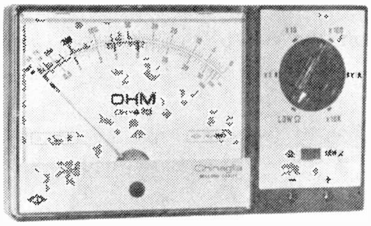
BEGINNERS CONSTRUCTION KIT

One of the latest products from Heath (Gloucester) Ltd. is an experimental, educational construction kit, type JK-18A.

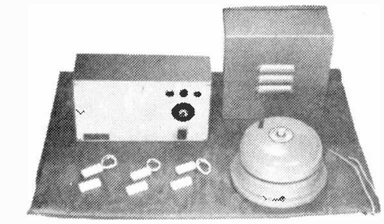
This kit enables the beginner to construct up to 35 different circuits and, at the same time, learn how each component functions. Spring terminal connections eliminate any soldering and all circuits are battery powered.



Dual in-line sockets from Dieter Assmann



OH470 ohmmeter from Chinaglia



Euroswitch alarm kit

Ranging from a 4 transistor radio to a rain alarm, all projects begin with an explanation of what the selected circuit does and how it is used.

A large schematic diagram is furnished for each experiment and includes a simple but complete explanation of what each part does. Each component is identified by a drawing and its schematic equivalent as used in circuit diagrams so that the constructor learns to read schematics while experimenting.

Full details of projects and price list for the Heath JK-18A kit is available from **Heath (Gloucester) Ltd, Bristol Road, Gloucester, GL2 6EE.**

RESISTANCE METER

Designed for resistance measurements over a wide range with an accuracy of 2·5 per cent, Chinaglia have developed the OH470 multi-range ohmmeter.

Using a 40μA moving coil movement the meter has six switched ranges covering 0·1 ohm to 50 Megohms. The meter is powered by two 1·5V internal batteries, includes test probes and a protective plastics case.

Further information on the complete range of Chinaglia meters is available from **Chinaglia, 19 Mulberry Walk, London, SW3 6DZ.**

DUAL IN-LINE SOCKETS

A comprehensive range of sockets for dual in-line packages are now being marketed by Dieter Assmann Electronics Ltd.

Socket for both in-line and staggered configurations of up to 40-pins can be supplied from stock for soldering directly into printed circuit boards, for use with free wiring or for wrapped wire connection.

For applications in which low profile is important a range of 8-pin, 14-pin and 16-pin sockets, type ZK and ZKF, having heights of 5mm and 3·9mm above the printed circuit board, are available.

Information on the complete series of sockets available can be obtained from **Dieter Assmann Electronics Ltd., Victoria Works, Water Lane, Watford, Herts, WD1 2NW.**

SPECIAL OFFER

In an effort to fulfil the increasing demands of the electronics enthusiast for competitively-priced, quality components, **A. Marshall (London) Ltd.,** established since 1953, have been opening retail shops in Glasgow, Paris and Bristol carrying their new extended range of components. The 1975 Marshall's catalogue now carries a range of over 3,000 types of semiconductors as well as an extended range of passive components and accessories.

To mark the opening of their new components shop in Bristol, towards the end of August, A. Marshall & Son Ltd. are making a special offer to all P.E. readers this month.

Readers of P.E. can purchase first class branded CMOS and TTL devices at special discount prices. This offer is for one month only.

For full details of devices available and prices, readers should turn to the A. Marshall advertisement in this issue.

APOLOGY

Due to production difficulties and recent VAT changes **Henry's Radio** would like to apologise to readers of P.E. for the delay in dispatching copies of their 1975 Components Catalogue.

Copies are now being dispatched and readers who have ordered copies should now be receiving them.

PE JOANNA PART 5

By A.J. BOOTHMAN B.Sc.

THE basic philosophy behind the cabinet design is to allow maximum wiring to be carried out from the rear, simplifying the interconnections between the keyswitch and the p.c.b.s. This is a considerable improvement over the prototype arrangement (see page 389 of the May issue) in which wiring was carried out from the top, thus making it impossible to remove a single board with ease, and reduces the wiring complexity.

KEYBOARD POSITION

The keyboard spans a gap between the front baseboard and the centre base spar, allowing immediate access to the keyswitch, and a further 4in gap exists between the spar and the rear panel of the cabinet, revealing the terminal pin edge of all p.c.b.s (Fig. 5.1).

The two base members in combination with the rear panel provide the main rigidity in the cabinet, further strengthened by the p.c.b. supports and keyboard when fitted, and fix to the two shaped end panels. The p.c.b. supports have been designed to hold the p.c.b.s, provide fixing points for the front panel, and support to the top panel. It should be noticed that the p.c.b. slots are spaced differently on each support. The bottom retainer strips prevent the p.c.b.s falling to the bottom of the cabinet. A bottom cover panel made of pegboard covers the wiring but allows ventilation of the cabinet.

Magnetic catches have been used on the prototype to retain the top panel.

ASSEMBLY OF THE CABINET

The front baseboard, centre base spar, rear and end panels should first be assembled using joints to match the skill of the constructor. The p.c.b. supports should then be fixed to the rear panel and centre base spar, and the p.c.b. retainers glued in position.

At this point the keyboard should be fixed into the cabinet inserting from the front. Large washers are used to trap the keyboard channel edging to both base bars ensuring that the keyboard is central by using the end cheeks as guides. When the keyboard is fixed, the keyboard trims can be fitted, followed by the end cheeks which are screwed down to the keyboard channel after drilling suitable holes in the channel. The top panel support, front panel support and front panel can now be fitted, followed by the rear p.s.u. support. If the unit has been constructed accurately the top and bottom cover panels should easily fit into place, and the magnetic catches can then be fixed.

KEYSWITCH ASSEMBLY

The keyswitch assembly consists of a printed circuit board to which gold plated springy wires are soldered and seven plastic blocks are fixed to support two gold plated rods (Fig. 5.2).

Before assembling the kit of parts together, the p.c.b. should be placed on the underside of the keyboard, and used as a template for drilling the six $\frac{3}{32}$in holes required to take the self-tapping screws which fix the switch assembly to the frame. The front edge of the switch assembly should be placed approximately $\frac{1}{4}$in from the keyboard actuators, and should be centralised over its length with respect to the actuators. When holes have been drilled, and the p.c.b. removed from the frame, the keyswitch is assembled as follows:

1. Slide the seven rod supports onto one rod.
2. Insert the second rod through the remaining rod holes, and space the supports roughly opposite the holes which have been countersunk from the non-copper side of the p.c.b.
3. Fix the rod supports to the copper side of the p.c.b, using the countersunk screws, nuts and locking washers. The track is formed to indicate the correct positions.
4. Cut the gold plated wire into 61 lengths of $1\frac{3}{4}$in, and tin approximately $\frac{1}{4}$in of one end of each wire.

5. Pass each wire between the two rods and solder the tinned end to a main pad. About ½in should be left to hang over the front edge of the p.c.b. The wire should be pressed flat to the p.c.b. close to the main pad using a matchstick, and the soldering iron applied to the wire and land for as short a time as possible.
6. The assembly can now be fixed to the underside of the keyboard using the self-tapping screws with two washers under each screw head.
7. The next operation is to adjust the bend of each wire to ensure that it seats satisfactorily against each rod in turn, whilst gently resting on the actuator in the non-depressed state. An attempt should be made to achieve a gentle curve in the wire commencing on the land side of the rod in order to prevent too much localised stress where the wire presses against the top rod.

The touch resistors are soldered to the pads provided, one end to the common touch rail, and the other to the land which also carries the gold-plated springy wire. Top and bottom octaves should be 1·8kΩ, and the middle three octaves 1·5kΩ. The resistor leads should be bent back under the resistor and cut short before soldering to the board, which then allows the component to be fixed within the small space available.

INTERWIRING PROCEDURE

The p.c.b.s should be inserted into the slots with components facing forward and the top panel fitted.

CUTTING LIST

CABINET

Front Base Board	36¾in × 4in × ⅝in
Centre Base Spar	36¾in × 2¼in × ½in
Rear Panel	38in × 4½in × ⅝in
End Panels (2 off)	14in × 4½in × ⅝in
Front Keyboard Trim	36¾in × 1¼in × ⅝in
Front (fascia) Panel	36¾in × 1½in × 3/16in
Top Panel	36¾in × 7in × 3/16in
Bottom Cover Panel (Pegboard)	36¾in × 10¼in × ⅛in
P.c.b. Supports—shaped (4 off)	6⅞in × 3¼in × ⅞in
P.c.b. Bottom Retainers (4 off)	4in × ⅞in × ⅛in
Top Panel Support (p.s.u. end)	4¾in × 1in × ¼in
Front Panel Support (p.s.u. end)	2⅛in × ½in × ½in
End Cheeks (2 off)	7in × 1½in × ⅞in
Rear p.s.u. Support	11in × ½in × ½in
Felt Strip	36¾in × ½in × ⅛in
Magnetic Catches 2 off	

LEGS

Top Spar	(2 off)	12½in × 1½in × ¾in
Bottom Spar	(2 off)	14in × 1¾in × 1in
Legs	(4 off)	Chrome plated tubing 24in × ¾in dia.
Bottom Tube		Chrome plated tubing 26in × ¾in dia

PEDALS

Rear Block		6½in × 2in × 1in
Foot Pedals	(2 off)	5in × 1in × ⅝in
Base		7½in × 7in × ⅛in
Springs and hinges		–

STOOL

End Panels (2 off)	19in × 16in × ⅝in
Top/Bottom Panels (2 off)	20in × 14in × ¾in
Side Panels (2 off)	20in × 6½in × ½in

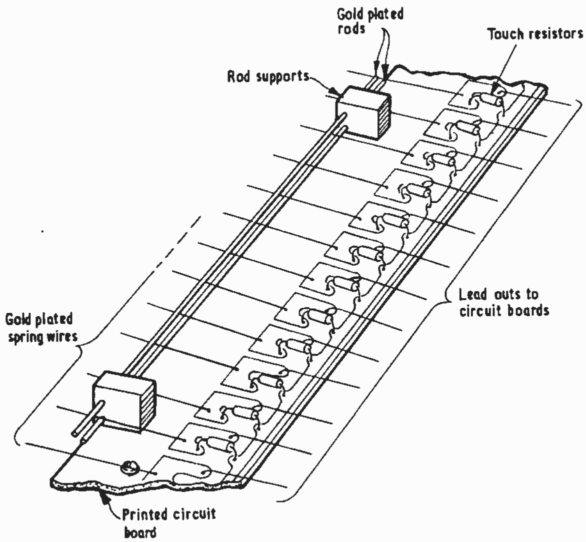


Fig. 5.2. Keyswitch assembly is screwed to the underside of the keyboard so that the actuators press against the spring wires

The cabinet should be turned upside down to reveal the back edge of the p.c.b.s (which have been effectively inserted upside down) and the keyswitch previously fitted as above. Wiring should be carried out as follows:

1. A group of three wires (suggest red, orange, yellow) should be soldered to the C_1, $C_1\#$, and D_1 pads on the keyswitch and threaded through a hole drilled through in the centre base spar. The hole is opposite the correct pins on the three Envelope Boards, and should be connected in the same order.
2. A group of five wires (red, orange, yellow, green, blue) should be soldered to the $E^b{}_1$, E_1, F_1, $E_1\#$, G_1 pads on the keyswitch and threaded through another drilled hole. This hole is opposite the pins in five Envelope Boards, and the wires should be soldered in the same order.
3. The operation should be repeated for $A_1{}^b$, A_1, $B^b{}_1$, B_1 (red, orange, yellow, green), passing through the $A^b{}_1$-B_1 hole in the centre base spar.

4. A further group of three wires (red, orange, yellow) should be soldered to the C_2, $C_2\#$, and D_2 pads, threaded through the hole marked C_2–D_2 and soldered to the relevant boards.

5. If this operation is repeated for 60 key-switch pads (excluding C_6), each Envelope Board uses a single colour for five connections and is easily seen to be correct. The C_6 connection is made to the Tone Generator Board, which has been inserted upside down.

TONE GENERATOR BOARD TUNING LOCATION

Since the Tone Generator Board has been inverted, the tuning potentiometer is not accessible. Dependent on the style of potentiometer used it may be possible to reposition it in the back of the p.c.b. in such a position that it is easily available from the top. Care should be taken to avoid shorting the copper track when an adjustment of tuning is being carried out.

INTERWIRING BETWEEN BOARDS

The next operation is to link the Envelope Boards for the outputs, +5V, zero volt, and sustain rails. This is best achieved using bare single strand wire pre-cut to the required length. The G connections associated with each input (L, M and H) on the Voice Board (Fig. 4.8) are redundant and should be ignored. Since the pins are double-ended, one half protruding from each side of the board, links can be soldered between the pins which can be easily undone should it be necessary to remove a single board at a later date. When all the boards are interlinked the interwiring of the three rear boards should be carried out as shown, leaving flying leads for connection to the +5V and zero volt connections on the Power Supply Unit.

