PRACTICAL

ELECTRONICS

SEPTEMBER 1972 20p

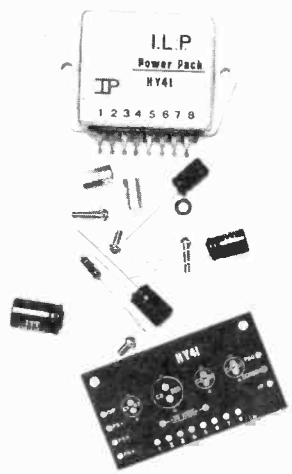
ELECTRONIC PIANO

Also in this issue

EXPERIMENTAL LOGIC UNIT • SQUARE WAVE GENERATOR

IP I.L.P. (Electronics) Ltd

THE HY41



The HY41 supersedes the popular HY40 introduced by ILP last year. This highly improved module achieves true High Fidelity with a dramatic reduction in distortion (typically 0.05% at 1KHz into 8 ohms!) and is electronically and mechanically compatible with the HY40.

With this important improvement the HY41 retains all of the quality characteristics found in the earlier version and P.C. board, Resistor, Capacitors, Hardware Mountings and comprehensive manual are included in the basic kit. No further components are required to construct a complete power amplifier of extremely high performance sufficiently versatile to provide power not merely for Hi-Fi but also for public address systems and industry.

The free manual gives a full circuit diagram of the HY41 and its various applications including a complete stereo amplifier.

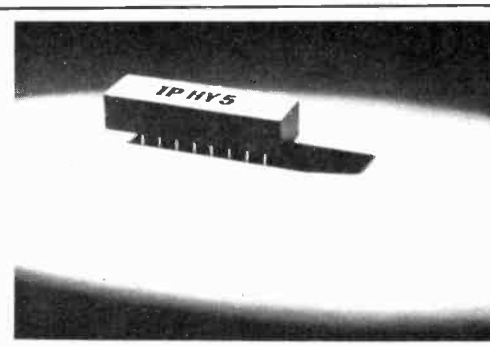
Like its predecessor the HY41 is based on conventional and proven circuit techniques developed over recent years.

OUTPUT POWER: British Rating 40 WATTS PEAK, 20 watts R.M.S. continuous.
LOAD IMPEDANCE: 4–16 ohms.
INPUT IMPEDANCE: 30K ohms at 1KHz.
VOLTAGE GAIN: 30db at 1KHz

TOTAL HARMONIC DISTORTION: less than 0.15% (typical 0.05%) at 1KHz.
FREQUENCY RESPONSE: 5Hz–50KHz ± 1db.
SUPPLY VOLTAGE: ± 22.5volts D.C.
SUPPLY CURRENT: 0.8 amps maximum.

PRICE: inc. comprehensive manual, P.C. board, five extra components and P. & P.:—
MONO: £4.90 **STEREO: £9.80**

UNIQUE HYBRID PRE-AMPLIFIER



The HY5 has rapidly established a position in the WORLD as the sole hybrid pre-amplifier to contain all feedback and equalization networks within an integrated pre-amplifier circuit.

Supplied with the HY5 are two stabilizing capacitors and by the addition of volume, treble and bass potentiometers it is ready for use.

Internally the HY5 provides equalization for almost every conceivable input, the desired function is achieved by use of a multi-way switch or by direct interconnection.

Two distinctive features of the HY5 are its inbuilt stabilization circuit, allowing it to be run off any unregulated power supply from 16–50 Volts and a balance circuit which, when linked by a balance control to a second HY5, forms a complete stereo pre-amplifier.

Specifically and critically designed to meet exacting Hi-Fi standards, the HY5 combines extremely low noise with a high overload capability. When used in conjunction with the HY41 and PSU45 forms a completely intergrated system.

INPUTS
Magnetic Pick-up (within ±1db RIAA curve) 2mV. 47K Ω
Tape Replay (external components to suit head). 4mV. 47KΩ
Microphone (flat) 10mV. 47K Ω
Ceramic Pick-up (equalized and compensatable) 20–2000mV. variable.
Tuner (flat) 250mV. 100K Ω
Auxiliary 1 250mV. 47K Ω
Auxiliary 2 2–20mV. 100K Ω

OUTPUTS
Main Pre-amp output 500mV.
Direct tape output 120mV.

ACTIVE TONE CONTROLS (Baxendall)
Treble ± 12db.
Bass ± 12db.

INTERNAL STABILIZATION
Enables the HY5 to share an unregulated supply with the Power Amplifier.

SUPPLY VOLTAGE
16–50 volts

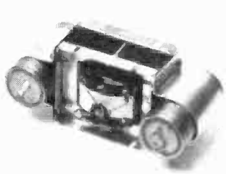
SUPPLY CURRENT
6mA approx.

OVERLOAD CAPABILITY
better than 26db on most sensitive input infinite on tuner and auxl.

OUTPUT NOISE VOLTAGE: 0.5mV.

PRICE: **MONO: £3.60** **STEREO: £7.20**

POWER SUPPLY PSU45



The versatile P.S.U.45 is designed to supply your HY41's +HY5's in stereo or mono format.

Specification

Input: 200–240 Volts.
Output: ± 22.5 Volts at 2 amps.
Overall Dimensions: L. 7"; D. 3.8"; H. 3.1"

PRICE: **£4.50 inc. P. & P.**

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ORGAN KITS

Build your own Electronic Organ, if you want the best value for your money. Yes you really save over 50% and get the best and up-to-date designs. There are four models to choose from.

★ Portable—4 octave keyboard with 10 voices, 3 pitches—vibrato, at **£103·00,** P/P £1·50.

★ Console—5 octave keyboard with 10 voices, 3 pitches . Keyboard can be split into solo and accompaniment. Vibrato built in amplifier and 50 watt 12" Goodmans speaker at **£167·00,** P/P £5·00.

★ Console—2 x 4 octave keyboards and 13 note pedal board, 29 voices, Vibrato, Delay Vibrato, Sustain Reverberation, Precussion, Wah Wah, etc. at **£406·00.** Carr. paid on complete kit U.K. only.

★ Console—2 x 5 octave keyboards and 32 note pedal boards, 32 voices. Vibrato, Delay Vibrato, Sustain Reverberation, Precussion, 3 Couplers, etc., at **£572·55** carr. paid on complete kit U.K. only.

We regret H.P. facilities are not available, but components can be bought separately. Trade and overseas enquiries welcomed. Send 25p for latest catalogue.

Please call in for demonstration. Business hours: 10 a.m. to 7 p.m. Monday to Saturday. Thursday closed.

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MULTI MINI VICE AND STAND

This unique all purpose vice is just like a 'third hand' countless uses for the electronics enthusiast —*assembly, soldering, gluing, wiring, drilling, etc.* Firm base, positive grip for all shapes of work, with independently adjustable twin jaws.

Truly a precision made bargain.

Also single jaw model £3·37 (22p P. & P.)

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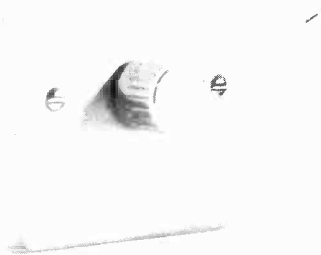
Vary the strength of your lighting with a

DIMMASWITCH



The DIMMASWITCH is an attractive and efficient dimmer unit which fits in place of the normal light switch and is connected up in exactly the same way. The white mounting plate of the DIMMASWITCH matches modern electric fittings. Two models are available, with the bright chrome knob controlling up to 300 w or 600 w of all lights except fluorescents at mains voltages from 200-250 v, 50Hz. The DIMMASWITCH has built-in radio interference suppression:

600 Watt—**£3·20.** Kit Form **£2·70**
300 Watt—**£2·70.** Kit Form **£2·20**

All plus 10p post and packing.
Please send C.W.O. to:—

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£2·50 per digit

4, 6, or 8 way PCB with Tube and Driver. BCD ip. ½" Calculator tubes or large GN4 type

PROFESSIONAL KEYBOARDS

Complete moulded reed, single switch assembly with fig. colour engraved in keytop. P.C. mounting, 0.1 pitch. PCB's available for most calculator designs.

52p per digit

12-hr. DIGITAL CLOCK

Complete kit Mains operated with case PCB only, £1·50 full inst.

£18·50

PCB8's and kits available for . . . Frequency Meter ★ Up/Down Counter ★ Digital Voltmeter ★ Calculator ★ I.C. Patchboard kit 10 ic. from £15.

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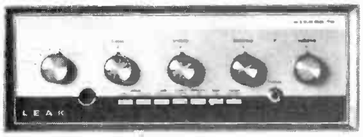
OLDHAM, LANCS.

LEAK AMPLIFIER BARGAINS



STEREO 70 Amp. (Cased). LIST PRICE £75·00 — **LASKY'S PRICE £55·00** each

STEREO 30 plus Amp. (Cased). LIST PRICE £62·50 — **LASKY'S PRICE £45·00** each C & P £1

LEAK TEAK CASES

Rosewood case for Stereo 30 or Stereo 70, please state which is required.

LIST PRICE £7·37 — **LASKY'S PRICE £2·75** C & P 25p

Teak case for Stereofetic tuner only.

LIST PRICE £7·37 — **LASKY'S PRICE £2·50** C & P 25p

Double case to hold Stereo 30 or Stereo 70 and Stereofetic tuner in Teak.

LIST PRICE £10·37 — **LASKY'S PRICE £4·95** C & P 35p

LEAK TRUSPEED

2-speed 45 and 33⅓ rpm belt drive turntable complete with plinth, cover and Shure cartridge.

LIST PRICE £69·50

LASKY'S PRICE £47·50 C & P £1·50

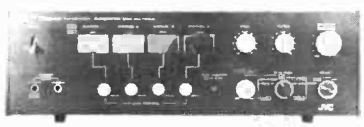
SINCLAIR PHASE LOCK LOOP STEREO FM TUNER

Incorporates varicap diodes, printed circuit, coils, squelch circuit I.C. Decoder, etc., supplied completely built and tested and ready to be mounted into any cabinet you choose. It may be used with any High Fidelity Amplifier. Power requirements 25/30V DC.

LIST PRICE £25·00 — **LASKY'S PRICE £16·95** C & P 25p

NIVICO MCA-V7E

4-CHANNEL AMPLIFIER

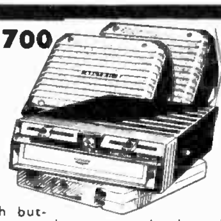


USE IT AS A 4-CHANNEL AMP
USE IT AS A STEREO AMP
USE IT WITH SYNTHESISED 4-CHANNEL SOUND FROM 2-CHANNEL SOURCE

The MCA-V7E can be used as a true 4-channel integrated amplifier from discreet 4-channel source using four speakers or have synthesised 4-channel sound using only two speakers. The MCA-V7E can also be used as a conventional stereo amplifier with two speakers only. Output 4 x 12·5W or 2 x 25W.

LIST PRICE £115·00 — **LASKY'S PRICE £78·00** C & P £1·00

BELTEK C5700 8 TRACK



Stereo car Player

Accepts all standard pre-recorded 8 track stereo cartridges. Features include automatic head cleaner, channel select and channel repeat push buttons, slider type volume and tone controls, channel balance. Output 5 watts per channel, frequency response 50Hz-10kHz. Output imp. 4 ohms, size 4¾(W) × 1⅞(H) × 6¼(D) in. Operates on 12V DC negative earth. Beautifully styled with black ivory and chrome trim.

BELTEK C5700 complete with mounting brackets and 8 track pre-recorded demonstration cartridge.

£19·75 C & P 30p

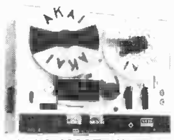
BELTEK R5310 FM TUNING ADAPTOR

Matches the C5700, the ideal car stereo system.

LASKY'S PRICE £18·95 C & P 25p

> Add **£3·75** to any BELTEK car player for pair of FANTAVOX KS701 car speakers.

AKAI TAPE RECORDER SCOOP!

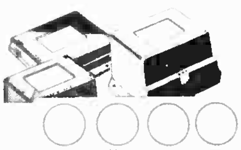


(C & P 75p on all Tape Decks.)

AKAI 4000D illustrated List Price £93·65	**Lasky's Price £61·50**
AKAI 1720L List Price £87·36	**Lasky's Price £58·95**
AKAI X1800SD List Price £162·79	**Lasky's Price £111·50**
AKAI X200D List Price £157·93	**Lasky's Price £106·50**
2 CSS-8 Speakers List Price £25·00	**Lasky's Price £15·95** C & P 50p

2 ADM 11/8 mics. Suitable for use on all Akai tape recorders. List Price £11·90. **Lasky's Price £7·50.** C & P 15p.

MULLARD UNILEX KITS



CONTROL

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

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

EP 9000 AMP. Output 4W per channel into 12 ohms. Output imp. 12-15 ohms or 8 ohms with series resistors. Freq. resp. 50Hz-16KHz. Size 3¾in x 4in x 1⅞in. **£2·25.**

EP 9002 POWER SUPPLY. Use with control, EP9001 and 2 x EP9000. For 220/250V mains. **£3·50.** C & P 15p each.

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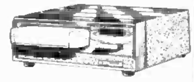
The clock measures 5¼" (W) x 2¾" (H) x 3" (D) (overall from front of drum to back of switch). SPEC.: 210/240V a.c. 50Hz operation; switch rating 250V, 3A. Complete with instructions. **NOW WITH ILLUMINATED DIAL COMPLETE WITH KNOBS FEATURES: ● MAINS OPERATION ● 12-HOUR ALARM ● AUTO "SLEEP" SWITCH ● HOURS, MINUTES AND SECONDS READ-OFF ● FORWARD AND BACKWARD TIME ADJUSTMENT ● SILENT OPERATION ● SHOCK AND VIBRATION PROOF ● BUILT IN ALARM BUZZER**

SPECIAL QUOTES FOR QUANTITIES — **LASKY'S PRICE £6·75** C & P 25p

BSR TD8S



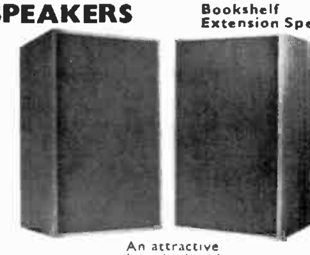
8 TRACK STEREO CARTRIDGE PLAYER

The TD8S is suitable for use with most modern stereo amplifiers and delivers a pre-amp output of 125mW. Power requirements: 210/250V AC, 50Hz. Frequency response: 50Hz-10KHz. 4 pole dynamically balanced synchronous motor. Black and woodgrain plastic cabinet. Size: 8½(W) × 3¾(H) × 10½ (D) in. C & P 35p

List Price £24·20 — **LASKY'S PRICE £17·95**

STEREOSOUND SPEAKERS

Bookshelf Extension Speakers



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

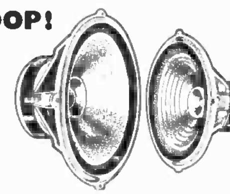
LASKY'S PRICE (PAIR) **£15·75** C & P 25p

LEAK SPEAKERS

150 Speakers (pair)	£38·95
250 ,, ,,	£48·95
600 ,, ,,	£68·75

C & P £2·50

FANTASTIC VALUE WHARFEDALE SCOOP!



BRONZE 8RS/DD 8in, 15 ohms

LIST PRICE £4·75 — **LASKY'S PRICE £2·95** C & P 20p

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SUPER 10RS/DD 10in, 15 ohms

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TWO FOR **£13·50**

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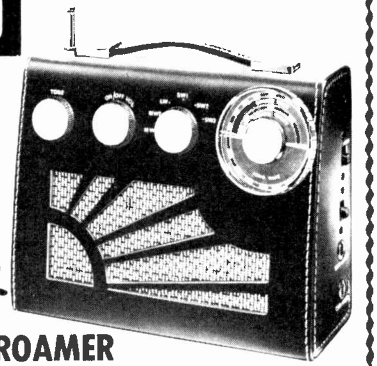
10 TRANSISTORS. 9 TUNABLE WAVEBANDS, MW1, MW2, LW, SW1, SW2, SW3, TRAWLER BAND, VHF AND LOCAL STATIONS AND AIRCRAFT BAND.

Built-in ferrite rod aerial for MW/LW. Retractable, chrome plated telescopic aerial, for peak short wave and VHF listening. Push-pull output using 600mW transistors. Car Aerial and tape record sockets. Switched earpiece socket complete with earpiece. 10 transistors plus 3 diodes. 8" × 2½" speaker. Air spaced ganged tuning condenser with VHF section. Volume/on/off, wave change and tone controls. Attractive case in black with silver blocking. Size 9in × 7in × 4in.

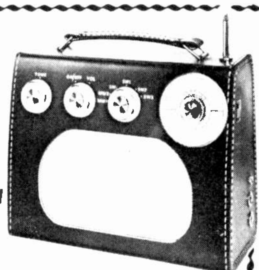
Easy to follow instructions and diagrams. Parts price list and easy build plans 30p (FREE with parts).

TOTAL BUILDING COSTS **£8·50**

P.P. & INS. 50p (OVERSEAS P. & P. £1)



ROAMER EIGHT Mk. I

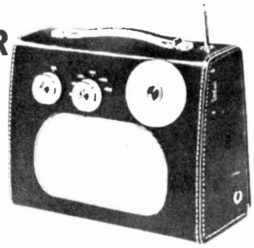


NOW WITH VARIABLE TONE CONTROL

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

TOTAL BUILDING COSTS **£6·98** P. P. & INS. 41p (OVERSEAS P. & P. £1)

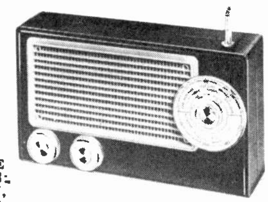
ROAMER SEVEN Mk. IV



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

TOTAL BUILDING COSTS **£5·98** P. P. & INS. 41p (OVERSEAS P. & P. £1)

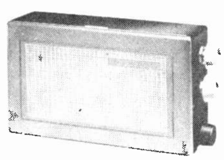
ROAMER SIX



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

TOTAL BUILDING COSTS **£3·98** P. P. & INS. 26p (OVERSEAS P. & P. £1)

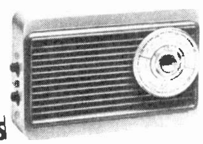
POCKET FIVE



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

TOTAL BUILDING COSTS **£2·29** P. P. & INS. 21p (OVERSEAS P. & P. 63p)

TRANSONA FIVE

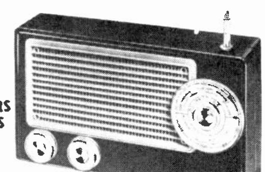


5 TRANSISTORS AND 2 DIODES

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

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

TRANS EIGHT



8 TRANSISTORS AND 3 DIODES

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

TOTAL BUILDING COSTS **£4·48** P. P. & INS. 31p (OVERSEAS P. & P. £1)

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BUILD RADIOS, AMPLIFIERS, ETC., FROM EASY STAGE DIAGRAMS. FIVE UNITS INCLUDING MASTER UNIT TO CONSTRUCT. Components include: Tuning Condenser: 2 Volume Controls: 2 Slider Switches: 3" Speaker: Terminal Strip: Ferrite Rod Aerial: 3 Plugs and Sockets: Battery Clips: 4 Tag Boards Balanced Armature Unit: 10 Transistors: 4 Diodes: Resistors: Capacitors: Three ¼in Knobs.

Units once constructed are detachable from Master Unit, enabling them to be stored for future use. Ideal for Schools, Educational Authorities and all those interested in radio construction.

ALL PARTS INCLUDING CASE AND PLANS **£5·50** P. P. & INS. 31p (OVERSEAS P. & P. £1)

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ROAMER EIGHT	☐	TRANS EIGHT	☐
TRANSONA FIVE	☐	ROAMER SIX	☐
POCKET FIVE	☐	EDU-KIT	☐

Parts price list and plans for ....

Name ....

Address ....

.... P.E. 4S

£25 *takes the wraps off* UNISOUND

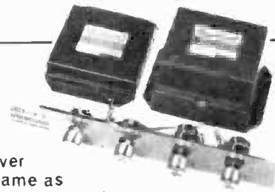
a new concept in stereo

The whole system is complete *including superb cabinets in simulated teak*—just simply screw together the components and you save pounds! Amplifier is based on the famous Mullard Unilex system. Garrard 2025TC turntable complete with stereo ceramic cartridge, teak simulated plinth and tinted acrylic cover. Plus the big 13" × 8" EMI twin cone speakers ready for mounting in their elegant cabinets which simply need screwing and gluing together. All glue and screws supplied.
Easy to follow step-by-step instructions guide you quickly and effortlessly to taking the wraps off truly realistic stereo sound.

£25 complete plus £2·80 P. & P.
Power output: 4 watts per channel into 8 ohms.
Inputs: 120 mV (for ceramic cartridges)
Diamond stylus **£1·25** extra
Stereo headphones with adaptor **£4**

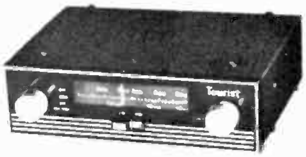
RTVC

See opposite page for addresses



If you prefer, you can buy the three modules—pre-amplifier power supply dual power amplifier, and control panel—by themselves for only **£6·95.** P. & P. 50p extra. No soldering, just simply screw together with screwdriver supplied. Their overall specification is the same as shown for the complete Unisound console using the high efficient I.C. monolithic power chips to ensure very low distortion at all power levels, correct operation in all ambient temperatures, full power over the audio spectrum.

TOURIST
MARK 3
CAR RADIO
ALL TRANSISTOR



Beautifully designed to blend with the interiors of all cars. Permeability tuning and long wave loading coils ensure excellent tracking, sensitivity and selectivity on both wave bands. R.F. sensitivity at 1MHz is better than 8 micro volts. Power output into 3 ohm speaker is 3 watts. Pre-aligned I.F. module and tuner together with comprehensive instructions guarantees success first time. 12 volts negative or positive earth. Size 7in 2in 4½in deep.

SET OF PARTS
£6·30 Plus P. & P. 50p
Speaker postage free when ordered with parts

Circuit diagram 13p, free with parts Speaker, baffle and fixing kit **£1·25** extra plus P. & P. 25p

DUETTO MK. II I.C.
STEREO AMPLIFIER

Sophisticated styling combined with up-to-date electronics means Hi-Fi. This is what the Duetto Mk. II offers at a realistic price. Mullard built stereo pre-amplifier tone control module and the highly efficient I.C. monolithic power chips ensure: reliability, very low distortion at all power levels, correct operation in all ambient temperatures, full power over the audio spectrum, etc.

Inputs: P.U. 150mV @ 2·2 Meg. (for cer. cartridge). Auxiliary 100mV @ 1 Meg. (for radio, tape, etc.).

Outputs: 5 watts rms per channel into 8–15Ω speakers. Switched stereo headphone socket with power correction.

Controls: Mono/stereo switch, selector switch, treble, bass, volume, balance and on/off switch. Neon indicator.

Tone Controls: Treble ± 14dB @ 15kHz. Bass ± 14dB @ 60 Hz.

Power Bandwidth: ± 2db 20Hz – 25kHz.

£11·50 plus P. & P. 60p

RELIANT MK. IV

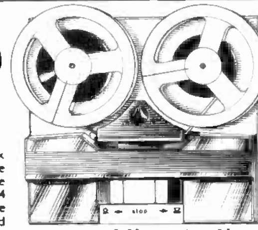
The Reliant Mk.IV provides a high standard of sound reproduction, with full mixing facilities. Its versatility makes it suitable for Discotheque, P.A., Home Entertainment Applications, etc.

- ★ Five Electronically Mixed Inputs
- ★ Three Individual Mixing Controls
- ★ Separate bass and treble controls common to all five inputs
- ★ Mixer employing F.E.T. (Field Effect Transistor)
- ★ Solid State Circuitry
- ★ Attractive Styling

1. Crystal Mic. or Guitar 9mV. 2. Moving coil Mic. or Guitar 8mV. Inputs 3, 4 and 5 are suitable for a wide range of medium output equipment (Gram, Tuner, Monitor, Organ, etc.). All 250mV sensitivity.
CONTROLS: 3 Volume controls. Bass control range ± 13dB @ 60 Hz. Treble control range ± 12dB @ 15KHz. Separate ON OFF Switch. Neon Indicator.
POWER OUTPUT: 12 Watts R.M.S. into 3 to 4 ohms speaker.
SIGNAL NOISE: Better than −60dB on inputs 3, 4 and 5 and −50dB on 1 and 2.
SUPPLY: 220 to 250V A.C. Mains.
SIZE: 12½in 6in 3½in.

PRICE
£10·50
Plus P. & P. 60p

CONTINENTAL 4-TRACK, 3-SPEED TAPE DECK
with high impedance heads



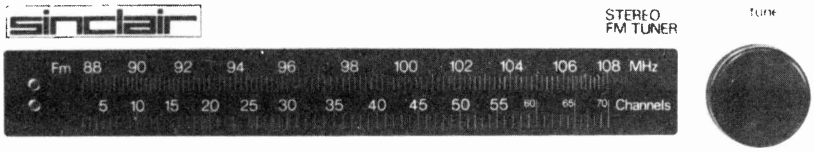
R.C. 74 tape deck. Three speeds—7½, 3¾ and 1⅞ i.p.s. 4-track record playback head. Plus 4-track erase head. Positive pressure pad system. Takes any tape spool up to and including 7in. The R.C. 74 is driven by a powerful 200/250V 50-cycle a.c. motor. A heavy, accurately balanced flywheel brings wow and flutter levels down to approx. 0.3% total at 3¾ and 7½ i.p.s. Fast rewind in both directions.
Controls couldn't be simpler! Just five push buttons that interlock to cut out accidental tape damage. Efficient servo-action type braking. Easy drop-in tape loading.
The R.C. 74 comes with an attractive moulded deck cover, which has positions for tone and volume controls. The unit is built into a rigid die-cast frame, and overall size of the whole unit is 12¾ × 11¾ × 6in. Every single deck fully tested before dispatch. Spools not supplied. £15. Plus 75p P. & P.

RTVC

See opposite page for addresses

Sinclair Project 60

Project 60 Stereo FM Tuner



Built and tested.
Post free.
£25

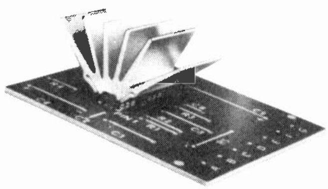
with phase lock-loop principle

Amongst the many advanced electronic features to be found in this remarkable stereo tuner, use of the phase lock loop principle ensures standards of audio quality better than from any other method of detection yet used. Varicap diode tuning, accurately formed printed circuit coils, an I.C. in the special stereo decoder section and switchable squelch circuit for silent tuning between stations contribute to the unsurpassed performance of this tuner, irrespective of price consideration. But the Project 60 FM Stereo Tuner is far from expensive – indeed, it offers fantastic value for money and will bring the thrill of stereo radio to many who previously may not have been able to afford it. The tuner may be used with any good system as well as Project 60, but if you use it with other Project 60 modules, you will find the matching front panels particularly impressive in appearance as well as function.

SPECIFICIATIONS

Number of transistors: 16 plus 20 in I.C
Tuning range: 87·5 to 108MHz.
Sensitivity: 7µV for lock-in over full deviation
Squelch level: typically 20µV.
Signal to noise ratio: ±65dB
Audio frequency response: 10Hz–15Khz (±1dB).
Total harmonic distortion: 0·15% for 30% modulation
Stereo decoder operating level: 2µV.
Cross talk: 40dB.
Output voltage: 2 × 150mV R.M.S. max. (typically 2 × 50mV. stereo)
Operating voltage: 25–30V DC at 100mA.
Indicators: Stereo on · tuning.
Size: 93 × 40 × 207mm.

Super IC.12 Integrated circuit high fidelity amplifier



Having introduced Integrated Circuits to hi-fi constructors with the IC.10, the first time an IC had ever been made available for such purposes, we have followed it with an even more efficient version, the Super IC.12, a most exciting advance over our original unit. This needs very few external resistors and capacitors to make an astonishingly good high fidelity amplifier for use with pick-up, F.M. radio or small P.A. set up, etc. The free 40 page manual supplied, details many other applications which this remarkable IC. make possible. It is the equivalent of a 22 transistor circuit contained within a 16 lead DIL package, and the finned heat sink is sufficient for all requirements. The Super IC.12 is compatible with Project 60 modules which would be used with the Z.50 and Z.30 amplifiers. Complete with free manual and printed circuit board.

SPECIFICATIONS

Output power: 6 watts RMS continuous (12 watts peak). 6–8Ω. **Frequency Response:** 5Hz to 100KHz ± 1dB. **Total Harmonic Distortion:** Less than 1%. (Typical 0·1%) at all output powers and frequencies in the audio band (28V). **Load Impedance:** 3 to 15 ohms. **Input Impedance:** 250 Kohms nominal. **Power Gain:** 90dB (1,000,000,000 times) after feedback. **Supply Voltage:** 6 to 28V. **Quiescent current:** 8mA at 28V. **Size:** 22 × 45 × 28mm including pins and heat sink.

Manual available separately 15p post free.

With FREE printed circuit board and 40 page manual.
£2.98 Post free

Project 605

The easy way to buy and build Project 60

Project 605 is one pack containing: one PZ5, two Z30's, one Stereo 60 and one Masterlink. This new module contains all the input sockets and output components needed together with all necessary leads cut to length and fitted with neat little clips to plug straight on to the modules. Thus all soldering and hunting for the odd part is eliminated. You will be able to add further Project 60 modules as they become available adapted to the Project 605 method of connecting.

Complete Project 605 pack with comprehensive manual, post free **£29.95**

Everything you need to assemble a superb 30 watt high fidelity stereo amplifier without having to solder.

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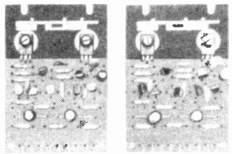
Sinclair Radionics Ltd, London Road, St. Ives, Huntingdonshire PE17 4HJ. Tel: St. Ives 64311

the world's most advanced high fidelity modules

Z.30 & Z.50 power amplifiers

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

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

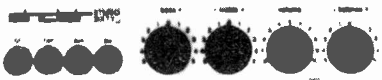


SPECIFICATIONS ***(Z.50 units are interchangeable with Z.30s in all applications).*** **— Power Outputs:**
Z.30 15 watts R.M.S. into 8 ohms using 35 volts: 20 watts R.M.S. into 3 ohms using 30 volts.
Z.50 40 watts R.M.S. into 3 ohms using 40 volts 30 watts R.M.S into 8 ohms using 50 volts.
Frequency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

Stereo 60 Pre-amp/control unit

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

Designed specifically for use on Project 60 systems, the Stereo 60 is equally suitable for use with any high quality power amplifier. Since silicon epitaxial planar transistors are used throughout, a really high signal-to-noise ratio and excellent tracking between channels is achieved. Input selection is by means of press buttons, with accurate equalisation on all input channels. The Stereo 60 is particularly easy to mount.

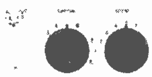


SPECIFICATIONS—Input sensitivities: Radio – up to 3mV. Mag. p.u. 3mV correct to R.I.A.A. curve ±1dB 20 to 25,000 Hz. Ceramic p.u. – up to 3mV Aux – up to 3mV. **Output:** 250mV **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE +12 to —12dB at 10KHz: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

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

Built, tested and guaranteed. **£5.98**

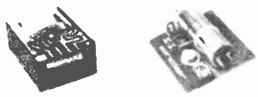
For use between Stereo 60 unit and two Z.30s or Z.50s. The unit is very easily mounted and is unique in that the cut-off frequencies are continuously variable. As attenuation in the rejected band is rapid (12dB/octave), there is less loss of the wanted signal than has previously been possible. Amplitude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



Power Supply Units

Designed specifically for use with the Project 60 system of your choice. Use PZ.5 for normal Z.30 assemblies and PZ.6 or PZ.8 where a stabilised supply is essential.

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



Typical Project 60 applications

System	The Units to use	together with	Units cost
Simple battery record player	**Z.30**	Crystal P.U., 12V battery volume control, etc	**£4.48**
Mains powered record player	**Z.30, PZ.5**	Crystal or ceramic P.U volume control, etc	**£9.45**
12W. RMS continuous sine wave stereo amp. for average needs	**2 x Z.30s, Stereo 60; PZ.5**	Crystal, ceramic or mag P.U., F.M. Tuner, etc.	**£23.90**
25W. RMS continuous sine wave stereo amp. using low efficiency (high performance) speakers	**2 x Z.30s, Stereo 60; PZ.6**	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	**£26.90**
80W. (3 ohms) RMS continuous sine wave de luxe stereo amplifier. (60W. RMS into 8 ohms)	**2 x Z.50s, Stereo 60; PZ.8, mains transformer**	As above	**£34.88**
Indoor P.A.	**Z.50, PZ.8, mains transformer**	Mic., guitar, speakers, etc., controls	**£19.43**

F.M. Stereo Tuner **(£25)** & A.F.U. **(£5.98)** may be added as required.

Guarantee

If, within 3 months of purchasing any product direct from Sinclair Radionics Ltd., you are dissatisfied with it, your money will be refunded at once. Many Sinclair appointed Stockists also offer this same guarantee in co-operation with Sinclair Radionics Ltd.

Each Project 60 module is tested before leaving our factory and is guaranteed to work perfectly. Should any defect arise in normal use, we will service it at once and without any charge to you, if it is returned within two years from the date of purchase. Outside this period of guarantee a small charge (typically £1.00) will be made. No charge is made for postage by surface mail. Air Mail is charged at cost.

sinclair

SINCLAIR RADIONICS, ST IVES, HUNTINGDONSHIRE PE17 4HJ

Please send ____________________
I enclose cash/cheque/money order.

Name ____________________

Address ____________________ PE972

FOR RAPID SERVICE

GARLAND BROS. LTD.

DEPTFORD BROADWAY, LONDON, SE8 4QN

TRANSFORMERS

all with 0-250 Volt primaries

Miniature
MM6 6V, 500mA + 6V, 500mA
MM12 12V, 250mA + 12V, 250mA
MM20 20V, 150mA + 20V, 150mA
£1·29 plus 13p p. & p.

L.T.
LT1 6·3V, 1·5A—**75p** plus 18p p. & p.
LT2 6·3V, 3A—**80p** plus 26p p. & p.
LT3 12V, 1·5A—**80p** plus 26p p. & p.
LT4 12V, 3A—**£1·32** plus 30p p. & p.
LT5 9-0-9V, 0·5A—**75p** plus 21p p. & p.
LT6 12-0-12V, 1A—**95p** plus 26p p. & p.
LT7 30-0-30V, 1A—**£1·87** plus 30p p. & p.

Multi-tapped
MT30/2 0-12-15-20-24-30V, 2A—**£1·95** plus 30p p. & p.
MT60/1 0-5-20-30-40-60V, 1A—**£1·97** plus 30p p. & p.
MT60/2 0-5-20-30-40-60V, 2A—**£2·90** plus 34p p. & p.

Charger
CT/01 1A—**£1** plus 26p p. & p.
CT/02 2A—**£1·25** plus 30p p. & p.
CT/03 4A—**£1·50** plus 30p p. & p.
Secondaries—0-5-11-17V.

Auto-transformers
AT30 30W—**£1·18** plus 30p p. & p.
AT75 75W—**£1·85** plus 30p p. & p.
AT150 150W—**£2·55** plus 34p p. & p.
AT300 300W—**£4·75** plus 42p p. & p.
AT1000 1000W—**£8·90** plus 62p p. & p.
All shrouded with terminal blocks. AT30 0-110-240V. All others 0-110-200-220-240V.

Speaker isolating transformer
1 : 1 ratio for 3-15Ω, 2W—**86p** plus 13p p. & p.

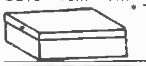
Speaker matching transformer
Tapped 3, 8, 16Ω. Will match almost any speakers to any amplifier. 15W max.—**90p** plus 20p p. & p.

