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SEPTEMBER 1973

20p

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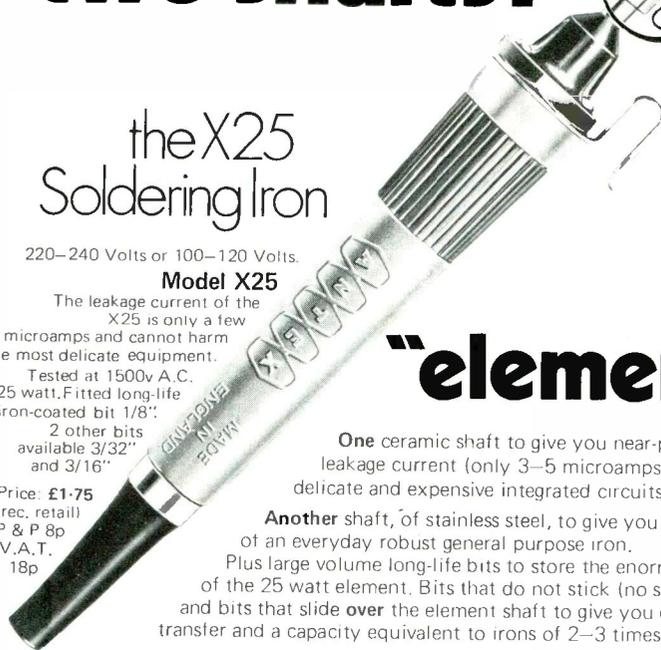
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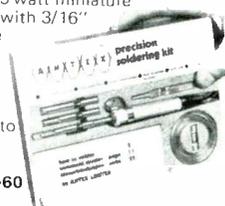
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- LOGIC TUTOR EXPERIMENTS—5** *by M. J. Hughes*
Exclusive OR Function 771
- NEW DEVICES . . . APPLICATIONS**
Describing the TGS (Thermal Gas Sensor) of the PE Electronic Nose 786

NEWS AND COMMENT

- EDITORIAL—A New Dimension in Sound** 751
- SPACEWATCH** *by Frank W. Hyde*
Boulders of Saturn—Gravity Controversy—ESRO and Satellites—Joint Projects 767
- NEWS BRIEFS**
Open University & Electronics—British Technology for USA—Measurements 780
- ELECTRONORAMA**
Cable laying in the Atlantic, from factory to sea floor 788
- MARKET PLACE**
A look at i.c. accessories and audio equipment 797
- INDUSTRY NOTEBOOK**
What's happening inside industry 798
- PATENTS REVIEW**
Cough Monitoring—Wind Direction Indicators 801
- READOUT**
Readers join in the log versus linear controversy 802

Our October issue will be published on Friday, September 14, 1973

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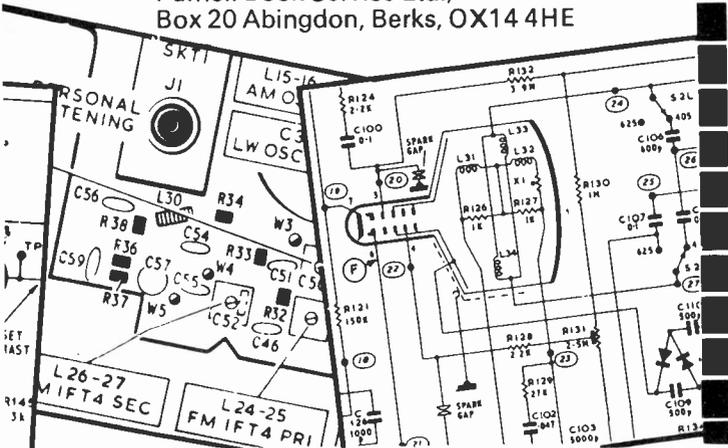
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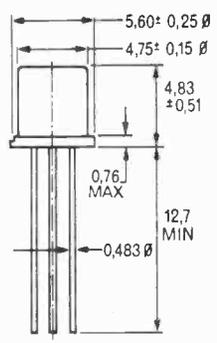




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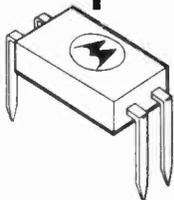


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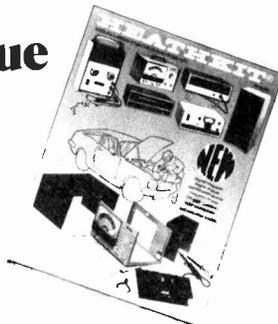
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TYPE "G" NPN Silicon, similar ZTX300 range.
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8 RELAYS FOR VARIOUS TYPES £1.10
P & P 27½p

Our famous PI Pak is still leading in value for money

Full of Short Lead Semiconductors and Electronic Components, approx. 170.

We guarantee at least 30 really high quality factory marked Transistors PNP and NPN, and

a host of Diodes and Rectifiers mounted on Printed Circuit Panels. Identification Chart supplied to give some information on the Transistors.

Please ask for Pak P.1. Only 55p. 11p P & P on this Pak.



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YES, a complete kit of parts including Printed Circuit Board. A four position switch gives X-hatch, Dots, Vertical or Horizontal lines. Integrated Circuit design for easy construction and reliability. This was a project in the September 1972 edition of Television.

This complete kit of parts costs £3.85, post paid.

A MUST for Colour T.V. Alignment.

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Now in kit form, we offer this "up-to-the-minute" electronic ignition system. Simple to make, full instructions supplied with these outstanding features: Transistor and conventional switchability, burglar proof lock-up and automatic alarm, negative and positive compatibility. This project is a "star" feature in the September edition of "Electronics Today International" magazine available from August 10th. Our kit is recommended by the ETI magazine.

Complete kit including P. & P. £7.92
Ready built & tested unit £3.02 EXTRA

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40 watt	1-12	13-25	26-50
90 watt	22p	20p	18p
	261p	241p	22p

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40 watt	1-12	13-25	26-50
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Sinclair Project 60

Now—the Z.50 Mk.2

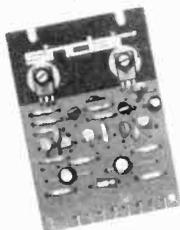
with built-in automatic transient overload protection

When originally introduced, the Sinclair Z.50 proved how it was possible to design and produce a popularly priced modular power amplifier having characteristics to challenge the world's costliest amplifiers. Many thousands of Z.50's are now giving excellent service day in, day out. But we have also learned that constructors do not always use their Z.50's ideally. That is why we have introduced modifications whereby risk of damage through mis-use is greatly reduced and performance further enhanced. The Z.50 Mk.2 has improved thermal stability, more accurately regulated D.C. limiting to ensure more symmetrical output voltage swing and clipping and still less distortion at lower power. Z.50 Mk.2 is compatible with all other Project 60 modules, and may be incorporated to advantage in existing systems. Eleven silicon epitaxial planar transistors are now used, two more than in the original Z.50; circuitry has been re-designed, making this versatile high performance amplifier better than ever.



with free manual
£5.48

Z.30 the power amplifier for quality and economy

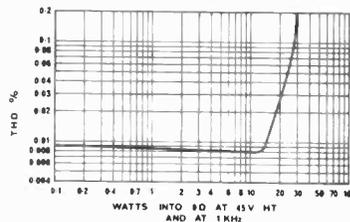


with free manual
£4.48

The Z.30 provides excellent facilities for the constructor requiring a high fidelity audio system of less power than that available from Z.50's. Using a power supply of 35 volts, Z.30 will deliver 15 watts RMS into 8 ohms, or 20 watts RMS into 3 ohms using 30 volts. Total harmonic distortion is a fantastically low 0.02% at 15 watts into 8 ohms with signal to noise ratio better than 70 dB unweighted. Input sensitivity 250mV into 100K ohms. Size 80 x 57 x 13 mm (3 1/8 x 2 1/4 x 1/2). Z.30, Z.50 and Z.50 MK 2 modules are compatible and interchangeable.

Brilliant new technical specifications

Input impedance 100 K Ω
Input (for 30w into 8 Ω) 400mV
Signal to noise ratio, referred to full o/p at 30v HT 80dB or better
Distortion 0.02% up to 20W at 8 Ω . See curve
Frequency response 10Hz to more than 200 KHz \pm 1dB
Max. supply voltage 45v (4 Ω to 8 Ω speakers) (50v 15 Ω speakers only)
Min. supply voltage 9v
Load impedance — minimum: 4 Ω at 45v HT
Load impedance — maximum: safe on open circuit



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.

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Sinclair Radionics Ltd., R.O. London Rd., St. Ives, Huntingdonshire PE17 4HJ (Phone: St. Ives 64311). Regd. Bus. No. England 699483.

the world's most advanced high fidelity modules

Stereo 60 Pre-amp/control unit



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 ± 1 dB 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.

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

Project 60 Stereo F.M. Tuner

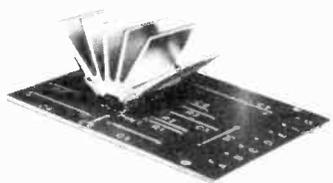


The phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio. Now, Sinclair have applied the principle to an F.M. tuner with fantastically good results. Other advanced features include varicap diode tuning, printed circuit coils, an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

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

Built and tested. Post free. **£25**

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 tran-

sistor 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). 6–8 Ω . **Frequency Response:** 5Hz to 100KHz ± 1 dB. **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 x 45 x 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

Power Supply Units The new PZ.8 Mk.3



The most reliable power supply unit ever made available to constructors. Brilliant circuitry makes failure from over load and even direct shorting of the output impossible. This is due to an ingenious re-entrant current limiting principle which, as far as we know has never before been available in any comparable unit outside the most expensive laboratory equipment. Ripple and residual noise have been reduced to the point of almost total elimination. This is, of course, the perfect unit for Project 60 assemblies, particularly where the new Z.50 MK.2 amplifiers are used. Nominal working voltage — 45

PZ.8 Mk.3—£7.98

(Mains transformer, if required) £5.98

PZ.5 30v. un stabilised

(not suitable for Project 60 tuner) £4.98

PZ.6 35v. stabilised

(not suitable for IC. 12) £7.98

Project 605

Sinclair
Project 605
Amplifier



the easy way to
buy and build
Project 60
without
soldering

Project 605 in one pack contains one PZ.5, two Z.30's, one Stereo 60 and one Masterlink, which has input sockets and output components grouped on a single module and all necessary leads cut to length and fitted with clips to plug straight on to the modules thus eliminating all soldering

Complete with comprehensive manual, post free
All you need for a superb 30 watt high fidelity stereo amplifier

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Practical Electronics September 1973

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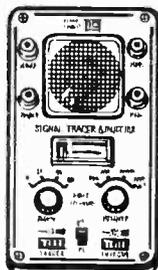


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SIGNAL TRACER/INJECTOR

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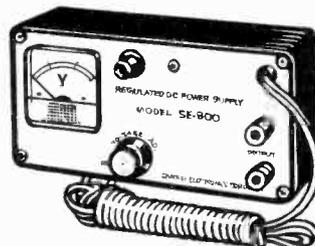
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Powerful trouble shooting signal injector.

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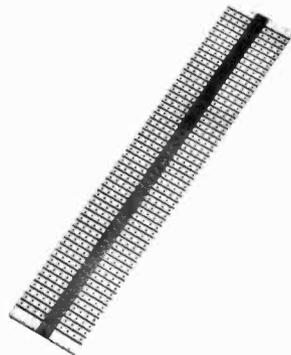
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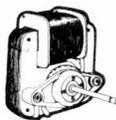
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500 ohm, operates as speaker or microphone, so useful in intercom or similar circuits. 87p each, 10 for £3-76.

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Heavy Duty Mains Power Pack. Output voltage adjustable from 15-40V in steps—maximum load 250W—that is from 6 amp at 40V to 15amp at 15V. This really is a high power heavy duty unit with dozens of workshop uses. Output voltage adjustment is very quick—simply interchange push on leads. Silicon rectifiers and smoothing by 3,000mF. Price £6-33 plus 65p post.

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Size approx. 6 1/2" x 3 1/2" x 2" deep with brass inserts in four corners and bakelite panel. This is a very strong case suitable to house instruments and special rigs, etc. Price 50p each. Paxolin lid 11p extra.

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2 pole, 2 way—4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at 22p each.

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7-0076 Copper conductors. 500 metre drums available in the following colours: Red/Brown, Yellow, Green/Grey, Blue/Green, Red/Orange, Green/White, Grey/White, Blue/Orange, Brown/Brown/White, Red/Grey, Blue/Grey, Blue/Brown. Price £2-20 per drum plus 40p post. State alternative colours. Ditto—but with 200 metres. Price £1-38 per drum plus 20p. Ditto—but with 100 metres. Price 83p per drum.

DOOR SWITCH

As fitted to refrigerators, etc. Switches off as door closes. White 17p each. Black 15p each.

GOODMANS P.M. SPEAKERS

8in x 5in hi flux 15 ohm coil very suitable for use with Mullard Unilux stereo amplifier or with the EP9000 in its own. £1-65 plus 20p post each. 7in x 4in also 15 ohm and suitable for use with the EP9000—not quite such good quality of course. Price £1-05 each.

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5 amp changeover contacts. 11p each. 10 for 99p. 15 amp Model 15p. Changeover 15p each.

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Useful for fluorescence in metals and for looking for water marks, etc., also for fitting over tropical fish tanks—African violets and other indoor plants which must have U.V. for healthy growth. The outfit comprises of a 12in U.V. tube—choke—starter holder and tube ends. Price £2-20 plus 20p post.

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Suitable for garden frame or propagating shelf, etc. Comprises 40W mains transformer, heating wire, connection strip and insulated wire with connection diagram. £1-85 plus 20p post.

80 WATT TUBULAR ELEMENTS

Brass encased with beaded flux ends. Standard replacements in most absorption type refrigerators but also has dozens of other uses. 48p each or 10 for £4-82.

SPIT MOTOR

200-250V Induction Motor, driving a Carter gear box with 1 1/2in. of output drive shaft running at 5 revs per minute. Intended for roasting chickens also suitable for driving models—windmills, coloured disc lighting effect, etc., etc. £2-04 plus 20p post and insurance.



MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied. Model 1153 300mW power output 72p. Model 1172 750mW power output 84p. Model EP9000 4 watt power output £1-60. EP9001 twin channel or stereo pre amp. £1-92. 10% discount if 10 or more ordered.

CENTRIFUGAL BLOWER

Miniature mains driven blower centrifugal type blower built by Woods. Powerful but specially built for quiet running—driven by cushioned induction motor with specially built low noise bearings. Overall size 4 1/2" x 4 1/2" x 4". When mounted by flange, air is blown into the equipment but to suck air out, mount it from centre using a clamp. Ideal for cooling electrical equipment or fitting into a cooker hood, film drying cabinet or for removing flux smoke when soldering etc. etc. A real bargain at £2-05.

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Easiest way to fault find—traces signal from aerial to speaker when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece. £2-20—twin stethoscopes instead of earpiece 83p extra—post and ins. 20p.

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Our Ref: MTM1 27V at 8A. Upright mounting fully shrouded—flying leads—fully tapped primary. Price £3-30. Our Ref: MTM2 12V at 1A. Upright mounting with fixing lugs, tag connection. 240V primary—12V 1A secondary. Price 83p. Our Ref: MTM3 6-3V 2A upright mounting with fixing lugs, tag connections, 240V primary 6-3V 2A secondary. Price 77p. Our Ref: MTM4 18V-1A with thermal cut-out, upright mounting with fixing lugs—tag connections. Primary 240V—secondary 18V at 1A. Price 88p. Mains Isolation MTM5. 350V earth shielded—flex leads—upright mounting lugs for fixing. Price £2-50 each. Mains Transformer Bargain. Standard mains 240V input. Secondary 2-4V 9A intermittent 5A continuous. Price 55p.

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Just what you need for work bench or lab. 4 x 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 7 feet of heavy cable. Wired up ready to work, £2-50 plus 20p post and insurance.

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This system which has proved to be amazingly efficient and reliable was first described in *Wireless World* about a year ago. We can supply kit of parts for an improved and even more efficient version (*Practical Wireless*, June). Price £2-55 plus 20p post. When ordering please state whether for positive or negative systems. De-luxe model including printed circuit board, etc. £7-95.

24-HOUR TIME SWITCH

Made by Smiths, these are A.C. mains operated, NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. Two completely adjustable time periods per 24 hours, 5A changeover contacts will switch circuit on or off during these periods. £2-75 post and ins. 25p. Additional time contacts 55p pair.

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For any lamp up to 1kw. Mounted on switch plate to fit in place of standard switch. Virtually no radio interference. Price £2-95, plus 20p post and insurance. Industrial model 5A £3-80.

BATTERY CONDITION TESTER

Made by Mallory but suitable for all batteries made by Ever Ready and others, most of which are zinc carbon types but also mercury manganese—nicad—silver oxide and alkaline batteries may be tested. The tester puts a dummy load on the battery and the meter scale indicates the condition depending upon which section the pointer rests. The section reads "replace", "weak" or "good". The tester is complete in its case, size 3 1/2" x 6 1/2" x 2" with leads and prods. Price £2-48 plus 20p postage.



DRILL CONTROLLER

NEW IKW MODEL Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. £1-65. Made up model also available. £2-75.

MAINS TRANSISTOR POWER PACK

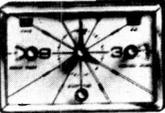
Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor condensers and instructions. Real snip only £1-10.

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So thin is undetectable under carpet but will switch on with slightest pressure. For burglar alarms, shop doors, etc. 14in x 18in £2-54. 23in x 10in £1-10.

SUMMER OFFER!

Mullard Unilux stereo amplifier at pre VAT price namely £10 for the four module, control units knobs and face plate.



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Thyristors, rectifiers, transistors, etc., which use heat-sinks can be easily protected. Simply make the contact thermostat part of the heat-sink. Motors and equipment generally, can also be adequately protected by having thermostats in strategic spots on the casing. Our contact thermostat has a calibrated dial for setting between 90 deg. to 190 deg. F. or with the dial removed range setting is between 80 to 800deg. F. Price 83p.

ROCKER SWITCH

13 amp self-fixing into an oblong hole. Size approximately 1" x 1 1/2" 8p each, 10 for 81p.

THERMAL CUTOUT

A miniature device 3in dia. on one screw fixing mount—can be used for motor overload protection, fire alarm, soldering iron, switch off, etc., etc. 15 amp contacts open with flame—radiant or conducted heat. 11p each or 10 for 99p.

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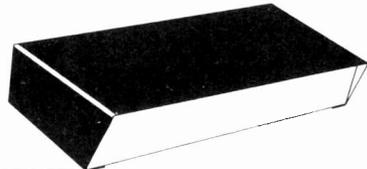
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THIS IS THE FIRST PAGE OF THE GREAT BI-PAK SECTION

BRAND NEW FULLY GUARANTEED DEVICES

AC107 0-22	AD162 0-37	BC148 0-11	BD137 0-50	BF188 0-44	OC19 0-39	2G371 0-18	2N2219 0-22	2N3054 0-51	2N4059 0-11
AC113 0-22	AD161 &	BC149 0-13	BD138 0-55	BF194 0-13	OC20 0-70	2G371B 0-13	2N2220 0-24	2N3055 0-55	2N4060 0-13
AC115 0-26	AD162(MP)	BC150 0-20	BD139 0-61	BF195 0-13	OC22 0-42	2G373 0-19	2N2221 0-22	2N3391 0-16	2N4061 0-13
AC117K 0-22	0-61	BC151 0-22	BD140 0-66	BF196 0-16	OC23 0-46	2G374 0-19	2N2222 0-22	2N3391A 0-18	2N4062 0-13
AC122 0-16	ADT140 0-55	BC152 0-19	BD155 0-88	BF197 0-16	OC24 0-42	2G377 0-33	2N2308 0-19	2N3392 0-16	2N4284 0-19
AC125 0-19	AF126 0-31	BC153 0-31	BD175 0-66	BF200 0-50	OC25 0-42	2G378 0-18	2N2309 0-16	2N3393 0-16	2N4285 0-19
AC126 0-19	AF115 0-27	BC154 0-33	BD176 0-68	BF222 0-10	OC26 0-28	2G381 0-18	2N2369A 0-18	2N3394 0-16	2N4286 0-19
AC127 0-19	AF116 0-27	BC157 0-20	BD177 0-72	BF257 0-50	OC28 0-55	2G382 0-18	2N2411 0-27	2N3395 0-19	2N4287 0-19
AC128 0-19	AF117 0-27	BC158 0-13	BD178 0-72	BF258 0-66	OC29 0-55	2G401 0-33	2N2412 0-27	2N3402 0-23	2N4288 0-19
AC132 0-16	AF118 0-39	BC159 0-13	BD179 0-77	BF259 0-94	OC35 0-46	2G414 0-33	2N2416 0-52	2N3403 0-23	2N4289 0-19
AC134 0-16	AF124 0-33	BC160 0-50	BD180 0-77	BF262 0-61	OC36 0-55	2G417 0-28	2N2711 0-23	2N3404 0-31	2N4290 0-19
AC137 0-16	AF125 0-28	BC161 0-50	BD185 0-72	BF263 0-61	OC41 0-22	2N388 0-39	2N2712 0-23	2N3405 0-46	2N4291 0-19
AC141 0-16	AF126 0-31	BC162 0-13	BD186 0-72	BF270 0-39	OC42 0-27	2N388A 0-61	2N2714 0-23	2N3414 0-17	2N4292 0-19
AC141K 0-19	AF127 0-31	BC168 0-13	BD187 0-77	BF271 0-33	OC44 0-17	2N404 0-22	2N2904 0-19	2N3415 0-17	2N4293 0-19
AC142 0-16	AF139 0-33	BC169 0-13	BD188 0-77	BF272 0-88	OC45 0-14	2N404A 0-31	2N2904A 0-23	2N3416 0-31	2N5172 0-13
AC142K 0-19	AF178 0-33	BC170 0-13	BD189 0-83	BF273 0-39	OC70 0-11	2N424 0-54	2N2905 0-23	2N3417 0-31	2N5457 0-35
AC151 0-17	AF179 0-55	BC171 0-16	BD190 0-83	BF274 0-39	OC71 0-11	2N427 0-46	2N2905A 0-23	2N3525 0-83	2N5458 0-35
AC154 0-22	AF180 0-55	BC172 0-16	BD195 0-94	BF275 0-66	OC72 0-16	2N588 0-46	2N2906 0-17	2N3646 0-10	2N5459 0-44
AC155 0-22	AF181 0-50	BC173 0-18	BD196 0-94	BF29 0-30	OC74 0-18	2N589 0-50	2N2906A 0-20	2N3702 0-11	2N5901 0-55
AC156 0-22	AF186 0-50	BC174 0-16	BD197 0-99	BF284 0-24	OC75 0-17	2N589 0-17	2N2907 0-22	2N3703 0-11	2N5902 0-46
AC157 0-27	AF239 0-41	BC175 0-13	BD198 0-99	BF285 0-33	OC76 0-17	2N589A 0-33	2N2907A 0-22	2N3704 0-12	2N5902 0-46
AC165 0-22	AL102 0-72	BC177 0-21	BD199 0-105	BF286 0-24	OC77 0-28	2N589 0-27	2N2923 0-16	2N3705 0-11	2N5903 0-61
AC166 0-22	AL103 0-72	BC178 0-21	BD200 0-105	BF287 0-27	OC81 0-17	2N589 0-39	2N2924 0-16	2N3706 0-10	2N5904 0-77
AC167 0-22	AS126 0-28	BC179 0-21	BD205 0-88	BF288 0-24	OC81D 0-17	2N706 0-09	2N2925 0-16	2N3707 0-12	2N5905 0-93
AC168 0-27	AS127 0-33	BC180 0-27	BD206 0-88	BF290 0-22	OC82 0-17	2N706A 0-10	2N2926 (C)	2N3708 0-08	2N5906 0-93
AC169 0-16	AS128 0-28	BC181 0-27	BD207 0-105	BF291 0-22	OC82D 0-17	2N708 0-13	2N2926 (V)	2N3709 0-10	2N5907 0-93
AC176 0-22	AS129 0-28	BC182 0-11	BD208 0-105	BF292 0-22	OC83 0-22	2N711 0-33	2N2926 (Y)	2N3710 0-10	2N5914 0-62
AC177 0-27	AS130 0-28	BC183 0-11	BD209 0-110	BF293 0-22	OC84 0-27	2N712 0-38	2N2926 (Z)	2N3711 0-10	2N5914 0-62
AC178 0-27	AS131 0-28	BC183 0-11	BD210 0-110	BF294 0-22	OC89 0-22	2N718 0-33	2N2926 (R)	2N3712 0-10	2N5914 0-62
AC179 0-31	AS132 0-28	BC183L 0-11	BF117 0-50	H8X19 0-17	OC140 0-22	2N718A 0-55	2N2926 (S)	2N3713 0-10	2N5914 0-62
AC180 0-19	AS133 0-28	BC184 0-13	BF118 0-77	H8X20 0-17	OC169 0-28	2N726 0-31	2N2926 (T)	2N3714 0-10	2N5914 0-62
AC180K 0-22	AS134 0-28	BC184 0-13	BF119 0-77	H8Y25 0-17	OC170 0-28	2N727 0-31	2N2926 (U)	2N3715 0-10	2N5914 0-62
AC181 0-19	AS135 0-28	BC184L 0-31	BF121 0-50	H8Y26 0-17	OC171 0-28	2N743 0-22	2N2926 (V)	2N3716 0-10	2N5914 0-62
AC181K 0-22	AS136 0-28	BC187 0-31	BF123 0-55	H8Y27 0-17	OC200 0-28	2N744 0-22	2N2926 (W)	2N3717 0-10	2N5914 0-62
AC187 0-24	AS137 0-28	BC207 0-12	BF125 0-60	H8Y28 0-17	OC201 0-31	2N744 0-22	2N2926 (X)	2N3718 0-10	2N5914 0-62
AC187K 0-24	AS138 0-28	BC207 0-12	BF125 0-60	H8Y29 0-17	OC202 0-31	2N744 0-22	2N2926 (Y)	2N3719 0-10	2N5914 0-62
AC188 0-24	BC107 0-10	BC209 0-13	BF125 0-61	H8Y30 0-20	OC203 0-28	2N744 0-22	2N2926 (Z)	2N3720 0-10	2N5914 0-62
AC188K 0-22	BC108 0-10	BC212L 0-12	BF125 0-61	H8Y39 0-20	OC204 0-28	2N744 0-22	2N2926 (A)	2N3721 0-10	2N5914 0-62
AC197 0-28	BC109 0-11	BC213L 0-12	BF154 0-50	H8Y40 0-31	OC205 0-39	2N1131 0-22	2N2926 (B)	2N3722 0-10	2N5914 0-62
AC198 0-22	BC113 0-11	BC214L 0-16	BF155 0-77	H8Y41 0-31	OC309 0-44	2N1132 0-24	2N2926 (C)	2N3723 0-10	2N5914 0-62
AC199 0-22	BC114 0-17	BC225 0-28	BF156 0-53	H8Y50 0-14	OC71 0-48	2N1302 0-16	2N2926 (D)	2N3724 0-10	2N5914 0-62
AC199 0-22	BC115 0-17	BC226 0-28	BF157 0-61	H8Y56A 0-14	ORP12 0-48	2N1303 0-16	2N2926 (E)	2N3725 0-10	2N5914 0-62
AC199 0-22	BC116 0-17	BC227 0-27	BF158 0-61	3Aa165 2-20	ORP13 0-48	2N1304 0-16	2N2926 (F)	2N3726 0-10	2N5914 0-62
AC199 0-22	BC117 0-17	BC231 0-29	BF159 0-66	3Aa166 2-20	ORP14 0-48	2N1305 0-19	2N2926 (G)	2N3727 0-10	2N5914 0-62
AC199 0-22	BC118 0-11	BCY32 0-33	BF160 0-44	C400 0-33	P346A 0-22	2N1306 0-23	2N2926 (H)	2N3728 0-10	2N5914 0-62
AC199 0-22	BC119 0-33	BCY33 0-24	BF162 0-44	C407 0-28	P397 0-46	2N1307 0-23	2N2926 (I)	2N3729 0-10	2N5914 0-62
AC199 0-22	BC120 0-88	BCY34 0-28	BF163 0-44	C424 0-22	ST140 0-14	2N1308 0-26	2N2926 (J)	2N3730 0-10	2N5914 0-62
AC199 0-22	BC125 0-13	BCY70 0-16	BF164 0-44	C425 0-55	ST141 0-19	2N1309 0-26	2N2926 (K)	2N3731 0-10	2N5914 0-62
AC199 0-22	BC126 0-20	BCY71 0-20	BF165 0-44	C426 0-39	T1843 0-33	2N1613 0-22	2N2926 (L)	2N3732 0-10	2N5914 0-62
AC199 0-22	BC132 0-13	BCY72 0-16	BF167 0-24	C428 0-22	U746 0-30	2N1711 0-22	2N2926 (M)	2N3733 0-10	2N5914 0-62
AC199 0-22	BC134 0-20	BCZ10 0-22	BF173 0-24	C441 0-33	2G301 0-31	2N1819 0-35	2N2926 (N)	2N3734 0-10	2N5914 0-62
AC199 0-22	BC135 0-13	BCZ11 0-28	BF176 0-33	C442 0-33	2G302 0-21	2N1890 0-50	2N2926 (O)	2N3735 0-10	2N5914 0-62
AC199 0-22	BC136 0-17	BCZ12 0-28	BF177 0-39	C444 0-39	2G303 0-21	2N1893 0-41	2N2926 (P)	2N3736 0-10	2N5914 0-62
AC199 0-22	BC137 0-17	BD121 0-66	BF178 0-33	C450 0-24	2G304 0-27	2N2147 0-79	2N2926 (Q)	2N3737 0-10	2N5914 0-62
AC199 0-22	BC139 0-44	BD123 0-72	BF179 0-33	MAT100 0-21	2G305 0-44	2N2148 0-63	2N2926 (R)	2N3738 0-10	2N5914 0-62
AD130 0-42	BC140 0-33	BD124 0-66	BF180 0-33	MAT101 0-22	2G308 0-39	2N2160 0-66	2N2926 (S)	2N3739 0-10	2N5914 0-62
AD140 0-53	BC141 0-33	BD125 0-55	BF181 0-33	MAT120 0-21	2G309 0-39	2N2162 0-39	2N2926 (T)	2N3740 0-10	2N5914 0-62
AD142 0-33	BC142 0-33	BD126 0-44	BF182 0-44	MAT121 0-22	2G339 0-22	2N2163 0-39	2N2926 (U)	2N3741 0-10	2N5914 0-62
AD143 0-42	BC143 0-33	BD133 0-72	BF183 0-44	MAT122 0-22	2G339A 0-22	2N2194 0-39	2N2926 (V)	2N3742 0-10	2N5914 0-62
AD149 0-55	BC145 0-50	BD135 0-44	BF184 0-28	MAT123 0-22	2G344 0-20	2N2217 0-24	2N2926 (W)	2N3743 0-10	2N5914 0-62
AD161 0-37	BC147 0-11	BD136 0-44	BF185 0-33	MAT124 0-22	2G345 0-18	2N2218 0-24	2N2926 (X)	2N3744 0-10	2N5914 0-62

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AA119 0-09	BY133 0-23	OA10 0-39
AA130 0-08	BY164 0-55	OA47 0-08
AA129 0-09	BYX38/39	OA70 0-08
AA30 0-10	0-46	OA79 0-08
AAZ13 0-11	BYZ10 0-39	OA81 0-08
BA100 0-11	BYZ11 0-33	OA85 0-10
BA116 0-23	BYZ12 0-33	OA90 0-07
BA126 0-24	BYZ13 0-28	OA91 0-07
BA145 0-16	BYZ16 0-44	OA95 0-08
BA154 0-13	BYZ17 0-39	OA200 0-07
BA155 0-16	BYZ18 0-39	OA202 0-08
BA156 0-15	BYZ19 0-31	SD10 0-06
BY100 0-17	CG62	SD19 0-08
BY101 0-13	(OA91 Eq.)	IN34 0-08
BY105 0-18	0-08	IN34A 0-08
BY114 0-13	CG65-1	IN914 0-07
BY126 0-18	(OA70-OA79)	IN916 0-07
BY127 0-17	0-07	IN414B 0-07
BY128 0-17	OA5	18021 0-11
BY130 0-18	OA58L	18951 0-07

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C 9	3	Micro Switches	0-55
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	50	100	200	400	600	800
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3A TO66	0-28	0-37	0-41	0-52	0-63	0-77
5A TO66	0-34	0-62	0-64	0-82	0-75	0-88
5A TO64	0-34	0-52	0-54	0-63	0-75	0-88
7A TO48	0-52	0-55	0-63	0-74	0-85	0-99
10A TO48	0-56	0-64	0-67	0-83	1-07	1-32
16A TO48	0-59	0-70	0-83	1-03	1-38	1-65
30A TO48	1-27	1-54	1-78	1-83	—	4-40

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	PIV					
	300mA	750mA	1A	1.5A	3A	10A
DO7	SO16	Plastics	SO16	SO10	SO10	SO32A
50-0-04	0-06	0-06	0-08	0-16	0-23	0-66
100-0-04	0-07	0-08	0-15	0-18	0-28	0-83
200-0-06	0-10	0-07	0-16	0-22	0-27	1-10
400-0-07	0-15	0-08	0-22	0-30	0-41	1-38
600-0-09	0-18	0-11	0-26	0-38	0-50	2-05
800-0-11	0-19	0-12	0-28	0-41	0-61	2-20
1000-0-12	0-30	0-16	0-33	0-51	0-70	2-75
1200-0-12	0-37	—	0-42	0-63	0-83	—

TRIACS

	2A	6A	10A
TO-9	TO-66	TO-48	
50p	5p	6p	
100V	33	55	82
200V	55	66	89
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T2	8 1K374 OC75
T3	8 1K1216 OC81D
T4	8 2K381T OC81
T5	8 2K382T OC82
T6	8 2K344H OC44
T7	8 2K343H OC43
T8	8 2K378 OC78
T9	8 2K399A 2N1302
T10	8 2G417 AF117

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

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Q 9	7 OC81 type transistors	0-55
Q10	7 OC71 type transistors	0-55
Q11	2 AC127/128 Complementary pairs pnp/npn	0-55
Q12	3 AF116 type transistors	0-55
Q13	3 AF117 type transistors	0-55
Q14	3 OC171 H.F. type transistors	0-55
Q15	7 2N2926 Sil. Epoxy transistors mixed colours	0-55
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Q17	5 npn 2 x 8T.141 & 3 x 8T.140	0-55
Q18	4 MADT'S 2 x MAT 100 & 2 x MAT 120	0-55
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Q31	6 Silicon switch transistors 2N708, npn	0-55
Q32	3 pnp Silicon transistors 2 x 2N1131, 1 x 2N1132	0-55
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Manufacturers "Fall Outs" which include Functional and Part-Functional Units. These are classed as "out-of-spec" from the maker's very rigid specifications, but are ideal for learning about I.C.'s and experimental work.