At this point connections should be made to the two keyswitch rod ends. Black nearest the keyboard and red furthest away from the keyboard, and a third colour of wire connected to the common touch resistor track on the keyswitch. The three wires should be threaded through the relevant hole in the centre base spar, and left long enough for later connection to the power supply.

Still referring to the wiring diagram, connections should be made between the C Envelope Board and the Voice/Preamp Board—i.e. L, M and H outputs, and the common sustain connection between Voice/Preamp and the F Envelope Board.

Zero volt, +5V, and high output connections should then be made to the Tone Generator Board from the A^b Board. The semitone outputs from the Tone Generator Board are wired to A^b, A, B^b, and B envelope signal input pins, whilst the remaining eight leads are passed through the centre base spar and distributed to the relevant Envelope Boards via the holes in the spar marked E^b–G and C–D signal input. Colour coding of these wires is desirable, and this can be arranged in a group of three (C–D) and a group of the five (E^b–G).

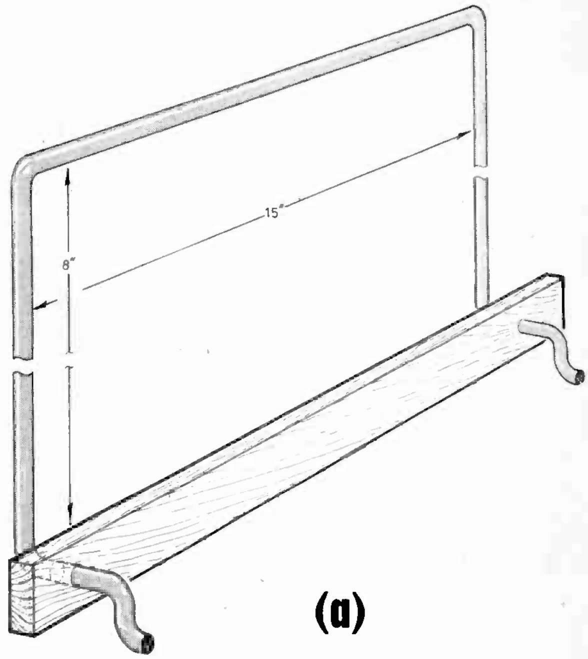
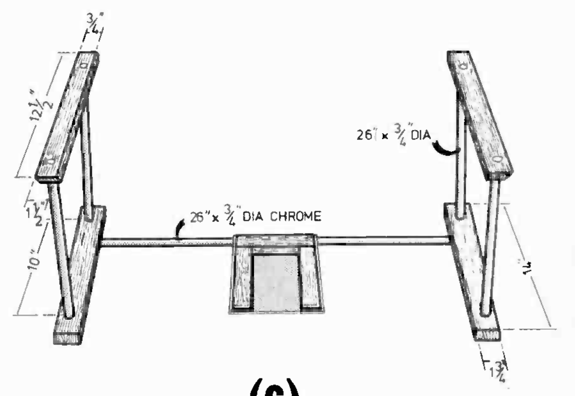
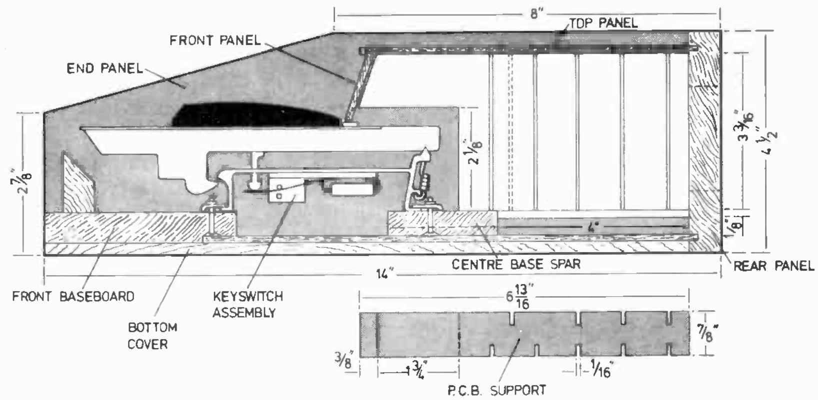


Fig. 5.1 (a). Music stand; (b) cross section of "Joanna" cabinet assembly; (c) leg assembly; (d) soft and sustain pedal details

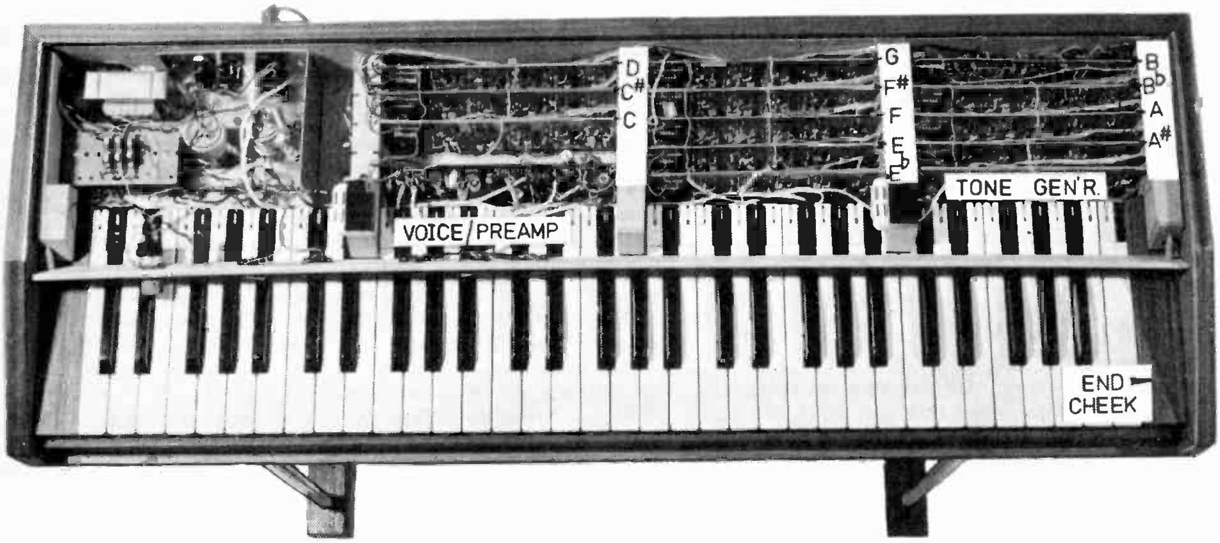


(c)

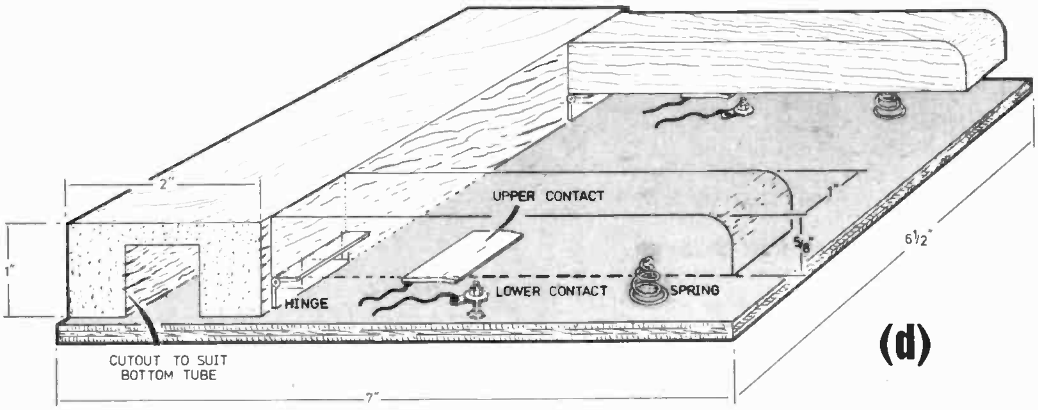


TOP PANEL
FRONT PANEL
END PANEL
FRONT BASEBOARD
BOTTOM COVER
KEYSWITCH ASSEMBLY
CENTRE BASE SPAR
REAR PANEL
P.C.B. SUPPORT
8"
14"
4"

(b)



VOICE PREAMP
TONE GEN'R.
END CHEEK
D
C#
C
G
F#
F
E
B
A
A#



UPPER CONTACT
LOWER CONTACT
HINGE
SPRING
CUTOUT TO SUIT BOTTOM TUBE
2"
1"
7"

(d)

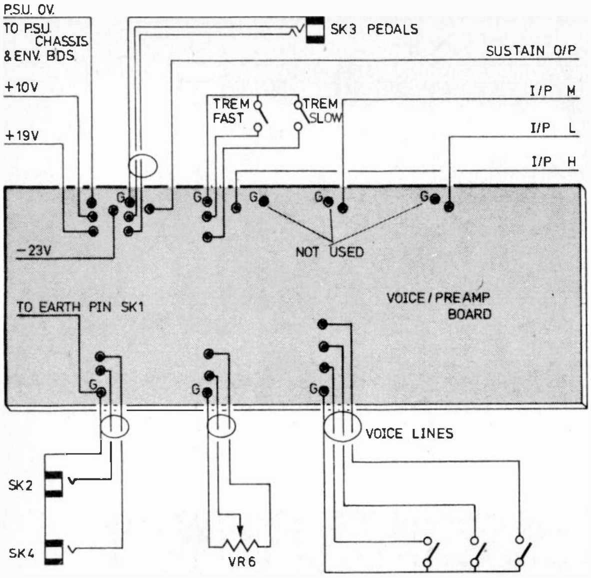


Fig. 5.3. Connection to Voice/Preamp Board including ground connections to minimise hum

WIRING FROM THE TOP

Before commencing top wiring the level control potentiometer, mains neon, and five control switches should be fixed in their respective positions on the front panel. Wiring can then be carried out in the following order:

1. Long leads (colour coded) should be soldered to the +19V (+V), and −23V (−V) pins on the Tone Generator Board, passed between the p.c.b. supports and keyswitch ready to connect to the Power Supply.
2. The four supply leads should be connected to the Voice/Preamp Board with similar coding for +19V and −23V as above.
3. All connections can now be made to the Power Supply Unit. The +10V supply (V/2) is obtained from the junction of C3 and IC1 in Fig. 2.1.
4. Coded interconnections should be made between the Voice/Preamp Board and SK2 and 4 and SK3 on the p.s.u. chassis, preferably using 2-core coaxial lead in both cases.
5. Coded interconnections should be made to the tremolo switches and voice switches, using coaxial lead for the latter link.
6. A coaxial lead should be used to link the Voice/Preamp Board and the level potentiometer.
7. Mains switch and neon connections should be made to the Power Supply Unit.

The various links between the Voice/Preamp Board and switches and sockets are illustrated in greater detail in Fig. 5.3. along with the ground interconnections to avoid any hum due to earth loops.

LEG ASSEMBLY

Details of the legs are shown in Fig. 5.1 and are constructed from four preferably hardwood blocks shaped and dimensioned as indicated, interconnected with chromium plated ¾in diameter tubing. The legs are screwed to the Cabinet, into both front and centre base spars.

PEDALS

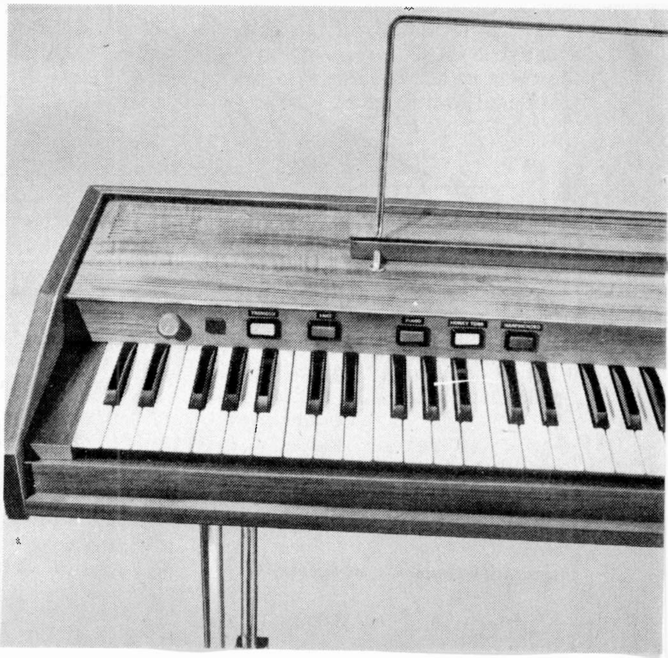
Pedal details are also given in Fig. 5.1. Again hardwood is used throughout.

This simple assembly, whilst fairly fragile, can stand up to sensible use, and is designed to give a neat appearance rather than for maximum strength. The rear block should be channelled or drilled to accept the bottom tube as a retainer. The simple switches are made by gluing phosphor bronze strip under the pedals to contact with the ends of screws recessed into the base. Compression springs should be held in position by indentations in the base and pedals.

