

PRACTICAL

# ELECTRONICS

APRIL 1971

17½p (3/6)

## AURORA

MUSIC  
INSPIRED  
LIGHT AND  
COLOUR

*Also inside*

- ★ BOAT SPEED INDICATOR
- ★ DOOR YODELLER

# ADCOLA Soldering Instruments add to your efficiency

## ADCOLA 64

for Factory Bench Line Assembly

A precision instrument—supplied with standard 3/16" (4.75 mm) diameter, detachable copper chisel-face bit\*.

Standard temp. 360°C at 23 watts.

Special temps. from 250°C—410°C.

### \*Additional Stock Bits

(illustrated) available

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B 38  $\frac{1}{8}$ " — 3.2 mm CHISEL FACE

B 14  $\frac{3}{32}$ " — 2.4 mm CHISEL FACE

B 24  $\frac{1}{16}$ " — 4.75 mm SCREWDRIVER FACE

B 12  $\frac{1}{16}$ " — 4.75 mm EYELET BIT

B 58  $\frac{1}{4}$ " — 6.34 mm CHISEL FACE

#### LONG LIFE

B 42 LL  $\frac{1}{8}$ " — 4.75 mm CHISEL FACE

B 33 LL  $\frac{1}{8}$ " — 3.2 mm CHISEL FACE

B 14 LL  $\frac{3}{32}$ " — 2.4 mm CHISEL FACE

B 44 LL  $\frac{1}{16}$ " — 4.75 mm SCREWDRIVER FACE



Don't take chances. We don't. All our ADCOLA Soldering Instruments are of impeccable quality. You can depend on ADCOLA day after day. That's why they're so popular. You get consistent good service... reliability... from our famous thermally controlled ADCOLA Element and the tough steel construction of this ideal production tool.

\* Write for price list and catalogue



**ADCOLA PRODUCTS LTD.,**

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## PRACTICAL ELECTRONICS

Specify

**CONTIL MOD-2 CASES**



PRACTICAL ELECTRONICS specify CONTIL MOD-2 CASES for housing the P.E. GEMINI AMPLIFIER, P.E. AURORA LIGHT DISPLAY SYSTEM, P.E. DIGITAL CLOCK. Also available ready punched for Sinclair Project 60, with or without active filter unit. Full kit of hardware is also available, including capacitors, for use with Z30 or Z50 at £3.63.

PVC COATED MATERIALS, PVC easy to clean, surface is scuff resistant. PVC/ALUMINIUM FOR FRONT AND BACK PANELS. PVC/STEEL FOR SIDES, TOP AND BOTTOM. LOW COST.	A	4.5	3"	6.5	£2.10
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	N	4.5	7"	13"	£3.33

★ See January issue for all sizes. Send for free leaflets and price list.



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# knight-kits

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Due to huge purchase these superb U.S.A. construction kits can be offered at 25%—50% off recommended list prices. Absolutely complete with most detailed construction and operating books. Available from all branches or by mail order for 37½p CARRIAGE AND PACKING on each kit. Two kits or more carr. free.

## KG-620 4½" VTVM KIT ★ NEW!

### SPECIFICATIONS

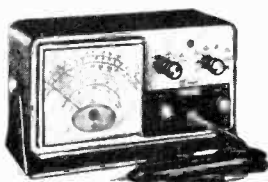


Ranges: 0-1.5-5-15-50-150-500-1,500V full scale; with optional High-Voltage Probe, to 25,000V.  
Accuracy: ± 3% Of full scale reading.  
Input Resistance: 11 megohms (1 meg in probe) up to 1,500V.  
Ranges (r.m.s.): 0-1.5-5-15-50-150-500-1,500V full scale (p-p); 0-2-14-12-140-120-1,300-1,200V full scale.  
Decibels: -10 to +65 in 2 ranges.  
Response: ± 1dB, 30Hz to 3MHz; ± 3dB, 30Hz to 5MHz; with optional H.F. Probe, to 250 MHz.  
Accuracy: ± 5% of full scale reading.  
Ranges: 0-1,000-10,000-100,000 ohms; 0-1-10-100-1,000 meg-ohms.  
Genie Scales: 10, 100, 1,000, 10,000, 100,000 ohms; 1 and 10 megohms.  
Battery 1½ V size U2.

Recommended List Price £18.27; **£9.95** Assembled Price £14 (RR Price £30)

## KG-625 Deluxe 6in Vacuum Tube Voltmeter Kit

Huge 6in Meter Scale ● Ranges: d.c. 0-0.5-1.5-5-15-50-150-500-1,500V full scale.  
● Accuracy: ± 3% of full scale reading  
● Input Resistance: 11MΩ to 1,500V  
● Ranges: a.c. 0-1.5-5-15-50-150-500-1,500V full scale. 0-1-2-11-12-110-120-1,300-1,200V full scale ● Accuracy: ± 5% ● Frequency Response: ± 1dB, 30Hz to 3MHz; ± 3dB, 30Hz to 3MHz ● Ohmmeter Ranges: 0-1,000-10,000 ohms; 0-1-10-100-1,000MΩ ● Battery: 1½ V U2.  
Recommended List Price £24.97; **£12.60**

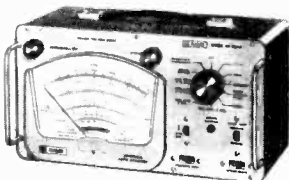


## KG-375A Deluxe Solid-State Auto Analyzer Kit

Tune-up and trouble-shoot any car, perform actual road tests

It's several testers in one... do all this

Set Engine Idle and Automatic Transmission Shift Points ● Detect Condition of Point Surfaces ● Detect Distributor Wear ● Check Voltage and Current Regulators ● Check Generators for both Current and Voltage Output ● Find Poor or Open Earth Circuits ● Detect Variation in Dwell Angle.  
Recommended List Price £23.87; **£16.80**



Assembled Price £22.05

### WHY NOT BUY THE PAIR?

## KG-371 Deluxe Solid-State Timing Light

Performance surpasses assembled units costing much more

Helps Set Ignition Timing ● Checks Synchronisation of Double Breaker Arms ● Checks for Sticking Automatic Spark-Advance Mechanism ● Checks Distributor Cam Wear ● Built-in d.c. Power Supply ● Reliable Solid-State Circuit ● Your car gives more miles per gallon; Improved performance; Greater reliability.  
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Available Assembled Only. **£9.95**



We offer you fully tensilised polyester/mylar and P.V.C. tapes of identical quality hi-fi, wide range recording characteristics as top grade tapes. Quality control manufacture. They are truly worth a few more coppers than acetate, sub-standard, jointed or cheap imports. TRY ONE AND PROVE IT

	STANDARD	LONG	DOUBLE	TRIPLE
3in 150ft	12p	3in 225ft	13p	3in 300ft
4in 300ft	22½p	4in 450ft	27p	4in 600ft
5in 600ft	45p	5in 900ft	52½p	5in 1,200ft
5in 900ft	52p	5in 1,200ft	55p	5in 1,800ft
7in 1,200ft	62½p	7in 1,800ft	92p	7in 2,400ft
				QUADRUPLE
				3in 600ft 42p

Post free less 5% on three reels. Quality and Trade inquiries invited. NOTE: Large tape stocks at all branches.

## SINCLAIR EQUIPMENT (Post 15p per order)

Z30—£3.95 | PZ5—£4.25  
Z50—£4.95 | PZ6—£6.95  
Stereo 60—£8.75 | PZ8—£5.25

Package Price: 1 x PZ5, 1 x Stereo 60 & 2 x Z30—£18.90  
MICROMATIC KIT—£2.30  
MICROMATIC BUILT £2.75

## E.M.I. LOUDSPEAKERS (Post 30p per order)

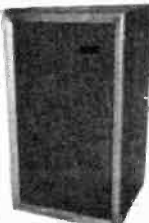
Quantity inquiries invited  
Hi-Fi 13in x 8in ceramic magnet, 10,000 line, 10 watts R.M.S.  
20 watts peak, 3, 8 or 15 ohms—£1.60  
ditto with crossover and E.M.I. 2in hi-fi tweeter, 8 or 15 ohms—£2.40  
ditto with flared parasitic tweeter cone, 3 or 8 ohms—£1.85

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Quantity inquiries invited  
Wingtop 54in, chromed, triple extension, pivoted with 53in lead/plug (value £1.60)—85p  
Retractable lock-down, chromed, 44ins, 5 sections (with 2 keys)  
47in screened lead and plug (value £2.45)—85p  
Send S.A.E. for free sale list of special items



## Introducing The New "Delta" 10 watt Enclosure



Incorporating the famous EMI 150 set consisting of a 13 x 8in. bass unit with a high flux ceramic magnet and a concentric tweeter impedance 8Ω 20 watt peak handling power (10 watts RMS) or 20 watts peak.

Heavy duty 16mm infinite baffle case in superb quality genuine golden teak veneers with solid mahogany contrasting leading edges. High quality foam loaded cloth fret. Acoustically loaded "Jason" rotating badge in genuine gold leaf for horizontal or vertical operation. Size 19in x 10in x 10in. Weight 16lbs. A price break through at only Carriage etc. 50p singly. **£12.50** each  
Carriage free in pairs.



## "GAMMA" 20 WATT ENCLOSURE

As above but with super heavy duty bass unit with 3-6lb magnet in Magnadure II material with 1.5in speech coil and super tweeter giving frequency range of 20-20,000 Hz. Standard 8Ω impedance in beautifully finished heavy teak veneers. Size 12½ x 12 x 23in. 20 Watts RMS, 40 watts peak. At a super keen price. Carriage and ins. 85p. Carriage price in pairs **£19.50**

## PLINTHS & COVERS

For Garrard (take all current models except heavy transcription types). Beautiful heavy solid perspex top with "stereo" badge high quality base with solid wood sides machined ready for R/P deck to drop in without any further work. Terrific value at only **£3.45** complete. Carr. and Insurance 37½p.

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# HOW TO TELL A STEREO SYSTEM THAT LOOKS GOOD FROM A STEREO SYSTEM THAT SOUNDS GOOD—BEFORE YOU PART WITH YOUR MONEY.

There's only one way to buy stereo equipment. Listen to it. Lots of it. Until you find the sound you like for the money you've got.

Sound advice. But try acting on it in 99% of hi-fi dealers and you'll be asked to show the colour of your money. We at Roc think that's unfair. So we fitted out our store in the Edware Road with a series of sound systems, so you can hear all the stereo you want until you find the equipment you like. With no hustling.

But if you're one of those poor unfortunates who cannot make it in person, we'll sell you a system by mail. We've got the best range in town from single speakers to complete stereo set-ups.

Here are just six of the systems we've got in stock.

Fill in the coupon and we'll have our systems brochure back to you by return.