ALUMINIUM BOXES

with lids and screws

Type	L.	W.	D.	Price	p. & p.
GB7 *	5¼in	2¼in	1½in	38p	15p
GB8 *	4in	4in	1½in	38p	15p
GB9 *	4in	2¼in	1½in	38p	13p
GB10*	5¼in	4in	1½in	44p	18p
GB11	4in	2½in	2in	38p	13p
GB12	3in	2in	1in	33p	13p
GB13	6in	4in	2in	52p	18p
GB14	7in	5in	2½in	63p	19p
GB15	8in	6in	3in	81p	26p
GB16	10in	7in	3in	92p	26p

* These sizes fit standard veroboards



EQUIPMENT CASES

with sloping front panel

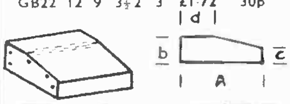
Type	H.	W.	D.	Price	p. & p.
SF1	2in	5¼in	2½in	45p	12p
SF2	2in	7¼in	3½in	60p	16p
SF3	2in	9¼in	4½in	75p	19p

Plain aluminium. Stove-enamelled silver-grey hammer finished, **20p** extra.

CONSOLE CASES

in plain aluminium, ideal for mixers, instruments, etc.

Type	W. in	A in	B in	C in	D in	Price	p. & p.
GB20	8	9	3½	2	3	£1·42	30p
GB21	10	9	3½	2	3	£1·58	30p
GB22	12	9	3½	2	3	£1·72	30p



VEROBOARD

Size	0·1 matrix	0·15 matrix
2½in × 3¾in	22p	16p
2½in × 5in	24p	25p
3¾in × 3¾in	24p	25p
3¾in × 5in	27p	29p
17in × 2½in	75p	57p
17in × 3¾in	£1	75p

Pins—either size; packet of 36, **18p**

ELECTROLYTICS

1µF	450V	19p	1,000µF	25V	27p
2µF	500V	20p	1,000µF	50V	39p
4µF	350V	14p	2,000µF	25V	36p
8µF	450V	16p	2,000µF	50V	53p
16µF	450V	17p	2,500µF	25V	45p
25µF	25V	7p	2,500µF	50V	60p
25µF	50V	8p	3,000µF	25V	48p
32µF	450V	24p	5,000µF	25V	55p
50µF	50V	10p	5,000µF	50V	98p
100µF	25V	10p	8–8µF	450V	18p
100µF	50V	10p	8–16µF	450V	20p
250µF	25V	12p	16–16µF	450V	27p
250µF	50V	17p	16–32µF	450V	63p
500µF	25V	18p	32–32µF	450V	49p
500µF	50V	25p	50–50µF	350V	38p

MINIATURE ELECTROLYTICS

1µF	63V	6p	10µF	64V	7p
2·2µF	63V	6p	16µF	40V	7p
4µF	40V	7p	30µF	15V	7p
4·7µF	63V	6p	47µF	16V	7p
8µF	15V	7p	47µF	25V	6p
8µF	40V	7p	68µF	16V	6p
10µF	25V	6p	100µF	10V	6p

ENTIRE MULLARD 015/016/017 RANGE ALSO STOCKED

CASSETTE OWNERS!

For Philips and similar cassette recorders.
PU12 Power unit for connection to 12V + or − E car electrical systems, giving 7½V, stabilised output. **£3·25**
PU14 As above but switched for 6V, 7½V or 9V output. **£5·10**
PP75 Mains power supply, output 7½V d.c. **£1·95**
All units are complete with cable and plug.

VARIABLE POWER SUPPLY

Input: 240V, a.c.
Output: Switched 3, 4·5, 6, 7·5, 9, 12 volts d.c. at 500mA **£4·20**

BATTERY ELIMINATORS

suitable for transistor radios and similar light current equipment
PP6 Input 240V a.c. Output 6V d.c.
PP9 Input 240V a.c. Output 9V d.c.
Price **£1·50** plus 12p p. & p.

NEW NEW
ILLUSTRATED 1972-73 CATALOGUE
Post Free 15p

CONTROLS, Log. or Lin.

Single, less switch, **15p**
Single, D.P. switch, **24p**
Tandem, less switch, **40p**
5kΩ, 10kΩ, 25kΩ, 50kΩ, 100kΩ, 250kΩ, 500kΩ, 1MΩ, 2MΩ

SLIDER CONTROLS, 87mm.

complete with knobs.
Single, **44p**; Tandem, **55p**. 10kΩ, 25kΩ, 50kΩ, 100kΩ, log. or lin

RESISTORS

Carbon
All 5%, high-stability, E12 values. ¼W, **1p**; ½W, **1½p**; 1W, **4p**; 2W, **6p**
Wire-wound
5W, **10p**; 10W, **12p**

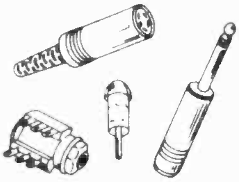
LOUDSPEAKERS

7in × 4in, 3Ω—**£1·12**, 8Ω—**£1·12**, 15Ω—**£1·40**.
8in × 5in, 3Ω—**£1·85**, 8Ω—**£1·77**, 15Ω—**£1·70**.
10in × 6in, 3Ω—**£2·32**, 8Ω—**£2·32**, 15Ω—**£2·32**.
8in round, 3Ω—**£2·10**, 8Ω—**£2·50**, 15Ω—**£2·10**.
Adastra "Hi-Ten", 10in, 10W, 8 or 15Ω—**£3·40**.
Please add 20p p. & p. to all speakers.

BONDED ACRYLIC FIBRE

B.A.F. wadding, 18in wide, 1in thick. The ideal lining for speaker enclosures. **25p** per yard.

PLUGS



Car aerial	14p
Co-axial	9p
D.I.N. 2 pin (speaker)	10p
D.I.N. 3 pin	13p
D.I.N. 4 pin	14p
D.I.N. 5 pin, 180	13p
D.I.N. 5 pin, 240	15p
D.I.N. 6 pin	15p
Jack, 2½mm unscreened	9p
Jack, 2½mm screened	10p
Jack, 3½mm unscreened	8p
Jack, 3½mm screened	12p
Jack, ¼in unscreened	12p
Jack, ¼in screened	20p
Jack, stereo, unscreened	20p
Jack, stereo, screened	35p
Phono, plastic top	5p
Phono, plated metal	12p
Phono, fitted 4 ft lead	8p
Wander, red or black	3p
Banana 4mm, red or black	6p

LINE SOCKETS

Car aerial	14p
Co-axial	17p
D.I.N. 2 pin (speaker)	15p
D.I.N. 3 pin	16p
D.I.N. 5 pin, 180	16p
D.I.N. 5 pin, 240	16p
Jack, 3½mm	15p
Jack, ¼in screened	49p
Jack, stereo, screened	30p
Phono, plated metal	14p

SOCKETS

Car aerial	8p
Co-axial, surface	8p
Co-axial, flush	9p
D.I.N. 2 pin (speaker)	10p
D.I.N. 3 pin	9p
D.I.N. 5 pin, 180	9p
D.I.N. 5 pin, 240	9p
Jack, 2½mm	10p
Jack, 3½mm	10p
Jack, ¼in unswitched	15p
Jack, ¼in switched	17p
Jack, stereo, switched	24p
Phono, single	5p
Phono, 2 on a strip	7p
Phono, 3 on a strip	9p
Phono, 4 on a strip	10p
Wander, single, red or black	5p
Wander, twin strip	7p
Banana 4mm red, or black	6p

CAPACITORS

2·2pF	500V	S/M	7½p
3·3pF	500V	S/M	7½p
5pF	500V	S/M	7½p
10pF	125V	P.S.	5p
10pF	500V	S/M	7½p
15pF	125V	P.S.	5p
15pF	500V	Cer.	4p
18pF	500V	S/M	7½p
22pF	125V	P.S.	5p
22pF	500V	S/M	7½p
25pF	500V	S/M	7½p
27pF	500V	Cer.	4p
33pF	125V	P.S.	5p
33pF	500V	S/M	7½p
39pF	500V	S/M	7½p
47pF	125V	P.S.	5p
47pF	500V	Cer.	4p
50pF	500V	S/M	7½p
56pF	500V	S/M	7½p
68pF	125V	P.S.	5p
68pF	500V	S/M	7½p
75pF	500V	S/M	7½p
82pF	500V	S/M	7½p
100pF	125V	P.S.	5p
100pF	500V	S/M	7½p
100pF	500V	Cer.	5p
120pF	500V	S/M	7½p
150pF	125V	P.S.	5p
150pF	500V	S/M	7½p
150pF	500V	Cer.	5p
180pF	500V	S/M	7½p
200pF	500V	S/M	7½p
220pF	125V	P.S.	5p
220pF	500V	Cer.	5p
250pF	500V	S/M	8p
270pF	500V	Cer.	5p
300pF	500V	S/M	8p
330pF	125V	P.S.	5p
330pF	500V	S/M	8p
390pF	500V	S/M	8p
470pF	125V	P.S.	5p
470pF	750V	Disc	5p
500pF	500V	S/M	8p
560pF	500V	S/M	8p
680pF	125V	P.S.	6p
680pF	500V	S/M	8p
820pF	500V	S/M	8p
0·001µF	100V	Mylar	3p
0·001µF	125V	P.S.	6p
0·001µF	400V	Poly.	3p
0·001µF	500V	S/M	10p
0·001µF	500V	Cer.	5p
0·001µF	1,000V	MDC	6p
0·0015µF	400V	Poly.	3p
0·0015µF	500V	S/M	10p
0·0015µF	500V	Cer.	5p
0·0018µF	500V	S/M	10p
0·002µF	100V	Mylar	3p
0·002µF	500V	Cer.	5p
0·0022µF	125V	P.S.	6p
0·0022µF	500V	S/M	10p
0·0022µF	1,000V	MDC	6p
0·0027µF	500V	S/M	15p
0·003µF	500V	Cer.	5p
0·0033µF	125V	P.S.	6p
0·0033µF	500V	Poly.	6p
0·0033µF	1,000V	MDC	6p
0·0036µF	500V	S/M	15p
0·0047µF	125V	P.S.	9p
0·0047µF	500V	Poly.	6p
0·0047µF	500V	S/M	20p
0·0047µF	1,000V	MDC	6p
0·005µF	100V	Mylar	3p
0·005µF	500V	Cer.	5p
0·0068µF	125V	P.S.	10½p
0·0068µF	500V	S/M	30p
0·0068µF	500V	Poly.	6p
0·0082µF	125V	P.S.	10½p
0·0082µF	500V	S/M	30p
0·01µF	18V	Disc	4p
0·01µF	125V	P.S.	10½p
0·01µF	160V	Poly.	4p
0·01µF	250V	M.F.	3p
0·01µF	400V	Poly.	3p
0·01µF	500V	Cer.	5p
0·01µF	500V	S/M	30p
0·01µF	600V	MDC	7p
0·01µF	1,000V	MDC	9p
0·015µF	160V	Poly.	3p
0·015µF	400V	Poly.	3p
0·02µF	100V	Mylar	3p
0·022µF	18V	Disc	5p
0·022µF	250V	M.F.	3p
0·022µF	400V	Poly.	3p
0·022µF	600V	MDC	7½p
0·022µF	1,000V	MDC	9p
0·033µF	250V	M.F.	4p
0·033µF	400V	Poly.	4p
0·047µF	12V	Disc	6p
0·047µF	160V	Poly.	3p
0·047µF	250V	M.F.	3p
0·047µF	400V	Poly.	4p
0·047µF	600V	MDC	8p
0·047µF	1,000V	MDC	10p
0·1µF	30V	Disc	6p
0·1µF	250V	M.F.	4p
0·1µF	400V	Poly.	5p
0·1µF	600V	MDC	10p
0·1µF	1,000V	MDC	13p
0·15µF	250V	M.F.	5p
0·22µF	160V	Poly.	6p
0·22µF	250V	M.F.	5p
0·22µF	400V	Foil	10p
0·22µF	1,000V	MDC	15p
0·33µF	250V	M.F.	8p
0·47µF	250V	Foil	8p
0·47µF	400V	Foil	15p
0·47µF	1,000V	MDC	20p
1·0µF	250V	M.F.	15p

Note:
S/M = silver mica 1% tol.
P.S. = polystyrene 2½% tol.
MDC—a.c. rating = 300V.
M.F. = Mullard min. foil.
Cer. = ceramic.

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Semicomps Northern, Kelso.
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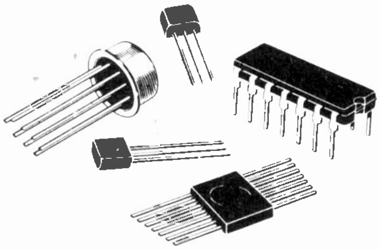

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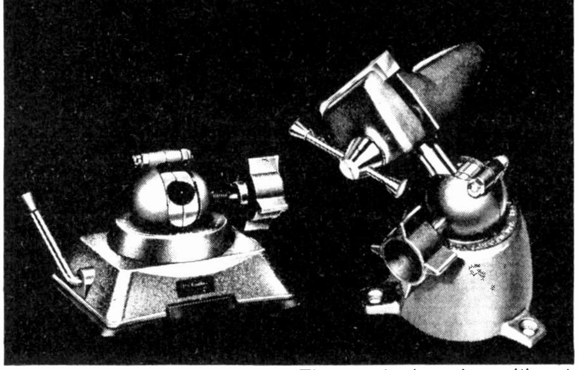
COLBERT
WORK POSITIONERS-300 SERIES



Colbert Pana-Vise WORK POSITIONERS are specially designed to quickly and easily achieve the most CONVENIENT, COMFORTABLE and TIME-SAVING work position.

Available with vacuum clamp or screw-on base. They can be ROTATED, TIPPED, TILTED, ANGLED, ELEVATED, LOWERED.

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8 WAVE BANDS
+ WORLD MAP & TIME ZONE DIAL

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	£p	£p	£p	£p	£p	£p
50	0·23	0·25	0·47	0·50	0·53	1·15
100	0·25	0·33	0·53	0·58	0·63	1·40
200	0·35	0·37	0·57	0·61	0·75	1·60
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600	0·53	0·57	0·77	0·97	1·25	
800	0·63	0·70	0·90	1·20	1·50	4·00

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

TRIACS

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

DIACS

FOR USE WITH TRIACS
BR100 D32 .. 37p each

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UT46. Eqvt. 2N2646, Eqvt. T1843. BEN3000 **27p** each, 25–99 **25p** 100 UP **20p**.

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

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

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

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

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20	For	0·50
50	For	1·00
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500	For	7·50
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OCP71 Type. **43p**

SIL. G.P. DIODES £p

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

Ideal for Organ Builders.

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

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

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MIXED ELECTRONIC COMPONENTS Exceptionally good value

Resistors, capacitors, pots, electrolytics and coils plus many other useful items. Approximately 3lbs in weight. Price incl. P. & P.
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Plus your satisfaction or money back guarantee.

BRAND NEW TEXAS GERM. TRANSISTORS
Coded and Guaranteed

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

All 50p each pak

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

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

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

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Size 15mm × 6mm

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Satisfaction GUARANTEED in Every Pak, or money back.

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U2	60 Mixed germanium transistors AF/RF	0·50
U3	75 Germanium gold bonded diodes sim. OA5, OA47	0·50
U4	40 Germanium transistors like OC81, AC128	0·50
U5	60 200mA sub-min. Sil. diodes	0·50
U6	30 Silicon planar transistors NPN sim. BSY95A, 2N706	0·50
U7	16 Silicon rectifiers Top-Hat 750mA up to 1,000V	0·50
U8	50 Sil. planar diodes 250mA, OA/200/202	0·50
U9	20 Mixed volts 1 watt Zener diodes	0·50
U11	25 PNP silicon planar transistors TO-5 sim. 2N1132	0·50
U13	30 PNP-NPN sil. transistors OC200 & 2S104	0·50
U14	150 Mixed silicon and germanium diodes	0·50
U15	25 NPN Silicon planar transistors TO-5 sim. 2N697	0·50
U16	10 3-Amp silicon rectifiers stud type up to 1000 PIV	0·50
U17	30 Germanium PNP AF transistors TO-5 like ACY 17-22	0·50
U18	8 6-Amp silicon rectifiers BYZ13 type up to 600 PIV	0·50
U19	25 Silicon NPN transistors like BC108	0·50
U20	12 1·5-Amp silicon rectifiers Top-Hat up to 1,000 PIV	0·50
U21	30 A.F. germanium alloy transistors 2G300 series & OC71	0·50
U23	30 Madt's like MAT series PNP transistors	0·50
U24	20 Germanium 1-Amp rectifiers GJM up to 300 PIV	0·50
U25	25 300Mc/s NPN silicon transistors 2N708, BSY27	0·50
U26	30 Fast switching silicon diodes like 1N914 micro-min	0·50
U29	10 1-Amp SCR's TO-5 can up to 600 PIV CRS1/25-600	1·00
U31	20 Sil. Planar NPN trans. low noise amp 2N3707	0·50
U32	25 Zener diodes 400mW D07 case mixed volts, 3–18	0·50
U33	15 Plastic case 1 amp silicon rectifiers 1N4000 series	0·50
U34	30 Sil. PNP alloy trans. TO-5 BCY26, 2S302/4	0·50
U35	25 Sil. planar trans. PNP TO-18 2N2906	0·50
U36	25 Sil. planar NPN trans. TO-5 BFY50/51/52	0·50
U37	30 Sil. alloy trans. SO-2 PNP, OC200 2S322	0·50
U38	20 Fast switching sil. trans. NPN, 400Mc/s 2N3011	0·50
U39	30 RF germ. PNP trans. 2N1303/5 TO-5	0·50
U40	10 Dual trans. 6 lead TO-5 2N2060	0·50
U41	25 RF germ. trans. TO-1 OC45 NKT72	0·50
U42	10 VHF germ. PNP trans. TO-1 NKT667 AF117	0·50
U43	25 Sil. trans. plastic TO-18 A.F. BC113/114	0·50
U44	20 Sil. trans. plastic TO-5 BC115/116	0·50
U45	7 3A SCR's TO-66 up to 600 Piv	1·00

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

POWER TRANSISTOR BONANZA!

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

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

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

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

1–24	25–99	100 up
50p	45p	40p

2N3055
115 WATT SIL POWER NPN
50p EACH

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

1–24 prs.	25–99 prs.	100 prs.
60p	55p	50p

EX-STOCK TYPE EACH AS PRICED

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

RTL MICROLOGIC CIRCUITS

Epoxy TO-5 case	1–24	25–99	100 up
	Price each		
uL900 Buffer	35p	33p	27p
uL914 Dual 2i/p gate	35p	33p	27p
uL923 J-K flip-flop	50p	47p	45p

Data and Circuits Booklet for I.C's Price 7p.

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14 and 16 Lead Sockets for use with DUAL-IN-LINE I.C's.
TWO Ranges PROFESSIONAL and NEW LOW COST.

Prof. type No.	1–24	25–99	100 up
TSO14 pin type	30p	27p	25p
TSO16 ,, ,,	35p	32p	30p
Low Cost No.			
BPS14	15p	13p	11p
BPS16	16p	14p	12p

NEW QUALITY TESTED PAKS

Pak	Description	Price £p
Q1	20 Red spot trans. PNP AF	0·50
Q2	16 White spot R.F. trans. PNP	0·50
Q3	4 OC77 type trans.	0·50
Q4	6 Matched trans. OC44/45/81/81D	0·50
Q5	4 OC75 transistors	0·50
Q6	4 OC72 transistors	0·50
Q7	4 AC128 trans. PNP high gain	0·50
Q8	4 AC126 trans. PNP	0·50
Q9	7 OC81 type trans.	0·50
Q10	7 OC71 type trans.	0·50
Q11	2 AC127/128 comp. pairs PNP/NPN	0·50
Q12	3 AF116 type trans.	0·50
Q13	3 AF117 type trans.	0·50
Q14	3 OC171 H.F. type trans.	0·50
Q15	5 2N2926 sil. epoxy trans.	0·50
Q16	2 GET880 low noise germ. trans.	0·50
Q17	3 NPN 1 ST141 & 2 ST140	0·50
Q18	4 Madt's 2 MAT 100 & 2 MAT 120	0·50
Q19	3 Madt's 2 MAT 101 & 1 MAT 121	0·50
Q20	4 OC44 germ. trans. A.F.	0·50
Q21	3 AC127 NPN germ. trans.	0·50
Q22	20 NKT trans. A.F. R.F. coded	0·50
Q23	10 OA202 sil. diodes sub-min.	0·50
Q24	8 OA81 diodes	0·50
Q25	6 IN914 sil. diodes 75PIV 75mA	0·50
Q26	8 OA95 germ. diodes sub-min. 1N69	0·50
Q27	2 10A 600PIV sil. rects. IS45R	0·50
Q28	2 Sil. power rects. BYZ13	0·50
Q29	4 Sil. trans. 2 × 2N696, 1 × 2N697, 1 × 2N698	0·50
Q30	7 Sil. switch trans. 2N706 NPN	0·50
Q31	6 Sil. switch trans. 2N708 NPN	0·50
Q32	3 PNP sil. trans. 2 × 2N1131, 1 × 2N1132	0·50
Q33	3 Sil. NPN trans. 2N1711	0·50
Q34	7 Sil. NPN trans. 2N2369, 500MHZ	0·50
Q35	3 Sil. PNP TO-5 2 × 2N2904 & 1 × 2N2905	0·50
Q36	7 2N3646 TO-18 plastic 300MHZ NPN	0·50
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BP09=SN7409	0·18	0·17	0·16
BP10=SN7410	0·15	0·14	0·12
BP13=SN7413	0·29	0·26	0·24
BP16=SN7416	0·43	0·40	0·38
BP17=SN7417	0·43	0·40	0·38
BP20=SN7420	0·15	0·14	0·12
BP30=SN7430	0·15	0·14	0·12
BP40=SN7440	0·15	0·14	0·12
BP41=SN7441	0·67	0·64	0·58
BP42=SN7442	0·67	0·64	0·58
BP43=SN7443	1·95	1·85	1·75
BP44=SN7444	1·95	1·85	1·75
BP45=SN7445	1·95	1·85	1·75
BP46=SN7446	0·97	0·94	0·88
BP47=SN7447	0·97	0·94	0·88
BP48=SN7448	0·97	0·94	0·88
BP50=SN7450	0·15	0·14	0·12
BP51=SN7451	0·15	0·14	0·12
BP53=SN7453	0·15	0·14	0·12
BP54=SN7454	0·15	0·14	0·12
BP60=SN7460	0·15	0·14	0·12
BP70=SN7470	0·29	0·26	0·24
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BP73=SN7473	0·37	0·35	0·32
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BP190=SN74190	3·50	3·25	3·00
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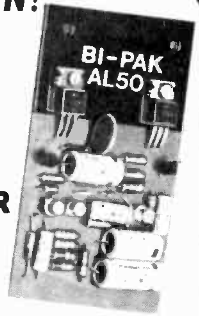

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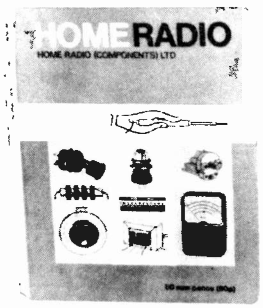

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VOL. 8 No. 9
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PRACTICAL ELECTRONICS

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GUILTY PARTY

THE use of technical devices to invade the privacy of the individual was one of the important matters considered by the Committee on Privacy whose report was presented to Parliament in July.

The devices in question are described in this report as falling into two well-defined categories: electronic and optical extensions of the human senses. By way of illustration the Report lists examples brought to the Committee's notice of devices for visual surveillance (optical instruments) and devices for aural surveillance (audio, radio, and tape recording instruments).

Clearly, certain electronic devices for aural surveillance are highly sophisticated examples of modern microelectronic techniques and have been intentionally designed for ready concealment. Other devices which could be used for snooping purposes are commonplace and are generally in use for entirely legitimate purposes. The Report recognises this fact, and rules out the possibility of banning the use of such aural devices by law, because all such devices would have some legitimate use. The person who uses such devices for unethical purposes is the real guilty party, who must be singled out for detection and be prosecuted.

The report makes two important recommendations in this respect.

(1) That unlawful surveillance by surreptitious means should be made a criminal offence.

(2) That it should be an offence for anyone to advertise technical devices with reference to their aptness for surreptitious surveillance.

Following from this second recommendation regarding advertising, it would be logical to assume that it would likewise become an offence to publish design and constructional information relating to devices specially intended for such surreptitious surveillance. To such a proposal this magazine has no objection, so far as devices intended avowedly for surreptitious operations are concerned: P.E. has certainly never countenanced the building of snooping or bugging devices.

But again, caution is required. As anyone familiar with electronics will appreciate, many harmless and perfectly legitimate projects can be adapted for (or simply put to) perverse uses. Electronics is no closed book. Components are freely obtainable. The determined snooper will always find ways and means to acquire devices or to modify existing equipment to meet his disreputable needs. So a complete clampdown on the publication of all technical information relating to designs potentially of value to a snooper is quite as impractical as the banning of all commercial devices that have some similar dangerous potentiality.

F.E.B.

THIS MONTH

CONSTRUCTIONAL PROJECTS

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NEWS AND COMMENT

Our October issue will be published on Friday, September 8

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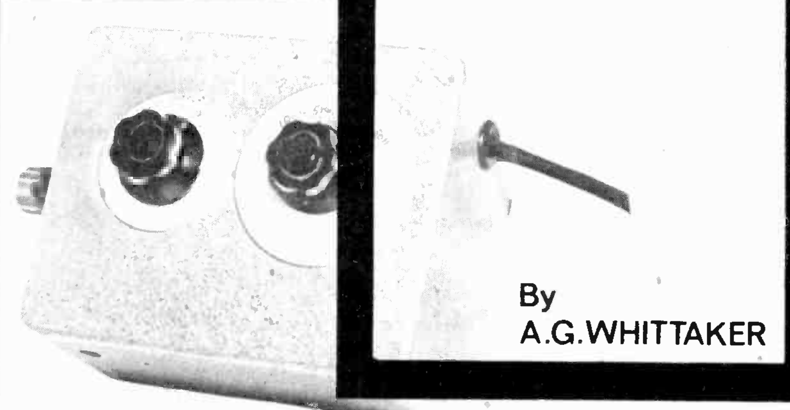
SQUARE WAVE GENERATOR



By
A.G.WHITTAKER

THIS article describes the construction and use of a transistorised square wave generator for providing four preset square wave frequencies selected to cover the three pass bands in which the audio engineer is most interested. This information enables the complete frequency and transient response of audio amplifiers to be determined by four simple measurements. The unit is completely portable, and self powered by two small 9V batteries.

CIRCUIT DESCRIPTION

From Fig. 1 it will be seen that the basic circuit is a free running multivibrator producing the waveform shown in Fig. 2. Resistor R5 together with the "fine frequency" control, VR1 and R3 and the selected capacitors on S1, form the *RC* time constants which govern the repetition rate of the output square wave.

Simplified formulae, which are sufficiently accurate for practical purposes, give the time constant for *C* and *R* as

$$\text{Time constant } t_1 = 0{\cdot}7\ C\ R$$
$$\text{and } t_2 = 0{\cdot}7\ C\ R$$

The values of *C* and *R* have been selected to give the four required time constants. These are:

1. 10kHz $t = 100\mu s$
2. 5kHz $t = 200\mu s$
3. 1kHz $t = 1ms$
4. 50Hz $t = 20ms$

There are selected by the two-pole 4-way wafer switch, S1.

Large values of *C*, the coupling capacitors, are needed to provide the pulse duration necessary for the 50Hz frequency. For this frequency the coupling capacitors are 0·22μF. If the circuit is required to generate 20Hz the coupling capacitors should be changed to 0·68μF.

Fine frequency adjustment is by VR1 and VR2 is the amplitude control with a two-pole switch attached.

The diodes clean up the waveform so that the wave shape is square, or more accurately, rectangular. Fig. 3a is a photograph of the 50Hz wave. Fig. 3b shows a 10kHz wave produced by the generator. Fig. 4 shows the 10kHz wave after it has been fed through a high fidelity amplifier.

The trace was given by connecting an oscilloscope across a 4 ohm resistive load shunted by a 1μF capacitor on the output terminals of the amplifier.

ASSEMBLY

The component parts of the signal generator are assembled on a piece of perforated or plain s.r.b.p.

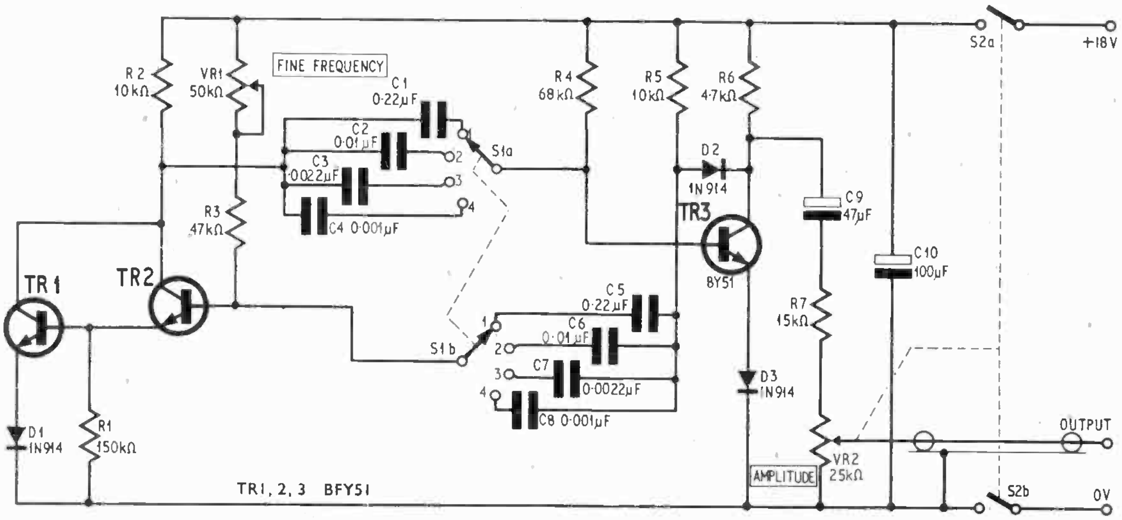


Fig. 1. The complete circuit of the square wave generator, with band selection switch S1a and S1b

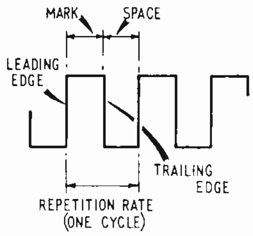


Fig. 2. The ideal square wave showing the leading and trailing edges and mark/space ratio

sheet, measuring 4in by 2·5in. Fig. 5 shows the component layout together with details of the switch wiring.

The complete assembly is mounted in a die-cast metal box measuring $4\frac{5}{8}$in × $3\frac{5}{8}$in × $2\frac{1}{8}$in (outside dimensions), as shown in Fig. 6. The generator assembly board is fixed inside the lid on three $\frac{3}{8}$in paxolin spacers. The amplitude control and the pulse frequency selection switch are fitted into the box as shown in the photograph. The fine frequency control is on the side.

The output lead of the generator is brought out through a rubber grommet on the opposite end; this is a 12in length of screened cable with crocodile clip terminations. The screen of the cable is connected to the metal box at the generator end, as shown in Fig. 6.

The unit is powered by two small 9V batteries connected in series, to give 18 volts. Since the current consumption is only between 4 and 6mA, PP3 style batteries are suitable, although the generator will function on one PP3 but the wave shape is better with the higher voltage. The power is switched on via a two-pole switch, which is attached to the gain or amplitude control.

OUTPUT

The output amplitude control adjusts the signal level suitable for the unit under test. The maximum amplitude is 8 volts peak to peak, and will be found to be constant over the four spot frequencies. The waveform has rise and fall times of 5μs.

APPLICATIONS

Square wave or step signals are frequently used in the production testing of audio equipment. The test engineer can see by the waveform reproduced on an oscilloscope screen, the following information.

The frequency pass band of the amplifier over a very wide range, depending upon how well the amplifier reproduces the wave shape as compared with the original input signal. A square wave comprises a fundamental frequency plus a series of odd harmonic overtones, i.e. f_1 = fundamental, f_3 = third harmonic, f_5 = fifth harmonic, f_7 = seventh harmonic and so on.

The squareness of the reproduced wave will depend upon the capability of the amplifier to respond to a wide pass band, and hence to the harmonic overtones. A restricted high frequency pass band will filter off the higher harmonics resulting in a wave shape with slanting sides, indicating an increase in the rise time, as illustrated in Fig. 7.

Thus the rise time is related to f_{max}, the highest frequency in the square wave spectrum.

$$f_{max} \text{ is given by } \frac{1}{2 \times \text{rise time}}$$

Since the rise time of this square wave generator is 5μs, f_{max} will extend to

$$f_{max} = \frac{1}{10 \times 10^{-6}} = 100\text{kHz}$$

Fourier analysis of a square wave shows it to have a continuous frequency spectrum extending from zero, or the d.c. value, to a very high odd harmonic frequency depending upon the steepness of the rise time.

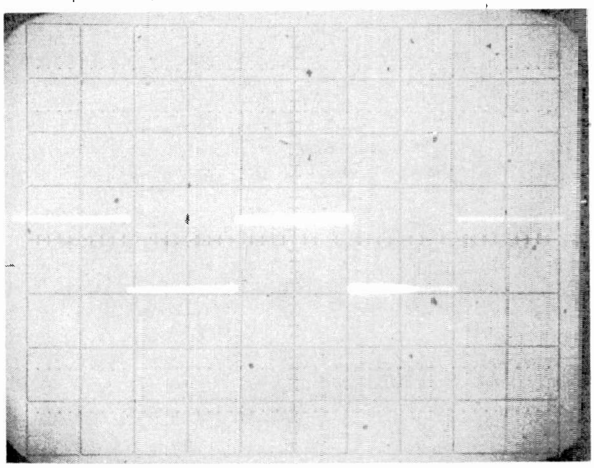


Fig. 3a. Oscillogram of the 50Hz waveform

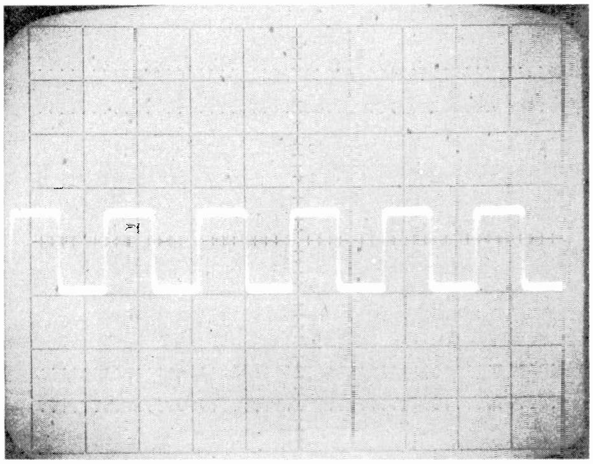


Fig. 3b. Oscillogram of the 10kHz waveform (timebase 50μs)

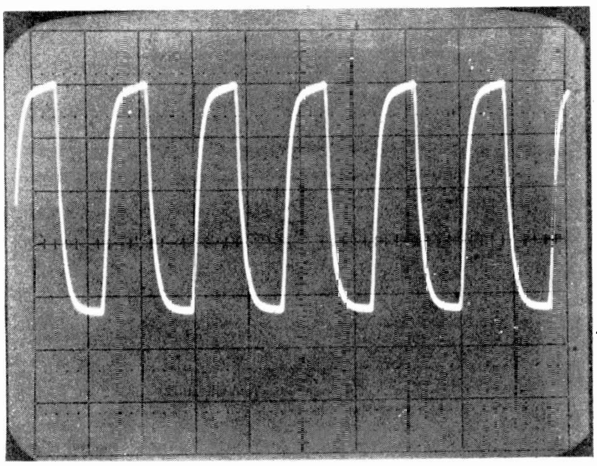


Fig. 4. Oscillogram of the 10kHz waveform across a 4 ohm load across the output of an amplifier

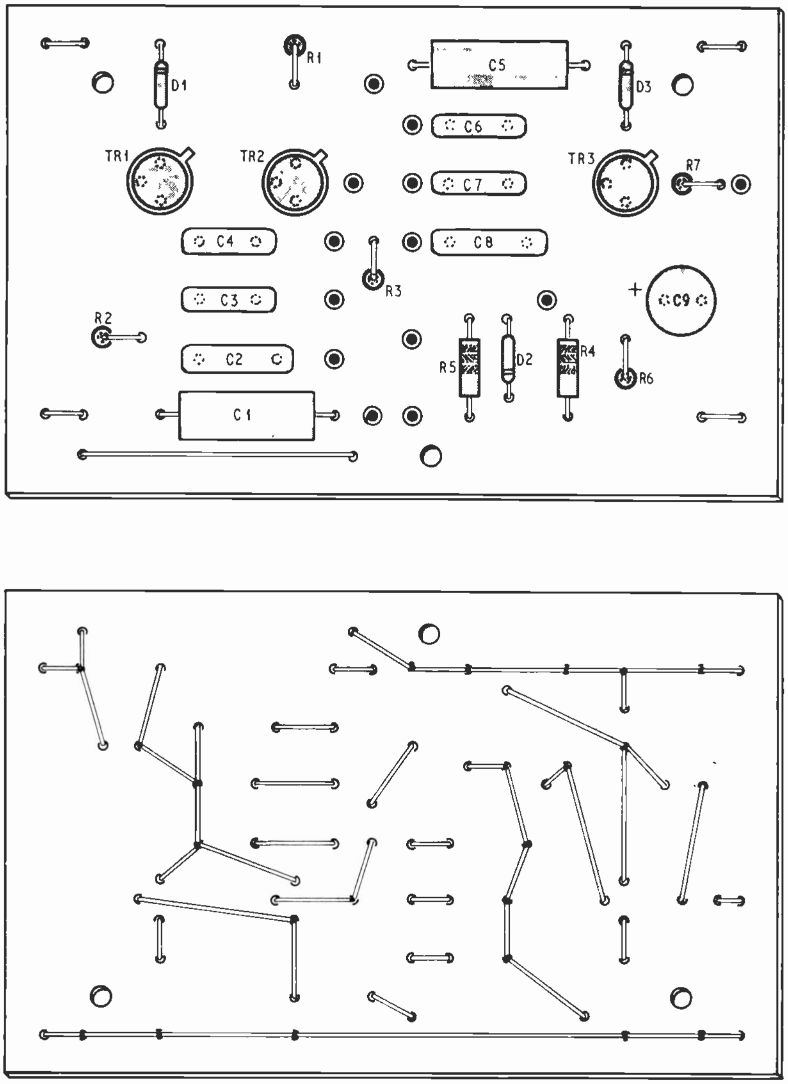


Fig. 5. Layout of components on plain s.r.b.p. sheet

COMPONENTS . . .