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UIC06	= 8 x 7406	0-55
UIC07	= 8 x 7407	0-55
UIC08	= 12 x 7410	0-55
UIC13	= 8 x 7413	0-55
UIC20	= 12 x 7420	0-55
UIC30	= 12 x 7430	0-55
UIC40	= 12 x 7440	0-55
UIC41	= 8 x 7441	0-55
UIC42	= 8 x 7442	0-55
UIC43	= 8 x 7443	0-55
UIC44	= 5 x 7444	0-55
UIC45	= 3 x 7445	0-55

Pak No.	Contents	Price
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UIC47	= 5 x 7447	0-55
UIC48	= 5 x 7448	0-55
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UIC51	= 12 x 7451	0-55
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UIC54	= 12 x 7454	0-55
UIC60	= 8 x 7460	0-55
UIC68	= 12 x 7460	0-55
UIC70	= 8 x 7470	0-55
UIC72	= 8 x 7472	0-55
UIC73	= 8 x 7473	0-55
UIC74	= 8 x 7474	0-55
UIC75	= 8 x 7475	0-55
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UIC80	= 8 x 7480	0-55
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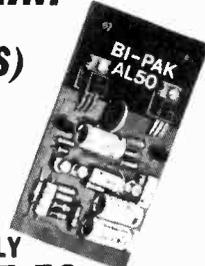
		1	25	100+			1	25	100+
SN7400	0-17	0-16	0-13	0-13	SN7486	0-35	0-34	0-33	0-33
SN7401	0-17	0-16	0-13	0-13	SN7489	6-05	5-78	5-50	0-84
SN7402	0-17	0-16	0-13	0-13	SN7490	0-74	0-71	0-64	0-64
SN7403	0-17	0-16	0-13	0-13	SN7491	1-10	1-04	0-97	0-64
SN7404	0-17	0-16	0-13	0-13	SN7492	0-74	0-71	0-64	0-64
SN7405	0-17	0-16	0-13	0-13	SN7493	0-74	0-71	0-64	0-64
SN7406	0-39	0-34	0-31	0-31	SN7494	0-85	0-82	0-75	0-64
SN7407	0-39	0-34	0-31	0-31	SN7495	0-35	0-82	0-75	0-64
SN7408	0-20	0-14	0-18	0-18	SN7496	0-86	0-83	0-86	0-86
SN7409	0-20	0-19	0-18	0-18	SN7400	1-82	1-76	1-71	1-71
SN7410	0-17	0-16	0-13	0-13	SN74104	1-07	1-04	0-97	0-97
SN7411	0-29	0-24	0-26	0-26	SN74105	1-07	1-04	0-97	0-97
SN7412	0-39	0-34	0-31	0-31	SN74107	0-44	0-42	0-40	0-40
SN7413	0-32	0-29	0-27	0-27	SN74110	0-51	0-50	0-55	0-55
SN7416	0-48	0-44	0-42	0-42	SN74111	1-38	1-27	1-21	1-21
SN7417	0-48	0-44	0-42	0-42	SN74118	1-10	1-05	0-99	0-99
SN7420	0-17	0-16	0-13	0-13	SN74119	1-40	1-38	1-21	1-21
SN7422	0-55	0-53	0-50	0-50	SN74121	0-44	0-41	0-38	0-38
SN7423	0-55	0-53	0-50	0-50	SN74122	1-54	1-43	1-32	1-32
SN7425	0-55	0-53	0-50	0-50	SN74123	3-08	2-97	2-86	2-86
SN7426	0-50	0-46	0-44	0-44	SN74141	0-74	0-71	0-64	0-64
SN7427	0-50	0-46	0-44	0-44	SN74145	1-65	1-54	1-43	1-43
SN7428	0-77	0-72	0-68	0-68	SN74150	3-30	2-97	2-75	2-75
SN7430	0-17	0-16	0-13	0-13	SN74151	1-10	1-05	0-99	0-99
SN7432	0-50	0-46	0-44	0-44	SN74133	1-32	1-21	1-05	1-05
SN7433	0-88	0-83	0-77	0-77	SN74134	1-08	1-07	1-05	1-05
SN7437	0-71	0-68	0-66	0-66	SN74153	1-54	1-43	1-32	1-32
SN7438	0-71	0-68	0-66	0-66	SN74156	1-54	1-43	1-32	1-32
SN7440	0-17	0-16	0-13	0-13	SN74157	2-09	1-98	1-87	1-87
SN7441	0-74	0-71	0-64	0-64	SN74160	1-98	1-87	1-76	1-76
SN7442	0-74	0-71	0-64	0-64	SN74161	1-98	1-87	1-76	1-76
SN7443	1-43	1-38	1-32	1-32	SN74162	4-40	4-13	3-85	3-85
SN7444	1-43	1-38	1-32	1-32	SN74163	4-40	4-13	3-85	3-85
SN7445	1-98	1-95	1-93	1-93	SN74164	2-42	2-37	2-31	2-31
SN7446	1-07	1-04	0-97	0-97	SN74165	2-48	2-42	2-37	2-37
SN7447	1-10	1-07	1-05	1-05	SN74166	3-85	3-58	3-30	3-30
SN7448	1-10	1-07	1-05	1-05	SN74174	2-53	2-42	2-31	2-31
SN7460	0-17	0-16	0-13	0-13	SN74175	1-76	1-65	1-54	1-54
SN7451	0-17	0-16	0-13	0-13	SN74176	2-75	2-64	2-53	2-53
SN7453	0-17	0-16	0-13	0-13	SN74177	2-75	2-64	2-53	2-53
SN7454	0-17	0-16	0-13	0-13	SN74178	2-75	2-64	2-53	2-53
SN7459	0-17	0-16	0-13	0-13	SN74181	2-20	1-98	1-76	1-76
SN7470	0-32	0-29	0-27	0-27	SN74182	2-20	1-98	1-76	1-76
SN7472	0-32	0-29	0-27	0-27	SN74184	3-85	3-58	3-30	3-30
SN7473	0-41	0-39	0-36	0-36	SN74190	2-15	2-09	2-04	2-04
SN7474	0-41	0-39	0-36	0-36	SN74191	2-20	2-04	1-98	1-98
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SN7476	0-44	0-43	0-43	0-43	SN74193	2-09	1-98	1-83	1-83
SN7480	0-74	0-71	0-64	0-64	SN74194	2-97	2-86	2-75	2-75
SN7481	1-32	1-27	1-21	1-21	SN74195	2-20	2-09	1-98	1-98
SN7482	0-96	0-95	0-94	0-94	SN74196	1-98	1-87	1-76	1-76
SN7483	1-21	1-16	1-05	1-05	SN74197	1-98	1-87	1-76	1-76
SN7484	1-10	1-05	0-99	0-99	SN74198	6-05	5-50	4-85	4-85
SN7485	3-96	3-85	3-74	3-74	SN74199	6-05	5-50	4-85	4-85

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- SPECIFICATION**
- Frequency Response 20Hz - 20kHz ± 1dB
 - Harmonic Distortion better than 0.1%
 - Inputs: 1. Tape Head 1.25mV into 50K Ω
 - 2. Radio, Tuner 35mV into 50K Ω
 - 3. Magnetic P.U. 1.5mV into 50K Ω
- All input voltages are for an output of 250mV. Tape and P.U. inputs equalised to RIAA curve within ± 1dB from 20Hz to 20kHz.
- Bass Control ± 15dB at 20Hz
 - Treble Control ± 15dB at 20kHz
 - Filters: Rumble (High Pass) 100Hz
 - Scratch (Low Pass) 8kHz
 - Signal/Noise Ratio better than -65dB
 - Input overload +26dB
 - Supply +35 volts at 20mA
 - Dimensions 292mm x 82mm x 35mm



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BP709P-μA709C	0.40	0.38	0.33
BP710-72710	0.40	0.46	0.44
BP711-μA711	0.40	0.48	0.44
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BP933	0-14	0-13	0-12
BP935	0-14	0-13	0-12
BP936	0-14	0-13	0-12
BP944	0-14	0-13	0-12
BP945	0-28	0-27	0-24
BP946	0-13	0-12	0-11
BP948	0-28	0-27	0-24
BP951	0-72	0-66	0-61
BP962	0-13	0-12	0-11
BP9003	0-44	0-42	0-39
BP9004	0-44	0-42	0-39
BP9087	0-44	0-42	0-39
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Cathode Current (mA)	2.3	14	8	
Numerical Height (mm)	16	13	9	
Tube Height (mm)	47	32	22	
Tube Diameter (mm)	19	13	12 wide	
I.C. Driver Rec.	BP41 or 141	BP41 or 141	BP47	
PRICE EACH	£1.87	£1.70	£1.50	

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POTENTIOMETERS
Miniature carbon track with ¼in. spindles. 5kΩ, 10kΩ, 25kΩ, 50kΩ, 100kΩ, 250kΩ, 500kΩ, 1MΩ, 2MΩ. Log or lin (and 1kΩ lin), 12p. Log or lin with switch 23p. Dual gang less switch 38p.

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8 pin DIL OP AMP
741C 36p.
14 pin 741C 45p.

McMURDO
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(As used in P.E. Sound Synthesiser.)

Diodes IN914 4p.
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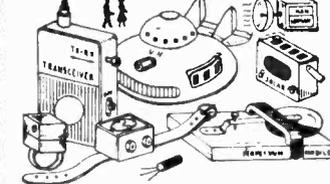
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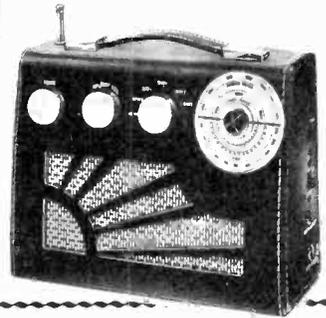
Built-in ferrite rod aerial for MW/LW. Retractable, chrome plated 7 section telescopic aerial, can be angled and rotated for peak short wave and VHF listening. Push-pull output using 600mW transistors. Car Aerial and tape record sockets. 10 transistors plus 3 diodes. Fine tone moving coil speaker. Ganged tuning condenser with VHF section. Separate coil for Aircraft Band. Volume/on/off, wave change and tone controls. Attractive case in black with silver blocking. Size 9in x 7in x 4in.

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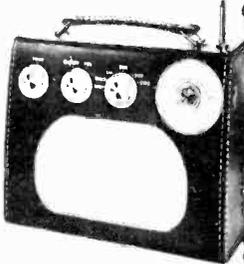
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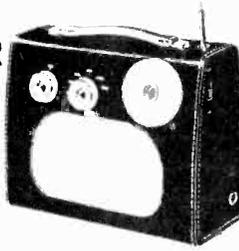
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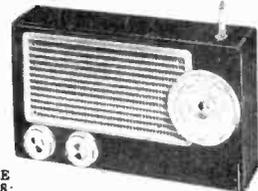


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ROAMER SIX

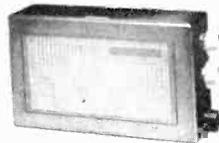


6 TUNABLE WAVEBANDS: MW, LW, SW1, SW2, TRAWLER

BAND PLUS AN EXTRA MW BAND FOR EASIER TUNING OF LUXEMBOURG, ETC. Sensitive ferrite rod aerial and telescopic aerial for short waves. 3in speaker. 8 stages—6 transistors and 2 diodes including micro-alloy R.F. transistors, etc. Attractive black case with red grille, dial and black knobs with polished metal inserts. Size 9in x 5 1/2in x 2 1/2in approx. Plans and parts price list 25p (FREE with parts).

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POCKET FIVE



3 TUNABLE WAVEBANDS: MW, LW, TRAWLER BAND WITH EXTENDED MW BAND FOR EASIER TUNING OF LUXEMBOURG, ETC. 7 stages—5 transistors and 2 diodes, supersensitive ferrite rod aerial, fine tone moving coil speaker. Attractive black and gold case. Size 5 1/2in x 1 1/2in x 3 1/2in. Plans and parts price list 15p (FREE with parts).

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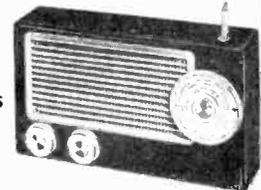


5 TRANSISTORS AND 2 DIODES

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 6 1/2in x 4 1/2in x 1 1/2in. Plans and parts price list 15p (FREE with parts).

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TRANS EIGHT



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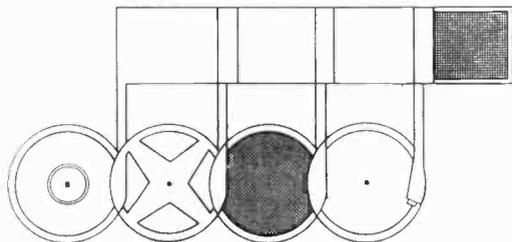
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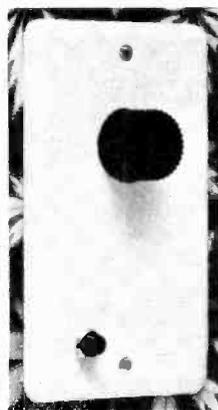
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OA90, OA91, OA95, 6p each; OA200, 9p; OA202, 10p.

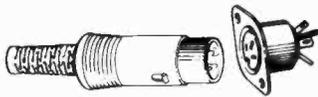
Other semiconductors: AC128, 17p; AF117, 32p; BFY51, 19p. Full lists and technical data will be found in Catalogue No. 6. See also amendments list.

Send S.A.E. for latest supplement of additional lists and price amendments to our No. 6 Catalogue

ZENER DIODES full range E24 values: 400mW: 2.7V to 36V, 14p each; 1W: 6.8V to 82V, 21p each; 1.5W: 4.7V to 75V, 48p each. Clip to increase 1.5W rating to 3 watts (type 266F) 4p.

DIN PLUGS AND SOCKETS

by Hirshmann, 4A rating

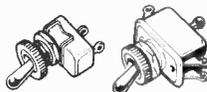


2 way LS —socket 10p, plug 12p
3 way scr.—socket 10p, plug 12p
5 way scr.—socket 11p, plug 15p

TRANSISTOR ACCESSORIES
TO3 cover, 7p; Heat sinks 1°C/W, type 6W1, undrilled, 60p.

SWITCHES

1011 SPST toggle, 20p; 409 DPDT toggle, 29p (these are chrome plated, 2.5A rating); 7201 sub-miniature DPDT 250V a.c./2A, 48p.

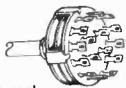


ROTARY SWITCHES

Radiospares Miniature Mako-switch (in assembly kit form). Shaft, 48p. Waters, MBB-2P5W, 1P11W; BBM1P12W, 2P6W, 3P4W, 4P3W, 6P2W, 32p each.

WAVECHANGE SWITCHES

IP12W, 2P6W, 3P4W, 413W, 24p each.



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Rated voltage:	3V	6.3V	10V	16V	25V	40V	63V	100V
Capacity μ F	0.47	—	—	—	—	—	10p	7p
1.0	—	—	—	—	—	10p	—	7p
2.2	—	—	—	—	—	—	7p	8p
4.7	—	—	—	10p	—	—	7p	8p
10	—	—	7p	—	7p	—	8p	8p
22	—	—	—	—	—	—	7p	9p
47	7p	—	—	—	—	—	8p	7p
100	8p	7p	7p	7p	7p	9p	11p	19p
220	7p	8p	8p	8p	9p	10p	17p	27p
470	8p	9p	9p	10p	12p	17p	24p	43p
1,000	10p	12p	17p	20p	24p	40p	—	—
2,200	14p	17p	22p	25p	36p	40p	—	—
4,700	25p	28p	37p	41p	54p	—	—	—
10,000	40p	43p	—	—	—	—	—	—

Prices subject to amendment by the manufacturer.

POLYCARBONATE—5% TOLERANCE

250V up to 0.1 μ F: 100V, 0.1 μ F and above.
0.01; 0.012; 0.015; 0.018; 0.022; 0.027; 0.033; 0.047; 0.056; 4p each; 0.068; 0.082; 0.1; 0.12; 0.15; 4p each; 0.18; 0.22; 5p each; 0.27; 0.33; 6p; 0.39; 7p; 0.47; 8p; 0.56; 10p; 0.68; 11p; 1 μ F; 13p. Prices subject to amendment by the manufacturer.

Mintron Digital Counter
Type 3015F. Seven Filament segment indicators to make 0-9 + decimal point. Compatible with standard logic modules, nett £2. Decoder driver type FLL 121T nett £1.36. DIL socket, nett £2.

RESISTORS — 10%, 5%, 2%

Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99	100 up
C	1/20W	5%	82 Ω —220K Ω	E12	9	8	7.5
C	1/8W	5%	4.7 Ω —470K Ω	E24	1	0.9	0.75 nett
C	1/4W	5%	4.7 Ω —10M Ω	E12	1	0.9	0.75 nett
C	1/2W	5%	4.7 Ω —10M Ω	E24	1-2	1	0.95 nett
C	1W	5%	4.7 Ω —10M Ω	E12	2.5	2	1.6 nett
MO	1/2W	2%	10 Ω —1M Ω	E12	4	3	2 nett
WW	1W	10%	1/20 Ω —0.22 Ω —3.9 Ω	E12	7	7	6
WW	3W	5%	1 Ω —10K Ω	E12	7	7	6
WW	7W	5%	1 Ω —10K Ω	E12	9	9	8

Codes: C = carbon film, high stability, low noise. MO = metal oxide, Electrofil TR5, ultra low noise. WW = wire wound, Plessey.

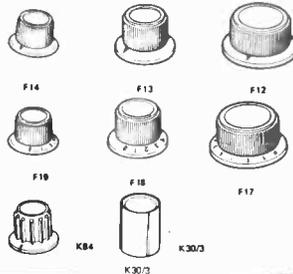
Values:
E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24 denotes series: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions of one penny on total value of resistor order.)

KNOBS

All grub screw fitting for $\frac{1}{4}$ in shafts. Black. For other types —see Catalogue No. 6, p. 54.

F.14 (20mm) pack of 2, 32p; F.13 (26mm) pack of 2, 38p; F.12 (33mm) pack of 2, 40p; F.19 (20mm) pack of 2, 32p; F.18 (26mm) pack of 2, 38p; F.17 (33mm) pack of 2, 40p; K.B.4 (20mm) pack of 4, 40p; K30/3 (17mm) aluminium, 24p each.



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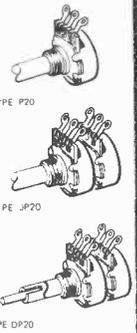
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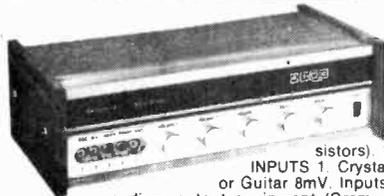
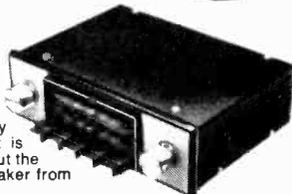
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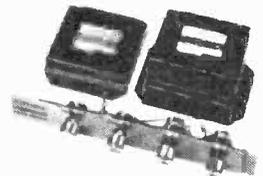


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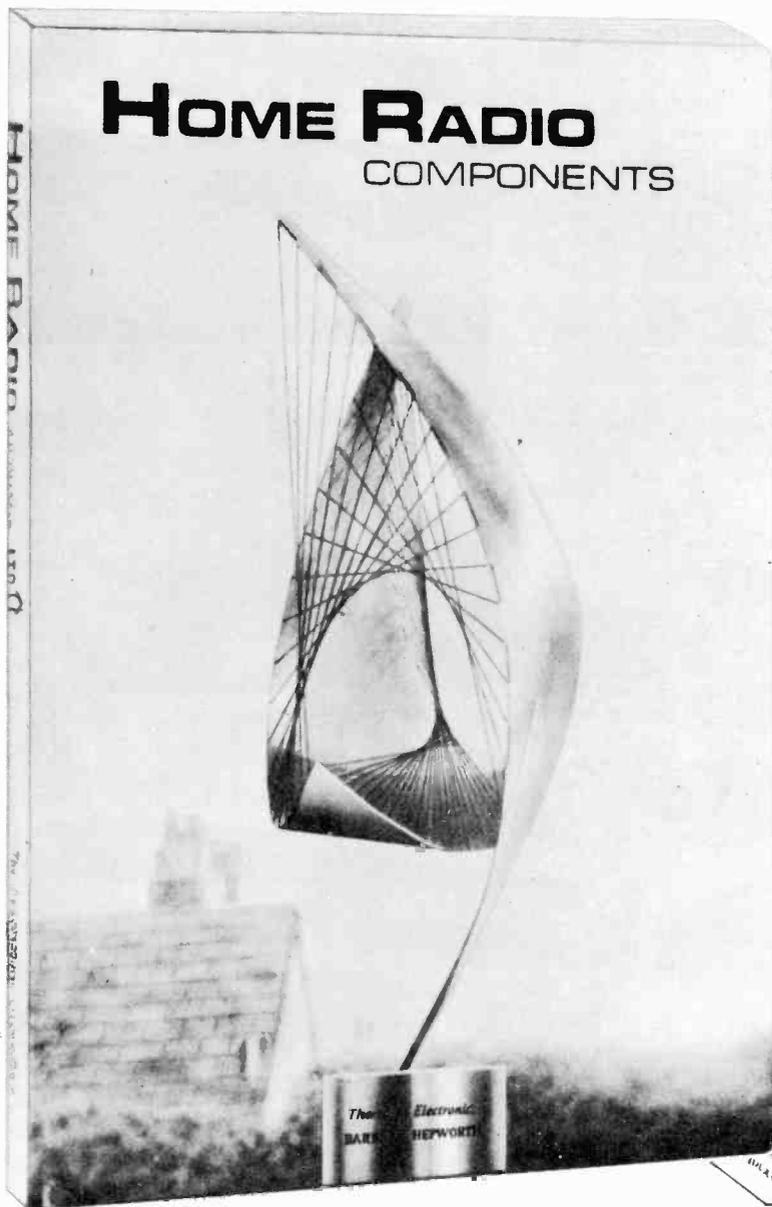
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FOUR years ago we commented upon the visionary views of the eminent musician Leopold Stokowski who had just then proposed the idea that stereo was by no means the ultimate in sound reproduction, but that a four channel system offered greater possibilities for extending musical pleasure by bringing the listener right into the midst of the performers.

Whilst applauding this somewhat revolutionary notion, we ventured to express our fears concerning the formidable nature of the task being set before the engineer. Timidity is out of place in electronics, and we should have known better!

In rather less than four years the technical problem of recording four channels upon disc in such a manner that their subsequent recovery would be possible using a normal stereo stylus has been solved. An account of the various rival systems and the current trend is given in the opening article of our new series featuring the P.E. Rondo—the first complete quadrasonic system to be offered to the constructor.

Now that the technical problems have (to all intents and purposes) been solved and both hardware and software are available, quadrasonic surround sound has become a reality and can be experienced in any home.

But what, exactly, does quadrasonic sound mean in the final analysis—in the strictly musical sense? If the ordinary listener is a little confused by what he has already sampled during demonstrations, this is not at all surprising. It is still early days for a new art. The recording companies show no single-minded approach to quadrasonics. In the US, CBS (originators of the strongly favoured SQ system) are experimenting with unconventional circular arrangements for orchestras when recording classical works in their studios, so providing the listener with the illusion of being right in the centre, on the conductor's rostrum. At home, EMI, in contrast, opts for the traditional concert platform set-up and uses the two rear channels in a rather subsidiary role, to add "concert hall ambience" to stereo.

In the case of popular music, recording engineers and producers seem permitted greater latitude to exploit the possibilities of four-channel recording. Less inhibited by nature, the pop musicians can be counted upon to make more dramatic use of the directional properties of quad, and new sound patterns will be devised, with the likelihood of the listener being assailed first from one corner then from another.

Following the establishment of stereo, the engineers accepted the next challenge and with the aid of the latest electronic technology have made the musician's dream possible. Now it is the creative artist's turn to experiment. Such a radical development in sound reproduction for the home sets a challenge for the composer and performer, in both the classical and pop areas. The impact of quadrasonics upon the world of music will be interesting to follow. It should produce some exciting and surprising sounds, though the initial period of experimentation may be a little wearing upon the listener's ears—and neck muscles.

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PE RONDO

QUADRAPHONIC

SOUND SYSTEM

BY R.A. COLE*

Audio systems are fast expanding into complex and very expensive set-ups offering all manner of facilities. In the PE RONDO system, PRACTICAL ELECTRONICS offers the home constructor a modular equipment housed in one case which may incorporate a selection of functions so as to form anything from a simple stereo amplifier system through to a complex AM/FM receiver/quadrasonic/stereo control and amplification system.

THE SAYING, "history repeats itself" must surely be proven when applied to recorded sound. At each stage of its development the eternal pessimists have sagely remarked that "it will never catch on"

When the first long playing records were introduced over two decades ago many record shops refused even to contemplate stocking them. The multiplicity of recording characteristics backed by various manufacturers of records caused even the hardiest of audio enthusiasts to think twice. The Jeremiahs considered that the LP was too fragile and the technical difficulties in reproduction too great.

But within a few years the LP was established and one standard recording characteristic was adopted.

STEREO

The introduction of the stereo LP caused just as much soul searching. Apart from plain disbelief that one groove could contain two signals, long and learned dissertations on recording techniques proliferated. There were even two contending methods of groove cutting, one "hill and dale" and the other "45-45" Blumlein method.

Fortunately this problem was soon decided in favour of the 45-45 method which is standard today. One of the earliest demonstration records had a commentator who spoke the historic words, "ping . . . pong", one word from each speaker, and immortalised "ping-pong" stereo.

Despite these problems the purist seems to live alongside the more gimmicky listener and all seem to be happy with their respective lots notwithstanding an occasional rumbling from the old ghosts of the past quarter century.

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See page 732

QUADRAPHONICS

Four channel sound has been with us now for several years and our enthusiast is just as confused as his predecessors by the old ghosts and Jeremiahs who seem to have reappeared for a 'new season of sport.'

The writer will attempt to remove as much of the confusion as he can and will clear the decks by stating that four channel sound is here to stay and that *any* of the techniques currently available enhances the enjoyment of recorded music.

Many elegant terms have been adopted in recent months to describe multichannel reproduction. The writer will use the inelegant but generally accepted nomenclature. However, when a term is confusing, definition of that term will be attempted.

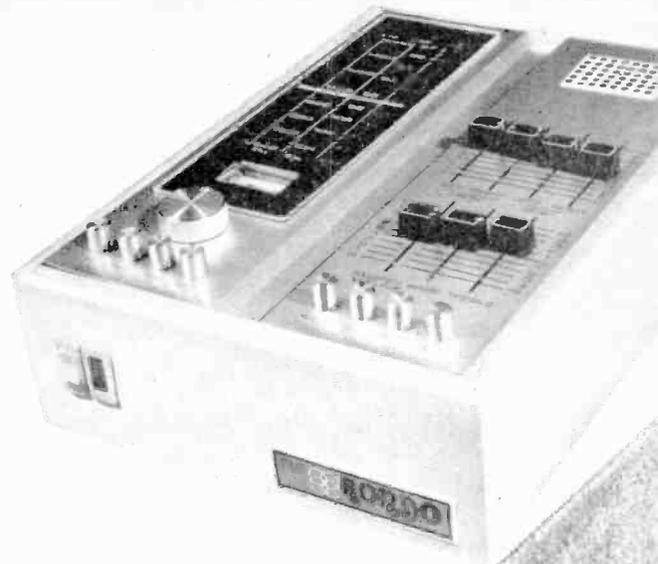
Equally, whilst there are numerous multichannel reproduction techniques that *could* have replaced the present direction of development, the writer will confine himself to the present direction dealing, in detail, with the viable techniques to which the major producers of software and hardware are committed. Brief mention will be made of future trends and, as existing techniques are liable to updating, a final article in the series will include reference to the state of the art at that date.

NOMENCLATURE

Four channel reproduction is generally called **QUADRAPHONY** (Quadraphonic) conveniently analogous with **STEREOPHONY** (Stereophon c).

AMBIENCE ENHANCING. A term applied to circuits which attempt to recover ambient information from a normal stereo disc. A noteworthy system is that promoted by Dynaco. Another is shown in Fig. 1.1 by B. B. Bauer (1961).

DISCRETE SYSTEM. One which has four independent channels which can achieve distinct and unconnected sound placement in each channel. Quadraphonic tapes can be called discrete. "Discrete" when applied to disc reproduction is a misnomer which is perpetuated in the description of the JVC CD4 system.



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- ◆ CBS/SQ Quadraphonic decoder

System details and construction of the decoder follow on Page 761



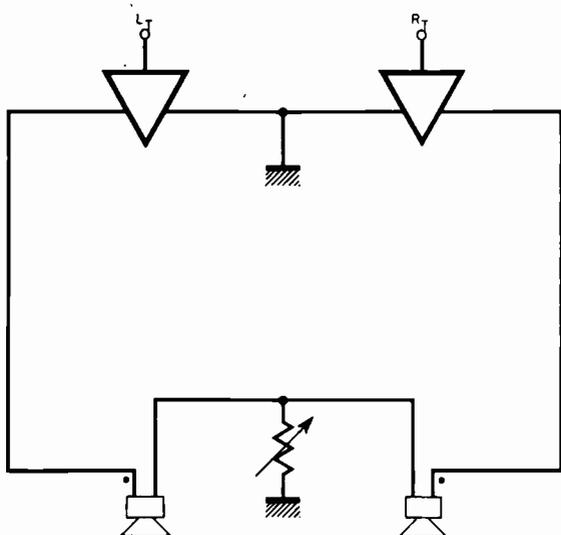


Fig. 1.1. Ambience enhancing in an attempt to recover ambient information from a normal stereo disc. This is the Bauer system developed in 1961

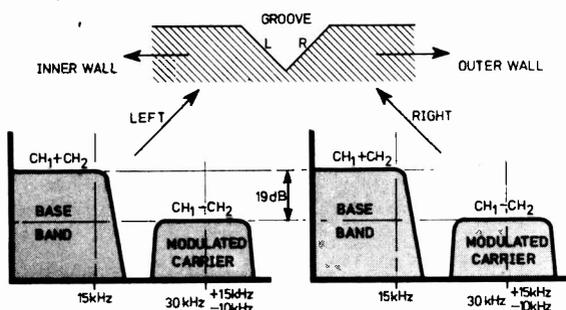


Fig. 1.2. Modulation direction and band separation on a CD4 disc

MATRIX. A term which, in Quadraphony, refers to the electronic mixing of four channels of sound into two composite channels for recording onto a disc followed by electronic re-creation of the original four channels of information. It is sometimes referred to as 4-2-4-matrixing. SQ, QS, RM and E-V are various matrixes.

CARRIER SYSTEM. For example, the JVC CD4 quadraphonic system, utilises two ultrasonic carriers and a matrix to achieve a recording on disc that can be demodulated upon playback to give four channels of information related to the original four recorded.

There are but three systems at present viable to which the major producers of hardware (equipment) and software (recordings—disc or tape) are committed and these can be broadly grouped into two. These are the JVC CD4 system, a carrier system, and the CBS SQ and Sansui QS systems, which are matrix systems.

THE CD4 SYSTEM

The CD4 system was developed by the Japan Victor Company (Nivico) and RCA, and first demonstrated publicly in September 1970. CD4 is a contraction of Compatible Discrete Four Channel. Work on similar lines was carried out by CBS before they opted for the SQ matrix.

The CD4 system combines matrixes with carriers by converting the four channels into sum and difference signals. Channel 1 + channel 2 ($CH_1 + CH_2$) is recorded on the left hand side of a 45-45 groove and $CH_3 + CH_4$ is recorded on the right hand side. The difference signals $CH_1 - CH_2$ and $CH_3 - CH_4$ modulate ultrasonic carriers and the resultants are superimposed upon the sum signals for recording.

The sum signals are called Base Bands and the difference signals are called Modulated Carriers (Fig. 1.2). The base bands are recorded to the RIAA characteristic and are the same as conventional stereo recording.

Due to a number of technical reasons the modulated carriers are frequency modulated below 800Hz and above 6kHz and phase modulated in between. (Recording is as shown in Fig. 1.3.)

Upon replay the two channel composite signals are demodulated and passed through a decoding matrix which "unscrambles" the sum and difference signals to give the four separated channels (Fig. 1.4).

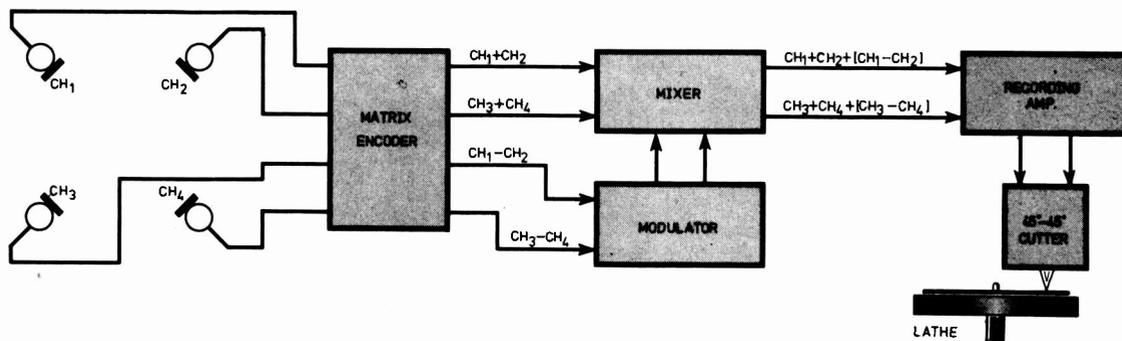


Fig. 1.3. Block schematic of the recording system used when making a CD4 disc

Due to limitations in today's recording technology the base band is limited from 30Hz to 15kHz and the 30kHz carriers are modulated in the range -10kHz to +15kHz. The CD4 specification for discs extends the upper frequency limit to 50kHz in anticipation of improvements in recording technology.

CD4 TECHNIQUES

The basic system has a number of problems which are diminished by the following techniques.

LOWER CUTTING SPEEDS

Cutting lathes have poor frequency response above 20kHz, so CD4 records are cut at half speed to compensate for this deficiency. This results in wider response but higher cost of production.

AUTOMATIC NOISE REDUCTION SYSTEM (ANRS)

A system similar to the Dolby noise reduction system is applied to eliminate noise which is generated in the difference signal path. This noise is primarily f.m. noise and crosstalk distortion.

CARRIER LEVEL CONTROL (CLC)

When the direct signal level is very high, the carrier signal can be degraded with resultant poor sound quality from the difference signals. CLC (Fig. 1.5) automatically increases the carrier level with increased direct signal level, and thus improves signal to noise ratio in the modulated carriers.

It improves abrasion resistance during playback and broadly improves pickup tolerance as well as reducing the base band interference mentioned above.

NEUTREX

This is the name of a new technique which assists the reproducing stylus to accurately trace the complex groove. The higher the baseband amplitude and the higher the frequency, the more pronounced is tracing distortion. Neutrex compensates the groove waveform to avoid the worst effects of tracing distortion as shown in Fig. 1.6 a, b and c.

CD4 STYLUS

Although CD4 records can be played with a spherical stylus of 0.5mm radius at 5 grams without

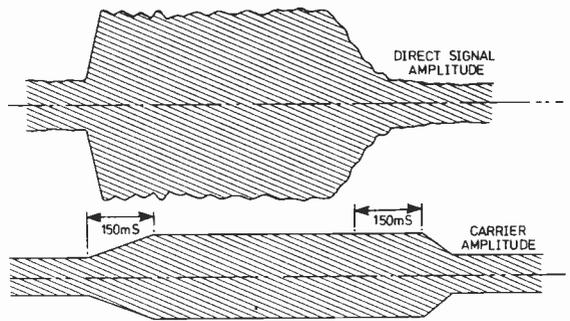


Fig. 1.5. Variations of carrier level which occur in CLC (Carrier Level Control)

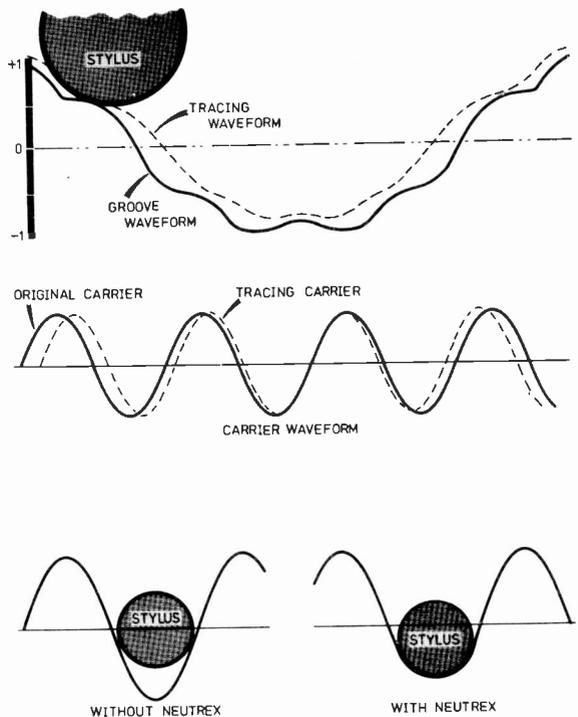


Fig. 1.6. The effects of Neutrex on the waveform traced out by the stylus

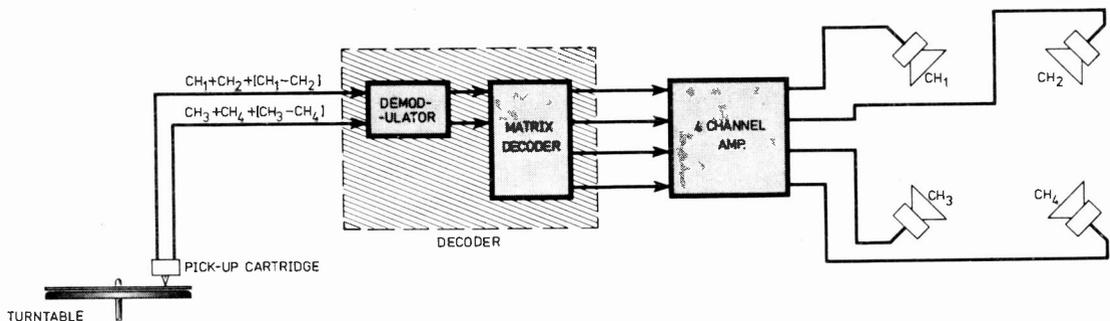


Fig. 1.4. Reversing the process of Fig. 1.3 when playing a CD4 disc

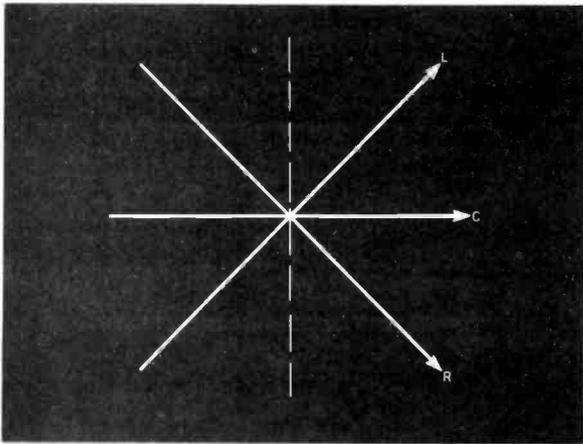


Fig. 1.7. The vector diagram for simple 45-45 stereo where the groove is modulated by two vectors at 90° to each other as shown by the lines L and R

disc. Reports as to quality are rather varied, the general consensus being that some of the "in-house" recordings from JVC are exceptional, but that most of the commercially available repertoire can only be described as old chestnuts. One can expect a noticeable improvement in all aspects of their software in future.

MATRIX SYSTEMS

A loose definition of matrix systems was given earlier. The precise definition of a particular quadraphonic matrix is only evident when expressed mathematically and such an analysis is outside the scope of this article.

There are also four psycho-acoustic principles which are significant in matrix design; the Haas effect; Front Source Dominance; Back Image Contraction and Quadrature Image Shift. The interested reader is commended for a discussion of these aspects to an article by Bauer, Gravereaux and Gust in the *Journal of the Audio Engineering Society of America*, Volume 19, Number 8, pp. 638-646.