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 Address \_\_\_\_\_

**R**  
**ROC ELECTRONICS LIMITED**  
 193 EDGWARE ROAD LONDON W2 1ET  
 TELEPHONE: 01-723 6211

**System I.** Price: £39.90  
 Amplifier Output: 4 Watts per channel  
 Frequency Response: 50-10000 Hz.  
 Inputs: Tuner, Ceramic Cartridge  
 Controls: Volume, Tone & Balance  
 Speakers: Capacity: 6 Watts  
 Frequency Response: 40-16000 Hz.  
 Turntable: Garrard 2025TC, Ceramic Cartridge, Base and Cover  
 Matching AM/FM/FM Stereo Tuner

**System II.** Price: £49.90  
 Amplifier Output: 8 Watts per Channel  
 Frequency Response: 40-18000 Hz.  
 Inputs: Tuner, Tape, Ceramic Cartridge  
 Controls: Volume, Bass, Treble and Balance  
 Speakers: Capacity: 10 Watts  
 Frequency Response: 40-19000 Hz.  
 Turntable: As system I.

**System III.** Price: (A) £59.90 (B) £69.90  
 Amplifier Output: 15 Watts per Channel  
 Frequency Response: 30-18000 Hz.  
 Inputs: Tuner, Tape, Magnetic & Ceramic  
 Controls: Volume, Bass, Treble and Balance  
 Speakers: As System II  
 Turntable: System IIIA Garrard 2025TC, Ceramic Cartridge, Base and Cover  
 System IIIB Garrard SP.25 MK III, Magnetic Cartridge, Base and Cover

**System IV.** Price: £79.90  
 Amplifier Output: 20 Watts per Channel  
 Frequency Response: 25-20000 Hz.  
 Inputs: Tuner, Tape Magnetic & Ceramic Cartridge  
 Controls: 2 Volume, Bass, Treble and Loudness  
 Speakers: Capacity: 20 Watts  
 Frequency Response: 35-20000 Hz.  
 Turntable: Garrard SP.25 MKIII, Magnetic Cartridge, Base and Cover  
 Matching AF/FM/FM Stereo Tuner: £36.00

**System V.** Price: £115.00  
 Tuner Amplifier Output: 18 Watts per Channel  
 Frequency Response: 30-20000 Hz.  
 Inputs: Tape & Magnetic Cartridge  
 Controls: 2 Volume, Bass, Treble and Tuning  
 FM Sensitivity: 2.5 micro volts  
 AM Sensitivity: 100 micro volts  
 Speakers: Capacity: 20 Watts  
 Frequency Response: 35-20000 Hz.  
 Turntable: As System IV

**System VI.** Price: £182.00  
 Amplifier Output: 30 Watts per Channel  
 Frequency Response: 20-30000 Hz.  
 Inputs: Auxilliary, Magnetic & Ceramic Cartridge  
 Controls: Volume, Bass, Treble, Balance, Loudness and Monitor  
 Speakers: Capacity: 30 Watts  
 Frequency Response: 35-20000 Hz.  
 Turntable: Thorens TD150AB Magnetic Cartridge, Base & Cover

# DISCOSOUND



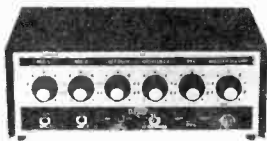
## D.J. DISCO-AMP

Designed specifically for use with discotheques and has many exclusive features not normally found on P.A. amplifiers. The unit will be of use to the professional D.J. as well as in clubs and mobile discotheques.

A complete Pre-fade listen (P.F.L.) cueing monitor section is featured with separate input for headphones (either stereo or mono) with an independent volume control for headphone monitoring, and a P.F.L. switch, so that either turntable can be monitored for accurate cueing up of records. A mic over-ride switch is also added which cuts the music volume by half. Specification: Output power 70 watts R.M.S.  $\pm$  1 db at 8 ohms. Frequency response: 30-20,000 Hz  $\pm$  3db. Harmonic distortion: Less than 1% at full output. Signal/noise ratio: Better than -65db. Inputs: Mic 1 & 2.5 mV at 50 K ohms. Turntable 1 & 2 100 mV at 1 meg ohm.

50 ohm or 600 ohm mic inputs may be ordered at extra cost. Size: Front Panel 16 1/2 in x 7 in. Cut out 15 1/2 in x 6 in. Fuses A.C. 1.5 amp (B.S.) mounted on back panel.

PRICE £85 inc. P. & P.



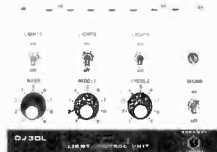
## D.J. 102 DISCOTHEQUE MIXER PRE-AMPLIFIER

Consists of a 4 channel mixer each with its own volume control and a complete P.F.L. monitoring system. Also features a mike cut down switch. For use with amplifiers having tone controls but not having the above facilities. Frequency response 20-20,000 Hz  $\pm$  2db. Distortion less than 1%. Signal to noise ratio better than -65db. Size 10 1/2 in x 4 in x 4 in. Self powered.

PRICE £25 inc. P. & P.

## D.J. 30L PSYCHEDELIC LIGHT CONTROL UNIT

3 channel light control unit that handles up to 1,000 watts per channel. Separate bass, middle and treble controls for full frequency separation. Completely built and tested



PRICE £37.50 inc. P. & P.

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### A RANGE OF SOLDERS IN HANDY DISPENSERS.

REF. ALLOY SWG

4A	60/40	18	15p *
Size 5 (fil-ustra-15)	Savbit	18	15p *
15	60/40	22	20p *

\*Recommended Price



### INVALUABLE FOR STRIPPING FLEX, THE NEW AUTOMATIC OPENING BIB WIRE STRIPPER AND CUTTER, easily adjustable for all standard diameters. Plastic covered handles can also be used as wire cutter. Recommended retail price 50p



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Transistors, etc. AC126 12/p. AF114 15p. AF117 20p. OA5 7/p. OA10 7/p. OA81 7/p. OA85 7/p. OC23 32/p. OC25 30p. OC26 37/p. OC28 42/p. OC32 42/p. OC44 14p. OC45 12/p. OC71 12/p. OC72 12/p. OC75 12/p. OC81 12/p. OC81D 12/p. OC82D 12/p. OC170 20p. OC171 12/p. OC72 12/p. OC75 12/p. BY100 800piv 14p. 6 Amp series: BY213 300piv 20p. BY212 600piv 25p. BY211 900piv 30p. BY210 1200piv 35p. (Charges 6/p up to 11, paid for 12 and over.) Sub-Min. Transformers: OUTPUT (3n for OC72, etc.) 14p. (1p to 6 6/p). MULTIMETER. Our famous 20000  $\Omega$  per V £4.92 (15p). Details and notes for 18K TCR LP, TCMS, TRSLP/STEREO, COLLARO 'O', RONETTE BF40LP, GARRARD GC/LP and GC/LP, ACOS GP65 67, all at 40p (6p) ACOS GP73, GP91, BSR ST4 (ST3, ST5), ST8 (ST9), SONOTONE STA, 9TA, 9TAHC, PHILIPS AC6306, 3050 (3053, 3056, 3301, 3302, 3304) Garrard GK825 all at 75p (6p). All are of the very highest quality. Double Diamond: ST4 (ST3, ST5), ST10 (ST9, ST8), 9TA, 9TAHC, 3206, G91 (For TP), GP93, GP94 cartridges; GP91SC for all GP91-SC cartridges. All at £1.50 (6p). PICK-UP CARTRIDGES. All standard fittings and stylus. MONO GP672 75p STEREO-COMPATIBLE (MONO) GP91/SC (£1.05). STEREO GP93 £1.27. STEREO CERAMIC GP94 £1.92. SONOTONE STEREO 9TAHC (DIA.) £2.37. GOLDRING G850 £4.87. G800 £13.50. G800E £13.50. G800 SUPER £19.50 (6p) all types or Reg. Post 22/p). STYLII FOR ALL ABOVE TYPES, including GOLDRING available. RECORDING TAPE. 8 1/2 in the finest quality Mylar available. Standard 3 1/2 in. 36p. 9 1/2 in. 50p. 7 1/2 in. 40p. 5 1/2 in. 50p. LONG PLAY 7 1/2 in. 50p. 5 1/2 in. 1200 ft. 56p. 7 1/2 in. 1800 ft. 80p. (7/p on 5 1/2 and 7 1/2) 9p on 7 1/2. MICROPHONES Crystal Mic 91, hand/desk 81p. MIC45 Curved metal handgrip £1. CM21 Grey hand/desk 52/p. Stick '60' £1.02. CM70 "Planet" machined metal tapered stick type with neck cord, adaptor to fit floor stands £1.47 (All 6p LAPEL (or hand) with clip 32/p (6p)). All are fitted with leads. Dynamic Cream hand/table MINY 77/p (9p) MS10, 50K  $\Omega$  for desk, tapered with base and slip-out adaptor £1.97. MS11, similar, but fixed on swivel swan neck to swivel-fitted base £2.21 (Either 15p). Type 200 Cardiod ball, 50K/600  $\Omega$ , omnidir., built-in vol. control, on/off switch, special lead, handle (as good as money can buy) £6.30. DM160, Non-Dir. Ball, 50K  $\Omega$ , switch, cable, adaptor £3.87 (27/p either). MICROPHONE INSERTS. Dia. 1.75" OR 0.9" either size 27/p (6p). EARPIECES with lead & min. jack plug (2.5 or 3.5mm, state which) Magnetic 9p Crystal (3.5 only) 24p. (Up to 3 for 6p on any.) HEADPHONES De Luxe STEREO 8-15 ohms, £2.47. Same, fitted vol. control each earpiece, £2.20. Both have lead and stereo jack plug (17/p). HIGH RES. 2000 ohms. Adjustable 92/p (12/p). SPEAKERS. 12" ROUND, fitted tweeter, 3 or 15  $\Omega$  (state which) £1.87 (27/p) (or for Stereo £4.25 pair, carr. paid. 2 1/2" 3 OR 8  $\Omega$  (state which) 37/p (6p). EMI 13" x 8", 3, 8 or 15  $\Omega$  (state which) £2.12 (25p) with single tapered para. tweeter cone 8 or 15  $\Omega$  (state which) £2.27 (25p); with two tweeters and crossover network 8 or 15  $\Omega$  (state which) £3.75 (25p). VIBRATORS. Genuine Plessey LVA 4-pin non-synch. 121H14, 2 1/2 ex. pins 27/p. Ann. 12V 4-pin, non-synch. 7466, longer, 22/p. 12V 7-pin synch. (12SR7) 82/p (all types 61p per vibrator). CONNECTING WIRE. Packs of 5 coils asstd. coils, ea. coil yds. Solid core 14p (6p). Flexible 16p (71p). Super thin for transistor wiring 16p (6p). PICK-UP WIRE. Super thin twin flex, screened and sheathed 6p yd. (6p up to 6yds.—over, free). RETRACTABLE Flex. Leads. (Curles) 611, phono plug ea. end 22/p. (2ft. 39p. 6ft. phono plug/phone socket other end 25p 12ft. 42/p (6p per lead, all types). BATTERY ELIMINATOR. 240 a.c. input 3, 6, 7 1/2 and v. 42/p (6p per lead, all types). APPLIANCE INCL. all makes cassette recorder and players £3.15 (24p). SEND S.A.E. for full free lists—Teleton and small 3W and 7 1/2W trans. amplifiers, Electrolytics, Vol. Controls, all types of radio switches, car and portable expanding aereals, Meters, Test procs, all types of Brit. & Cont. standard and min. plugs and sockets, SDR's, Thyristors, croc. clips (various), terminals, etc. etc. and many "Special Offer" lines at lowest possible prices.