Resistors
- R1 150kΩ
- R2 10kΩ
- R3 47kΩ
- R4 68kΩ
- R5 10kΩ
- R6 4·7kΩ
- R7 15kΩ

Potentiometers
- VR1 50kΩ linear carbon
- VR2 25kΩ log. carbon with double pole on-off switch S2

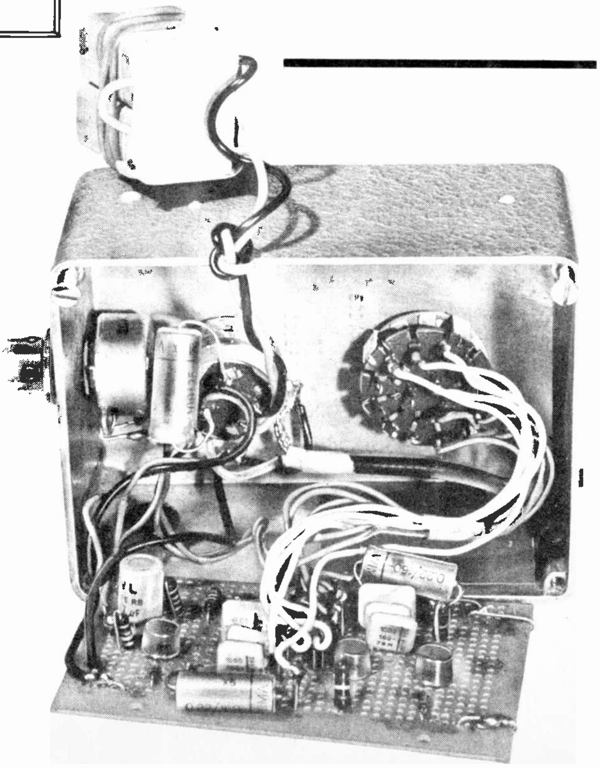
Capacitors
- C1 0·22µF
- C2 0·01µF
- C3 0·0022µF
- C4 0·001µF
- C5 0·22µF
- C6 0·01µF
- C7 0·0022µF
- C8 0·001µF
- C9 47µF elect. 25V
- C10 100µF elect. 25V

Diodes
- D1,2,3 1N914 (3 off)

Transistors
- TR1, 2, 3 BFY51 or BC108 (3 off)

Switches
- S1 2-bank, 2-pole, 4-way wafer
- S2 2-pole, on-off (mounted on VR2)

Miscellaneous
- Die-cast box (see text)
- Plain or perforated srbp sheet
- Batteries 9V type PP3 (2 off)
- Pointer knobs with skirts (3 off)
- Battery connectors (2 off)



The wave shape in Fig. 7 has been purposely drawn with exaggerated sides to illustrate the rise and fall times, but in a good square wave generator they should be almost vertical. The rise time is the time taken for the leading edge of the wave to rise from 10 per cent to 90 per cent of its final steady value. The fall time taken for the trailing edge to fall from 90 per cent to 10 per cent of its final steady value, as shown in the sketch in Fig. 7.

Thus we may see that if the amplifier under test increases the rise time, this is an indication of a limitation in bandwidth response.

DISTORTION

Ideally the reproduced square wave as seen on a good oscilloscope should consist of the top and bottom horizontal lines only, the rise and fall times being so rapid as to be almost invisible. Fig. 8 shows the various distortions that may be introduced to the square wave signal, together with the information obtained from the wave forms shown.

The waveforms in Fig. 8 are observed by connecting an oscilloscope to the output of the amplifier, across

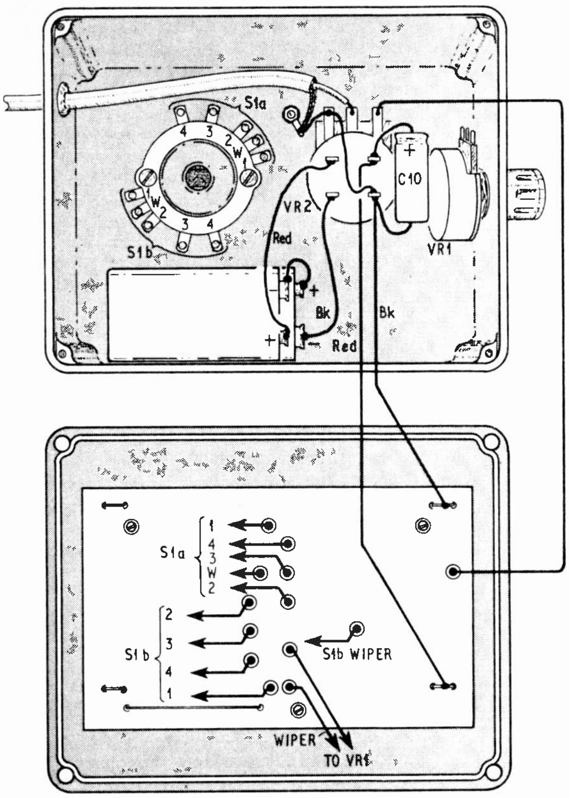


Fig. 6. Assembly of board and controls in the box

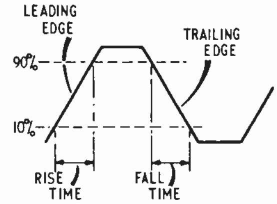
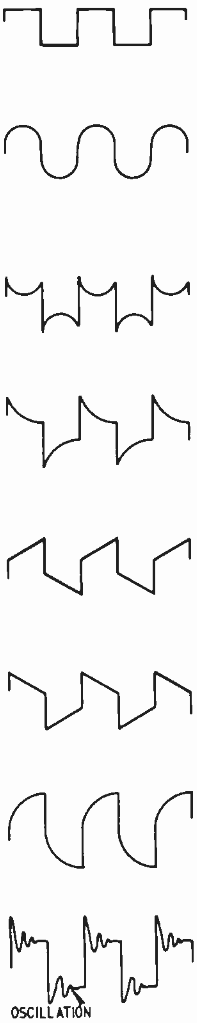


Fig. 7. Exaggerated waveform illustrating rise time and fall time of a square wave

Fig. 8. Approximate wave shape distortions of a square wave with the causes of distortion



(a) The ideal waveform from the square wave generator into the amplifier test

(b) High frequency attenuation. The curvature in the wave shape may be varied by manipulation of the treble control

(c) Low frequency attenuation. The curvature may be varied by manipulation of the bass control

(d) This wave shape is produced by low frequency attenuation plus a leading phase shift. Severe forms of this produces differentiation in waveform

(e) A lagging phase shift at low frequencies produces this wave shape

(f) A leading phase shift at low frequencies produces this form

(g) Combined high frequency attenuation and low frequency phase shift produces a wave of this form

(h) Ringing or overshoot. A damped wave train oscillation, caused by transient instability, in the amplifier under test. This is also an indication of poor response to the attack or decay of the signal (i.e. poor transient response)

a fixed load resistor corresponding in value to the loudspeaker impedance (see Fig. 9). This is usually shunted by a 1μF capacitor which may cause the amplifier to oscillate if it has a tendency towards instability.

With the square wave generator connected to the input terminals, the wave shape on the scope screen should show no ringing. At frequencies of 1kHz and 5kHz there should be a good square wave shape with no rounded corners, and it should be practically identical with the input signal. At 10kHz, one may observe a slight rounding of the corners on the leading edge of the wave, but there should be no overshoot or ringing.

Fig. 9 shows the test set-up for making the measurements shown above. The controls should be set initially in the flat position. The square wave generator gain control should be adjusted so that the input signal does not overload the input stages. Finally, set the amplifier volume control to give the signal level at which it is desired to make the square wave measurements. This is usually the full rated undistorted output power of the amplifier.

The square wave generator will cover three pass bands, low frequency band 50Hz, middle range 1kHz, high frequency 5kHz and 10kHz bands. ★

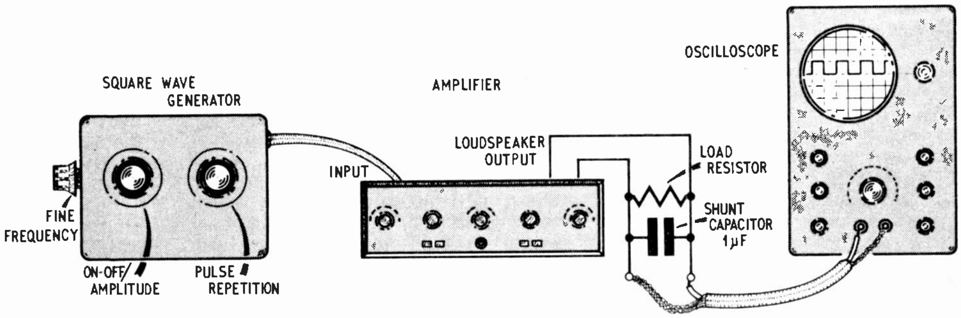
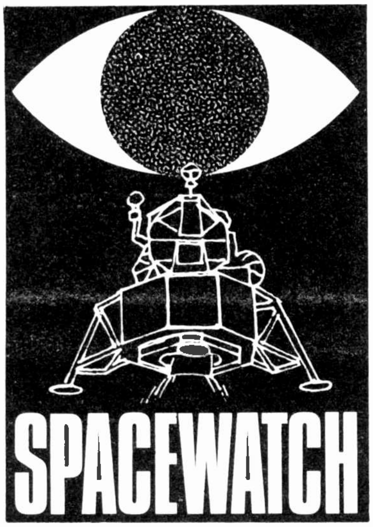


Fig. 9. Test set-up for checking an audio amplifier



BY FRANK W. HYDE

TRAGEDY OF *TD-1*

The largest and most expensive venture by ESRO (European Space Research Organisation), the launching of the ultra-violet observatory *TD-1* has suffered an instrumental failure which was quite unexpected. The main recorder can now only give real time data and therefore limits the amount of total data to 14 per cent.

Only while the satellite is visible to the ground station network can data be recovered. In an attempt to salvage as much data as possible the ground network has been extended so that about 25 per cent of the observations will be recovered.

The vehicle carried a back-up recorder but this failed quite early on in the mission due to an electrical fault. It is doubly tragic that this should have occurred because the first full orbit results were startlingly successful. Up till the time of breakdown the amount of data recovered was of great value and extensive in its implications and the team responsible for the collation of data do not consider that the mission is a loss.

The *TD-1* cost £8 million to build and weighs about half a ton. Up to the end of April one third of the sky had been surveyed with the highly sophisticated ultra-violet telescope.

The principle object of this orbiting ultra-violet observatory was to study the young parts of the far out universe. The distribution of the young hot stars that radiate in the ultra-violet region has been determined and a great deal added to the knowledge of the chemical structure, abundance and size of these stars. Only from an observatory in space is it possible to make this investigation. The spacecraft has a planned life of six months.

PHOTOGRAPHS IN FAR ULTRA VIOLET

On the return journey from the Moon, the *Apollo* mission had some scheduled extra-vehicular activities. Part of this was devoted to taking more than 200 photographs in far ultra-violet light. These pictures are of immense value to astronomers because hydrogen emits very strongly at a frequency of 1,216 angströms (the Lyman alpha region), it is a valuable tool that can be used in space but not from the ground.

Pictures of the state of the geocorona of the earth were particularly interesting. The low density hydrogen halo that surrounds the earth was clearly visible and in areas of the tropics the additional ultra-violet radiation can be seen. Another interesting feature of these pictures was the presence of auroral activity over the south pole. In this case an immensely long streamer was seen radiating from the south magnetic pole.

A great achievement was the photographing of the Large Magellanic Cloud. This miniature galaxy which is part of our own galactic family is only 200,000 light years from the solar system. In the pictures large areas of hydrogen gas in which bright spots are prominent, indicate the formation of hot blue stars radiating very strongly in the far ultra-violet. Other bright areas indicate the regions where concentrations of hydrogen precede the birth of stars according to current thinking. This is the kind of data that will enable astronomers to establish the relation of interstellar distribution and the regions of star birth.

SHUTTLE CRAFT PROGRAMME UNDERWAY

The development phase in the space shuttle project has now been reached and the orbiter contract is under way. Some doubts have been expressed on the system chosen. This is partly because there are a number of unknowns to be considered.

Basically the orbiter will have a solid fuel booster, an external tank to be jettisoned and air breathing engines. The development contracts for these units will be given separately and the final models delivered to the orbiter contractor.

The booster system envisages two solid fuel rockets which are to be mounted on the opposite sides of the fuel tank which will be fitted to the underside of the orbiter. On lift-off the three engines of the orbiter using liquid fuel will fire simultaneously with the solid fuel engines of the boosters.

Some seven million pounds of thrust will be available and when the combined vehicle reaches a height of 25 miles (40km) the boosters will be detached and splash down in the ocean. These are re-usable so are to be recovered for repetitive use. The orbiter itself will continue on under its own power and later jettison the fuel tank.

If this system is to succeed then there must be near 100 per cent reliability. Thus back-up systems will be important. The reliability of the simple solid fuel rocket will contribute to this end in a large measure. All the control systems and ignition controls will have built-in redundancy. Guidance control and other essential systems will be on board the orbiter itself. A great deal of confidence is placed in X-ray checking and strict quality control towards the standards required.

The re-usability of boosters has not so far been tried in an operational mission, though the *Minuteman* vehicles have had some testing. They have been fired, refuelled and then fired again. Structural testing of the units will be set at a higher standard after the first firing. Another point in favour of the solid fuel booster is that ocean recovery is easier and survival longer than liquid fuel rockets.

Each booster is expected to be of a high weight order around 100 tons each. In the preliminary designs an impact speed of about 50ft per second was considered, but now it is set at somewhere between 75/100ft per second. The descent speed will be of the order of 1,000 miles per hour before the parachutes are deployed. Studies of recovery systems have used from three to nine parachutes. There have been free fall tests of *Titan* boosters (unstressed for recovery) which have survived and on examination found to be structurally satisfactory.

RUSSIAN SPACECRAFT STUDIES MARS

The temperature of Mars, the red planet, has provided some interesting data about the condition of its surface and up to half a metre below. There appear to be variations between the northern and southern latitudes. The temperature of minus 40°C in lower northern areas, is much higher than the southern part around latitude 60°, where it falls to minus 70°C.

The Russian spacecraft *Mars-3* is fitted with a small radiotelescope which operates on a frequency of approximately 9GHz (3·4cm). It is arranged in such a way that emission and polarisation of the radiation can be determined. It has a fixed aerial system of 60cm diameter. It can establish the temperature down to a depth of half a metre.

Because the orbit of the probe is elongated, 1,500km at perigee and 200,000km at apogee, observations extent from latitude 60° south to 30° north.

ELECTRONIC PIANO

Part 1

By A. J. Boothman B.Sc.

Authentic piano sounds from an instrument a quarter the size of a conventional pianoforte and at a fraction of the cost.

It combines in one instrument . . .

SPECIFICATION . . .

Musical Compass

Five Octaves F to F — 61 notes

Frequency Compass

Fundamental Frequency Range — 43 Hz to 1·4 kHz approx.

Nominal Output Levels

External Amplifier

450 mV into 1 MΩ
200 mV into 10 kΩ
60 mV into 2 kΩ

Headphone or external loudspeaker

2·5 Watts into 8Ω

Internal loudspeakers

Approximately 3 Watts

Mains Input

200–250 Volts 50 Watts

Sound Envelope (nominal times)

Attack Period	30 ms
Decay Period	300ms
Keyboard Sustain	3·5s
Pedal Sustain	3s

Tremolo Frequency Range

5Hz–10Hz

Physical Dimensions and Weight

Case when packed	42in × 21in × 7·5in
Height of legs	24in
Weight	60 lbs

Controls

Keyboard
1. Main Amplifier on/off Switch
2. Touch Control
3. Tremolo on/off Switch
4. Level Control

Foot Pedals
1. Sustain
2. Soft

Side Panels
1. Master Volume
2. Tremolo Rate
3. Tremolo Intensity
4. Mains on/off Switch

WHY design an electronic piano rather than a small portable electronic organ? Here the author must revert to personal prejudice, shared he believes by many musicians, in that the organ has a very dominant presence within any small (or large) group and impresses on the sound an overall characteristic tonal coloration which cannot be overcome.

Perhaps a more universally acceptable point would be that the percussive nature of the piano cannot be reproduced in any reasonably priced organ, and that this characteristic is extremely desireable in a large amount of modern popular music or jazz.

THE ELECTRONIC PIANO IN THE HOME

The traditional piano is large for the average modern home, and can be very restricting to furniture disposition. In recent years, because of the skilled techniques involved in the manufacture of such a product, the piano has also become expensive. The instrument described here can be built for a material cost of approximately £100 and is constructed in such a way that in addition to occupying a fairly small space in normal operation, it can actually be stored away, if necessary, within the space of two average suitcases.

Two other features which offer a bonus are the possibility of fitting a spare set of short legs for the use of children, and the obvious advantage in the use of head-phones for prolonged periods of practice.

SYSTEM DESCRIPTION

Referring first to the block diagram of Fig. 1 it can be seen that an output from the power supply unit is taken to the touch control which is mounted at the side of the keyboard. One of five possible levels of attack is selected on this control which determines the d.c. level applied to the common connection side of the 61 switches operated by the keyboard. When a note is depressed this voltage is carried forward to the relevant envelope circuit (p.c.b.s) and triggers the commencement of a tone with the required degree of attack.

The decay characteristic is fixed for the period during which the key is depressed, and will in fact follow a similar pattern after the key is released provided that the sustain pedal is operated.

The outputs from the 13 boards are fed to a three stage pre-amplifier. Shunt modulator type tremolo is also included on the pre-amplifier printed circuit board. A high level output is available for driving an external amplifier, and an internal power amplifier drives small internal speakers, or external loudspeakers or headphones.

MAIN P.C.B.s

The functions carried out by one of the 13 main printed circuit boards (p.c.b.s) is shown in Fig. 2. The first 12 boards each give five octave separated outputs for pitches F to E, and the thirteenth board is greatly reduced in component content as it only has to provide one pitch (Top F).

The basic pitches are produced by Hartley oscillators, followed by integrated bistable dividers. Outputs at frequencies f to f/16 are each fed to a separate transistor which mixes the signal with a fast attack, long decay envelope. Each mixer is followed by a tone forming circuit, and the five notes are then fed to a single stage amplifier which boosts the output from the board.

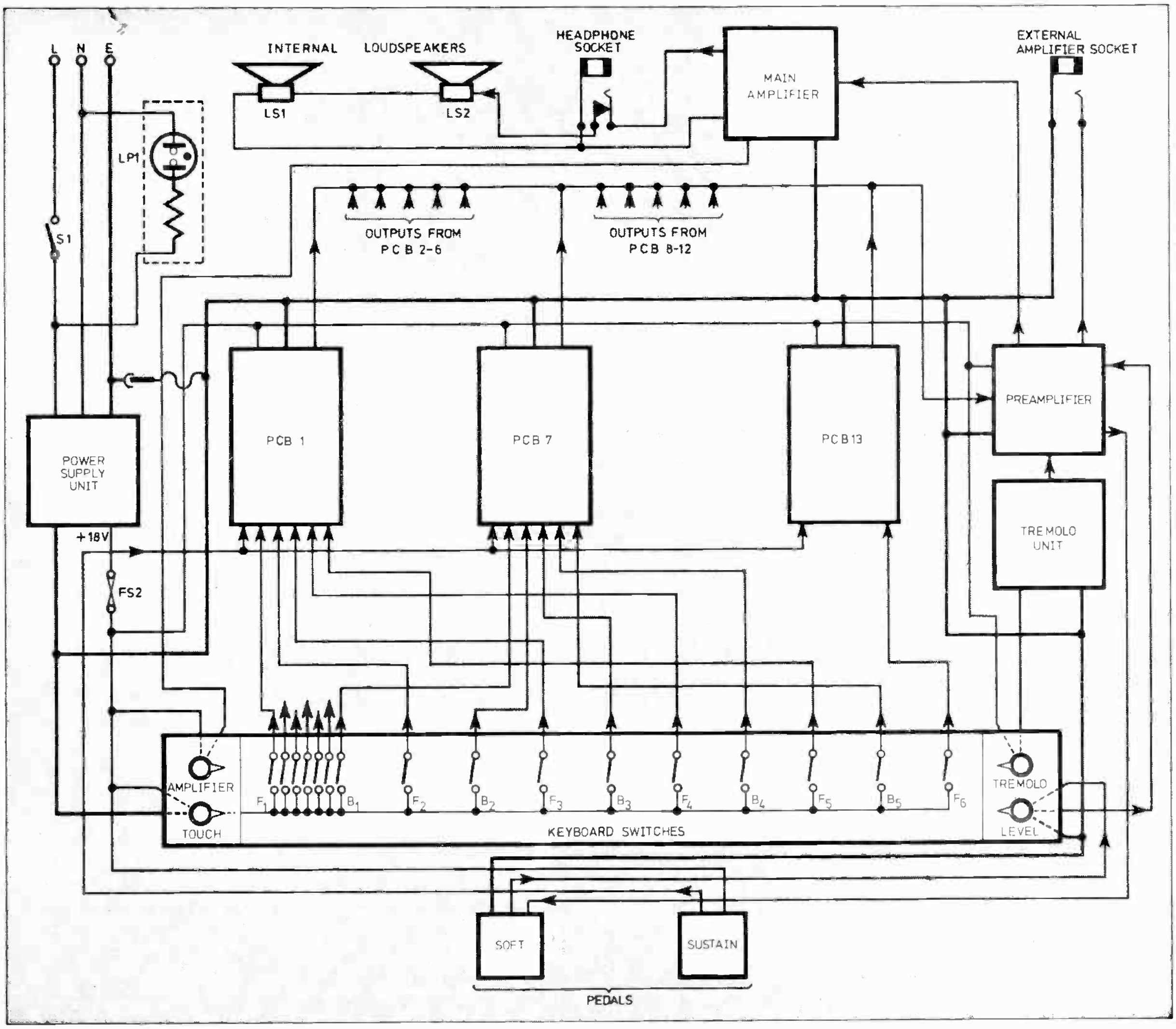


Fig. 1.1. Block diagram of electronic piano

Soft and sustain pedals are linked to the amplifier gain and the envelope circuits respectively.

KEYBOARD CONTROLS

Four keyboard controls are available to the pianist. The internal amplifier and tremolo circuit have simple on/off switches, whilst the touch control gives five optional degrees of attack, and the level control gives five alternative levels of volume. All knobs were chosen for quick flip operation whilst playing the instrument.

PHYSICAL DESCRIPTION

The piano is contained in a wooden case 42in × 21in × 7·5in which includes a dual purpose lid acting as both the music stand, and the container for the legs during transport.

The keyboard is fixed to its own wooden subframe, complete with gold plated switch contacts and interwiring. The switches corresponding to each of the five octave keys of each pitch are wired to a single 6-way connector strip, which includes a terminal for the sustain connection. The connector strips are positioned such that each length lines up with the corresponding pitch board.

The 13 main printed circuit boards which hold the bulk of the electronic components are easily removed for test or repair purposes, along with the pre-amplifier and tremolo units. A control panel on the end of the instrument has the master volume, tremolo controls, and external amplifier output socket. The box containing the p.c.b.s can be removed from the piano independent of the keyboard subframe assembly.

The power supply unit is a separate sub-assembly within the main box, as is the internal power amplifier which is mounted along with the internal speakers on the front panel immeditely above the keyboard. This front panel can also be removed as a separate independent unit, thus completing the modular construction format.

The pedals are separate units which plug into the base of the piano, and are transported in the special accessory compartment which is also designed to accommodate the power lead.

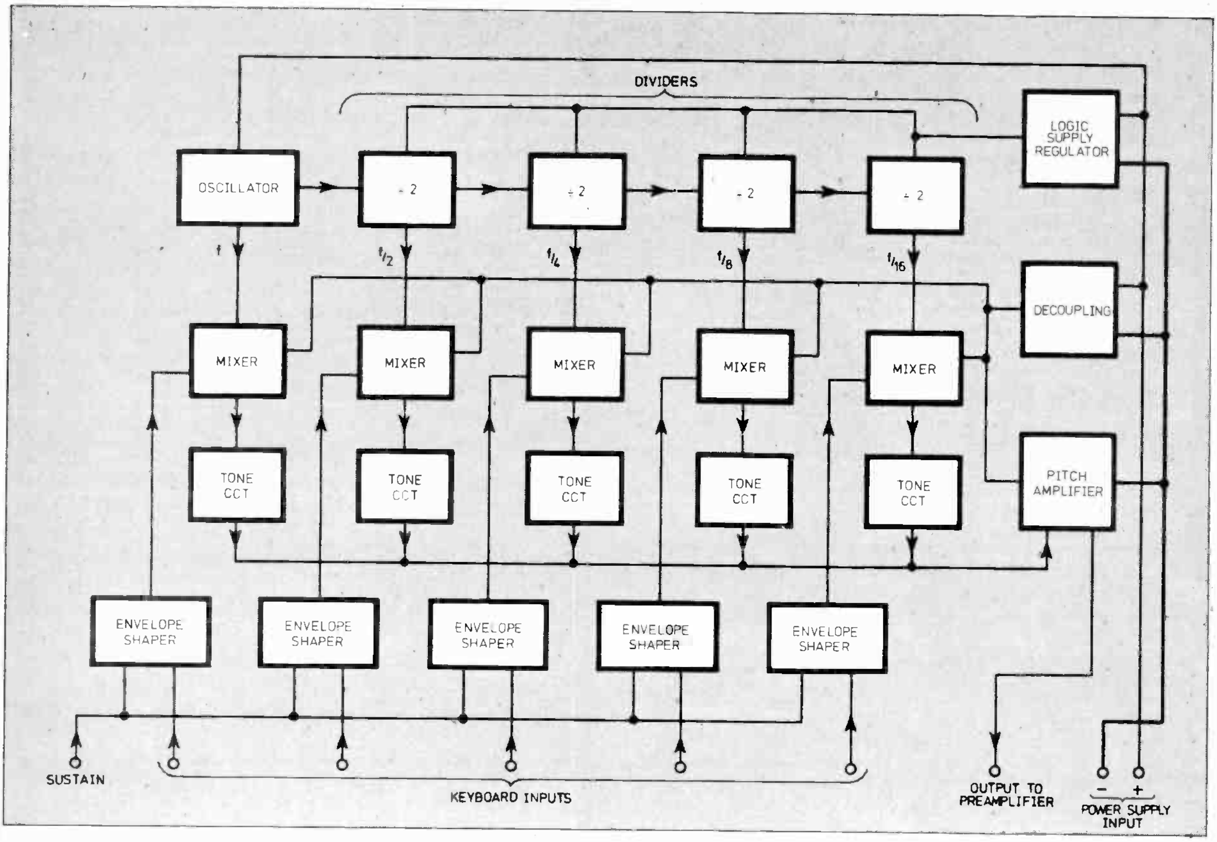


Fig. 1.2. Block diagram of pitch p.c.b.

BULK COMPONENT LIST

To take advantage of any concessions offered by retailers for bulk purchases we include the following list which covers the majority of components used in the piano.

Individual component lists will appear as usual with circuit diagrams as they occur.

Resistors — Quantity

	Quantity
68Ω	15
270Ω	80
390Ω	14
1kΩ	95
1·8kΩ	95
3·9kΩ	16
5·6kΩ	130
10kΩ	160
27kΩ	135
56kΩ	145
100kΩ	22
560kΩ	18
820kΩ	130
All 5% ⅛ watt carbon	
270Ω 5% 2·5 watt wirewound	12

Capacitors — Quantity

			Quantity
0·05μF	polyester	125V	18
0·1μF	polyester	125V	16
0·2μF	polyester	125V	45
0·5μF	polyester	15V	30
1μF	elect.	15V	15
5μF	elect.	15V	62
10μF	elect.	15V	64
100μF	elect.	6·4V	25
100μF	elect.	15V	29

Diodes — Quantity

ZS170 (Ferranti) — 350
or any silicon planar diodes of 20V P.I.V.

KS 047A 4·7V 400mW zener diodes — 14

Transistors — Quantity

ZTX300 — 110

Integrated Circuits — Quantity

ZN7474E — 24

Miscellaneous

SEI Feralex pot core VF723/739/P		13
SEI Bobbin	MM733A	13
SEI Assembly	MM773	13
Main printed circuit boards		13

The pot core assemblies and p.c.b.s can be obtained from Clef Products (Electronic Division), Yew Tree Lane, Poynton, Stockport, Cheshire.

COMPONENT PURCHASES

In a project of this nature it is essential that all components should be easily available, a fact which has been checked with some care. The cost suggested earlier assumes that all items are purchased from current advertisers within this magazine, with additional addresses given where necessary. The component content can be roughly broken down into the following three cost groups, and this should assist in the planning of the expenditure throughout the period of the project. These are.

1. Semiconductors, resistors and capacitors £40
2. Hardware (pot core assemblies, switches, p.c.b.s) £40
3. Keyboard and switch contacts £20

Sources for the first two groups are well covered in the various parts lists which will be given during the project, but some general comments are made here on keyboard suppliers.

KEYBOARDS

Three keyboards have been investigated by the author, two of which were versions of the Morelli (Italian) keyboard, and the third of which was a Swedish keyboard. All keyboards as supplied were C-C and this therefore required modification work which was in fact carried out on one Italian and one Swedish board. Suppliers of both keyboards have stated that F-F boards could be supplied to order on a delivery of about six weeks, but details of the modifications are given later in case any constructor has easy access to a C-C board or prefers to buy from stock.

MORELLI A

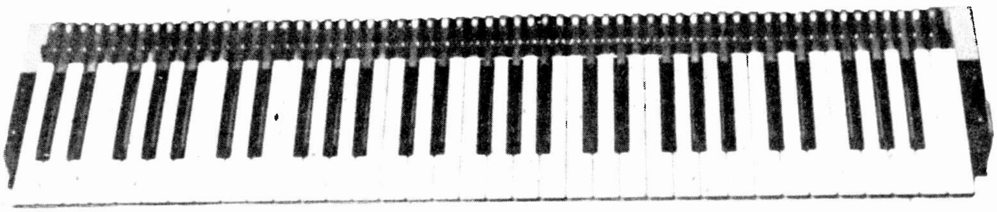
The prototype piano has a Morelli A keyboard which can be obtained from Elvins Electronic Musical Instruments. It is characterised by a simple metal frame without end fixing points and without any form of mounting hinge. It is easy to modify to F-F by cutting the frame in order to remove the bottom C-E section which is then attached to the top end of the board.

MORELLI B

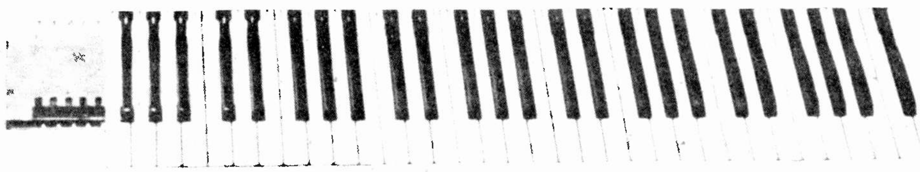
This is the version of the Italian board submitted by Harmonics Limited, and is characterised by metal end fixing points and a rear hinge. Harmonics have stated that they will be able to supply an F-F board with the same mechanical outline, and this should prove a very convenient unit. The author has not actually attempted to modify the C-C version of this particular board but it should be possible to handle it in the same way as above. Later mechanical details will give method of mounting this keyboard.

SWEDISH KEYBOARD

A Swedish keyboard is supplied by Kimber-Allen and is notably lighter in weight than the other two boards. The author has successfully modified it to F-F. Again, details for doing this will be given later. Kimber-Allen have also stated that they will be able to supply F-F boards to order. The keyboard is slightly longer than the two Italian boards, but is easily accommodated within the console area.



The Morelli B keyboard



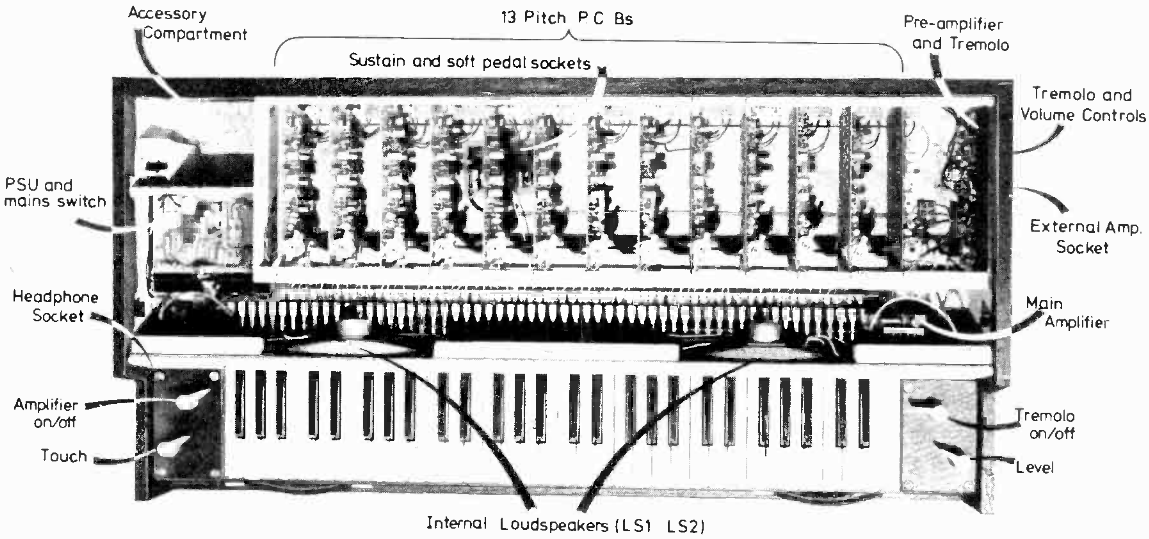
The Swedish keyboard with the lower C-E section removed prior to modification to an F-F keyboard

The keyswitch assembly for the Morelli A keyboard is manufactured by Clef Products. This switch assembly is suitable for all the aforementioned keyboards.