POWER AMPLIFIER

The electronic piano is a device which is generally improved by high peak power capability, one commercial manufacturer incorporated a 150W peak power rated system into his design. Completely satisfactory results have however been obtained from the system quoted above, and it is possible that a rating between 15 and 25W (sine wave) could be acceptable.

One amplifier parameter only seems to have greater than normal importance in this application and that is intermodulation distortion. This is the effect where the mixing of two notes, say at a third interval, produces a strong difference frequency signal which is detectable as a non musically related note to the two intended notes. This is particularly noticeable in the higher registers of the keyboard where the difference frequency is a note far removed towards the lower end of the keyboard and is in the easily audible range.



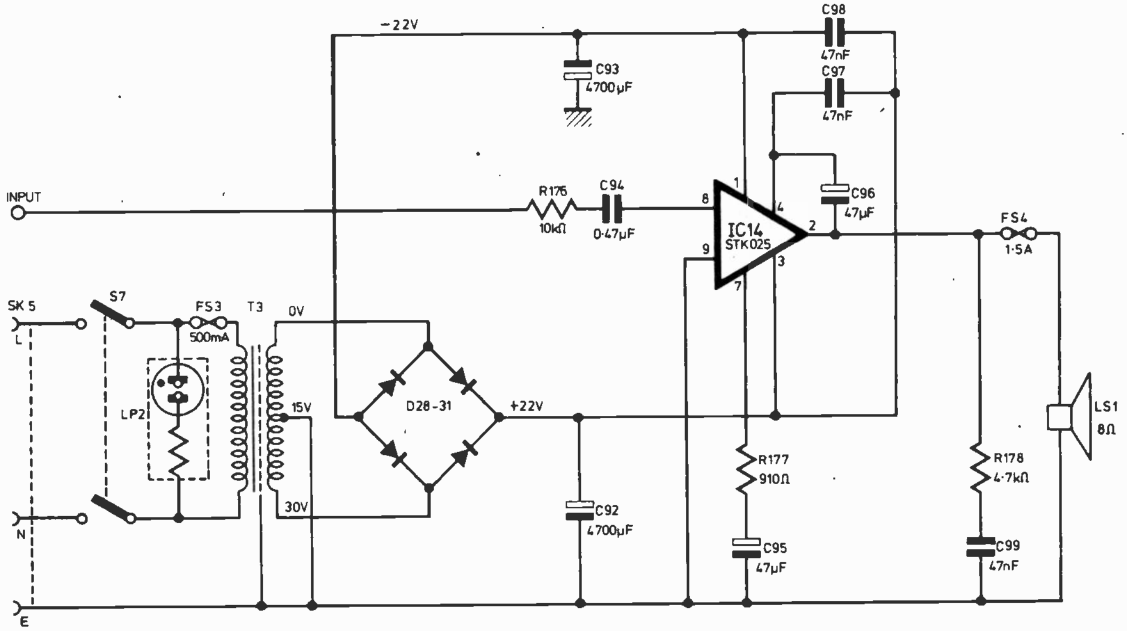


Fig. 5.4. Circuit of Amplifier

It must be admitted that the author is somewhat critical on this point although it does not affect his enjoyment of the instrument, and many observers have judged the effect to be acceptable—it can be found on the majority of commercial organs.

Intermodulation can occur throughout any amplifier chain, and is minimised by maximising the linearity of the system. The final intermodulation culprit is the output stage of the Power Amplifier, and is related to the level of crossover distortion. A number of amplifier designs provide adjustment of the output stage quiescent conditions to reduce crossover but the move to hybrid integrated modules removes this facility. Hybrid modules of course make for very easy construction and economy, and this must be weighed against the level of intermod which can be tolerated. The author's instrument continues to use such an amplifier and these notes are only included to make the situation clear, and not to deter the constructor from the use of these devices.

The circuit details of the amplifier and p.s.u. using a Sanyo STK025 are given in Fig. 5.4. The external components are mounted on a group board, and the completed unit fixed into the stool.

LOUDSPEAKERS

From the tone/voicing point of view the loudspeaker used with the "Joanna" is more important than the Power Amplifier. It is also important that the speaker has a relatively high power handling capacity, designed for use with electronic musical instruments where a rugged construction is vital.

If it is intended to use an existing hi-fi amplifier it is strongly recommended that the normal hi-fi speaker not be used since it is very likely that its capacity is insufficient to handle the peak power which can be and will be supplied by the amplifier when used in this application. Since the piano relies

COMPONENTS . . .

AMPLIFIER

Resistors
R176 10kΩ
R177 910Ω
R178 4·7Ω

Capacitors
C92–C93 4,700μF elect 25V (2 off)
C94 0·47μF
C95–C96 47μF elect. 25V (2 off)
C97–C99 47μF (2 off)

Semiconductors
IC14 STK025
D28–D31 Bridge Rectifier (50V r.m.s. 2A)

Miscellaneous
F53 500mA fuse and panel fuseholder
F54–1·5A fuse and panel fuseholder
LP2–Mains neon
S7–Mains switch
SK5 3 pin miniature mains socket
SK6 mono jack socket
T3–Transformer 30V centre tapped 2A
Heatsink (R.S. 149)
Groupboard
LS1–8Ω 25W r.n.s.

Touch Resistors
R179–R214 1·5kΩ 1W (36 off)
R215–R239 1·8kΩ 1W (25 off)

Music Stand
Metal Frame 36in × ¼in dia. aluminium rod
Wooden crossbow 17in × ¾in × ¼in

Keyswitch
CPS1027 (Clef Products)

on very high peak power signals of short duration to produce an acceptable overall mean power, the ratio of peak to mean power required is much higher than in the average programme (music) played through your hi-fi system, and the danger is that you will increase playing volume without realising until you produce distortion. Distortion due to overloading the amplifier is not generally dangerous, but distortion due to overloading the speaker is fatal to that component.

The author has used 25W of amplifier (sine wave rating) and 50W (nominal) of heavy duty speaker over a period of five years with two designs of electronic piano, and whilst speakers of lower rating have been damaged in experiments, no deterioration has occurred in either a Fane POP50 or Goodmans 12P. This is not to say that other equivalent units are not available, but any speaker used should be designed for heavy duty work and its rating be treated conservatively.

SPEAKER VOICING

From the voicing point of view the design as presented is matched to the Goodmans 12P, mounted facing downwards in the stool. Some variation in tone quality occurs dependent on the floor covering as might be expected, but the range is acceptable. This speaker appears to apply a heavy top cut to the system, which could particularly affect the Harpsichord voice if the voice circuits were not generally bright. Experiments have been tried with smaller 8in heavy duty units, where an improved treble response is present. In order to restore the mellow piano tone, capacitors were connected across R103, R105 and R107 with values of 47nF in each case. This restored the basic tone, finely adjusted by VR3, 4 and 5, but the body of sound in the bass associated with a 12in speaker was sadly missing.

STOOL

Cutting details for the stool used to house the Goodmans 12P are given and the introductory photo should prove adequate for constructional guidance. The volume is below that recommended by Goodmans, and the constructor may prefer to make a more conventional cabinet to house the speaker and amplifier.

FAULT FINDING

Generally in the event of a fault occurring in one note it can be easily located to one of the 61 similar circuits, and either experienced or inexperienced substitution of components attempted. Reference to the relevant theory in the series should assist in this.

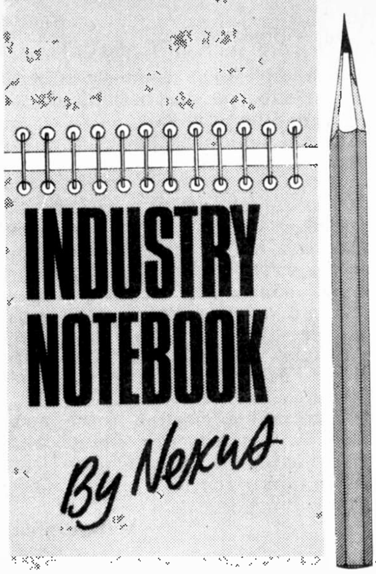
Some possibilities and causes of malfunction are quoted—it is not intended to convey the impression that such faults should be expected to occur.

1. **Incorrect p.s.u. levels**—Any general malfunction should first be followed by a check on power supply voltages. There can be a fairly widespread on voltage levels—see Part 2, but particularly a severe fall in levels can effect the operation of dividers and the master tone generator.
2. **"Frog"**—this could appear as a distinctive grumbling distortion of a note played on its own and may be present in all notes to some degree. Such an effect would be caused by a frequency modulation of the tone generation system at a mains frequency and indicates poor smoothing either in the p.s.u. (C1, 2, 4) or if only evident where a note is played it is likely to be a fault in either C5 or C6 on the tone generator board.
3. **Excessive break through**—If one or more notes break through predominantly into the background, output diodes D22 to D26 on the Envelope Boards should be suspected and changed for the note concerned. Some breakthrough will always be present and this is minimised by adjustment of VR3, 4 and 5, particularly the latter, on the Voice/Preamp Board. Maximum breakthrough will occur on the Harpsichord setting and is minimised by adjustment of VR2.
4. **Spurious sustain**—If a note sustains without the Sustain Pedal, the keyswitch should be checked for that note to ensure that it rests comfortably on the ground rod in the non playing condition. Sometimes this can be confused for breakthrough.
5. **Overload distortion.** As explained earlier, this may occur in the speaker if underated or the Power Amplifier. Under exceptional circumstances it may occur in the preamplifier if the Power Amplifier is of very low sensitivity, VR9 (preset gain) should be adjusted to give zero distortion on the Piano stop for maximum level setting and heavy playing. Remember that two stops at once gives twice the power, and three stops gives three times the power. The level control on the front panel should be reduced when multi-stops are used.
6. **Mains hum**—If this is continuous it is likely to be due to interwiring—particularly with respect to ground connections.
7. **Intermodulation distortion**—This has been covered in detail above. Do not expect perfection in this—it is an effect normally present in a wide range of electronic musical instruments.

NOTE: The mains fuse FS1 in Fig. 2.1 should be 1A. C10 and C11 should be 47nF in Fig. 2.4. It has been found that two diodes in series are necessary in the D22–D26 and D11 positions.

The transformer specified for T2 is commonly found with a 230V primary giving a high output. A resistor of 220 ohms between 0V and the junction of C1 and C2 will reduce the voltage across C1 and C2 on load.

—This concludes the Joanna series of articles. ★



SWEDISH SOLID STATE

When you come late into the field you need to find market gaps in which to become established commercially. This is never more true than in solid state technology where, to all intents and purposes, the big volume market is controlled by the giants of the industry operating internationally.

So newcomers ASEA-HAFO, a subsidiary of the Swedish ASEA electrical group, made the decision not to compete at all in the big league but to go exclusively for the more specialised custom-built market. As ever, timing of the operation was important and the company was building up its potential just at the time that the giants were losing all interest in the custom-built market where, almost by definition, volume is low.

But even with a comparatively modest operation the start-up costs are high if an adequate service is to be offered. When I visited the ASEA Group recently I was able to see for myself where the money goes. There is a fine modern production plant, purpose built, with all services piped in below floor, clinically clean and immaculately equipped. Another building in the locality houses design staff, mask production and an opto-electronics group.

In the past three years £2 million has been invested in the operation and another £2 million is earmarked for expansion. But turnover by the end of this year is estimated in round figures at £3 million and the first investment has already been recovered.

Paradoxically, while thinking small ASEA-HAFO was also thinking big, but in different areas. With the big volume market virtually closed the products would have to be rather special to attract profitable business in the low-volume area. The first stage in planning was therefore to set up a substantial computer-aided-design (CAD) facility geared to l.s.i. CMOS technology. The actual production process is licensed from RCA.

The most extraordinary part of the story is that the CAD department was built from scratch with no previous experience. Hardware and software could be bought but only at a price which ASEA-HAFO couldn't then afford, especially on the software side. Today there is a fine computer installation with some 200 software routines which together give a wide range of CAD programmes. Mechanisation continues into automated mask making and, after semiconductor production, into automatic testing.

Today ASEA-HAFO has a full capability in production of CMOS l.s.i., bipolar circuits, thick film hybrids and opto-electronics. Typical custom orders are for 10,000 units in CMOS and the business is going well with a design capacity of one circuit per month.

ASEA-HAFO could not have succeeded without the massive backing of the ASEA Group, founded in 1883 and dubbed the GEC of Sweden. With 40,000 employees it ranks 11th in the world league of electrical companies. From a mass of company statistics I think the most significant is that sales per person employed in 1974 was £14,000, a fine example of productivity achieved through quiet efficiency and heavy investment in plant and machinery.

One of the most fascinating products I saw was the ASEA Industrial Robot which, suitably programmed, can do repetitive jobs like pallet loading of components and some of the hardier tasks in bad environments such as welding and die-casting. A wonderful production aid which can work 24 hours a day without fatigue and clearly is designed to displace people. When I asked whether there was trade union pressure against its introduction I was told the unions welcomed it because it saves the members doing dull and dirty work, an attitude which has helped Sweden become prosperous.