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# Britains most popular kits..

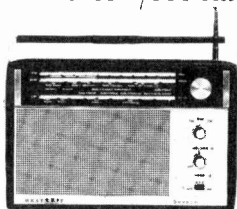
**Heathkit the beginner as well as the experienced mans first choice.**  
**Want to know more . . .** the unique Heathkit one-step-at-a-time construction manual is your guarantee to kit building success. To see for yourself how easy it all is, simply order the manual for the model of your choice (price only 10/- each). If you order a kit at a later date the manual price can be deducted. Your first step is to send for the Free catalogue, yours for only the price of a postage price stamp.

## Stereo Record Player



Exciting Sound — Budget Price  
 Kit: K/SRP-1 - - £32.50  
 Carr. 80 NP

## 'SEVERN' AM/FM Radio



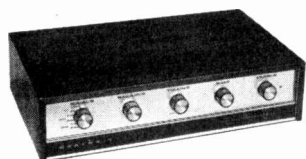
Beautiful Looks — Luxury Sound  
 Kit: K/SEVERN - £19.90  
 Carr. 50 NP

## Powerful Car Radio



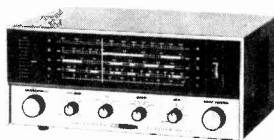
Heathkit Value—Powerful Output  
 Kit: K/CR-1 (Less Speaker) £13.80  
 Carr. 30 NP

## 30W Stereo Amplifier



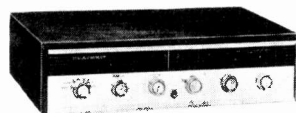
Stereo Gram, Radio, Aux inputs  
 Kit: K/TSA-12 £36.00  
 (cab extra) Carr. 50 NP

## Economy SW Receiver



World-wide Reception  
 1 to 30 MHz plus 550-1620 KHz  
 Kit: K/GR-64 - - £25.00  
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## Stereo tuner/amplifier



One of todays best values  
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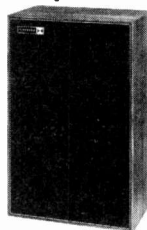
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25/4/71

# The Gerry





# y Adler Story.

Once upon a time Gerry Adler worked a 25 hour day making and selling valve filament testers. And very efficient they were too.

But at that time the Japanese could make them for about half the price, and sent Gerry one to prove it. It was as good as the ones he was making, so he sold it. And every other one he could get into the country.

After a time Gerry decided to go one step further. He designed some electronic equipment and had it built to his specification in Japan. Then he sold it here under the brand name 'Eagle'. Nothing particularly remarkable about that. But Gerry couldn't stand the idea of a barrier between him and his manufacturers. So he went to Japan. He poked his nose into all the electronics factories to find out how the Japanese worked. And when he got back he started to learn Japanese, and to study their history, culture and way of life. That way he had fewer communication problems and could get what he wanted.

That's what matters to Gerry. He's very fussy about what goes out under the Eagle banner. Because Eagle aren't in the filament testing business any more. They make just about everything electronic: amplifiers, test equipment, PA systems, intercoms, old uncle substation and all. Eagle is now twelve years old, and has opened offices in New York, Tokyo and Brussels.

This isn't just so much chest expansion on Gerry's part. He puts his money where his mouth is. If you think one of his products is not as good as a rival's, or it's faulty, or it's not all it should be, Gerry wants to know.

So write to him personally. He'll do something about it. He wants to make sure the Gerry Adler story has a happy ending.

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# NEW FROM TRS

This money saving **STEREO 8 + 8 AMPLIFIER** in a new **PRE-ASSEMBLED MODULAR PRESENTATION**

A new conception in modular assembly which makes construction even easier than ever and results even better. Two pre-amp and two power amp modules, factory built, tested and guaranteed by a world famous maker come to you ready mounted with mains power unit on chassis forming part of the attractive TRS cabinet which simply need wiring for immediate use. A generous 8 watt RMS output per channel into 3-5 ohms is assured. Cabinet with aluminium front, charcoal grey top and wood sides measures 12in x 8in x 2in. Very attractive appearance.

- Frequency resp.: 50Hz-16kHz  $\pm$  3dB.
- Input: 110mV per P.U., radio 240mV.
- Output: 8W per channel, RMS into 3-5 $\Omega$ . Slightly less per 8-15 $\Omega$  speakers.
- Record and playback facilities
- Bass/Treble/Volume/Balance/ Input/On-off controls.
- Extra easy to install.



Complete kit assembled ready to wire up with mains lead and instructions. Unsurpassed value at only

**£17.50**

Carriage and packing 38p in U.K.  
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## COMPONENTS CORNER

**VYNAIR** speaker and cabinet covering by ICI. Send 5p for samples—refundable on purchase. 12 $\frac{1}{2}$ p per sq. ft. £1.38 per yd. 48in wide.

**BONDACOUST** speaker wadding 1in thick, 18in wide, per yard 42 $\frac{1}{2}$ p.

**VEROBOARD** in all latest sizes and forms. inc. 2 $\frac{1}{2}$ in x 3 $\frac{1}{2}$ in, 16p; 2 $\frac{1}{2}$ in x 5in or 3 $\frac{1}{2}$ in x 3 $\frac{1}{2}$ in, 23p; 3 $\frac{1}{2}$ in x 5in, 26p; 17in x 3 $\frac{1}{2}$ in, 75p.

**VOLUME CONTROLS.** Long spindles all values 5Kohms to 2meg., log or lin., less switch 17 $\frac{1}{2}$ p; with switch 25p.

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**RESISTORS, CAPACITORS, WIRE,** etc., etc.

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5-10 basic kit (mono) £18.99. Carr. 28p.  
2 valve mono pre-amp basic kit for above £7-65. Carr. 28p.  
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### TRS 50 WATT VALVE AMPLIFIER

A ruggedly built unit in ventilated steel case with carrying handles: size 12in x 8in x 8in. Two input channels mixable (10mV and 150mV) bass and treble controls. EL 34's output (mono) in push-pull, with fixed bias. Excellent for P.A., musical group work, etc. Brand new and guaranteed £30. Carriage 75p.

# TRS RADIO COMPONENT SPECIALISTS

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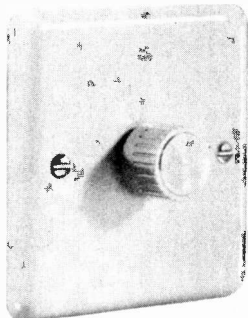
Acos stereo 6P93-1 (sapphire) £1.25.  
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Loft Mounting Arrays. 7 element, 45-; 11 element, 52.6; 14 element, 60-; 18 element, 70-; Wall Mounting with Cranked Arm, 7 element, 65-; 11 element, 75-; 14 element, 82.6; 18 element, 90-; Chimney Mounting Arrays Complete, 7 element, 80-; 11 element, 87.6; 14 element, 95-; 18 element, 105-. Complete assembly instructions with every aerial. Low Loss Co-axial Cable, 1.8 yd. King Teletesters—Labgear U.H.F. Boosters from 75-. Bellini Lee "Concord" all Band V.H.F. U.H.F. mains operated pre-amp £7.10.0. State clearly channel number required on all orders. p.p. Aerials 8-. Accessories 3-. C.W.O. or C.O.D.

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F.M. Radio Loft S.D. 19.6, "H", 38.6, 3 element array, 57.6, Standard co-axial cable, 1 - yd. Coax plugs, 1.8. Outlet boxes, 6-. Diplexer crossover boxes, 17.6. p.p. Aerials, 8-; accessories, 3-; C.W.O. or C.O.D. (min. C.O.D. charge 3.6.) 1 - for fully illustrated Lists.

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No batteries—no wires. Just plug in the mains for instant two-way, loud and clear communication. On/off switch and volume control with lock system. Price £12.95. P. & P. 50p extra.

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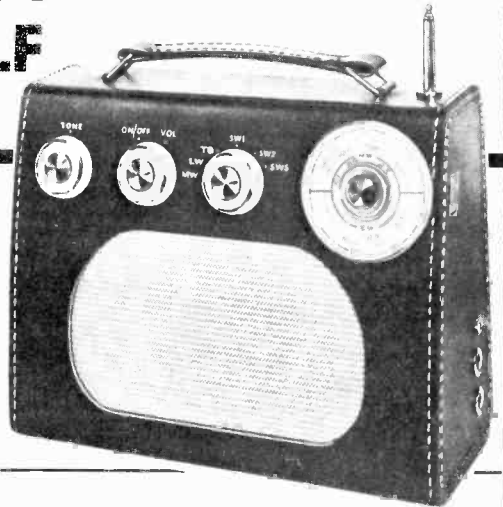
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## NEW! roamer eight mk 1 WITH VARIABLE TONE CONTROL

7 Tunable Wavebands: Medium Wave 1, Medium Wave 2, Long Wave, S.W.1, S.W.2, S.W.3 and Trawler Band. Built-in ferrite rod aerial for Medium and Long Waves. 4 section 24in. retractable chrome plated telescopic aerial for Short Waves for maximum performance. Push-pull output using 600Mw type transistors. Socket for car aerial. Tape record socket. Selectivity switch. Switched earpiece socket complete with earpiece for private listening. 8 transistors plus 3 diodes. Famous mkrke 7 4in speaker. Air spaced ganged tuning condenser. On/off switch volume control. Wave change switch and tuning control. Attractive case in rich chestnut shade with gold blocking. Size 9 7 4in approx. Easy to follow instructions and diagrams make the Roamer Eight a pleasure to build. Parts price list and easy build plans 25p (6/-) (FREE with parts).