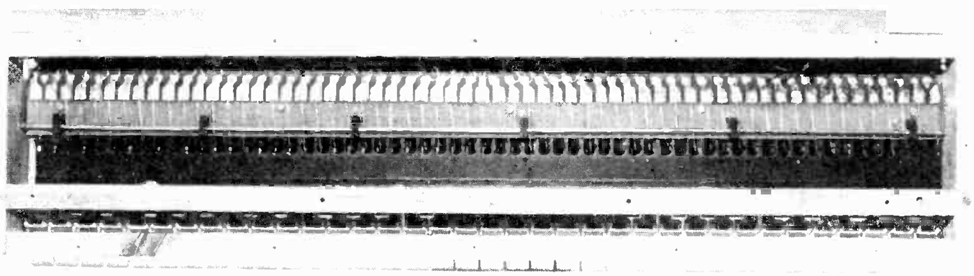
OTHER KEYBOARDS

The mechanical design of the piano is very simple and it should be possible to accommodate virtually any keyboard. The choice of F-F is based on a musical evaluation of the requirements of this sort of instrument, and whilst it would make no difference to the electronics to cover C-C (except in the choice of tuning capacitors) the author very strongly recommends that F-F be considered as essential to the character of the instrument.

Next month, constructional details for the p.s.u. will be given together with pre-amplifier and tremolo circuitry and assembly



Details of interior of electronic piano



Underside view of Clef keyswitch assembly

YATES ELECTRONICS
(FLITWICK) LTD.
ELSTOW STORAGE DEPOT
KEMPSTON HARDWICK
BEDFORD

C.W.O. PLEASE. POST AND PACKING PLEASE ADD 10p TO ORDERS UNDER £2.

Catalogue which contains data sheets for most of the components listed will be sent free on request. 10p stamp appreciated.

OPEN ALL DAY SATURDAYS

RESISTORS
½W Iskra high stability carbon film—very low noise—capless construction.
⅓W Mullard CR25 carbon film—very small body size 7·5 x 2·5mm.
2% ELECTROSIL TR5

Power watts	Tolerance	Range	Values available	Price 1–99	Price 100+
½	5%	4·7Ω–2·2MΩ	E24	1p	0·8p
½	10%	3·3MΩ–10MΩ	E12	1p	0·8p
½	2%	10Ω–1MΩ	E24	3·5p	3p
½	10%	1Ω–3·9Ω	E12	1p	0·8p
⅓	5%	4·7Ω–1MΩ	E12	1p	0·8p
4	10%	1Ω–10Ω	E12	6p	5·5p

Quantity price applies for any selection. Ignore fractions on total order.

DEVELOPMENT PACK
0·5 watt 5% Iskra resistors 5 off each value 4·7Ω to 1MΩ.
E12 pack 325 resistors £2·40. E24 pack 650 resistors £4·70.

POTENTIOMETERS
Carbon track 5kΩ to 2MΩ, log or linear (log ¼W, lin ½W).
Single, 12p. Dual gang (stereo), 40p. Single D.P. switch 24p.

SKELETON PRESET POTENTIOMETERS
Linear: 100, 250, 500Ω and decades to 5MΩ. Horizontal or vertical P.C. mounting (0·1 matrix).
Sub-miniature 0·1W, 5p each. Miniature 0·25W, 6p each.

TRANSISTORS

AC107	15p	BC108	10p	BFY51	22p	OCP71	40p	2N3703	12p
AC126	12p	BC109	10p	BFY52	22p	ORP12	50p	2N3704	13p
AC127	12p	BC147	10p	B5Y 56	32p	2N2369	16p	2N3705	12p
AC128	12p	BC148	13p	OC26	45p	2N2646	60p	2N3706	11p
AC131	12p	BC149	13p	OC28	45p	2N2926R	9p	2N3707	12p
AC132	12p	BC157	13p	OC35	45p	2N2926O	9p	2N3708	10p
AD140	50p	BC158	13p	OC42	12p	2N2926V	9p	2N3709	11p
AD161	33p	BC159	13p	OC44	12p	2N2926G	10p	2N3710	11p
AD162	36p	BD131	75p	OC45	12p			2N3711	11p
AF114	20p	BD132	75p	OC70	12p	2N3054	58p	2N4062	12p
AF115	20p	BF179	32p	OC71	12p	2N3055	60p	ZTX302	15p
AF116	20p	BF181	25p	OC72	12p	2N3442	140p	ZTX500	16p
AF117	20p	BF194	15p	OC81	12p			ZTX503	16p
AF118	38p	BF195	15p	OC82D	12p	2N3702	13p	40362	58p
BC107	10p	BFY50	22p						

ZENER DIODES
400mW 5% 3·3V to 30V, 15p.

LINEAR I.C.'s (D.I.L.)
709 **50p** 741, **50p**
710 **50p** 748, **50p**

DIL Socket 14 and 16 pin. 16p

DIODES

RECTIFIER

BY127	1250V	1A	12p
BZV10	800V	6A	25p
BZY13	200V	6A	20p
IN4001	50V	1A	7p
IN4004	400V	1A	8p
IN4007	1000V	1A	12p

SIGNAL

OA85	7p
OA90	5p
OA91	5p
OA202	7p
IN4148	5p
BA114	8p

BRUSHED ALUMINIUM PANELS
12in x 6in = **25p**; 12in x 2½in = **10p**; 9in x 2in = **7p**.

SLIDER POTENTIOMETERS
86mm x 9mm x 16mm, length of track 59mm
SINGLE 10kΩ, 25kΩ, 50kΩ, 100kΩ, log or lin 40p
DUAL GANG 10kΩ + 10kΩ, etc, log or lin 60p
Knob for above 12p
FRONT PANEL 65p
20 gauge panel 12in × 4in with slots cut for use with slider pots.
Grey or matt black finish, complete with fixings for 4 pots.

MULLARD POLYESTER CAPACITORS C296 SERIES
400V: 0·001μF, 0·0015μF, 0·0022μF, 0·0033μF, 0·0047μF, **2½p.** 0·0068μF, 0·01μF, 0·015μF, 0·022μF, 0·033μF, **3p.** 0·047μF, 0·068μF, 0·1μF, **4p.** 0·15μF, **6p.** 0·22μF, **7½p.** 0·33μF, **11p.** 0·47μF, **13p.**
160V: 0·01μF, 0·015μF, 0·022μF, 0·033μF, 0·047μF, 0·068μF, **3p.** 0·1μF **3½p.** 0·15μF **4½p.** 0·22μF, **5p.** 0·33μF, **6p.** 0·47μF, **7½p.** 0·68μF, **11p.** 1·0μF, **13p.**

MULLARD POLYESTER CAPACITORS C280 SERIES
250V P.C. mounting: 0·01μF, 0·015μF, 0·022μF, **3p.** 0·033μF, 0·047μF, 0·068μF, **3½p.** 0·1μF, **4p.** 0·15μF, 0·22μF, **5p.** 0·33μF, **6½p.** 0·47μF, **8½p.** 0·68μF, **11p.** 1·0μF, **13p.** 1·5μF, **20p.** 2·2μF, **24p.**

MYLAR FILM CAPACITORS 100V
0·001μF, 0·002μF, 0·005μF, 0·01μF, 0·02μF, **2½p.** 0·04μF, 0·05μF, 0·068μF, 0·1μF, **3½p.**

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ELECTROLYTIC CAPACITORS—MULLARD C426 SERIES **6p each.**
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	0·1	0·15
2½ × 3¾	22p	16p
2½ × 5	24p	24p
3¾ × 3¾	24p	24p
3¾ × 5	27p	27p
17 × 2½	75p	57½p
17 × 3¾	100p	78p
17 × 5 (plain)	—	82p
17 × 3¾ (plain)	—	60p
17 × 2½ (plain)	—	42p
2½ × 5 (plain)	—	12p
2½ × 3¾ (plain)	—	11p
Pin insertion tool	52p	52p
Spot face cutter	42p	42p
Pkt. 50 pins	20p	20p

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Standard screened	18p	2·5mm insulated	8p
Standard insulated	12p	3·5mm insulated	8p
Stereo screened	35p	3·5mm screened	13p
Standard socket	15p	2·5mm socket	8p
Stereo socket	18p	3·5mm socket	8p

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Plug 12p. Socket 8p.
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PLASTIC PLANAR TRANSISTORS

This article outlines the planar epitaxial process, and describes in detail the construction and assembly of one well known type of plastics encapsulated silicon transistor manufactured by Ferranti Ltd.

By F. BRIERLEY

COMPARED with their germanium counterparts, silicon semiconductors can operate at higher temperatures, have much lower leakage current figures and are much less affected by temperature changes.

The mass production of silicon semiconductors is made possible by a very sophisticated modern technology involving advanced photographic and chemical laboratory techniques, coupled with the use of high precision handling equipment and automatically controlled assembly machines. Many of the processing steps must take place in ultra-clean rooms with strictly controlled temperature and humidity levels.

The silicon used has an impurity content of less than ten parts in a thousand million and the chemicals and gasses used in processing are of high purity analytical laboratory standard. De-ionised water is used for the many washing operations which take place between processes.

PLANAR EPITAXIAL PROCESS

Most modern, high quality, silicon transistors, are manufactured by the planar epitaxial process. This process will be described briefly, followed by a description of the construction and assembly of one particular style called *E-Line* transistors, in plastics packages by the Ferranti Company.

The development of the planar process has made it possible to create thousands of transistors simultaneously on a thin slice of silicon. Planar transistors are extremely reliable and have very stable characteristics. They can be manufactured with operating frequencies of well over 2GHz.

An important feature of the planar process is that the surface of the processed slice is covered by a layer of oxide, which protects the devices from contamination by moisture and impurities that may be encountered. This inherent protection is of great value both prior to and after the encapsulation process.

The planar epitaxial process is a modified form of the basic planar process. It was developed in order to manufacture transistors with high collector breakdown voltages and low saturation voltages. These apparently conflicting requirements are satisfied by means of a very thin high resistivity epitaxial layer, in which the emitter, base and collector regions are formed.

The thin, high resistivity collector layer gives the required high collector breakdown voltage characteristics. By making the substrate of low resistivity

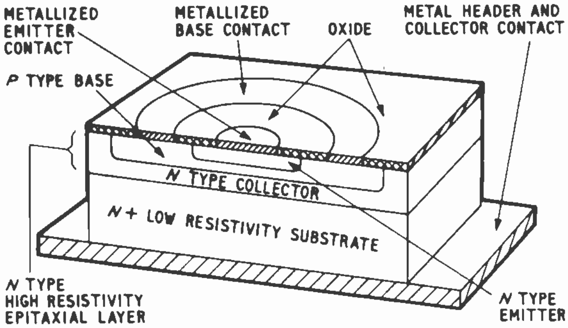


Fig. 1. Sectional view of a silicon planar epitaxial transistor chip

silicon, the overall collector resistance is kept low and thus the transistor saturation voltage is also low.

The sketch (Fig. 1) shows, in simplified form, a sectional view through a planar epitaxial *npn* transistor; note how the junctions are protected by an oxide layer. The base and emitter contacts are made to metallised areas on the top of the silicon chip, the collector connection is usually taken from the underside of the chip via the metal header and the N+ low resistivity substrate.

PULLING THE CRYSTAL

A principal route of manufacture begins with the pulling of a monocrystalline bar of silicon from refined polycrystalline silicon of known resistivity. Fig. 2 shows a crystal pulling furnace. The polycrystalline silicon, together with closely controlled amounts of boron, phosphorous or arsenic dopants, is loaded into a graphite crucible which is enclosed within a quartz chamber. Boron is used for *p*-type characteristics, arsenic and phosphorous for *n*-type.

The electrical resistivity of the crystal is determined by the quantity of dopant added. Heavily doped silicon exhibits low resistivity and is known as "N+" or "P+" according to the nature of the dopant.

A flow of inert gas is passed through the quartz chamber while the silicon is heated by an r.f. generator When the silicon has melted, a seed of monocrystalline silicon is lowered to the surface of the molten silicon. The temperature of the melt is then reduced to a value just above the melting point of silicon so that, as heat flows from the melt to the cooler seed crystal, the silicon in the immediate neighbourhood solidifies on to the seed crystal. The seed crystal is rotated and slowly withdrawn from the melt. The silicon atoms orientate themselves into the same crystal lattice pattern as the seed and thus a continuous single crystal is "pulled" from the melt.

Crystal diameter is governed by the temperature of the melt and by the rate of pulling, both these factors must be controlled very precisely. In the early days of semiconductor manufacture, one-inch diameter crystals were considered large; now, diameters of two inches are quite usual and crystals of three or even four inches in diameter are not rare.

The bars of monocrystalline silicon are sawn into slices and then lapped, etched and polished to obtain an optically flat surface (see Figs. 3 and 4). The polished slices, now around 0·01in thick, are cleaned in readiness for epitaxial deposition.

EPITAXY

In the epitaxial process, a layer of silicon of high resistivity, and with the same orientation as the slice, is grown onto the low resistivity substrate. The slices are placed in a treated graphite carrier in a quartz tube and are heated to approximately 1,200 C by an r.f. heating coil.

High purity hydrogen, to which silicon tetrachloride and a *p* or *n* dopant have been added, is passed over them and a thin layer of silicon grows onto the slices by vapour phase deposition. An automatic system controls gas and vapour flow rates and time of deposition. The resistivity and depth of the epitaxial layer are checked before slices are passed to the next production stage. It is into this epitaxial layer that the junctions upon which the operation of the device depends, will be diffused.

OXIDATION AND PHOTOLITHOGRAPHY

After epitaxy, the cleaned and tested slices receive a protective oxide coating in an oxidising furnace and are then cleaned again in preparation for a series of photographic and chemical processes, known collectively as photolithography, by which a number of masks are used to define areas of the protective oxide which are to be etched away, in order to allow subsequent diffusion or metallising processes to take place.

The masks are derived from original master drawings with a scale of 250 times full size. Working in ultra clean conditions, a high resolution camera produces a reduced copy, ten times full size. A step and repeat camera, working at a reduction of 10–1, is then used to make a master photographic plate on which a full size image of the mask is repeated several thousand times across the plate, over an area

Fig. 2. A crystal pulling furnace

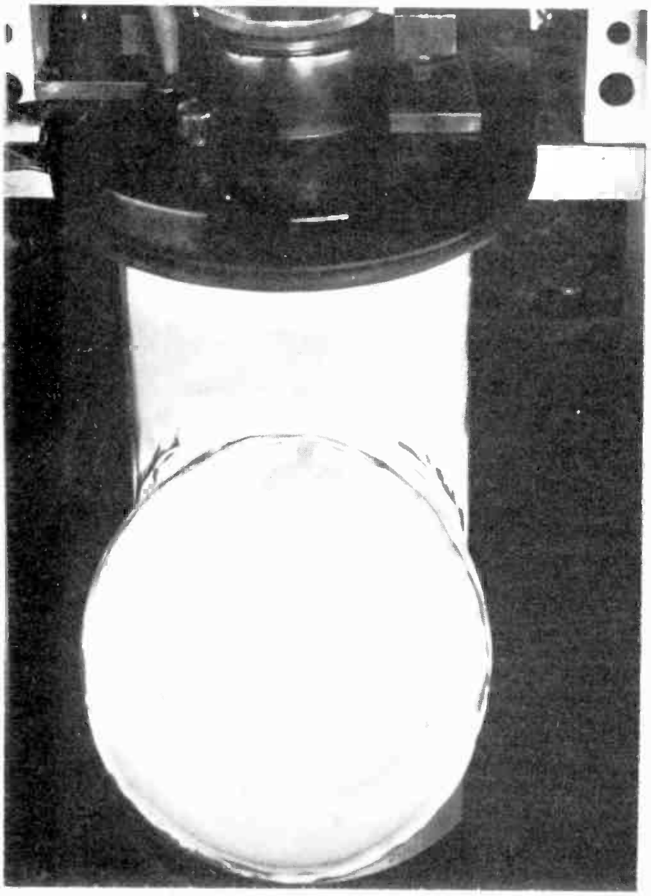


Fig. 3. A crystal sawing machine

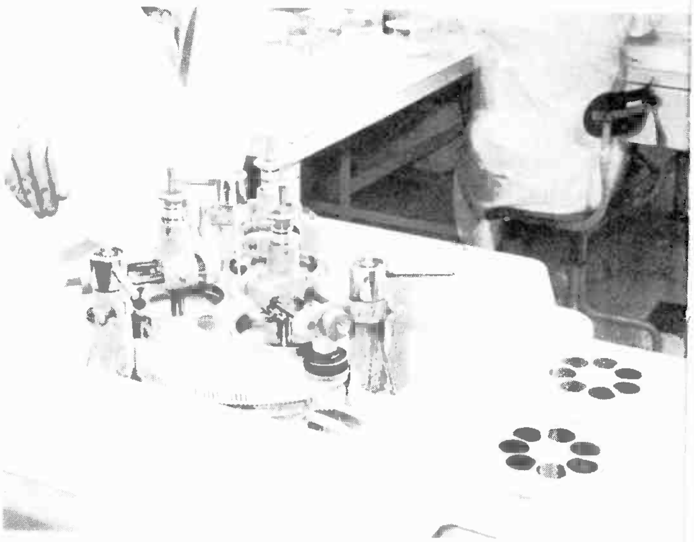
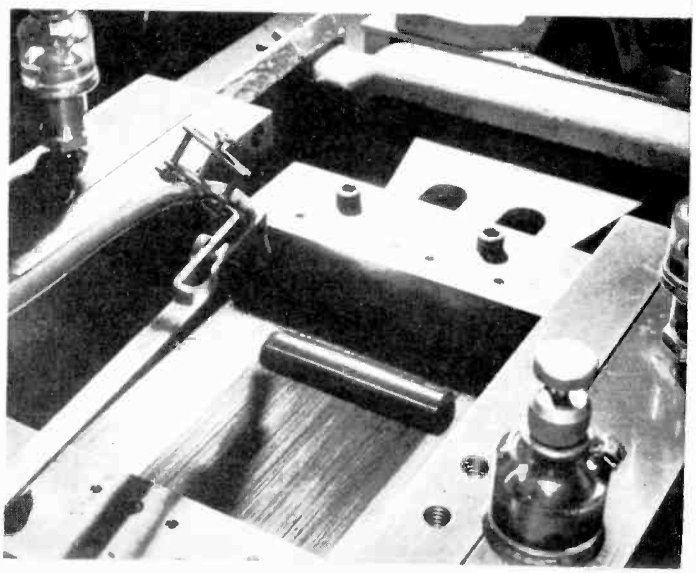


Fig. 4. Slice polishing machine



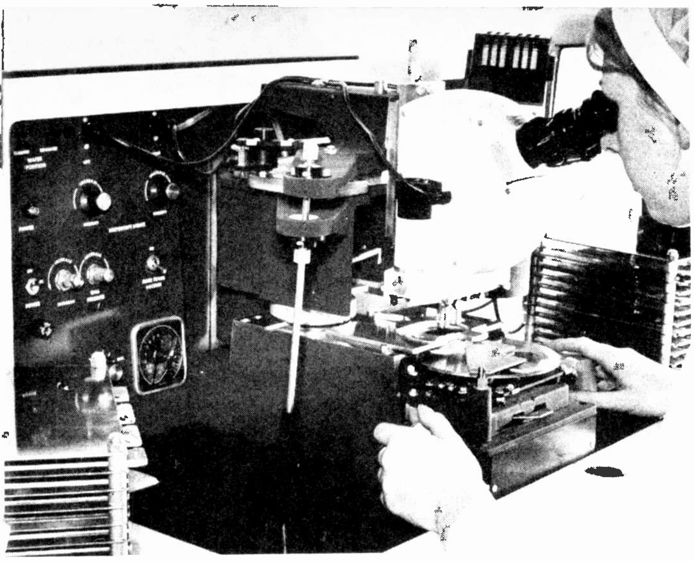


Fig. 5. Mask alignment

equivalent to the useful area of the silicon slice. The camera stepping accuracy is one quarter of a micron and four masks are generated simultaneously.

From the master plates, working masks are made by contact printing. The hazards to be contended with during mask making include, faults in photographic plates, accidental damage occurring in contact printing, and foreign bodies settling on the plates during processing. Emulsion type working mask plates have a relatively short life, necessitating regular inspection and frequent renewal in order to preserve a high yield of good devices. Chrome plates, introduced more recently, have a longer working life.

NUMBER OF MASKS

The number of different masks required for a particular transistor design depends upon the design complexity; for a relatively simple device, there may be one mask for the base, one for the emitter and one for the area to be metallised. Other designs may require five, or more, different masks.

Assuming that three masks are to be used, the cleaned, oxide covered slices are coated with a measured quantity of photo-resist emulsion which is distributed evenly over the slice by a centrifuging operation. Coated slice and the base mask are brought together in the alignment machines (Fig. 5) and a controlled exposure is made under ultra-violet light. The slice is then developed and the photo-resist coating is dissolved away from the unexposed areas. An acid etch then removes the exposed oxide.

BASE DIFFUSION

After cleaning, the slice is ready for the base diffusion. This process takes place in a diffusion furnace, at a temperature in the range 1,000 to 1,280°C, where the slices are exposed to an atmosphere of *p* or *n* doped nitrogen. The dopant diffuses into the silicon epitaxial layer, through the etched areas, to form the required collector/base junction.

Coincidentally with this, an oxide layer is formed over the silicon. The slices are then coated again with photo resist and the next masking operation takes place.

The development, etching and diffusion processes, which follow the second masking operation, form the base/emitter junction and a further oxide layer. The characteristics of the diffused junctions can be determined precisely by control of the processing conditions.

The oxide is etched away from defined regions in the base and emitter areas to permit contact to be made. A thin film of aluminium is then evaporated over the slice, making contact with the base and emitter; the unwanted areas of the aluminium are then etched away.

Each successive mask must be aligned very accurately with the pattern made on the slice by the previous mask and the alignment machines are capable of working to a tolerance of one micron in pattern position.

These processes take place in air-conditioned clean rooms fitted with laminar flow cabinets. A stream of continuously filtered air passes through these laminar flow cabinets in which the alignment machines and other equipment are housed.

QUALITY CONTROL

Inspection takes place at all production stages and completed slices are tested by automatic probe testing machines under computer control. The test probes of the machines locate, in turn, on the metallised contact areas of each transistor on the slice. Any transistor failing the test is marked, automatically, for removal at a later stage.

SEPARATION

The tested slices are separated into individual transistor chips by scribing between the patterns and cracking the slice along the scribed lines.

A method of expanding the cracked slice has been devised by Ferranti which enables all the chips to be spread out but preserved in their original arrangement with respect to each other, so that they can be picked up without difficulty by vacuum probes employed in the dice alloying operation. An expanded cracked slice is shown in Fig. 6.

CONSTRUCTION OF THE E-LINE STYLE

The basic processes that have been described are common to all planar epitaxial transistors.

It is in the processes of assembling the silicon chip to its header, the bonding of wires from the base and emitter electrodes to the pins, and in the encapsulation process, that plastics transistors differ from conventional metal can transistors.

The major proportion of the direct manufacturing cost of a conventional transistor is incurred in the assembly and encapsulation stages which, between them, employ the largest portion of the total labour force.

A high degree of automation of the assembly and encapsulation processes of the *E-Line* transistor has brought about a significant reduction in the cost of these operations and thus in the price of finished devices. Automatic machinery simplifies the task of the operator and makes high speed production possible.

The degree of skill required by the operator is minimised and the processing conditions are regulated automatically by the machines themselves so that a high yield of good devices and consistent product quality are obtained.

The reliability of the product is determined by the overall design, including the design of the production equipment. E-Line transistors make use of a strip nickel framework specifically designed for use with the automatic assembly machines. The framework, illustrated in Fig. 7, is provided with location holes along its edges, these holes are employed to transport the framework through the alloying and bonding machines.

Each strip of framework is made to carry 128 transistors. The collector lead terminates in a depressed "flag" to which the silicon chip is alloyed. Investigation has shown that the main route by which moisture might reach the chip is along the interface between the lead wire and the plastic encapsulation; this path has been made as long a practicable in order to protect the transistor from adverse climatic environments.

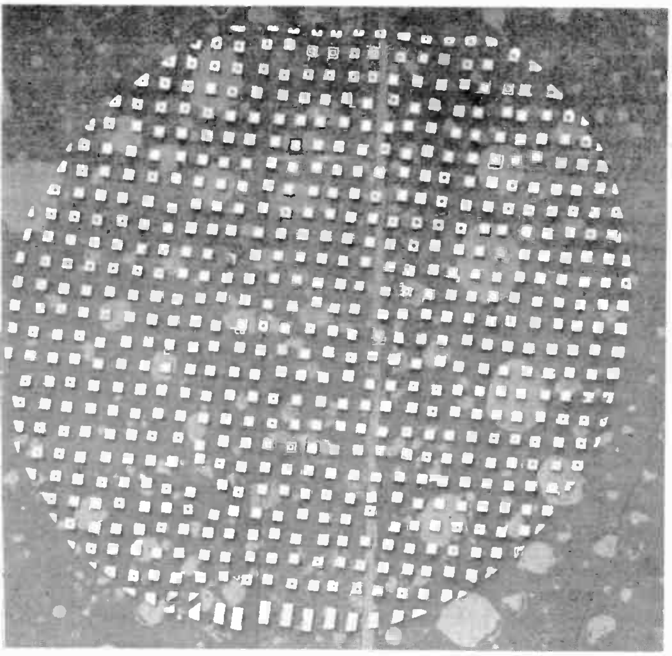
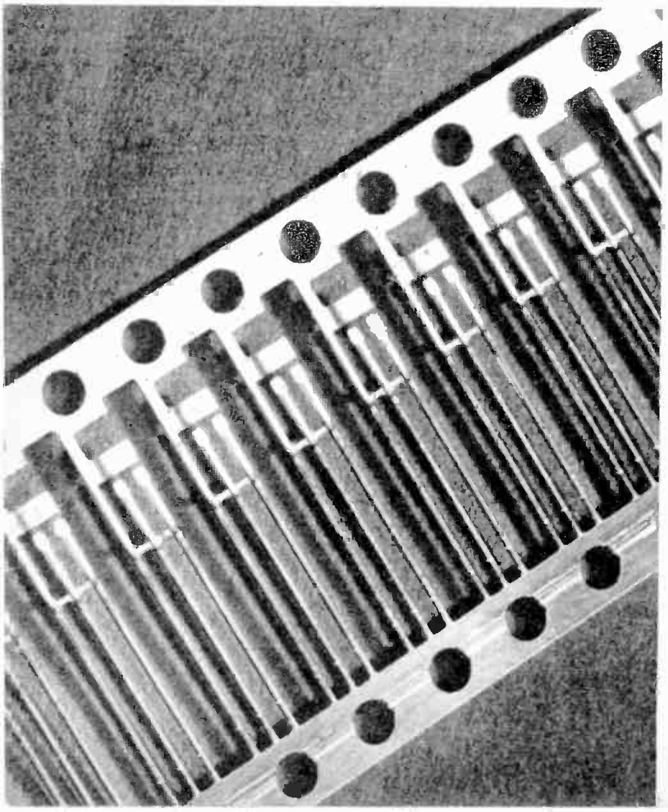


Fig. 6. An expanded slice on a plastic backing

Fig. 7. The E-Line strip framework



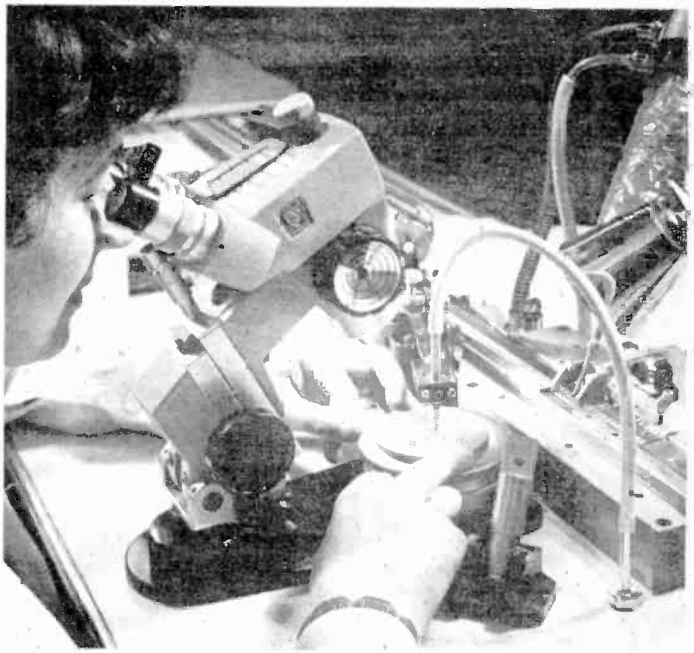


Fig. 8. Alloying machine for E-Line transistors

Fig. 9. The bonding operation

ALLOYING

Each collector flag of the framework is coated with gold and the framework is fed into the automatic alloying machine where the flag is heated to alloying temperature by a heated platform. The machine operator selects a transistor chip by adjusting a rotatable plinth on which the chips are laid and centring a chip under the cross wires of a microscope.

The selected chip is picked up automatically by a vacuum probe and placed onto the heated collector flag where, under pressure and vibration, a gold/silicon eutectic forms, alloying the chip firmly into position. The framework is automatically carried through the alloying and bonding machines by the feed mechanisms acting upon the location holes.

Accurate location of the chip and bond wires is necessary and the feed mechanisms and location holes ensure that the framework is positioned within the machines to a tolerance of 0·001in. A close-up view of one of the automatic alloying machines is shown in Fig. 8.

BONDING

The framework, with 128 dice attached, is passed from the alloying machine and fed into the bonding machine where the emitter and base connections will be made. As the framework is stepped through the machine, fine gold wires are ball bonded to the metallized base and emitter pads on the chip.

The operator views the operation through the microscope and ensures that the bonds are positioned centrally on the bonding pads. The machine automatically bonds the free ends of the base and emitter bond wires to the emitter leads on the framework. A photograph of the bonding operation is shown in Fig. 9.

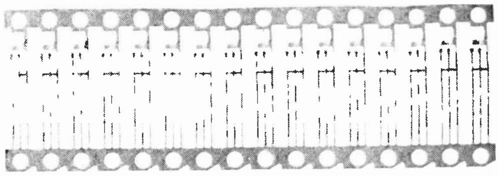
ENCAPSULATION

An encapsulation, whatever form it may take, is intended to provide certain requirements. These are: protection from the environment, vibration and shock; ease of handling and mechanical protection; heat dissipation.

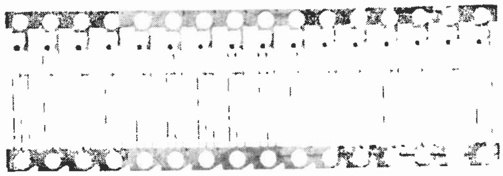
Since the encapsulation can determine the reliability of the device, many evaluation trials have been carried out in order to select a plastic encapsulant and a method of encapsulation that would satisfy performance requirements. The method which is currently being used involves the moulding of a non-hygroscopic plastics substance with the desired electrical and mechanical properties, employing a transfer moulding press.

After bonding has been completed, the 128 unit framework is cut into eight sections, each carrying 16 transistors. One edge of the framework is then removed and the sub-frame then appears as illustrated in stage 4 of Fig. 10. Two of these sub-frames are clamped into a moulding jig consisting of two halves held close together by a high pressure hydraulic system.

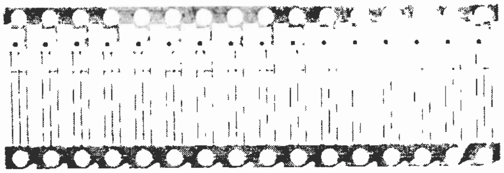
The plastics encapsulant is heated to 150°C and then, when its viscosity is similar to that of water, it is forced into the mould at a pressure of 90 pounds/sq in. The encapsulant flows freely around the chip and lead wires producing a mechanically strong, high density structure. The moulded sub-frames, now as shown in stage 5 of Fig. 10, are removed from the moulding jig and, after curing,



STAGE 1. Part of the 128 unit framework before alloying

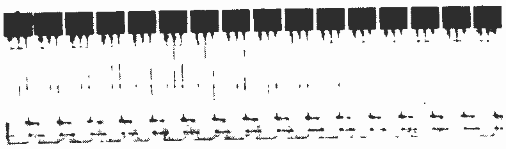


STAGE 2. Transistor chips alloyed to the framework

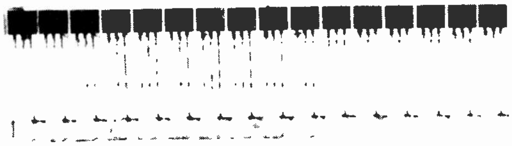


STAGE 3. Emitter and base bonded to the leads by fine gold wires

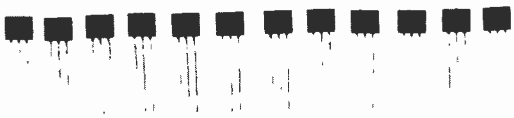
STAGE 4. One stage of the framework removed



STAGE 5. After encapsulation



STAGE 6. Lead wire supports removed



STAGE 7. After tinning and separation

Fig. 10. Stages in the manufacture of E-Line transistors

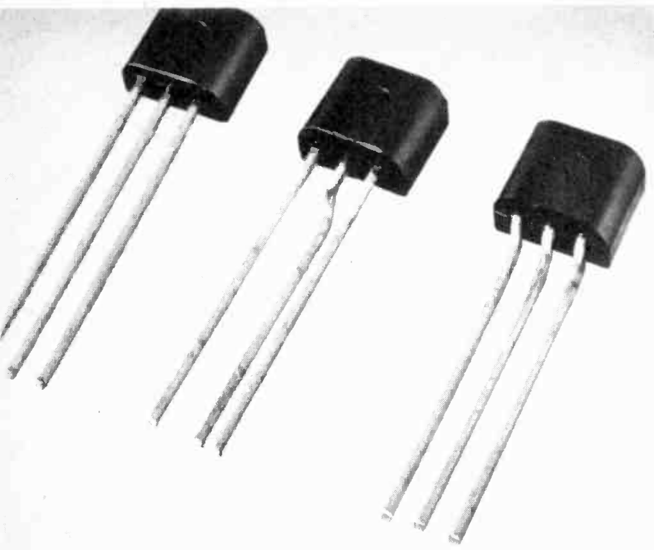


Fig. 11. Variations of lead-out arrangement for printed circuit wiring: left—normal; centre—triangular TO-18; right—"flat-pack" mounting

the unwanted parts of the framework are removed.

Any moulding flash is then removed and the transistor leads are tinned, for ease of soldering. The devices are then ready for testing and type stamping.

The lead spacing is specifically designed to be compatible with the standard 0·050in (1·27mm) hole pitch for printed circuit boards and the devices are normally supplied with straight leads.

They can be supplied with leads preformed to the TO-5 or TO-18 configuration, or for flat mounting, and examples of three lead configurations (normal, TO-18 and "flat" mounting) are shown in Fig. 11.