In matrix systems the four channels are not independent and there is crosstalk between channels. The degree of crosstalk, and the channels between which the crosstalk exists, varies from system to system. Depending upon which matrix is used the sound images can be somewhat changed.

The effect of matrixing is best shown on vector diagrams. Two channel stereo can be illustrated simply by Fig. 1.7. The 45-45 groove modulations are represented by two vectors at 90° to each other and shown as the arrowed lines L and R.

If the signal recorded moves the stylus in only one of these two directions the signal passed through the system to the speakers will be only left or only right. If both these basic modulations occur simultaneously the image will appear to lie centre front. It will be seen that such a movement of the stylus is a lateral movement parallel to the record plane and that this is simply mono. Any other angular differences will result in different positional images between the two speakers.

significant wear after 100 playings, the frequency response is poor and distortion is quite high. An elliptical stylus can effect substantial improvement but specially developed styli must be used for really high fidelity reproduction.

The Shibata stylus and the Ichikawa stylus were developed for this purpose. Both are similar in concept and have around four times the contact area with the groove compared with a conventional stylus. They represent the closest practical shape to the original cutting stylus but are quite expensive due to their complexity.

It is also vital that the cartridge has a wide frequency response, up to around 45kHz, to reproduce discs of today's technology. Due to the limitation of the ending diameter of the CD4 disc groove to 5.2in, playing times are somewhat reduced but special plastics have been developed to reduce carrier wear and system deficiencies.

This remarkable technological achievement gives a viable method of quadraphonic reproduction from

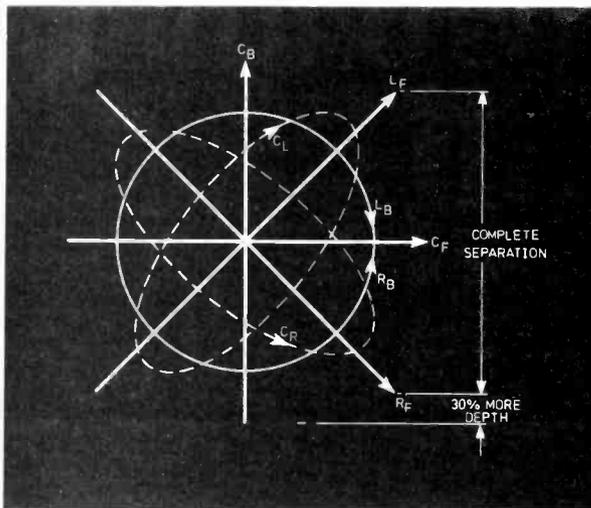


Fig. 1.8a. Vector diagram of the CBS SQ matrix

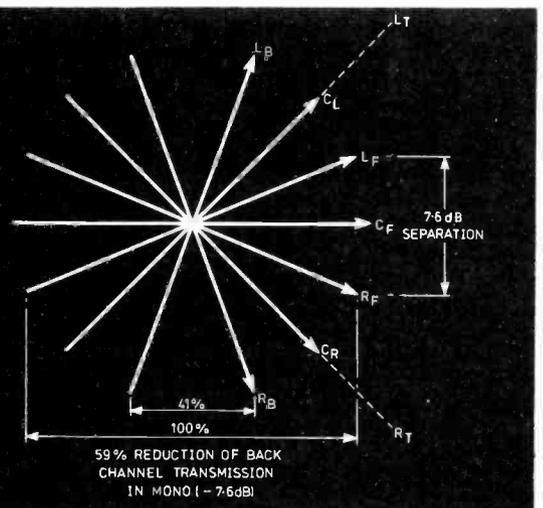


Fig. 1.8b. Vector diagram of Sansul QS-RM matrix

THE CBS SQ MATRIX

Fig. 1.8a shows the vector diagram of the CBS SQ Matrix. SQ simply stands for Stereo-Quadraphonic. It will be seen that the same three basic vectors exist in the SQ diagram as in the two channel stereo diagram of Fig. 1.7. These are the same left front (LF) right front (RF) and centre front (CF), hence the SQ matrix disc provides totally undiluted stereo information to the front loudspeakers with full channel separation.

Stylus movements in the direction marked CB provide centre back images. An additional basic modulation is provided which, for simple tones, is circular about the axis.

Clockwise modulations provide LB information and anticlockwise modulations provide RB information. This modulation appears as a helix due to the forward motion of the record groove.

Further modulations appear as ellipses rotating counter to each other representing centre left (CL) and centre right (CR) positions. LB and RB information is recorded on the left and right walls respectively but with a quarter cycle (90° phase difference)

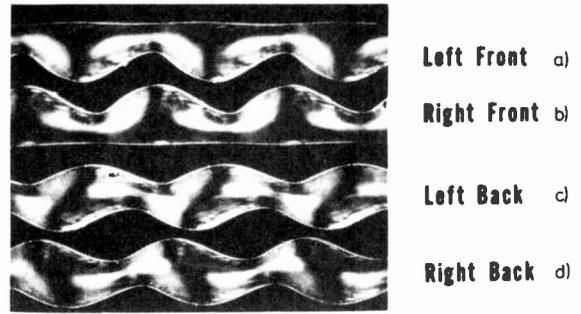


Fig. 1.9. The grooves of a stereo and an SQ modulated disc. (a) and (b) are the same as on a normal stereo disc whilst (c) and (d) show the helical modulation

primarily in classical music, have expressed the opinion that a matrix decoder of the type described above well meets the requirements for quadraphonic surround-sound reproduction.

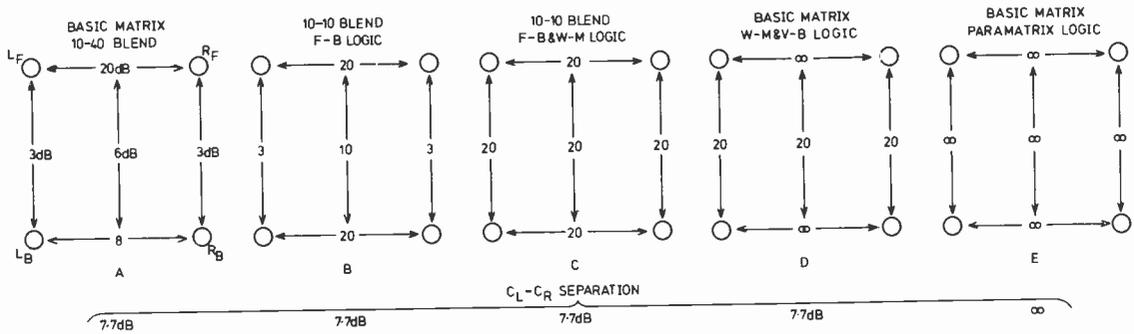


Fig. 1.11. The various stages in SQ decoder development from 10-40 fixed blend (a) to the future possibility of Paramatrix logic (e)

between them, resulting in the apparent circular motion. In recorded music the modulations are very much more complex than the simple tones represented by the helices described.

The photograph of Fig. 1.9 shows magnified grooves of an SQ record. They are all simple tones: (a) and (b) are the same as they would be on ordinary stereo record; (c) and (d) show the additional helical modulation present on an SQ disc to provide back images. The photograph clearly shows the stereo compatibility of the SQ disc which can be played by ordinary stereo cartridges to give full stereo.

The basic SQ matrix exhibits out of phase and unwanted signals at the back speakers when a signal is intended for the left front speaker. These out of phase signals are 0.707 of the level of the intended signal. Similarly out of phase signals appear at the front speakers when signals are directed to the left back speaker. The system is therefore asymmetrical.

Blend resistors added to the front and back signal pairs cancel out some of the unwanted signals with the attendant reduction of back separation to 8 dB. The so far recognised ideal blend is the 10-40 blend, where a 10% front and 40% back blend is used, and is called the 10-40 CBS SQ Matrix (See Figs. 1.10 and 1.11a). Many users, especially those interested

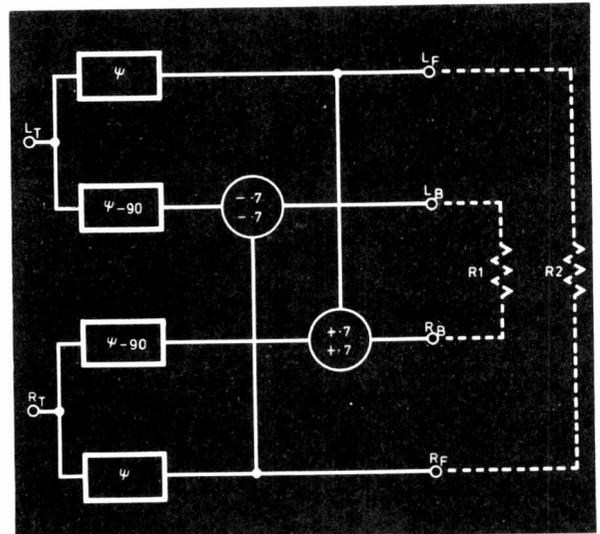


Fig. 1.10. Block diagram of a basic SQ matrix decoder. R1 and R2 provide the channel blend and the values mentioned give the recommended 10-40 blend

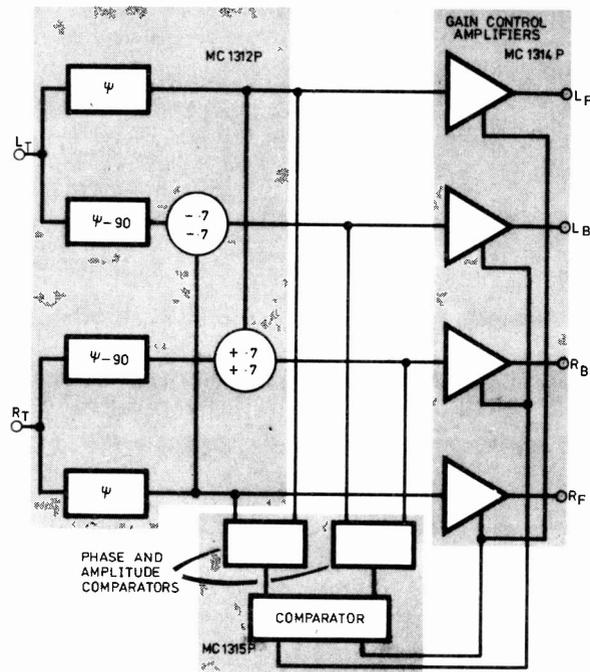


Fig. 1.12. The SQ logic-enhanced decoder using three chips, the MC1312P, the MC1315P and the MC1314P

LOGIC DIRECTED DECODERS

Greatly improved channel separation can be achieved by making use of both electronic logic and three psycho-acoustic phenomena with which we are all familiar. The first phenomenon occurs because of reverberation in a normal living room. This makes it difficult to locate the source of a steady state sound. Secondly, the origin of a varying source of sound, like speech or music, can be easily located. Finally, when there are two or more similar sources present we tend to believe that the one which we hear first is the sole source of the sound.

Logic directed circuits contain output amplifiers with voltage controlled gain characteristics which respond to predetermined amplitude and phase positions of the unwanted transferred signals as sensed by the logic. A signal in one of the front channels causes the production of two signals in the back channels identical in amplitude and in precise quadrature orientation.

This relationship is sensed by a comparator which results in instant enhancement of the front channels and rapid attenuation of the back channels. The converse is equally true and the resultant quadraphonic field approaches that produced by the four independent channels of the master tape.

With a signal to one channel only, this channel is kept open by the logic and any transferred signals are greatly attenuated thereby providing substantially discrete channels of information. These decoders are known as Front-Back (F-B) Logic Directed Decoders (See Figs. 1.11b and 1.12).

Logic directed decoders, in their simplest forms, may exhibit the effect of the logic circuit being confused by complex information. This appears as a "pumping" effect between front and back speakers.

ADVANCED LOGIC DIRECTED DECODERS

The latest advances in SQ Decoder technology have very recently been finalised and the writer thanks Mr. Benjamin B. Bauer, Vice-President C.B.S. Laboratories for his great personal assistance in these matters.

The circuit shown in Fig. 1.13 is the latest logic system and includes Wave Matching (W-M) logic and variable blend (V-B) as options.

The inter-channel separation for the front and back channel pairs is infinite in the basic matrix so only front/back separation needs to be improved.

If, for example, a transient signal is directed to left-front the W-M logic circuits recognise this as a front signal and adjust the levels between front and back so that 20dB separation in this direction is obtained. Another word for W-M is "corner-directed" logic.

If the left-front signal begins to decay and another transient signal is applied to LB the LB signal is emphasised. However, the steady state portion of the remaining LF signal becomes transferred to the LB but the ear assumes continued transmission from LF due to transient source dominance.

Thus the W-M logic can continually emphasise new transient sources in direction whilst maintaining the total power of all the preceding signals. (See Fig. 1.11c F-B and W-M Logic).

DYNAMIC BLEND

It has been previously explained how fixed 10-40 blend can enhance the separation between CF and CB signals. The same principle can be applied to logic but using a dynamic variable blend instead of fixed blend. If a CF signal, e.g. solo voice, is applied the channels at once become blended causing the signal to emerge from its proper centre-front location.

By careful design there will be almost complete front/back signal separation without any significant audible loss between front and back channel pairs. (See Fig. 1.11d W-M and V-B logic).

LATEST DEVELOPMENTS

Perhaps the most significant of the recent advances in SQ technology is the introduction of the integrated matrix chip manufactured by Motorola under CBS sponsorship, see Fig. 1.13. The MC1312 is the basic SQ Matrix Decoder and the MC1315 the Full Logic Module embodying both F-B and W-M logic. A Power Transfer Module MC1314 has the dual purpose of accepting the logic commands and translating them into enhanced quadraphonic action. It can also act as a gain control and loudspeaker balance element.

The circuit in Fig. 1.13 combines all the foregoing functions, including variable blend, which is controlled by means of an f.e.t. 2N5485 and four operational amplifiers. There is additionally provision for volume and balance (F/B, LF/RF, LB/RB) controls and a dimension control to adjust the logic action to suit ambient listening conditions. All of the logic and control functions are optional additions to the basic matrix decoder.

Reference has previously been made to Fig. 1.11 which shows the channel separations obtainable from each variation of the SQ Decoder. CL/CR separation

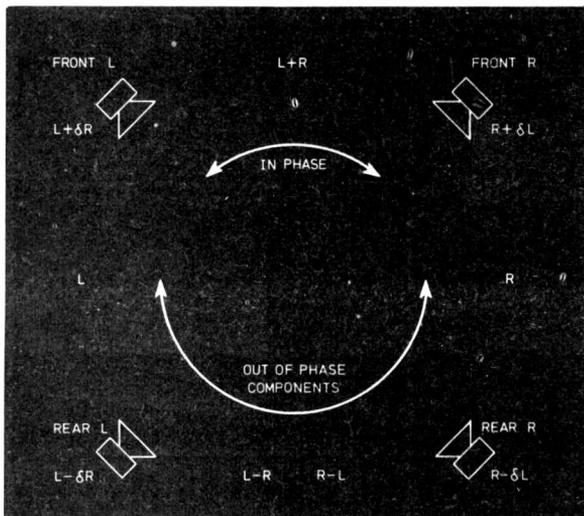


Fig. 1.14. The Sansui QS-RM system

speakers. The unwanted images (out of phase components—see Fig. 1.14) appear in the speakers either side of the speaker to which signals are being directed. This means that images appear somewhat more accurately in the direction intended.

It follows that this matrix is more symmetrical than SQ. The rear channels are also reduced to 41% of their original level for mono signals and heavy back modulations may be reduced by 2.3dB due to the need for around 30% extra cutting depth for back images. The principal loss however is of stereo compatibility.

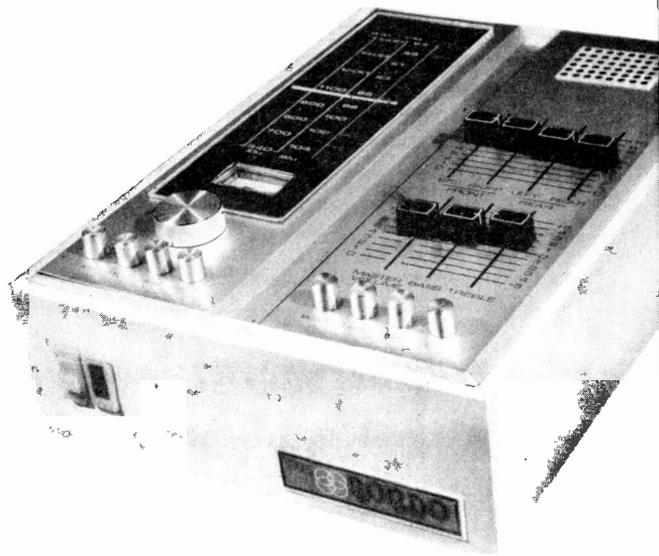
Within its limitations the system gives acceptable results. Sansui have also developed a technique for reducing unwanted signals with the name Variomatrix.

THE FUTURE

The large companies have made such substantial capital commitments and technical advances in Quadraphonics that the course of this art is "pre-ordained" for some time to come. Work is being carried out by others in methods to reduce the bandwidth necessary for the difference paths in carrier techniques which, although reducing technical difficulties, would seem to be a retrograde step from the quality aspect.

A very interesting technique devised by Duane Cooper (University of Illinois) and Takeo Shiga (Nippon Columbia Co. Ltd.), and called a Phasor matrix, distributes the phase differences in sectors of 45° which means that the speakers either side of the wanted speaker receive signals that are +45° or -45° phase shifted.

This system, called BMX by Cooper, can be made more directionally accurate by the addition of more channels. These channels can be of narrower bandwidth without degrading performance. This matrix is in its early stages and has not been adopted by any recording company to date and only experimental discs have been produced so far.



COMPATIBILITY

Compatibility can be considered from two standpoints; one being compatibility of any quadraphonic system with another, and the other being compatibility with stereo material.

Quite obviously a CD4 record will not be quadraphonically compatible with matrix records. Matrix records are compatible with each other to a degree which, of course, is limited by their differences. It is possible to play an SQ record through a QS decoder or *vice versa* and obtain really enjoyable results which, although inaccurate, do enhance listening pleasure.

All are stereo-compatible but QS has a much reduced stereo separation. All matrix records can be broadcast by v.h.f. stereo radio and when received as stereo, may be decoded into quad.

CD4 records cannot be broadcast by present stereo radio transmitters. Over 200 transmitters in the U.S.A. have broadcast matrix quad and it is hoped that similar broadcasts may be undertaken by the IBA in their test v.h.f. transmissions in the U.K., later this year.

SOFTWARE AND HARDWARE

There are some 40 CD4 recordings available in the U.K. at present, mostly by JVC themselves. CBS SQ records number over 100 and also in excess of 20 have been produced by EMI. The U.S. situation is around the same for CD4 but over 200 SQ LPs are available. About 20 SQ records of European origin are listed. There are at least twelve QS records marketed.

At the June 1973 Chicago Conference more than 40 makes of record playing equipment were exhibited. All of these had built-in SQ circuitry in multiple models. Around a dozen offered facilities for integral CD4 circuitry. The big volume suppliers, who furnish over 90% of the market, offered SQ capability only.

It seems a reasonable conclusion that the availability of SQ hardware will accelerate the rate at which SQ discs become available compared with CD4.

SPECIFICATION

CBS SQ 10-40 BLEND MATRIX DECODER

Input Impedance
3M Ω typical

Distortion
0.1 per cent typical

Maximum Handling Capability
2.0V r.m.s.

Signal to Noise Ratio
Short circuit -80dB. Bandwidth 20Hz-20kHz

Channel Separation

L _F -R _F	20dB
L _B -R _B	8dB
L _F -L _B	3dB
R _F -R _B	3dB
C _F -C _R	6dB
L _C -R _C	7.7dB

Supply Voltage
+20V d.c. @ 16mA

PREAMPLIFIER

Inputs

F. M. Radio	100mV @ 50k Ω
A. M. Radio	100mV @ 50k Ω
Disc	3mV @ 47k Ω
Tape	100mV @ 50k Ω

Output
100mV @ 10k Ω to amplifier tone controls
100mV @ 10k Ω to tape recorder unaffected by volume and tone controls

Signal to Noise Ratios

Disc -60dB	} unweighted
Others -70dB	

Crosstalk
-50dB @ 1kHz

Dynamic Range
38dB before clipping

Distortion
0.05 per cent at rated sensitivity

Supply
 \pm 15V d.c. at 5mA

tone controls and balance

Inputs
2 \times 100mV @ 10k Ω from preamplifier
4 \times 100mV @ 50k Ω playback from tape (4 channel)
(inserted via balance potentiometers after tone controls)

Outputs
2 \times 100mV @ 10k Ω to quad decoder
4 \times 100mV @ 10k Ω to tape recorder (4 channel)
(into recorder before balance potentiometers and after tone controls)

Gain
Unity

Bass Control
 \pm 16dB @ 30Hz

Treble Control

+10dB	} @10kHz
-13dB	

Balance
Zero to full output on each channel

Crosstalk
-50dB @ 1kHz

Dynamic Range
38dB before clipping

Distortion
0.05 per cent at rated sensitivity

Supply
 \pm 15V d.c. @ 5mA

POWER AMPLIFIERS (two per board)

Input Impedance
10k Ω

Frequency Response
At 20W into 8 Ω continuous sine wave
-1dB from 10Hz to 20kHz
-3dB from 5Hz to 30kHz

Power Output
20W per channel into 8 Ω continuous sine wave

Total Harmonic Distortion
20W into 8 Ω <0.1 per cent
50mW into 8 Ω <0.1 per cent

Stability
Will drive electrostatic loudspeakers

Damping Factor
120 into 8 Ω

Supply
 \pm 25V d.c. @ 2.0A } for both amplifier boards
 \pm 15V d.c. @ 5mA }

TUNER

F.M. + DECODER

Frequency Range
87.5MHz to 104MHz

Sensitivity
3.0 μ V I.H.F. (Institute of High Fidelity Manufacturers)
20 μ V for 58dB signal-to-noise ratio
10 μ V for full limiting

Total Harmonic Distortion
Mono 0.6 per cent
Stereo 1.0 per cent

Stereo Separation
35dB @ 1kHz

A.M.

Frequency Range
550kHz to 1.6MHz

Capture Voltage
100 μ V at midband

Distortion
Approximately one per cent total harmonic distortion

Supply
+24V d.c. @ 100mA

SPEAKER SYSTEMS

Power Handling
20W continuous sine wave

Impedance
8 Ω

Loading
Infinite Baffle

Frequency Response
35Hz-22kHz \pm 5dB

Drive Units
2 \times HIF 13E 130mm Long Throw Units
2 \times 6.5 TW Bi 65mm Tweeters

Crossover Network
Six-element network dividing at 500Hz and 6kHz

OVERALL DIMENSIONS

Cabinet
254mm (10in) \times 120mm (4 $\frac{3}{4}$ in) (add 15mm for height of knobs) \times 326mm (12 $\frac{3}{4}$ in)

Speaker Enclosures
242mm (9 $\frac{1}{2}$ in) \times 405mm (16 $\frac{1}{4}$ in) \times 216mm (8 $\frac{1}{2}$ in)

PE RORDO

PE RONDO

SYSTEM DETAILS AND DECODER MODULE

THE PE RONDO

The current increasing interest in quadraphonics, coupled with the introduction of integrated circuit decoder chips supported by a growing bank of software has created the ideal atmosphere for the home constructor to build his comprehensive Quadraphonic System.

The PE RONDO system has been developed and planned especially for the home constructor and incorporates advanced technology throughout.

Figure 1.15 shows the system in block diagram form and a full technical specification is given elsewhere. The system incorporates power supplies,

power amplifiers, both f.m. and a.m. radio tuners, stereo decoder, quadraphonic decoder system, tone, volume, balance controls and selectors, and pre-amplifiers and characteristic compensation circuits. All this circuitry is incorporated in a neat and compact wooden case with a shallow metal plinth in which are mounted the input and output terminations.

The system is completed with a set of four loudspeakers for those who wish to make their own.

The approximate cost to build is £70 plus V.A.T. for the main unit; and £62 for the loudspeakers (4). (Suitable turntable units can be found in the price range £25-£40).

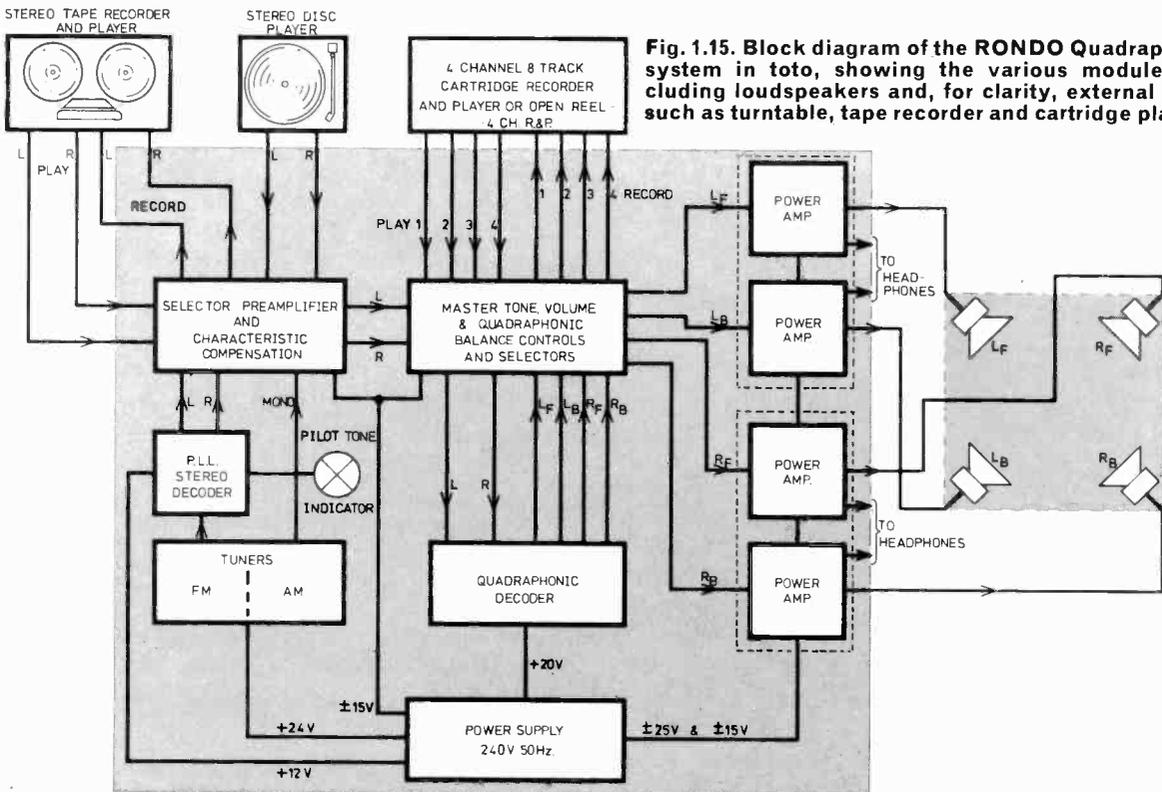


Fig. 1.15. Block diagram of the RONDO Quadraphonic system in toto, showing the various modules, including loudspeakers and, for clarity, external items such as turntable, tape recorder and cartridge player

CBS SQ DECODER MODULE

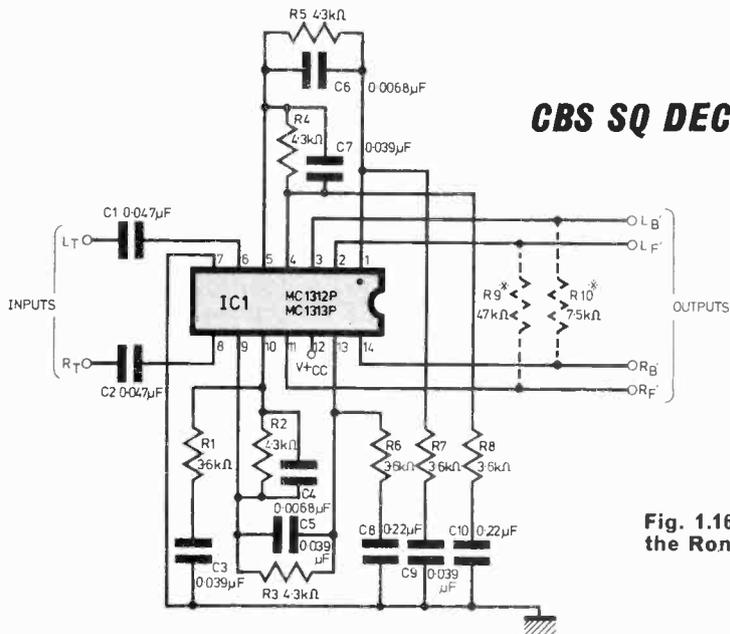


Fig. 1.16. Circuit diagram of the Rondo decoder board

Fig. 1.17. Component layout for the Rondo decoder board

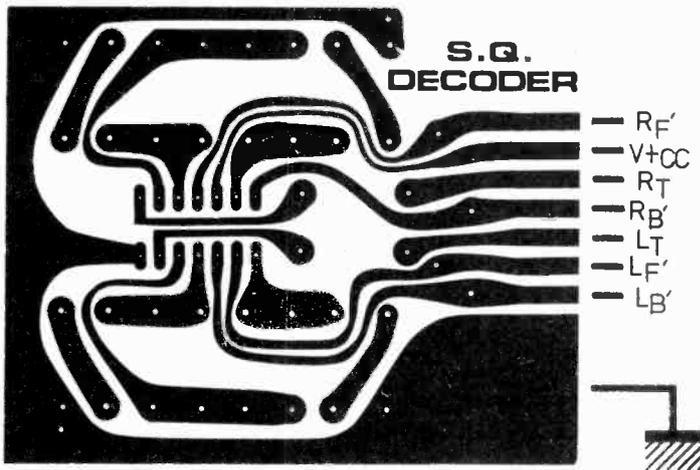
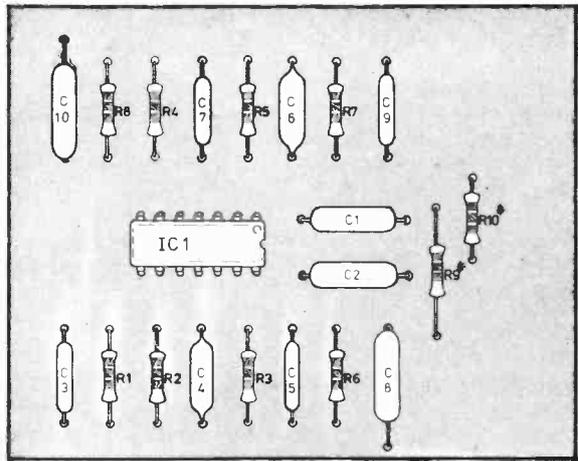


Fig. 1.18. Printed circuit copper layout for the Rondo decoder board

COMPONENTS . . .

CBS MATRIX DECODER

Resistors

R1	3.6k Ω	R6	3.6k Ω
R2	4.3k Ω	R7	3.6k Ω
R3	4.3k Ω	R8	3.6k Ω
R4	4.3k Ω	R9	47k Ω
R5	4.3k Ω	R10	7.5k Ω

see text

All 5% $\frac{1}{4}$ W carbon or metal oxide

Capacitors

C1	0.47 μ F 20% 63V	C6	0.0068 μ F
C2	0.047 μ F 20% 63V	C7	0.039 μ F
C3	0.039 μ F	C8	0.22 μ F
C4	0.0068 μ F	C9	0.039 μ F
C5	0.039 μ F	C10	0.22 μ F

All 5% 63V polyester except where stated

Integrated circuit

IC1 MC1312P CBS SQ Monolithic Decoder
Available only as part of a complete kit from CBS Licensees or retailers who have purchased as a complete kit from CBS Licensees. This is due to licensing restriction imposed by the Licensor CBS Inc.

Printed Circuit Board

Fibre glass as part of kit of parts from: Sonax Electronics, Spencer House, Brettenham Road, London, N.18.

the supply of the products to licensed equipment manufacturers only.

In the present instance CBS have given permission for supply of the i.c. to constructors provided it is sold as part of a kit for making up the decoder. All other parts of the RONDO system are available freely in the normal manner.

CONSTRUCTION

The decoder chip is packaged in a dual-in-line 14-pin package under the code number MC1312P and is marked with a dot to indicate correct orientation of the chip when mounting, as can be seen from Fig. 1.16, the circuit diagram of the decoder.

Most of the components shown external to the chip are phase shift networks referred to earlier. In addition, there are the two input capacitors, C1 and C2, which decouple the chip circuitry and the two fixed blend resistors, R9 and R10, shown dotted.

The phase shift networks have pre-determined time constants and must utilise stable components of $\pm 5\%$ tolerance.

The printed circuit board layout master is shown in Fig. 1.18 and the component layout, the opposite side of the PCB, is shown in Fig. 1.17. It will be seen that two different mounting pitches are provided for C8 and C10. This is so that these capacitors may be selected from several manufacturers offering different lead-out pitch distances.

The components are mounted on the board from the non-plated side in the configuration shown and it is probably best to mount all components and bend the leads slightly, before starting soldering, to hold the components in position. This makes certain the layout is correct before any hard-to-reverse steps are taken.

Don't forget to take care with the soldering operation, only applying the iron for long enough to make a good joint, particularly on the i.c. pins. It's all too easy to damage an i.c. with conducted heat from the pins.

After soldering, the board should be cleaned of any flux and solder splashes with a brush.

TO COME

In following articles we will deal with the construction of power supply, power and pre-amplifiers; volume and balance controls and tone controls. All the r.f. circuitry will be described including both a.m. and f.m. receivers and an associated stereo decoder for the f.m. unit. Finally suitable speakers will be described for those who wish to make their own.

The equipment described so far is, in one form or another, available commercially. However, in the articles to come, one of the very latest ideas in quadraphonics will be described—an extension of the CBS SQ matrix board using the latest logic to give front/back logic, wave matching logic, and variable blend. This latter is so new that PE readers will be amongst the first in Europe to have it.

Of course, this does not detract from the basic matrix board described in the present article, and very exciting results can be obtained with this.

Next Month: Audio amplifiers and power supply

FLEXIBILITY

Examination of Fig. 1.15 shows clearly that a number of advantages accrue from using a modular construction which integrated circuits and printed circuit boards allow.

In the first place, the system can be built in stages.

Secondly, the system can first be built as a stereo system and later converted. Indeed, the constructor can, if he wishes, make use of an existing stereo system in conjunction with a RONDO stereo section to complete the quadraphonic system.

By including suitable switching circuitry the quadraphonic system can be extended to accept any future, or for that matter existing, decoders which might become available.

The PE RONDO specification is broken down into the various sections for simplicity and ease of understanding.

THE DECODER

This first constructional article deals with the perhaps simplest but most important part of a Quadraphonic system—the decoder.

The CBS SQ 10-40 decoder chip is manufactured by Motorola under licence from CBS Inc. The licence is part of a commercial agreement involving

SAXON ENTERTAINMENTS LTD.

STANDARD & CUSTOM-BUILT AUDIO & ELECTRONIC EQUIPMENT. NEW & SECONDHAND MUSICAL INSTRUMENTS. DISTRIBUTORS FOR A.K.G. HIGH QUALITY MICROPHONES

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New Versions using 3A "Plastic Power" Driver Transistors now available.



To meet demand, we have included a more powerful module in our well-established and proven range. All these power amplifiers are carefully assembled, tested and guaranteed. They offer superb value for reliability and versatility.

SA35 35W RMS uses 7 transistors and 7 diodes. Carr. paid. **£4.45**

A NEW ADDITION IS THE **SA50 at £5.65**

Carr. paid. A rugged, well built unit, capable of 50W RMS out, with all the advantages of Saxon Amplifier design and quality. Ready now.

SA100 makes an ideal unit in disco assemblies

A real glutton for work. Reliable, tough and compact. 11 transistors, 6 diodes. Carr. paid. **£10.90**

BRIEF SPEC. FOR ALL THREE MODULES

Freq. response	15-40,000Hz ± 1dB	All modules incorporate OPEN AND SHORT CIRCUIT PROTECTION, plus proof against over-dissipation and faulty inductive loads in its SA100
Distortion	0.2% at 1kHz	
Loads	4 to 16 ohms	
Quiescent current	15mA	
Noise	Better than -75dB	
Supply voltage	SA35-45V SA50 45/65V SA100 40-70V	
Size	4 1/2in x 4in x 1in (SA100) 4in x 3in x 1in (SA35/SA50)	

Circuits, connecting instruction and application data are supplied free with all modules.

POWER SUPPLIES FOR THE SA25/35 & SA100 AUDIO MODULES

PU45	Unstabilised supply for 2 SA25/35's	£4.90
PU70	Unstabilised supply for one or two SA100	£7.75 carr. 40p
PS45	Stabilised module for 2 SA25's or two SA35's	£3.50 carr. free
MT45	Transformer for above, heavy duty	£2.85 carr. 20p
MT30	Transformer for unstabilised supply complete with rectifier diodes mounted	£3.50 carr. 20p
PS70	Stabilised supply module for one or two SA100's	£4.90 carr. free
MT70	Transformer for PS70	£4.90 carr. 40p

ALL MODULES ARE BUILT ON GLASS FIBRE P.C. BOARD AND SUPPLIED FULLY TESTED

TWO NEW PA/MIXER CONTROL UNITS

Built for hard work!

In extra slimline easy-fit case.