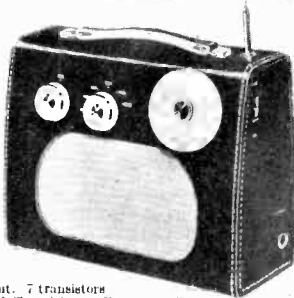
**Total building costs** **£6.98** P. & P. 38p (7/7) Overseas P. & P. 85p (17/-)  
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## roamer seven mk IV

7 FULLY TUNABLE WAVEBANDS—M.W.1, M.W.2, L.W., S.W.1, S.W.2, S.W.3 and Trawler Band. Extra Medium waveband provides easier tuning of Radio Luxembourg, etc. Built in ferrite rod aerial for Medium and Long Waves. Retractable 4 section 24in chrome plated telescopic aerial for peak short wave listening. Socket for Car Aerial. Powerful push-pull output. 7 transistors and two diodes including Micro-Alloy R.F. Transistors. Famous mkrke 7 4in P.M. speaker. Air spaced ganged tuning condenser. Volume/on/off control. Wave change switches and tuning control. Attractive case with carrying handle. Size 9 7 4in approx. Easy to follow instructions and diagrams make the Roamer 7 a pleasure to build. Parts price list and easy build plans 15p (3/-) (FREE with parts).

**Total building costs** **£5.98** P. & P. 38p (7/7) Personal Earpiece with plug and switched socket for private listening, 30p (6/-) extra.  
(£5.19.7) Overseas P. & P. 85p (17/-)

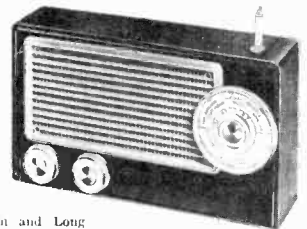


## NEW!

## transeight SIX WAVEBAND PORTABLE WITH 3in. SPEAKER

Attractive case in black with red grille and black knobs and dial with spun brass inserts. Size 9 7 5 1/2 2 1/2in. approx. Tunable on Medium and Long Waves, 3 Short Waves and Trawler Band. Sensitive ferrite rod aerial for M.W. and L.W. Telescopic aerial for Short Waves. 8 improved type transistors plus 3 diodes. Push-pull output. Battery economiser switch for extended battery life. Ample power to drive a larger speaker. Parts price list and easy build plans 25p (6/-) (FREE with parts).

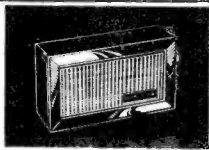
**Total building costs** **£4.48** P. & P. 28p (5/7) Earpiece with plug and switched socket for private listening, 30p (6/-) extra.  
(£4.9.7) Overseas P. & P. 65p (13/-)



## pocket five

### MEDIUM WAVE, LONG WAVE AND TRAWLER BAND PORTABLE WITH SPEAKER

Attractive black and gold case. Size 5 1/2 x 1 1/2 x 2 1/2in. Tunable over both Medium and Long Waves with extended M.W. band for easier tuning of Luxembourg, etc. 7 stages 5 transistors and 2 diodes, sensitive ferrite rod aerial, fine tone moving coil speaker. Easy build plans and parts price list 8p (1/7) (FREE with parts). Earpiece with plug and switched socket for private listening, 30p (6/-) extra.



**Total building costs** **£2.23** P. & P. 18p (3/7)  
(£2.4.7) Overseas P. & P. 50p (10/-)

## transona five

### MEDIUM WAVE, LONG WAVE AND TRAWLER BAND PORTABLE WITH SPEAKER

Attractive case with red speaker grille. Size 6 1/2 x 4 1/2 x 1 1/2in. 7 stages 5 transistors and 2 diodes, ferrite rod aerial, tuning condenser, volume control, fine tone moving coil speaker. Easy build plans and parts price list 8p (1/7) (FREE with parts). Earpiece with plug and switched socket for private listening, 30p (6/-) extra.

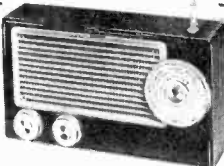


**Total building costs** **£2.38** P. & P. 19p (3/9)  
(£2.7.7) Overseas P. & P. 50p (10/-)

## IMPROVED MODEL !

### roamer six SIX WAVEBAND PORTABLE WITH 3in. SPEAKER

Attractive black case with red grille and black knobs and dial with spun brass inserts. Size 9 7 5 1/2 2 1/2in. approx. Tunable on Medium and Long Waves, two Short Waves, Trawler Band plus an extra M.W. band for easier tuning of Luxembourg, etc. Sensitive ferrite rod aerial and latest telescopic aerial for Short Waves. Improved circuit. 8 stages—6 transistors and 2 diodes including Micro-Alloy R.F. Transistors, etc. Easy build plans and parts price list 10p (2/-) (FREE with parts). Earpiece with plug and switched socket for private listening, 30p (6/-) extra.



**Total building costs** **£3.98** P. & P. 23p (4/7)  
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$\frac{1}{4}$	10%	1 $\Omega$ -3.9 $\Omega$	E12	1-0p 0-7p
$\frac{1}{4}$	5%	4.7 $\Omega$ -1M $\Omega$	E12	1-0p 0-7p
$\frac{1}{4}$	10%	1 $\Omega$ -10 $\Omega$	E12	7 $\frac{1}{2}$ p 7 $\frac{1}{2}$ p

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

### DEVELOPMENT PACK

0.5 watt 5% Iskra resistors 5 off each value 4.7 $\Omega$  to 1M $\Omega$ .

E12 pack 325 resistors £2.20.

E24 pack 650 resistors £4.20.

### MULLARD POLYESTER CAPACITORS C296 SERIES

400V: 0.001 $\mu$ F, 0.0015 $\mu$ F, 0.0022 $\mu$ F, 0.0033 $\mu$ F, 0.0047 $\mu$ F, 2 $\frac{1}{2}$ p. 0.0068 $\mu$ F, 0.01 $\mu$ F, 0.015 $\mu$ F, 0.022 $\mu$ F, 0.033 $\mu$ F, 3p. 0.047 $\mu$ F, 0.068 $\mu$ F, 0.1 $\mu$ F, 4p. 0.15 $\mu$ F, 6p. 0.22 $\mu$ F, 7 $\frac{1}{2}$ p. 0.33 $\mu$ F, 11p. 0.47 $\mu$ F, 13p. 160V: 0.01 $\mu$ F, 0.015 $\mu$ F, 0.022 $\mu$ F, 0.033 $\mu$ F, 0.047 $\mu$ F, 0.068 $\mu$ F, 3p. 0.1 $\mu$ F, 0.15 $\mu$ F, 0.22 $\mu$ F, 4p. 0.33 $\mu$ F, 6p. 0.47 $\mu$ F, 7 $\frac{1}{2}$ p. 0.68 $\mu$ F, 11p. 1.0 $\mu$ F, 12 $\frac{1}{2}$ p.

### MULLARD POLYESTER CAPACITORS C280 SERIES

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### MYLAR FILM CAPACITORS

100V: 0.001 $\mu$ F, 0.002 $\mu$ F, 0.005 $\mu$ F, 0.01 $\mu$ F, 0.02 $\mu$ F, 2 $\frac{1}{2}$ p. 0.04 $\mu$ F, 0.05 $\mu$ F, 0.068 $\mu$ F, 0.1 $\mu$ F, 3 $\frac{1}{2}$ p.

### CERAMIC DISC CAPACITORS

100pF to 10,000pF, 2p each.

### CAPACITOR DEVELOPMENT PACK

Selection of 100 ceramic and polyester capacitors, 100pF to 1.0 $\mu$ F, £2.90.

### ELECTROLYTIC CAPACITORS—One Price—5p Each

Mullard C426 series ( $\mu$ F/V): 25/6.4, 50/6.4, 100/6.4, 200/6.4, 320/6.4, 16/10, 32/10, 64/10, 125/10, 200/10, 10/16, 20/16, 40/16, 80/16, 125/16, 6.4/25, 12.5/25, 25/25, 50/25, 80/25, 4/40, 8/40, 16/40, 32/40, 50/40, 2.5/64, 5/64, 10/64, 32/64. Miniature P.C. mounting ( $\mu$ F/V): 10/12, 50/12, 100/12, 200/12, 5/25, 10/25, 25/25, 100/25.

### POTENTIOMETERS

Carbon track 5k $\Omega$  to 1M $\Omega$ , log or linear (log  $\frac{1}{2}$ W, lin  $\frac{1}{2}$ W).

Single, 12 $\frac{1}{2}$ p. Dual gang (stereo), 40p.

### SKELETON PRESET POTENTIOMETERS

Linear: 100, 250, 500 $\Omega$  and decades to 5M $\Omega$ . Horizontal or vertical P.C. mounting (0-1 matrix).

Sub-miniature 0.1 watt, 4p each. Miniature 0.25 watt, 5p each.

### SEMICONDUCTORS

AC126 15p	BFY52 22 $\frac{1}{2}$ p	OC81 15p	2N3055 72p
AC127 15p	BSY56 30p	OC82 15p	2N3702 15p
AC128 15p	BSX21 25p	ORP12 47 $\frac{1}{2}$ p	2N3703 14p
AD140 40p	BY124 7 $\frac{1}{2}$ p	IN4001 7 $\frac{1}{2}$ p	2N3704 17 $\frac{1}{2}$ p
AF115 17 $\frac{1}{2}$ p	BYZ10 30p	IN4002 10p	2N3705 15p
AF117 17 $\frac{1}{2}$ p	BYZ13 20p	IN4003 11p	2N3706 12p
BC107 14p	OA85 7 $\frac{1}{2}$ p	IN4004 12 $\frac{1}{2}$ p	2N3707 18 $\frac{1}{2}$ p
BC108 10p	OA91 7 $\frac{1}{2}$ p	IN4005 14p	2N3708 10p
BC109 10p	OA202 7 $\frac{1}{2}$ p	IN4006 15p	2N3709 11p
BFY50 22p	OC71 15p	IN4007 16p	2N3710 12p
BFY51 19p	OC72 15p	2N2926 11p	2N3711 14p

### ZENER DIODES

400mW 5% 3.3V to 30V, 17 $\frac{1}{2}$ p.

### VEROBOARD

2 $\frac{1}{2}$ x 3 $\frac{1}{2}$	0-1 22p	0-15 16p	17 x 3 $\frac{1}{2}$ (plain)	0-15 52 $\frac{1}{2}$ p	0-1 —
2 $\frac{1}{2}$ x 5	24p	24p	17 x 2 $\frac{1}{2}$ (plain)	37 $\frac{1}{2}$ p	—
3 $\frac{1}{2}$ x 3 $\frac{1}{2}$	24p	24p	2 $\frac{1}{2}$ x 5 (plain)	17 $\frac{1}{2}$ p	—
3 $\frac{1}{2}$ x 5	27p	27p	2 $\frac{1}{2}$ x 3 $\frac{1}{2}$ (plain)	15p	—
17 x 2 $\frac{1}{2}$	75p	57 $\frac{1}{2}$ p	Pin insertion tool	47 $\frac{1}{2}$ p	47 $\frac{1}{2}$ p
17 x 3 $\frac{1}{2}$	100p	75p	Spot face cutter	37 $\frac{1}{2}$ p	37 $\frac{1}{2}$ p
17 x 5 (plain)	—	75p	Pkt. 3 $\phi$ pins	15p	15p

### ROTARY SWITCHES

2P2W, 1P12W, 2P6W, 3P4W, 4P3W, 22 $\frac{1}{2}$ p.