MORE THAN A HANDSHAKE

If all has gone well, the dramatic handshake in space between American astronauts and Russian cosmonauts will have taken place (it was due on July 15) following the docking of the *Apollo* and *Soyuz* spacecrafts.

The ceremonial aspects of the occasion will perhaps have added credence to current political moves at detente between the two nations. But after this phase of the operation, which you may have seen on television, the real work began. In the American case the astronauts were due to conduct some 20 scientific investigations over the following five days. And of several groups of experiments the most important for the electronics industry was that involving the processing of semiconductor materials in a high temperature furnace under conditions of weightlessness.

This series of experiments was started during the *Skylab* missions in 1973 and 1974. Results were promising. An improved furnace was carried on the *Apollo-Soyuz* mission as part of the programme to confirm earlier *Skylab* findings. If crystal imperfections can be eliminated by "growing" them under weightless conditions it should be possible to produce more transistors per given area of material and thus produce integrated circuits with the ultimate in component density.

The orbiting factory may not be too far in the future. It is quite conceivable that within a few years we shall not think it at all unusual that deliveries of semiconductor crystals should arrive regularly on earth from outer space.

MARITIME COMSATS

A more immediate prospect is the realisation of commercial ship's communication by marine satellite. W. Martin Lovell, deputy technical director, Marconi Space and Defence Systems, gave an up-date on the situation of the European MAROTS programme at a Communication Conference in Rotterdam.

Starting as a British national programme, MAROTS has now been transferred to the European Space Agency (ESRO). Structure thermal tests are due for completion this year, the engineering model completed by mid-76, the qualification model completed early in 1977 and the flight model ready for launch by *Delta 3914* in October 1977.

As well as being responsible for the communications module, Marconi are pressing ahead with a shipborne terminal for general marine use. The big market will not come until the 1980's when the system has been demonstrated and successful and ship owners decide they can't afford to be without it.

Nobody is better qualified in marine communication than Marconi, the first company in the world to exploit maritime communication by radio 75 years ago.

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

F.M. CENTRE TUNING METER

IN v.h.f./f.m. broadcasts, the best reception is arrived at when one tunes to the centre of the S curve of the detector stages, i.e. 0V d.c. output from the detector coil (when conventional detector is employed).

Fig. 1 shows a circuit which allows conversion of a signal strength meter into a centre tuning indicator; the only modification required is the addition of a centre mark on the meter scale.

The circuit gets its input directly off the detector output (before any coupling capacitors). The f.e.t. serves two purposes: (a) very high input impedance, so as not to affect the audio and stereo switching signals and (b) it responds to negative signals, yet does not require an additional negative rail.

One would find that due to the large spread of parameters, one would have to alter slightly the values of R1, which could be regarded as the gain control. R3 may also have to be changed, depending on the meter employed.

To adjust the circuit, it is required to tune into the far right of the f.m. scale, far from any broadcast station, and adjust the preset until the meter indicates centre.

Since no modification to the meter itself is required, this circuit lends itself easily for switching from centre tuning function to peak signal tuning function.

M. Greenfeld,
Leeds.

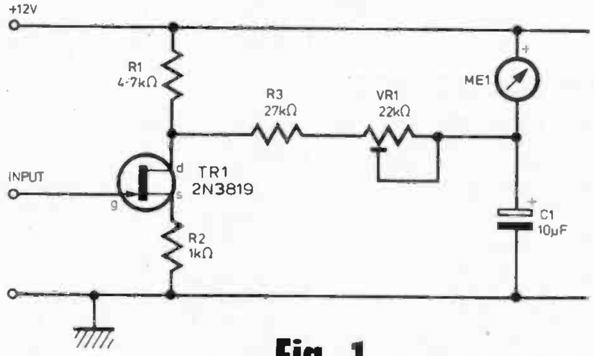


Fig. 1

TWO FUNCTION R/C CODER

THE circuits shown in Figs. 1 and 2 were developed as a result of the 1971 series "Logical Radio Control". I had difficulty in getting the coder described in the series to work reliably and so it was modified so that the train of monostable-generated pulses was triggered by an astable multivibrator.

This gave a system of fixed cycle time which, if the individual pulse lengths were kept short, made the generation of a synchronising pulse unnecessary as long as a suitable decoder was used.

Difficulty in obtaining the retriggerable monostable (F9601) resulted in the development of a 2-channel decoder.

The coder can easily be built on Veroboard or a p.c.b. can be made up. Due to the short rise and fall times of the pulses, short wiring is desirable. Decoupling of the supply with 0·1μF capacitors is also advisable. The prototype was powered from a 6V battery with an OA81 diode connected in the +ve lead.

Testing with an oscilloscope should show a waveform of 36ms pulses (at the collector of TR3) 0·3ms apart. The output of IC3 should be pulses whose length will depend on the setting of VR1 and VR2. The length of these pulses should be variable from approximately 1ms to 7·5ms.

For those requiring control over more than two functions it would be possible to add at least one more if not two more monostables but care must be taken that the maximum total pulse length does not exceed the fixed cycle time of 36ms.

S. D. G. Tucker,
Oxford.

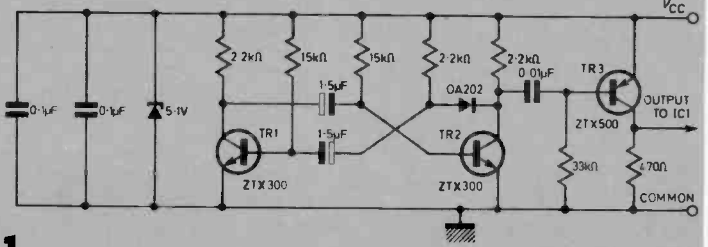


Fig. 1

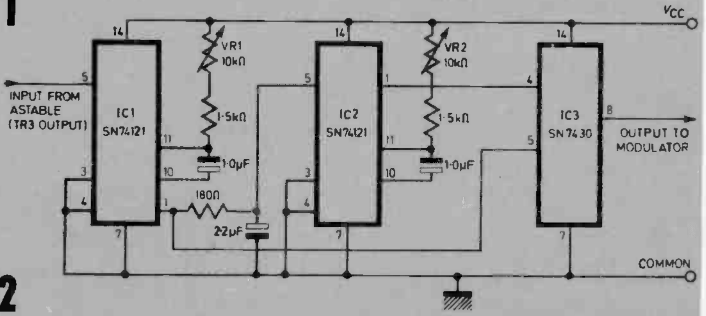


Fig. 2

PATENTS REVIEW...

CAR GAS DETECTOR

BP 1 387 488

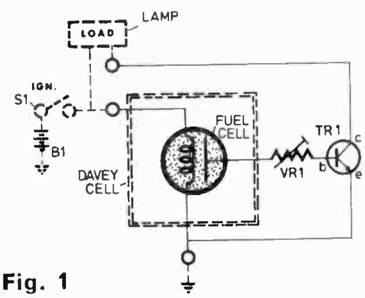


Fig. 1

Claims for a simple gas detector primarily for use in motor vehicles is outlined in BP 1 387 488 filed by TRW Inc.

Exposure to anything over fifty parts per million of carbon monoxide for a period in excess of one hour can affect the capability of a driver, even though twice this concentration at three hours' exposure will be needed to cause perceptible effects. Thus, a leaky exhaust pipe can take the edge off a driver's performance without him realising it.

The circuit Fig. 1 shows a fuel cell which includes an electrode in the form of a heating element. This element is connected between supply, via ignition switch, and car earth to maintain a temperature of about 600°C. The element is surrounded by a porous refractory shroud of silica and alumina, the shroud being coated by a porous layer of tin oxide or other catalytic metal oxide.

A second electrode is connected via VR1 to the base of TR1. The latter has its collector-emitter circuit connected to the warning lamp and earth respectively.

The catalytic coating causes oxidation of any carbon monoxide present and the release of ions. This causes current to flow across the electrodes and TR1 to conduct and operate the alarm.

The value of VR1 is adjusted to control triggering of the alarm, for instance at a concentration of carbon monoxide in the atmosphere of 100 parts per million.

LOUDSPEAKER FILTERING

In BP 1 385 346, Saba Schwarzwalder Apparate-Bau-Anstalt August Schwer Sohne GmbH refers to the undesirable group radiation or interference effects which occur when several identical loudspeakers are used in a single small cabinet.

Where it is required to use one high frequency tweeter or midrange unit with more than one identical bass speakers, it is unacceptable to have the bass speakers sharing the same load at the region of crossover with the middle or high range units. Although the bass units may share the same load over a part of their operating frequency range, all but one of them must be rolled off to zero well before the crossover range. According to the inventors, this roll-off should be at around 12dB per octave and start at least an octave below the crossover point.

A suitable circuit is shown in Fig. 1. Two low frequency speakers of identical type are independently filtered. Loudspeaker LS1 is in series with inductance L1 and in parallel with C1. LS2 is in series with L2 and in parallel with C2.

As shown in Fig. 2, the filter for LS1 is a low-pass filter with a top cut-off of substantially f_0. The filter has a slope of 12dB per octave and overlaps the curve of the high pass filter for a tweeter. The filter for LS2 also acts as a low pass filter but with a cut-off at f_1 which lies more than an octave lower than f_0. Thus, only LS1 is effective at the overlap region and there is no group effect.

BP 1 385 346

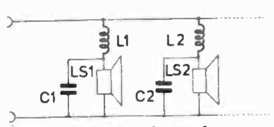


Fig. 1

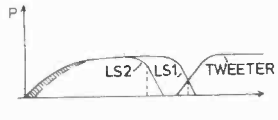


Fig. 2

TV SOUND UNIT

BP 1 389 228

In BP 1 389 228, Dinosaur Electronics Limited,* assignees of Anthony Burton of Windsor, claim commercial protection for a TV sound unit. This enables high fidelity sound to be derived from a conventional TV receiver by picking up stray i.f. sound radiation, demodulating it and feeding it to the auxiliary socket of a conventional hi-fi system. The patent appears to cover the commercially available Telefi, and the claims are probably broad enough to monopolise most other stray pick-up systems, including last month's PE design.

As previously explained in this column, British Patent Law is not such an ass as to prevent amateur constructors from conducting private experiments in their own homes (for instance based on circuitry published in the electronics press); but any home constructor who feels inclined to move on into even low-scale production of a patented device should take legal advice before doing so.

The Dinosaur patent explains how the tuner output of a conventional television receiver is passed to an i.f. amplifier and vision detector. This feeds a vision signal to the video circuits and a sound carrier signal to a sound i.f. amplifier, a limiter and a frequency discriminator.

The sound carrier signal is equal to the difference between the vision and the sound carrier frequencies and is frequency modulated with sound information. Inevitably there is stray radiation from the i.f. strip, and in 1971 the inventor lodged a patent claim for the straightforward but clever approach of capturing some of this stray signal by a tuned pick-up and amplifying and demodulating it to provide a high quality audio signal.

The patent covers all types of pick-up, including a coil or aerial and various transformer circuitry for connecting the pick-up to the external amplifier and demodulator.

**The above mentioned patent is now held by Rola Celestion Ltd., manufacturers of the "Telefi" sound unit.*

Copies of Patents can be obtained from the Patent Office Sales, St. Mary Cray, Orpington, Kent. Price 33p each.

TRANSDUCERS

PART 6 Opto-electronic Devices

By P. R. ALLCOCK*

THIS final article of the series looks at some opto electronic devices and digital encoding transducers for monitoring shaft rotation or position.

SOME BASICS OF LIGHT

Technically, the term "light" means electromagnetic radiation having a frequency or wavelength which can be perceived by the human eye. The percentage of the available electromagnetic spectrum occupied by visible radiation is in fact very small and covers the wavelength range from 4,000 to 7,000 Å (Angstrom units). The wavelength and frequency of the electromagnetic waves are related to the velocity of light by the well-known relationship:

$$\text{Velocity} = \text{Frequency} \times \text{Wavelength}$$

The velocity of light is approximately 3×10^8 metres/second and is a constant. Consequently short wavelengths correspond to the high frequencies and vice versa. The wavelength range above, quoted in Å can be related to more common units of length by noting that

$$1\ \text{Å} = 10^{-8}\text{cm and } 10{,}000\ \text{Å} = 10^{-3}\text{mm} = 1\mu\text{m}$$

Thus the wavelength range of visible light is from 0·4 to 0·7 thousandths of a mm which is very short when compared to the radio wavelengths in everyday use.

There are two related aspects of light that are used, together or separately, to explain many phenomena associated with light. Optical phenomena such as interference and diffraction patterns are explained by a wave theory such as that involved with radio waves. However, other phenomena are better explained by the quantum theory in which particle-like aspects of light are considered. According to this theory, light can be considered as discrete quanta or packets called photons.

These photons are uncharged particles each having an energy which depends only on their frequency or wavelength as given by

$$\text{Energy (in electron volts)} = \frac{h\,c}{\lambda}$$

where h is a constant (known as Planck's constant), c is the velocity of light and λ is the wavelength of the light.