TESTING

High-speed automatic testing machines carry out comprehensive tests on all of the *E-Line* transistors manufactured. The transistors are fed automatically into the machines and are fully tested according to the required specifications and automatically sorted into appropriate categories. Test programmes are held on punched cards and can be changed as desired for different device types.

Random samples are taken from the production batches and subjected to mechanical and environmental tests in order to ensure that consistent product quality is being maintained. After testing, the type numbers are stamped on to the devices by automatic machinery according to the test figures attained.

RELIABILITY EVALUATION

The tests conducted include prolonged storage at low temperature, high temperature storage with normal voltage applied and current flowing, temperature cycling between −55°C and +175°C, and accelerated ageing by storage at high temperature.

A long term moisture test, at 100 per cent humidity with a programmed temperature variation every 24 hours, has confirmed that the *E-Line* encapsulation resists the ingress of moisture extremely well.

Stability tests have shown these devices to be equivalent in performance to those mounted in conventional metal can encapsulations.

A measure of the reliability of plastics encapsulated transistors can be taken from the fact that the *E-Line* series are the first plastics encapsulated transistors to have been accepted for Defence Standard classification and meet the requirements of the BS9000 specifications.

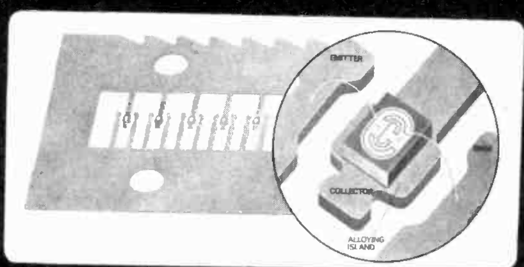


Fig. 12. Dice alloyed and bonded to a Micro-E frame

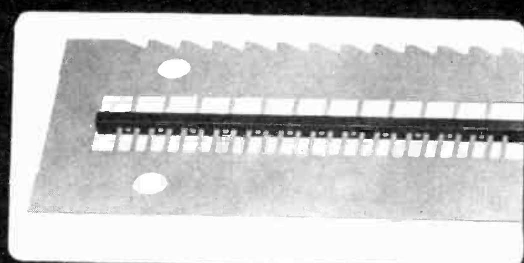


Fig. 13. The framed dice are given a transfer mould

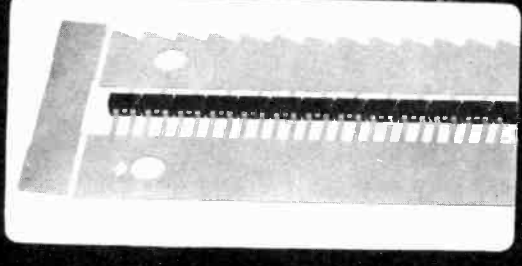


Fig. 14. The Micro-E frame is formed and trimmed and the moulded dice separated by cutting

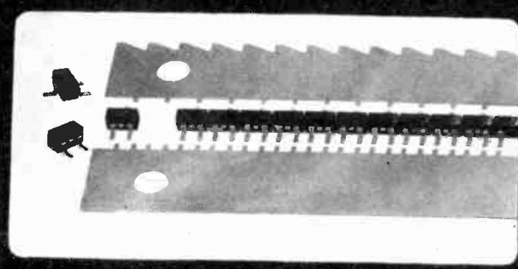


Fig. 15. The leads are cropped releasing the finished transistors

GLOSSARY OF TERMS . . .

Some of the terms used in the article may not be known to the general reader. This brief glossary is an attempt to define such terms in sufficient detail to make the article more readily understood.

CHIP or DICE

A small piece of silicon, containing one transistor element, obtained by scribing and cracking a processed slice into individual devices.

FLASH (moulding)

Superfluous moulding material.

HEADER

The structure, carrying the external leads, on to which the chip is secured and which forms the lower part of a conventional "metal can" encapsulation.

JUNCTION

A transition region between semiconducting regions of differing electrical properties.*

N TYPE SILICON
P TYPE SILICON

A silicon atom has four electrons in its outer orbit. The atom has no charge because the total negative charge of all its electrons is balanced by the positive charge of the nucleus. The outer electrons are called "Valence" electrons, hence, silicon, having four of them, is "tetravalent".

If an atom of a pentavalent element (having five outer electrons) such as Arsenic or Phosphorous, is introduced into the crystal lattice, there will be one surplus electron which will be free to act as a current carrier. The crystal charge remains zero because the negative charge due to the electrons of the added pentavalent atom is still balanced by the positive charge of the nucleus of that atom. Since the free current carriers resulting from the addition of pentavalent atoms are electrons (negative charges), the crystal is known as *n*-type.

Similarly, the addition of a trivalent element (having three outer electrons), e.g. boron, causes deficiencies of electrons (known as "holes") in the crystal lattice. The holes (positive charges) behave as free current carriers and the crystal is known as *p*-type.

PLANAR TECHNIQUE

The formation of *p*-type and/or *n*-type regions in a semiconductor crystal by diffusing impurity atoms into the crystal through holes in an oxide mask, which is on the surface. The latter is left to protect the junctions so formed against surface contamination.*

* B.S. 204:1960

APPLICATIONS

Currently, there are some 50 different types in the *E-Line* range, catering for almost every application including popular general purpose types, switching transistors, and low noise u.h.f. types with minimum useful bandwidths of 1GHz. A series of diode pairs, with either common anode or common cathodes completes the range.

MICRO-MINIATURE TYPES

A range of micro-miniature plastics encapsulated transistors and diode pairs (called Micro-E) has been developed specifically for hybrid integrated circuit applications. These devices are equally suitable for thick film or thin film circuits and also for conventional printed circuit boards.

Despite their small size, 0·085in (2·16mm) by 0·054in (1·38mm) by 0·055in (1·4mm high), most of these devices can dissipate up to 350mW and have an operating temperature range of −55°C to +175°C. The range includes *npn* and *pnp* complementary transistors, low level and medium current amplifiers, high speed switches, zener diodes, photo transistors, v.h.f. and u.h.f. amplifiers and oscillators, and high speed diodes.

Micro-miniature plastics encapsulated transistors are especially suitable for use in implanted heart pacemakers. The photographs in Figs. 12 to 15 show stages in the manufacture of *Micro-E devices*. Fig. 16 shows a thick film circuit using these devices and a thin film circuit is shown in Fig. 17. ★

Fig. 16. Micro-E transistors are suitable for mounting on thick film circuits. Notice the scale approximately 4½ times

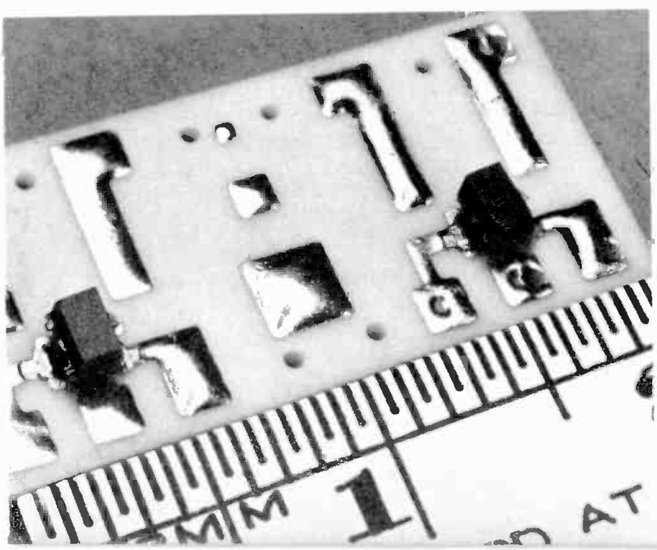
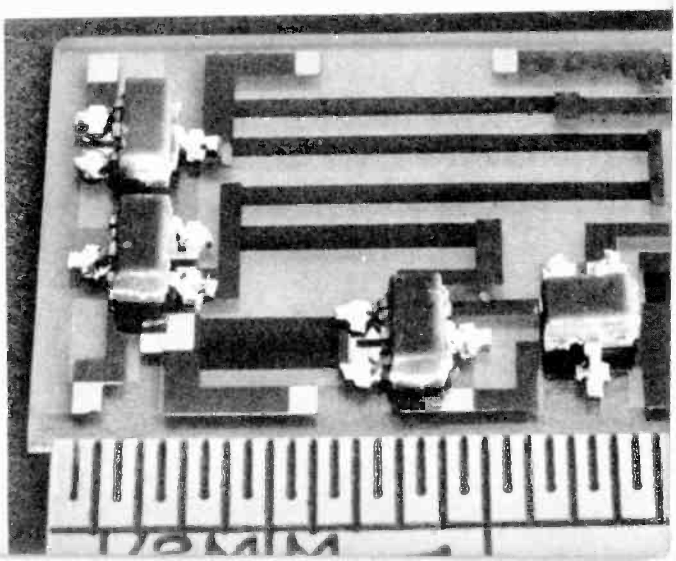
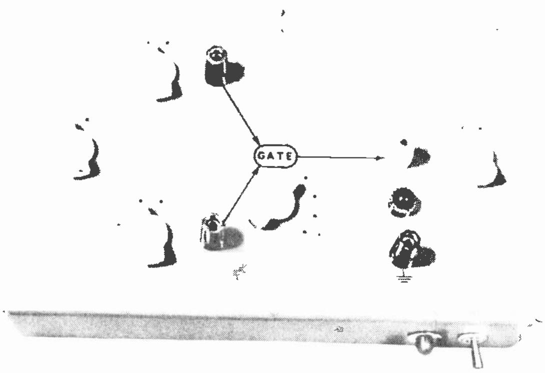
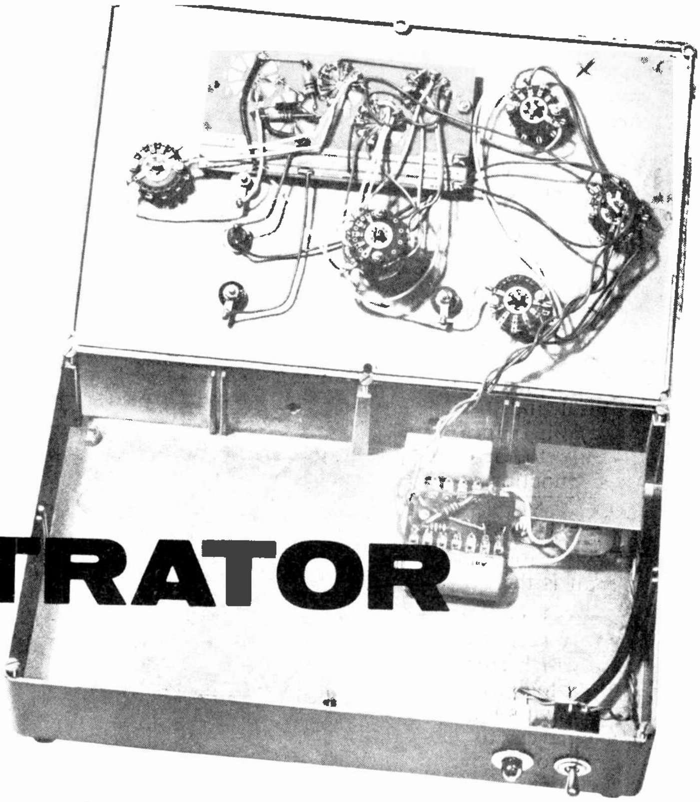


Fig. 17. Micro-E devices can also be mounted on thin film circuits. Scale approximately 5½ times







LOGIC DEMONSTRATOR

A simple means of showing the definitions of logic functions

By N. M. MORRIS

THE present trend in logic system design is towards the increasing use of microcircuits, and in its wake lie many associated problems of education. In this article the development of an experimental circuit is described, together with the reasons for it, in which all the conventional logic functions are generated by a simple switching sequence. Some elementary knowledge on switching logic is expected or can be acquired by reading text books on the subject.

DUAL FUNCTION

Many manufacturers of microcircuits offer logic gates under a name which suggests that each gate performs a dual function. For example, the μL914 is often referred to as a NOR/NAND gate. At first sight this can be very confusing, and unless the user has some knowledge of the meaning of logic signal levels (i.e. positive logic and negative logic), the difficulty may not be resolved!

In *positive logic* the more positive of the two switching voltages is logic "1", and the lower is logic "0". In *negative logic* the more positive of the two voltages is taken as logic "0", and the lower of the two logic "1".

In both systems a positive potential is taken to be greater than a negative potential (irrespective of the numerical values). Thus, if the two voltage levels which exist in a logic system are +0·2V and +3V (typical of a μL914 system), then the +0·2V signal corresponds to positive logic "0" (or negative logic "1"), whilst +3V is equivalent to positive logic "1" (or negative logic "0").

It is evident that the two logic levels are the inverse of one another, that is

positive logic "1" = NOT negative logic "1"
positive logic "0" = NOT negative logic "0"

or positive logic "1" = negative logic "0"
positive logic "0" = negative logic "1"

Clearly a gate which performs a specific function in one system appears to perform another logic function in the opposite system. For example, the μL914 gate can be used either as a positive logic NOR gate or as a negative logic NAND gate. Hence the meaning of the expression NOR/NAND.

LOGIC GATE DEFINITION

So far we have assumed that the logic signal levels applied to the input of the gate are operative at its output. There is no valid reason for this assumption. For instance, if positive logic levels are used at the input of the gate, and negative logic levels are used at the output, what then is the function performed by the gate? The solution to this problem has already been developed, and the results are in Table 1.

Thus a positive logic NOR gate (i.e. positive logic levels are employed at both input and output) perform the NOR function with input and output positive logic, and it generates the NAND function with input and output negative logic.

For a negative logic NOR gate (i.e. negative logic levels are employed at both input and output) the NOR function is performed and in the NAND function the input and output are positive logic.

INVERTERS

In an attempt to illustrate these functions, the

Table 1: INPUT/OUTPUT LOGIC DEFINITIONS

LOGIC LEVELS		FUNCTION		INVERTED OUTPUTS	
Input	Output	Positive Logic Gate	Negative Logic Gate	Positive Logic Gate	Negative Logic Gate
POS.	POS.	NOR	NAND	OR	AND
POS.	NEG.	OR	AND	NOR	NAND
NEG.	POS.	AND	OR	NAND	NOR
NEG.	NEG.	NAND	NOR	AND	OR

most satisfactory method would be to make up a demonstration unit using integrated circuits.

The basic experimental circuit, using positive logic NOR gates, allows all the required logic functions to be generated and is shown in Fig. 1. Gate G3 is the principal gate, while gates G1, G2, and G4 in conjunction with switches S1 and S2 act as logic level inverters. (The inverter is used to change an output of 1 to 0 and an output of 0 to 1.)

Let us assume for the moment that positive logic levels are being used throughout, so that the switches are in the position shown (note: the plus and minus signs on the switches merely indicate the logic signal levels 1 and 0, and not the polarity of the voltage at that point). In this event, inputs X and Y are applied directly to G3, and the output is the positive logic NOR function of the inputs, otherwise expressed as $\overline{X + Y}$.

If S2 is switched to the minus position, gate G4 acts as a logic level inverter, and the output from the circuit is then the negative logic version of the signal from G3, i.e., output $= \overline{\overline{X + Y}} = X + Y$

It is seen that the function generated by a NOR gate which employs positive input logic and negative output logic is the OR function of the inputs.

By switching S1 to the minus position, the input logic levels to G3 are inverted, and the output is found to be the NAND function of the inputs. The AND function is generated by leaving S1 in the minus position, and S2 in the plus position. Thus by a simple switching sequence it is possible to generate the four basic logic functions, i.e. NOR, OR, AND and NAND.

All that now remains is to provide additional switching and logic circuitry to enable the input signals (X and Y) and the output signal to be inverted, so that all 16 configurations in Table 1 can be generated.

PRACTICAL CIRCUIT

The schematic diagram of the unit is shown in Fig. 2. A supply of about +15V is used (anything between about 12V and 16V will do), the high voltage being necessary to energise the lamp drive unit which is described later. The total current drawn by the logic section in Fig. 2 is about 40mA at a voltage of approximately 3·9V, the supply being drawn from a simple Zener diode stabilised power supply (Fig. 4).

A resistor is included in the input circuit to match the output resistance of a μL914 gate. The input logic levels are selected by S2 (Fig. 2). In the upper position positive logic signal levels are applied to inputs X and Y, while negative logic levels are applied when the wipers of S2 are in the lower position.

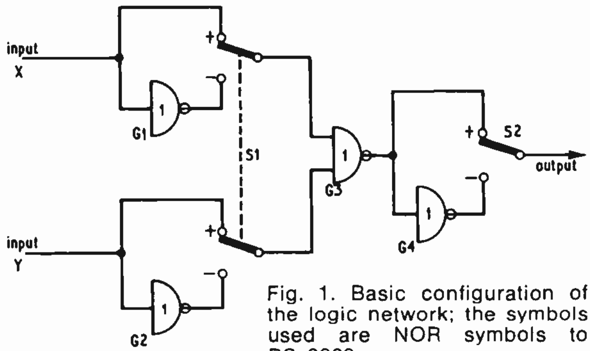


Fig. 1. Basic configuration of the logic network; the symbols used are NOR symbols to BS 3939

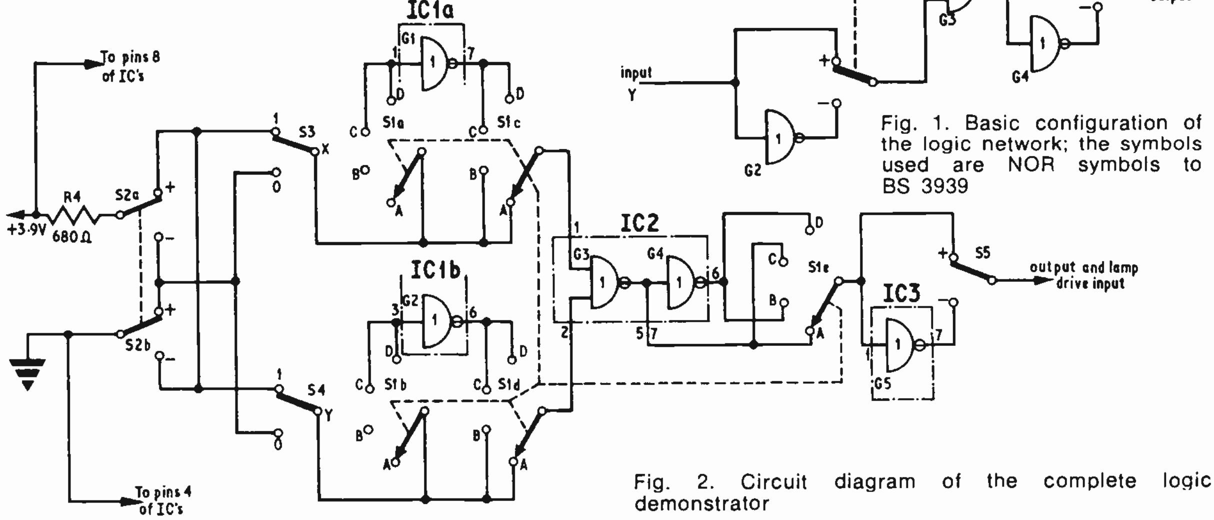


Fig. 2. Circuit diagram of the complete logic demonstrator

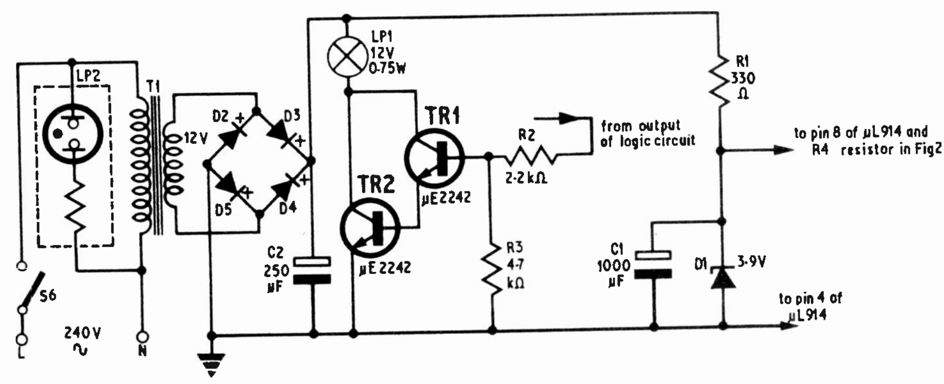


Fig. 3. Power supply and lamp drive unit

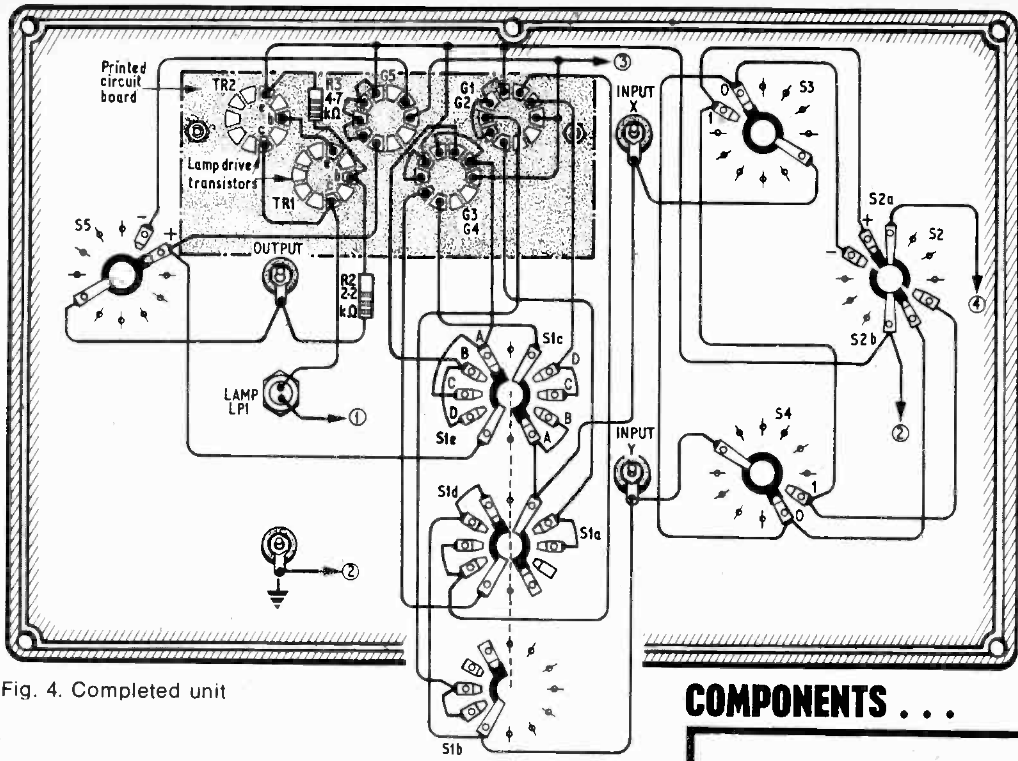
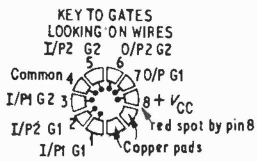
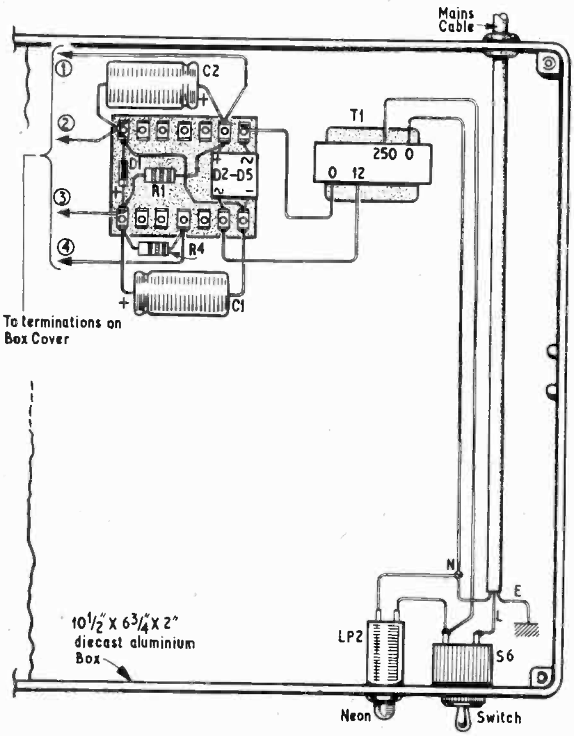


Fig. 4. Completed unit





COMPONENTS . . .

Resistors
R1 330Ω ½W R3 4·7kΩ
R2 2·2kΩ R4 680Ω
All ±10% ¼W carbon except R1

Capacitors
C1 1,000μF elect. 6V C2 250μF elect. 25V

Transformer
T1 Mains transformer, 12V 1A secondary

Diodes
D1 3·9V 1W Zener
D2 to D5 12V 0·5A Bridge rectifier

Transistors
TR1, 2 μE2242 or BC108 (2 off)

Integrated Circuits
IC1, 2, 3 μL914 (3 off)

Switches
S1 3-bank, 2-pole, 4-way, rotary
S2 2-pole, 2-way, rotary
S3, 4, 5, 1-pole, 2-way, rotary (3 off)
S6 1-pole, on-off, toggle

Miscellaneous
LP1 12V 0·75W indicator lamp
LP2 Mains neon with ballast resistor
Case, diecast box (see text)
Component boards (see diagrams)
Screw terminals

Switches S3 and S4 are used to select the appropriate input signals to lines X and Y, respectively; these lines are brought out to terminals on the front panel to allow the actual voltage levels to be monitored.

FOUR FUNCTIONS

Switch S1 is a 5-pole, 4-way switch made up from a 2- or 3-bank wafer assembly, and allows four basic functions to be generated. These four connections are arbitrarily designated A, B, C, and D, and the student has to determine the type of gate by truth-table tests.

Since positive logic NOR gates are used, the positive logic functions generated by the respective positions of S1 are:

Position	Function	Position	Function
A	NOR	C	AND
B	OR	D	NAND

These functions are generated by gates G1 to G4 inclusive. Gate G5 is used as an inverter in conjunction with switch S5 so that it is possible to select either positive or negative output logic levels.

The wiring of the integrated circuits is shown in Fig. 3. The output from the logic network is taken to a terminal on the panel so that the voltage can be monitored, but for demonstration purposes it is desirable to have visual indication of the output.

LAMP DRIVE

The lamp drive circuit is shown in Fig. 4, and consists of a super-alpha pair of transistors with a suitable input attenuator (almost any low-cost transistors will do if they have the current and voltage rating). Due to the simplicity of the circuit, it lends itself to printed circuit board construction, and the completed unit is shown in Fig. 5.

By means of a series of truth table tests, the student can see quickly what function is generated at each setting of the function switch. ★

BOOK REVIEWS

INTRODUCTION TO SEMICONDUCTOR DEVICES

By F. J. Bailey
Published by George Allen & Unwin
238 pages, 8¾in × 5½in. Price £3·95 hardback, £1·95 paperback

LONG chapters on solid-state physics usually form a prelude to books on semiconductor devices but in this case the author has reduced all this to a purely qualitative description based on the concept of the atom as a planetary system with charged particles revolving round a nucleus. This simplistic concept would be inadequate to explain such things as light emitting diodes or Gunn diodes but seems perfectly adequate in describing the range of devices in this book.

All the most common devices are included: diodes, Zener diodes, bipolar transistors, junction and insulated gate f.e.t.s and thyristors. There is also a section on integrated circuit technology. Descriptions are clear and give information of real practical value.

The section on integrated circuits seems rather too extensive for an "introduction" and the omission of the unijunction transistor which is now so common is surprising.

For the engineer or student this is a well written and thought out book, requiring no extensive knowledge of mathematics.

S.R.L.

CECIL E. WATTS—PIONEER OF DIRECT DISC RECORDING

By Agnes Watts
Printed and produced for the authoress by William Clowes & Sons Ltd.
150 pages, 9½in × 6½in. Price £2·25

A MAN of unusual qualities was "Dust-Bug Cecil", as he became affectionately known; a warm generosity, a determination to achieve by any means what he set out to do. Cecil E. Watts was a perfectionist, and an idealist—even his love for the authoress (his wife) in the earlier years seems to take second place while producing sound recordings on disc in poor accommodation. The First World War inflicted nauseating injury to his left leg and foot through a "pineapple" bomb. His selfless determination subsequently resulted in hospital treatments for respiratory and heart illness during the early years of MSS Recording Co.

From this platform, this biography builds a picture of the devotions of Cecil to his work and of his wife's unending tolerance of his determination and at times stubbornness. The Second World War laid restrictions on his activities to continue improving the standard of disc recording, until a renewed business obligation arrived in which he was requested to help the Post Office produce entertainment for H.M. Forces on disc. Through the MSS Recording Co. Ltd. and British Homophone, many of today's recording artists and engineers can indeed look upon Cecil as the co-founder of their livelihoods.

Although there is an unfortunate lack of chronology, this biography conveys much of the feelings of his wife and through her the character of Cecil and the history of disc recording techniques in England. There are abundant excellent photographs that enhance the story.

M.A.C.

POINTS ARISING

CHARGER-POWER UNIT *(June 1972)*

Page 511, Fig. 2 A connecting lead from the junction of D2 and D4 should be taken to socket SK2.

CALLERCORD *(August 1972)*

Page 688, Fig. 6. A connecting link from the junction of D15, C15 negative should be connected to the copper strip which has the supply lead "E" soldered at one end.

Page 690, Fig. 7. The diode D9 should be reversed.

P.E. GEMINI TUNER *(April, May, June 1972)*

The authors ask us to point out that there have been reported cases of misconnecting the i.c. CA3075. Pins 6, 7, 11, 12, 13, 14 must be left unconnected and for this reason small areas of copper around these pins are etched away on the p.c.b. Soldering these pins to the earth copper pad causes excessive power dissipation and may damage the i.c. permanently, also preventing the CA3075 from operating.

ELECTRONORAMA

New colour video display system

THE Moore Reed colour video system consists of a single keyboard and electronics package used in conjunction with a standard 625 line TV monitor. A "stand alone" unit requiring no special interface, the VT 109 Display is designed to accept serial or parallel inputs from any one of the many computers in common industrial use. It may be readily added on to an existing computer control facility or used as an integral part of new systems.

The use of colour adds considerable clarity to complex combinations of alphanumeric and graphic information. Displays which would otherwise appear cluttered and even unrecognisable in monochrome can be transformed by the addition of colour. Conversely a greater volume of information can be displayed.

Individual characters, symbols, types of information and sections of diagrams can all be clearly picked out in different colours. Any four of seven colours are supplied as standard. Additional colours are available if required.

In addition to offering colour alphanumerics the VT 109 incorporates complete sets of graphic symbols.

Vehicle identification

INDIVIDUAL vehicle identification and status can automatically be obtained with Motorola's new CD.100 mobile radiotelephone system. Designed to operate in any of the land mobile v.h.f. or u.h.f. bands the system incorporates five tone sequential selective calling techniques. Manual or automatic response from the mobile equipment is decoded at the radio control centre, displayed and recorded individually on an alpha/numeric display or collectively on a cathode ray visual display.

Manual updating of the mobile data equipment can provide status, location or other forms of information, dependent upon the way the system is pre-programmed.

Motorola have recently received contracts from several ambulance authorities for the CD.100 system, which is particularly valuable to the medium to large fleet operators, and significantly reduces use of the frequency spectrum.

New low temperature manpack

SEEN in the environment for which it is specifically designed, the new Racal-Mobilcal TRA.921L manpack provides satisfactory working over a wide temperature range. With a 20W output in the range 2–8MHz, Syncal "L" offers 6,000 synthesizer-controlled channels at 1kHz spacing.

Designed for simplicity of operation and maintenance, the all solid-state construction and the use of conservatively rated components ensure extremely reliable performance under the most demanding environmental (−40°C to +55°C) and operational conditions. Racal-Mobilcal manpacks are today in service in over 100 countries throughout the world.

Communication 72, an International Conference and Exhibition, was held recently at Brighton. Some of the electronic equipments displayed are pictured and described below.

Line scan recording oscilloscope

Of particular interest among Honeywell test instruments on show was the new 1856 Line Scan Recording Oscilloscope which provides excellent resolution (0·1mm spot diameter) with considerable versatility —up to 2μs per cm X scan speeds and 250 cm/sec paper drive speeds. A Y deflection capability permits the printing of conventional wave forms (d.c. to 100kHz) as well as providing simulated contour displays when combined with Z modulation—both in spectrum analysis and pictorial displays.

For use wherever line scanned information is transmitted, the Honeywell 1856 has high-speed picture build-up with near instantaneous print-out. Its flexibility in design provides also for spectrum analysis and conventional waveform recording.

Pocket pager

Wide area paging is now possible with Motorola's latest paging receiver. Pageboy II is a miniature pocket pager employing monolithic integrated circuitry throughout and has a unique built-in memory which can discreetly store a "page" to avoid embarrassment to the user.

Weighing less than 4 ounces and occupying only 4·9 cubic inches, the Pageboy II receiver houses a battery which provides up to 1,500 hours operation.

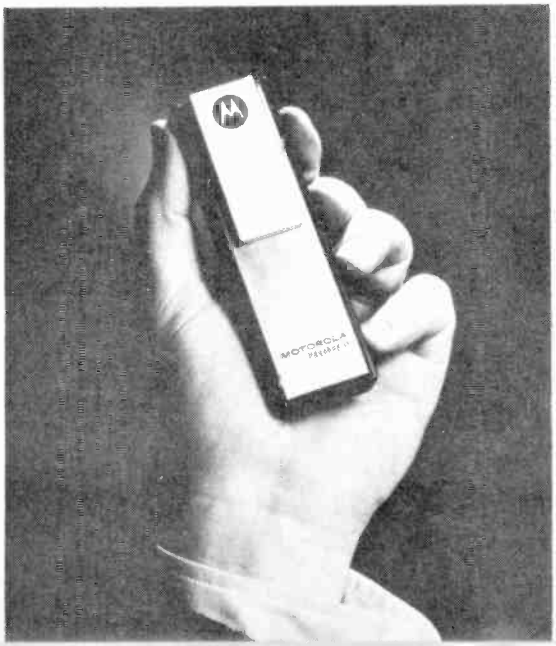
Both "tone only" and "tone plus speech" models are available together with an extra loud version for use under high ambient noise conditions.

Motorola have recently installed citywide paging schemes in many major U.K. cities involving their Pageboy I equipment. The introduction of the super-sensitive Pageboy II unit makes county and nationwide systems economically viable and already several potential large-scale users are evaluating the system.

P.c.b. digital tester

The Swift Digital Tester will be demonstrated during the exhibition. This low-cost portable ATE for use in the production, inspection and development testing of digital printed circuit board assemblies was introduced by Honeywell last year.

The system performs one million tests per second and indicates either a pass or fail with diagnostic assistance being given by a visual indication of the outputs at which discrepancies exist. Pre-set high and low pulse voltage limits are selected by push-button so that in most cases a board can be tested under both high and low tolerance conditions within a few seconds.



Gerry Brown . . .

ON THE FRINGE

PSYCHO BLUES

Mark my words, noise is going to be a racket (if you'll forgive the cliché) that over the next couple of years or so will cost an awful lot in prevention.

Peter Walker, Minister for the Environment, has already publicly stated that this will be next on his list of pollutants to get the axe. So, I guess, industrial people and even discotheques will shortly be in hot water if they pay no heed to the accumulative deafness that they could be inflicting upon unwitting individuals.

But, laudable though Mr Walker's intentions may be to reduce the effects of noise, particularly its insidious ability at high levels to produce permanent surdity, there remains the additional, rarely considered (and in many ways more pernicious), bogey. Namely, the psychological effect.

What, after all, *is* noise? I once heard it referred to as unwanted sound, and no doubt any other definition would fall short of the truth. This being so, pretty well anything comes under criticism from neighbours' children yowling like terriers after their street football, to dawn-calling dustbin-men over-zealous to get into fettle for "It's a Knockout!"