### PLUGS AND SOCKETS

Standard $\frac{1}{4}$ in screened	17 $\frac{1}{2}$ p	2.5mm insulated	7 $\frac{1}{2}$ p
Standard $\frac{1}{4}$ in insulated	14p	3.5mm insulated	7 $\frac{1}{2}$ p
Stereo $\frac{1}{4}$ in screened	35p	3.5mm screened	12 $\frac{1}{2}$ p
Standard $\frac{1}{4}$ in socket	15p	2.5mm socket	7 $\frac{1}{2}$ p
Stereo $\frac{1}{4}$ in socket	17 $\frac{1}{2}$ p	3.5mm socket	7 $\frac{1}{2}$ p

### BRUSHED ALUMINIUM PANELS

12" x 6" = 25p; 12" x 2 $\frac{1}{2}$ " = 10p; 9" x 2" = 7p.

C.W.O. please. Post and packing, please add 7 $\frac{1}{2}$ p to orders under £2. Data sheets are available for most of the components listed, and will be sent free on request.

BE39 ELSTOW STORAGE DEPOT, KEMPSTON HARDWICK, BEDFORD

Send 5p for New Comprehensive I.C. and Semiconductor price list (24 pages)

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RCA	4p	MOTOROLA	1-9	10+	20+	MULLARD	4p
CA3000	1-80	MC708G	0.91	—	0.76	LINEAR	—
3005	7	MC724P	0.66	—	0.65	TAA241	1.62 $\frac{1}{2}$
7	2-65	MC788P	0.82	—	0.69	242	4.25
11	0.75	MC789P	0.66	—	0.66	243	1.60
12	0.90	MC790P	1.24	—	1.08	263	0.77 $\frac{1}{2}$
13	1.05	MC792P	0.66	—	0.66	293	0.97 $\frac{1}{2}$
14	1.25	MC799P	0.66	—	0.65	300	1.75
18	0.85	MC1303L	2.70	—	2.25	310	1.25
18A	1.10	MC1304P	3.60	—	3.00	320	0.72 $\frac{1}{2}$
19	0.85	MC1582G	4.61	—	3.84	320	1.75
20	1.30	MC1435L	3.45	—	2.87	435	1.47 $\frac{1}{2}$
20A	1.60	MC1590G	0.95	—	0.82	521	1.32 $\frac{1}{2}$
21	1.60	Data sheets	0.12	extra	—	522	3.60
22	1.80	FAIRCHILD	1-5	6-11	12+	530	4.95
23	1.80	29	2p	3p	4p	511	—
26	1.00	29A	1-65	0.40	0.37	520	0.97 $\frac{1}{2}$
28A	0.75	30	1.40	0.40	0.37	TAD100	1.97 $\frac{1}{2}$
28B	1.05	35	1.25	0.40	0.37	TAD110	1.87 $\frac{1}{2}$
29	0.90	36	0.75	1.05	0.97	MULLARD DTL	—
29A	1.65	39	0.85	0.60	0.57	FCH101	0.87 $\frac{1}{2}$
30	1.40	41	1.10	0.75	0.67	FCH121	1.05
35	1.25	42	1.10	0.75	0.67	FCH201	1.32 $\frac{1}{2}$
36	0.75	43	1.40	1.20	1.00	FCH231	1.50
39	0.85	44	1.20	0.75	0.67	FCJ101	1.82 $\frac{1}{2}$
41	1.10	45	1.25	0.85	0.75	FCJ111	1.55
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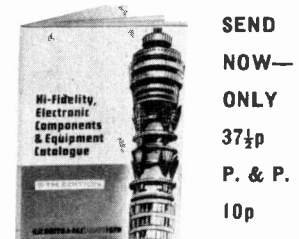
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2N1308	25p	BC113	25p	OA85	12p	6BW7	75p	DK96	42p	PCF80	50p
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2N1613	25p	BC125	55p	OA91	7p	6C4	33p	DL84	45p	PCF82	35p
2N1711	25p	BC126	55p	OA95	7p	6D16	50p	DL96	42p	PCF82	35p
2N1888	32p	BC147	17p	OA200	7p	6CL6	50p	DM70	32p	PCF82	35p
2N1893	32p	BC148	17p	OA201	7p	6C4	50p	DY86	32p	PCF82	35p
2N2147	75p	BC149	20p	OA210	17p	6CW4	60p	DY87	32p	PL200	70p
2N2160	65p	BC167	15p	OC19	37p	6F64	30p	E88CC	65p	PL26	55p
2N2193	47p	BC172	17p	OC20	97p	6F13	30p	E180F	65p	PL26	55p
2N2217	40p	BC177	25p	OC22	50p	6F14	65p	E180F	65p	PL26	55p
2N2218	40p	BC182L	10p	OC23	60p	6F15	65p	EAF42	35p	PL43	45p
2N2219	40p	BC184L	12p	OC24	60p	6F18	45p	E8B1	20p	PL48	40p
2N2368	37p	BC196	25p	OC25	37p	6F23	45p	EBC41	35p	PL500	75p
2N2369	20p	BC212L	12p	OC26	25p	6H6	20p	EBC81	35p	PL504	80p
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2N2454	30p	BCY31	30p	OC29	62p	6J5	20p	EF83	40p	PY32	55p
2N2455	30p	BCY32	30p	OC30	62p	6J5GT	20p	EF89	35p	PY80	35p
2N2646	50p	BCY33	25p	OC36	25p	6J6	20p	ELB21	60p	PY81	30p
2N2647	50p	BCY34	25p	OC41	25p	6J7	20p	E8C6	60p	PY81	30p
2N2923	17p	BCY38	40p	OC42	30p	6K6G	35p	E8C8	60p	PY88	38p
2N2924	17p	BCY42	15p	OC44	17p	6L6GT	35p	ECU40	60p	PY88	38p
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2N2926Y	12p	BCY72	15p	OC70	12p	68A7	40p	ECF80	35p	U26	75p
2N2926O	12p	BCZ11	15p	OC71	15p	68G7	35p	ECF82	35p	U50	32p
2N3053	25p	BD123	25p	OC72	25p	68T7	35p	ECF86	65p	U52	33p
2N3054	50p	BD123	30p	OC73	30p	68T7	35p	ECH21	57p	U191	65p
2N3055	75p	BD124	80p	OC74	30p	68L7	35p	ECH35	60p	U281	40p
2N3391A	30p	BF115	25p	OC75	25p	68N7	35p	ECH42	70p	U282	40p
2N3416	37p	BF117	40p	OC76	25p	68Q7	35p	ECH81	30p	U301	40p
2N3370	11-25	BF167	25p	OC77	40p	6V	20p	ECH83	40p	U801	21
2N3702	12p	BF178	25p	OC78	25p	6V6G	25p	ECL80	40p	UABC80	35p
2N3703	12p	BF180	27p	OC81	25p	6X5GT	30p	ECL82	35p	UAF42	55p
2N3704	17p	BF181	27p	OC81B	20p	6X5GT	30p	ECL83	35p	UFC41	60p
2N3705	15p	BF182	25p	OC83	25p	6X6G	40p	ECL86	40p	UFC42	60p
2N3706	25p	BF184	25p	OC84	25p	6X6GT	27p	EP37A	40p	UBF80	40p
2N3707	15p	BF185	25p	OC139	25p	10C2	50p	EF39	60p	UBF89	35p
2N3708	17p	BF194	17p	OC140	37p	10F1	50p	EF40	60p	UCC84	48p
2N3709	15p	BF195	15p	OC169	20p	10P13	55p	EF41	60p	UC85	40p
2N3710	12p	BF200	30p	OC170	25p	10P14	11-10	EF42	70p	UC86	55p
2N3711	12p	BF224	30p	OC171	30p	12A76	30p	EF80	60p	UC87	55p
2N3819	35p	BF225	30p	OC200	40p	12A77	30p	EF85	50p	UC87	55p
2N3903	25p	BF244	47p	OC201	60p	12A77	30p	EF86	30p	UCHR1	35p
2N3904	25p	BFX12	25p	OC202	75p	12A76	30p	EF89	28p	UCL82	35p
2N3905	30p	BFX13	25p	OC203	60p	12A77	30p	EF91	35p	UCL83	60p
2N3906	30p	BFX19	30p	OC204	40p	12A7X	30p	EF92	40p	UF41	60p
2N4058	17p	BFX30	30p	OC205	62p	12B86	35p	EF193	30p	UF80	35p
2N4059	25p	BFX44	37p	OC207	75p	12B87	40p	EP184	45p	UF85	40p
2N4061	15p	BFX85	40p	OC207	75p	12B87	40p	EP184	45p	UF85	40p
2N4062	15p	BFX86	40p	OC207	75p	12B87	40p	EP184	45p	UF85	40p
2N4286	15p	BFX87	35p	ORP60	40p	20D1	45p	EL33	11-25	UF89	35p
2N4287	17p	BFY90	25p	P346A	25p	20F2	75p	EL34	25p	UL41	60p
2N4288	15p	BFY18	25p	PL4001	14p	20L1	11-10	EL41	55p	UL41	30p
2N4289	17p	BFY20	65p	PL4002	16p	20P1	50p	EL42	55p	UL84	45p
2N4290	15p	BFY50	25p	PL4003	16p	20P3	60p	EL41	55p	UR85	30p
2N4291	15p	BFY51	20p	PL4004	17p	20P4	11-10	EL84	25p	VR150/30	35p
2N4292	15p	BFY52	25p	PL4005	17p	20P5	11-20	EL85	45p	VR150/30	35p
2N4354	27p	BFY90	67p	PL4006	20p	25L6	45p	EL81	32p	VR150/30	35p
2N4355	27p	B8X19	17p	PL4007	24p						
28102	25p	B8X20	17p	T1843	40p						
28103	37p	B8X21	37p	T1844	12p						
28104	37p	B8X76	17p	T1845	17p						
40220	50p	B8Y26	15p	T1846	17p						
40361	50p	BC107/8/9	15p								
40362	60p	BC107/8/9	15p								
AC107	37p	B8Y38	20p	25+	10p						
AC126	25p	B8Y39	25p	100+	9p						
AC127	25p	B8Y39	25p	500+	7p						
AC128	25p	B8Y39	25p	2N3055							
AC154	15p	B8Y56	90p	100+	65p						
AC176	25p	B8Y93A	15p	100+	50p						

## VALVES

38p	25Z4	30p	EL55	35p
45p	25Z5	45p	EM80	40p
50p	25Z6	50p	EM81	50p
55p	30C15	55p	EM84	55p
55p	30C17	55p	EM85	55p
25p				

### RUSSIAN C1-16 DOUBLE BEAM OSCILLOSCOPES

5MHz Pass Band. Separate Y1, Y2 amplifiers. Calibrated triggered sweep from 0.2µsec to 100msec/cm. Supplied complete with all accessories and instructions. £87. Carr. paid.