Notice that this relationship shows the energy as increasing as the wavelength decreases. The energy associated with any particular wavelength of light can be obtained from the above equation, which can be simplified by putting in the values of c and h thus,

$$\text{Energy } E \text{ (in eV)} = \frac{12{,}400}{\lambda\ \text{(Angstrom)}}$$

* North Staffordshire Polytechnic

Table 6.1. Optical energy gaps of photodetector materials

Material	Chemical Symbol	Energy Gap at 300°K (eV)
Cadmium Sulphide	CdS	2·4
Cadmium Selenide	CdSe	1·7
Gallium Arsenide	GaAs	1·4
Silicon	Si	1·1
Germanium	Ge	0·7
Indium Arsenide	InAs	0·43
Lead Sulphide	PbS	0·37
Lead Selenide	PbSe	0·26
Indium Antimonide	InSb	0·23

For the visible spectrum limits this will give us

Violet light ($\lambda \approx$ 4,000 Å), E = 3·1 eV
Red light ($\lambda \approx$ 7,000 Å), E = 1·77 eV

Incidentally, the electron-volt unit of energy is the energy acquired by an electron when raised through a potential difference of one volt. Compared to the more familiar units of energy, the Joule, the eV unit is very small and the two units are related by

$$1\ \text{Joule} = 6{\cdot}24 \times 10^{18}\ \text{eV}$$

Photons can be emitted from the atoms of certain materials when electrons within change their energy from a high level to a lower level. The energy of the emitted photon will be equal to the energy lost in falling from the high to the low level. This energy difference is known as the energy gap and is also usually expressed in eV. Photons can also be absorbed by a variety of materials. If the energy of the entering photon is greater than the inherent energy gap of the material the valence electrons in the material can be excited and lifted up to the conduction band level with the resultant creation of free electron (and hole) current carriers. This particular process is in fact the basis of operation of all photodetectors, regardless of the particular media. Typical energy gaps for several materials used in the manufacture of photodetectors are shown in Table 6.1.

BASIC PHOTO-DETECTOR PARAMETERS

The photodetector transducer is the heart of most opto-electronic systems and the selection of the best detector for the particular application is often very important. Obviously the photodetector must be considered in relation to the light source, which might be the sun, a filament lamp, a light emitting diode or a laser. Photodetectors can be divided into two classes.

1. Thermal Detectors in which the radiation is absorbed, converted into heat, and the detector responds to the change of temperature.
2. Quantum Detectors which respond directly to the incident photons. This class can be subdivided into

(a) Photo-emissive, where the incident photons release electrons from the surface of the detector material. This phenomena occurs in vacuum, as in vacuum photo-diodes or phototube multipliers.
(b) Photo-voltaic, where a voltage is self-generated when light strikes the detector without any external bias. The solar cell is a well known example of this type but photo-diode operation is also based on this effect.
(c) Photo-conductive, where the conductivity of the photo sensor changes as a function of the incident light. These can be undoped devices such as photoresistors, or doped photoconductors such as photodiodes and similar devices.

In the selection of a photodetector transducer it is usually necessary to consider the following four parameters in relation to the application.

SPECTRAL RESPONSE

This is really a measure of the wavelength range over which the detector can respond. If the lightsource spectrum ranges from, say, 4,000 to 8,000 Å with a peak at 6,000, then a detector with a similar response, or at least an appreciable spectral overlap, should be used.

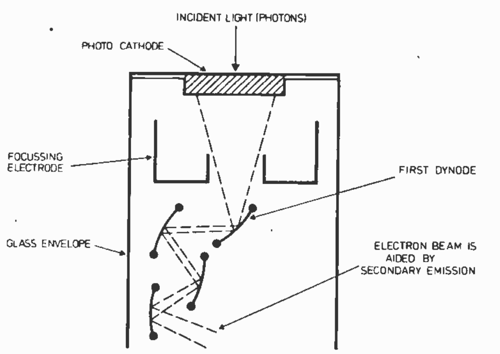


Fig. 6.1. Operating principle of the photomultiplier tube in diagrammatic form

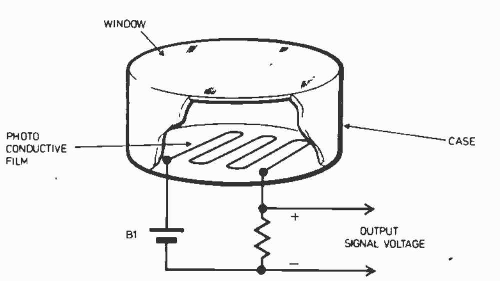


Fig. 6.2. Simplified construction and circuitry associated with a CdS cell

FREQUENCY RESPONSE

This relates to the speed with which the detector can respond to changes in the level of the incident light and is important when modulated radiation is to be used.

NOISE

Any random fluctuation of output current or voltage constitutes an unwanted noise signal. The term dark current is often used to denote the d.c. photodetector output current that exists under dark conditions whereas the noise current is the random a.c. output. Noise is directly proportional to the square root of the detector area.

RESPONSIVITY

This refers to a detector's sensitivity or output per unit light input. The responsivity can be expressed in various ways such as output current in milliamperes per input radiant light flux in watts.

SIGNAL/NOISE PERFORMANCE

The minimum detectable signal level will depend on the amount of noise produced within the photodetector. The performance is sometimes specified in terms of a Noise Equivalent Power (NEP) which is defined as the input (signal) power required to produce a signal/noise ratio of unity when using a bandwidth of 1Hz. Since the noise depends on the area of the photodetector and the bandwidth being considered, care must be taken when comparing different devices.

A variety of common photodetectors will now be dealt with in some greater depth.

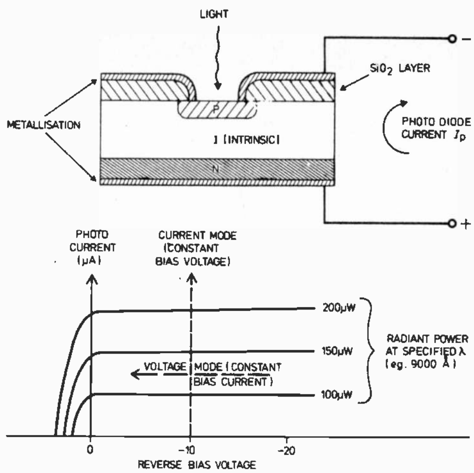
PHOTOMULTIPLIERS

One of the traditional devices for detecting light is the photomultiplier tube. These devices provide high sensitivity and speed and the operating principle is illustrated in Fig. 6.1. Incident light releases electrons from a photocathode which has peak spectral response in the 4,000 to 5,000 Å range. The electrons are focused and accelerated towards the first dynode by appropriate electric fields and here additional electrons are released by the process of secondary emission. The number of secondary electrons emitted per incident primary electron, ranges between 1 and 5 typically and by using a series of dynodes, current gains (overall) of 10^5 or more can be obtained.

Photomultipliers and their newer counterparts, continuous channel multipliers, are usually the best choice for applications requiring extremely low-level light detection with frequency responses greater than a few megahertz. However, a wide range of solid state photo sensor/amplifier configurations are possible which can give comparable speed or sensitivity, and superior performance can often be achieved in low speed applications.

BULK PHOTOCONDUCTORS

In these devices a thin film of photo-conductive material is exposed to the incident light. Provided the energy is sufficient the photons can release electron-hole pairs in the material and the resistance of the cell therefore falls as the intensity of the light increases. An external battery and circuit is required for these devices and Fig. 6.2 illustrates the principles outlined for one particular device, the CdS cell.



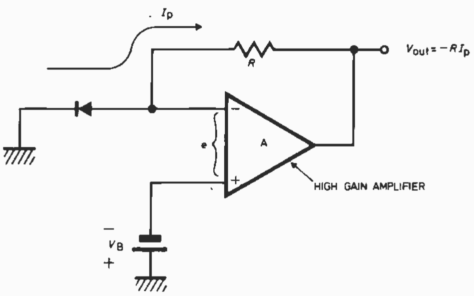


Fig. 6.4. A constant bias voltage circuit for a photodiode

Such cells exhibit an approximately exponential variation of resistance with ratios of dark to light resistance of about 1,000:1. The response is relatively slow, especially when the light source decreases or goes off, since it takes longer for the electrons to "drain" back to the valence band due to trapping in imperfections within the material. Resistive photo conductors also exhibit temperature effects which vary with light level and generally speaking the faster response materials are less temperature stable than the slow response types.

PHOTODIODES

In this case the detector uses a doped semiconductor p-n junction and the incident radiation generates hole/electron pairs providing the photon energy exceeds the energy gap requirements. The pair generation will occur at various depths depending on the energy of the photons and the nature and thickness of the materials. If the pairs are produced outside the junction depletion region there is a greater probability of them recombining so the depletion region is often widened by increasing the reverse bias across the diode.

This also decreases the transit time of the holes and electrons. Sometimes an intrinsic layer is interposed between the p and n regions and this gives the device a p.i.n. structure which also produces a wider depletion region. The p.i.n. photodiode has a lower junction capacitance by virtue of the increase in the "plate" separation and this makes the device much faster than the conventional p-n type.

The p.i.n. structure also exhibits low noise and dark current plus greater efficiency at the longer wavelengths.

A typical structure is shown in Fig. 6.3 together with typical current-voltage characteristics. Operation with fixed reverse bias gives a current mode (high internal resistance) characteristic in which the output current is a linear function of incident radiation over about ten decades. Operation at constant bias current is also possible but gives more distortion in "linear" applications and a greater dependance on environment and bias current stability.

Fig. 6.4 illustrates the current mode where the reverse bias voltage across the diode is provided by the amplifier action and supply V_B. The virtual earth principle resulting from $A \gg 1$ means that e is almost zero. The diode bias is thus fixed at V_B volts and the photodiode current, I_p, is used to drive the amplifier as a current to voltage converter, to give an output voltage proportional to diode current.

AVALANCHE PHOTODIODE

The avalanche photodiode is a special photodiode designed for operation in the avalanche breakdown region in order to achieve internal photo-current multiplication. The electrons, produced by pair generation, drift into the avalanche region of the device where they are rapidly accelerated by an intense electric field. The high velocities give a high probability of generation of additional electrons by impact ionisation. The ionisation rate is a strong function of applied voltage because the electric field strength determines the energy of the generated current carriers and hence the overall current multiplication. The avalanche photodiode is a sort of solid state equivalent to the photo multiplier tube.

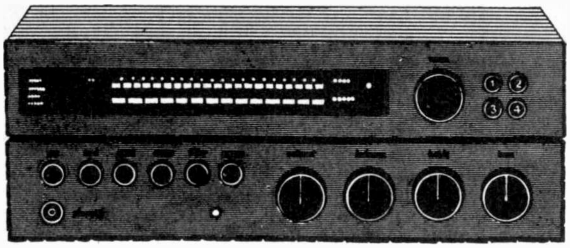
SOLAR CELLS

The advent of the space age resulted in extensive research into the area of direct conversion of solar energy into electrical energy. More recently, a growing need for energy conservation has come about and it seems likely that solar cell development will continue for certain applications. To be a good energy converter the solar cell spectral response should match the sun's spectrum which peaks at about 5,000 Å and yields an irradience level of about 100mW/cm² at the earth surface. For energy conversion applications it is also desirable to have a high power conversion efficiency.

Typical solar cells for such applications must have low internal resistances and the basic structure, operation and fabrication are similar to the silicon photodiode. The doping levels and areas are much higher however and the top layer of the junction is very thin to extend the U.V. response to match the solar spectrum. In some cells the contact resistance is decreased by using a fine mesh contact and normally the cells are operated without bias in the photo voltaic mode.