Using grouped pairs of inputs (high Z and low Z inputs) with individual bass, treble and volume controls on each pair, plus master controls. These low-noise units will feed all makes of amplifiers, making them ideal for clubs, discos, etc. Standard jack sockets, compact design. In strong metal cases. All Units guaranteed for 3 years.

- HIGH AND LOW IMPEDANCE INPUTS
- BASS/TREBLE/VOLUME ON EACH PAIR
- MASTER CONTROL ON OUTPUT

M4H
4 high Z, 4 low Z inputs, 4 sets of controls. Case 10" x 8" and only 2 1/4in deep. Carr. paid. **£18.50 + V.A.T.**

M6HL
12 inputs (6 high Z, 6 low Z). Carr. paid 18" x 8" x 2 1/4". **£27.50 + V.A.T.**

Channel section modules, for building your own: gain—16 x (24dB) Tone controls—18dB swing. Carr. paid. **£3.50 + V.A.T.**

CONTROL UNITS

Mono (as shown). **£6.50**
Carr. 20p.
Stereo. **£15.80**
Carr. 30p.



Two decks, and full headphone monitoring. The unit is mains operated and measures 17 1/2in x 3in x 4in deep and is finished with a smart white on black face. The controls are: Left/Right deck fader, volume, bass, treble, Headphone Selector and volume, Microphone volume, bass treble, mains on/off. **COMPARABLE TO UNITS AT OVER TWICE THE PRICE.** (N.B.—Stereo only has mic. Input.)

PLEASE ADD 10% FOR V.A.T. TO TOTAL VALUE OF YOUR ORDER
S.A.E. brings Saxon equipment and bargains list

120 WATT HEAVY DUTY MODULE

Rugged class A driver stage. This module will run from all our mixers, etc., and most other makes. Delivers 120W into an eight ohm load and employs 4 TO3 can (115W) output transistors.
SPECIFICATION
Power output, 120W into 8 ohms
Freq. response, 20-20,000Hz ± 2dB
Input sensitivity, 200mV into 10K
Construction, Fibreglass board
Size, 8in x 4in x 4in (5in with supply)
Low distortion parallel push-pull output stage.

● 160 watts version with power supply (Carr. 50p) **£27.90**

Module only **£13.90** (Carr. 20p)
Module and power supply (Carr. 40p) **£18.95**



3 CHANNEL UNIT

Includes bass, middle and treble as well as master controls, 2 amplifier sockets eliminate need for split leads. Up to 3kV lighting load. Smartly finished steel case. Carr. 30p. **£19.75**

SOUND AND LIGHT UNITS

Our popular 3 channel model handles up to 3kV (3,000W) of lighting and incorporates versatile sound control arrangement to enable professional standards to be achieved. Both units are excellent examples of Saxon quality and value.

SINGLE CHANNEL UNIT

Operates from 5-100W amplifiers. Supplied for bass note operation, is easily adapted for treble or mid-range at a cost of about 5p. Carr. pd. **£8.90**

COMPLETE AMPLIFIERS

CSE 100 £34.90 carr. free

This versatile unit is now available in a black vynide case and so represents even better value than ever delivering speech and music powers of up to 100W RMS and continuous signal outputs of 70W. Two individually controlled inputs with wide range bass and treble controls.



SAXON 100 £48.50 carr. free



With an RMS output of 120W speech and music, 100W continuous power, four individually controlled FET input stages and wide range bass and treble controls, this amplifier has established itself as a unit offering quality and reliability at low cost.

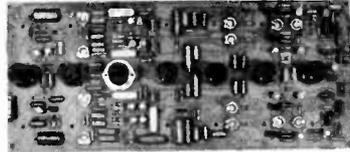
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12in 25W 8/15 ohms £5.95 carr. 30p. 15in 50W 8/15 ohm £14.50 carr. 30p. 12in 40W 15,000 gauss magnet system 8/15 ohm £11.50 carr. 40p. 600 Watt 3 colour Light Boxes Smart Reline finish £15 carr. free.

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D11 DHL IDEAL DISCO MIKE ONLY £9.45 (rrp £11.00). S.A.E. for special price list.

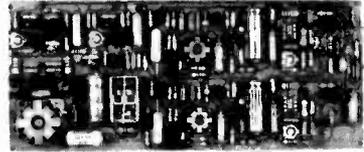
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(PE Mar./Apr. 73). S/c's, i.c.'s, Rs, Cs, Relay and pc-base, Pot, Cores and pc-bases, Sw's, Pots, Panel Lamp—Mono, £11.80; Stereo, £18.70. PSU, £2.50. PCB—Main Assy. (3 1/2in x 9in) (Stereo) also holds relay and cores, £1.85. PCB—Sub-Assy. (2 1/2in x 6 1/2in) (Stereo) holds Sw-assoc. Rs, Cs, Presets and mounts on Sw's, 80p.

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AC128	12p BD131	49p	2N2218A	13p	OA200	8p
AC187	12p BD132	49p	2N2220	10p	OA202	8p
AC188	12p BF194	15p	2N2221	10p	IN914	5p
AD161	30p BF195	15p	2N2483	10p	IN4001	6p
AD162	30p BFY50	22p	2N2484	9p	IN4004	7p
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AF115	12p OC26	40p	2N2926G	9p	IN4148	5p
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3.5mm Screened 10p	3.5mm 7p

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160V: 0.1µF, 0.15µF, 4p; 0.22µF, 5p; 0.33, 6p; 0.47µF, 7p; 0.68µF, 10p; 1µF, 13p.
Radial lead P.C. type:
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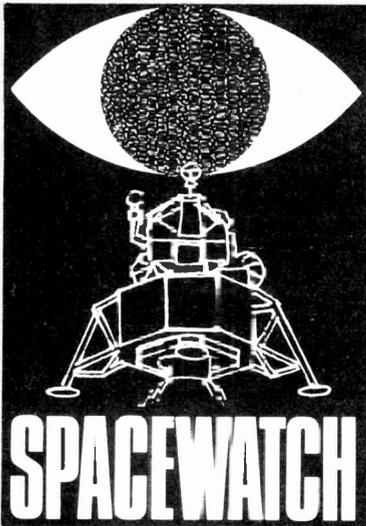
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BY FRANK W. HYDE

BOULDERS OF SATURN

There has been confirmation of the reports, mentioned in the June issue, that the rings of Saturn were in fact large boulders. Measurements were made using the emission at 20 micrometre wavelength and the temperatures recorded were 89°K for the inner ring, 94°K for the middle ring and 89°K for the outer ring.

It appears that the measured temperature is dependent upon the angle the Sun makes with the rings. This fact is consistent with the boulders being of the order of 1m in diameter.

The fact that the shadow, which Saturn casts on the rings, affects the results is rather puzzling if the boulders are of the size suggested. However, there is an explanation and that is fine dust also present or alternatively that the inner ring is subject to bombardment by a particle zone similar to the Van Allen belts.

The work in this field was done by R. Murphy at the Mauna Kea observatory in Hawaii.

GRAVITY CONTROVERSY

There has been considerable controversy over the reality of the gravity waves which Weber insists he measures.

Studying new published data from the Bell laboratories, a team has made an analysis of Weber's events and has introduced the known data of geophysical and meteorological measurements and solar activity. So far there has been no confirmation and the work being carried out with new apparatus does not support Weber, in spite of its sensitivity.

This sort of investigation was also suggested by a group from Russia.

The Russians have already correlated solar activity and the variations of the magnetosphere as well as other phenomenon.

The results obtained seem to offer another explanation for the events which Weber records. The group at the Bell laboratories under Dr. J. A. Tyson have found evidence of correlation between the magnetosphere ring current and Weber's results. The extent of magnetic effects are global in extent and therefore account for the coincidences that are observed at Weber's two stations at Maryland and Argonne which are 1000km apart.

GEOMAGNETIC FLUCTUATIONS

Although Weber's instruments are magnetically shielded by steel in the form of a vacuum tank, it is suggested by the Bell team that this shielding may not be good enough at the very low frequencies involved in the geomagnetic fluctuations.

This suggestion is plausible because it could explain the daily variations that Weber observes and his interpretation too that these variations are from the galactic centre which is swept by the beams of his detectors every day.

In view of the American and Russian results, the explanation could as easily be that these changes are caused by the daily changes in the ionosphere caused by the Sun.

It is seriously suggested that the careful studies of Weber may be coloured by wishful thinking for no one could doubt the integrity of his work. The cosmologists may feel that the problems that would beset them, if Weber had proved to be right, have now been avoided.

ESRO AND SATELLITES

Magnetospheric studies have been a special programme of the European Space Research Organisation and the progress in this field was revealed recently at a symposium.

Data from the measurements and observations by ten satellites was made available. These included the results from *Heos-2*.

Some of the projects were a combined operation with *Heos-1* and *Iris*. This applied in particular to the penetration of the solar particles ejected when the Sun is active, through the magnetosphere to Earth.

It emerged from the observations that there was a peculiar precipitation pattern which formed over the

Earth's polar caps. Using *Heos-1* and *Iris* the particles could be studied in space, as well as close to the polar caps, at the same time.

The major advance in knowledge came from the results of *Heos-2*. The highly eccentric orbit of this satellite enables a region, not previously studied, 240 000km above the north pole to be explored. One of the outstanding discoveries was that the outer boundaries of the magnetosphere are some 30 per cent further out than was indicated by measurements from lower levels.

Another rather unexpected result was that it appeared that the magnetotail at the magnetopause contains a layer of electrons at energies higher than 1MeV.

Recently the neutral point on the magnetopause boundary has been studied in detail. A discovery was made here that the hot plasma comes down the cusp region at a magnetic latitude of 78°. A few degrees nearer the pole cold plasma in the ionosphere leaves to move into the geomagnetic tail.

JOINT PROJECTS

Future projects have been agreed and there is to be a joint project between ESRO and NASA for launchings in 1978 and 1979. One will be a heliocentric satellite and the data will deal with the interplanetary conditions and these will combine with the results from two others. Known as a mother and daughter pair, they will orbit close together near the Earth.

The correlation of the results of magnetic and particle measurements should resolve some of the present ambiguities. There will also be an intensive study using ground stations, balloon, rocket and satellite.

The satellite will be the *GEOS* to be launched in 1976. This will be the first geostationary satellite for Europe and will study the distribution of the thermal plasma and that of waves and energetic particles.

Many of these projected studies will be assisted by the *Skylab* programme and the shuttle programme.

There is now a great need for a settlement of the various theories and a sorting of the anomalies that exists. It is certain that some of the finer points of nuclear fission may well be revealed by the combined experiments to be made as well as completing knowledge about the interplanetary medium, the solar wind and the underlying basic measurements which are at present obscured by the equatorial electrojet and the auroral current. There are both chemical and mechanical means of achieving such objects.

INGENUITY UNLIMITED

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

CAR WIPER CONTROL

THE CIRCUIT in Fig. 1 was designed to overcome the shortcomings of a normal windscreen wiper set-up which does not have the facility for a slow wipe. The normal speed used in very fine rain causes the windscreen to smear and become too dry; the wiper blades judder and squeal, and their life is shortened considerably.

The circuit uses a simple u.j.t. oscillator to determine the wipe periods. The time interval is governed by the values and settings of R1, VR1 and C1. The unijunction fires when the voltage on C1 is approximately 0.7 of the supply voltage; this gives a period equal to the CR product. With the values given this varies from 2 to 22 seconds, a more than adequate range.

A linear potentiometer incorporating a switch, wired for fast wipe on switch-on, was used in the prototype unit. The scales shown in Fig. 2 show typical settings for alternative wiring for both linear and logarithmic potentiometers.

The "monostable" action of self-parking wipers is achieved with a switch connected to the wiper linkage, which is open when the wipers are at rest, see Fig. 3. This action is essential to the operation of the circuit; fortunately the vast majority of cars have self-parking wipers.

The current pulse in L1 is reflected in L2; CSR1 fires and latches on. The wipers start their cycle and switch S3 closes. The action of S3 closing puts a short across CSR1 and the current through it ceases and the thyristor switches off. The wipers continue their cycle and park normally.

As the starting surge of a wiper motor is very large a 16A thyristor was used. A heat sink for CSR1 was not used as it is only conducting for a short period at the start of each cycle and the continuous current is well below the rated value. It was decided to leave CSR1 in circuit all the time as the starting surge is well above the rating of the potentiometer switch.

A suitable pulse transformer can be made from 1½in of ferrite rod. L1 consists of 100 turns of 26swg enamelled copper wire and is covered with a layer of p.v.c. tape. L2 is wound in the same direction as L1 and consists of 150 turns of 26swg enamelled copper wire. The start of each winding should be marked with a spot of paint.

The indicator lamp could be omitted but was found to be useful, especially at low speeds when one can forget that the unit is operating after 21 seconds of nothing happening.

The only connections that need to be made to the car's electrical system are the negative earth, the positive supply from a convenient point (the "hot" wiper switch terminal), and points "A". In a car with two-speed wipers "A" should be on the lower speed.

N. E. Thomas,
London, S.W.17.

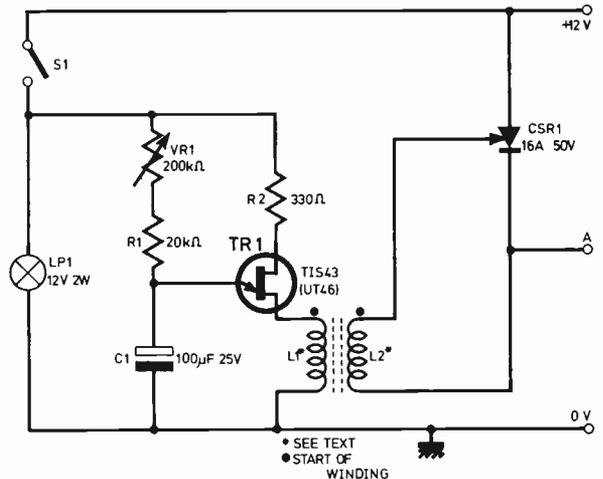


Fig. 1. Circuit diagram for unijunction car windscreen wiper controller

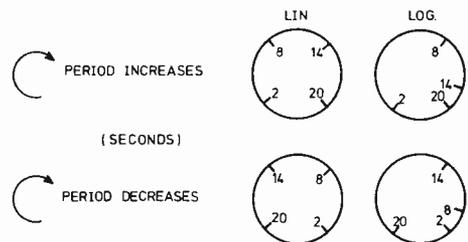


Fig. 2. Typical scale settings for linear and logarithmic potentiometers

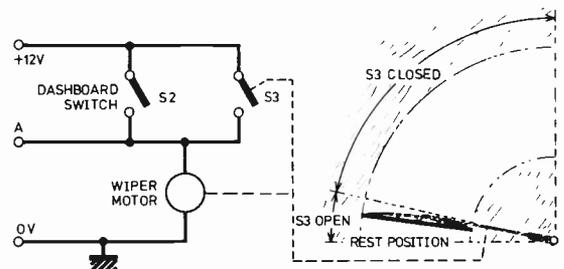


Fig. 3. Showing how the "monostable" action of the self-parking wipers is achieved

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Elac 6 1/2in d/c roll/s 8 ohm	£2-32
Elac 6 1/2in d/cone 8 ohm	£2-50
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Wharfedale Super 10 RS/DD	£3-00
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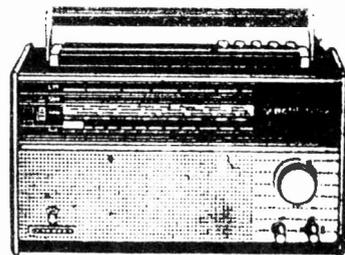
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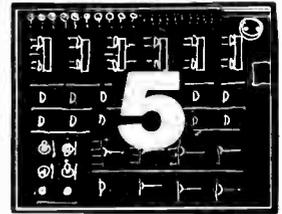
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LOGIC TUTOR EXPERIMENTS..

EXCLUSIVE OR FUNCTION



AN answer to last month's problem is shown in Fig. 5.1. In effect we are making two 3 input OR gates—using NAND logic—and then combining the outputs of these in a third OR gate. We rely on the Boolean Algebraic ASSOCIATIVE rule to permit this operation. As was the case when we simulated a six input AND we need a surprisingly large number of gates to carry out this simple operation. Frequently it is necessary to have a multi-input OR function in a logic system and many designers prefer to use discrete diode resistor logic followed by an inverter rather than integrated NAND gates when more than about four variables have to be ORed together.

EXCLUSIVE OR

This month we look at the EXCLUSIVE OR function. The normal OR truth table shows the output to be level 1 when both inputs are 1. To obtain EXCLUSIVE OR we must arrange that the output is 1 ONLY when one input OR the other is 1; when both are 1 the output must go to level 0 as shown in the truth table of Fig. 5.2. In Boolean terms we say the output (Q) is 1 when A is 1 AND B is 0 or B is 1 AND A is 0. This is written as $Q = A\bar{B} + B\bar{A}$.

It is easy enough to formulate a logic circuit that will do this using simple AND/OR/INVERT logic (Fig. 5.2.). This circuit can then be directly converted into NAND logic by substituting a NAND followed by an inverter for each of the AND gates and a NAND preceded by inverters to give the OR at the output. If you draw out the equivalent NAND circuit in full you will find that you have two pairs of inverters following each other; the effect of this is to cancel the inverting functions and the NAND circuit for EXCLUSIVE OR becomes that shown in Fig. 5.3. You can patch this up on Logic Tutor and verify that the output is 1 only when one or the other of the inputs is 1.

AN ALTERNATIVE CIRCUIT

Because EXCLUSIVE OR is a compound gate function there are various ways of arriving at a circuit that will produce the desired effect. One of the most economic ways—which is not so easy to arrive at—is shown in Fig. 5.4. This uses only four NAND gates but gives the same result as the previous circuit; try it on Logic Tutor and see. Try using Boolean

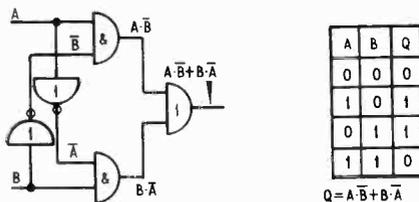


Fig. 5.2. EXCLUSIVE OR truth table and its representation in AND-OR-INVERT logic

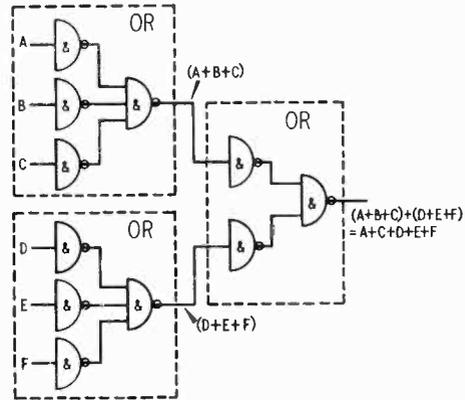


Fig. 5.1. An answer to last month's problem

Algebra and De Morgan's Theorem to show that the output is truly $A\bar{B} + B\bar{A}$ —some of the nodal expressions are given to help you. The full proof will be given next month. As an extra exercise see if you can devise any other circuits that will give the EXCLUSIVE OR function—try not to use more than six gates.

The EXCLUSIVE OR is sometimes called a "NON-EQUIVALENCE" gate. The reason for this is that you can say the output is 1 when the two inputs see different logic levels—when both inputs are the same the output goes to 0. It is thus a simple matter to convert an EXCLUSIVE OR into a comparator by inverting its output. A comparator gives an output of 1 when both inputs are the same.

by M. J. Hughes

Next month we will deal with the WIRED OR function.

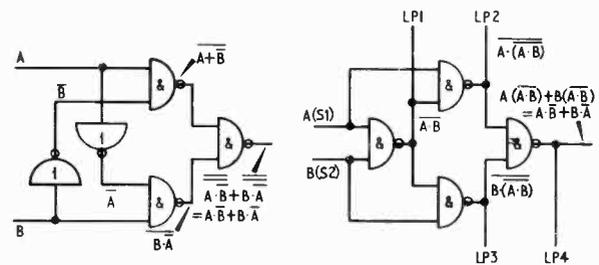
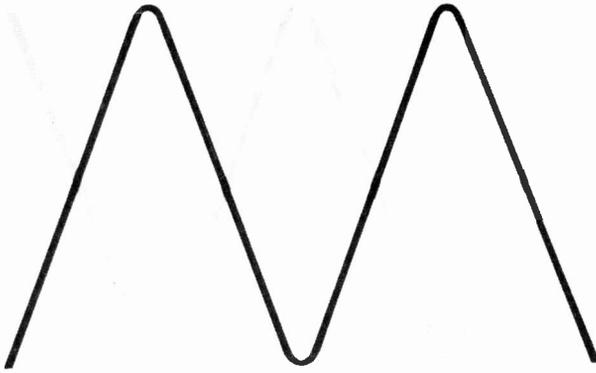


Fig. 5.3. The basic circuit of Fig. 5.2 in NAND logic showing the Boolean expressions at each node

Fig. 5.4. A more economical EXCLUSIVE OR—using four NAND gates. Use the Logic Tutor to verify the circuit is correct



PHASING UNIT

BY D. BENFIELD

THERE is a continual demand for sound effects units which can be put together easily and cheaply by the home constructor. Indeed, it is this last feature, namely cost, which gives such devices an advantage over equivalent commercial units which are usually prohibitively expensive. To this end, the "phase box" about to be described has been made as simple as possible, consistent with an acceptable performance.

PRINCIPLE OF OPERATION

The essence of musical phase effect is to play a piece of music through two channels, with a slight time delay on one input.

To produce the required effect, the input signal is passed through a variable time delay network; the output from this is then mixed with the original signal which formed the input as shown in the block diagram of Fig. 1.

At a certain frequency, depending on the delay introduced, complete cancellation occurs during the mixing process and, by varying this frequency, the well known phasing effect is produced.

THE DELAY NETWORK

The basic circuit used to produce the required phase shift is shown in Fig. 2.

If equal amplitude sinewave inputs, of frequency f , are applied to "A" and "B," but with the input to "B" inverted with respect to "A," then the output will also be of the same amplitude, but will have a phase lag of $2 \tan^{-1}(2\pi fRC)$ degrees.

Note that when $2\pi fRC = 1$, then the phase lag is 90 degrees. Thus, assuming we have suitable anti-phase driving signals at our disposal, we can cascade two such networks and, at a frequency given by $f = 1/2\pi RC$ we would get a total phase lag of 180 degrees.

Such antiphase signals are easily obtained by using a single transistor stage with equal emitter and collector resistors. Omitting biasing arrangements, we have the circuit of Fig. 3 for a single stage of our two-stage phase delay network.

The required phasing effect is obtained by varying the frequency at which cancellation occurs in the mixer stage; this is most easily altered by making R a variable component, which means a dual-gang potentiometer since two stages are being used.

FULL CIRCUIT

The phase delay is introduced by the circuitry around TR1 and TR2 as in Fig. 4. TR3 acts as an emitter follower so that a reasonably high impedance is presented to TR2 collector circuit, in order to isolate this stage from the low input resistance of the mixer.

The operating conditions for TR1 are set up by R1 and R2, while direct coupling through VR2a and R5 to TR2 base enables further bias chains and coupling capacitors to be eliminated; similar remarks apply to TR3 stage. This does mean, however, that there is a risk of unpleasant "plops" being produced should a slider of VR2 become momentarily disconnected. To overcome this, the unused ends of VR2a, b tracks should be connected to their respective sliders, and so maintaining a bias path for TR2 or TR3.

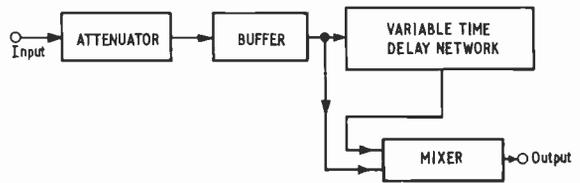


Fig. 1. Block diagram showing principle of operation

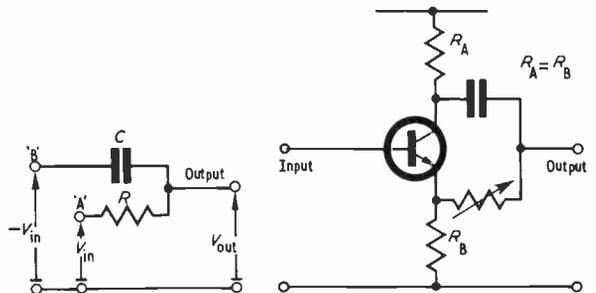
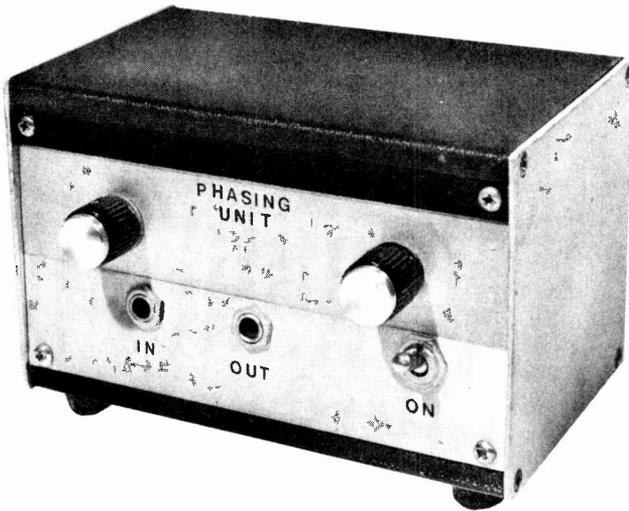


Fig. 2. The basic phase shift network employed

Fig. 3. Circuit for producing antiphase signals

COMPONENTS . . .



Potentiometer VR1 provides a means of controlling the output level from the unit, by attenuating the input signal. This method is to be preferred here since it enables high level sources to be used without overloading the unit, which could occur if the level control were placed at the output.

The mixer circuit uses a single transistor, TR4. Bias conditions are maintained by the potentiometer formed by R10 and R11. By this means the collector potential is set at approximately five volts, regardless of supply voltage variations.

The inputs—direct signal and phase delayed signal—are applied to the two capacitors C2 and C3. Compensation for any difference in signal level can be provided by making either or both input resistors variable.

CONSTRUCTION

The original was assembled on a small piece of 0.1in matrix copper clad Veroboard, as this permits a neat and compact layout—see Fig. 5.

Resistors

R1	100k Ω	R7	1k Ω
R2	47k Ω	R8	220 Ω
R3	1.5k Ω	R9	470 Ω
R4	1.5k Ω	R10	15k Ω
R5	220 Ω	R11	100k Ω
R6	1k Ω	R12	2.7k Ω

All resistors are $\frac{1}{8}$ W 10% carbon

Potentiometers

VR1	5k Ω log pot
VR2a, b	10k Ω + 10k Ω linear dual-gang
VR3	10k Ω linear carbon preset

Capacitors

C1	6.4 μ F, 25V elect.
C2	6.4 μ F, 25V elect.
C3	6.4 μ F, 25V elect.
C4	6.4 μ F, 25V elect.
C5	0.1 μ F, mylar
C6	0.1 μ F, mylar

Transistors

TR1-TR4 BC168 (4 off)

Switch

S1 Double pole on/off toggle

Miscellaneous

JK1, JK2 Standard jack sockets (2 off)
B1 PP3 9V, battery connectors, 0.1in Veroboard
Instrument case 6 $\frac{1}{2}$ in \times 4in \times 4in (G. W. Smith)

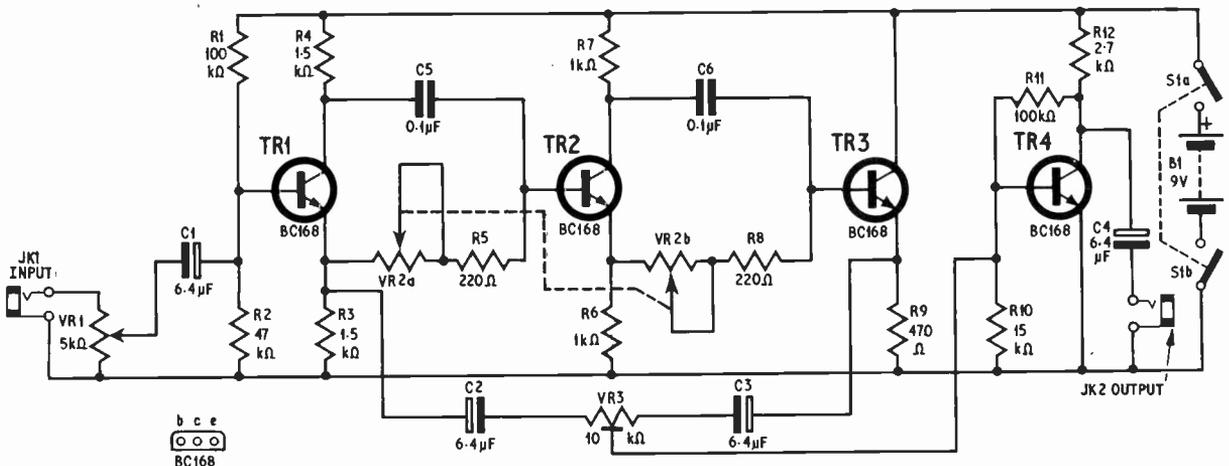
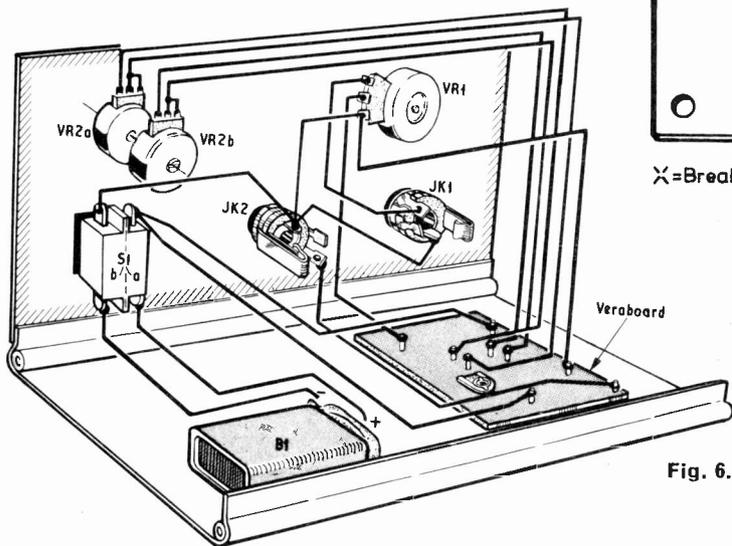
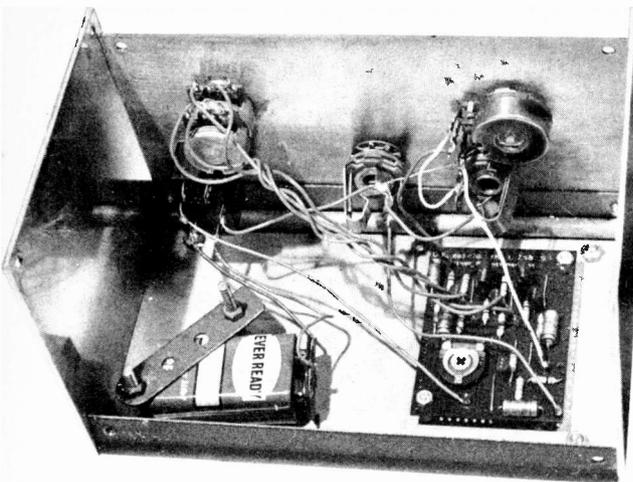


Fig. 4. Circuit diagram of Phasing Unit



The final wiring to input, output, VR1, VR2 and on-off switch can now be carried out; Fig. 6 shows the chassis mounted component connections.

The unit is conveniently powered by a small nine volt battery, but it will work from any supply between six and twenty volts. Current drain is approximately five milliamps from a nine volt supply.

SETTING UP

Initially set VR3 to mid-position and both panel controls to their extreme counter clockwise positions. Switch on and check that current drain is about 5mA, using a suitable meter in series with the supply.

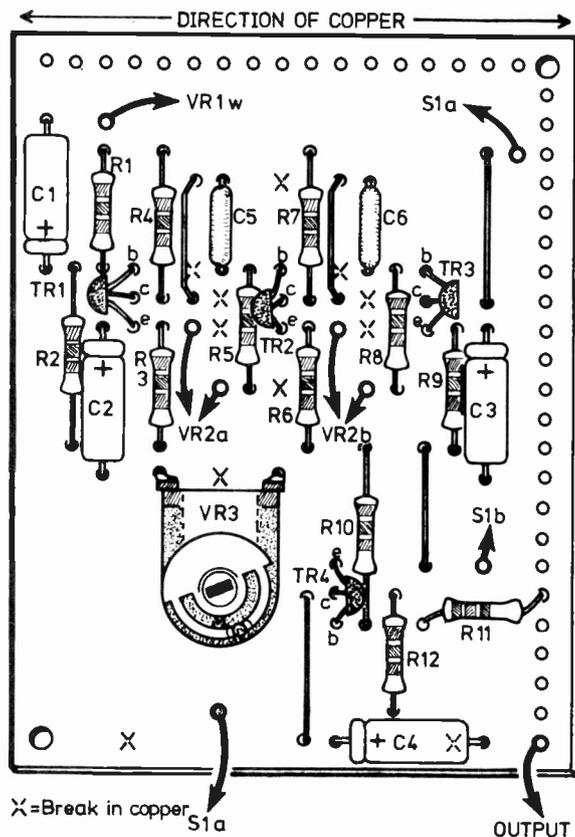


Fig. 5. Component layout and wiring on 0.1in matrix Veroboard

Fig. 6. Complete interwiring detail

The input should now be connected to a source of "white noise." Failing this however, an f.m. receiver which is not tuned to any station makes a very good substitute here. Set the level control to a convenient position whereupon the characteristic hiss should be heard.

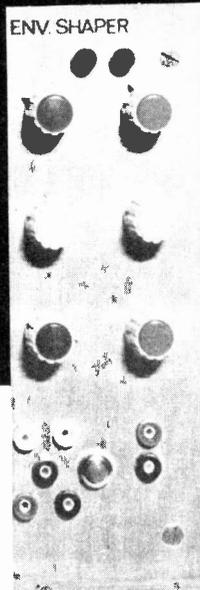
Rotate the "phase" control VR2 to its extreme position; some sort of phasing may be heard but not much. Rotate this control back about $\frac{1}{8}$ of a revolution. Preset VR3 should now be adjusted for a minimum noise level, the correct position being fairly well defined. Upon rotating the phase control VR2 back and forth, the familiar phasing effect should now be heard. If this is not the case, check all connections, especially the links on the circuit board.

The unit may now be tried out with music input from, say, a tape recorder. The final degree of phasing heard depends largely on the content of the music used; Pop records provide a suitable starting point with their varied frequency content, and on some of these the effect can be quite startling. ★

PE Sound Synthesiser 8

ENVELOPE SHAPER

By G.D. SHAW



ONE of the fundamental characterising parameters of a sound is that in which the audibility of the sound varies with time. Some sounds become audible very rapidly and almost immediately die away again whilst others make a relatively slow approach to their full volume and take an even longer period to die away. The loudness modulation of any sound is known generally as the envelope and is very important in providing a feature which allows of recognition. Changes in the envelope format of an otherwise well-known sound can often change the character of the sound completely.

A simple experiment designed to illustrate this latter point involves the use of a tape recorder and a piano. Make a recording of a series of notes or chords selected from various parts of the piano register and repeat these with the sustain pedal held down. The recording should now be replayed backwards. With a four track recorder the simplest way of doing this is to unthread the recorder without rewinding, reverse the position of the spools and thread up again putting a twist in the tape so that the shiny, or backing side of the tape is towards the heads. This particular method results in a considerable loss of sound quality but illustrates the characteristic quite well. If the constructor is fortunate enough to own a mono or two track recorder in addition to a four track the recording should be made on the former machine and replayed, with spool positions reversed, on the latter.

PIANO ENVELOPE FORMAT

The change in the original sound of the piano, on reverse replay, will be found to be quite remarkable and, depending on the octave and sustain given to the original note or chord, will be found to bear a close resemblance to other musical instruments such as the organ or cello.

The piano is particularly suited to this form of experiment due to the nature of its envelope format which is characterised by a rapid rise to full volume followed by a relatively long period, dependent upon sustain pedal use, during which the volume is gradually diminishing. Fig. 8.1 illustrates a simplified form of piano envelope.

The peak volume followed by a rapid partial decay to the gradually diminishing sustain is a characteristic common to many musical sounds which are initiated by a form of percussion. Instruments such as the triangle, timpani, cymbal, glockenspiel and so on, all display similar basic characteristics in their envelopes.

Apart from the particular form of the percussive envelope the majority of sound envelopes will fall somewhere within the range of shapes illustrated in Fig. 8.2 all of which may be considered to be derivations of the basic trapezoid shown in Fig. 8.3.

The Envelope Shaper in the Sound Synthesiser is essentially a trapezoid generator in which the attack, sustain, and decay parameters are all adjustable, within the limits of the controls, to provide a range of formats similar to those illustrated in Fig. 8.2.