### MARCONI CT44/TF956 AF ABSORPTION WATTMETER

1 µwatt to 6 watts. £20. Carr. £1.

### TELLI DECADE RESISTANCE ATTENUATOR

Variable range 0-11dB. Connections. Unbalanced T and Bridge T. Impedance 600 Ω range (0-1dB × 10) + (1dB × 10) + 10 + 20 + 30 + 40dB. Frequency: d.c. to 200kHz. (—3dB). Accuracy: 0.05dB. + indication 0.5 × 0.01. Maximum input less than 4W (50V). Built in 600 Ω load resistance with internal/external switch. Brand new £27.50. P. & P. 25p.



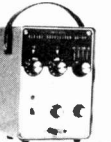
### BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR



Sine 18-200,000Hz; Square 18-50,000Hz. Output max +10dB (10K Ω). Operation internal batteries.

Attractive two-tone case 7 1/2" × 5 1/2" × 2 1/2". Price £17.50. Carr. 17p.

### BELCO DA-20 SOLID STATE DECADE AUDIO OSCILLATOR



New high quality portable instrument. Sine 1Hz to 100kHz. Square 20Hz to 20kHz. Output max +10dB (10K Ω). Operation 220/240V a.c. Size 215mm × 150mm × 120mm. Price £27.50. Carr. 25p.

### T.E.40 HIGH SENSITIVITY A.C. VOLTMETER

10 meg. input 10 ranges: -0.1 / -0.03 / -1 / -3 / 1 / 3 / 10 / 30 / 100 / 300V. R.M.S. 4c/s. ±1-2mV. Decibels -40 to +50dB. Supplied brand new complete with leads and instructions. Operation 230V a.c. £17.50. Carr. 25p.



### TE-65 VALVE VOLTMETER



High quality instrument with 28 ranges. D.c. volts 1.5-1,500V. A.c. volts 1.5-1,500V. Resistance up to 1,000 megohms. 220/240V a.c. operation. Complete with probe and instructions. £17.50. P. & P. 30p. Additional Probes available: R.F. £2.12; H.V. £2.50.

### 230 VOLT A.C. 50 CYCLES RELAYS



Brand New. 3 sets of changeover contacts at 5 amp rating. 50p each. P. & P. 15p. £100 lots £40. Quantities available.

## MULTIMETERS for EVERY purpose!



**TECH PT-34, 1,000 O.P.V.** 0/10/50/250/500/1,000V a.c. and d.c. 0/1/100/500mA. d.c. 0/100K. £1.97; P. & P. 12p.



**MODEL TE-200, 20,000 O.P.V.** Mirror scale, overload protection. 0/5/25/125/1,000V d.c. 0/10/50/250/1,000V a.c. 0/30/1A/250MA. 0/60K/6 meg. -20 to +62dB. £3.75. P. & P. 15p.



**MODEL 500, 30,000 O.P.V.** with overload protection, mirror scale 0/5/25/125/1,000V d.c. 0/2.5/10/25/100/250/500/1,000V a.c. 0/50/500/50/1,000 mA. 12 amp. d.c. 0/60K/6 Meg./60 Meg. £3.87; Post paid.



**MODEL TE-70, 30,000 O.P.V.** 0/3/15/60/300/600/1,200V d.c. 0/6/30/120/600/1,200V a.c. 0/30/1A/3/30/300MA. 0/16K/160K/1.6M/16 meg. £5.50. P. & P. 15p.



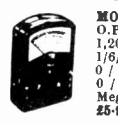
**TMK MODEL TW-50K, 46 ranges, mirror scale.** 60K Volt d.c. 5K/Volt a.c. D.c. volts: 0.125, 0.25, 1.25, 2.5, 5, 10, 25, 50, 125, 250, 500, 1,000V. A.c. volts: 1.5, 3, 5, 10, 25, 50, 125, 250, 500, 1,000V. D.c. current: 25, 50µA, 2.5, 5, 25, 50, 250, 500mA, 5, 10A. Resistance: 10K, 100K, 1 meg., 10 meg. Decibels: -20 to +81.3dB. £3.87; P. & P. 17p.



**TE-900 20,000 VOLT GIANT MULTIMETER.** Mirror scale and overload protection. 6in full view meter. 2 colour scale. 0/2.5/10/250/1,000/5,000V a.c. 0/25/125/510/500/250/1,000V d.c. 0/50µA/1/10/100/500/10A. d.c. 0/2K/200K/20 meg. ohm. £15. P. & P. 25p.



**MODEL 5025, 57 ranges, giant 6 1/2in meter, polarity reverse switch.** Sensitivity: 50K/Volt d.c. 5K/Volt a.c. D.c. Volts: 0.125, 0.25, 1.25, 5, 10, 25, 50, 125, 250, 500, 1,000V. A.c. Volts: 1.5, 3, 5, 10, 25, 50, 125, 250, 500, 1,000V. D.c. current: 25, 50µA, 2.5, 5, 25, 50, 250, 500mA, 5, 10A. Resistance: 2K, 10K, 100K, 1 meg, 10 meg. Decibels: -20 to +85dB. £12.50. P. & P. 17p.



**MODEL TE12, 20,000 O.P.V.** 0/0.6/30/120/600/1,200/3,000/6,000V d.c. 1/6/30/120/600/1,200V a.c. 0/60µA/3/5/60/600MA. 0/1K/600K/6meg./60Megohm 30PF. 2 MF. £5.97; P. & P. 17p.

### FTC-401 TRANSISTOR TESTER

Full capabilities for measuring A, B and IC0, npn or pnp. Equally adaptable for checking diodes. Supplied complete with instructions, battery and leads. £3.97; P. & P. 15p.



**HONOR TE.10A, 20k Ω/Volt** 5/25/50/250/500/2,500V a.c. 10/50/100/500/1,000V a.c. 0/50/1A/250MA. 0/60K/6 meg. ohm. -20 to +22dB. 10-0, 100 mfd. 0.100-0.1 mfd. £3.47; P. & P. 15p.

**MODEL TE-300, 30,000 O.P.V.** Mirror scale, overload protection 0/0.6/3/15/60/300/1,200V d.c. 0/6/30/120/600/1,200V a.c. 0/30/1A/300MA/600MA/600MA/8 meg. -20 to +63dB. £5.97; P. & P. 15p.

**MODEL TE 80, 20,000 O.P.V.** 0/10/50/100/500/1,000V. a.c. 0/5/25/50/250/500/1,000V d.c. 0.5µA. 5/50/500MA. 0/6K/60K/600K/6 Meg. £4.87; P. & P. 15p.

**MODEL TE-90, 50,000 O.P.V.** Mirror scale, overload protection. 0/0.13/60/300/600/1,200V d.c. 0/6/30/120K/1,200V d.c. 0/6/30/60K/600MA. d.c. 16K/160K/1.6/16 meg. -20 to +63dB. £7.50. P. & P. 15p.

**TMK MODEL TW-200B.** Features: Resettable Overload Button. Sensitivity: 20K Ω/Volt d.c. 5K Ω/Volt a.c. D.c. volts: 0-0.5, 2.5, 10, 50, 250, 1,000V. A.c. volts: 0-0.5, 0.5, 5, 50, 500mA. Resistance: 0-5K, 50K, 0-500K, 5 meg. Decibels: -20 to +62dB. £11.50. P. & P. 17p.

**MODEL AB-100D, 100K Ω/Volt.** 5in. mirror scale. Built-in meter protection 0/3/12/60/120/300/600/1,200V d.c. 0/6/30/120/300/600V a.c. 0/10µA/6/60/300/12A. 0/2K/200K/2M/200M. -20 to +17dB. £12.50. P. & P. 17p.

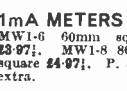
**TMK LAB TESTER, 100,000 O.P.V.** 6 1/2in scale buzzer short circuit check. Sensitivity: 100,000 OPV d.c. 5/Volt a.c. D.c. volts: 0.5, 2.5, 10, 50, 250, 1,000V. A.c. volts: 3, 10, 50, 250, 500, 1,000V. D.c. current: 10, 100µA, 10, 100, 500mA, 2.5, 10A. Resistance: 1K, 10K, 100K, 10 meg, 100 meg. Decibels: -10 to +40dB. Plastic case with carrying handle, size 7 1/2" × 6 1/2" × 3 1/2". £18.90. P. & P. 25p.

### SKYWOOD SW-500



50 K Ω/Volt. Mirror scale DC Volts 0.6/3/12/30/300/600. AC Volts 3/30/300/600. DC Current 20µA/6/60/600mA. Resistance 10K/100K. -20 to +57dB. £7.50. P. & P. 15p.

### 270° WIDE ANGLE



**1mA METERS** MW1-6 60mm square £3.97; MW1-8 80mm square £4.97; P. & P. extra.



**UNR-30 RECEIVER** 4 Bands covering 550KHz-30MHz. B.F.O. Built in Speaker 220/240V a.c. Brand new with instructions. £15.75. Carr. 37p.

**WS62 TRANSCEIVERS** Large quantity available for EXPORT! Excellent condition. Enquiries invited.



**UR-IA SOLID STATE COMMUNICATION RECEIVER** 4 Bands covering 55KHz-30MHz. FET, 8 Meter, Variable BFO for 8RB. Built in Speaker, Brandread, Sensitivity Control. 220/240V a.c. or 12V d.c. 12 1/2in. 4 1/2in. 7in. Brand new with instructions. £25. Carr. 37p.



**LAFAYETTE HA-600 RECEIVER** General coverage 150-400KHz, 500KHz-30MHz. FET front end, 2 mech. filters, product detector, variable B.F.O., noise limiter, 8 Meter, Brandread, RF Gain. 15in. × 9 1/2in. × 8 1/2in. 220/240V a.c. or 12V d.c. Brand new with instructions. £45. Carr. 30p.



**LAFAYETTE HA-800 SOLID STATE AMATEUR COMMUNICATION RECEIVER** 3-5-4, 7-7-3, 14-14-35, 21-21-45, 28-29-7, 30-54MHz. Dual conversion, 2 mech. filters, product detector, variable BFO, 8 Meter, 100KHz calibrator. 220/240V a.c. or 12V d.c. 15in. 9 1/2in. 8 1/2in. Brand new with instructions. £57.50. Carr. paid (100KHz Crystal £1.97; extra).

### FULL RANGE OF TRIO EQUIPMENT

**EDDYSTONE VHF RECEIVERS MODEL 7702.** 19-185 Mc/s. Excellent condition. £150.

**VOLTAGE STABILIZER TRANSFORMERS** 150-260V input. Output 230V. Available 150W or 225W. £12.50. Carr. 25p.

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Excellent quality - Low price - Immediate delivery

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2.5A .....	2.5A .....
5A .....	5A .....
8A .....	8A .....
10A .....	10A .....
12A .....	12A .....
20A .....	20A .....