Solar cells are often used in photographic exposure meters. In this application the solar cell is superior to a photodiode due to the larger area and therefore high

Sinclair System 4000



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2G371	0·40
2G381	0·22
2G414	0·30
2G417	0·25
2N404	0·22
2N697	0·16
2N698	0·30
2N706	0·12
2N706A	0·12
2N708	0·15
2N709	0·40
2N1091	0·55
2N1131	0·25
2N1132	0·24
2N1302	0·18
2N1303	0·18
2N1304	0·28
2N1305	0·22
2N1306	0·28
2N1307	0·28
2N1308	0·28
2N2147	0·78
2N2148	0·60
2N2160	0·78
2N2218	0·28
2N2219	0·25
2N2369A	0·16
2N2444	1·99
2N2613	0·75
2N2646	0·50
2N2904	0·20
2N2904A	0·25
2N2906	0·20
2N2907	0·23
2N2924	0·13
2N2925	0·15
2N2926	0·12
2N3054	0·48
2N3055	0·45
2N3702	0·11
2N3705	0·15
2N3706	0·11
2N3707	0·18
2N3709	0·10
2N3710	0·11
2N3711	0·11
2N3819	0·88
2N4289	0·30
2N5027	0·53
2N5088	0·33
2S301	0·59
2S304	1·15
2S501	0·75
2S703	1·00
AA129	0·20
AAZ12	0·75
AAZ13	0·12
AC107	0·51
AC126	0·25
AC127	0·25
AC128	0·15
AC187	0·21
AC188	0·20
ACY17	0·40
ACY18	0·27
ACY19	0·27
ACY20	0·22
ACY21	0·22
ACY22	0·16
ACY27	0·25
ACY28	0·25
ACY39	0·78
ACY40	0·22
ACY41	0·22
ACY44	0·32
AD140	0·50
AD149	0·50
AD161	0·44
AD162	0·44
AF106	0·30
AF114	0·25
AF115	0·25
AF116	0·25
AF117	0·24
AF118	0·57
AF119	0·20
AF124	0·30
AF125	0·30
AF126	0·30
AF127	0·30
AF139	0·41
AF178	0·55
AF179	0·65
AF180	0·55
AF181	0·50
AF186	0·48

	£p
AFZ11	1·15
AFZ12	2·00
ASY26	0·25
ASY27	0·33
ASY28	0·25
ASY29	0·30
ASY36	0·25
ASY50	0·20
ASY51	0·40
ASY53	0·20
ASY55	0·20
ASY62	0·25
ASY66	0·33
ASZ21	1·00
ASZ23	0·75
AU104	1·00
AUY10	1·00
BC107	0·14
BC108	0·13
BC109	0·14
BC113	0·15
BC115	0·20
BC116	0·20
BC116A	0·23
BC118	0·20
BC121	0·20
BC122	0·20
BC125	0·68
BC126	0·65
BC140	0·55
BC147	0·10
BC148	0·08
BC149	0·10
BC157	0·14
BC158	0·12
BC160	0·63
BC169	0·14
BCY31	0·45
BCY32	0·85
BCY33	0·38
BCY34	0·45
BCY38	0·55
BCY39	1·50
BCY40	0·80
BCY42	0·30
BCY70	0·18
BCY71	0·22
BCZ10	0·60
BCZ11	0·65
BD121	1·00
BD123	1·00
BD124	0·65
BDY11	1·45
BF115	0·20
BF167	0·25
BF173	0·28
BF181	0·35
BF184	0·22
BF185	0·22
BF194	0·10
BF195	0·13
BF196	0·15
BF197	0·15
BF861	0·25
BF898	0·25
BFX12	0·20
BFX13	0·26
BFX29	0·28
BFX30	0·28
BFX35	0·98
BFX63	0·50
BFX84	0·25
BFX85	0·28
BFX86	0·25
BFX87	0·25
BFX88	0·24
BFY10	0·50
BFY11	0·50
BFY17	0·40
BFY18	0·45
BFY19	0·55
BFY24	0·45
BFY44	1·00
BFY50	0·21
BFY51	0·20
BFY52	0·20
BFY53	0·17
BFY64	0·36
BFY90	0·81
BSX27	0·50
BSX60	0·93
BSX76	0·18
BSY26	0·17
BSY27	0·20
BSY51	0·50
BSY95A	0·12
BSY95	0·12
BT102/500R	0·75
BTY42	0·92
BTY79/100R	0·75
BTY79/400R	1·10
BY100	0·27
BY126	0·14
BY127	0·12
BY182	0·85

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BY213	0·25
BYZ10	0·45
BYZ11	0·40
BYZ12	0·40
BYZ13	0·42
BYZ15	1·25
BYZ16	0·60
BZY88	0·10
C111	0·55
CRS1/05	0·35
CRS1/40	0·50
CS4B	1·90
CS10B	3·50
DD000	0·15
DD003	0·15
DD006	0·25
DD007	0·40
DD008	0·38
GD3	0·33
GD4	0·10
GD5	0·33
GD8	0·25
GD12	0·10
GET102	0·50
GET103	0·40
GET113	0·35
GET114	0·30
GET115	0·90
GET116	0·85
GET120	0·50
GET872	0·30
GET875	0·40
GET880	0·60
GET881	0·25
GET882	0·35
GET885	0·40
GEX44	0·08
GEX45/1	0·45
GEX941	0·45
GJ3M	0·50
GJ4M	0·50
GJ5M	0·25
GJ7M	0·50
HG1005	0·50
HS100A	0·20
MAT100	0·20
MAT101	0·25
MAT120	0·20
MAT121	0·25
MJE340	0·47
MJE520	0·63
MJE2955	1·27
MJE3055	0·77
MPF102	0·40
MPF103	0·36
MPF104	0·35
MPF105	0·36
NKT128	0·45
NKT129	0·30
NKT211	0·25
NKT213	0·25
NKT214	0·24
NKT216	0·40
NKT217	0·45
NKT218	0·45
NKT219	0·33
NKT222	0·30
NKT224	0·25
NKT251	0·24
NKT271	0·20
NKT272	0·20
NKT273	0·20
NKT274	0·20
NKT275	0·25
NKT277	0·20
NKT278	0·25
NKT301	0·85
NKT304	0·75
NKT403	0·70
NKT404	0·66
NKT678	0·30
NKT713	0·30
NKT773	0·25
NKT777	0·38
OA5	0·72
OA6	0·12
OA47	0·08
OA70	0·10
OA71	0·20
OA73	0·15
OA74	0·15
OA79	0·10
OA81	0·18
OA85	0·15
OA86	0·15
OA90	0·07
OA91	0·07
OA95	0·07
OA200	0·08
OA202	0·06
OA210	0·20
OA211	0·35
OAZ200	0·50
OAZ201	0·45
OAZ202	0·45
OAZ203	0·45
OAZ204	0·45

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OAZ205	0·45
OAZ206	0·45
OAZ207	0·45
OAZ208	0·40
OAZ209	0·40
OAZ210	0·40
OAZ211	0·40
OAZ222	0·45
OAZ223	0·45
OAZ224	0·45
OAZ241	0·25
OAZ242	0·15
OAZ244	0·25
OAZ246	0·15
OAZ290	0·38
OC16	1·00
OC16T	1·00
OC19	0·50
OC22	1·00
OC23	1·25
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OC30	0·40
OC35	0·55
OC36	0·60
OC41	0·35
OC42	0·40
OC43	0·70
OC44	0·20
OC44M	0·17
OC45	0·20
OC45M	0·18
OC46	0·27
OC57	0·60
OC58	0·60
OC59	0·60
OC66	0·50
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OC78	0·25
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OC81	0·29
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OC81M	0·20
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OC81Z	0·45
OC82	0·28
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OC83	0·27
OC84	0·30
OC114	0·38
OC122	1·00
OC123	1·10
OC139	0·40
OC140	1·14
OC141	0·80
OC169	0·20
OC170	0·30
OC171	0·30
OC200	0·54
OC201	1·00
OC202	0·90
OC203	0·55
OC204	0·65
OC205	1·00
OC206	1·10
OC207	1·00
OC460	0·20
OC470	0·30
OCP71	1·20
ORP12	0·60
ORP60	0·55
ORP61	0·48
SX68	0·20
SX631	0·45
SX635	0·55
SX640	0·75
SX641	0·75
SX642	0·60
SX644	0·85
SX645	0·85
TIC44	0·29
V15/30P	0·75
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	0·43
XB102	0·30
XB103	0·35
XB113	0·30
XB121	0·43

	£p
Z8170	0·10
Z8271	0·18
ZT21	0·25
ZT43	0·25
ZTX107	0·12
ZTX108	0·08
ZTX300	0·13
ZTX304	0·24
ZTX500	0·13
ZTX503	0·16
ZTX531	0·25

INTEGRATED CIRCUITS

7400	0·16
7401	0·16
7402	0·16
7403	0·16
7404	0·26
7405	0·22
7406	0·42
7407	0·42
7408	0·28
7409	0·28
7410	0·16
7411	0·25
7412	0·30
7413	0·36
7416	0·36
7417	0·36
7420	0·16
7422	0·25
7423	0·37
7425	0·37
7427	0·37
7428	0·40
7430	0·16
7432	0·37
7433	0·37
7437	0·37
7438	0·37
7440	0·22
7441AN	0·92
7442	0·79
7450	0·16
7451	0·16
7453	0·16
7454	0·16
7460	0·16
7470	0·36
7472	0·38
7473	0·41
7474	0·42
7475	0·59
7476	0·45
7480	0·60
7482	0·87
7483	1·10
7484	1·00
7486	0·47
7490	0·55
7491AN	1·00
7492	0·70
7493	0·70
7494	0·80
7495	0·80
7496	0·95
7497	3·87
74100	1·89
74107	0·45
74110	0·58
74111	0·86
74118	0·90
74119	1·68
74121	0·50
74122	0·70
74123	1·00
74141	0·90
74145	1·26
74150	1·75
74151	1·00
74154	2·00
74155	1·00
74156	1·00
74157	0·95
74170	2·52
74174	1·57
74175	1·10
74176	1·26
74190	2·00
74191	2·00
74192	2·00
74193	2·00
74194	1·30
74195	1·10
74196	1·20
74197	1·20
74198	2·77
74199	2·52

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current capability leading to a more robust meter movement. The use of the photovoltaic mode means that a battery is not required and the output current is a linear function of the incident radiation for several decades.

PHOTOTRANSISTOR

This device combines the ability to detect light and provide gain in a single device. The structure is similar to that of a conventional planar transistor except that a window or lens is provided in the case. The incident light generates hole-electron pairs in the vicinity of the relatively large reverse biased collector-base junction and these give rise to additional current by virtue of transistor action.

The dark current is also magnified by this same mechanism so that there is no basic improvement in signal/dark current ratio. The collector-base capacitance also affects the frequency response which is usually inferior to that obtained from a photodiode/amplifier combination. Variation of transistor gain (β) with current also affects the linearity and consequently their best area of application is in "ON-OFF" situations such as punched card and paper tape readers.

Linear arrays of devices have been produced for such applications. More recently photo field effect and related devices have been developed for specialised uses and light activated thyristors are yet another example of the growth that is taking place. Infra red detectors have also been developed, largely due to military applications in the first instance and many of these require operation at low temperatures.

LIGHT SOURCES

The most common form of light source is the incandescent lamp which is available in a wide variety of shapes and sizes. Gas discharge lamps are also well known and widely used in neon displays and fluorescent lighting systems, but there is a growing area of applications for low cost, solid state light sources such as the light emitting diode (l.e.d.).

A multitude of crystals have been used to produce l.e.d.s and today various coloured light sources and displays are available. Combined light source-detector combinations are also available and are usually known as opto-couplers. These can be based on any of the available opto devices but the l.e.d. photodiode (or phototransistor) is perhaps the most common. These devices can give a high degree of electrical isolation and find application in such areas as patient monitoring and diagnostic medical equipment interfaces. Combinations of devices have also been developed as photopotentiometers and photo-choppers but the photon-coupling is a common feature of all these devices.

DIGITAL ENCODERS

A fairly common requirement is to monitor the position of a rotating shaft and one way of doing this is to use a shaft encoding disc which carries a particular optical pattern. The pattern is arranged to interrupt a series of light signals in such a way that a digital code is generated that represents the shaft position. The principle is illustrated in Fig. 6.5 which shows a pattern for generating a 3-bit Gray code. This code is so arranged that only one bit of the code changes at any one time and thus the alignment problems of binary-coded discs are avoided. The three circular bands on the disc are broken

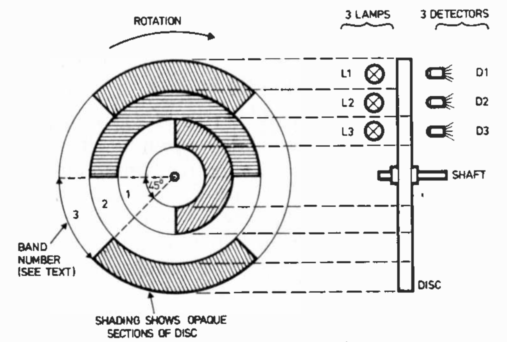

Fig. 6.5. Disc pattern and general arrangement for generating a 3-bit Gray-code for shaft rotation position detection

Table 6.2. 3-Bit Gray-coded disc patterns

	Band 1	Band 2	Band 3	3-Bit Code
Same Pattern	L	L	[L]	111
	[L]	L	[B]	110
	[B]	L	[B]	010
	B	[L]	[L]	011
	B	[B]	[L]	001
	[B]	B	[B]	000
	[L]	B	[B]	100
	L	[B]	[L]	101
Same Pattern	L	[L]	L	111

Notes **Logical 1 = L (Light passes)**
Logical 0 = B (Light blocked)
☐ Shows the bit which is changing

into segments and it is assumed that the shaded segments cut off the light sources from their respective photo-detectors when they fall between the lamps and detectors (such as L1, D1). Starting with all bands "transparent", as in the region where the band numbers are shown, and assuming clockwise rotation of the disc with the letter L corresponding to the passage of "light" and B for "black" (or dark-current conditions in the detector) we get the sequence of events shown in Table 6.2.

The position of the disc is identifiable, to within any one sector of 45°, by a unique 3-bit code. As the disc rotates only one bit change occurs at the sector boundaries due to the relative position of the segments within the three bands.