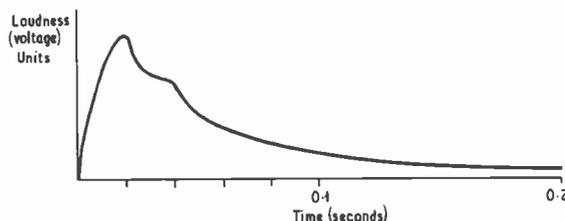


Fig. 8.1. Typical piano envelope



Fig. 8.2. Simplified range of sound envelope formats

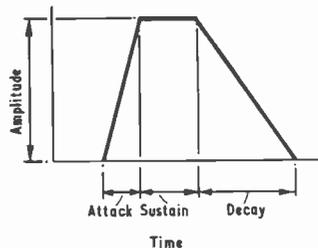


Fig. 8.3. Basic envelope trapezoid

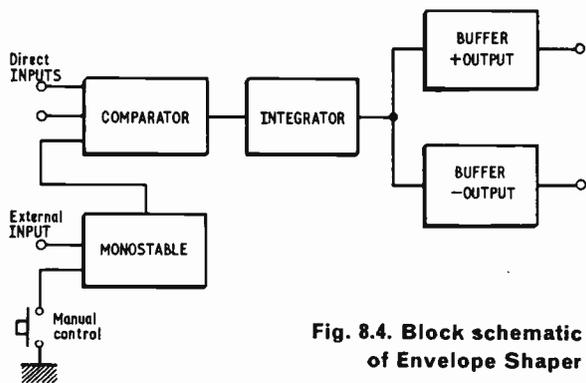


Fig. 8.4. Block schematic of Envelope Shaper

BLOCK SCHEMATIC

A schematic arrangement of the envelope shaper is shown in Fig. 8.4. The heart of the circuit is an integrator which drives two buffer amplifiers providing independent positive and negative going envelopes. The integrator itself is driven by a comparator having a variable reference level and thus any change in the input signal level to the circuit as a whole has no effect on the overall envelope amplitude. The comparator may be triggered directly by an external signal or via a monostable with a variable timing period.

CIRCUIT DIAGRAM

Fig. 8.5 shows the theoretical circuit of the envelope shaper. IC1 is the comparator which has a reference level set by R5-VR1 and ranging between 0V and -5V. Thus the comparator will recognise only negative going signals which exceed the reference level, and, with no signals present, will normally sit at its negative saturation state. Four triggering modes are catered for and selected by S1.

In the first the comparator is triggered directly by external signals arriving at the inverting input via R1 and R2.

Triggering is accomplished in the second mode by means of the keyboard synchronising pulse which is routed via R3. The pulse level swings between +10V and will thus override any other trigger signal less than -10V arriving at the comparator via R1 and R2. Equally, it is possible to combine keyboard synchronisation with other external signals providing that the peak value of these exceeds -10V.

In the third mode of operation the comparator is triggered by a capacitively coupled monostable (IC5) which is, in turn, triggered by negative going transitions in signals arriving at the external socket.

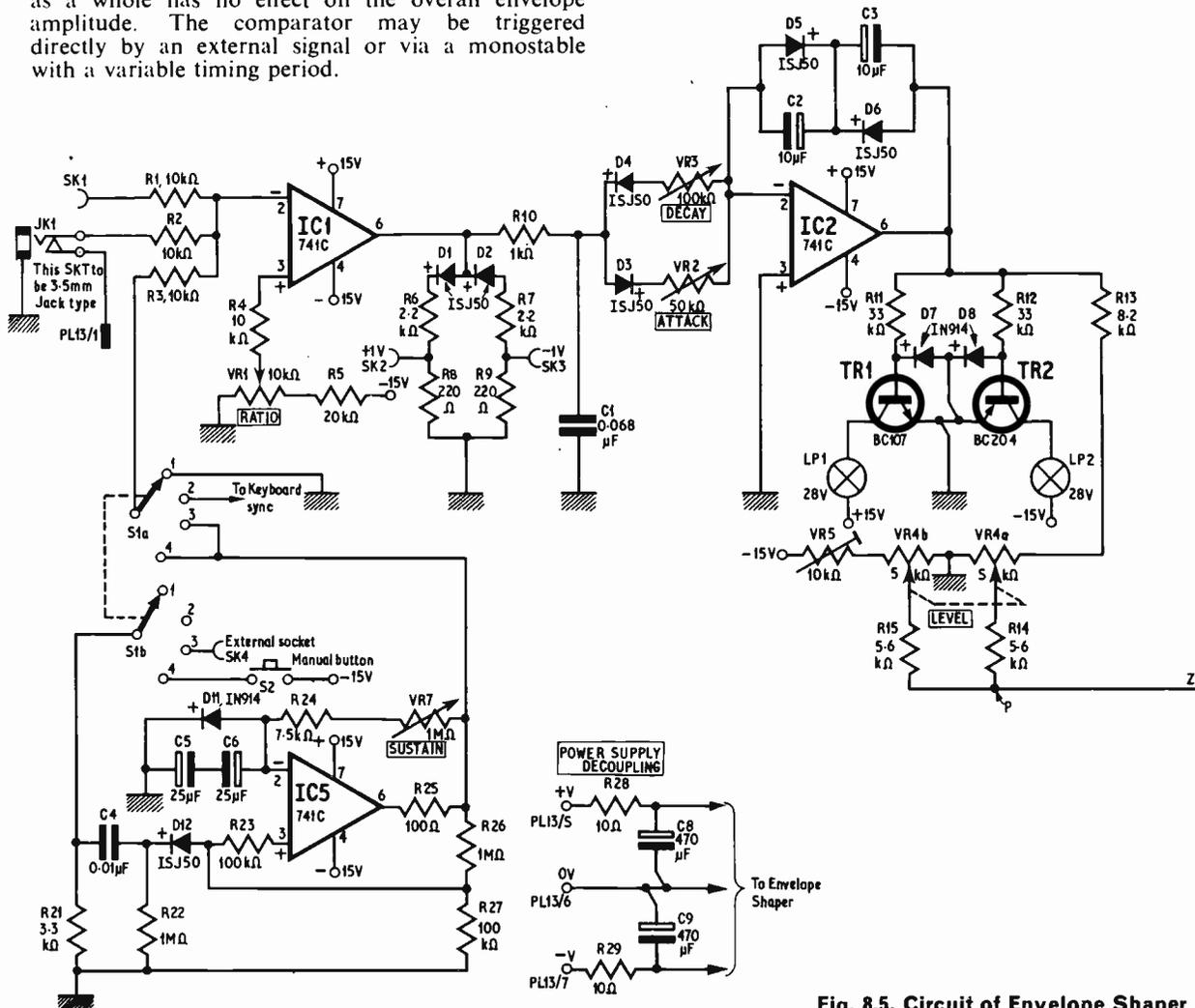


Fig. 8.5. Circuit of Envelope Shaper

In this latter mode the pulse level of the monostable swings between $\pm 14V$ and thus effectively overrides all other signals arriving at the comparator inputs.

Finally, in mode four, the monostable is triggered manually by means of a push button. In modes three and four the on period of the monostable is controlled over 100/1 range by means of VR7 and, with the value shown, can be varied between 15mS and 1,500mS. Since the shortest period of sustain is less than the combined fastest attack/decay time of about 20mS the resultant envelope is slightly lower in amplitude than it would otherwise normally be. However, for most purposes this may be adequately compensated for by adjustment of the envelope level control (VR4).

SIGNAL ROUTING

Output signals from the comparator are routed via R10 and D3/VR2 or D4/VR3 to the inverting input of the integrator built around IC2. In the absence of signals into the comparator, the provision of a negative reference level means that the comparator normally sits at negative saturation and the integrator at positive saturation. A negative-going signal greater than the reference level causes the comparator to change states and the positive going pulse is routed into the integrator via D3/VR2 and charges C3. When the trigger signal is removed, or changes polarity, C3 discharges via VR3/D4 and R10 and the original situation is restored.

The rate at which C3 charges and discharges is governed by the setting of VR2 and VR3 respectively. With both controls at minimum the fastest rate of attack or decay is determined by R10 and, with the values shown, is about 10mS. Thus the attack time can be varied by VR2 between 10mS and 500mS while the decay time can be varied by VR3 between 10mS and 1000mS.

The sustain period of the envelope signal may be varied in two ways. In the first, the on time of the comparator output pulse is determined by the period of that part of the input signal which lies above the reference level. The on time may thus be varied by adjustment of the ratio control VR1 in those instances when the comparator is triggered directly by an external signal.

In the second case the comparator is triggered by a monostable either from within the envelope shaper (IC5) or from the keyboard. In each case the on period is determined by adjustment of the monostable sustain control.

BUFFER AMPLIFIERS

The output from the integrator is routed to two buffer amplifiers of unity gain. IC3 is wired as a follower whilst IC4 forms an inverting amplifier. Interposed between the integrator and output buffers is a balancing divider network comprising R13, VR4a/b, VR5, R14 and R15.

The purpose of this network is to drop the integrator output swing to a usable level and to balance its maximum positive transition with an equal value negative voltage supplied via VR5/VR4b. Thus with the integrator sitting at positive saturation the output voltage of the network, measured at point P in the circuit, is effectively zero. Taking into account the forward drops of diodes D9 and D10 the buffer outputs will therefore swing between zero and about 3.2V.

INDICATOR LIGHTS

An indication of the state of the integrator is provided by two lamps which are switched by TR1 and TR2. With the integrator sitting at positive saturation TR1 is turned on and LP1 lights thus indicating an envelope off situation. When the integrator changes state TR1 is biased off thus extinguishing LP1 while TR2 is turned on and LP2 lights up indicating an envelope-on state.

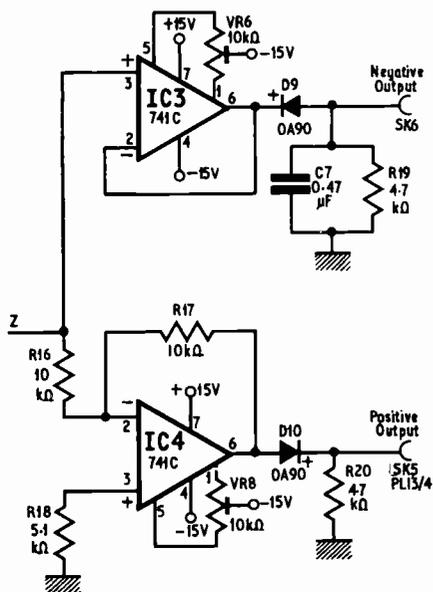
The provision of two indicator lights is useful in those circumstances in which the envelope shaper is being operated by external signals direct into the comparator. Here the lights can provide a visual measure of the envelope on/off times in relation to the frequency of the triggering signal. For the majority of other purposes however the envelope off indicator may be considered superfluous and may be omitted from the circuitry to serve the requirements of economy. The circuit elements involved are LP1, TR1, D7 and R11.

Finally it is often useful to be able to synchronise the beginning and end of an envelope with other modules in the synthesiser. To this end diodes D1 and D2 together with dividers R6-8 and R7-9 provide pulses of 1V amplitude direct from the comparator output. As with the envelope off indicator these particular components are not necessary to the operation of the envelope shaper as such and may be omitted if automatic programming is not to be the principal function of the module.

Fig. 8.6 shows the recommended circuit board layout for the envelope shaper while Fig. 8.7 gives details of front panel and McMurdo plug wiring.

MODULE CONSTRUCTION

Construction of the module is quite straightforward and the only critical requirement lies in the wiring of VR4a/b and the setting up of the associated



COMPONENTS . . .

ENVELOPE SHAPER

Resistors

R1-R4	10k Ω (4 off)
R5	20k Ω
R6, R7	2.2k Ω
R8, R9	220 Ω (2 off)
R10	1k Ω
R11, R12	33k Ω (2 off)
R13	8.2k Ω
R14, R15	5.6k Ω (2 off)
R16, R17	10k Ω (2 off)
R18	5.1k Ω
R19, R20	4.7k Ω (2 off)
R21	3.3k Ω
R22, R26	1M Ω (2 off)
R23, R27	100k Ω (2 off)
R24	7.5k Ω
R25	100 Ω
R28, R29	10 Ω (2 off)

All 5% $\frac{1}{2}$ watt carbon

Capacitors

C1	0.068 μ F polyester
C2-C3	10 μ F elect. 25V (2 off)
C4	0.01 μ F polyester
C5, C6	25 μ F elect. 25V (2 off)
C7	0.47 μ F polyester
C8-C9	470 μ F elect. 25V (2 off)

Potentiometers

VR1	10k Ω linear min. moulded carbon
VR2	50k Ω linear min. moulded carbon
VR3	100k Ω linear min. moulded carbon
VR4	5k Ω linear ganged moulded carbon
VR5-VR6	10k Ω carbon preset (2 off)
VR7	1M Ω linear
VR8	10k Ω carbon preset

Integrated Circuits

IC1-IC5 741C (5 off)

Transistors

TR1 BC107
TR2 BC204

Diodes

D1-D6	1SJ50 (6 off)
D7, D8	IN914 (2 off)
D9, D10	OA90 (2 off)
D11	IN914
D12	1SJ50

Miscellaneous

LP1, LP2 28V sub-miniature lamps (2 off)
SK1-SK6 2mm miniature sockets (6 off) JK1-
3.5mm miniature jack socket, S1-2 pole 6 way
switch S2-miniature push button switch.

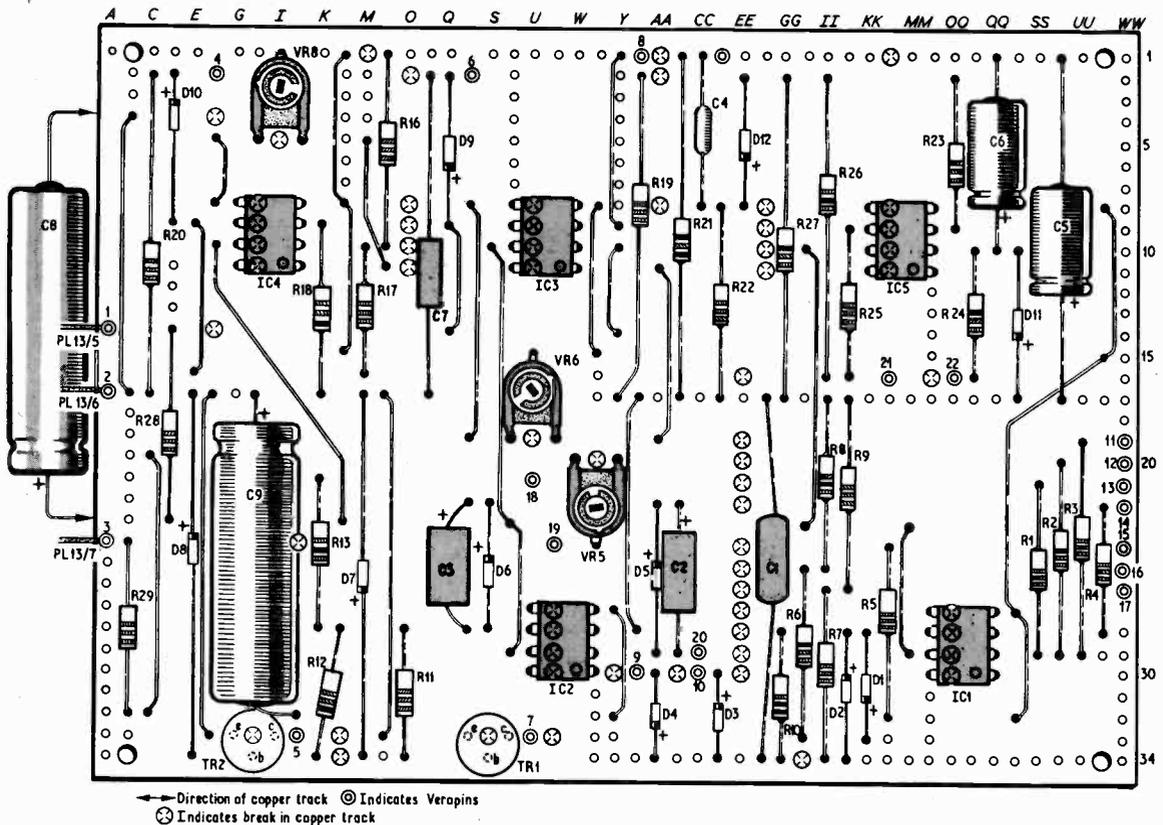


Fig. 8.6. Board layout and wiring

balancing divider. This may be done as follows. With power on, put S1 in the direct mode and set VR1 to its maximum setting. This will ensure that the integrator is sitting at positive saturation. Set VR5 to near mid-position and with VR4 at its maximum setting connect a high resistance voltmeter (5V range) between point P and ground. The voltmeter should read approximately 2.5V negative. Adjust VR5 to bring the voltmeter reading as close to zero as is possible.

Reset VR4 to minimum and progressively reduce the sensitivity of the voltmeter adjusting VR5 as necessary to maintain a zero-volt reading. This latter manipulation serves to adjust and compensate for the minimum end resistance of VR4 which should remain at its minimum setting for the next stage of adjustment. Remove the high resistance voltmeter and re-connect between the output of IC3 and ground. Connect point P directly to ground and adjust VR6 so that the output of IC3 is zero.

Repeat the measurement with the voltmeter connected between the output of IC4 and ground making any necessary adjustments to VR8 in this case. It should be borne in mind that variation of

the offset presets VR6-8 will result in an output voltage change of only a few millivolts, a 400 millivolt swing being typical when the amplifiers are run at unity gain. If the voltmeter is insufficiently sensitive it will be necessary to use an oscilloscope for this latter measurement. It is important that the measurement be made at the output pin of the buffer amplifiers as opposed to the output socket. Disconnect point P from ground and, with all other controls as initially set, swing VR4 to its maximum position and observe the change in output voltage, if any, at the output pins of IC3 and IC4.

If the overall change is within 400mV the error may be halved by adjustment of VR5 and the remaining 200mV error reduced, or eliminated, by adjustment of the offset controls VR6 and 8 on IC3 and IC4 respectively. If the error is greater than 400mV it will be necessary to adjust the value of R13 accordingly. This latter course, however, is unlikely to be necessary since the two halves of a ganged pot would normally be expected to be taken from the same batch of stators and consequently the resistive tolerance of both halves is likely to be within fairly close limits.

The adjustments detailed above are only critical if it is envisaged that the envelope shaper be used for v.c.o. programming in addition to its main purpose of amplitude modulation.

USING THE MODULE

In most commercially available synthesisers the envelope shaper usually incorporates a voltage controlled amplifier as an integral part of the circuitry. In the Sound Synthesiser however the envelope shaper is treated as a discrete entity in the interests of simplicity and thus it is not possible to route signals through it in the same way as is featured in the Moog or EMS range of instruments. Thus the description of usage of the module in this particular article will be restricted to v.c.o. programming and covered at greater length in next month's article which deals principally with the Voltage Controlled Output Amplifiers.

Reverting for a moment to the description of the operation of the Envelope Shaper it will be recalled that the envelope is initiated when the comparator switches from one saturation state to the other and that the period of sustain is essentially governed by the time for which the comparator is in its temporary state. Thus, since the attack period of the envelope occurs during the on time of the comparator, it follows that the overall sustain of the envelope is equal to the on time of the comparator less the period of attack.

This particular point is quite important because under certain conditions the set period of attack could be greater than the on time of the comparator. This means that C3 does not become fully charged and thus the envelope does not achieve its full amplitude. Fig. 8.8a illustrates the effect when, with the comparator being triggered by a repetitive signal, its on time is gradually increased either by increasing the period of the triggering signal or by adjustment of the ratio control.

If the input signal is derived from, say, two Ramp Generators and the Sample and Hold in combination and the combined amplitude adjusted such that only the peaks are greater than the comparator reference level, the resultant signal from the envelope shaper will resemble that shown in Fig.

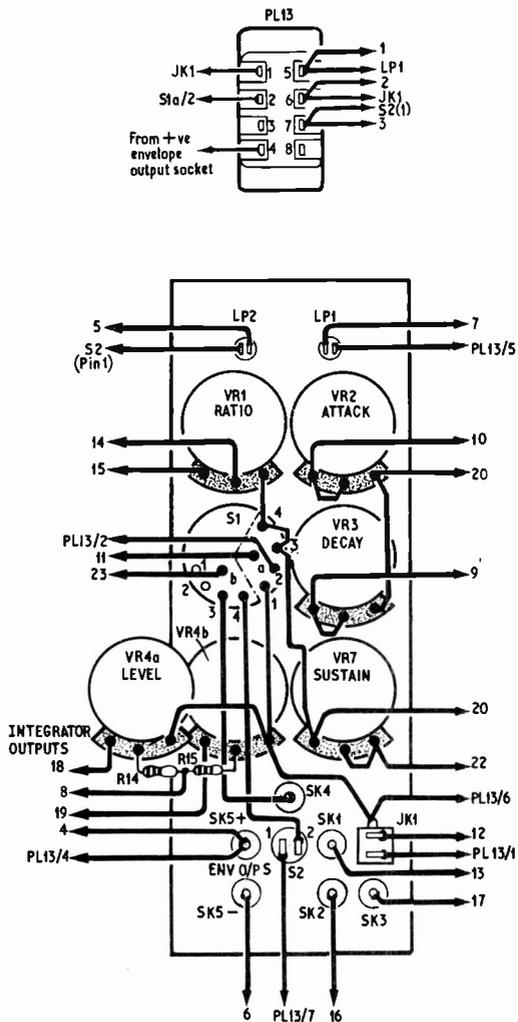


Fig. 8.7. Front panel control layout and wiring

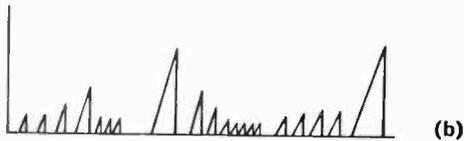
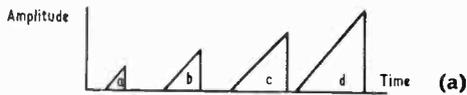


Fig. 8.8(a). Showing the effect when the attack time is longer than the on time of the comparator. Greatest effect is at 'a' and increasing the on period progressively through 'b', 'c' and 'd' increases the envelope amplitude; (b) typical envelope series resulting from the above

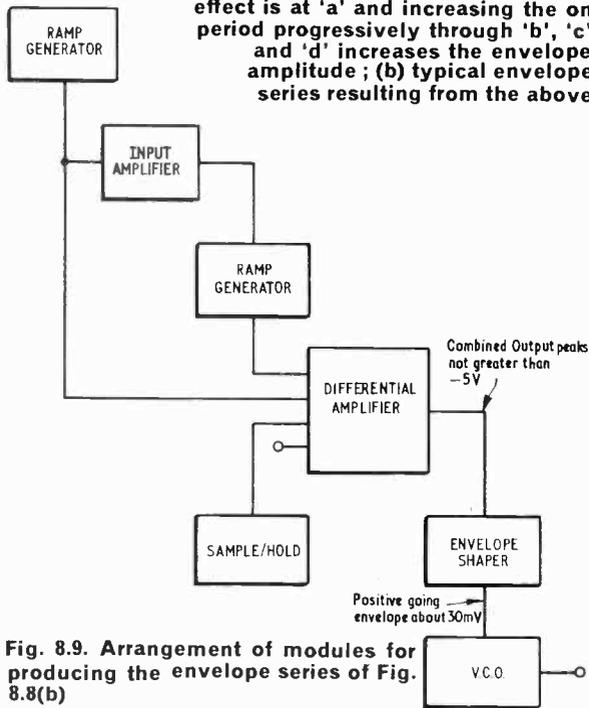


Fig. 8.9. Arrangement of modules for producing the envelope series of Fig. 8.8(b)

8.8b. If the positive going waveform is now used to program a v.c.o. which has been manually set to its maximum frequency the resultant output can be adjusted so as to provide a variety of birdsong which is very realistic. Fig. 8.9 shows a typical arrangement of modules for the provision of this type of sound.

SHIP'S SIREN

Sounds resembling a ship's siren may be synthesised by routing the envelope shaper direct to a v.c.o. and programming the envelope manually. The various controls should be set as follows: SW1 (Mode) = manual; Attack = Maximum; Decay = Minimum; Sustain = Midway; Output Level = 1/20 rotation (0.5 on a ten-point, 270 degree calibration). Use the negative going envelope and adjust the programmed v.c.o. to minimum frequency.

If the v.c.o. output is routed via the reverberation amplifier a high degree of realism may be achieved. Remember that the input to the reverberation amplifier should not exceed 500 mV peak-to-peak.

Next month: The voltage controlled output amplifiers and differential amplifier.

NEWS BRIEFS

Open University Course in Electronics

A NEW post-experience course by the Open University entitled "Electromagnetics and Electronics", aims to provide an understanding of the scientific basis of electronics and electronic circuit design. The course is intended for higher level university study in science and technology and for those who need a knowledge of electronics but who do not intend to study at a higher level.

The course assumes little prior knowledge of electronics or electromagnetics but does assume a background of scientific or technical education beyond GCE "O" level.

The course consists of 17 written correspondence units linked to 17 television and five radio programmes.

Applications are now invited for the course which starts next February and lasts until November. As with all post-experience courses no formal academic qualifications are needed. They are self-contained courses designed to teach new developments or update knowledge of a subject. The course tuition fee is £45 plus £37 for the residential summer school. Application forms are available from the Post-Experience Student Office, P.O. Box 76, Milton Keynes, MK7 6AA.

British Missile Technology for U.S.A.

UNDER a licence agreement signed in London between Marconi Space & Defence Systems Ltd. and the Raytheon Company of Massachusetts, British guided missile technology is to be sold to the U.S.A.

This agreement will enable a joint programme to be conducted between Raytheon and British industry to develop a new, medium-range, all weather, air-to-air missile based on the U.S.-Raytheon AIM-7E Sparrow, to be built in Britain by Hawker Siddeley Dynamics Ltd.

Improved Accuracy of Electrical Measurements

THE National Physical Laboratory's Division of Electrical Science have announced that, due to recent advances in measurement techniques, they are able to improve the uncertainties they are able to give in respect of a wide range of measurements. These uncertainties are offered for the calibration of high quality reference standards.

For example the uncertainty in the 1V d.c. reference has been reduced from 2 in 10^6 to 1 in 10^6 ; that of a one ohm resistance from 1 in 10^6 to 4 in 10^7 .

Bulgin Distributors

FOR those readers who have difficulty in obtaining Bulgin components we publish below a list of their current distributors for London and the Home Counties: Cables & Components Ltd., Park Avenue, London, NW10 7XN.

Home Radio (Components) Ltd., 234-240 London Road, Mitcham, Surrey, CR4 3HD.

Lugton & Co. Ltd., 209-212 Tottenham Court Road, London, W1A 2BN.

Norman Rose (Electrical) Ltd., "Norman House", 8 St. Chads Place, Grays Inn Road, London, WC1X 9HJ.

Duval Ltd., 44 George Street, Oxford.

S.D.S. (Portsmouth) Ltd., Hulsea Industrial Est., Portsmouth, PO3 5JW.

IT'S A SELECTIVE ISSUE - NEXT MONTH

FREE IN THE OCTOBER ISSUE
P.E. AUDIO I.C.
IDENTICHART

Whether you are thinking of building an amplifier or you want some ideas on using i.c.s in audio circuits the P.E. Audio I.C. Identichart is a must for you. It gives comprehensive data on over 80 i.c.s ranging from low level preamplifiers to hybrids rated at 50W. As well as data, the chart contains suggestions for using i.c.s in mixers, tape recorders, record players, etc.

Semiconductor Tester

Select—Match—Compare and measure your discrete semiconductors. A general purpose discrete semiconductor tester capable of measuring the main parameters of transistors, rectifier and signal diodes, Zener diodes, thyristors and unijunctions, as well as providing both voltmeter and ammeter functions as an added bonus.



PRACTICAL ELECTRONICS keeps you abreast of Technology

Part Two of the P.E. Rondo Quadraphonic system takes you through the audio amplifier sections of four solid-state 20W power amplifiers.

PLUS

This month we start a new series on Phase Locked Loops, the technology which makes state-of-the-art equipment like the Rondo and other a.m./f.m. systems possible.

PRACTICAL ELECTRONICS

OCTOBER ISSUE ON SALE SEPTEMBER 14, 1973



AUDIO LOGIC PROBE

BY B. WOODLAND

SIMPLE logic probes such as are used for troubleshooting in logic integrated circuit projects generally consist of a single transistor amplifier driving a lamp display. A logical 1 lights the lamp while a logical 0 has no effect.

The major drawback of such probes is the necessity to divide one's attention between the display and the equipment under test. In a complex system it is difficult to watch displays of both probe and equipment, especially if manipulations to the system are necessary to expose the faults.

The probe detailed here was devised to overcome these difficulties whilst retaining relative simplicity and low cost. A high frequency tone is emitted when the probe detects a logic 1 and a lower frequency indicates a logic 0. As a bonus the probe will give positive indication of short duration pulses which are extremely difficult to detect by other methods.

PRINCIPLE OF OPERATION

A complete circuit diagram of the probe is shown in Fig. 1. Four NOR gates are capacitively coupled in pairs to form two free running multivibrators running at two easily distinguishable audio frequencies. Neither multivibrator is able to oscillate unless its unused input (labelled X and Y) is at logical 0.

When the function switch is in the logic position the input to the lower frequency oscillator (G3 and G4) is connected directly to the probe sensor so that a logic 0 input (at Y) will sound the lower tone.

The higher frequency generator input (X) is connected indirectly to the sensor, the transistor TR1 acting as an inverter so that a logic 1 at the sensor causes a logic 0 at point X causing the higher frequency to be generated. (The preset VR1 is used to adjust the logic 0 output of TR1 to less than 0.4V with a 2.4V input, 2.4V being the minimum TTL logic 1).

AUDIO OUTPUT

The outputs of the two audio oscillators are applied to the inputs of a simple gate made from two silicon diodes. The resultant output is amplified by TR2. Strictly speaking no amplifier is needed to drive the recommended transducer (a crystal insert) but its inclusion does allow for the substitution of a medium impedance earphone for more volume.

PULSE POSITION

When the function switch is in the pulse position the probe sensor is connected to the clock input of a TTL bistable (IC2). Even a very short pulse on the sensor will cause the bistable to change state with the accompanying change in tone frequency.

POWER SUPPLY

If the suggested crystal insert transducer is used then the probe needs to be supplied with 5V at 20mA. This quite modest demand is best supplied by the circuit under test and the construction shows two crocodile clips for this purpose.

If a loudspeaker or earpiece is to be used then a separate battery supply is recommended, with the necessary changes in construction to accommodate it.

CONSTRUCTION

The circuit is built on a small piece of 0.1in Vero-board with the strips running across the width, see Fig. 2. The integrated circuits are soldered directly to the board to keep the profile low. Single cored sleeved wire is used for interwiring, the function switch and the insert being the only components not accommodated on the board.

The probe is housed in a 6in aluminium tube of 1in internal diameter. This was in fact a tube used to hold denture cleaning tablets. The crystal insert is glued to the closed end of the tube, its leads passing through holes drilled in the tube. The power supply leads pass through a hole in the side protected by a grommet. Use highly flexible and good length leads as are used on multimeters.

The sensor consists of a 2in length of brass stud-ding bolted to the plastic cap of the tube. The function switch is fixed as shown, and the circuit board is inserted into the tube after first being wrapped in a piece of plastic sheet to act as insulation. Keep leads from the circuit board to the switch and the sensor as short as is practicable.



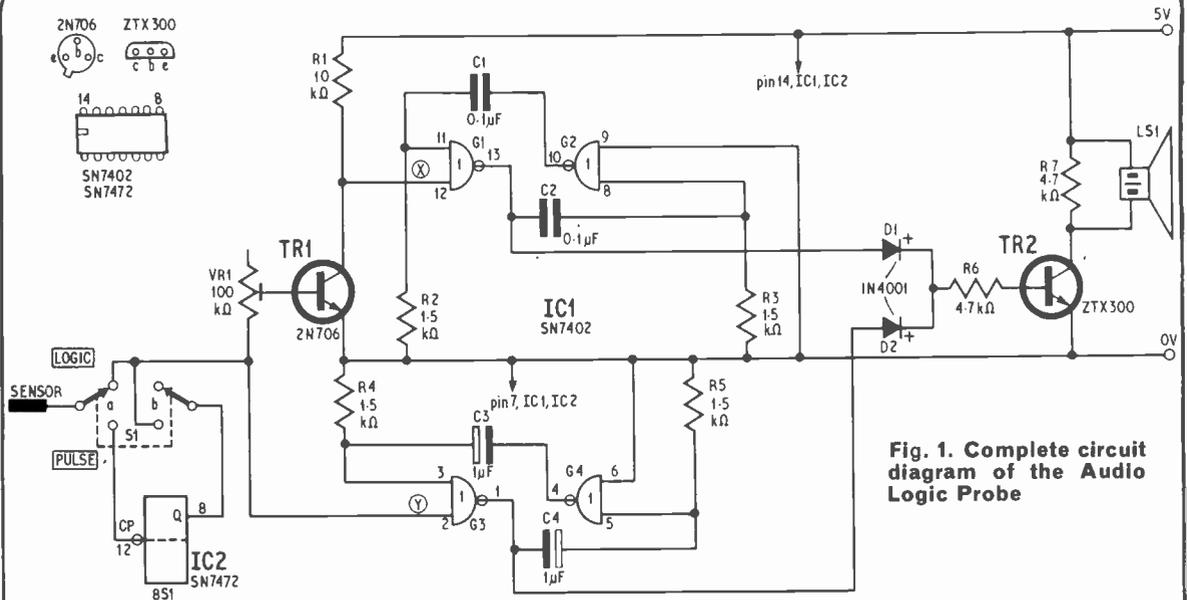


Fig. 1. Complete circuit diagram of the Audio Logic Probe

COMPONENTS . . .

Resistors

- R1 10k Ω
- R2-5 1.5k Ω (4 off)
- R6, R7 4.7k Ω (2 off)
- All $\pm 10\%$ $\frac{1}{4}$ W carbon

Potentiometer

- VR1 100k Ω miniature preset

Capacitors

- C1, C2 0.1 μ F (2 off)
- C3, C4 1 μ F 6V electrolytic (2 off)

Semiconductors

- TR1 2N706 or similar
- TR2 ZTX300 or similar
- D1, D2 1N4001 or similar (2 off)
- IC1 SN7402N
- IC2 SN7472N

Miscellaneous

- LS1 1in diameter crystal insert
- S1 D.P.D.T. miniature slide switch
- 3.6in \times 1in 0.1in Veroboard, strips running widthwise
- Brass studding and nuts, crocodile clips, aluminium container

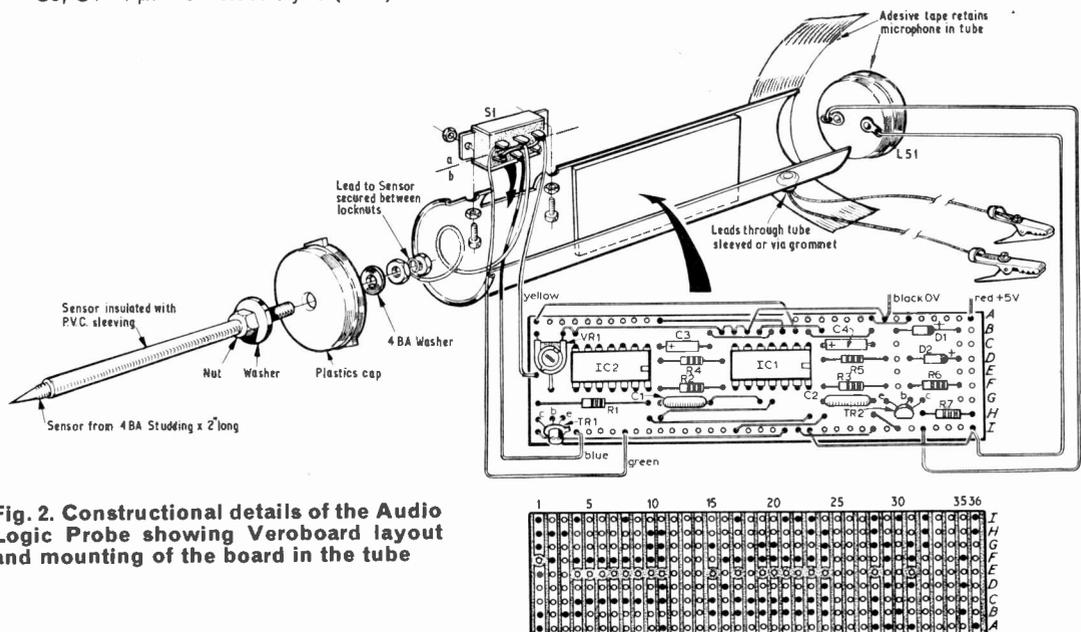


Fig. 2. Constructional details of the Audio Logic Probe showing Veroboard layout and mounting of the board in the tube

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Complete kit-£29.95! (INC.VAT)

The Cambridge – new from Sinclair

The Cambridge is a new electronic calculator from Sinclair, Europe's largest calculator manufacturer. It offers the power to handle the most complex calculations, in a compact, reliable package. No other calculator can approach the specification below at anything like the price – and by building it yourself you can save a further £14!