ALL MODELS INPUT 230 VOLTS, 50/60 CYCLES, OUTPUT VARIABLE 0-260 VOLTS Special discounts for quantity

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Three position switching to suit changes in the weather. Switch up for full heater (2kW), switch down for half heat (1kW), switch central blows cold for summer cooling—adjustable thermostat acts as auto control and safety cut-out. Complete kit £3.75. Post and ins. 38p.

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2,400 ft. of the best magnetic tape money can buy. Made by E.M.I., 1in. wide almost unbreakable and on a 10 1/2in. metal computer spool. Users have claimed successful results with video as well as sound recordings £1 plus 33p post. Cassette to hold spool 50p extra.



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(A 30 Amp Switch.) Just the thing if you want to come home to a warm house without it costing you a fortune. You can delay the switch on time of your electric fires, etc., up to 14 hours from setting time or you can use the switch to give a boost on period of up to 3 hours. Equally suitable to control processing. Regular price probably around £5. Special snip price £1.50. Post and ins. 23p.

### 1 HOUR MINUTE TIMER

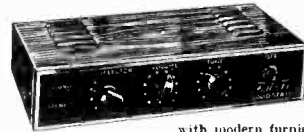
Made by famous Smiths company, these have a large clear dial, size 4 1/2in. x 3 1/2in., which can be set in minutes up to 1 hour. After preset period the bell rings. Ideal for processing, a memory jogger or, by adding simple lever, would operate micro-switch. £1.15.



### THE FULL-FI STEREO SIX

#### The amplifier sensation of the year

You will be amazed at the fullness of reproduction and at the added qualities your records or tuner will reproduce. Built into metal cabinet elegantly styled and teak finished to blend



with modern furnishings, this amplifier uses an integrated solid state circuit with an output power of 6 watts R.M.S. split over the two channels. The amplifier is ideal for use with normal pick-ups and tuners, it has a double wound mains transformer and ganged volume and tone controls—also switching for Mono to Stereo, tuner or pick-up. Other controls include "treble lift and cut", "balance" and separate mains on/off switch. Price is £9 plus 38p post and insurance.

### STANDARD WAFER SWITCHES

Standard size 1 1/2 wafer—silver-plated 5-amp contact, standard 3/4in spindle 2in long—with locking washer and nut. No. of Poles 2 way 3 way 4 way 5 way 6 way 8 way 9 way 10 way 12 way

1 pole	33p	33p	33p	33p	33p	33p	33p	33p	33p
2 poles	33p	33p	33p	33p	33p	33p	33p	55p	55p
3 poles	33p	33p	33p	33p	55p	55p	55p	75p	75p
4 poles	33p	33p	33p	55p	55p	55p	55p	95p	95p
5 poles	33p	33p	55p	55p	75p	75p	75p	£1.15	£1.15
6 poles	33p	55p	55p	55p	75p	75p	75p	£1.35	£1.35
7 poles	55p	55p	55p	75p	95p	95p	95p	£1.55	£1.55
8 poles	55p	55p	55p	75p	95p	95p	95p	£1.75	£1.75
9 poles	55p	55p	75p	75p	£1.15	£1.15	£1.15	£1.95	£1.95
10 poles	55p	55p	75p	95p	£1.15	£1.15	£1.15	£2.15	£2.15
11 poles	55p	75p	75p	95p	£1.35	£1.35	£1.35	£2.35	£2.35
12 poles	55p	75p	75p	95p	£1.35	£1.35	£1.35	£2.55	£2.55

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### SPARTAN Portable RADIO

Long and medium wave, 7 transistor, size 6in. x 4in. x 1 1/2in. with larger than usual speaker giving very good tone. Built-in ferrite aerial and telescopic aerial for distant stations. A real bargain complete with leather case, carry sling, carplug and case. £3.75 plus 25p post and ins.



### MULTI-SPEED MOTOR

Replacement in many well known food mixers. Six speeds are available. 500, 850, and 1,100 r.p.m. from either or both of the nylon sockets (where the beaters of the food mixers normally go) and 8,000, 12,000 and 15,000 r.p.m. (ideal polishing speeds) from the main drive shaft. Very powerful and useful motor size approx. 2in. diameter 5in. long. Price 80p plus 23p post and ins.



### MAINS OPERATED CONTACTOR

220/240V 50 cycle solenoid with laminated core so very silent in operation. Closes 4 circuits each rated at 10A. Extremely well made by a German Electrical Company. Overall size 2 1/2 x 2 1/2 in. £1 each.



### DOUBLE ENDED MAINS MOTOR

On feet with holes for screw-down fixing. To drive models, oven, blower heater, etc. 50p each, plus 18p post and insurance, 6 or more post free.



### 0.005mFd TUNING CONDENSER

Proved design, ideal for straight or reflex circuits. 13p each, £1.20 doz.



**ELECTRONICS (CROYDON) LTD**  
Dept. PE, 266 London Road, Croydon CR0 2TH  
Also 102/3 Tamworth Road, Croydon



### ELECTRIC CLOCK WITH 25 AMP SWITCH

Made by Smith's, these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set. Ideal for switching on tape recorders. Offered at only a fraction of the regular price—new and unused only **£2**, less than the value of the clock alone—plus insurance 14p.



### FLUORESCENT CONTROL KITS

Each kit comprises seven items—Choke, 2 tube ends, starter, starter holder and 2 tube clips, with wiring instructions. Suitable for normal fluorescent tubes or the new "Grolux" tubes for fish tanks and indoor plants. Chokes are super-silicon, mostly resin filled. Kit A—15-20W. Kit B—30-40W. Kit C—60W. Kit D—80W. Kit E—65W. Kit F—150W. Kit G—81 125W tube **£1.75**. Kit H is for 6in, 9in and 12in miniature tubes, **£1**. Kit MF2 for 2 1/2in 13W miniature tube, **£1**. Postage on Kits A and B 23p for one or two kits then 23p for first kit then 18p for each kit ordered. Kit C, D and E 23p on first kit then 18p for each kit ordered. Kit F 33p then 23p for each kit ordered. Kit H 18p on first kit then 18p on each two kits ordered.

### BLANKET SWITCH

Double pole with neon let into side so luminous in dark, ideal for dark room light or for use with waterproof element—new plastic case **30p** each. 3 heat model **40p**.



### BLANKET SIMMERSTAT

Although looking like, and fitted as an ordinary blanket switch, this is in fact a device for switching on for varying time periods, thus giving a complete control from off to full heat. Although suitable for controlling the temperature of any other appliances using 230V AC, listed at **£1.40** each we offer these while our stocks last at only **65p** each.

### REED SWITCHES

Glass encased, switches operated by external magnet—gold welded contacts. We can now offer 3 types: **Miniature**, 1in long x approximately 1/4in diameter. Will make and break up to 1A up to 300 volts. Price **13p** each, **£1.20** dozen. **Standard**, 2in long x 1/4in diameter. This will break currents of up to 1A, voltages up to 260 volts. Price **10p** each, **90p** per dozen. **Flat**, Flat type, 2in long, over 1/4in thick, flattened out so that it can be fitted into a smaller space or a larger quantity may be packed into a square solenoid. Rating 1 amp 200 volts. Price **30p** each, **£3** per dozen. Small ceramic magnets to operate these reed switches **8p** each, **80p** dozen.

### HIGH CAPACITY ELECTROLYTICS

Brand new, not ex-shipment.  
100 mfd. 25V, **8p** each **60p** doz.  
200 mfd. 25V, **8p** each **75p** doz.  
250 mfd. 50V, **16p** each **£1.65** doz.  
400 mfd. 40V, **22p** each **£2.30** doz.  
500 mfd. 12V, **10p** each **£1.05** doz.  
500 mfd. 25V, **18p** each **£1.80** doz.  
500 mfd. 50V, **24p** each **£2.40** doz.  
500 mfd. 350V, **43p** each **£4.50** doz.  
1000 mfd. 12V, **15p** each **£1.50** doz.  
1000 mfd. 18V, **17p** each **£1.70** doz.  
1000 mfd. 64V, **37p** each **£4** doz.  
2000 mfd. 25V, **34p** each **£3.95** doz.  
5000 mfd. 12V, **24p** each **£2.40** doz.  
10,000 mfd. 6V, **29p** each **£3** doz.  
10,000 mfd. 15V, **43p** each **£4.50** doz.  
15,000 mfd. 10V, **53p** each **£5** doz.  
60,000 mfd. 8V, **£1.10** each **£11** doz.  
70,000 mfd. 13V, **£2** each **£20** doz.

**8 AMP 18V BATTERY CHARGER KIT**—comprising 230/40 mains transformer with 3 amp secondary and 3 amp rectifier **£1.15** + 23p post. **12 VOLT 1 AMP POWER PACK**, This comprises double-wound 230/240V mains transformer with full wave rectifier and 2000 n/f/d smoothing. Price **£1.40**.

**SOXOTONE STEREO CARTRIDGE**. Turnover type, ref. No. 15 T1. This fits most British pickups and is a really excellent reproducer. Limited quantity, **£1**.

**5 AMP 3-PIN SOCKETS**. These are always good stock, you never know when you will need some. Famous make, brown bakelite, standard size, 12 for **65p** plus 13p post.

**DITTO WITH 5 AMP**, 12 for **£1** plus 23p post. **13 AMP SOCKETS, FLUSH MOUNTING**. Bakelite, cream, less switch, 6 for **£1**.

**BAKELITE PANELS, MANY THICKNESSES**. We have just taken delivery of approximately 10 tons of bakelite in varying thicknesses from 2in. to a few thou. If you have a need for any of this then we would be glad to supply. The thickest is very heavy and could be used, for instance, as a bed for a motorised unit. Medium thickness is useful for front panels of instrument, etc., etc. Cut to your size price is **30p** per lb. plus **30p** cutting charge plus carriage.

**2 AMP 3-PIN SWITCHED SOCKETS** for surface mounting, brown bakelite. Made by famous maker. **13p** each or **£1.20** dozen.

**100 ASSORTED SILICON RECTIFIERS G.P. AND SWITCHING DIODES**. Small and very small sizes. A real snip for experimenters, **65p** per 100.

### 20 AMP ELECTRICAL PROGRAMMER

**Learn in your sleep:** Have Radio playing and kettle boiling as you awake—switch-on lights to ward off intruders—have warm house to come home to. All these and many other things you can do if you invest in an Electrical Programmer. Made by the famous Smith's Instrument Company. This is essentially a 230/240 volt mains operated Clock and a 20 amp switch, the switch-off time of which can be delayed up to 12 hours (continuously variable not stepped). Similarly the switch-on time can be delayed. This is a beautiful unit, size 5 1/2 x 3 1/2 in. deep. Metal encased, glass fronted with chrome surround. Offered at **£2.40** plus postage and insurance 23p.