Shaft speed can be determined by using a series of holes, equally spaced around the periphery of a disc, to chop a light beam and so produce a pulse train whose repetition rate is proportional to speed of rotation. Obviously N holes in a disc rotating at n revs. per second will produce an output having a frequency of $N \times n$ pulses/sec.

Light sensitive devices can obviously be used in a wide variety of applications. For example it is possible by suitable diffraction gratings or discs, to produce interference patterns involving alternate light and dark bands. These patterns of "lines" can be detected and/or counted by opto-devices and using these techniques it is possible to measure angles of inclination of the gratings, or rotation angles of discs and shafts, to very high accuracy.

ACKNOWLEDGEMENTS

In a short introductory series it is impossible to cover all the transducers and related devices that are in current use. However, the series should provide the reader with some basic information which can be extended by selected reading. The author has been influenced by various people, papers and books over a number of years and several manufacturers have been very helpful in supplying details of their devices. The author wishes to acknowledge all these sources and suggests the following references for study by those who wish to pursue the subject further:

Practical Instrumentation Transducers by F. J. Oliver (PITMAN)
Transducer Measurements by K. Arthur (TEKTRONIX)
Piezo Electric Ceramics (Phillips, Application Book)
Piezo Electric Air Transducers (Mullard App. Notes TP1343)
Industrial Linear and Non Linear Resistors (TP1174 Mullard)
Basic Electronic Instrument H/B by C. F. Coombs (McGRAW HILL)
Strain Gauges, Theory and Handling by H. Kiihl (PHILLIPS)
Understanding Thermocouples: Instrument and Control Engineering (October, November 1968)
I.E.E. Conference on Servocomponents 1969
Servo Systems. Electronic Data Library Vol. 2 (Morgan-Grampian 1969)
The E-Cell Application No. 5, Electron, 1st June 1972
The Question of Thermistors, Electron, 13th July 1972
Thermistor Manual — Fenwal Electroncis
Instrument Technology by E. B. Jones (NEWNES-BUTTERWORTH).

★

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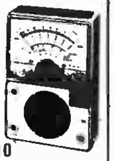
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U4312 MULTIMETER
extremely sturdy instrument for general electrical use. 667opv. 0/0.3/1.5/7.5/30/60/150/300/600/900V DC & 75mV. 0/0.3/1.5/7.5/30/60/150/300/600/900V AC. 0/300uA/1.5/6/15/150/60/600mA/1/1.5/6A DC. 0/1.5/6/15/60/150/600mA/1.5/6A AC. 0/200/3k/30k ohms. DC accuracy 1%. AC 1.5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions.

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100,000 opv. Mirror scale. Built-in meter protection. 0/3/12/60/120/300/600/1200V DC. 0/6/30/120/300/600V AC. 0/10μA/6/60/300mA/12 Amp. 0/2K/200K/2M/200 Meg Ohm. −20 to +17dB.

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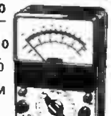
Input impedance 10 Megohms. Ranges:—0/.25/1/2.5/10/50/1000V DC. 0/2.5/10/50/250/1000V AC. 0/25uA/2.5/25/250 mA DC. 0/5k/50k/500k/5 M 500 Megohms

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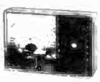
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HIOKI 750X VOLT-OHM-MILLIAMETER
43 ranges: 0—0.3/0.6/1.5/3/6/12/30/60/150/300/600/1,200V DC. 0—3/6/15/30/60/120/300/600/1,200V AC. Current: 0—30/60uA/1.5/3/15/30/150/300 mA/6/12A. Resistence: 0—3/300k/3/30Mohms. Decibels: −10 to +17dB. Output:—0—3/6/15/30/60/120/300V. Accuracy ± 3% DC, ± 4% AC. Sensitivity: 50,000 opv DC, 5,000 opv AC. 4 inch meter. Built in protection. Size: 57 x 102 x 153mm.

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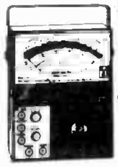
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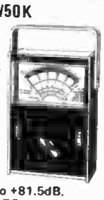
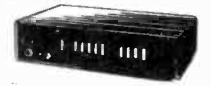
OUR PRICE £11.85 P/P & Ins 60p

TMK 200 MULTIMETER KIT
Build yourself a quality 20000 opv. multimeter and save money. Complete kit with meter scale, movement and rotary range selector ready mounted in cabinet. All parts, batteries, test prods and instructions. Ranges: 0/0.6/6/30/120/600/1200V D.C. 0/6/30/120/600/1200V A.C. Current: 0/0.6/6/60/600mA. Resistance: 0/10/100K/1/10 Meg ohms. Decibels: −20 to +63db. Size: 90 x 150 x 35mm.

OUR PRICE £9.65 P/P & Ins 30p

TMK MODEL TW50K
46 ranges, mirror scale. 50k/V DC 50k/V AC. DC Volts: 0.125/0.25/1.25/2.5/5/10/25/50/125/250/500/1000. AC Volts 1.5/3/5/10/25/50/125/250/500/1000. DC current 25/50uA/2.5/5/25/50/250/500mA/5/10A. Resistence: 10k/100k/1 Meg/10 Meg ohms. −20 to +81.5dB.

OUR PRICE £13.50 P/P & Ins 60p

SINCLAIR DM2 DIGITAL MULTIMETER

Will measure AC and DC volts, AC and DC current, and resistance in a total of 20 ranges. The large light emitting diode display will read up to 1999 and automatically indicate polarity. Indication of positive and negative overload is also provided. The instrument is fitted with a combined carrying handle and bench stand and sockets are provided for the connection of an external power supply.
RANGES:
DC VOLTS: 1v, 10, 100v, 1000v.
AC VOLTS: 1v, 10v, 100v, 1000v.
DC CURRENT: 1mA, 10mA, 100mA, 1000mA.
AC CURRENT: 1mA, 10mA, 100mA, 1000mA
RESISTANCE: 1k, 10k, 100k, 1000k.
OUR PRICE £63.70 P/P & Ins 50p

Model HT100B4 MULTIMETER
Overload protected, shock proof circuits. 9.5uA Meter with mirror scale. Sensitivity 100kV. Polarity change switch. Ranges: 0.5/2.5/1-/50/250/500/1,000 Volts DC. 2.5/10/50/250/1,000 Volts AC. DC resistence' 0—20/200k/2/20 Meg. ohms. DC current:— 10/250uA/2.5/25/250 mA/10A. AC current:—0—10A. −20 to +62dB. Operates from 2 x 1.5V batteries. Size: 180 x 134 x 79mm.

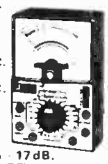
OUR PRICE £21.50 P/P & Ins 60p

KAMODEN TT35 TRANSISTOR TESTER
High quality instrument to test reverse leak current and DC current. Amplification factor of NPN, PNP, diodes, transistors, SCR's etc. 4" square clear scale meter. Operates from internal batteries. Complete with instructions, leads carrying handle.

OUR PRICE £18.90 P/P & Ins 60p

MODEL C7208FM
30,000 opv DC. 15,000 opv AC. 6/3/15/60/300/600/1200V. DC. 6/30/120/600/1200 V. AC DC Resistance x 1, x 10, x 100, x 1000 (50Ω centre scale) DC Current 30uA/3/30/600mA. −20 to +63dB.

OUR PRICE £9.65 P/P & Ins 30p

MODEL AF.105 VOM
50,000 opv. Mirror scale. Meter protection. 0/3/3/12/60/120/300/600/1200V DC. 0/6/30/120/300/600/1200V DC. 0/30μA/6/60/300 mA/12 Amp. 0/10K/1m/10m/100 Meg Ohms. −20 to 17dB.

OUR PRICE £13.50 P/P & Ins 60p

370WTR MULTIMETER
Features AC current ranges. 20,000opv. 0/0.5/2.5/10/50/250/500/1000V DC. 0/2.5/10/50/250/500/1000V AC. 0/50uA/1/10/100 mA/1/10A DC. 0/100mA/1/10A AC. 0/5k/50k/500k/5 Meg/50 Meg. Decibels: −20 to +62dB.

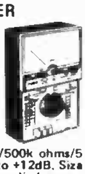
OUR PRICE £21.50 P/P & Ins 60p

S100TR MULTIMETER TRANSISTOR TESTER
100,000opv. Mirror scale. Overload protection. 0/0.12/0.6/3/12/30/120/600V DC. 0/6/30/120/600V AC. 0/12/600uA/12/300mA/6/12A DC 0/10k/1 Meg/100 Meg. −20 to +50dB. 0.01—0.2MFD Transistor tester measures Alpha, Beta and ICO. Complete with instructions, batteries and leads.

OUR PRICE £22.65 P/P & Ins 60p

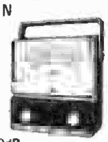
TRANSISTORISED L.C.R. A.C. BR/8 MEASURING BRIDGE

A new portable bridge offering excellent range and accuracy at low cost. Resistance: 6 ranges: 0.1 ohm-11.1 megohm ± 1% Inductance: 6 ranges: 1 microhenry-111 henries ± 2% Capacity: 6 ranges: 10pf-1110 mfd ± 2% Turns Ratio: 6 ranges: 1:1/1000-1:11100 ± 1% Bridge Voltage at 1,000cps. Operated from 9-volt battery. 100 micro-amp meter indication. Size 7¾" x 5" x 2".
OUR PRICE £29.70 P/P & Ins 60p

U4324 MULTIMETER
High sensitivity.
20,000opv. Ranges: 0.6/1.2/3/12/30/60/120/600/1200V DC. 3/6/15/60/150/300/600/900V AC. Current: 0.06/0.6/6/60/600mA/3A DC. 0.3/3/30/300mA/3A AC. Resistence: 25/500 ohms/0.5/5/50/500k ohms/5 Mohms. Decibels: −10 to +12dB. Size 167 x 98 x 63mm. Supplied complete with test leads, spare diode and instructions.

OUR PRICE £10.60 P/P & Ins 60p

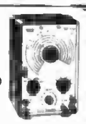
MODEL 500
30,000 opv with overload protection. Mirror scale. 0/0.5/2.5/10/25/100/250/500/1000V DC. 0/2.5/10/25/100/250/500/1000V AC. 0/50uA/5/50/500mA. 12A DC. 0/60k/6 meg/60 megohms.

OUR PRICE £15.05 P/P & Ins 60p

MODEL C7080EN
Giant 6" mirror scale. 20,000 opv. 0/0.25/1/2.5/10/50/250/1000/5000V DC. 0/2.5/10/50/250/1000/5000V AC. 0/50uA/1/10/100/500mA/10A DC. 0/2k/200k/20 Meg. −20 to +50dB.

OUR PRICE £21.50 P/P & Ins 60p

LB4 TRANSISTOR TESTER
Tests PNP or NPN transistors. Audio indication. Operates on two 1.5V batteries. Complete with instructions etc.

OUR PRICE £4.85 P/P & Ins 20p

TE-20D RF SIGNAL GENERATOR
Accurate wide range signal generator covering 120 kHz-500 MHz on 6 bands. Directly calibrated. Variable R.F. attenuator audio output, Xtal socket for calibration. 220/240V a.c. Brand new with instructions. Size 140mm x 215mm x 170mm.

OUR PRICE £24.30 P/P & Ins 60p

U91 Clamp VOLT AMMETER
For measuring AC voltage and current without breaking circuit. Ranges: 300/600V AC. Current: 10/25/100/250/500A. Accuracy 4%. Size 283 x 94 x 36mm. Complete with carrying case, leads and fuses.

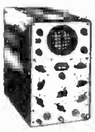
OUR PRICE £15.10 P/P & Ins 60p

U4317 MULTIMETER
High sensitivity instrument for field and laboratory work. Knife edge pointer, 86mm. mirror scale. Overload protection. Ranges: 100mV/0.5/2.5/10/25/50/100/250/500/1000 V DC. 0.5/2.5/10/25/50/100/250/500/1000V AC. Current: 50uA/0.5/1/5/10/50/250mA/1/5A DC. 0.25/0.5/1/5/10/50/250mA/1/5A AC. Resistance: 0.5/10/100/200 ohms/1/3/30/300k ohms. Decibels: −5 to +10dB Battery operated. Size: 210 x 115 x 90mm. Supplied in carrying case complete with leads.

OUR PRICE £18.35 P/P & Ins 60p

KAMODEN 72.200 Multitester
High sensitivity tester. 200,000 opv Overload protected. Mirror scale. Ranges:—0/.06/.3/3/30/120/600/1200V DC. 0/3/12/60/300/11200 V AC. 0/6uA/1.2mA/120mA/600mA/12A DC 0/12A AC. −20 to +63dB. 0/2k/200k/2 Meg/200 Megohms.

OUR PRICE £24.30 P/P & Ins 60p

C15 PULSE OSCILLOSCOPE
For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth: 10MHz. Sensitivity at 100kHz VRMS/mm: 0.1—25; HOR. AMP. Bandwidth: 500kHz. Sensitivity ay 100kHz VRMS/mm: 0.3—25 Preset triggered sweep 1—3000usec. Free running 20—200 kHz in nine ranges. Calibrator pips. 220 x 360 x 430mm. 115—230V AC.