Of course, unwanted sound for one person is not necessarily unwanted for someone else, either from the psychological viewpoint, or, in the case of the already deaf, on the basis of intensity. Thus, it seriously looks as though hapless souls afflicted by psychological noise will have to resort to earmuffs if some kind of neurosis is to be avoided. It is highly unlikely that the offenders, basking in a euphoria of excess dB's, will tolerate being cajoled into attenuation, much less cessation!

HELP FOR THE OLD

With the sun brightly shining as we sit on a breakwater and idly dangle a toe or two in the briny, it is all too easy to forget the coming Winter and the terrors it can bring for many old folk.

During the cold months, aside from the consequences of slipping on ice and breaking a femur, there always exists the strong possibility of developing a condition of hypothermia (very much lowered body temperature) resulting from poorly or unheated homes. This, if permitted to continue for long can ultimately result in unconsciousness and death. Not a very pleasing thought, particularly since most older folk do not notice temperature drops all that easily and may therefore be totally unaware of the danger at the time.

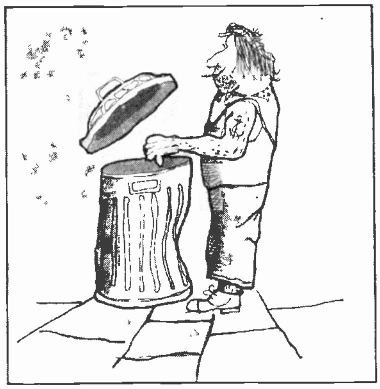
But this is just one problem. As I see it, the biggest threat to most senior-citizens is the difficulty of *communicating* any form of distress situation automatically to the outside world. One old chap I used to know thought up a manually-operated device that went part-way to beating the problem.

The device amounted to a lamp-box which flashed a "help!" notice to passers-by, provided it was first switched on; trouble was, one day he had a nasty fall and couldn't raise himself from the floor to reach the switch! Luckily for him, a caller was due and prevented what might have been a dodgy situation.

Some while later, he and I devised a set-up (see Fig. 1) which overcame most of the disadvantages of the earlier device. This arrangement is virtually fail-safe and relies upon a principle which requires the alarm to be reset from time-to-time to ensure that it doesn't go off.

Once the reset switch has been depressed, a long-duration timer runs down for, say, 12 hours, at the end of which its output operates a Schmitt trigger to set a 2 minute timer. This timer immediately sets off a warning light (and buzzer, if required) which indicates that the reset switch must be again depressed. Provided, at this stage, the system is reset, no further warning will be given until another 12 hours have passed.

However, if during the 2 minute period no attempt is made to reset, as when an emergency exists, then the short-term timer will cause the Schmitt trigger to switch. In so doing, a pulse will set the flip-flop causing a "help!" lamp to flash attention to the front window.



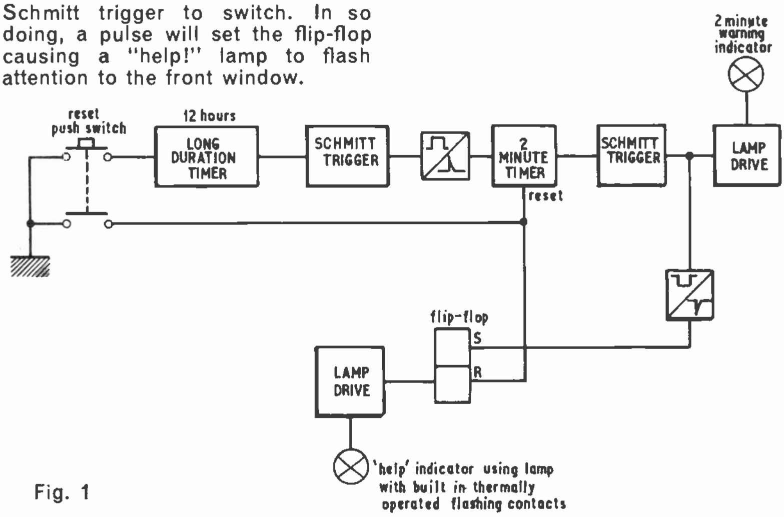


Fig. 1

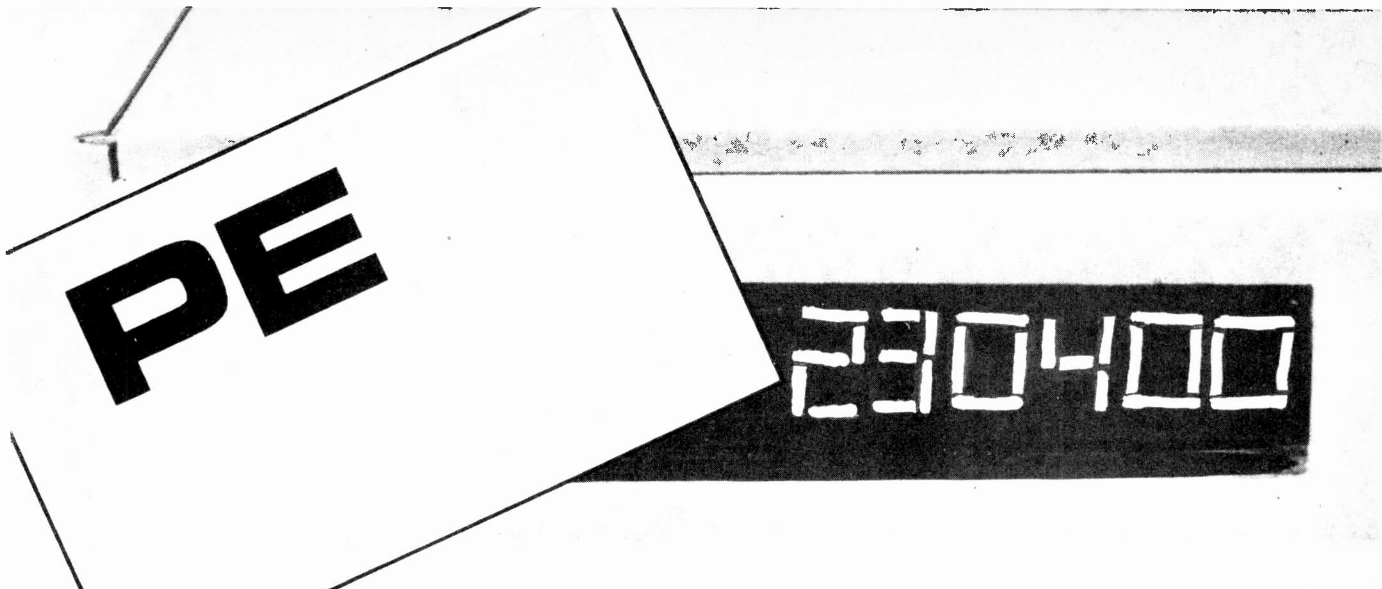
Refinements like a temperature warning, and a "holiday switch" to override the system while the owner is away could be incorporated. Another improvement might be a standby battery to take over in the event of a power cut.

Why not design and build one for someone you know, or even someone you don't? It could save their life!

PSITRONICS

In an age when science appears just about able to achieve anything, short of effecting an improvement in the cost of living or in an understanding between nations, it is refreshing to notice what is rapidly appearing to be a revival in the "cult" to apply electronics to psi, or paranormal phenomena.

Among a number of P.E. readers this subject seems to have been reapproached following my discussion about "Occultaphonics" in this column a few months back. Indeed, Pete' Morton, who contacted me recently, has suggested that a group be formed to investigate various types of design for psitronic (his handle!) equipment. His letter (see *Readout*) says that he will be pleased to hear from other readers interested in the subject, or those who are actively working with any experimental gear in this field.



By R.W.COLES PART 3

CONSTRUCTION OF THE DISPLAY PANEL

LAST month the construction of the main chassis was described. In this month's part the logic and construction of the display panel will be dealt with. The outputs from the power supply whose description also appeared last month will be used when it comes to the testing stage.

DISPLAY BOARD

Any calculator depends heavily on its display system not only because it is obviously necessary to register the answers to the problems being worked out, but also because it is required to display any data entered through the keyboard so that keying errors can be corrected immediately.

Digi-Cal has an entry capacity of six digits and an answer capacity of up to eight digits, making a display length of eight digits necessary. In addition to the display of numerical data the display is required to illuminate a decimal point in any one of four locations, the exact position being determined by the setting of the decimal point thumbwheel (for answers) and the contents of the decimal place counter (for entries).

The display format chosen for Digi-Cal is the "seven segment" system specified because of its simplicity and low cost.

With any display format, but particularly with the seven segment system, a multi-digit readout can look confusing if insignificant zeros are not blanked in some way to leave the significant digits uncluttered. For Digi-Cal a leading-edge ripple blanking circuit has been incorporated which produces a very easily interpreted display of the form normally used in written calculations.

DISPLAY DEVICES

When choosing the display devices three different types were considered, the gas-filled Nixie tube, the Light Emitting Diode (L.E.D.) and the incandescent filament.

Nixie tubes were rejected because of their bulkiness and high-voltage requirements and L.E.D.s because of their high cost. The device eventually selected was the Minitron type 3015F which is an incandescent filament, seven-segment readout with a built in decimal point, housed in a package with the same pin configuration as a dual-in-line integrated circuit.

GLOSSARY OF TERMS USED

CALL-UP bring data from a store or register
ENABLE allow the inputs or outputs of a device to become active. Also the reverse **DISABLE**
DATA BUS a wire or group of wires used to carry data to or from a number of different locations (see TIME SHARING)
DUMMY INPUT a temporary input to a device used to simulate an input that could occur (Note that with TTL i.c.s. an input with no connections to it will be equivalent to a logic 1)
RIPPLE BLANKING or ZERO SUPPRESSION the method of improving readability by switching off, i.e. blanking, all display devices whose inputs are insignificant zeros.
DIODE MATRIX a two-dimensional array of diodes used for a variety of purposes such as decoding and read only memory
READ ONLY MEMORY a system whereby unalterable data is held in store to be called up when required
ONE-OF-EIGHT or ONE-OF-TEN DECODER a decoder which takes a binary number as its input and produces only one active output (out of eight or ten) as its output
DECADE COUNTER a system which has ten states each of which is produced in turn when clock pulses are present at its input
CLOCK a system which produces pulses of fixed duration at a fixed repetition rate
TIME SHARING or MULTIPLEXING the method of selecting data from a number of sources in turn and presenting them on a single wire or group of wires
STROBE PULSE a pulse which enables a system for a fixed period only

The small size and low current requirements, along with their ready availability made the Minitron indicators ideal for the display, and ensured that both the indicators and the drive electronics could be built on the same piece of Veroboard, eliminating all of the messy readout-to-board wiring required with most systems.

DRIVE ELECTRONICS

The Minitron indicators are used in Digi-Cal as part of a completely self-contained display board working in the "time shared" mode.

Time sharing, or multiplexing the indicators in a display system involves scanning each digit of the display in turn, and switching it on for only a fraction of the total display period.

The basic principles of time shared displays were laid out in last month's article in the *Alpha Numeric Displays* series, and for this reason we need only discuss them briefly here.

One of the advantages of a multiplex system is that only one seven-segment decoder is required, instead of one per digit as in a static system. The single decoder is connected to each digit of the display in turn by means of an electronic commutator which at the same time calls-up the data to be displayed in that digit position from its stored location.

The scanning rate is made high enough that no flicker is detected by the human eye, and the energising voltage of the indicators is increased from its nominal d.c. value to compensate for the fact that each indicator is on for only a short time compared with the time it is off.

Another advantage of time sharing is that since all the data for display is not required simultaneously, connections between the data store and the display can be made by means of a time shared "data bus" (see *Alpha Numeric Displays,* Pt. 6) consisting of only four wires in this case.

BLOCK DIAGRAM DETAILS

The skeleton block diagram of the display system is shown in Fig. 3.1.

The 1kHz clock is used to drive a binary counter whose own outputs are fed to a decoder which produces a one-of-eight response to drive the electronic switches which connect the 20 volt line to the Minitron common terminals.

The one-of-eight output is also used to "call-up" each bit of the data in turn from the entry and the answer registers of the calculating unit. Both the entry and the answer data buses are routed to the display board where one of the two is selected for display by a gating arrangement controlled by the programme.

The selected data is fed to a seven segment decoder which produces as its output a series of "earth" connections corresponding to the segment pattern for that numeral.

The seven outputs from the decoder are wired to all the Minitron segment wires (via an isolating diode matrix) but since only one of the Minitrons will be connected to the 20 volt supply only that device will indicate the data on the bus. In the following time period of course, a different Minitron will be "enabled" and a different B.C.D. code will appear on the bus.

CIRCUIT OPERATION

The circuit of the display is shown in Fig. 3.2, and before going into a detailed guided-tour it would be useful to spend a while correlating the various components on the circuit with their counterparts in the block-diagram (but note that a few of the components cannot be found a home in this way).

In the detailed circuit the clock (Fig. 3.3) is used to drive an SN7490 (IC6) decade counter which has its D output connected to the RESET input so that as soon as a count of eight appears the counter is reset to all zeros from which it starts to count up again.

The output from the SN7490 is decoded by an SN7442 one-of-ten decoder (IC5), which in this case is made into a one-of-eight version by connecting its D input to earth permanently.

The SN7442 outputs are "active low" which means that all outputs except the energised one will be in

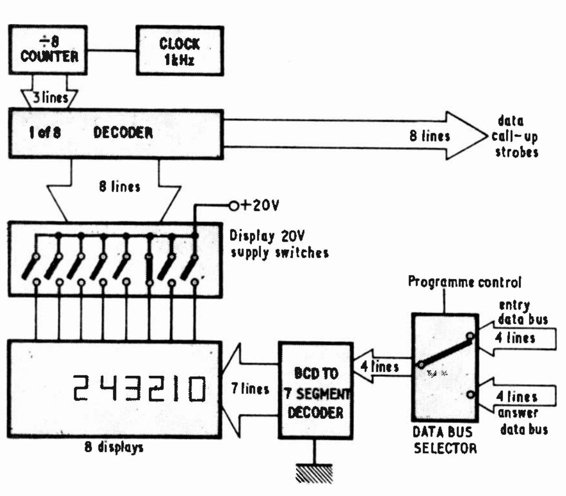
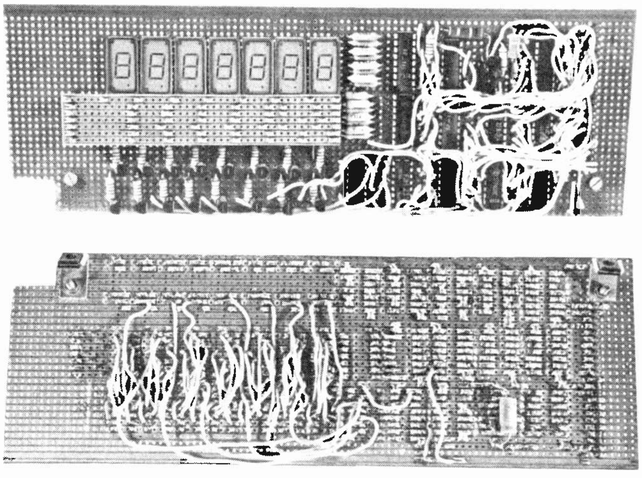


Fig. 3.1. Block diagram showing the main sections of the display panel



Photographs of the two sides of the Veroboard panel in the prototype. Construction is complete except for one Minitron. Note the underside wiring from the diode matrix to the Minitrons

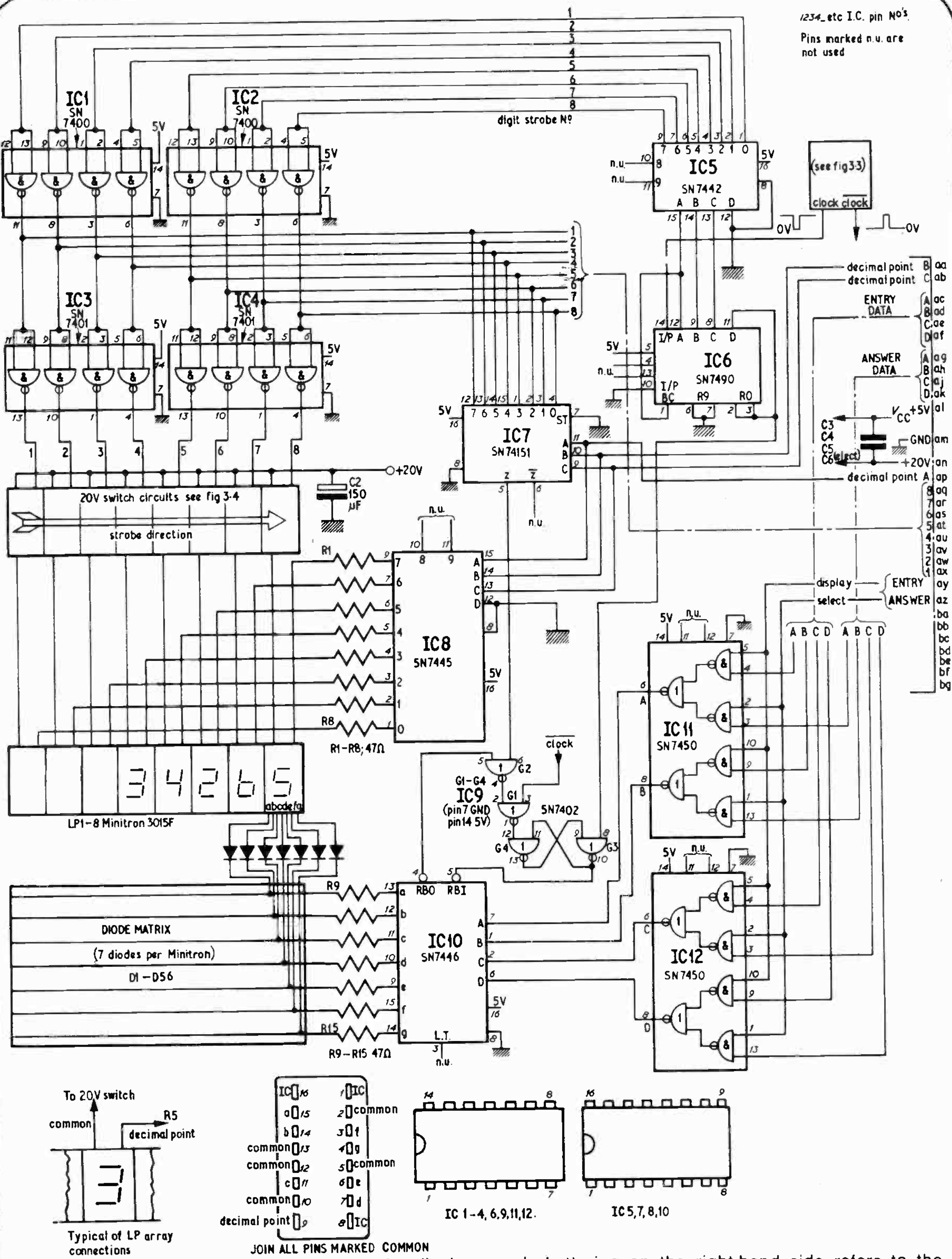


Fig. 3.2. The complete circuit diagram of the display panel. Lettering on the right-hand side refers to the copper strips as shown in Fig. 3.5

the "logic 1" state. This is the wrong sense to drive the following circuits so two quad NAND gates IC1, IC2 (SN7400) are used as inverters to give a one-of-eight code which is "active high".

The eight lines so produced are used both to drive the eight electronic switches routing the 20V supply to the selected Minitron, and to call-up the correct data from the remote storage registers.

ELECTRONIC SWITCH

The circuit of each of the eight 20 volt switches is shown in Fig. 3.4 along with one of the eight open-collector gates used to drive it.

The SN7401 gates also act as inverters so that the selected gate will have an "active low" output, or in other words, a low impedance earth connection, this earth connection being used to turn on the *pnp* switch via a resistor and Zener diode.

The Zener diode is used to protect the output transistor of the gate which has quite a low collector breakdown voltage of about 15 volts. The Zener actually employed in this position is the reverse biased base emitter junction of an *npn* transistor with a breakdown voltage of about 6·5 volts: using a transistor instead of a purpose-built Zener is actually cheaper where voltage tolerances are loose.

It is worth noting that the breakdown voltage of SN7401 gates is not guaranteed above seven volts by the manufacturers, but in tests these gates have nearly all shown breakdowns of 15 volts or more which is satisfactory for these purposes, and should a particularly poor device be found (this will be indicated by its digit being "on" permanently) the gate can be replaced.

DATA BUSES

Returning to the main circuit, the two data buses are fed to four AND-OR-INVERT gates IC11, IC12 (2 × SN7450) which act as four single pole change-over switches with the extra feature that they also invert the data on the buses, a desirable feature in fact, since this data is in complement form to start with.

Selection of the required data bus is performed by two control wires which come from a bistable in the control programme, the selected bus being fed from the SN7450s to the SN7446 seven segment decoder inputs (IC10).

Each of the SN7446 outputs corresponds to one of the display segments labelled "a" to "g", and these outputs are wired to all eight of the appropriate segment connections on the Minitrons via a diode matrix and current-limiting resistors.

The diode matrix is necessary to ensure isolation between the separate indicators, and consists of one diode for each segment of each Minitron, making 56 in all.

The current-limiting resistors are included to limit the high inrush of current to the outputs of the decoder possible when an indicator is first switched on and is cold. Since the output of the decoder is subject to continuous switching in a time shared system these resistors are vital.

DECIMAL POINT

The decimal point in the Minitron indicator is effectively an extra segment, one of its connections being made to the COMMON terminals, and the other being available for control purposes.

In the Digi-Cal system the control wire for the selected decimal point is grounded through a one-of-eight decoder, the filament being switched on along with the appropriate numeral segments when the correct digit-strobe is present and the COMMON terminal simultaneously connected to the 20V supply.

The required position of the decimal point is defined by a three bit binary code which can originate in one of two places the appropriate one being selected in the keyboard circuit by the control programme.

The three wires bringing the code to the display carry it in inverted form so that 111 means "no decimal places" and 000 means "seven decimal places".

The three bit binary number is fully decoded to its one of eight equivalent by an SN7445 decoder (IC8) and the appropriate connections made via current-limiting resistors to the decimal point control lines on the Minitrons.

Eight separate decimal point positions are not required by the arithmetic section of Digi-Cal which as it stands can only cope with four separate decimal points.

The display unit is wired for eight positions, firstly to allow for improved calculating circuitry and secondly to make the display a self-contained system which can be used for any other purpose should this be required.

If desired by the constructor, the few extra wires redundant in Digi-Cal can be left out as well as R1 to R4.

RIPPLE BLANKING

Up to now the ripple blanking circuitry (IC9 and IC7) has been ignored, and this has been done because it is essentially an "add on extra" feature making it possible to leave it out altogether without affecting the operation of the rest of the circuit.

Despite the fact that it is optional, however, it must be said that the display readability is sadly reduced without it and its incorporation is highly recommended.

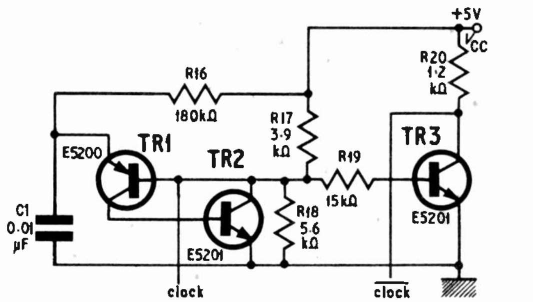


Fig. 3.3. Circuit diagram of the clock generator circuit

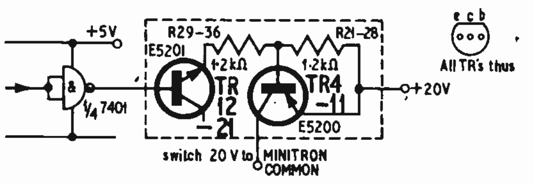


Fig. 3.4. Circuit diagram of the 20V switching circuits, eight of which are required

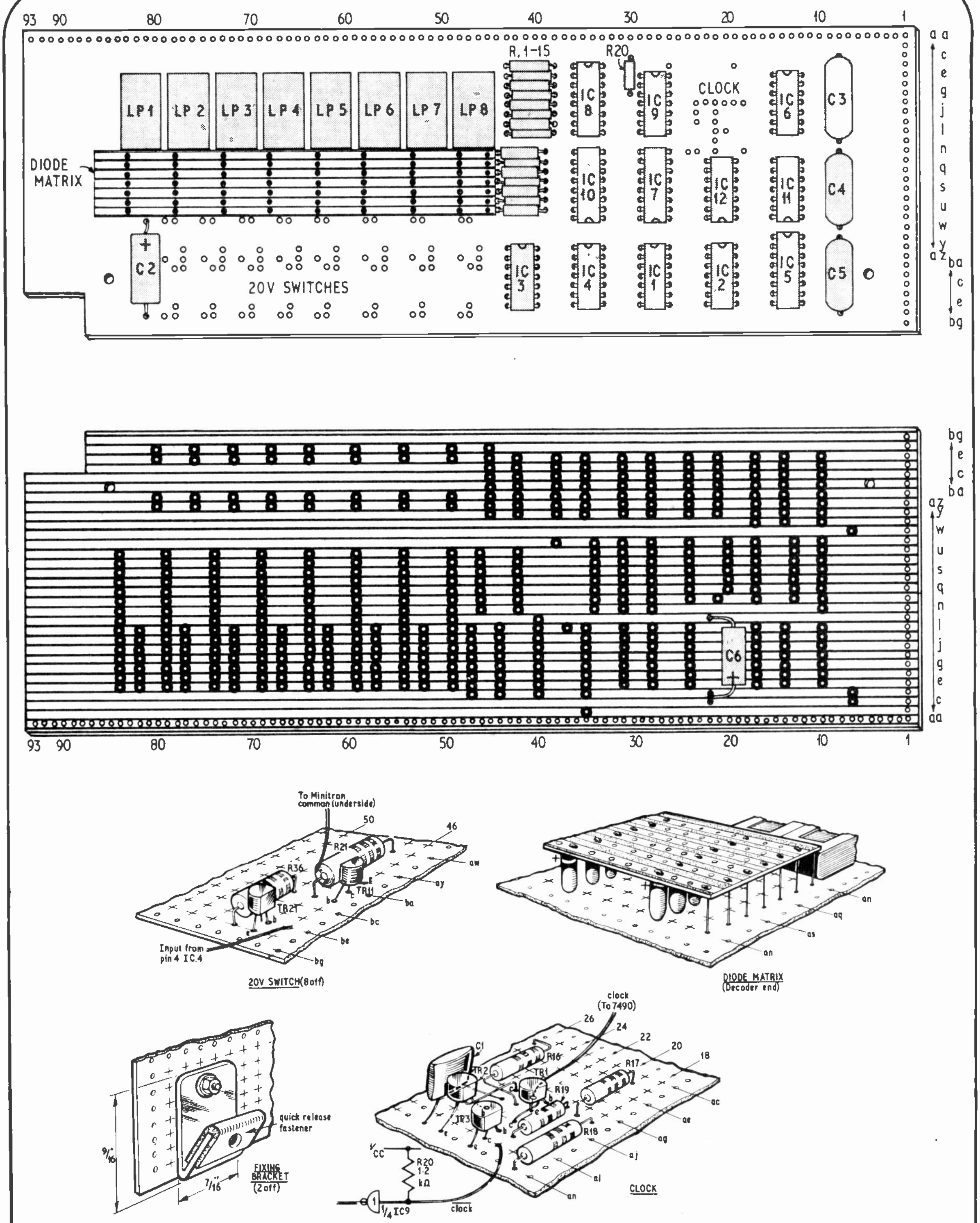


Fig. 3.5. Component layout and copper strip breaks for the Veroboard display panel. Details of the construction of the clock, diode matrix and 20V switches are shown in the smaller diagrams

In a time shared system the ripple blanking information has to be stored for future use with subsequent digits as they arrive on the data-bus, and in the Digi-Cal display this storage is effected by means of a "custom-designed" flip-flop in the form of an SN7402 quad two input NOR gate, IC9.

The display strobing system operates from left to right across the display, the most significant digit being displayed first, and as each digit is decoded by the SN7446 an extra output is produced for use in the ripple blanking circuit.

This output is a "zero detect" output which will go low if the data at the input of the decoder is 0000. If this ripple blanking output is low at the start of a strobing run across the display then that first digit is blanked by a low input to the decoder's ripple blanking input and at the same time the fact that this digit is a zero is "remembered" by the SN7402 flip-flop.

If the next digit is also a zero it will be blanked in turn and so on until the first significant number appears at the decoder inputs at which time the flip-flop will be set by the corresponding high output on the ripple blanking output (RBO) pin.

From this point on, any digit, regardless of whether it is a zero will be displayed until the flip-flop is reset by the strobe counter reset pulse at the end of a run.

DECIMAL POINT ZEROS

The system as just described performs the suppression of all leading edge zeros as required, but can give peculiar results in some conditions.

If the answer or entry to be displayed consists of all zeros for example then they will all be blanked to give a display consisting of nothing but a decimal point, an obviously unsatisfactory state of affairs, and one which can be corrected by arranging to have the ripple blanking flip-flop set by either the appearance of a significant digit *or* the appearance of the digit immediately preceding the decimal point even though it be a zero, whichever arrives first in each display run.

With this proviso an eight digit answer consisting of all zeros would be displayed as 0·00 (two decimal places selected).

Arranging for the ripple blanking flip-flop to be set in this way is quite straightforward except for the fact that the decimal point position can be in any one of eight places, a complication which is overcome by the use of an SN74151 eight line to one line multiplexer (IC7).

This device operates in a similar manner to a one pole eight way switch, the switch position being determined by the three bit binary code input, which in this case is the decimal point position code.

The eight inputs are provided by the display strobes, only one of which will be selected by any particular code for transmission to the Z output. When the selected strobe appears it is routed straight to the flip-flop SET input and it removes the blanking signal until the end of the display run when the flip-flop is reset and the process repeated.

CONSTRUCTION

The baseboard for the display consists of a single piece of Veroboard cut from a West Hyde type 122 board which has a matrix of 0·1in.

COMPONENTS . . .

DISPLAY PANEL

Resistors

R1–15	47Ω (15 off)
R16	180kΩ
R17	3·9kΩ
R18	5·6kΩ
R19	15kΩ
R20–36	1·2kΩ (17 off)

All ¼W, ±10% carbon

Capacitors

C1	0·01μF
C2	150μF 15V elect.
C3–5	0·047μF (3 off)
C6	10μF 15V elect.

Transistors

TR1	E5200
TR2, TR3	E5201 (2 off)
TR4–11	E5200 (8 off)
TR12–21	E5201 (8 off)

All West Hyde types

Diodes

D1–D56 West Hyde type "red" (56 off)

Integrated Circuits

IC1, IC2	SN7400 (2 off)
IC3, IC4	SN7401 (2 off)
IC5	SN7442
IC6	SN7490
IC7	SN74151
IC8	SN7445 (*or* SN74145 see text)
IC9	SN7402
IC10	SN7446 (*or* SN7447 see text)
IC11, IC12	SN7450 (2 off)

Display Devices

LP1–8 Minitron 3015F (8 off)

Miscellaneous

0·1in matrix Veroboard (9·3in × 3·3in)

The dimensions of this board along with the copper strip break layout are given in Fig. 3.5.

The component layout is also shown in Fig. 3.5, and when wiring up this diagram should be used in close conjunction with Fig. 3.2.

With a circuit board of this complexity it is impossible to give a point to point wiring diagram, so all the pin numbers of the integrated circuits have been given on Fig. 3.2.

The best strategy to employ when wiring up is first to label all the i.c.s with sticky labels so as to correspond to the i.c. numbers in Fig. 3.2. Wiring should be carried out using thin single core wire and wherever a number of wires need to share the same i.c. pin a terminal pin can be used to make this easier.

The circuit should be built up in blocks, checking the functioning of each block before proceeding to the next. The first block should be the clock circuit, followed by the counter (IC6), the decoder (IC5), then one digit strobe gating circuit (one gate of IC2, the corresponding gate of IC4 and its associated 20V switching circuit).

When wiring the integrated circuits it is a good idea to wire up all the power supply lines (5V and 0V) before the logic gates themselves as this allows the functioning of the i.c. to be checked as its wiring is completed. *continued on page 776*

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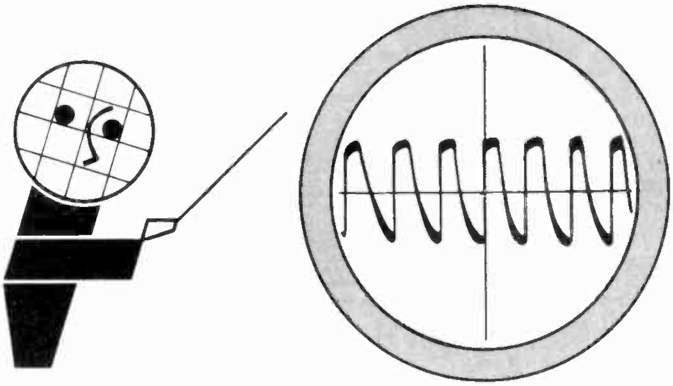

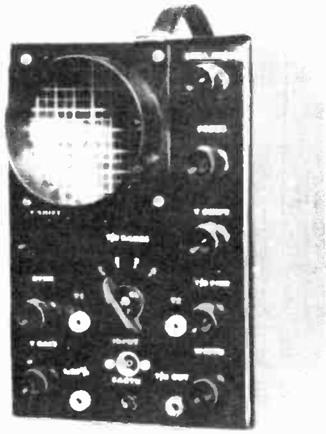

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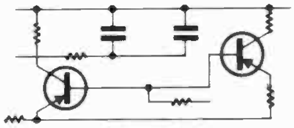

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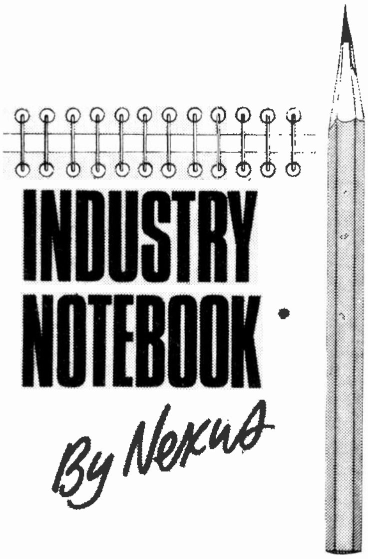


LASERS IN THE NEWS

A laser optical wideband transmission system is under development at the Signals Research and Development Establishment (SRDE) at Christchurch. A single flexible glass fibre is used as the transmission medium and it can be laid just as any ordinary electrical conducting cable (i.e. round corners) and harnessed and laced with other cables. A gallium arsenide laser is used with a simple silicon photodetector at the other end. An alternative non-laser system also being investigated uses bundles of fibres and simple gallium arsenide lamps.

The advantage of the system is its high immunity against electromagnetic pick-up and it is therefore particularly valuable in environments which are electrically "noisy". The development is seen as one answer to the problem of interference-free data transmission or voice communication in bad environments such as ships.

The German company Siemens is experimenting with lasers from an entirely different angle although still in communications. They like it for the astonishing number of communications channels available over a single laser beam but, of course, there is still the problem of atmospheric attenuation in free space.

An experimental installation has now been set up in Munich over a 5·4 kilometre path between the district of Obersendling and Giesing. A 5W CO_2 laser is used, emitting an invisible infrared beam which, say Siemens' engineers, is less susceptible to atmospheric influence than the visible beam emitted by helium-neon lasers. It has been found that transmission is still possible in heavy mist, moderate rain, fog and snow and, in fact, any atmospheric disturbance where deterioration of the signals is less than 8dB/kilometre.

For high volume short-range traffic in cities, say between tower blocks, the system shows considerable promise especially for data transmission where, if there should be a temporary break in communications due, perhaps, to heavy rain, the data can be temporarily stored and then transmitted in high speed bursts when the channel is open.

Nobody has yet made a fortune from lasers but they could become big business in this sort of application when one considers that every major city could be using scores of such links in the 1980's merely because the local land-lines are already overloaded as, indeed, they will be.