Truly pocket-sized

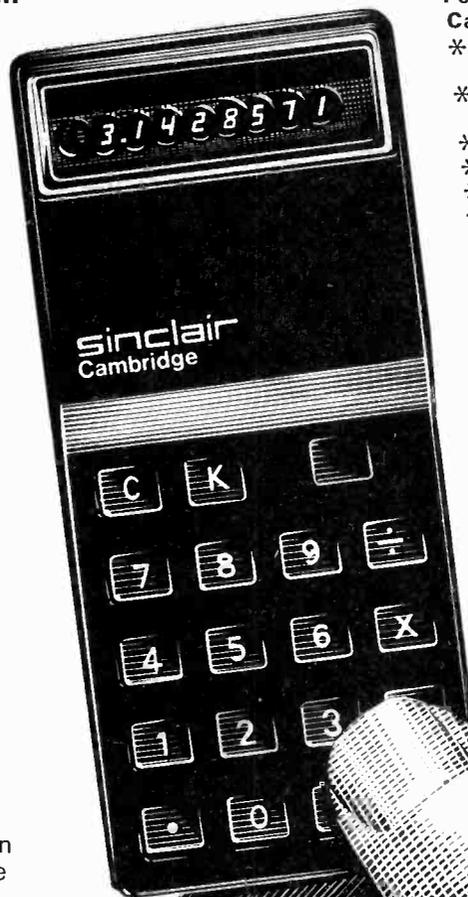
With all its calculating capability, the Cambridge still measures just $4\frac{1}{2}'' \times 2'' \times \frac{11}{16}''$. That means you can carry the Cambridge wherever you go without inconvenience – it fits in your pocket with barely a bulge. It runs on ordinary U16 batteries which give weeks of life before replacement.

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All parts are supplied – all you need provide is a soldering iron and a pair of cutters. Complete step-by-step instructions are provided, and our service department will back you throughout if you've any queries or problems.

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- * Fully-floating decimal point.
- * Algebraic logic.
- * Four operators (+, -, x, ÷), with constant on all four.
- * Constant acts as last entry in a calculation.
- * Constant and algebraic logic combine to act as a limited memory, allowing complex calculations on a calculator costing less than £30.
- * Calculates to 8 significant digits, with exponent range from 10^{-20} to 10^{79} .
- * Clear, bright 8-digit display.
- * Operates for weeks on four U16 batteries. (Replacement set costs about 15p.)

A complete kit!

The kit comes to you packaged in a heavy-duty polystyrene container. It contains all you need to assemble your Sinclair Cambridge. Assembly time is about 3 hours.

Contents:

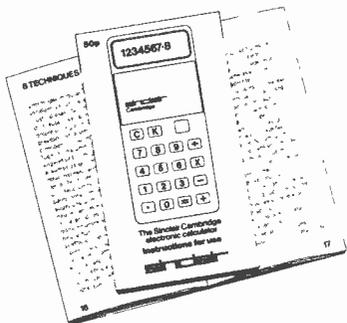
1. Coil.
2. Large-scale integrated circuit.
3. Interface chip.
4. Thick-film resistor pack.
5. Case mouldings, with buttons, window and light-up display in position.
6. Printed circuit board.
7. Keyboard panel.
8. Electronic components pack (diodes, resistors, capacitors, transistor).
9. Battery clips and on/off switch.
10. Soft wallet.



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If you just use your Sinclair Cambridge for routine arithmetic – for shopping, conversions, percentages, accounting, tallying, and so on – then you'll get more out of your money's worth.

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Practical Electronics September 1973

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*Delete as required.		_____
		PLEASE PRINT

NEW DEVICES ... APPLICATIONS

SEMICONDUCTOR GAS SENSOR

In this section we present a selection of both new devices and applications, with news of applications developed for existing devices.

Generally only basic circuit details will be given sufficient for the experimenter to create his own equipment.

THE GAS SENSOR used in the Electronic Nose (July 1973) is a device which is probably new to most readers and thus warrants a more detailed description. The sensor to be described (T.G.S.) is manufactured by Figaro Engineering, a firm based in Japan.

The T.G.S. consists of two electrodes encapsulated in a bead of bulk-type crystalline semiconductor material

heater, the driving voltage being between 1.0 and 1.5 volts. The nominal resistance of the filament is 2 ohms. The value shown for R_L is typical for low voltage applications.

When first switched on the sensor shows high conductivity until warmed up sufficiently for combination with oxygen to occur. It then settles down to a low "in air" output (see Fig. 3).

The T.G.S. will react to all the common combustible gases and vapours, for example hydrogen, propane, butane, petrol fumes, methane (natural gas), acetone benzene, etc. It will also respond to carbon monoxide, making it suitable as a smoke detector.

The sensor will not discriminate between gases but reacts to the total deoxidising effect.

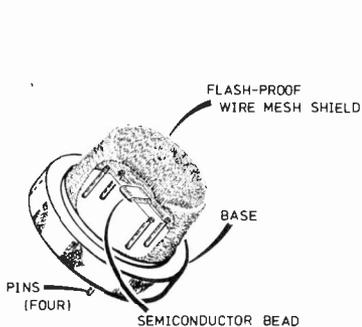


Fig. 1. Construction of the T.G.S. gas sensor

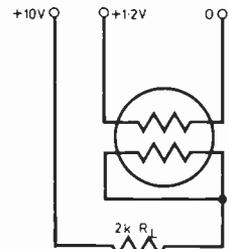
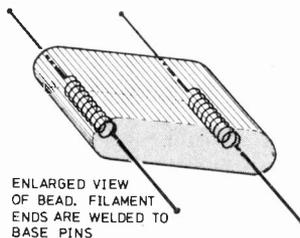


Fig. 2. The simplest circuit for use with the T.G.S

as shown in Fig. 1. This material is based on tin oxide (SnO_2) suitably doped and of n -type character.

When heated in the presence of oxygen—as happens when heated in air—anionic absorption of oxygen takes place on the surface of the material leading to a drastic reduction in the number of free electrons available and hence reduced conductivity. In contact with a deoxidising gas or vapour, cationic absorption occurs and the number of free electrons increases as does conductivity.

The sensor can be compared to a "gas dependent resistor" and the circuits built around them are similar to those built around light dependent resistors.

SIMPLE CIRCUIT

The simplest type of circuit is shown in Fig. 2 where it can be seen that one of the electrodes acts as a

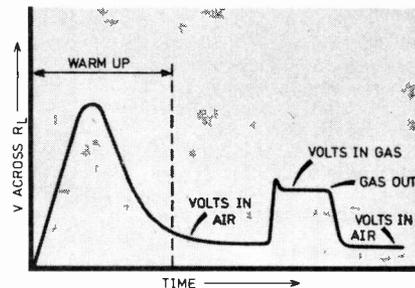


Fig. 3. After switch-on the conductivity of the sensor rises sharply as shown in this graph. After warm-up the typical response to a gas is shown

PRACTICAL POINTS

The device is symmetrical; either filament can be used as the heater. The recommended side for use as the heater is marked with a small circle punched on the screen base. The T.G.S. base will plug into a B7G valve base.

To avoid cooling of its surface the sensor should be shielded from exposure to draughts or high velocity gas flows.

The T.G.S. works equally well on a.c. or d.c., and polarity is unimportant. Fig. 4 shows a basic circuit using a.c. rather than d.c. as the source. For battery operation a dropper resistor is the easiest but the most wasteful way of obtaining a heater voltage. Other methods include d.c./a.c. inverter or separate battery, e.g. NiCad.

If an amplifying circuit is coupled to the sensor, then the total load resistance of the sensor must be kept at the recommended value (2 kilohms), i.e. if the input tends to shunt the load resistor, then the load resistor should be increased to restore the total resistance to the required value.

After storage or when the T.G.S. has been switched off for some hours, the device will conduct heavily at switch-on until its temperature has enabled the semiconductor to stabilise in air. On completion of initial stabilisation the device will only conduct the presence of deoxidising gases (see Fig. 3).

As in all semiconductors some spread of characteristics occurs and so some adjustment should be built into the circuit for calibration purposes.

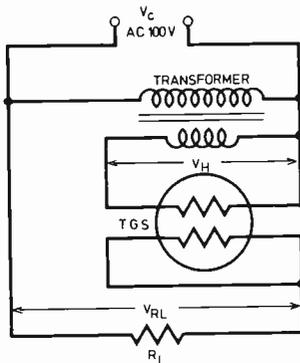


Fig. 4. This circuit shows how the T.G.S. may be used with an a.c. system

ALARM LEVEL

For domestic and marine use an alarm level of 0.2 to 0.3 per cent is recommended. This represents about $\frac{1}{5}$ of the lower explosive level in the case of bottled gas and $\frac{1}{20}$ of the lower explosive level for methane (natural gas).

The gas sensor described in this article is available from the following advertisers in P.E.—Trampus Electronix, Watford Electronics, Yates Electronics.

● PRACTICAL ELECTRONICS will be publishing another project using the gas sensor in the near future. ★

ALL READERS PLEASE NOTE

If you know someone (young or old) who would like to take up electronics as a hobby, you can do them a good turn. Bring to their attention our companion magazine EVERYDAY ELECTRONICS which specialises in simple projects and elementary theory.

The September issue contains these fascinating and inexpensive projects.

- ◆ *A Personal M.W. Radio*
- ◆ *Aquarium Thermostat*
- ◆ *Model Train Controller*

STARTING ELECTRONICS FROM SCRATCH

In the October issue, EVERYDAY ELECTRONICS launches an exciting new series explaining in simple terms basic theory and describing simple experiments that can be performed by the beginner.

Remember, Teach-In'74 starts in the October issue of EVERYDAY ELECTRONICS.

No one interested in learning about electronics can afford to miss this vital series.

THE GOOD COMPANIONS



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September EE on sale Friday, August 17



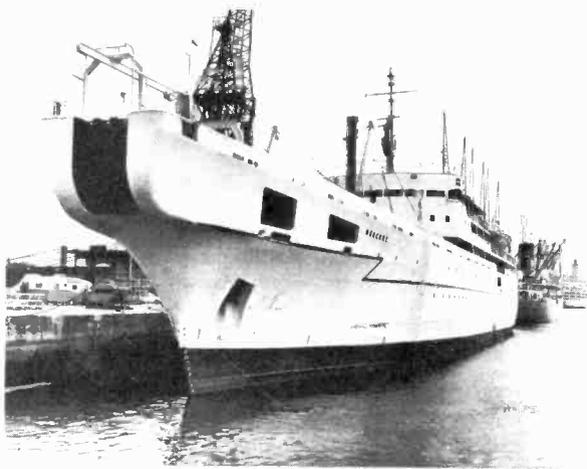
ELECTRONORAMA

THE loading of the cable ship *Mercury* (8,962 tons) with the first 200 miles of a £30 million telephone cable linking Britain and Canada was completed at Southampton on June 20. Handling more than 1,800 telephone conversations simultaneously the cable, CANTAT-2, will be the biggest single telephone cable across the Atlantic, carrying more telephone calls than all the existing trans-Atlantic cables combined. The cable system will be used for communication between the U.K. and mainland Europe, and Canada and the U.S.A. and will come into service early in 1974.

GROWTH IN CALLS

Being financed and operated jointly by the British Post Office and the Canadian Overseas Telecommunications Corporation, the 3,000-mile cable is being provided to meet the massive growth in telecommunications between Britain and North America. In ten years 'phone calls between Britain and Canada have risen eightfold from

The cable ship *Mercury* being loaded at the quayside at STC's Southampton plant



135,000 calls a year in 1962 to their present level of more than a million a year. This will rise again to nearly 6 million a year by 1980. Growth in calls between the U.K. and the U.S.A. has risen from half-a-million in 1962 to more than 4½ million in a year in 1972, and by 1980 this will have reached 24 million a year.

The laying of CANTAT-2, which is being manufactured by the submarine systems division of Standard Telephones and Cables Ltd., comes 20 years after Britain and the U.S.A. decided to lay the first telephone cable across the Atlantic.

Each circuit in the first telephone system cost at the time more than £294,000. In CANTAT-2 the application of modern transmission techniques has dramatically reduced the cost of each circuit to £16,500. This has been an important factor in keeping down the cost of trans-Atlantic telephone calls.

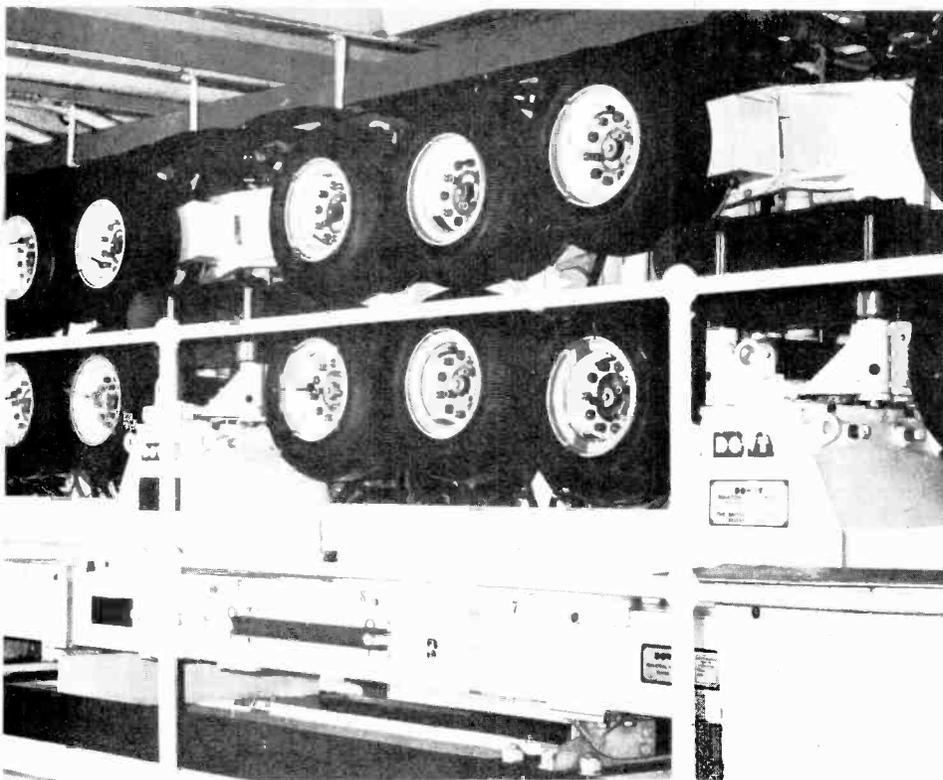
CABLE ROUTE

CANTAT-2 will run from Widemouth Bay, Cornwall to Beaver Harbour, near Halifax, Nova Scotia. It will be laid by two ships, *Mercury* and the Canadian icebreaker/cable layer *John Cabot*. Both ships are fitted with a new design of linear cable engine developed by the Post Office Research Department, and which considerably speeds cable laying.

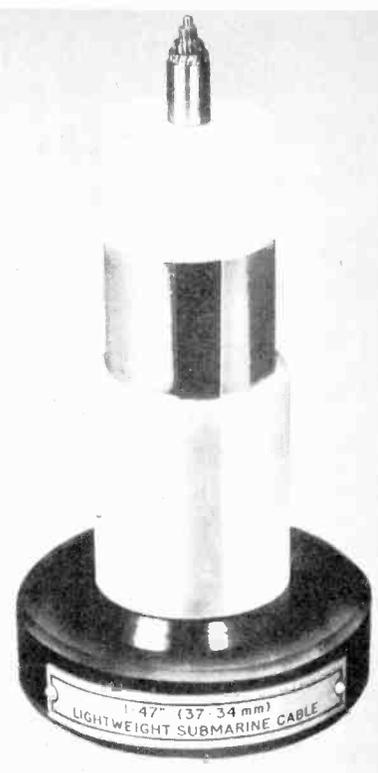
Mercury is to lay more than 2,600 nautical miles from the U.K. and across the North Atlantic Ocean. Because of the high risk of damage by trawlers the cable is to be buried beneath the seabed where it crosses the rich fisheries of the Canadian continental shelf.

The powerful *John Cabot*, equipped with a seabed plough and assisted by a manned miniature submarine, has already started to bury a 170-mile section of the cable. A similar submarine will be used to bury some sections of cable on the U.K. continental shelf.

Mercury, laying the deep-water section of CANTAT-2, has been fitted with one of the most accurate navigation systems commercially available to enable her to chart the cable route with extreme accuracy. The system, called Hydroplot, was developed for the Hydrographic Department of the Royal Navy and uses U.S. Navy navigation satellites to pinpoint the ship's position to within 300 feet. An Elliot 905 computer integrates all the ship's other navigation aids and cable-laying information and provides a visual display unit for the navigator.



The linear cable engine for drawing cable from the ship's storage tank and paying it out to the ocean floor. The wheels can expand to accommodate the torpedo shaped equalisers or repeaters



A sample of the submarine cable for deep water. External armour is added for the shore end lengths.

A specially clothed operative assembling a repeater



REPEATERS AND EQUALISERS

In order to amplify the telephone signals on their long journey, 473 special amplifiers, or repeaters, are used each being spaced at 6 mile intervals. Since these units are expected to work on the ocean floor for periods up to 25 years, quality control and testing is naturally very stringent with manufacture taking place in special clean areas.

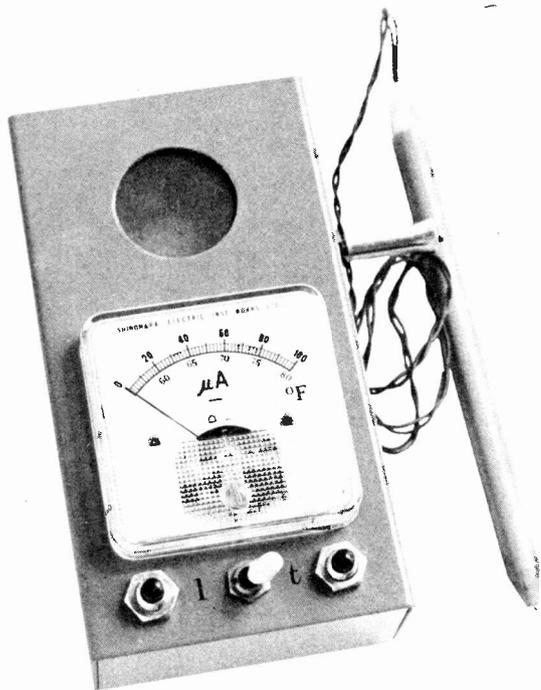
Every 15 repeaters in the cable length an equaliser is used. These are to compensate for the small differences that occur between the gain characteristics of the repeaters and the loss characteristics of the cable sections. These can be affected by sea temperature and pressure. Inserting equalisers into the system approximately every 15 repeaters overcomes such problems. As the system is laid it is continuously monitored and tested and the data collected is used in the design and building of the final circuitry for the equaliser while the cables are at sea.

Splicing the cable into each repeater also takes place on board.

CIRCUITS

CANTAT-2's 1,840 circuits are arranged as 23 super-groups, transmitting in the frequency band 312-6,012kHz in the U.K.-Canada direction and 8,000-13,700kHz in the Canada-U.K. direction. In addition four speaker circuits of nominally 3kHz bandwidth each, use the frequency bands 6,024-6,036kHz in the U.K.-Canada direction and 7,976-7,998kHz in the Canada-U.K. direction, for system and circuit maintenance.

The cable itself is predominantly of lightweight design and will weigh no more than five tons a mile. Less than two inches in diameter for most of its length the cable has an outer conductor of aluminium. Its strength is centred in a steel rope inside an inner copper conductor. External armour will be used to protect the cable at the U.K. shore end.



ENLARGER EXPOSURE METER & THERMOMETER

BY J.M. BARTLETT

FOR the photographer who develops and prints his own negatives there are two factors that are vitally important. The first is the temperature of the chemicals, and a thermometer is an absolute must at every stage. Developing, rinsing, fixing, and finally washing must all be done at known and controlled temperatures; in colour developing the entire process must be carried out in five or more separate operations with all the liquids controlled to within half a degree Fahrenheit of each other.

This article describes an electronic thermometer with a sensing time of only two to three seconds and a potential accuracy of 0.2 degree F, so that quick and accurate checking can be made without wondering if the thermometer has "settled down".

Secondly, the exposure time required for enlargements is usually obtained after a time consuming test strip has been made. This unit also incorporates an enlarger exposure meter that senses the amount of light in the centre of interest, or a mid tone grey area, so that a proof print can be obtained first time.

BASIC BRIDGE CIRCUIT

Both circuits have been designed around the basic bridge circuit. In Fig. 1, voltages V_A and V_B are developed in the left arm and right arm respectively. When $V_A = V_B$ no current flows in the meter and the bridge is said to be balanced. (This is when $R_A/R_B = R_C/R_D$.) If V_B falls then current will flow in the meter, the deflection set by R_M (the total resistance in the meter arm, including the internal resistance of the meter).

If the current in the two arms is very much higher than the current through the meter, then the small amount of meter current will have no significant effect on V_A and V_B . Since in these circuits the sensing components draw a current comparable to, or less than, the meter, special circuits are used to ensure that the bridge operates properly.

EXPOSURE METER

The exposure meter circuit is that part drawn above the meter in Fig. 2. It is operated by S1, a push button which ensures that the circuit is active only when required, and a long battery life is possible.

Zener diode D1 supplies a semi-stabilised voltage of 5.6V (nominal), making the response stable even with an ageing battery. VR1 and R2 form the left side of the bridge circuit (similar to R_A and R_B) but because of the high resistances involved with the light sensor one of the "special circuits" must be used.

The light sensing is done by a photo conductive cadmium sulphide (CdS) cell, an ORP 12, referred to as PCC1 on the circuit diagram, which has a resistance of nearly 10 megohms in total darkness.

As light strikes the sensitive area its resistance drops, but with the very low light intensities of interest (0.01 lux to 0.8 lux) its resistance does not drop below about 100 kilohms. The current through

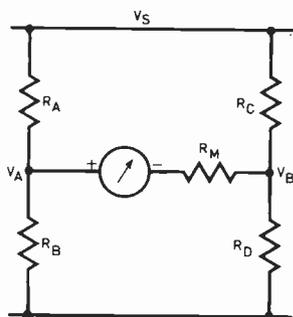


Fig. 1. Basic Wheatstone Bridge circuit

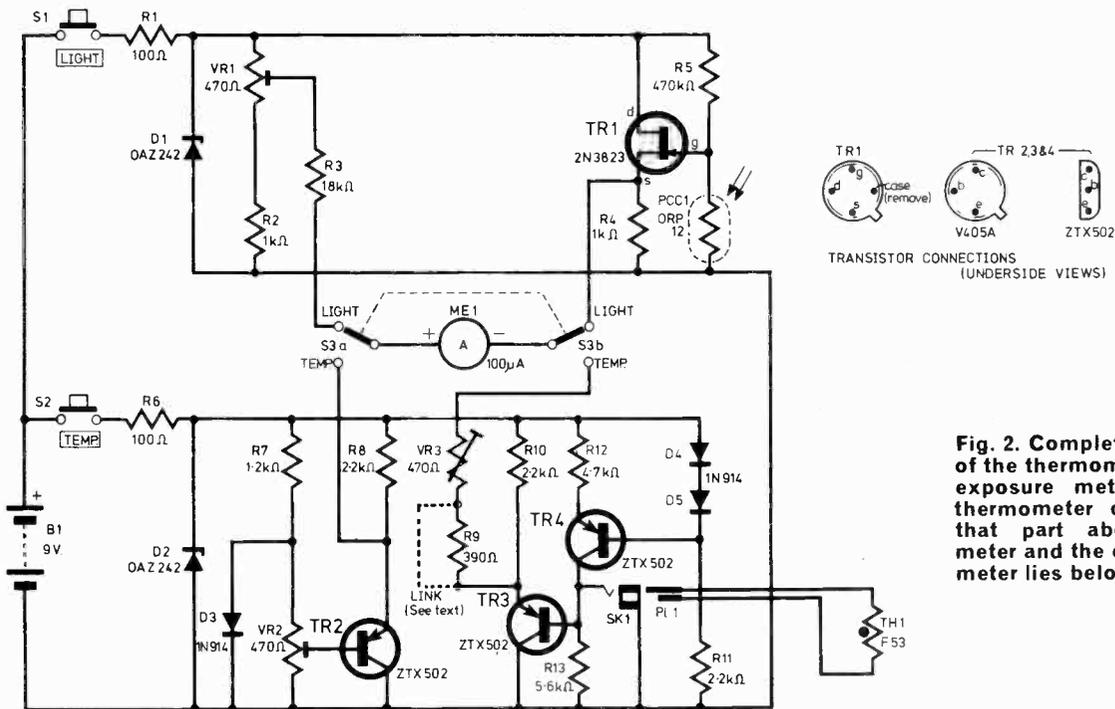


Fig. 2. Complete circuit of the thermometer and exposure meter. The thermometer circuit is that part above the meter and the exposure meter lies below it

R5 and PCC1 is therefore only in the order of a few microamps so a field effect transistor (TR1) is used to the voltage without taking current from the sensing device.

The input resistance at the gate (g) of TR1 is several megohms whereas the resistance at the source (s) is low enough to operate the meter. The voltage of TR1 source is therefore equivalent to V_B in Fig. 1.

SETTING UP

To set zero deflection on the meter cover the light cell with black adhesive tape (a finger is inadequate since it is remarkably translucent) and adjust VR1. The response of TR1 and PCC1 will vary and R3 should be selected to give the best working range for the individual user. It will be between 15 and 22 kilohms, with 18 kilohms a good starting point.

If the device gives a high deflection for long exposure times it is too sensitive, and R3 should be increased. If it gives a low reading for short exposures it is not sensitive enough and R3 should be reduced. If a deflection of $60\mu A$ for a 10 second exposure is taken as a datum point the response will be similar to the graph given (Fig. 3). Any variation, however, is really irrelevant, as the following paragraph explains.

CALIBRATION OF THE EXPOSURE METER

Select a centre of interest or mid-tone grey on the negative and, placing the unit on the base board, stop the enlarger down to give a deflection of $10\mu A$ on the meter.

Make a test strip in the conventional way and record the best exposure time. Increase the stop to give a deflection of $20\mu A$ and repeat with another test strip. Continue with several stop settings up to full scale deflection and plot a calibration curve that

COMPONENTS . . .

Resistors

R1	100 Ω	R8	2.2k Ω
R2	1k Ω	R9	390 Ω (see text)
R3	18k Ω (see text)	R10	2.2k Ω
R4	1k Ω	R11	2.2k Ω
R5	470k Ω	R12	4.7k Ω
R6	100 Ω	R13	5.6k Ω
R7	1.2k Ω		

All $\pm 5\%$ $\frac{1}{4}$ W carbon

Potentiometers

VR1-3 470 Ω miniature horizontal skeleton preset (3 off)

Transistors

TR1 2N3823
TR2-4 ZTX502 or V405A or similar (3 off)

Diodes

D1, D2 OAZ242 5.6V 230mW Zener (2 off)
D3-5 1N914 (3 off)

Light Dependent Resistor

PCC1 ORP12

Miscellaneous

TH1 F53 thermistor (ITT No. 1129E)
ME1 100 μA f.s.d. (ITT No. 8516C or SEW MR45P)
S1, S2 Push to make, release to break push-buttons (2 off)
S3 D.P.D.T. miniature toggle
PL1, SK1 3mm Jack plug and socket
Metal or plastic case (ITT No. 27524X)
B1 9V PP3 battery and connector

Printed circuit board as in Fig. 4

The meter for which the printed circuit board is designed, the thermistor and the box are available from ITT Electronic Services, Edinburgh Way, Harlow, Essex.

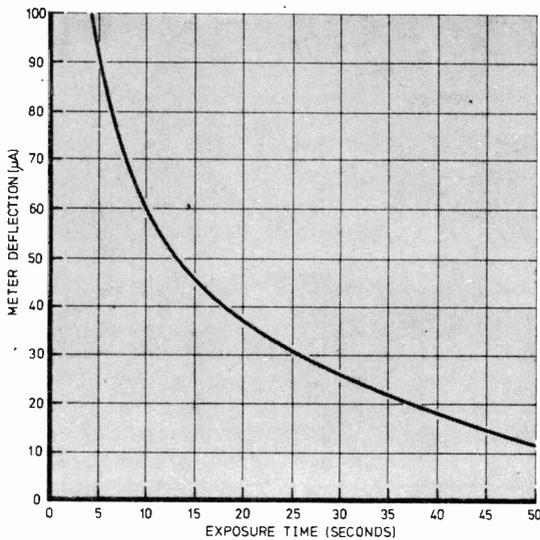


Fig. 3. Graph showing a typical calibration curve for the exposure meter

will give an exposure time against deflection. This will be the calibration curve for that particular meter but will be similar to Fig. 3.

Different paper speeds will give different exposure times but in the majority of cases it will be found that paper speeds vary very little.

DIFFUSER

The argument of "spot" metering or "general" metering is one on which there is room for individual preference. Sampling only a half inch diameter circle was found to be too critical, with small movements of the detector producing wide variations of deflections. Diffusing the whole negative at the enlarger lens can give a false reading if there is a lot of shadow, or a lot of sky, but it was found that sampling a one inch diameter circle is a good compromise. It is small enough to measure the light at the centre of interest but not so small as to be upset by a small dark (or light) patch.

The diffuser is best made from Perspex, rubbed with fine emery cloth if only clear material is available, but can also be made from any translucent material. Draughtsman's tracing film is quite tough and easily cut with scissors, but greaseproof paper is rather fragile for permanent use. It is advisable to leave fixing the diffusing window until the end since there is very little room remaining after the battery is slid into place.

A special note of warning. The light cell is sensitive to *all* light, even darkroom safelights, so the calibration *must* be done with only the enlarger switched on, the meter being read by the fringe light from the projected negative.

Depressing the push button in daylight sends the needle hard against the full scale backstop so should be avoided for obvious reasons!

The beauty of this device is that if a good print is obtained on a small enlargement the same light intensity (and meter deflection) can be reproduced for greater enlargement giving the same print contrast and quality. Alternatively, a new exposure can be measured with the new enlarger/stop conditions.

ELECTRONIC THERMOMETER

The sensing device in this thermometer is a thermistor, which is a glass-encapsulated, thermally sensitive resistor. By passing a constant current through it, a voltage is created across it, so by measuring this voltage we effectively measure its resistance, and hence its temperature.

Again a push button is used and a semi-stabilised voltage created by D2. The left arm of the bridge is R7, VR2 and D3.

Approximately 0.7 volts is developed across D3, a proportion of which is applied via VR2 to the base of TR2 which is used as an emitter follower, thus ensuring that the potential set by VR2 is not upset by the meter current. Thus the potential of TR2 emitter is very stable and at worst is only likely to vary by about 2mV.

The constant current for the thermistor is derived by R12, TR4, D4, D5 and R11. D4 and D5 each drop 0.7 volts, i.e. 1.4V total, and the emitter-base junction of TR4 drops 0.7 volts. This gives a total of 0.7 volts across R12 which is then selected to give the required current which in this case is 0.15mA.

The thermistor chosen was STC type F53 although type GL53 would have been adequate. The "GL" range can dissipate a little extra power but are physically much smaller and in some respects not quite so easy to handle, but are more rugged than the longer "F" range. There is little to choose between them and the final choice could well be left until a probe assembly has been selected.

Resistance of R13 is approximately equal to the thermistor resistance at the mid-range temperature (67.5 degrees F). Either 5.6k Ω or 4.7k Ω could be used since the actual resistance calculated was 5.2k Ω , and there is a 20 per cent tolerance to be added to, and subtracted from that.

CURRENT LIMITATION

When a current is passed through any resistor, power is dissipated within the component and it gets warm. When a thermistor gets warm its resistance falls (that is why one is being used in the first place).

Photograph showing the F53 thermistor used in the thermometer. Also shown is a GL53 thermistor (top) and the thermometer probe

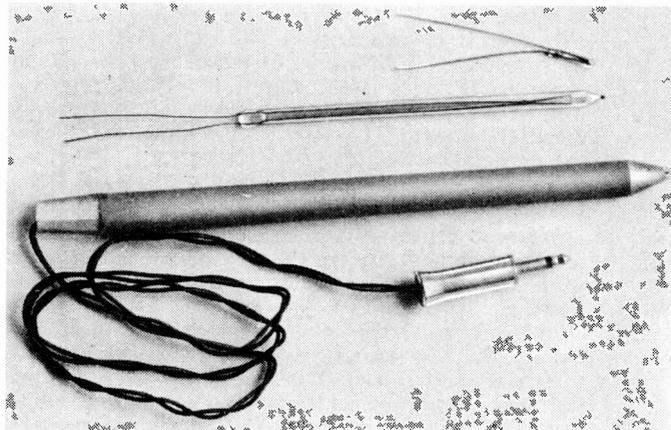


Fig. 4. Full size printed circuit board. The black areas indicate copper

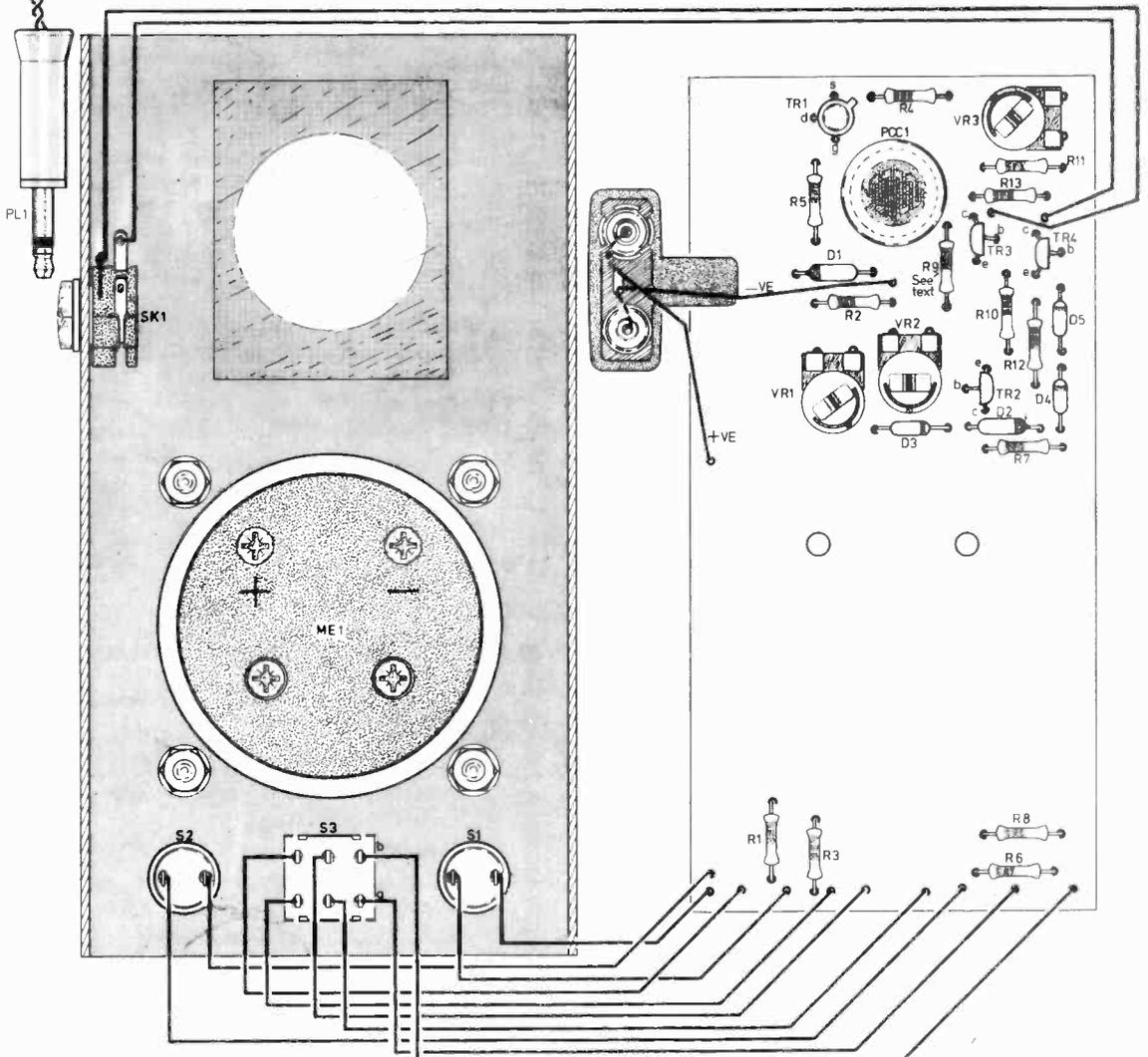
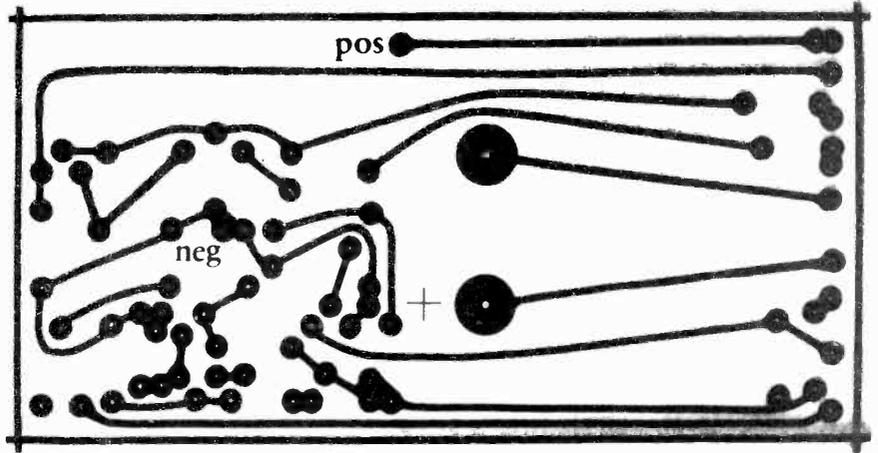
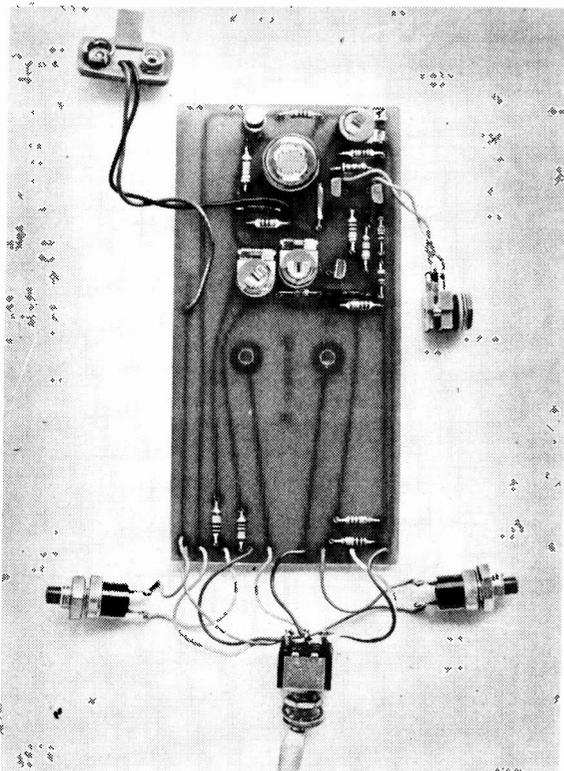


Fig. 5. Constructional details of the complete unit. The ITT meter has screw terminals which the printed circuit board is designed to fit. The probe is an old felt pen body



Photograph showing the internal layout of the unit

Provided it is small it matters little since the error is constant, and if it is calibrated in air and used only in air it will have no significant effect.