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

SOUND-TO-LIGHT (P.E. Apr./Aug. 71)
The ever-popular AURORA—4 or 8 channels each responding to a different sound frequency and controlling its own light. Can be used with most audio systems and lamp intensities. A MUST for any Disco, and a fascinating visual display for the home.

4 channel component set (excl. thyristors)	£11·49
8 channel component set (excl. thyristors)	£20·32
Power supply component set	£4·78
PCB for 4 frequency channels.	£2·50
PCB for power supply and 8 lamp drivers	£1·25
1 Amp 400V thyristors (1 per chan. requ.) each	75p
Panel meter (1mA) (optional)	£3·50

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

Component set incl. PCB £2·95

TAPE-NOISE LIMITER
Very effective circuit for reducing the hiss found in most tape recordings.

Component set (incl. PCB)	£2·30
Regulated power supply (incl. PCB)	£3·71

P.E. SYNTHESISER

The well-acclaimed and highly versatile large-scale mains-operated Sound Synthesiser complete with keyboard circuits, and having a wider range of functions than the P.E. Minisonic, though the two may be used in conjunction with each other to great advantage. Published in P.E. Feb. 1973 to Feb. 1974.

Full details of component sets, printed circuit boards and discount facilities are in our list. Send S.A.E.

HI-FI TAPE-LINK (P.E. Mar./Apr. 73)
Designed for use with reasonable quality tape-decks, this high performance pre-amp includes record, playback and metering circuits.

Stereo component set (excl. panel meter)	£22·05
Mono component set (excl. panel meter)	£13·31
Power supply component set	£3·72
Stereo main PCB	£2·50
Stereo sub-assembly PCB	86p

P.E. GEMINI 30W STEREO AMPLIFIER
An exceptionally high quality Stereo Amplifier system. Details in our lists. While stocks last.

Main Amplifier:	
Set of resistors, capacitors and presets	£5·96
Stereo printed circuit board	£1·28
Pre-Amplifier	
Set of resistors, capacitors, potentiometers and switches—	
Standard tolerance set	£10·57
Superior tolerance set	£16·04
Stereo PCB (as published)	£2·20
Regulated Power Supply:	
Set of resistors, capacitors and preset	£4·58

GUITAR EFFECTS PEDAL (P.E. Jul. 75)

Component set	£6.16
Printed Circuit Board	£1.10

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

Component set	£3·41
Printed circuit board	£1·10

RHYTHM GENERATOR

Programmable for 64,000 rhythm patterns from 8 effects circuits (high and low bongos, bass and snare drums, long and short brushes, blocks and cymbal), and with variable time signatures. Really fascinating and useful! (Published in P.E. Mar./Apr. 1974).

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Full details of component sets, PCB s and discounts are in our list—send S.A.E

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

Component set for above functions (excl. sw s)	£5·86
Printed circuit board	£1·44

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

Component set (incl. PCB) £2·10

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

Component set (incl. PCB) £2·20

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

Component set (incl. PCB) £3·50

P.E. JOANNA

The new Electronic Piano published in P.E., series commencing May 1975. Send S.A.E for our details and discounts.

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

Component set incl. PCB £2·40

OTHER PCBs (all as published) While stocks last

Bench Power Supply (P E Sept. 74)	80p
Digital Power Supply (P.E. Aug 72)	50p
Electronic Piano:	
Pre-amp PCB (P.E. Oct. 72)	95p
Power Supply PCB (P.E. Oct 72)	65p
Power Slaves (P.E. Aug. 74)	
Power Supply PCB	55p
Rondo:	
CBS SQ Decoder PCB (P:E. Sept. 73)	60p
Pre-amp PCB (P E. Oct 73)	60p
Tone, Balance and Vol-control PCB (Oct. 73)	£1·50
Triffid I.C. Radio (P.E. Feb. 73)	60p

BIOLOGICAL AMPLIFIER (P.E. Jan./Feb. 73)
Multi-function circuits that, with the use of other external equipment, can serve as lie detector, alphaphone, cardiophone, etc.

Pre-Amplifier Module	
Component set and PCB	£3·48
Basic Output Circuits	
Combined component set with PCBs, for alphaphone, cardiophone, frequency meter and visual feed-back lamp driver circuits	£4·96
Audio Amplifier Module	
Type PC7	£5·50

PHOTOPRINT PROCESS CONTROL (P.E. Jan./Feb. 72)
For colour and B & W, an indispensable dark-room unit for finding exposure, controlling enlarger timing, and stabilising mains voltage.

Component set (excl. meter)	£8·85
Printed circuit board	£1·60
Panel meter (1mA)	£3·50

ENLARGER EXPOSURE METER AND THERMOMETER (P.E. Sept. 73)
Dual-purpose dark-room unit with good accuracy. While stocks last.

Component set with PCB but excl. meter	£4·00
Panel meter (100μA)	£3·50

P.E. MINISONIC

A portable, battery or mains operated, miniature sound synthesiser, with keyboard circuits. Although having slightly fewer facilities than the large P.E. Synthesiser, the functions offered by this design give it great scope and versatility.

Full details of component sets, printed circuit boards and discount facilities are in our list. Send S.A.E.

REVERBERATION UNIT (P.W. Nov./Dec. 72)
A high quality unit having microphone and line input pre-amps, and providing full control over reverberation level.

Component set (excl. spring unit)	£6·82
Printed circuit board	£1·40
9 inch spring unit	£4·95
Panel meter (50μA) (optional)	£3·50

ULTRASONIC TRANSMITTER-RECEIVER (P.E. May 1972)
A highly sensitive, tight-beam, long-range, invisible beam" detection circuit with numerous applications.

Component set with PCBs but excluding transducers £4·40

SEMICONDUCTOR TESTER (P.E. Oct. 73)
Essential test equipment for the enterprising home constructor

Set of resistors, capacitors, semiconductors, potentiometers, makaswitches and PCB	£6·56
Panel meter (500μA)	£3·50

SINE AND SQUARE WAVE GENERATOR (P.E. July 1975)

Component Set	£7.16
PCB for above components	£1.55
Power Supply Set	£6.32
PCB for Power Supply	72p

Semiconductors

		BFY50	22p	2N3703	12p
		BFY51	22p	2N3704	12p
		BFY52	24p	2N3819	35p
AC128	20p	BSY95A	22p	2N3823E	39p
AC176	20p	MJE2955	110p	2N4060	12p
BC107	13p	MJE3055	75p	2N4871	38p
BC108	13p	NKT0033	112p	2N5245	51p
BC109	13p	OC28	60p	2N5777	45p
BC147	12p	OC71	14p		
BC148	12p	OC72	14p		
BC149	12p	OC84	25p		
BC157	13p	ORP12	60p		
BC158	13p	ZTX107	12p		
BC159	13p	ZTX503	15p		
BC182L	12p	ZTX531	23p		
BC184	12p	2N706	13p		
BC204	14p	2N914	22p		
BC209C	14p	2N1304	22p		
BC212L	15p	2N2219	27p		
BC213	15p	2N2905	27p		
BC478	29p	2N2907	22p		
BCY71	22p	2N3054	66p		
BF178	40p	2N3702	12p		

Diodes

1N914	4p
1N4001	6p
1N4002	7p
1N4004	8p
1N4005	8p
1N4007	10p
OA91	7p
OA200	8p
OA202	8p
1GP7	12p
1SJ50	11p
ZIL (ZIJ)	75p

Integrated Circuits

709 8-pin DIL	40p
709 TO5	40p
723 TO5	95p
741 8-pin DIL	32p
747 14-pin DIL	115p
748 TO5	63p
748 8-pin DIL	63p
748 14-pin DIL	63p
μA7815 TO220	165p
CA3046	69p
MFC6040	83p
SG3402N	189p
AY-1-0212	550p

Zeners

3 3V 400mW	12P
3·9V 400mW	15P
4 7V 1W	25P
5 1 400mW	15P
5 6V 400mW	15P
5 6V 1 3W	20P

Electrolytic Capacitors (μF/V)

0 47 63V	8p	47 40	6p	470/25	16p
1 0/63V	8p	47 63	7p	470/40	20p
1 5/63V	8p	100/4	6p	680 6 3	10p
2 2/63V	6p	100/10	6p	680/25	20p
4 7/63	6p	100/25	6p	680/40	25p
6 8 40	6p	100 40	7p	1000/10	14p
10/25	6p	100/63	13p	1000/16	25p
10/63	6p	150/16	8p	1000/25	30p
15/40	8p	150/63	13p	1000/40	54p
22/10	6p	220/10	6p	2200/25	45p
22/25	6p	220/16	7p	2200/40	71p
33/6 3	6p	220/25	11p	2800/100	390p
33/16	6p	220/40	14p	3300/63	133p
33/40	8p	220/63	21p	3300/100	390p
33/50	6p	330/10	6p	4700/16	60p
47/10	6p	470/6 3	6p	4700 25	75p
47/25	8p	470 10	12p	4700/40	93p

Polyester (μF)

0 01	3p
0 015	3p
0 022	3p
0 033	3½p
0 047	3½p
0 068	3½p
0 1	4p
0 15	5p
0 22	5½p
0 33	7p
0 47	9p
0 68	11p
1 0	14p
2 2	24p

Tantalum (μF/V)

0 1 35	12p
0 22 35	12p
0 47 35	12p
1 0/35	12p
1 5/35	16p
2 2/35	12p
4 7 35	12p
10/16	14p
10/25	16p
15/6 3	16p
22 16	16p
47 6 3	16p
47 16V	25p
100/3	16p

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Optional: Fee for compensation against loss or damage in post (U.K., Eire & C.I. only): 35p.

Overseas—will be charged extra, minimum charge 70p. Details of kit weights, and postage rates will be sent with list.
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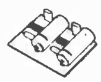
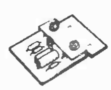
AUDIO MODULES — *today's most challenging values!*

POWER AMPS

SS103
Compact I.C. amp 3 watts R.M.S. Single channel (mono). On P.C.B. size 3¼in × 2in. Needs 10–20V supply. **£1·75**

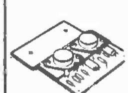


SS103-3
Stereo version of above (two I.C.s) **£3·25**



NEW! SS105 Mk. 2
A compact all-purpose power amp. Can be run from 12V car battery. Size 3¼in × 2in. Useful 5W output (mono) into 3Ω using 12V. Excellent value. **£2·25**

SS110 Mk. 2
Similar in size to SS105 but will give 10W output into 4Ω using 24V (mono). Two in stereo give first-class results, suitable for many domestic applications. **£2·75**



SS140
Beautifully designed. Will give up to 40W R.M.S. into 4Ω. Excellent S.N.R. and transient response. Fine for P.A., disco use, etc. Operates from 45V d.c. Two in bridge formation will give 80W R.M.S. into 8Ω. **£3·60***

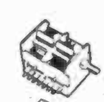
PRE-AMP/CONTROL MODULES

SS100
Active tone control unit to provide bass and treble facilities (stereo). **£1·60**

SS101
Pre-amp for stereo ceramic cartridges, radio and tape. **£1·60**

SS102
Pre-amp for low-output stereo magnetic cartridges, radio and tape. **£2·25**

BUILD A STEREO F.M. TUNER with these modules



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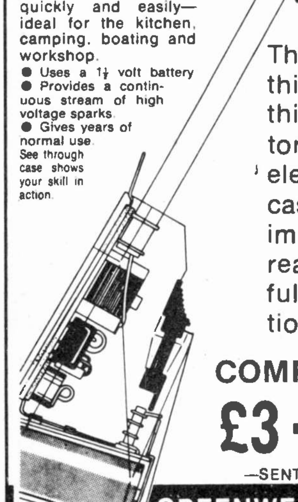

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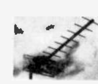

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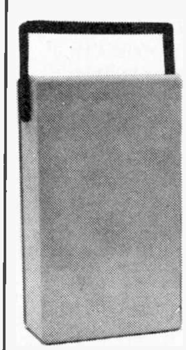

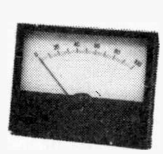

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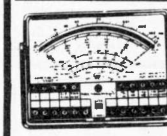

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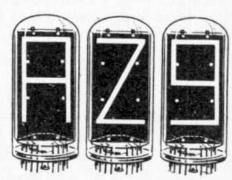

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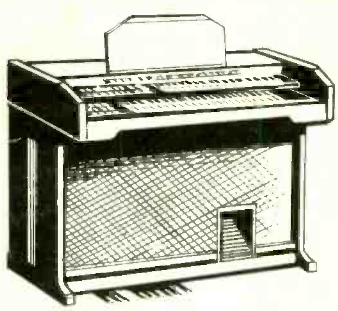

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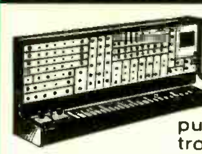

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