CONTROLLING UPPER AIR SPACE

I was fortunate in being one of the very few journalists to be invited to inspect the new Eurocontrol air traffic control centre in Maastricht, Holland. The Centre has been designed to control the upper air space over Belgium, Holland and part of north west Germany. It has been built by a consortium of companies comprising Plessey Radar (UK), Thomson-CSF (France) and AEG-Telefunken (Germany).

It is a massive complex of sight computers, 140 cathode ray display units, and operating positions for 80 controllers and trainees. Now only in partial operation, it is in its final stages of development and should be in full operation by late 1973. The Centre is costing some £5 million and looks like being a good investment as it is clearly a pattern for similar centres elsewhere in Europe and, possibly, in other parts of the world. The Eurocontrol Commission of Ministers has already announced a further installation to be based on Karlsruhe.

Meanwhile there is uproar over the British ATC centre at West Drayton with much of the blame for its operational shortcomings allegedly being attributed to the Marconi computer system. J. W. Sutherland, chief of Marconi Radar Systems, is defending the computers and blaming constantly changing operational requirements which have resulted in computer capacity below that now required. Wherever the problem lies, the consequence is that larger and faster computers are now needed and are being ordered.

The only crumb of comfort is that the Americans have been in similar trouble and, surprisingly, Eurocontrol who should have profited by the experience of America and Britain, having started much later, has already decided that three IBM 370/155 computers will be needed in place of the present 360/50 complex as air traffic growth was underestimated, especially that of charter flights.

Mutual recriminations between specifiers and equipment suppliers may help injured pride but don't help the provision of quick solutions to problems. The successful implementation of very large integrated electronic systems is clearly much more difficult than was thought. It was refreshing to hear Eurocontrol administrators admit quite openly that a mistake had been made which would be speedily rectified.

MAKING THE GRADE

Giant GEC and medium-sized Racal have both announced record profits and growth during a period when business conditions have been anything but easy. Which just goes to show that well-managed companies can make progress in bad times as well as good.

The Unitech Group has recently acquired APT Electronics and might well be looking for further expansion through acquisition. One Unitech company to keep an eye on is Data Recognition Ltd., specialising in Optical Mark Reading (OMR) equipment for data-entry into computing systems. OMR is proving to be something more than the poor man's optical character recognition system. It is now taking off in a big way, fully justifying the faith of NRDC who backed Data Recognition's pioneering work and now see it coming to fruition with several large contracts in hand.

MICROWAVE 73

Europe's first full-scale Microwave International Exhibition and Conference, scheduled for next year, already looks like being a winner. A call for papers has been put out and I understand that the exhibition stand space has already been more than half sold.

The event is to be at the Metropole Hotel, Brighton, which is turning out to be something of an up-and-coming electronics centre. Communication 72 was a success which is to be repeated in 1974. The annual Internepcon show is now a "must" in everybody's diary and the Electro-Optics show is another big draw. And it's not just because Brighton is a jolly place to have a conference and exhibition, although it clearly must be a factor. More important is the organisation, the quality of the speakers, the technical standing of the delegates and the rigid exclusion of literature-snatchers.

PATENTS REVIEW...

CONNECTING UP SLAVE BATTERIES

In BP 1 270 799 Joseph Lucas (Industries) Limited suggest a simple answer to the irritations which can occur when a car battery is semi-flat or flat and a slave battery has to be connected in parallel with the flat one to start the vehicle.

Connection to the flat battery is by non-conventional crocodile clips. Each clip is formed from two halves in normal "clothes peg" manner, but the two halves are insulated from each other to provide two separate "flat" terminals at each crocodile clip. As well as the double crocodile clips, X1 and X2, a pair of conventional "slave" clips X3 and X4 are used for connection to the slave battery.

One terminal of each "flat" pair (11b, 12b) are connected together through diode D1 and relay coil RLA in series, a warning lamp LP1 being shunted across the relay coil, see Fig. 1.

BP 1 270 799

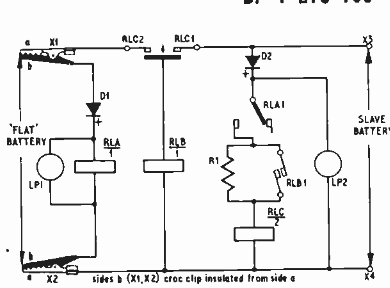


Fig. 1

The "slave" terminal X3 connects to fixed contact RLC1 of an electromagnetic relay of which another fixed contact RLC2 connects to "flat" terminal X1a. The relay contacts are bridged by RLC relay wipers when the coil is energised. One end of RLC coil is connected to the "flat" terminal X2a and the other end to the slave terminal X3, via resistor R1, contact RLA1 which is normally open (but can be closed by the relay coil) and diode D2.

The relay coil RLC, R1 and RLA1 contact is bridged by another warning lamp LP2. Finally the RLC wiper contacts are connected to both the terminals 12a ("flat") and X4 ("slave") through relay coil RLB1 which controls contact RLB1 bridging the resistor R1.

In use the terminals X1a, b and X2a, b, are connected to the flat battery and any useful current flows through the relay coil RLA to close RLA1 and lights up the lamp LP1.

The terminals X3 and X4 go to slave battery and the lamp LP2 lights up. If lamps LP1 or LP2 fails to light, the indication is that a connection has been made the wrong way round with the diodes blocking any discharge and so averting problems. Failure of lamp LP1 to light can also, of course, mean a totally flat battery.

The relay RLC is energised (so long as RLA contacts have closed) and the RLC wiper contacts link the RLC2 and RLC1 contacts together to provide a simple parallel connection of both batteries. Relay coil RLB also operates to open RLB contacts and so limit the current through coil RLC. The circuit thus automatically provides various safety factors. If the battery is hopelessly flat, then there will be insufficient current through RLA coil to pull over the contact RLA1. If either battery is connected up the wrong way round, the diodes will block and prevent damage. Also, if either clip is removed RLA coil will be "open circuit" and RLC wiper contacts will open.

FIBRE OPTIC IGNITIONS

A CLEVER use for light guides turns up in British Patent 1 257 794. This is from the British firm Associated Engineering Ltd., and is for an optical system which controls ignition systems in internal combustion engines.

In its basic form the mechanical rotor arm arrangement is replaced with an equivalent optical arrangement, Fig. 1. A solid state source, such as a gallium arsenide diode, emits light continuously and is picked up by one end of a rotating L-shaped light guide. The other end of this light guide sweeps past a sequence of fixed light guides; one for each of the engine cylinders. The light from each stationary guide is detected and passed to a pulse forming circuit. The output pulses are then fed to separate h.t. coils in series with each sparking plug.

In a more sophisticated arrangement the stationary light guides are in pairs for each cylinder of the engine, see Fig. 2. The gallium arsenide diode produces a continuous low level light output which is fed by the rotating guide to the first light guide of each pair and then to an associated photoelectric detector and pulse trigger circuit. A delay circuit is introduced between the detector and trigger circuit so that the triggering pulse may be varied in accordance with differing engine timing requirements.

The low level output from the gallium arsenide diode is sufficient to produce an output from the detector stage and this output is sufficient to trigger a high intensity light pulse from the diode. This high intensity light pulse is picked up by the second light guide of each pair and initiates sparking by feeding pulses to an h.t. coil in the same way as the basic circuit.

The delay which is introduced into the first circuit can be controlled by engine parameters such as r.p.m. or manifold pressure and allows advancing or retarding of the trigger pulses, and thus sparking. This way, engine timing can be optimised.

BP 1 257 794

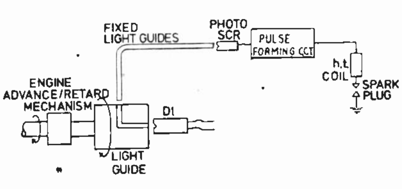


Fig. 1

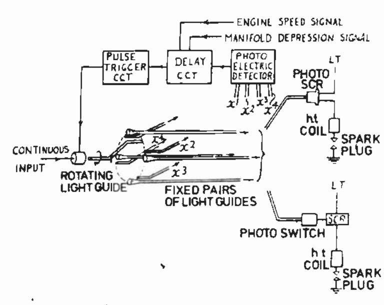


Fig. 2

ALPHA NUMERIC DISPLAYS Part 7

By R.W. Coles

Other types of Display

IN THIS final part of the series we are going to have a look at some display technologies which are still on the fringe of amateur project usefulness, the first because it is relatively new, and the second because devices are not currently available from the usual suppliers.

It is readily apparent that today's "fringe" device is tomorrow's best solution, and no discussion of the display scene would be complete without a mention of these two novel and useful techniques.

LIQUID CRYSTALS

Sounding like a contradiction in terms, these new display devices are expected to eventually share the bulk of the display market with L.E.D.s, complementing these devices because of their suitability for large area displays.

The operating principles are based on the utilisation of a class of organic materials which exhibit a regular crystal-like structure even when they have melted from the solid and become liquid. This effect occurs over a fairly restricted temperature range, and much of the development centering on these materials has been aimed at increasing their operating temperature range.

There are various types of liquid crystal structures, all of which are capable of useful employment in display devices, the most popular at the moment being the "nematic" type in which the cigar-shaped molecules are aligned with each other in a two dimensional sheet over the normal liquid crystal temperature range.

The liquid is normally transparent, but if it is subjected to a strong electric field ions move through it and disrupt the well-ordered crystal structure, causing the liquid to turn an opaque, milky colour. Removal of the applied field allows the crystal structure to reform and the material regains its transparency.

PRACTICAL LIQUID CRYSTAL DISPLAY

The basis of a useful display technique is inherent in the behaviour of the nematic molecules, and the way in which this is realised can be seen in Fig. 7.1 which shows an exploded view of a typical liquid crystal display "plaque".

The liquid crystal material is held in the centre cell of a glass sandwich, the inner surfaces of which are coated with a very thin conducting layer of tin oxide, which can be either transparent or reflective as required. The oxide coating on the front sheet of the indicator is etched to produce a seven (or more) segment pattern with fine interconnections to edge terminal pads, each of the segments being insulated from each other.

The voltage typically required to render the segments opaque is 30V and this voltage can be applied in either sense, a fact which makes a.c. operation quite feasible, even desirable, because of the reduction of electrolytic transport, i.e. erosion of the electrodes and the consequent increase in life.

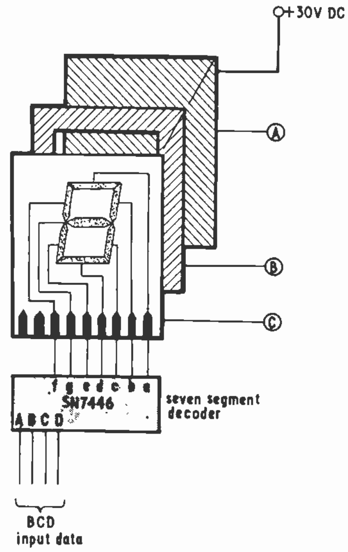
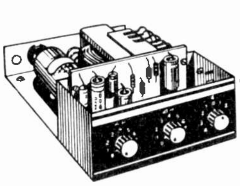


Fig. 7.1. Construction of a typical liquid crystal display. Sheet A is a glass sheet covered with a conductive layer (which can either be transparent or reflective), sheet B is a spacer to produce a cavity to contain the liquid crystal and sheet C is the front glass sheet which has a (transparent) conductive layer in the form of a seven-segment layout

SUPERSOUND 13 HI-FI MONO AMPLIFIER



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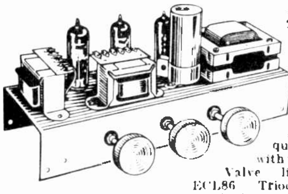

A.c. mains 200-240 volts. Using heavy duty fully isolated mains transformer with full wave rectification giving adequate smoothing with negligible hum. Valve line up:–2 ECL86 Triode Pentodes. 1 EZ80 as rectifier. Two dual potentiometers are provided for bass and treble control, giving bass and treble 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 300mV 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 11in. w · 4in. x. Overall height including valves 5in. Ready built and tested to a high standard. **Price £8·92.** P. & P. 45p.

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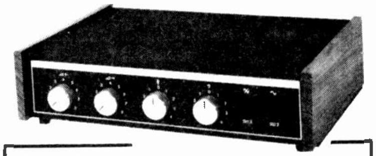

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Note: The above amplifier is suitable for feeding two mono sources into inputs (e.g. mike, radio, twin record decks, etc.) and will then provide mixing and fading facilities for medium powered Hi-Fi Discotheque use, etc.

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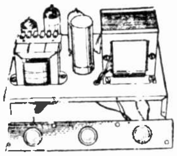

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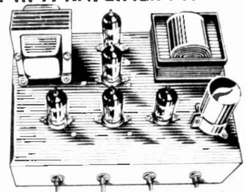

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VERSATILITY

One of the unique aspects of liquid crystal displays is that, like the printing on this page, they rely on ambient illumination and generate no light of their own. This means that liquid crystal readouts can be used in any situation where the printed word can be read, and the stronger the ambient lighting the better, a complete reversal of the general indicator trend where readability decreases as ambient light increases.

The liquid crystal usefulness does not end here, however, because if the rear electrode is made transparent instead of reflective then back illumination can be provided by a standard indicator lamp, rendering these devices equally suitable when ambient lighting is poor, see Fig. 7.2.

Extending back illumination a step further, by adding a lens arrangement, a projection system can be constructed which uses the liquid crystal plaque rather like the slide in a slide projector to give an enlarged image.

AVAILABILITY

Liquid crystal displays are potentially very cheap indeed but at present they are still fairly expensive because they are not being mass produced, though development is continuing apace.

The main researchers and potential suppliers in the U.K. appear to be the Marconi company, though no doubt interest from other firms will increase now that practical displays have been shown to be a sound proposition.

For the future, Marconi also have a display under development which uses a cholesteric molecular arrangement to give an indicator which changes from one colour to another as the field is varied, and it seems that a variety of colour combinations will be possible.

FLUORESCENT PHOSPHOR DEVICES

This high sounding technology is in fact one of the most widely used techniques in the industry and is the mechanism employed in both monochrome and colour television display tubes as well as the humble "magic-eye" tuning indicator, and the oscilloscope.

With such a long-standing application in the picture display field it is hardly surprising that the fluorescent phosphor principle should be used in the alpha-numeric readout field, and in fact a number of techniques have been employed.

Phosphor devices of all types employ an anode plate which is coated with phosphor material; when the phosphor is bombarded with high energy electrons from a cathode the energy in the electron stream is converted by the phosphor into light energy of a particular frequency which causes the coating to "fluoresce".

Different phosphor materials emit light of different frequencies (i.e. colours) and in the colour television tube for example, groups of three different phosphors (triads) emit red, green and blue light to form the picture required.

When electron bombardment is stopped the phosphor continues to fluoresce for a while until the stored energy is spent, and different types of phosphors can be obtained with varying persistence from a few milliseconds to several seconds. The tube for a slowly rotating radar display would need a long persistence phosphor and that of a high speed scan television tube a phosphor with a short persistence for example.

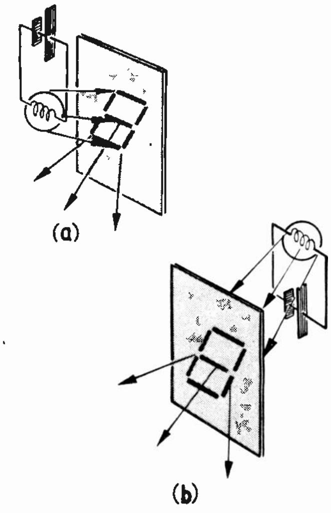


Fig. 7.2. (a) Using front illumination, the "on" segments are opaque to reflect the light (b) with back illumination the "on" segments are transparent

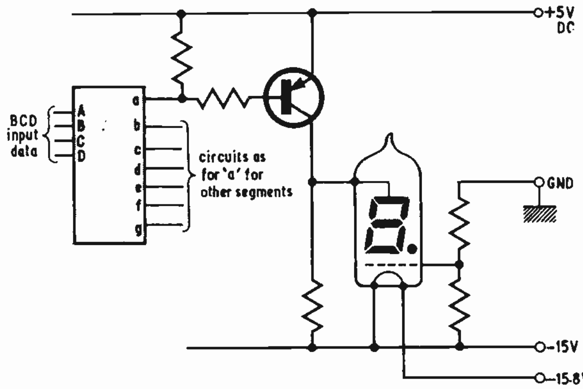


Fig. 7.3. Typical drive circuit for a seven-segment fluorescent phosphor display tube

SEVEN SEGMENT TUBES

The circuit arrangement for a typical fluorescent segment tube is shown in Fig. 7.3. The cathode of these tubes are of the directly heated type familiar from the days of the 1·4 V filament battery valves once so widely used in portable radios.

The grid operates in the same way as that of a radio valve and is used to turn the whole tube on or off when a suitable bias is applied. This facility is used in time-shared systems when only one indicator at a time is turned on, and its incorporation saves a good deal of the electronics necessary to achieve time sharing with other systems.

The seven separate anodes are phosphor coated and generally employ a green phosphor because this is a colour much favoured by calculator manufacturers. Each segment anode is "enabled" by taking it about 20V positive with respect to the cathode whereupon it is bombarded by electrons and begins to emit the desired green light.

The entire tube assembly is housed in a glass envelope of about half the size of a B7G valve, and usually connections are made via flying leads.

This type of tube has been championed in the United States and Japan, and is widely used in the small Japanese desk calculators now appearing on the market.

The drive requirements for these devices are rather complicated due to the voltages and polarities necessary, and they have never really caught on in Britain despite their low cost and suitability for use in long time-shared readouts. This is a pity since the numeral appearance and legibility is superior to the thread-like filament indicators and devices of this type could be put to good use in a variety of amateur projects.

CATHODE RAY TUBES

When displaying large quantities of alpha-numeric data the most common readout system employed is the familiar cathode ray tube which can handle anything from a few tens to a few hundreds of characters depending on size.

It is unlikely that amateur projects of today would require such capacity, but here again there are possible applications for amateur experimenters, and in these, potential users think that anything like a c.r.t. display would have to be too complex, a couple of simple but practical systems will be outlined.

DOT MATRIX

The simplest type of alpha-numeric display raster to "paint out" on a tube is a dot matrix which is generated by feeding synchronised staircase waveforms to the X and Y deflection amplifiers.

Fig. 7.4 shows how such a matrix can be generated on the screen of an oscilloscope, an oscilloscope being used since, firstly, it already contains X and Y amplifiers and power supplies, and, secondly, it is likely to be already part of the equipment of some experimenters.

The system shown in the diagram is intended to display only one matrix which can contain any one of 64 different characters depending on the input code, but of course the system can be expanded quite easily to write either one complete row of characters or several complete rows to make a "page".

The system is controlled by a clock which drives two counters in series. The outputs from the counters are used both to address a "read-only-memory" and to drive a simple digital-to-analogue converter which, by means of binary weighted resistors, generates a staircase waveform to drive the X and Y reflection circuits of the oscilloscope.

The combination of these two deflections causes the spot to describe a 6 by 8 matrix of dots on the tube face, the dots appearing while the waveforms are horizontal and travel between dot positions occurring when they are vertical.

To actually write a letter or number in the matrix all that is required is to control the electron gun of the tube so that it only paints a dot where required in the matrix.

The control of the bright-up of an oscilloscope is usually called Z modulation and is achieved by switching the c.r.t. cathode on and off. Many

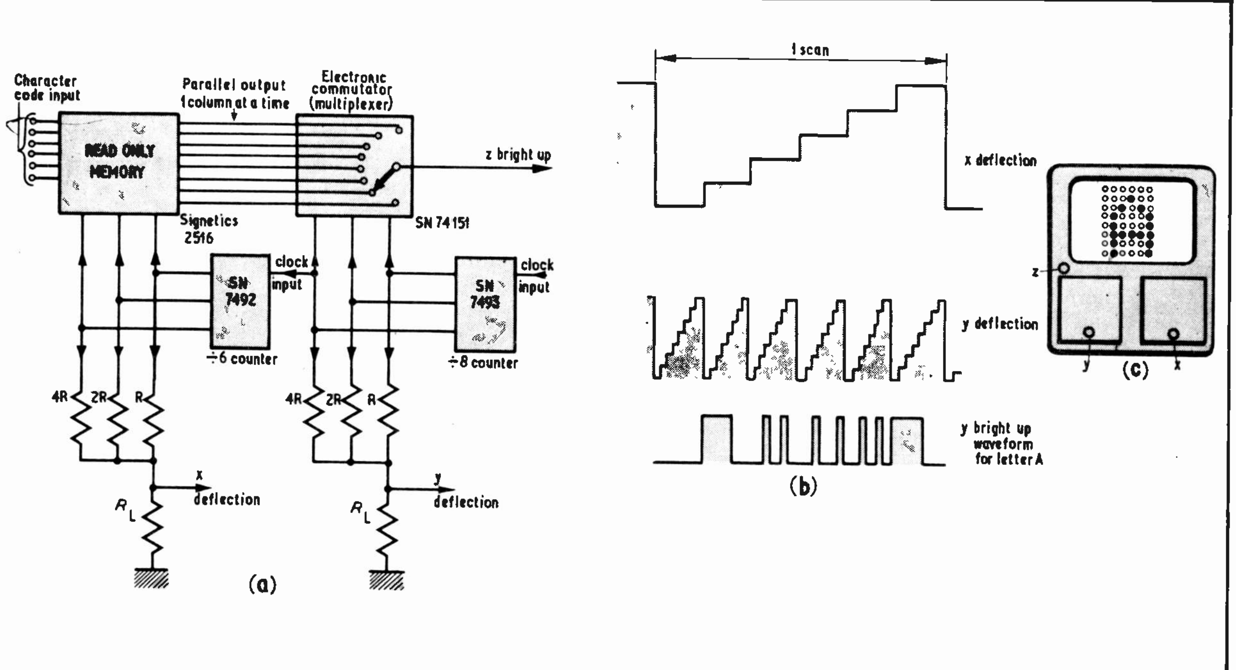


Fig. 7.4. The method of displaying dot-matrix characters on an oscilloscope. (a) Circuit using a read-only-memory; (b) waveforms produced by the circuit; (c) the form of the display on the oscilloscope screen

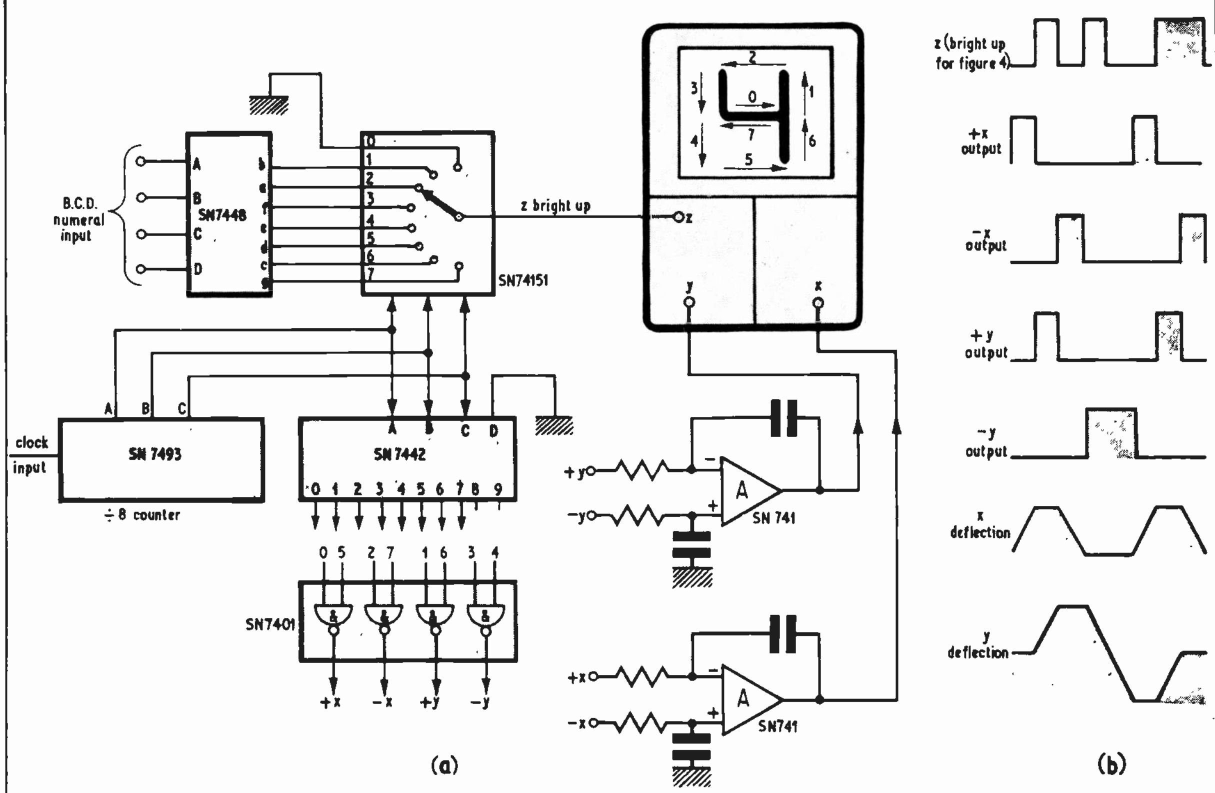


Fig. 7.5. The method of displaying seven-segment characters on an oscilloscope (a) shows the circuit required and (b) shows the waveforms produced

oscilloscopes have this facility brought out to a front panel socket, others can be easily modified.

READ ONLY MEMORY

The bright-up information for the 64 possible characters of the A.S.C.I.I. code (see Part 1) is contained in a factory programmed "read-only-memory" (r.o.m.), such as the Signetics type 2516, each character being allotted 6 × 8 separate storage locations which can hold either a logical "one" which means a dot is displayed in this position, or a logical "nought" which means a dot is not displayed in this position.

The 6 × 8 matrix holding the particular character required is selected by the input data and each of the six columns is selected in turn by the output from the divide-by-six counter, the data for each column appearing in parallel form on the eight output lines.

As the data is not required in parallel form it is serialised (a column at a time) by an eight input multiplexer controlled by the divide by eight counter. The serial train of ones and noughts at the output of the multiplexer is used to control the Z input to the oscilloscope, in synchronism with the stepping deflection waveforms, and thus illuminates the dots corresponding to the desired character on the screen.

Dot matrix r.o.m. controlled character displays are becoming increasingly popular with computer manufacturers and factory programmed r.o.m.s are available at low cost for a variety of raster formats besides the simple dot type. The most popular is the "TV scan" type which utilises conventional 625-line television electronics for the display drive circuitry.

SEVEN SEGMENT SCAN

By cutting the character repertoire down to numerals only and accepting the more stylised format of the seven segment system, an even simpler oscilloscope character generator can be built, Fig. 7.5. This scheme uses only a handful of i.c.s and discrete components and can again be expanded to write more than one character quite simply. The scan and bright-up are again controlled by a clock driven counter which divides by eight.

Eight display periods are necessary rather than just seven because the scan has to cover the centre bar twice in order to return to the starting position.

The b.c.d. input code is converted into a segment controlling, parallel output in the seven-segment decoder, and this output is converted into a serial string of bright-up signals by a multiplexer controlled by the counter.

The counter is also decoded to give digital outputs corresponding to plus x (deflect spot to right) minus x (deflect spot to left), plus y (deflect spot up), and minus y (deflect spot down). The spot must stay

This display system developed at the Mullard Central Applications Laboratory can display up to 16 rows of 80 characters, each character being generated on a 7 × 5 dot matrix

where it is positioned until commanded to change position, and the simple deflection waveforms required are generated from the digital commands by two differential integrators which can utilise readily available operational amplifier i.c.s.

APPLICATIONS

There is a rather expensive oscilloscope on the market which uses a built in alpha-numeric character generator to write on the screen, alongside the waveform being examined, the settings of its important controls. This is a very useful feature, albeit a bit of a luxury, and using the techniques previously outlined a similar scheme could be built into a humbler oscilloscope if desired.

By substituting a "bare bones" deflection system for the oscilloscope a "built-in" display system for any type of instrument which requires to give an alpha-numeric readout could be arranged, though this would only be an economic proposition if several lines of data were to be displayed.

THE FUTURE

This series has attempted to show the variety and versatility of alpha-numeric display devices, ranging from the well-established cold cathode tubes to liquid crystal types which are still in a development stage.

An increasing proportion of the resources of the large electronics firms is being devoted to the development of cheaper and more efficient display devices since this is recognised to be an area with an immense potential market. No doubt during the time that this series has been running some new technologies have been developed.

As with all integrated circuits the price of display devices is bound to come crashing down as soon as production is really underway and there seems little doubt that the days of the electromagnetic meter are well and truly numbered! ★

P.E. DIGI-CAL

continued from page 762

Following the construction of one digit strobe circuit, the seven segment decoder (IC10) and one group of matrix diodes (corresponding to the position of the previously wired digit strobe gate) can be wired in and the single digit display tried out with dummy inputs to the SN7446.

TESTING ONE DIGIT

If this single digit operates correctly then the other digits can be connected up one at a time and tested in the same way. When all digits are wired in then all of them will display the dummy input to IC10.

Wiring up the data bus selection gates IC11, IC12 can be carried out next and these can be checked by using dummy data on either the ANSWER DATA inputs or the ENTRY DATA inputs the unwanted input being disabled by earthing its control wire.

Apart from using fixed earthing jumpers to provide the dummy inputs, it is possible to use the A, B, and C outputs of the SN7490 counter with the D input of IC10 shorted to earth. With this arrangement the displayed data counts in synchronism with the counter, the display showing 01234567. Removing the earth from the D input will give eight and nine in the first two positions of the display (the other six can be ignored) thus checking all possible inputs to the SN7446.

With the basic display system in operation the decimal point (IC8) and ripple blanking (IC9) can be added and tested.

Connections to the edge of the board were made with an edge connector socket in the prototype, but this is not necessary and connections can be made permanently via terminal pins if desired.

DIODE MATRIX

A second piece of Veroboard is used to provide the seven segment bus outputs from the decoder, this method of construction giving a very pleasing appearance and solid mechanical structure to the completed matrix.

The seemingly impossible task of lowering a piece of Veroboard down onto the protruding wires of 56 diodes all at once was eventually overcome by countersinking the holes in the Veroboard using a drill bit, thus providing a funnel which unerringly guided the wires into the correct holes.

It is of course necessary to arrange the diodes in neat ranks on the mother board, and to crop their leads to about $\frac{1}{4}$in before lowering the matrix board.

VOLTAGE RATINGS

The SN7445 and SN7446 devices specified in the components list and circuit have a breakdown voltage of greater than 30V which is more than adequate for this application, but as many constructors will have noticed there are devices which are logically identical but with 15V breakdown ratings more freely available in the shape of the SN74145 and the SN7447 respectively.

The prototype employed the latter types with no ill effects, but if these types are chosen it must be realised that a certain amount of gambling is involved since you may purchase a device with one or more outputs which break down very close to the 15V minimum quoted in the specification.

Next month: Keyboard logic and hardware

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.

EXTENSION LEADS

To make life easier in the home, particularly as powered tools have increased in popularity and use, **IXP Ltd.**, have designed two extension cable reels so that power can be supplied to practically any part of the home.

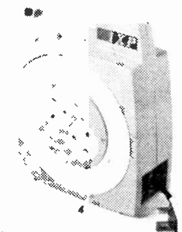
Ideal for the electrician, gardner and d.i.y. enthusiasts, as well as the caravan, car or boat owner the model A.12 provides 100ft of cable. The totally enclosed reel, hardly bigger than a medium size transistor radio, is made of high-impact plastics and measures 10½in × 8¼in × 3in, including a shaped carrying handle.

Two 13A sockets are fitted to one side of the reel, giving the user the opportunity to use just one power line for more than one tool at once (e.g., drill and inspection light, portable television and caravan/boat battery charger, etc.). The cable is easily wound on and off the reel which limits the possibility of the cable kinking or knotting.

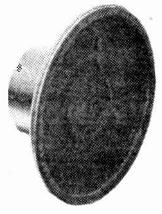
For the person who requires an extra long cable length, such as the electrician or industrial user, the model A.13 has a cable length of 245ft rated at 15A. The 12in diameter reel is of toughened insulating rubber mounted on an easy to carry metal frame.

A feature of the model A.13 is a special brake and lock mechanism to control cable rewind and lock the reel when fully coiled. Two 13A sockets are also fitted to this model.

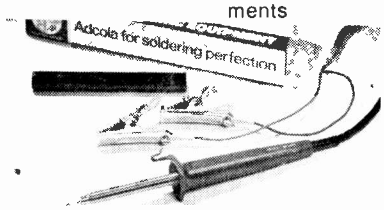
Both models should be obtainable through your local ironmonger, electrical shop or garden centre or from IXP Ltd., Henshaw Lane, Yeadon, Leeds, LS19 7RZ. The recommended retail prices are £5.60 for model A.12 and £12.70 for model A.13.



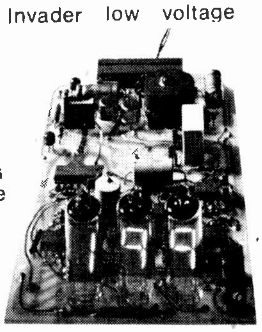
Model A.12 Extension Lead from IXP



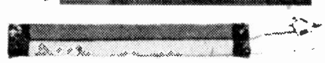
Miniature Speaker marketed by B & Y (Gates) Electronic Developments



Adcola Invader low voltage iron



Digital Voltmeter Card from West Hyde Developments



Photentiomatic potentiometer marketed by Photain Controls

LOW VOLTAGE IRON

To augment their Invader soldering iron range **Adcola Products** have introduced a low voltage iron to operate from a standard car battery.

Designed for use in situations where there is no access to normal mains supply, the battery model is intended to appeal to the d.i.y. enthusiasts, model makers, motorists and boat owners.

The new model features the same slim moulded plastics handle, weighs less than 2oz and features a simple replaceable plug-in element.

Two models, are available with soldering bit diameters of 3/16in and ¼in, rated at 23 and 27 watts respectively to provide an operating bit temperature of 360°C. Crocodile clips are provided at the end of the 12ft cable for connection to the battery terminals.

The time taken to heat up to soldering temperature is dependent upon the condition of the battery used as a power source, but will normally melt solder in a couple of minutes and will reach full operating temperature in less than five minutes.

The tool is supplied with a fire resistant tubular transit sleeve which fits over the element and bit, allowing the user to replace the iron in a tool box safely after use without having to wait for the tip to cool.

The Invader 3/16in diameter bit model BL646, retails at £2.37 and the larger model BL1076 for £2.47. A wide range of standard copper and iron plated long life bits are also available.

DIGITAL VOLTMETER

A digital panel meter card is announced by **West Hyde Developments Ltd.** Using their well known Atron numicator tubes, which can have filters of any required colour, the panel voltmeter can be powered from any 5V source.

Designated the WH2.5, the cards are available in four ranges from 0·2V to 200V and there are options for bi-polar or a.c. types. The low cost means that middle range industrial instruments can now have digital displays giving clear readings from a single 5V supply.

The glass epoxy board assembly has its own bias oscillator for the op-amps used and the standard unit can either use the internal sample rate of two per second or a manual external sample rate of up to 20Hz.

On the bi-polar type the polarity indication is by a plus or minus sign and is fully automatic. The common mode rejection is claimed to be 100dB at d.c. and the series mode rejection 30dB at 50Hz.

Full technical details and typical applications can be obtained from West Hyde Developments Ltd., Ryefield Crescent, Northwood Hills, Northwood, Middlesex, HA6 1NN.

MINIATURE LOUDSPEAKER

A high quality miniature moving coil loudspeaker designed and developed for all-purpose uses and ideally suited for pocket pageing systems has just been marketed by **B & Y (Gates) Electronic Developments Ltd.**

The speaker has a power rating of 0·1W; a claimed frequency response of up to 5kHz; an impedance of 15 ohms and measures 1·5in diameter × 0·65in deep.