Similarly, if calibrated and used in liquids only the error is "calibrated out". But if a thermistor is calibrated in liquids and then used in air, the heat generated within the bead cannot be dissipated as efficiently and the bead resistance drops, making it appear hotter than it really is. The current must therefore be kept to the lowest possible if both liquid and air temperatures are to be measured.

Although primarily designed for liquids this unit might be used for air measurements as well, and by using only 0.15mA in the constant current source the air temperature registers a mere 0.05 degree F higher than the liquid temperature.

Using this small current means that another emitter follower must be used to drive the meter, with VR3 and R9 setting the full scale deflection. With these stabilising features and calibrated at zero and f.s.d. a mid point error of less than 0.2 degree F can be expected.

CALIBRATION OF THE THERMOMETER

It is intended that this should be used over a 25 degrees F change from 55 degrees F to 80 degrees F. This gives ample resolution within the 60 degrees F to 70 degrees F range which is the most popular area for photographic work, yet enables solutions to be mixed quickly by monitoring the wider range. Also the meter scale was already subdivided into five increments, so it was easy to read a temperature range that could be divided into five increments also.

The best thermometer available to the constructor must be used to calibrate the instrument since this unit can only be as good as the "standard". With the probe tip immersed in a liquid of 55 degrees F the meter is set to zero using VR2, and at 80 degrees F the full scale deflection is set by VR3; R9 will probably not be required in which case a wire link can be used in its place. Space was left for it, however, in case the voltage across the meter is low and further resistance was required to limit the current; 390 ohms will probably suffice but in rare cases it may be necessary to insert a larger value.

The fronts of SEW meters unclip, exposing the dial, whereby the temperature range can be added either with Letraset or careful printing.

MECHANICAL DETAILS

The box photographed is available from ITT Electronic Services (see Components List), and comes ready painted in a two-tone blue/grey eggshell, and the printed circuit board (Fig. 4) was designed to fit this box. Being a rather well-packed board it precluded the use of Veroboard or similar construction. However, a small plywood box could be made to take a larger board, and, if suitably polished, could still look attractive though less compact.

The one inch hole for the diffuser window was easily punched out with a "Q-max" punch, but the meter hole was a little more tricky. Unfortunately "Q-max" do not make a punch to suit so for this drill a circle of $\frac{1}{16}$ in holes and join them up with a needle file, finishing with a run round with a scraper, a slow process but an effective one.

The thermometer probe utilises a disused felt tip pen with the felt removed. The thermistor was slid down the barrel until the tip emerged, then the barrel was filled with silicone bath tub caulk which held both the wiring and thermistor firmly in place. The pen cap was retained as a tip protector for when the unit is not in use.

Components are shown mounted on the board in Fig. 5 which also shows interwiring details. The battery lies alongside the "window". The printed circuit board is held by screws to the meter.

The total cost of this unit is about £8, for which the constructor will have an instrument which would cost very much more commercially—if such an instrument existed. ★

PRACTICAL ELECTRONICS

● INDEX

An index for volume 8 (January 1972 to December 1972) is now available price 11p inclusive of postage.

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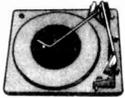
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MARKET PLACE

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.

NEW 'SCOPES

Two new scopes from recently formed **Scopex Instruments**, are low cost precision instruments: the 4D-10 with a vertical bandwidth of 10MHz and the 4D-25 with a bandwidth of 25MHz. Both have been designed with the philosophy of combining performance with simplicity of operation. To further the philosophy Scopex introduced the "easy where it counts" triggering where the triggering point and the polarity are selected on just one control. This facility is available on both 'scopes.

The 4D-10 sells for £95 and the 4D-25 for £175. On a cost/performance basis they are both excellent value. Further details can be obtained from Scopex Instruments, Pixmore Avenue, Letchworth, Herts.

I.C. ACCESSORIES

Accessories in the integrated circuit field is a vastly growing market and readers may be interested in two new aids from **Ultra Electronics Components Ltd.**

The first item is a versatile printed circuit board for i.c.s and DIL devices. Basically it is a standard circuit card with rows of single-way connectors which will accept DIL devices.

Ideal for "knocking-up" experimental circuits, interconnection between devices is achieved by the use of patching leads. A distribution block connects to the board edge pads and enables the board to be plugged into racking systems if required.

The second item is a multi-contact "peg" or pincer which can be clamped over i.c.s and the lead-out pins in the handle used for test points. Contacts on the inside of the jaws automatically align with the i.c. pins.

When the need for desoldering i.c.s from printed circuits arises the "peg" as been found to be very useful as an extraction tool.

Two types are available at the moment, type OEC370 for 14 or 16 DIL packages with 0.1in pitch between contacts and type OEC371 for 24 to 60 contact devices with 0.1in pitch contacts.

Further particulars for both devices can be obtained from **Ultra Electronic Components Ltd.**, Fassetts Road, Loudwater, Bucks.

STEREO KIT

A compact, new stereo record system that can be simply assembled has been introduced by **Radio & T.V. Components**. At £17.95 the Stereo 21 System provided excellent sound quality on demonstration and the near 6W total output should prove more than adequate for the average living-room.

The complete system includes a BSR 3-speed deck, ceramic cartridge and twin 8in x 5in elliptical speakers. None of the units are sold separately.

Two factors have contributed in keeping down the price: direct selling from R & TV to the public and simple d.i.y. assembly. You don't need to know anything about electronics in the construction; you simply enclose the speaker components in their wrap-around casings, wire the plug, plug in and you are enjoying stereo sound.

Further information can be obtained from **Radio & T.V. Components (Acton) Ltd.**, 21 High Street, Acton, London, W.3.

CARTRIDGE PLAYER

One of the side effects of the booming in-car entertainment market lies in the problem of utilising the same source of sound for home listening. Growth in the sales of pre-recorded 8-track, stereo cartridges has not been matched by the introduction of an economic sound system capable of being used in conjunction with existing stereo equipment in the home.

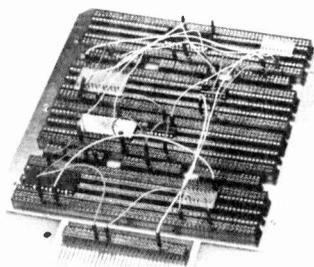
Now with the Budget 8, R & T-V C has introduced a reliable, British engineered, cartridge player which retails for £9.90. Based on the latest BSR T 145 8-track cartridge playing mechanism, and incorporating its own stereo pre-amplifier stages the unit simply plugs into the auxiliary socket on most stereo audio systems to provide high quality reproduction in the home from the same cartridges used in the car.

LITERATURE

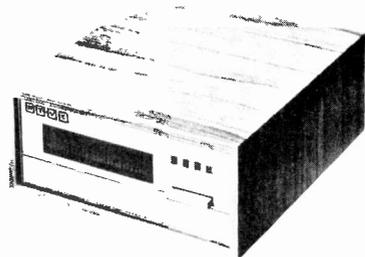
Next month P.E. is including a special i.c. audio chart which, we hope, readers will find very useful.

Whether you are thinking of building an amplifier or you want some ideas on using i.c.s. in audio circuits, the P.E. Audio I.C. Identichart gives comprehensive data on over 80 i.c.s. ranging from low level pre-amplifiers to hybrids rated at 50W.

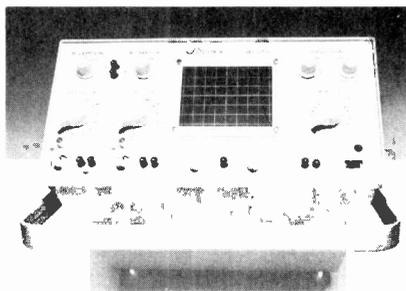
As well as data, the chart contains suggestions for using i.c.s. in mixers, tape recorders, record players etc.



Universal circuit card from Ultra Electronics



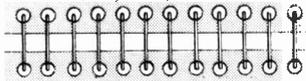
RTVC Budget 8 player



4D25 'scope from Scopex Instruments



Completed stereo 21 kit by RTVC



INDUSTRY NOTEBOOK

By Nexus

EXPANSION

The current boom is by no means uniform in impact across the whole of the electronics industry but there are welcome signs of expansion in many quarters.

Even conservative Ferranti is looking for a Stock Exchange listing as a way of raising more capital. Ferranti is one of the largest private companies in business in the UK and, according to reports, has no intention of "going public" in the generally accepted sense. It is still expected that the Ferranti family interests will control more than 50 per cent of voting rights.

High-flying Unitech Group has also been looking for more capital to finance the recent acquisition of Rathdown Industries and Lee Green Precision Industries. These two companies have broadened the Unitech base by adding component manufacture (mechanical counters, small pressings, precision machinings and co-axial connectors) to the Group's other activities.

One of the rising stars in the Group is Weir Electronics, acquired by Unitech in 1963 when it first moved to Bognor with a staff of only four people. I was recently at the opening, by local M.P. and Minister for Industrial Development, Christopher Chataway, of a new 30,000 sq ft production unit. Staff is now 300 and turnover £1.5 million. Extrapolating the growth curve suggests that Weir will hit £3 million turnover by 1975.

Weir is one of those fascinating companies that are honest with themselves as well as with their customers — a rare combination. They admit to having had some expensive diversions into fields (for example, in instruments) where there was little chance of success. Present (and profitable) tack is to stay a low-technology company

turning out a first-class engineering job. Huge OEM orders for stabilised power supplies for companies like Rank Xerox, ITT and Business Computers are now the backbone of the business.

But one of the really big successes for Weir could come from a comparatively low-cost electronic seat-belt interlock for cars which is now being evaluated by British and overseas car manufacturers. The new Weir development is in time for the US market where the interlock will be mandatory on all cars registered next year and thereafter.

Other new products in the pipeline include motor speed control, electronic lighting control and an as yet unspecified incursion into telecommunications.

How about unstoppable Electrocomponents Associated Group, basically our old friend Radiospares wearing a new hat? Turnover has rocketed to £7.24 million up 20 per cent, with profits up 25.8 per cent to over £1.5 million. The Electroplan subsidiary which was set up to supply instruments as a complementary operation to the component business is not yet in profit. I understand, but should be making a contribution by the end of the year.

BULLSEYE

I haven't fired a shot in anger for close on 30 years and if someone had told me when I last squeezed a trigger that one day I should destroy a tank using a laser beam I should have thought them mad. It wasn't likely that such a suggestion should have been made because the laser lay some years in the future.

Anyway, your scribe, somewhat nervous before an audience of British Army top brass, not to mention a couple of dozen foreign military attaches, successfully polished off a couple of Chieftains at 700 metres on the tank range at Bovington Camp. There was all the excitement of seeing the "enemy" going up in smoke with the added satisfaction of knowing that nobody was getting hurt.

The equipment was Solartron's SIMFIRE tank gunnery simulator which has brought the company back into the simulator business with a bang and has already scored a sales bullseye with 16 armies, while another 25 armies are evaluating it. Even the United States Army is ordering it.

Solartron started the project as a private venture but the Ministry of Defence soon became interested and backed it with a £250,000 development contract. The big payoff is now at hand.

RESEARCH

Commercial pressures over the past few years have tended to direct

research men into avenues of investigation which have some identifiable end-product in mind. But there is still plenty of "pure" research in the Philips laboratories at Eindhoven which I recently visited. As an example, I can quote the work on surfaces and surface layers which, despite the advent of the scanning electron microscope and other techniques, is still little understood and has great significance in the production process of semi-conductor devices.

But one of the most interesting developments I saw and, incidentally, of great commercial potential, was the electrochromic display. This was in 7-segment form and although passive in the sense that it is not light-emitting like gas discharge tubes or LEDs, has the enormous advantage that, once formed by the application of the appropriate voltage, the character remains when the voltage is removed until erased by re-applying the voltage with reversed polarity.

Several such devices have been described in the literature but, until now, all have had substantial disadvantages. The Philips team on the project has now reached a stage where the new device has been fully patented and so I can reveal that the principle of operation is based on the oxidation-reduction reaction of diheptylviologendibromide in water. Difficult to pronounce, perhaps, but it's a formula that works. The display is a cheerless purple-blue in colour but has excellent contrast and needs only half a volt to activate it.

To be in the top league of R and D is not easy. Philips has been in research since the early '90s (last century) when founder Gerard Philips did some of the pioneer work on filament lamps. The present score is 4,000 people in the research laboratories in Holland, France, England, Belgium and West Germany.

To keep up with the inventions and innovations that pour out of the labs, the Eindhoven patents department alone employs 200 people of which 60 are scientists. The mind boggles!

KEYBOARD KING?

In contrast to mighty Philips with 350,000 employees, watch Sammy Zilkha's bid for the throne as keyboard king. Keyboards is one of the fastest growing areas of electronic industry activity and his new but still tiny company, Alphameric Keyboards, looks all set to win a big share of it. Hardly had he announced the product, the electronic heart of which is a Zilkha-designed MOS LSI, than a joint venture agreement was being completed with an American company.

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SN7409	0-45	0-42	0-35	SN7475	0-55	0-52	0-50	SN74161	2-60	2-40	2-25
SN7410	0-20	0-18	0-16	SN7476	0-45	0-42	0-39	SN74162	3-40	3-25	3-20
SN7411	0-28	0-28	0-20	SN7480	1-25	1-15	1-10	SN74163	3-40	3-25	3-20
SN7412	0-42	0-40	0-35	SN7481	1-80	1-15	1-10	SN74164	2-75	2-30	2-10
SN7413	0-30	0-27	0-25	SN7482	0-87	0-80	0-70	SN74165	4-00	3-60	3-00
SN7414	0-30	0-27	0-25	SN7483	0-80	0-75	0-70	SN74166	4-00	3-60	3-00
SN7415	0-30	0-27	0-25	SN7484	0-90	0-85	0-80	SN74167	6-80	6-00	5-10
SN7420	0-20	0-18	0-16	SN7486	0-45	0-41	0-38	SN74174	4-10	3-55	3-05
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SN7440	0-20	0-18	0-16	SN74105	1-45	1-35	1-20	SN74191	1-95	1-85	1-75
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SN7445	2-00	1-75	1-60	SN74119	1-80	1-78	1-65	SN74195	1-85	1-70	1-60
SN7446	2-00	1-75	1-60	SN74121	0-80	0-65	0-50	SN74196	1-50	1-40	1-30
SN7447	1-75	1-60	1-45	SN74122	1-85	1-25	1-10	SN74197	1-50	1-40	1-30
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PATENTS REVIEW...

WIND DIRECTION INDICATORS

Direction indicators are used on small sailing boats to show the wind direction relative to the heading of the boat and so help the helmsman choose the best angle to sail. Conventionally an electrical transmitter is connected to a wind vane on the masthead and the transmitter produces signals which are fed to a receiver and rotor in the cockpit. But such systems have to date been relatively insensitive.

In BP 1 290 331 from EMI a refined system is described. In Fig. 1 a star wound transmitter transformer T1 has three windings spaced by angles of 120 degrees and signals are taken from points 1, 2 and 3. A rotor winding is fed by a 400Hz signal from a converter powered by the boat's battery. The rotor is ganged to a wind vane on the boat's mast.

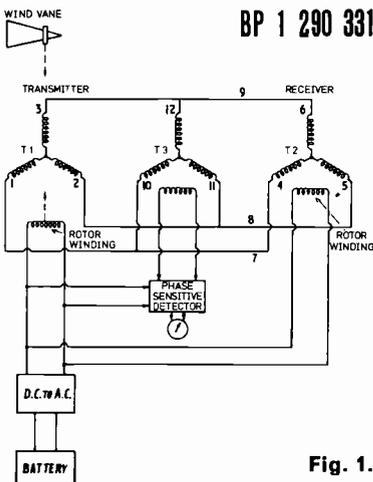


Fig. 1.

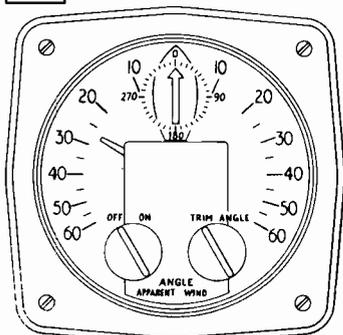


Fig. 2.

The signals from points 1, 2 and 3 are fed to points 4, 5, 6 on a second star wound transformer T2, which functions as a receiver. This receiver also has a rotor winding supplied with the 400Hz signal.

As the rotor turns with the wind direction changes the amplitudes of the a.c. currents in the leads 7, 8, 9 vary with sine and cosine functions. Corresponding fields are set up in the receiver transformer T2 and its rotor follows these. The receiver rotor is coupled to a direction pointer on a cockpit indicator (Fig. 2).

All this is conventional and the invention proper concerns the provision of a second transmitter which is formed as a third star wound transformer T3. Points 10, 11, 12 on this transformer are connected to the leads 7, 8 and 9 and this transformer has a rotor winding which is normally stationary but can be pre-set by a knob on the cockpit indicator.

The signal produced by the T3 rotor is fed to a phase sensitive detector with the 400Hz signal as its reference. For any position of T1 rotor there is one angular position of T2 rotor which produces zero voltage.

The output of the phase detector is fed to a milliammeter with a pointer which moves over an apparent wind scale on the indicator. Scale calibration is such that the pointer shows the angular deviation to one side or another of the null, determined by the angular setting of T3 rotor and represented as scale zero, see Fig. 2. The milliammeter therefore provides a highly sensitive indication of deviation with angular amplification.

Usually T3 rotor is adjusted by the trim/angle control so that the pointer reads zero when the boat is heading directly into the wind. Thereafter the pointer gives a very sensitive and very accurate indication of the wind direction relative to the boat heading.

COUGH MONITORING

Some fairly simple circuitry from Abbott Laboratories in the USA is described in BP 1 312 846. Although the main intention is to monitor the rate of coughing of a patient for diagnostic purposes, the

basic principle of the invention will be applicable to many other fields where it is desired to monitor and count the number of similar sounds above a threshold value which have occurred during a predetermined time.

The patient wears a small microphone either on his shirt collar or taped to his throat. The microphone feeds a small f.m. transmitter which transmits the cough noises to a remote receiver. See Fig. 1.

The receiver is coupled to counting circuitry and a monitoring loudspeaker by the secondary of transformer T1. The loudspeaker can also be brought temporarily into circuit to assist accurate and mutual tuning of the transmitter and receiver.

The secondary of T1 feeds the full-wave rectifier of the threshold circuit. The output of the rectifier bridge is connected across VR1.

Adjustment of VR1 slider allows the threshold level to be set so that only cough signals above a predetermined power level are passed, via C1, to the gate of CSR1. The thyristor CSR1 is normally biased into its non-conductive state.

The anode of CSR1 is connected to a conventional electrical step counter which records the number of pulses supplied to its input. Thus, the counter displays the number of coughs above the pre-set threshold level.

BP 1 312 846

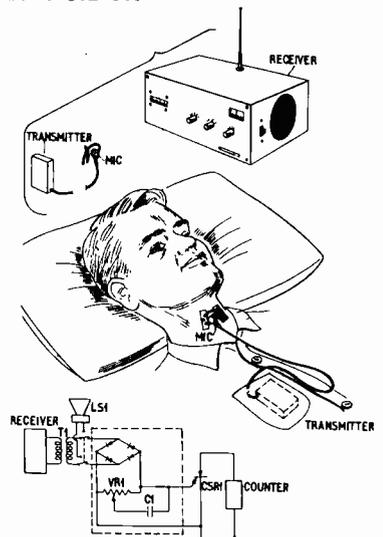


Fig. 1.

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.

First experience

Sir—Regarding Mr. Baily's letter in the July issue of P.E., I am inclined to agree with him on the subject of log-law applied to v.c.o.s.

My first experience of synthesisers was a small set up comprising three linear oscillators and two filters coupled to a spare keyboard. The intention at that time was to use it in conjunction with an organ, but at no time could it be matched to the organ. I was then informed that a "log-tuned" oscillator was the better circuit since it distributed the frequency evenly over the keyboard virtually to any range.

Having now acquired, what I call, a log-tuned synthesiser, I find no problem at all in matching it with other instruments.

Brett Ross,
Redditch, Worcs.

Extremely versatile

Sir—I have been following the P.E. Synthesiser design with interest since its advent, with a view to using the circuits in my own synthesiser which I had been designing for some time when your synthesiser came out. Whilst on the whole the circuits have been designed very well, there are some points which could be improved upon.

The most important of these is the choice of linear v.c.o.s. I am fortunate in that I have been able to play on nearly all the commercially available synthesisers, and although they vary greatly in many respects, they are united in the use of log v.c.o.s.

With log v.c.o.s a keyboard can be adjusted to accompany out of tune guitars and flat pianos, and I have fitted fifth, third, tone and semitone transpose switches, as on the Synthi AKS, to accompany tunes played in a different key to which I have learnt the tune. The range of my keyboard can be 1Hz bottom

C, 16Hz top C, or with top C nearly ultrasonic, and it is in tune over the entire range (except for a slight droop in frequency at the upper limit caused by the slow switching time of 741's). A linear keyboard is limited to the 4 octaves for which it was tuned. With all the evidence pointing to the necessity of a logarithmic response, it seems a false economy to leave out a log converter from the otherwise excellent v.c.o. design.

Regarding Mr. Baily's letter, although I agree with him in general, I must defend the use of integrated circuits and dual-rail power supplies. The 741, despite drawbacks concerning frequency response, is an extremely versatile device well suited to use in complex analogue systems like synthesisers, considerably simplifying construction of circuits in which it is used.

To use a control as a signal, or vice versa, both must cover the same voltage range. If the signals are a.c. about OV, the controls should also be centred on earth, entailing \pm power supplies. This is another feature common to all commercial synthesisers.

The patching system is the heart of a synthesiser, and although patchcords are the best choice for a modular system, I dislike them because they are inconvenient, requiring two insertions to make one link, they allow only 1-to-1 patches unless parallel inputs are provided, obscure the face of the machine and are prone to hum loops. There are also advantages, the system is easily extendable and signals can be brought in from external sources directly into the system.

The patchboard arrangements in Fig. 6.9b will not work as a resistor is required to mix outputs if more than one is connected to an input. Output impedance should be as low as possible to minimise unwanted crosstalk via outputs, and ideally all inputs should be virtual earths for good mixing, but this is of little importance for all inputs except v.c.o. frequency control.

This needs a virtual earth so that each input plugged to it has the same effect regardless of what else is connected. With the VCS3 the oscillator input impedance is 10k, and if a programming source other

than the keyboard, say joystick or vibrato oscillator is added, then the octave width needs adjusting.

Although I disagree with parts of the design, some of the modules are as good, if not better than those in any other synthesiser and I will be incorporating these without modification into my own synthesiser.

R. Gwinn,
Surbiton, Surrey.

A little unfair

Sir—Having commenced building the P.E. Synthesiser I would like to add my own comments to those of Mr. Baily in the July issue, when he criticises Mr. Shaw's designs.

Firstly, Mr. Baily is being a little unfair in his cost comparison. Agreed, we could obtain a more versatile instrument for £200 using Dewtron modules, but one must take into account the lavishly expensive external shell recommended by Mr. Shaw to house his own Synthesiser. Any prospective constructor should note that Mr. Shaw's recommended cabinet, other metalwork, nuts, bolts, McMurdo plugs and panel knobs cost about £60.

I costed the project very carefully against commercial instruments (biased naturally towards my particular requirements) and opted to work from Mr. Shaw's circuits. After all, one doesn't have to use the recommended cabinet work—the project is expensive enough without using it to exploit modular construction of dubious modular value. An additional benefit, however, is that Mr. Shaw's designs are impressive to say the least, and I should learn a lot from them.

Having said that, I must agree with Mr. Baily regarding Mr. Shaw's dismissal of logarithmic voltage/frequency relationship in the v.c.o.s. It is not so much the loss of chord facilities as in the reduction of the instrument's versatility. In fairness Mr. Shaw wanted to reduce setting up difficulties and did mention the SN76502 log amp for those who wanted to try their hands at log control.

Otherwise, my only two criticisms are: (1) the absence of a sine wave source. Electronic music composition does occasionally demand this peculiarly pure tone. (2) The absence of a band pass filter whose central frequency and spread can be controlled even manually—a necessity for composition based only on a controlled noise source.

I. Stuart-Colwill,
London, S.W.16

We have received many reader's letters in a like vein requesting a log v.c.o. design. To satisfy this, G. D. Shaw is currently designing a circuit which will be published in the near future.

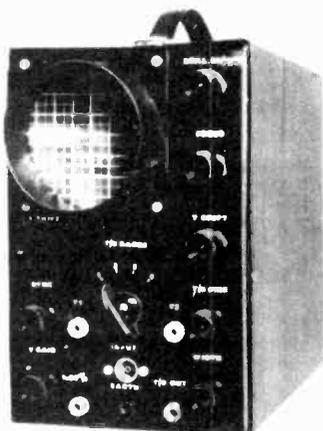
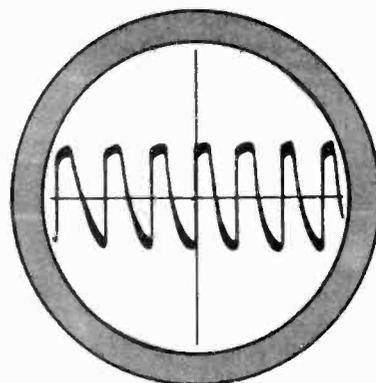
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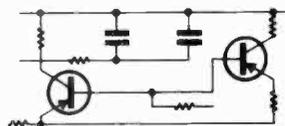
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1N845	0-20	AS238	0-25	BY218	0-20	
1N725A	0-20	AS250	0-20	BY288C8V3	0-40	
1N914	0-05	AS251	0-40	0-10	OA2242	0-25
1N4007	0-12	AS253	0-20	BZ788C8V3	0-25	
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20381	0-25	AS223	0-75	CS4B	2-50	
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2N897	0-15	AC108	0-12	DD006	0-18	
2N898	0-30	BC109	0-10	DD007	0-40	
2N706	0-10	BC113	0-16	DD008	0-38	
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2N1305	0-22	BC147	0-12	GET115	0-75	
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2N2160	0-61	BC169	0-14	GET881	0-25	
2N2218	0-23	BC231	0-45	GET882	0-35	
2N2219	0-25	BC232	0-85	GET885	0-35	
2N2369A	0-15	BC233	0-35	GET886	0-35	
2N2444	1-90	BC234	0-25	GET887	0-45	
2N2443	0-28	BC238	0-55	GET891	0-30	
2N2446	0-50	BC239	1-00	GJ3M	0-50	
2N2904	0-20	BC240	0-80	GJ4M	0-38	
2N2904A	0-25	BC242	0-30	GJ5M	0-25	
2N2906	0-20	BC270	0-15	GJ7M	0-50	
2N2907	0-28	BC271	0-20	HG1005	0-50	
2N2924	0-25	BC272	0-20	H190A	0-20	
2N2925	0-15	BC271	0-65	MAT100	0-20	
2N2926	0-10	BD121	1-00	MAT101	0-25	
2N3054	0-45	BD123	1-00	MAT120	0-20	
2N3055	0-45	BD124	0-80	MAT121	0-25	
2N3702	0-10	BD111	1-45	MJE520	0-65	
2N3705	0-15	BF112	0-20	MJE530	0-25	
2N3706	0-11	BF117	0-50	MJE5305	0-70	
2N3707	0-18	BF167	0-23	NKT128	0-45	
2N3709	0-10	BF173	0-25	NKT129	0-30	
2N3710	0-11	BF181	0-33	NKT211	0-25	
2N3711	0-11	BF184	0-22	NKT213	0-25	
2N3819	0-35	BF185	0-22	NKT214	0-24	
2N3927	0-35	BF194	0-13	NKT216	0-40	
2N3988	0-33	BF195	0-18	NKT217	0-45	
28301	0-59	BF196	0-15	NKT218	1-13	
28304	1-15	BF197	0-15	NKT219	0-33	
28501	0-37	BF261	0-25	NKT222	0-30	
28703	1-00	BF298	0-25	NKT224	0-25	
AA129	0-20	BF232	0-20	NKT231	0-24	
AA212	0-75	BF213	0-25	NKT275	0-20	
AZ133	0-10	BF229	0-25	NKT272	0-20	
AC107	0-35	BF230	0-28	NKT273	0-20	
AC126	0-25	BF235	0-28	NKT274	0-20	
AC127	0-25	BF263	0-20	NKT275	0-25	
AC128	0-20	BF284	0-20	NKT277	0-20	
AC187	0-20	BF285	0-25	NKT278	0-25	
AC188	0-20	BF286	0-25	NKT301	0-55	
ACY17	0-35	BF287	0-25	NKT304	0-75	
ACY18	0-27	BF288	0-22	NKT403	0-70	
ACY19	0-27	BF210	1-00	NKT404	0-60	
ACY20	0-22	BF211	1-25	NKT678	0-30	
ACY21	0-22	BF212	0-25	NKT713	0-20	
ACY22	0-18	BF218	0-45	NKT773	0-25	
ACY27	0-25	BF219	0-55	NKT777	0-38	
ACY28	0-25	BF224	0-45	O78B	0-38	
ACY30	0-65	BF244	1-00	OA6	0-12	
ACY40	0-22	BF250	0-20	OA47	0-08	
ACY41	0-22	BF251	0-20	OA70	0-10	
ACY44	0-32	BF252	0-20	OA71	0-10	
AD140	0-50	BF253	0-17	OA73	0-15	
AD149	0-50	BF264	0-45	OA74	0-15	
AD161	0-81	BF290	0-75	OA79	0-10	
AD162	0-39	BSX27	0-60	OA81	0-10	
AF106	0-30	BSX60	0-90	OA85	0-15	
AF114	0-25	BSY26	0-18	OA86	0-15	
AF115	0-25	BSY26	0-18	OA90	0-07	
AF116	0-25	BSY27	0-18	OA91	0-07	
AF117	0-20	BSY51	0-50	OA95	0-07	
AF118	0-50	BSY93A	0-12	OA200	0-08	
AF119	0-20	BSY93	0-12	OA202	0-10	
AF124	0-30	BT102/500P	1-10	OA210	0-25	
AF125	0-30	BTY42	0-92	OA211	0-30	
AF126	0-30	BTY79/100R	0-80	OA2200	0-60	
AF127	0-30	BTY79/100R	0-80	OA2201	0-45	
AF139	0-38	0-75	0-75	OA2202	0-45	
AF178	0-55	BTY79/400R	1-10	OA2203	0-45	
AF179	0-65	BY100	0-15	OA2204	0-45	
AF180	0-55	BY126	0-14	OA2205	0-45	
AF181	0-60	BY127	0-16	OA2206	0-45	
AF188	0-40	BY182	0-85	OA2207	0-45	
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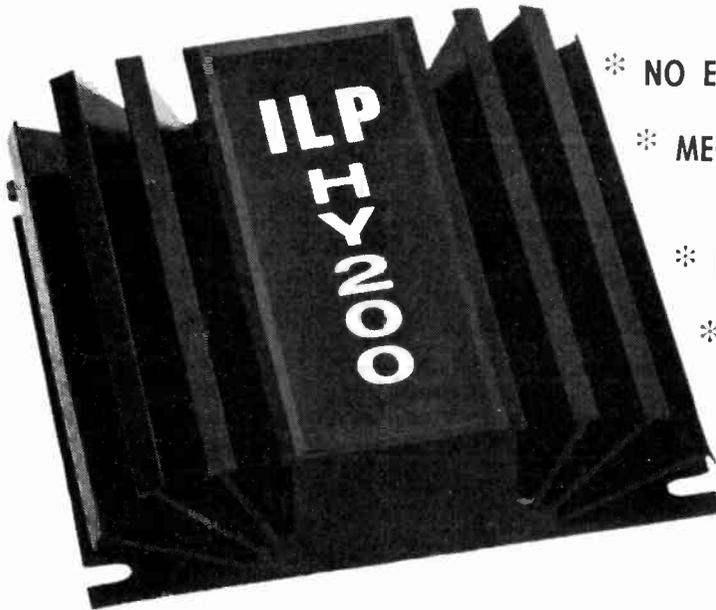
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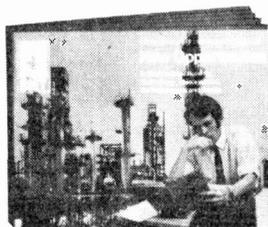
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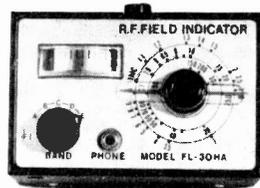
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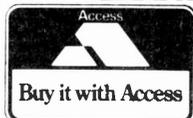
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20309	0-85	2N3570	1-25	40363	0-61	BC136	0-15	BF115	0-23	BSY61	0-25
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20374	0-15	2N3702	0-11	40406	0-44	BC141	0-39	BF123	0-25	BSY64	0-30
2N174	0-10	2N3703	0-10	40407	0-33	BC142	0-24	BF125	0-25	BSY65	0-15
2N404	0-43	2N3704	0-14	40408	0-50	BC143	0-21	BF152	0-20	BSY78	0-40
2N456	0-75	2N3705	0-10	40409	0-38	BC144	0-24	BF153	0-20	BSY79	0-40
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2N457A	0-75	2N3708	0-13	40411	2-20	BC147	0-12	BF158	0-23	C111	0-03
2N481	3-25	2N3708	0-07	40414	3-55	BC148	0-12	BF159	0-27	D40N3	0-55
2N696	0-15	2N3709	0-09	40467A	0-69	BC149	0-12	BF160	0-23	GET111	0-45
2N697	0-15	2N3710	0-12	40468A	0-44	BC155	0-18	BF161	0-42	GET114	0-20
2N698	0-25	2N3711	0-09	40600	0-89	BC154	0-18	BF163	0-20	GET115	0-50
2N699	0-25	2N3712	0-05	40601	0-67	BC157	0-14	BF166	0-35	GET119	0-35
2N706A	0-12	2N3713	1-08	40602	0-46	BC158	0-13	BF167	0-21	GET135	0-50
2N708	0-18	2N3714	1-16	40603	0-83	BC159	0-14	BF173	0-34	GET538	0-20
2N709	0-33	2N3715	1-23	40604	0-50	BC160	0-27	BF177	0-29	GET880	0-30
2N711	0-20	2N3716	1-20	40636	1-16	BC167B	0-11	BF178	0-35	GET883	0-20
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2N1893	0-34	2N3903	0-22	AC144	0-31	BC263	0-28	BF457	0-53	MJ400	0-78
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2N2147	0-70	2N3905	0-21	AD140	0-55	BC301	0-34	BF821A	0-20	MJ421	0-88
2N2148	0-94	2N3906	0-22	AD142	0-50	BC301	0-34	BF822	0-20	MJ430	0-75
2N2192	0-40	2N4036	0-46	AD143	0-45	BC303	0-54	BF861	0-27	MJ440	0-71
2N2192A	0-40	2N4037	0-40	AD149V	0-68	BC303	0-54	BF888	0-28	MJ480	0-75
2N2193	0-40	2N4038	0-40	AD150	0-68	BC307	0-10	BF910	0-61	MJ481	0-85
2N2193A	0-40	2N4039	0-40	AD150	0-68	BC307A	0-10	BF911	0-61	MJ486	0-94
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2N2196	0-37	2N4062	0-11	AD162	0-45	BC308B	0-09	BF930	0-20	MJ901	2-65
2N2196A	0-37	2N4302	0-25	AF109R	0-40	BC309	0-10	BF937	0-30	MJ1001	2-84
2N2218A	0-20	2N4303	0-47	AF114	0-25	BC309A	0-10	BF944	0-33	MJ1800	1-88
2N2219	0-37	2N4316	0-20	AF115	0-24	BC309B	0-10	BF963	0-48	MJ2500	2-92
2N2219A	0-37	2N4917	0-17	AF116	0-25	BC309B	0-10	BF968	0-28	MJ2611	3-25
2N2220	0-61	2N4918	0-50	AF117	0-25	BC309B	0-10	BF968	0-28	MJ2953	1-00
2N2221	0-20	2N4919	0-63	AF118	0-50	BC337	0-19	BF983	0-29	MJ3000	2-47
2N2221A	0-33	2N4920	0-71	AF121	0-22	BC338	0-19	BF986	0-24	MJ3001	2-79
2N2222	0-31	2N4921	0-60	AF124	0-24	BCY30	0-43	BF987	0-28	MJ3701	0-93
2N2222A	0-31	2N4923	0-60	AF125	0-20	BCY31	0-61	BF988	0-25	MJ4502	4-44
2N2269	0-11	2N5172	0-12	AF126	0-18	BCY32	1-15	BF989	0-46	MJ5340	0-47
2N2269A	0-17	2N5174	0-22	AF128	0-19	BCY33	0-18	BF990	0-35	MJ5370	0-78
2N2446	0-60	2N5175	0-25	AF170	0-25	BCY34	0-35	BFY11	0-45	MJ5381	0-80
2N2447	1-20	2N5176	0-32	AF172	0-25	BCY38	0-53	BFY12	0-35	MJ5520	0-59
2N2711	0-15	2N5190	0-92	AF178	0-55	BCY39	1-05	BFY18	0-35	MJ5521	0-73
2N2712	0-12	2N5191	0-98	AF179	0-55	BCY40	0-81	BFY19	0-35	MJ51092	1-98
2N2713	0-17	2N5192	1-24	AF180	0-55	BCY42	0-18	BFY20	0-60	MJ51102	1-57
2N2714	0-17	2N5193	1-24	AF181	0-55	BCY43	0-18	BFY21	0-60	MJ5201	1-19
2N2904	0-28	2N5194	1-10	AF200	0-35	BCY58	0-21	BFY37	0-20	MJ2901	1-56
2N2904A	0-28	2N5195	1-46	AF209	0-41	BCY70	0-17	BFY43	0-65	MJ2955	0-83
2N2905	0-33	2N5245	1-05	AF240	0-72	BCY71	0-22	BFY50	0-22	MJ1613	0-43
2N2906	0-24	2N5457	0-35	AF279	0-64	BCY72	0-13	BFY51	0-18	MM1711	0-49
2N2906A	0-24	2N5458	0-33	AF280	0-64	BCY77	0-37	BFY52	0-20	MM1732	0-64
2N2907	0-32	2N5459	0-33	AFY42	0-74	BCY78	0-40	BFY53	0-15	MM2712	0-64
2N2907A	0-32	2N5460	0-33	AFY42	0-74	BCY78	0-40	BFY53	0-15	MM2712	0-64
2N2923	0-12	2N5919	0-22	AL102	0-75	BCZ10	0-55	BFY64	0-41	MP8111	0-32
2N2924	0-15	2N5919	0-22	AL103	0-70	BCZ11	0-50	BFY76	0-22	MP8112	0-40
2N2925	0-18	2N5919	0-22	AL103	0-70	BCZ11	0-50	BFY76	0-22	MP8113	0-47
2N2926	0-18	2N5919	0-22	AL103	0-70	BCZ11	0-50	BFY76	0-22	MP8A05	0-25
2N2926	0-18	2N5919	0-22	AL103	0-70	BCZ11	0-50	BFY76	0-22	MP8A06	0-25
Green	0-12	40611	0-81	AS729	0-86	BD116	0-50	BFY78	0-38	MP8A01	0-44
Yellow	0-10	40612	0-81	AS729	0-86	BD123	0-52	BFY93	0-38	MP8A12	0-40
Orange	0-10	40613	0-81	AS750	0-85	BD124	0-67	B8X19	0-13	MP8A14	0-24
2N3053	0-81	3N154	0-84	AS755	0-85	BD130	0-67	B8X20	0-14	MP8A55	0-30
2N3054	0-80	3N159	1-17	BU103	1-25	BD131	0-40	B8X21	0-20	MP8A65	0-28
2N3055	0-50	3N187	1-55	BU107	1-25	BD132	0-60	B8X26	0-40	MP8A66	0-28
2N3090	0-20	3N200	2-40	BU108	1-25	BD133	0-43	B8X27	0-84	MP8A67	0-28
2N3091	0-20	3N201	1-05	BU109	1-25	BD134	0-40	B8X28	0-25	MP8U01	0-44
2N3091A	0-22	3N201	1-05	BU113	0-13	BD137	0-55	B8X29	0-47	MP8U05	0-48
2N3391A	0-18	BC114	0-12	BD138	0-68	B8X60	0-54	B8X30	0-14		
2N3392	0-18	BC115	0-16	BD139	0-71	B8X61	0-54	B8X31	0-14		
2N3393											



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2N4310	0.540	2N4037	0.480	2N5055	0.380	2N4288	0.180	2N3646	0.130	2N3015	0.485
2N4311	0.880	2N4121	0.120	2N5056	2.000	2N4966	0.120	2N3685	0.880	2N3019	0.540
2N4312	0.540	2N4122	0.180	2N5057	2.370	2N4967	0.180	2N3686	0.580	2N3020	0.580
2N4313	0.880	2N4123	0.140	2N5058	0.880	2N4968	0.140	2N3687	0.150	2N3053	0.180
2N4314	0.280	2N4124	0.140	2N5126	0.140	2N7005	0.180	2N3688	0.150	2N3054	0.450
2N4315	0.280	2N4125	0.180	2N5129	0.080	2N7008	0.140	2N3693	0.150	2N3072	0.580
2N4316	0.280	2N4134	1.000	2N5130	0.080	2N7118	0.220	2N3694	0.150	2N3073	0.455
2N4318	0.280	2N4135	1.000	2N5131	0.100	2N7222	0.080	2N3724	0.420	2N3107	0.540
2N4320	0.880	2N4140	0.270	2N5132	0.080	2N7444	0.180	2N3724A	1.100	2N3108	0.540
2N4324	1.000	2N4141	0.280	2N5133	0.080	2N7553	0.180	2N3725	0.425	2N3109	0.540
2N4329	2.000	2N4142	0.370	2N5134	0.080	2N7800	0.270	2N3725A	1.000	2N5143	0.105
2N4330	0.280	2N4143	0.380	2N5135	0.080	2N780A	0.270	2N3734	1.170	2N5810	0.270
2N4330A	0.440	2N4200	1.070	2N5137	0.180	2N834	0.255	2N3735	2.700	BC107	0.120
2N4351	0.880	2N4200	2.000	2N5138	0.080	2N814	0.280	2N3803	0.185	BC108	0.185
2N4351A	0.880	2N4227	0.280	2N5139	0.080	2N815	0.280	2N3804	0.180	BC109	0.140
2N4352	0.880	2N4228	0.270	2N5140	0.170	2N816	0.280	2N3805	0.175	BC177	0.180
2N4353	0.280	2N4248	0.110	2N5141	0.185	2N817	0.280	2N3806	0.185	BC178	0.180
2N4359	0.240	2N4249	0.120	2N5142	0.185	2N818	0.280	2N3845	0.800	BC179	0.180
2N4360	0.480	2N4250	0.180	2N1711	0.220	2N829	0.185	2N3846	1.280	BC21A	0.340
2N4361	0.280	2N4257	0.175	2N1893	0.270	2N829A	0.740	2N3947	1.370	BC21B	0.340
2N4362	0.480	2N4258	0.220	2N1890	0.280	2N830	0.180	2N2369	0.155	BC262A	0.360
2N4364	0.280	2N4259	0.240	2N2017	0.870	2N830A	0.080	2N2369A	0.170	BC262B	0.380
2N4368	0.880	2N4258A	0.275	2N2102	0.375	2N856	0.220	2N2483	0.210	BC263A	0.380
2N4369	0.480	2N4274	0.135	2N2152	0.485	2N860	2.210	2N2484	0.240	BC263B	0.380
2N4344	0.880	2N4275	0.125	2N2182A	0.375	2N865	1.000	2N2508	0.710	BCY70	0.155
2N4350	0.790	2N4313	0.280	2N2193	0.470	2N1131	0.225	2N2510	0.710	BCY71	0.220
2N4352	0.150	2N4384	0.210	2N2193A	0.670	2N1132	0.225	2N2511	1.130	BCY72	0.128
2N4353A	0.790	2N4385	0.240	2N2194	0.485	2N1420	0.215	2N2586	1.000	BF328	0.455
2N4354	0.280	2N4386	0.280	2N2195	0.680	2N1813	0.180	2N2604	1.380	BF83	0.740
2N4345	4.000	2N4400	0.180	2N2196	0.485	2N3564	0.180	2N2605	0.640	BFX29	0.280
2N4346	1.280	2N4401	0.240	2N2195A	0.670	2N3565	0.110	2N2657	3.070	BFX30	0.330
2N4347	1.750	2N4402	0.180	2N2217	0.275	2N3566	0.120	2N2658	4.980	BFX8	0.280
2N4348	1.000	2N4403	0.240	2N2218	0.280	2N3567	0.120	2N2690	3.080	BFX85	0.280
2N4349	2.100	2N4416	0.110	2N2218A	0.240	2N3568	0.170	2N2891	3.080	BFX86	0.230
2N4350	2.000	2N4817	0.180	2N2219	0.240	2N3569	0.180	2N2894	0.220	BFX87	0.220
2N4353	0.130	2N4843	0.080	2N2219A	0.270	2N3676	1.220	2N2894A	0.085	BFY28	0.210
2N4354	0.280	2N4854	0.170	2N2221	0.180	2N3678	0.120	2N2904	0.225	BFY50	0.180
2N4355	0.455	2N4855	0.170	2N2221A	0.280	2N3638A	0.120	2N2904A	0.255	BFY51	0.180
2N4356	0.455	2N4856	0.170	2N2222	0.100	2N3639	0.280	2N2905	0.270	BFY52	0.190
2N4355	0.790	2N4857	0.170	2N2222A	0.240	2N3640	0.280	2N2905A	0.280	BSY38	0.170
2N4358	0.485	2N4858	0.170	2N2223	0.180	2N3641	0.180	2N2906	0.220	BSY39	0.170
2N4359	0.485	2N4859	0.170	2N2223A	0.280	2N3642	0.180	2N2906A	0.245	BSY51	0.200
2N4362	0.530	2N4870	0.180	2N2270	0.080	2N3643	0.180	2N2907	0.210	BSY52	0.200
2N4363	0.870	2N4871	0.240	2N2287	0.080	2N3644	0.180	2N2907A	0.220	BSY53	0.200
2N4368	0.480	2N4872	0.280	2N2293	1.280	2N3645	0.180	2N3011	0.180	BSY54	0.200
								2N3012	0.530	BSY55A	0.130

THYRISTORS

Type No.	Price	IT (RMS)	V DROM
NAS106F	0.250	4A	50
NAS106A	0.310	4A	100
NAS106B	0.380	4A	200
NAS106D	0.380	4A	400
NAS106F	0.283	6A	50
NAS206A	0.340	6A	100
NAS206B	0.485	6A	200
NAS206D	0.653	6A	400
NAS306F	0.313	8A	50
NAS306A	0.380	8A	100
NAS306B	0.480	8A	200
NAS306D	0.725	8A	400
NAS406F	0.360	10A	50
NAS406A	0.434	10A	100
NAS406B	0.584	10A	200
NAS406D	0.812	10A	400
NAS806F	0.438	16A	50
NAS806A	0.543	16A	100
NAS806B	0.830	16A	200
NAS806D	1.015	16A	400

NAS1640	0.342	1.6A	400
NAS4510	0.260	4.5A	100
NAS4520	0.480	4.5A	200
NAS4540	0.840	4.5A	400
NAS6510	0.380	6.5A	100
NAS6520	0.440	6.5A	200
NAS6540	0.700	6.5A	400
NAS8510	0.430	8.5A	100
NAS8520	0.480	8.5A	200
NAS8540	0.770	8.5A	400
NAS10010	0.480	10A	100
NAS10020	0.520	10A	200
NAS10040	0.840	10A	400

EPOXY 4 AMP AND 6 AMP BRIDGE RECTIFIERS

Type No	IF	VRM	Price
N7001	4A	50PIV	0.320
N7012	4A	100PIV	0.380
N7013	4A	200PIV	0.430
N7014	4A	400PIV	0.580
N7015	4A	600PIV	0.755
N7021	6A	50PIV	0.380
N7022	6A	100PIV	0.430
N7023	6A	200PIV	0.540
N7024	6A	400PIV	0.850
N7025	6A	600PIV	0.810

TRIACS WITH INTERNAL TRIGGERS

Type No.	Price	IT (RMS)	V DROM
NASQ1610	0.310	1.6A	100
NASQ1620	0.330	1.6A	200
NASQ1640	0.380	1.6A	400
NASQ4510	0.380	4.5A	100
NASQ4520	0.440	4.5A	200
NASQ4540	0.710	4.5A	400
NASQ6510	0.480	6.5A	100
NASQ6520	0.480	6.5A	200
NASQ6540	0.780	6.5A	400
NASQ8510	0.480	8.5A	100
NASQ8520	0.580	8.5A	200
NASQ8540	0.830	8.5A	400
NASQ10010	0.580	10A	100
NASQ10020	0.580	10A	200
NASQ10040	0.880	10A	400

2 AMP ENCAPSULATED PLASTIC BRIDGE RECTIFIERS

N6001	2A	50PIV	0.350
N6002	2A	100PIV	0.380
N6003	2A	200PIV	0.460
N6004	2A	400PIV	0.430
N6005	2A	600PIV	0.500

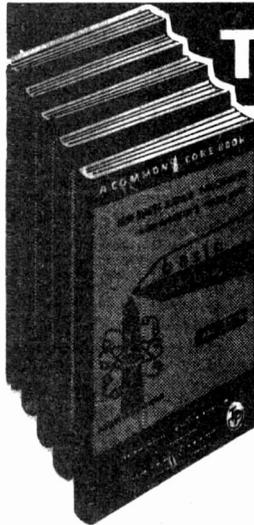
PLASTIC RECTIFIER

1N4001	0.080
1N4002	0.080
1N4003	0.080
1N4004	0.100
1N4005	0.110
1N4006	0.120
1N4007	0.130

TRIACS

Type No.	Price	IT (RMS)	V DROM
NAS1610	0.295	1.6A	100
NAS1620	0.314	1.6A	200

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28 ranges. D.c. volts 1.5-1,500V. a.c. volts 1.5-1,500V. Resistance up to 1,000 megohms. 200/240V a.c. operation. Complete with probe and instructions. £17-50. Post 30p. Additional probes available: R.F. £2-12; H.V. £2-50.



KAMODEN 72.200 MULTITESTER

High sensitivity tester. 200,000 o.p.v. Overload protection. Mirror scale. Ranges: 0/0.06/0.3/3/30/120/600/1,200V d.c. 0/3/12/60/300/1,200V a.c. 0/10µA/1/2mA/120mA/600mA/12A d.c. 0/12A a.c. -20 to +63dB. 0/2kΩ/200kΩ/2MΩ/200MΩ. £16-95. Post 30p.



MODEL U4811 SUB-STANDARD MULTI-RANGE VOLT AMMETER

Sensitivity 330 ohms/Volt a.c. and d.c. Accuracy 0-5% d.c. 1% a.c. Scale length 165mm. 0/300/750µA/1.5/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5 amp. d.c. 0/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5 amp. a.c. 0/75/150/300/750V d.c. 0/750V/1.5/3/7.5/15/30/75/150/300/750V a.c. Automatic cut out. Supplied complete with test leads, manual and test certificates. £49. Post 50p.



KAMODEN HM720B F.E.T. V.O.M.

Input impedance 10MΩ. Ranges: 0/0.25/1/2.5/10/50/250/1,000V d.c. 0/2.5/10/50/250/1,000V a.c. 0/25µA/2.5/25/250MA d.c. -20 to +62dB. 0/5k/50k/500k/5MΩ/500MΩ. £14-95. Post 30p.



TE-40 HIGH SENSITIVITY A.C. VOLTMETER

10 meg. input 10 ranges: 0/1/003/1/3/1/10/30/100/300V. R.M.S. 4eps. -1.2 Mc/s. Decibels -40 to +50dB. Supplied brand new complete with leads and instructions. Operation 230V. a.c. £17-50. Carr. 25p.



TMK MODEL 117 F.E.T. ELECTRONIC VOLTMETER

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MODEL L-55 FET V.O.M.

Input impedance 10 meg ohms. 0/0.3/1.2/8/30/120/600V d.c. 0/3/12/60/120/600V a.c. 0/120µA/120µA/600µA. 0/1K/100K/10 meg/100 meg ohms. £15-97. Post 25p.



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Range 0-1,000 Megohms, 500 Volt. Meter operated. Wide range clear meter 4 1/2" x 4". Complete with deluxe carrying case, batteries, instructions. £19-95. Post 30p.



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TO-3 PORTABLE OSCILLOSCOPE

8in tube, Y amp. Sensitivity 0-1V p-p/CM. Bandwidth 1.5cps-1.5MHz. Input imp. 2 meg Ω 25pF X amp. sensitivity 0-9V. p-p/CM. Bandwidth 1.5cps-800KHz. Input imp. 2 meg Ω 20pF. Time base 5 ranges 10cps-300KHz. Synchronisation. Internal/external. Illuminated scale 140mm x 215mm x 330mm. Weight 15 1/2lb. 220/240V a.c. Supplied brand new with hand-book. £47-50. Carr. 50p.



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5MHz Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5in x 4in C.R.T. Calibrated triggered sweep from 0-20µsec. to 100 mill-sec per cm. Free running time base 50 Hz-1MHz. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. £87. Carr. paid.



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Accurate wide range signal generator covering 120 KHz-500 MHz on 6 bands. Directly calibrated. Variable R.F. attenuator audio output. Xtal socket for calibration. 220/240V a.c. Brand new with instructions. £17-50. Carr. 37p. Size 140mm x 215mm x 170mm.



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MODEL S-260B

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2.5 amp	£8.05

Carriage and Packing Extra

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Solid state. Variable output 0-24V d.c. up to 1 amp. Dual scale meter to monitor voltage and current. Input 220/240V a.c. Size 185 x 85 x 105mm. £8.97. Post 25p.



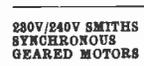
PS.200 REGULATED P.S.U.

Solid state. Variable output 5-20V d.c. up to 2 amp. Independent meters to monitor voltage and current. Output 220/240V a.c. Size 7 1/2in. x 5 1/2in. x 3 1/2in. £19.95. Post 25p.



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TYPE 8W.100 100mm x 80mm Fronts

50µA	£4.15
50-0-50µA	£3.95
100µA	£3.95
100-0-100µA	£3.90
500µA	£3.70
1mA	£3.60
20V d.c.	£3.60
50V d.c.	£3.60
300V d.c.	£3.60
1 amp d.c.	£3.60



TYPE MR.52P 4 1/2in. x 4 1/2in. Fronts

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50-0-50µA	£4.25
100µA	£4.25
100-0-100µA	£4.05
500µA	£3.90
1mA	£3.80
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1 amp	£3.10
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5V d.c.	£3.10
10V d.c.	£3.10
20V d.c.	£3.10
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300V d.c.	£3.30
15V a.c.	£3.30
1mA	£3.10
5mA	£3.10

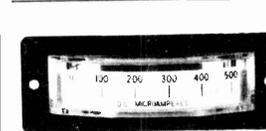


TYPE 8D.640 63.5mm x 85mm Fronts

50µA	£3.05
50-0-50µA	£3.05
100µA	£3.00
100-0-100µA	£3.00
200µA	£3.00
500µA	£3.00
1mA	£2.90
5mA	£2.90
10mA	£2.90
50mA	£2.90
100mA	£2.90

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50µA	£2.80
50-0-50µA	£2.80
100µA	£2.75
100-0-100µA	£2.75
200µA	£2.70
500µA	£2.70
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5mA	£2.60
10mA	£2.60
50mA	£2.60
100mA	£2.60
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1 amp	£3.25
2 amp	£3.25
5 amp	£3.25
10 amp	£3.25
3V d.c.	£3.25
50µA	£2.55
50-0-50µA	£2.50
100µA	£2.45
100-0-100µA	£2.40
200µA	£2.35
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1mA	£2.35
1-0-1mA	£2.35
2mA	£2.25
5mA	£2.25
10mA	£2.25
20mA	£2.25
50mA	£2.25
100mA	£2.25
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50-0-50µA	£2.65
100µA	£2.60
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500µA	£2.50
1mA	£2.40
5mA	£2.40
10mA	£2.40
50mA	£2.40
100mA	£2.40
500mA	£2.40
1 amp	£2.40

"SEW" BAKELITE PANEL METERS

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1 amp	£2.60
5 amp	£2.60
15 amp	£2.60
30 amp	£2.60
50 amp	£2.60
5V d.c.	£2.60
10V d.c.	£2.60
20V d.c.	£2.60
50V d.c.	£2.60
150V d.c.	£2.60
300V d.c.	£2.60
500µA	£2.50
500-0-500µA	£2.50
1mA	£2.50
1-0-1mA	£2.50
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Dual range	
600mA/5A d.c.	£7.00
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50-0-50µA	£3.40
100µA	£3.40
100-0-100µA	£3.30
500µA	£3.35
1mA	£3.30
20V d.c.	£3.30
50V d.c.	£3.30
300V d.c.	£3.30
1 amp d.c.	£3.00
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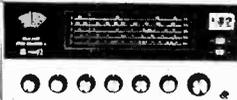
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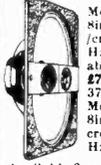


4 bands covering 550kHz-30MHz continuous and electrical bandspread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. 88B-CW. ANL. Variable BFO. 8 meter. Sep. bandspread dial. 1F frequency 445kHz audio output 15W. Variable RF and AF gain controls. 115/250V a.c. Size: 7in x 13in x 10in with instruction manual.
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For balancing and gain selection of loudspeakers, with additional facility for stereo headphone switching. 2 gain controls, speaker on-off slide switch, stereo headphone sockets 6in x 4in x 2 1/2in.
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Incorporates built-in amplifiers giving 21 x 2W r.m.s. output. Push button track selector, illuminated track indicators, slider controls for volume, balance and tone. Attractive cabinet with black and silver trim. Output impedance 8 ohms. 220/240V a.c.
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Can be used with most hi-fi amplifiers. Push button track selector and illuminated track indicators. Attractive cabinet with black and silver trim. Output level 750mV. 220/240V a.c.
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AR1000 Sportsman AM/FM Portable

5 wavebands covering M: 535 - 1065kHz; F.M.: 88-108MHz; A.I.R.: 108 - 135MHz; P.B.: 147-174MHz; W.B.: 162.5MHz. Large horizontal slide dial with logging scale. Slider volume and squelch controls. 7 section telescopic aerial for F.M. and built in ferrite bar for A.M., A.F.C. 3in speaker. Earpiece socket. Green leatherette covered cabinet with metal side panels. Size 152 x 79 x 219mm. Battery/mains operation.
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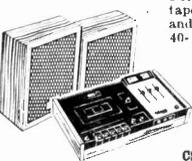
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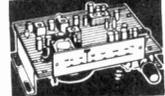
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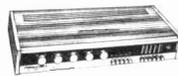
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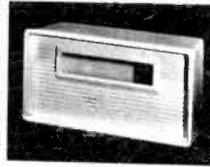
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4700µF	29p	680µF	9p	680µF	25p
		1000µF	17p	1000µF	25p
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150µF	6½p	47µF	6½p	4.7µF	6½p
470µF	11p	100µF	8p	6.8µF	6½p
680µF	13p	220µF	10p	10µF	6½p
1500µF	18p	470µF	13p	22µF	6½p
2200µF	18p	680µF	20p	68µF	10p
3300µF	26p	1000µF	22p	100µF	11p
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AU110 41-10	BD132 90p	NKT677G 33p	TIP63 13p	IN159 13p
AU111 77p	BD135 42p	NKT677G 33p	TIP64 13p	IN160 13p
BC107 9p	BD136 50p	NKT7132 32p	TIP65 13p	IN161 13p
BC108 9p	BD141 1-87	NKT7732 32p	TIP66 13p	IN162 13p
BC109 9p	BD142 50p	OC19 55p	TIP67 13p	IN163 13p
BC113 154p	BF159 33p	OC20 55p	TIP68 13p	IN164 13p
BC116 16p	BF173 29p	OC23 33p	TIP69 13p	IN165 13p
BC125 15p	BF177 25p	OC26 24p	TIP70 13p	IN166 13p
BC126 25p	BF178 29p	OC28 33p	TIP71 13p	IN167 13p
BC132 16p	BF179 35p	OC29 33p	TIP72 13p	IN168 13p
BC134 16p	BF194 15p	OC35 38p	TIP73 13p	IN169 13p
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Log or Linear
50 Single 13p, Dual gang (stereo) 44p
Single type with D.P. switch 18p extra.

SLIDE POTENTIOMETERS

55mm, TRACK
SINGLE GANGED, LOG or LIN 1k to 1M, 45p each
TWIN GANGED, LOG or LIN 1k to 500k, 66p each.

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Small high quality type (linear only).
All values 100-5 meg ohms.
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-2.5 watt 81p each

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34in x 5in	33p	32p

5in x 17in (plain) 94p
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Vero cutter, 50p; Pin insertion Tools (0-1 and 0-15 matrix) at 81p.

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The second article in this important series analyses the relationship between negative feedback design and steady state forms of distortion. It also discusses transient phenomena as a major factor in design theory and looks at several designs in this context.

Wireless World

September issue 20p

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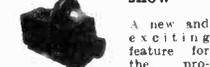
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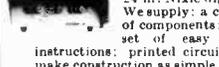
Specification—Projector: 150W, convection cooled, at 30ft the projected image = 16ft; Motor: 1 rev per 2 min. Liquid Wheel: 6in diameter multicolour. The Motor is fitted to the Projector and can only be purchased as a single unit. The Liquid Wheel, however, is our very popular standard model & may be purchased separately. A bargain—Projector with Motor ready for instant use, £15; 6in Liquid Wheel, £5 = £20 + 75p carr.

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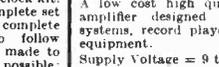
Enables you to work your Transistor Radio, Amplifier or Cassette, etc., from the a.c. mains through this compact Eliminator. Just by moving a plug you can select the voltage you require, 6, 7½ or 9 volt. This means all your transistor power pack applications can be handled by this one unit. Approx. size 2½in x 2½in x 3½in. Our Price £2.75 plus 10p P. & P. Same model suitably wired for the Philips Cassette £3 plus 10p P. & P.

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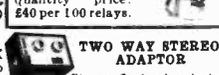
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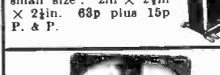
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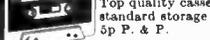
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2½in 80 ohm, 50p; 2½in 40 ohm, 50p. Please include 5p P. & P. on each L.S.



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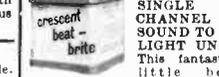
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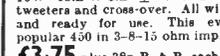
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PSYCHEDELIC LIGHT CONTROL UNIT



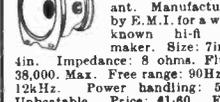
Three Channel: Bass—Middle—Trebble. Each channel has its own sensitivity control. Just connect the input of this unit to the loudspeaker terminals of an amplifier, and connect three 250V up to 500W lamps to the output terminals of the unit, and you produce a fascinating sound-light display. (All guaranteed) £18.50 plus 38p P. & P.

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A top quality speaker ideal where small size is important. Manufactured by E.M.I. for a well-known hi-fi set maker. Size: 7in x 4in. Impedance: 8 ohms. Flux: 38,000. Max. Free range: 90Hz to 12kHz. Power handling: 5W. Unbeatable. Price: £1.60. Free postage on this item.

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After many requests, Electro Spares are now supplying lists of components for all the projects featured in "Practical Electronics", commencing with May 1973 issue. Just forward an S.A.E. (preferably 9" x 4" minimum), and state which project is of interest to you—we will forward an individually priced list of the components required.

No need to buy a full kit—you need only purchase the parts you require at any one time.

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We regret we cannot supply lists for projects published before May 1973 issue.

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30 Watts (R.M.S.) per Channel into 8 ohms!
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Type 350 -20 watt with tweeter 8 ohms. P.P. 37p.	7.25	9THAC/G Sonotone stereo ceramic (diamond) simline	1.70
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with a 13in x 8in or 8in cut out			
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±W Iskra high stability carbon film—very low noise—capless construction.
±W Mullard CR25 carbon film—very small body size 7.5 x 2.5mm.
±W 25W ELECTROSIL TR5

Power watts	Tolerance	Range	Values available	Price
1/4	5%	4.7Ω-2.2MΩ	E24	1p 0.8p
1/2	10%	3.3MΩ-10MΩ	E12	1p 0.8p
1	2%	10Ω-1MΩ	E24	3.5p 3p
2	10%	1Ω-3.9Ω	E12	1p 0.8p
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10	10%	1Ω-10Ω	E12	6p 5.5p

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

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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 ±W, lin ±W).
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).
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AC128 12p	AF139 32p	BF173 20p	OC44 12p	2N3705 12p
AC131 12p	AF178 32p	BF177 28p	OC45 12p	2N3706 11p
AC132 12p	AF180 40p	BF178 32p	OC70 12p	2N3707 12p
AC176 12p	AF181 40p	BF179 32p	OC71 12p	2N3708 10p
AC187 22p	BC107 9p	BF180 32p	OC72 12p	2N3709 11p
AC188 22p	BC108 9p	BF181 32p	OC81 12p	2N3710 11p
AD140 50p	BC109 9p	BF194 15p	OC82D 12p	2N3711 11p
AD149 35p	BC147 13p	BF195 15p	2N2904 20p	2N3711 11p
AD161 33p	BC148 13p	BF197 15p	2N2926G 9p	40360 35p
AD162 36p	BC149 13p	BF200 32p	2N2926Y 9p	40361 35p
AF114 20p	BC157 14p	BFY50 20p	2N2926G 9p	40362 40p
AF115 20p	BC158 14p	BFY51 20p	2N2926G 9p	40408 40p
AF116 20p	BC159 14p	BFY52 20p	2N3054 58p	ZTX302 15p
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BZ100 800V	6A	25p
BZ113 200V	6A	20p
IN4001 50V	1A	7p
IN4004 400V	1A	8p
IN4007 1000V	1A	10p

SIGNAL

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

BRUSHED ALUMINIUM PANELS

12in x 6in = 25p; 12in x 2 1/2in = 10p; 9in x 2in = 7p

SLIDER POTENTIOMETERS

86mm x 9mm x 16mm, length of track 59mm.
SINGLE 10K, 25K, 100K, log or lin. 40p.
DUAL GANG, 10K + 10K etc. log or lin. 60p.
KNOB FOR ABOVE 12p.
FRONT PANEL 65p.
18 Gauge panel 12in x 4in with slots cut for use with slider pots. Grey or matt black finish complete with fixings for 4 pots.

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VA10555	15p
VA10665	15p
VA1077	15p
R53	£1.35

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2N5060 50V 0.8A	30p
2N5064 200V 0.8A	47p
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106F 50V 4A	40p
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100pF to 10,000pF, 2p each.

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(μF/V) 1/0/63, 1.5/63, 2.2/63, 3.3/63, 4.7/63, 6.8/40, 10/25, 10/63, 15/16, 15/40, 15/63, 22/10, 22/25, 22/63, 33/6.3, 33/40, 47/4, 47/10, 47/25, 47/40, 47/63, 68/6.3, 68/16, 100/4, 100/10, 100/25, 100/40, 150/6.3, 150/16, 150/25, 220/4, 220/10, 220/16, 330/4, 330/10, 470/6.3, 5p each. 68/63, 150/40, 220/25, 330/16, 470/10, 680/6.3, 1,000/4, 9p. 100/63, 150/63, 220/40, 470/25, 680/16, 1,000/10, 1,500/6.3, 12p. 220/63, 470/40, 680/25, 1,000/16, 1,500/10, 2,200/6.3, 15p. 330/63, 680/40, 1,000/25, 1,500/16, 2,200/10, 3,300/6.3, 4,700/4, 18p.

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0.1μF 35V	2.2μF 35V	22μF 16V
0.22μF 35V	4.7μF 35V	33μF 10V
0.47μF 35V	6.8μF 25V	47μF 6.3V
1.0μF 35V	10μF 25V	100μF 3V

VEROBOARD

0-1	0-15
2 1/2 x 3 1/2	22p
2 1/2 x 5	16p
3 1/2 x 3 1/2	24p
3 1/2 x 5	24p
17 x 2 1/2	27p
17 x 3 1/2	75p
17 x 5	78p
17 x 5 (plain)	82p
17 x 3 1/2 (plain)	60p
17 x 2 1/2 (plain)	42p
2 1/2 x 5 (plain)	11p
2 1/2 x 3 1/2 (plain)	12p
Pin insertion tool	52p
Spot face cutter	42p
Pkt. 50 pins	20p

JACK PLUGS AND SOCKETS

Standard screened	18p	2.5mm insulated	8p
Standard insulated	12p	3.5mm insulated	13p
Stereo screened	35p	3.5mm screened	8p
Standard socket	15p	2.5mm socket	8p
Stereo socket	18p	3.5mm socket	8p

D.I.N. PLUGS AND SOCKETS

2 pin, 3 pin, 5 pin 180°, 5 pin 240°, 6 pin
Plug 12p. Socket 8p.
4 way screened cable, 15p/metre.
6 way screened cable 22p/metre.

BATTERY ELIMINATOR

£1 50
9V mains power supply. Same size as PP9 battery.

LARGE (CAN) ELECTROLYTICS

1600μF 64V	74p	2500μF 64V	80p	4500μF 16V	50p
2500μF 40V	74p	3200μF 100V	£2.60	4500μF 25V	£1.68
2500μF 50V	58p	3200μF 50V	58p	5000μF 50V	£1.10

HIGH VOLTAGE TUBULAR CAPACITORS—1,000 VOLT

0.01μF	10p	0.1μF	13p	0.22μF	20p
0.022μF	12p	0.47μF	13p	0.47μF	22p

POLYSTYRENE CAPACITORS 160V 2 1/2% 10pF to 1,000pF E12 Series Values 4p each.

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The GDI is the world's first semiconductor that can convert a concentration of gas or smoke into an electrical signal. The sensor decreases its electrical resistance when it absorbs oxidizing or combustible gases such as hydrogen, carbon monoxide, methane, propane, alcohol, North Sea gas, as well as carbon-dust containing air or smoke. This decrease is usually large enough to be utilized without amplification. Full details and circuits are supplied with each detector.
Detector GDI, £2. Kit of parts for detectors including GDI and P.C. board but excluding gas, £2. Mains operated detector £5.20. 12 or 24V battery operated audible alarm £7.30. As above for PP9 battery, £6.40.

PRINTED BOARD MARKER

97p
Draw the planned circuit onto a copper laminate board with the P.C. Pen, allow to dry, and immerse the board in the etchant. On removal the circuit remains in high relief.

LARGE RANGE ITT/TEXAS IC's NOW IN STOCK

PRICES ARE CALCULATED ON TOTAL NUMBER ORDERED REGARDLESS OF MIX

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7401	p	p	p	p	7450	18	16	14	13	74121	43	40	38	36
7402	18	16	14	13	7451	18	16	14	13	74141	100	95	90	85
7403	18	16	14	13	7453	18	16	14	13	74145	150	140	135	130
7404	20	18	16	14	7470	30	28	25	24	74150	330	280	250	220
7405	20	18	16	14	7472	30	28	27	26	74151	110	100	95	89
7406	50	45	40	35	7473	40	38	36	35	74152	120	110	105	95
7407	56	50	44	38	7474	40	37	36	32	74154	200	180	170	160
7408	36	30	27	23	7475	55	52	50	49	74155	150	120	100	86
7409	36	30	27	23	7476	40	36	32	30	74156	130	120	100	96
7410	18	16	14	13	7480	100	95	90	85	74180	155	136	112	105
7411	23	21	20	18	7481	125	115	110	105	74190	195	190	185	180
7412	36	30	27	23	7482	100	96	90	85	74191	195	190	185	180
7413	34	28	26	22	7483	100	97	95	92	74192	200	190	180	164
7416	45	43	39	34	7484	120	115	110	105	74193	200	180	170	150
7420	18	16	14	13	7485	250	245	240	230	74196	200	190	180	170
7421	36	30	27	23	7486	45	42	37	33	74197	200	195	180	170
7426	32	29	23	20	7490	75	67	60	52					
7430	20	18	16	14	7491A	100	92	87	79					
7432	40	36	32	28	7492	75	70	65	60	709	14 pin DIL			32p
7440	20	18	16	14	7493	75	68	60	52	741	8 pin DIL			34p
7441	80	75	70	65	7494	95	90	85	80	741	14 pin DIL			28p
7442	80	75	70	65	7495	105	100	95	90	723	14 pin DIL			35p
7443	125	120	115	115	7496	100	90	80	85	747	14 pin DIL			85p
7447	175	165	150	120	74100	250	240	235	230	748	8 pin DIL			35p

LINEAR IC's

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741	8 pin DIL	34p
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P.E.9

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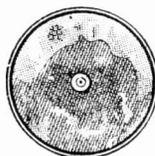
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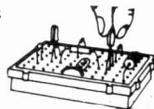
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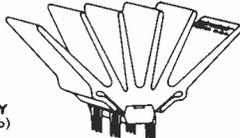
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BC183	8p	BZ198C-27V	70p	MPF105(2N5459)	40p	W05	31p	2N3820	60p	40320	40p
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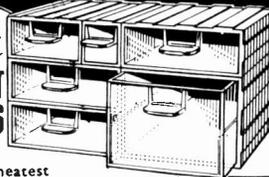
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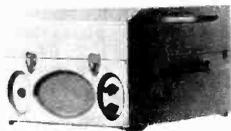
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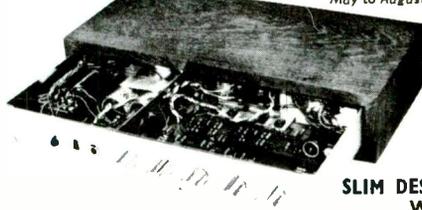
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