Full technical specifications together with a typical frequency response graph may be obtained from B & Y (Gates) Electronic Developments Ltd., 26 Uxbridge Road, London, W5 2BP.

PHOTOPOTENTIOMETER

An interesting new device that may appeal to the constructor is announced by **Photain Controls.** Known as a "Photentiomatic" it is a potentiometer which is controlled by light.

It consists of a strip of either Cadmium Sulphide or Cadmium Selenide photoconductive material mounted on a ceramic strip, complete with connecting wires. When connected to a suitable input (up to 25 V d.c.) and subjected to a moving strip of light it provides an output voltage which is directly proportional to the position of the light on the strip of photoconductive material.

Details of its applications, characteristics and price is available from Photain Controls Ltd., Randalls Road, Leatherhead, Surrey.

Readout—
A SELECTION FROM OUR POSTBAG

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

Computer constructors needed

Sir—I would be pleased to hear from any of your readers who are interested in the formation of an Amateur Computer Constructors' Society.

M. R. Lord,
7 Dordells,
Basildon, Essex.

The needs of youth

Sir—As one of your younger readers (16) I would like to say that your magazine, although excellent, caters far too much for the older generation. I do not need a shaver inverter, a wash wipe controller, or an ultrasonic intruder alarm. What I need, and a few hundred others like me, is a reverberation unit and/or an echo unit. How about it?

Incidentally, why don't you construct a synthesiser. Before you say "this boy is a fool" (you would be quite right, but that is beside the point) you could start with a ring modulator then progress to voltage controlled oscillators and so on.

I know that you will say that all these projects are too hard for the average constructor but I'm sure they are not.—Please give them a thought.

Neville Powell,
Chiswick, W.4.

Psitronics

Sir—I was very interested indeed to read your item under the heading "Occultaphonics" in *On The Fringe*, May edition, as for some months now I have been experimenting along the same lines using a white noise generator and recorder.

The idea that white noise could be described as a full saturated communication channel is, as you suggest, a very old one: several writers have allowed themselves to be hypnotised by the notion that white noise must in theory contain all possible information—all the correct answers (as well as all the incorrect ones!) to every question that ever will be asked.

Indeed, back in 1952 a science fiction writer Raymond Jones suggested in a story called "Noise Level" that the brain contains a pure noise generator, with associated filters to permit only semantically meaningful forms to emerge into consciousness. Creativity might then be defined as using mental disciplines to force open wider these filter gates which gradually narrow with the educative process.

For a long time I regarded this aspect of white noise as no more than a philosophical curiosity. My present experimental interest was sparked off by reading "Breakthrough" by Konstantin Raudive (English edition by Colin Smythe, 1971). The "Raudive voices", alleged messages from identifiable dead people recorded by several different methods onto magnetic tape, have caused quite a stir in psychical research circles.

The techniques used are quite elementary, and the testimonials in the Appendix to the book, many from reputable and hard-headed electronics engineers not obviously given to Spiritualist fantasies, demonstrate that Raudive can produce his phenomena on sealed tapes running through new recorders.

The "Raudive voices" intersect with your P.E. item over the question of white noise. In his book Raudive details three methods of producing the messages on tape. Direct microphone, in which the new voices appear between and sometimes in response to the comments and questions of those present; radio, when a recording is made of an unmodulated carrier from any radio—the voices then appear to modulate the carrier. And via a "diode", which appears to be, from the diagram published, no more than a crude broadband tuned circuit and detector. The messages then appear superimposed on the jumbled output from the tuned circuit.

All the messages, it is claimed, have the same characteristics whatever method is used.

It is fairly clear from the book that Raudive's training and interest in electronics are not large. In particular it seems obvious that his three methods are just different ways of producing white (or perhaps pink) noise. Nevertheless, we have here a field of immense interest for these experiments effectively circumvent the main objections to physical research: that is non-scientific, i.e. not quantifiable or recordable or repeatable.

I don't think we have to accept Raudive's thesis or post-mortem communication as the minimum working hypothesis for two reasons: the messages are mostly polylingual as is Raudive himself; and they give no information not available to himself. These factors make me suspect the answer lies in the telepathic modulation of (or possibly selection from) a white noise carrier wave. And this might equally be the explanation of Gerry Brown's R.A.F. phenomenon. A bored operator, his mind "idling": the literature of a parapsychology suggests this half-dreaming state is the ideal condition for psi activity whether telepathy, clairvoyance or spontaneous bodily projection.

Although I have a keen amateur interest in electronics I don't have the ability to design circuitry or devise fruitful channels of research without expert help. So what I am suggesting, if you think it worthwhile, is the setting up of a forum of readers interested in "Psitronics": physical researchers, technicians (the more sceptical the better), and "mediums" (perhaps publicity would throw up more of these). In any case, I'd be pleased to hear views on the points I've raised.

Peter R. Morton,
Thornaby, Teesside.

Good devices

Sir,—It has been brought to my attention that in the June issue of your magazine, in *Points Arising*, reference is made to the manufacturers of the 2N3055 transistor as used in the P.E. Scorpio Ignition System.

We feel that the observations made regarding satisfactory manufacturers are narrow and confining, and we ourselves have been supplying Solitron devices since the inauguration of this project. As far as we know we have had no failures due to manufacturing defects.

However, a number of our customers have written to us and are under the impression that we are selling sub-standard goods because we are not providing RCA or Ferranti devices. As a result, we have been put to some considerable effort to put people's mind at ease on this point.

J. A. Marshall,
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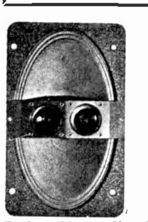

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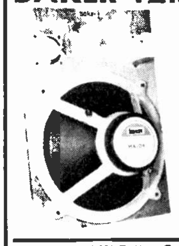

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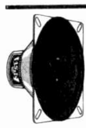
ELAC CONE TWEETER



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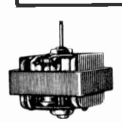

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2	15	2½p	640	10	8p
2·5	50	3p	1000	3	6p
4	10	3p	1000	6	8p
6·4	50	3p	1000	12	10p
8	25	3p	1000	25	15p
10	6	3p	1000	50	35p
10	15	3p	2000	12	10p
10	25	3p	2000	25	15p
10	40	4p	2500	12	10p
10	50	4p	2500	25	30p
16	15	3p			
16	25	3p			
20	25	3p			
25	15	3p			
25	25	3p			
25	50	4p			
32	50	4p			
40	6	3p			
50	10	3p			
50	50	7p			
64	10	4p			
64	15	4p			
64	25	4p			
64	40	5p			
100	6	3p			
100	25	4p			
100	50	8p			
200	6	4p			
250	6	4p			
250	10	4p			
250	15	6p			

Zener Diodes
VZY88 type tested and polarity marked all values, 2–13V, **5p each**

Semi-conductors

2N706	10p
2N708	13p
5N1303	17p
2N3866	80p
2N3055	60p
BC108	11p
BCY30	22p
BFY51	20p
B5X21	16p
OC35	40p
OC36	43p
μL914	30p
7400/01/10/30	15p
MC1027	£2

Disc Ceramics

pF	V	
1	500	2p
5	750	2p
10	750	2p
20	750	2p
25	750	2p
40	750	2p
60	750	2p
75	750	2p
100	750	2p
120	750	2p
220	750	2p

pF	V	
1000	50	2½p
4700	30	2p
0·01	30	3p
0·01	350	2p
0·022	30	2p
0·047	30	2p
0·1	25	3p

Polyester

mF	V	
0·001	400	2p
0·01	200	3p
0·068	160	3p
0·12	150	3p
0·22	250	4p
0·47	160	5p
10	100	40p

BARGAIN PACKS

14/0076 PCV wire 5 × 10 yds	30p
Small Multi-cable 4 way 10 yds	50p
Miniature Co-Ax 10 yds	50p
Gen. purpose switching diode	25 for 25p
70V Neon wire ends	5 for 20p
Miniature Pushbutton	2 for 20p
Transformer 32–0–32 at 150mA	50p
S.B.C. 2 Pin Metal Lamp-holder	5 for 30p

MINIATURE R.F. CHOKES
0·22μH, 2·2μH, 12μH, 15μH, 22μH **8p each**

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CLEAR PLASTIC METERS

TYPE SW. 100
100 x 80 mm

50µA	£3·60	500µA	£3·20
50-0-50µA ..	£3·45	1mA	£3·10
100µA	£3·45	20V d.c. ...	£3·10
100-0-100µA	£3·35	50V d.c. ...	£3·10
		300V d.c. ..	£3·10
		1A d.c.	£3·10
		5A d.c.	£3·10
		300V a.c. ..	£3·10
		VU Meter ..	£3·75

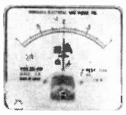
BAKELITE PANEL METERS

TYPE S-80
80 mm square fronts

50µA	£3·20	1A d.c. ...	£2·60
50-0-50µA ..	£3·10	5A d.c. ...	£2·60
100µA	£3·10	300V a.c. ..	£2·60
100-0-100µA	£3·00	VU Meter ..	£3·37
500µA	£2·75		
1mA	£2·60		
20V d.c. ..	£2·60		
50V d.c. ...	£2·60		
300V d.c. ..	£2·60		

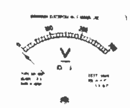
"SEW" CLEAR PLASTIC METERS

Type MR.85P. 4¼in 4¼in fronts.



		50mA	£2·80
		100mA	£2·80
		500mA	£2·80
		1A	£2·80
		5A	£2·80
		15A	£2·80
		30A	£2·90
		20V d.c. ...	£2·80
		50V d.c. ...	£2·80
		150V d.c. ..	£2·80
50µA	£3·60	300V d.c. ..	£2·80
50-0-50µA ..	£3·10	15V a.c. ...	£2·80
100µA	£3·10	300V a.c. ..	£2·80
100-0-100µA	£3·00	S Meter	
200µA	£3·00	1mA	£2·87
500µA	£2·90	VU Meter ..	£3·60
500-0-500µA	£2·80	1A a.c.* ...	£2·80
1mA	£2·80	5A a.c.* ...	£2·80
1-0-1mA....	£2·80	10A a.c.* ..	£2·80
5mA	£2·80	20A a.c.* ..	£2·80
10mA	£2·80	30A a.c.* ..	£2·80

Type MR.38P. 1 21/32in square fronts.



		150mA	£1·60
		200mA	£1·60
		300mA	£1·60
		500mA	£1·60
		750mA	£1·60
		1A	£1·60
		2A	£1·60
		5A	£1·60
		10A	£1·60
		3V d.c.	£1·60
		10V d.c. ...	£1·60
50µA	£2·10	15V d.c. ...	£1·60
50-0-50µA ..	£1·90	20V d.c. ...	£1·60
100µA	£1·90	100V d.c. ..	£1·60
100-0-100µA	£1·75	150V d.c. ..	£1·60
200µA	£1·75	300V d.c. ..	£1·60
500µA	£1·65	500V d.c. ..	£1·60
500-0-500µA	£1·60	750V d.c. ..	£1·60
1mA	£1·60	15V a.c. ...	£1·70
1-0-1mA....	£1·60	50V a.c. ...	£1·70
2mA	£1·60	150V a.c. ..	£1·70
5mA	£1·60	300V a.c. ..	£1·70
10mA	£1·60	500V a.c. ..	£1·70
20mA	£1·60	S Meter	
50mA	£1·60	1mA	£1·70
100mA	£1·60	VU meter ..	£2·10

Type MR.52P. 2½in square fronts.

50µA	£3·10	20V d.c. ...	£2·00
50-0-50µA ..	£2·60	50V d.c. ...	£2·00
100µA	£2·60	300V d.c. ..	£2·00
100-0-100µA	£2·50	15V a.c. ...	£2·10
500µA	£2·30	300V a.c. ..	£2·10
1mA	£2·00	S Meter	
5mA	£2·00	1mA	£2·10
10mA	£2·00	VU Meter ..	£3·20
50mA	£2·00	1A a.c.* ...	£2·00
100mA	£2·00	5A a.c.* ...	£2·00
500mA	£2·00		
1A........	£2·00	10A a.c.* ..	£2·00
5A........	£2·00	20A a.c.* ..	£2·00
10V d.c. ...	£2·00	30A a.c.* ..	£2·00

Type MR.45P. 2in square fronts.

50µA	£2·25	10V d.c. ...	£1·50
50-0-50µA ..	£2·10	20V d.c. ...	£1·50
100µA	£2·10	50V d.c. ...	£1·50
100-0-100µA	£1·87	300V d.c. ..	£1·50
200µA	£1·87	15V a.c. ..	£1·80
500µA	£1·75	300V a.c. ..	£1·80
500-0-500µA	£1·70	S Meter	
1mA	£1·70	1mA ...	£1·85
5mA	£1·70	VU Meter .	£2·25
10mA	£1·70	1A a.c.* ..	£1·70
50mA	£1·70	5A a.c.* ...	£1·70
100mA	£1·70	10A a.c.* ..	£1·70
500mA	£1·70		
1A	£1·70	20A a.c.* .	£1·70
5A	£1·70	30A a.c.* ..	£1·70

Type MR.65P. 3½in × 3¼in fronts.

50µA	£3·37	20V d.c. ...	£2·20
50-0-50µA ..	£2·75	50V d.c. ...	£2·20
100µA	£2·75	150V d.c. ..	£2·20
100-0-100µA	£2.65	300V d.c. ..	£2·20
200µA	£2·65	15V a.c. ...	£2·30
500µA	£2·40	50V a.c. ...	£2·30
500-0-500µA	£2·20	150V a.c. ..	£2·30
1mA	£2·20	300V a.c. ..	£2·30
5mA	£2·20	500V a.c. ..	£2·30
10mA	£2·20	S Meter	
50mA	£2·20	1mA	£2·37
100mA	£2·20	VU meter ..	£3·37
500mA	£2·20	50mA a.c.*	£2·20
1A	£2·20	100mA a.c.*	£2·20
5A	£2·20	200mA a.c.*	£2·20
10A.......	£2·20	500mA a.c.*	£2·20
15A.......	£2·20	1A a.c.* ...	£2·20
20A.......	£2·20	5A a.c.* ...	£2·20
30A.......	£2·30		
50A.......	£2·50	10A a.c.* ..	£2·20
5V d.c.	£2·20	20A a.c.* ..	£2·20
10V d.c. ...	£2·20	30A a.c.* ..	£2·20

"SEW" BAKELITE PANEL METERS

Type MR.65 3¼in square fronts.

		500mA	£1·95
		1A	£1·95
		2A	£1·95
		5A	£1·95
		15A	£1·95
		30A	£1·95
		50A	£1·95
		5V d.c. ...	£1·95
		10V d.c. ...	£1·95
		20V d.c. ...	£1·95
		50V d.c. ..	£1·95
		150V d.c. ..	£1·95
		300V d.c. ..	£1·95
25µA	£3·50	30V a.c.* ..	£1·95
50µA	£2·37	50V a.c.* ..	£1·95
50-0-50µA ..	£2·35	150V a.c.*	£1·95
100µA	£2·35	300V a.c.*	£1·95
100-0-100µA	£2·25	500mA a.c.*	£1·95
500µA	£2·20	1A a.c.* ...	£1·95
1mA	£1·95	5A a.c.* ...	£1·95
1-0-1mA....	£1·95	10A a.c.* ..	£1·95
5mA	£1·95	20A a.c.* ..	£1·95
10mA	£1·95	30A a.c.* ..	£1·95
50mA	£1·95	50A a.c.* ..	£1·95
100mA	£1·95	VU meter ..	£3·10

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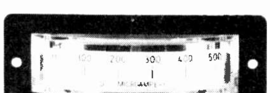
50µA	£5·00	20V d.c. ...	£4·40
100µA	£4·65	50V d.c. ...	£4·40
1mA	£4·40	300V d.c. ..	£4·40
50-0-50µA ..	£4·65	Dual range	
1-0-1mA....	£4·40		
1A d.c.	£4·40	500mA/5A d.c.	£4·65
5A d.c.	£4·40		
10V d.c. ...	£4·40	5V/50V d.c.	£4·65

EDGEWISE METERS



PE.70 3 17/32in 1 15/32in · 2½in deep.

50µA	£3·10	500µA	£2·75
50-0-50µA ..	£3·00	1mA	£3·45
100µA	£3·00	300V a.c. ..	£3·45
100-0-100µA	£2·90	VU meter ..	£3·40
200µA	£2·90		

MULTIMETERS for EVERY purpose!

MODEL LT.101 1000 O.P.V. 0/10/50/250/1000 V. D.C. 0/10/50/250/1000 V. A.C. 0/1/100 M.A. 0/150 K ohms. **£1·97.** P. & P. 15p.

TMK MODEL MD.120. Mirror scale. 20kΩ/volt d.c., 10kΩ/volt a.c. 30/60/300/600/3,000V d.c. 6/120/1,200V a.c. Current 0–60µA/0–12/0–300mA. 0–60kΩ/0–6MΩ −20 to +63dB. **£4·62½.** P. & P. 15p

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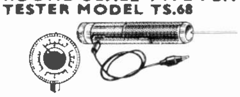
ROUND SCALE TYPE PENCIL TESTER MODEL TS.68



Completely portable, simple to use pocket sized tester. Ranges 0/3/30/300V a.c. and d.c. at 2,000 o.p.v. Resistance 0–20kΩ. ONLY **£1·97.** P. & P. 13p.

TMK MODEL 117 F.E.T. ELECTRONIC VOLTMETER

Battery operated, 11 meg input. 26 ranges. Large 4¾in mirror scale. Size 5⅞in × 4⅞in × 2¾in. D.c. volts 0·3–1,200V. A.c. volts 3–300V R.M.S. 8·0 800V P-P. D.c. current 0·12–12MA. Resistance up to 2,000M ohm. Decibels −20 to +51dB. Complete with leads/instructions. **£17·50.** P. & P. 20p.

TE-20D RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120Kc/s 500Mc/s on 6 bands. Directly calibrated Variable R.F. attenuator, audio output. Xtal socket for calibration. 220/240V. A.C. Brand new with instructions. **£15.** Carr. 37½p. Size 140 × 215 × 170 mm.

TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20c/s to 200 kc/s on 4 bands. Square: 20c/s to 30 kc/s. Output impedance 5,000 ohms. 200/250V a.c. Supplied brand new and guaranteed with instruction manual and leads. **£17·50.** Carr. 37½p.

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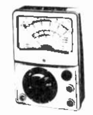
MW1-6 60mm square **£3·97½.** MW1-8 80mm square **£4·97½.** P. & P. extra.

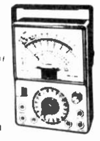


HIOKI MODEL 720X 20,000 O.P.V. Overhead protection. 5/25/100/500/1000V D.C. 10/50/250/1000V A.C. 50µA/250mA. 20K/2 meg ohm. −5 to +62db. **£4·97.** P. & P. 15p.

MODEL PL436. 20kΩ/Volt d.c. 8kΩ/Volt a.c. Mirror scale. 0·6/3/12/30/120/600V d.c. 3/30/120/600V a.c. 50/600µA/60/600mA. 10/100K/1 Meg/10 meg Ω. −20 to +46dB. **£6·97½.** P. & P. 12½p.

MODEL 5025. 57 ranges, giant 5¼in meter, polarity reverse switch. Sensitivity: 50K/Volt d.c. 5K/Volt a.c. D.c. Volts: 0·125, 0·25, 1·25, 5, 10, 25, 50, 125, 250, 500, 1,000V. A.c. Volts: 1·5, 3, 5, 10, 25, 50, 125, 250, 500, 1,000V. D.c. current: 25, 50µA, 2·5, 5, 25, 50, 250, 500mA, 5, 10A. Resistance: 2K, 10K, 100K, 1 meg, 10 meg. Decibels: −20 to +85dB. **£12·50.** P. & P. 17½p.

HIOKI MODEL 700X 100,000 O.P.V. Overload protection. Mirror scale.



·3/·6/1·2/1·5/3/6/12/30/60/120/300/600/1200VDC 1·5/3/6/12/30/60/150/300/600/1200 VAC 15/30µA/3/6/30/60/150/300 mA 6/12 AMP DC 2K/200K/2 Meg/20 meg ohm −20 to + 63 db
£13·50 P. & P. 20p

RUSSIAN 22 RANGE MULTIMETER

Model U437 10,000 o.p.v. A first class versatile instrument manufactured in U.S.S.R. to the highest standards. Ranges: 2·5/10/50/250/500/1000V d.c., 2·5/10/50/250/500/1000V a.c. D.c. current 100 mA / 1 10 / 100mA/1A. Resistance 300 ohms/3/30/300kΩ, 3MΩ. Complete with batteries, test leads, instructions and sturdy steel carrying case. **OUR PRICE £5·97.** P. & P. 25p.

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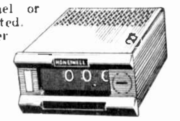
3in tube. Y amp. Sensitivity 0·1V p-p/CM. Bandwidth 1·5 cps-1·5MHz. Input imp. 2megΩ 25pF X amp. sensitivity 0·9V -800KHz. Input imp. 2 megΩ 20pF. Time base. 5 ranges 10cps-300KHz. Synchronisation. Internal/external. Illuminated scale 140 × 215 × 330 mm. Weight 15½lb 220/240V a.c. Supplied brand new with handbook. **£40.** Carr. 50p.

HONEYWELL DIGITAL VOLTMETER VT.100



Can be panel or bench mounted. Basic meter measures 1 volt d.c. but can be used to measure a wide range of a.c. and d.c. volt, current and ohms with optional plug-in cards.
Specification:– Accuracy: ± 0·2, ± 1 digit. Resolution: 1mV. No. of digits: 3 plus fourth overrange digit. Overrange: 100% (up to 1·999). Input impedance: 1000 Meg ohm. Measuring cycle: 1 per second. Adjustment: Automatic zeroing, full scale adjustment against an internal reference voltage. Overload: to 100V d.c. Input: Fully floating (3 poles). Input power: 110-230V a.c. 50/60 cycles. Overall size: 5⅝in. × 2 13/16in. × 8 3/16in
AVAILABLE BRAND NEW AND FULLY GUARANTEED AT APPROX. HALF PRICE. **£49·97½ Carr. 50p**

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ALL DEVICES BRAND NEW AND FULLY GUARANTEED

Transistors

2G301	20p
2G302	20p
2G303	20p
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2G309	30p
2G371	15p
2G374	20p
2G381	22p
2N388A	49p
2N404	20p
2N696	15p
2N697	15p
2N698	25p
2N699	30p
2N706	10p
2N706A	12p
2N708	15p
2N709	62p
2N718	25p
2N718A	30p
2N726	30p
2N727	30p
2N914	17p
2N916	17p
2N918	30p
2N929	22p
2N930	20p
2N987	40p
2N1090	22p
2N1091	22p
2N1131	25p
2N1132	25p
2N1302	17p
2N1303	17p
2N1304	22p
2N1305	22p
2N1306	25p
2N1307	25p
2N1308	25p
2N1309	25p
2N1507	17p
2N1613	20p
2N1631	35p
2N1632	30p
2N1637	30p
2N1638	27p
2N1639	27p
2N1701	162p
2N1711	24p
2N1889	32p
2N1893	37p
2N2147	72p
2N2160	57p
2N2193	40p
2N2193A	42p
2N2194	27p
2N2194A	30p
2N2217	25p
2N2218	20p
2N2219	20p
2N2220	25p
2N2221	25p
2N2222	20p
2N2222A	25p
2N2297	30p
2N2368	15p
2N2369	15p
2N2369A	15p
2N2410	42p
2N2483	27p
2N2484	32p
2N2539	22p
2N2540	22p
2N2613	35p
2N2614	30p
2N2646	40p
2N2711	25p
2N2712	25p
2N2713	27p
2N2714	30p
2N2904	20p
2N2904A	25p
2N2905	25p
2N2905A	20p
2N2906	20p
2N2906A	25p
2N2907	23p
2N2923	15p
2N2924	15p
2N2925	15p
2N2926G	10p
2N2926O	10p
2N2926Y	10p
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XB112	12p
XC141	35p
ZTX107	15p
ZTX108	12p
ZTX109	15p
ZTX300	12p
ZTX301	15p
ZTX302	20p
ZTX303	20p
ZTX304	25p
ZTX500	15p
ZTX501	15p
ZTX502	20p
ZTX503	17p
ZTX504	40p
ZTX531	25p

Integrated Circuits

CA3000	180p
CA3005	117p
CA3007	262p
CA3011	75p
CA3012	88p
CA3013	105p
CA3014	124p
CA3018	84p
CA3018A	110p
CA3019	84p
CA3020	126p
CA3020A	160p
CA3021	156p
CA3022	130p
CA3023	126p
CA3026	100p
CA3028A	74p
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FCH201	130p
FCH211	130p
FCH221	130p
FCH231	150p
FCJ101	160p
FCJ111	150p
FCJ121	275p
FCJ131	275p
FCJ141	525p
FCJ201	100p
FCJ211	275p
FCK101	430p
FCL101	230p
FCY101	102p

FJH101	25p
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FJH121	25p
FJH131	25p
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FJH171	25p
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FJJ101	50p
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FJJ131	60p
FJJ141	125p
FJJ181	75p
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FJJ211	125p
FJJ251	125p
FJL101	125p
FJY101	25p
IC12	180p
L900	40p
L914	40p
L923	40p
LM380	£1·22p
MC724P	60p
MC780P	247p
MC788P	146p
MC790P	124p
MC792P	66p
MC799P	66p
MC1303L	200p
MC1304P	225p
MC1305P	386p
MC838P	549p
MC1435P	345p
MC1552G	461p
MC1709CG	94p
MFC4000P	55p
SN7400	20p
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TAA530	495p
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TAD110	150p
SL403D	150p
SL702C	147p
UA702A	280p
UA702C	77p
UA703C	137p
UA709C	45p
UA710C	125p
UA716	187p
UA723C	100p
UA730C	160p
UA741C	80p

BRIDGE RECTIFIERS PLASTIC ENCAPSULATED

600PIV 1A	50p	50PIV 4A	40p
50PIV 2A	45p	100PIV 4A	50p
100PIV 2A	50p	200PIV 4A	55p
200PIV 2A	55p	400PIV 4A	65p
400PIV 2A	60p	600PIV 4A	70p
		50PIV 6A	45p
		100PIV 6A	55p
		200PIV 6A	65p
		400PIV 6A	75p
		600PIV 6A	85p

SILICON RECTIFIERS MINIATURE WIRE ENDED PLASTIC

SERIES	IN 1 AMP	PL 1·5 AMP	CL 3 AMP
4001 50PIV	7p	8p	19p
4002 100PIV	7p	9p	20p
4003 200PIV	8p	10p	22p
4004 400PIV	8p	10p	25p
4005 600PIV	10p	12p	26p
4006 800PIV	12p	15p	27p
4007 1000PIV	15p	16p	30p

50+ less 15% 100+ less 20%

SILICON RECTIFIERS STUD MOUNTING

	6A	10A	17·5A	35A
100PIV	—	45p	50p	£1·22
200PIV	25p	50p	55p	£1·42
400PIV	30p	55p	62p	£1·77
600PIV	32p	60p	72p	£2·12
800PIV	35p	75p	87p	£2·47
1000PIV	40p	85p	£1·05	£2·77

50+ less 15% 100+ less 20%

ZENER DIODES

400MW	1·5WATT	10 WATT
3·3-33V	2·4-100V	3·9-100V
10p each	25p each	40p each

25+ less 15% 100+ less 20%

TRANSISTOR DISCOUNTS:— 12 + 10%; 25 + 15%; 100 + 20% any one type. Postage on all Semi-Conductors 7p extra.
S.A.E. FOR FULL LISTS

VALVES

OA2	38p
OB2	45p
OZ4	30p
IL4	20p
1R5	40p
1S5	30p
1T4	25p
1U4	30p
1U5	60p
2D21	35p
3Q4	50p
3S4	35p
3V4	48p
5R4	75p
5U4	35p
5V4	45p
5Y3	40p
5Z4G	40p
6/30L2	80p
6AC7	40p
6AG7	40p
6AK5	35p
6AK6	60p
6AL5	20p
6AM6	30p
6AQ5	38p
6AS6	40p
6AT6	35p
6AU6	25p
6AV6	30p
6BA6	25p
6BE6	30p
6BH6	75p
6BJ6	50p
6BQ7A	40p
6BR7	90p
6BR8	70p
6BW6	85p
6BW7	80p
6BZ6	40p
6C4	33p
6CD6	125p
6CL6	50p
6CW4	65p
6F1	62p
6F6G	35p
6F13	45p
6F14	70p
6F15	65p
6F18	50p
6F23	85p
6H6	17p
6J4	50p
6J5	25p
6J5GT	30p
6J6	20p
6J7	45p
6K8G	40p
6L6GT	45p
6LD20	50p
6Q7	40p
6SA7	40p
6SG7	40p
6SJ7	40p
6SK7	40p
6SL7	35p
6SN7	35p
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6X5G	30p
6X5GT	40p
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10F1	75p
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10P14	110p
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12AT7	30p
12AU7	30p
12AX7	30p
12AV6	40p
12BA6	40p
12BE6	40p
12BH7	45p
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20P1	50p
20P3	60p
20P4	110p
20P5	120p
25L6	50p

25Z4	30p
25Z5	42p
25Z6	65p
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30C17	90p
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30FL1	75p
30FL12	120p
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30L17	80p
30P12	80p
30P19	85p
30PL1	75p
30PL13	93p
30PL14	90p
35L6	50p
35W4	35p
35Z4	35p
35Z5	50p
50B5	50p
50C5	50p
80	55p
85A2	50p
807	50p
1625	50p
5763	70p
6146	160p
AZ31	55p
CY31	35p
DAF91	30p
DAF96	45p
DF91	22p
DF96	45p
DK91	40p
DK92	55p
DK96	50p
DL92	35p
DL94	48p
DL96	45p
DM70	40p
DY86	32p
DY87	33p
E88CC	100p
E180F	100p
EABC80	35p
EAF42	35p
EB91	20p
EBC41	55p
EBC81	30p
EBF80	40p
EBF83	40p
EBF89	32p
EBL21	60p
EC86	60p
EC88	60p
ECC40	65p
ECC84	30p
ECC85	40p
ECC88	40p
ECF80	35p
ECF82	35p
ECF86	65p
ECH21	57p
ECH35	100p
ECH42	75p
ECH81	30p
ECH83	45p
ECL80	45p
ECL82	35p
ECL83	70p
ECL86	40p
EF37A	120p
EF39	50p
EF40	50p
EF41	65p
EF42	70p
EF80	25p
EF85	35p
EF86	30p
EF89	28p
EF91	30p
EF92	35p
EF183	35p
EF184	35p
EH90	40p
EL34	50p
EL41	60p
EL42	65p
EL81	55p
EL84	25p
EL85	43p
EL91	35p

EL95	35p
EM80	45p
EM81	60p
EM84	35p
EM85	100p
EM87	70p
EY51	40p
EY86	40p
EY87	42p
EZ40	55p
EZ41	50p
EZ80	27p
EZ81	29p
GZ32	48p
GZ34	60p
KT66	205p
KT88	200p
MU14	75p
PABC80	40p
PC86	60p
PC88	60p
PC97	45p
PC900	48p
PCC84	40p
PCC85	40p
PCC88	55p
PCC89	50p
PCC189	55p
PCF80	30p
PCF82	34p
PCF84	60p
PCF86	60p
PCF800	80p
PCF801	50p
PCF802	50p
PCF805	80p
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PCL83	65p
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PL82	45p
PL83	45p
PL84	40p
PL500	75p
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PY81	30p
PY82	35p
PY83	38p
PY88	40p
PY800	40p
PY801	50p
U25	80p
U26	80p
U50	40p
U52	35p
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U281	40p
U282	40p
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UAF42	55p
UBC41	50p
UBC81	40p
UBF80	40p
UBF89	35p
UCC84	49p
UCC85	40p
UCF80	55p
UCH21	60p
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UCL82	35p
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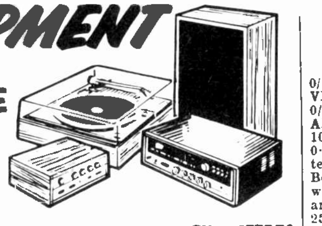

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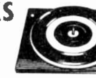

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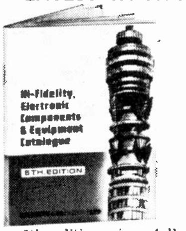

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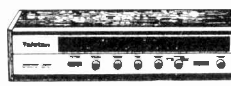

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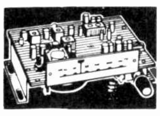

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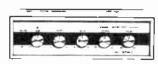

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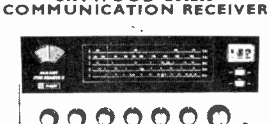

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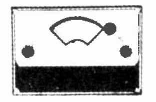

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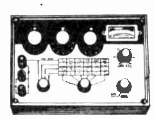

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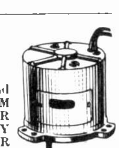

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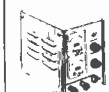

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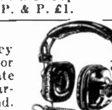

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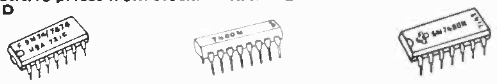

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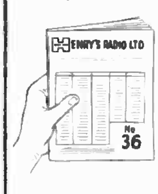

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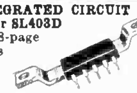

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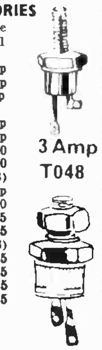

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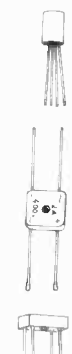

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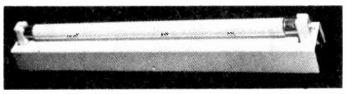

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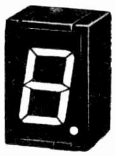

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BFY53	0·17
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GD12	0·05
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GET103	0·22
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GET115	0·45
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OC77	0·40
OC78	0·20
OC79	0·22
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OC81D	0·20
OC81M	0·20
OC81DM	0·18
OC81Z	0·40
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OC82D	0·20
OC83	0·25
OC84	0·25
OC114	0·38
OC122	0·60
OC123	0·65
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OC204	0·40
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74121	0·60
74122	1·35
74123	2·70
74141	1·00
74145	1·50
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74170	4·10
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74175	1·35
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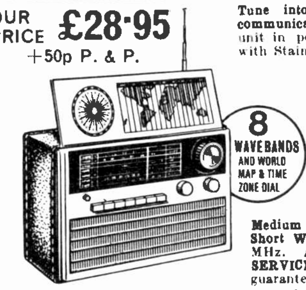

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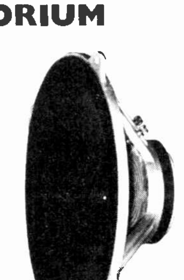

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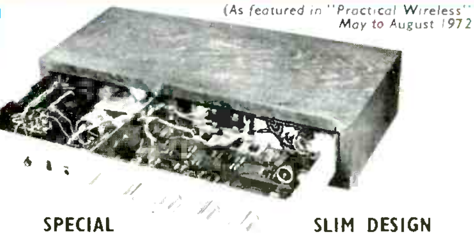

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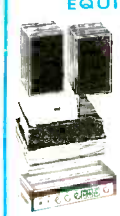

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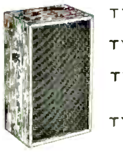

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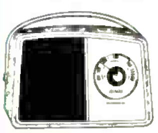

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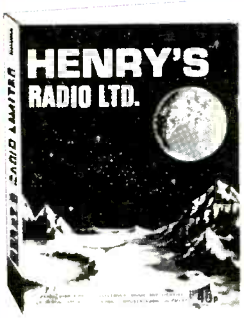

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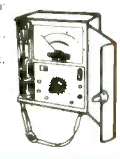

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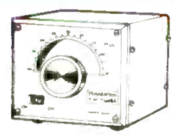

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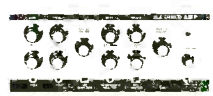

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