### HI-FI SPEAKERS (15, 30, 40 & 100W)

**FULL FI 12 INCH LOUSPEAKER**. This is undoubtedly one of the finest loudspeakers that we have ever offered, produced by one of the country's most famous makers. It has a die-cast metal frame and is strongly recommended for Hi-Fi load and Rhythm Guitar and public address. Flux Density 11,000 gauss—Total Flux 44,000 Maxwells—Power Handling 15 watts R.M.S. Cone Moulded fibre—Freq. response 30-10,000 c.p.s.—Specify 3 or 15 ohms—Mains resonance 60 c.p.s.—Chassis Diam. 12in.—12 1/2in. overall length—Baffle hole 11 in. diam.—Mounting holes 4 holes—1 1/2 in. diam. on pitch circle 1 1/2 in. diam.—Overall height 5 1/2 in. A 66 speaker offer for only **£4**, plus 37p p. & p. 12in. 40 watt **£7** carr. 43p. 15in. 25 watt **£8** carr. 53p. 18in. 100 watt **£19.50** carr. **£1.50**.



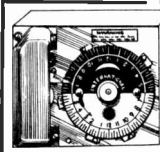
### INTEGRATED CIRCUIT BARGAIN

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

### THIS MONTH'S SNIP

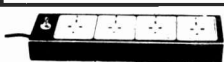
#### ELECTRIC TIME SWITCH

Made by Smith's these are AC mains operated, NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. Completely adjustable time periods per 24 hours, 3 amp changeover contacts will switch circuit on or off during these periods. **£2.50**, post and ins. 23p. Additional time contacts 50p pair.



#### DISTRIBUTION PANELS

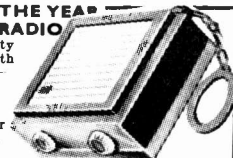
Just what you need for work bench or lab. 4 x 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 7 feet of heavy cable. Wired up ready to work, **£2** less plug; **£2.25** with fitted 13 amp plug; **£2.40** with fitted 15 amp plug, plus 23p P. & I.



### BARGAIN OF THE YEAR

#### MICROSONIC KEYCHAIN RADIO

7 transistor Key chain Radio in very pretty case, size 2 1/2 x 2 1/2 x 1 1/2 in.—complete with soft leather zipped bag. Specification—Circuit: 7 transistor superheterodyne. Frequency range: 630 to 1,600 Kc/s. Sensitivity: 5 mV/m. Intermediate frequency: 465Kc/s or 455Kc/s. Power output: 40mW. Antenna: ferrite rod. Loudspeaker: Permanent magnet type. In transit from the East these sets suffered slight corrosion as the batteries were left in them but when this corrosion is cleared away they should work perfectly—offered without guarantee except that they are new. Price only **£1.25** plus 13p post and insurance, less batteries. 6 for **£7**, post free. Pair of rechargeable batteries and charger **85p**.



### 4 AMP VARIAC CONTROLLERS

With this you can vary the voltage applied to your circuit from zero to 270 volts without generating undue heat. One obvious application therefore is to dim lighting. Ex equipment but little used—as good as new offered at approx. half price—**£5** plus 70p post and ins.



### 19-PIECE SOCKET SET

Complete with wall or bench rack. An ideal gift for the motorist, **80p** + 23p. post and insurance. Most useful sizes from 1/4in to 1 1/2in.



### HONEYWELL PROGRAMMER

This is a drum type timing device, the drum being calibrated in equal divisions for switch setting purposes with trips which are infinitely adjustable for position. They are also arranged to allow 2 operations per switch per rotation. There are 15 changeover micro switches each of 10 amp type operated by the trips. The 15 circuits may be changed per revolution. Drive motor is mains operated 5 revs per min. Some of the many uses of this timer are Machinery control, Boiler firing, Dispensing and Vending machines, Display lighting animated and signs, Signalling, etc. Price from Makers probably over **£10** each. Special snip price **£5.75** plus 25p post and insurance. Don't miss this terrific bargain.



Where postage is not stated then orders over **£5** are post free. Below **£5** add 14p. Semiconductor add 5p post. Over **£1** post free. S.A.E. with enquiries please.

### MAINS CONNECTOR

A quick way to connect equipment to the mains safely and firmly; disconnection by plugs prevents accidental switching on; has sockets which allow insertion of meter without disconnection; cable inlets firmly hold one hair wire on up to four 7,029 cables. **65p** each.



### CONTROL DRILL SPEEDS

### DRILL CONTROLLER

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. **£1.50**, plus 13p post and insurance.



### BALANCED ARMATURE UNIT

500 ohm, operates speaker or microphone, so useful in intercom or similar circuits, **33p** each, **£3.50** doz.

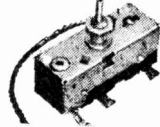
### PROTECT VALUABLE DEVICES

**FROM THERMAL RUN-AWAY OR OVERHEATING:** Thyristors, rectifiers, transistors, etc., which use heat-sinks can easily be 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 90deg. to 190deg.F. or with the dial removed range setting is between 80 to 800deg.F. Price **50p**.



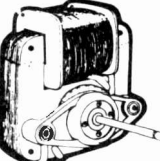
### THERMOSTAT WITH PROBE

This has a sensor attached to a 15A switch by a 14in length of flexible capillary tubing—control range is 20 F to 150°F so it is suitable to control soil heating and liquid heating especially when in buckets or portable vessels as the sensor can be raised out and lowered into the vessel. This thermostat could also be used to sound a bell or other alarm when critical temp. is reached in stack or heap subject to spontaneous combustion or if liquid is being heated by gas or other means not controllable by the switch. Made by the famous Teddington Co., we offer these at **65p** each. Postage and insurance 14p.



### MAINS MOTOR

Precision made—as used in record decks and tape recorders—ideal also for extractor fan, blower, heaters, etc. New and perfect. Snip at **60p**. Postage 15p for first one 5p for each one ordered.



### NEED A SPECIAL SWITCH? Double Leaf Contact

Very slight pressure closes both contacts, **6p** each, **60p** doz. Plastic push-rod suitable for operating, **5p** each, **45p** doz.



### MINIATURE WAFER SWITCHES

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 3 way—1 pole, 12 way. All at **18p** each. **£1.50** dozen, your assortment.



### WATERPROOF HEATING ELEMENT

26 yards length 70W. Self-regulating temperature control. **50p** post free.

### MICRO SWITCH

5 amp. changeover contacts, **9p** each, **£1** doz. 15 amp Model **10p** each or **£1.05** doz.



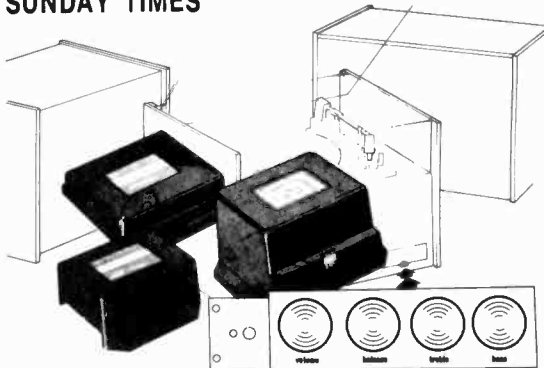
## ELECTRONICS (CROYDON) LTD

Dept. PE, 266 London Road, Croydon CR0 2TH  
Also 102/3 Tamworth Road, Croydon

# Laskys

## MULLARD UNILEX AUDIO MODULES

Do-it-yourself stereo as featured in the SUNDAY TIMES



With nothing more than simple tools and the parts described below, you can build your own stereo system with excellent results guaranteed. The heart of the system comprises our Mullard Unilex modules and a control unit. All the modules and the control unit are supplied to you fully built and only require connecting together. Screw terminals and each module is housed in a tough plastic case, giving you complete freedom to use any of the recommended cabinets or your own design to suit your home.

- Control Unit:** Fitted with Bass, Treble, Volume and Balance controls. A metal fascia panel is supplied and all wires are ready fitted for connecting to the pre-amp. Size 5in. x 10in. x 1in. Plus 2in. long control shafts. **£3.25**
- Pre-amplifier Module Type EP-9001:** Input impedance: P/U 2.2M Tuner 1M Input Sens.: P/U 320mV, Tuner 140mV. Treble control range—14dB to 14dB at 16KHz. Bass control range—14dB to 14dB at 60Hz. Size: 4in. x 5in. x 1in. **£3.10**
- Amplifier Module Type EP-9000:** Output 4 watts per channel to 12 ohms to 15 ohms or 8 ohms with series resistor. Frequency resp. (to 3dB at 50mW): 50Hz to 16KHz. Harmonic distortion less than 2% at typical listening level. Size: 30in. x 4in. x 10in. **£5.80 per pair**
- Power Supply Module Type EP-9002:** For use with control unit, EP-9001 and 2 x EP-9000. For 220/250 volt AC mains. Size 50in. x 30in. x 3in. **£4.60**

### PACKAGE DEAL

Two EP-9000 Modules **£5.80** • EP-9002 Module **£4.60** • EP-9001 Module **£3.10** • Control Units **£3.25** • Instruction Book 25p. **TOTAL LIST PRICE £17.00**  
**PACKAGE PRICE £14.95** post 20p.

## FANTAVOX 105

### MODEL VHF 105

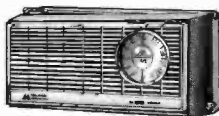
An item for the radio enthusiast bringing instant reception of the ground-to-air, air-to-ground waveband. For use with any standard AM or FM radio covering 535-1600 KHz 88-108 MHz respectively — with no electrical conversion or connection required. The model VHF-105, self powered by one 9V (PP3 type) battery, is merely placed close to the receiving set and then tuned over 110 to 135 MHz which covers the whole aircraft communications band. Volume and reception effectiveness is adjusted by moving both sets to the most favourable position and balancing the vol. controls of each accordingly. The Model VHF-105 has a smartly designed black plastic cabinet with brushed metal front panel and 18in. chrome telescopic antenna, size only 4 x 2 1/4 x 2 1/4 in. (inc. knobs) Complete with battery and full instructions.



**LASKY'S PRICE £3.60** Post 10p

### MIDLAND 10-406 AM/AIRCRAFT RADIO

The first pocket size receiver of its type allowing you to tune-in to the entire air communications band covered by 108-137 MHz in addition to full AM medium wave Intermediate frequencies: AM 455 KHz; VHF 10.7 mc/s. Output power: 200mW 2 1/4 in. P.D. 8 ohm speaker. A built in ferrite rod aerial is provided for AM reception. The 10-406 is finished in blue with chrome trim, chrome telescopic antenna. Size 6 1/2 x 3 1/4 x 1 1/4 in. Complete with batteries, magnetic earphone, instructions and circuit data.



**LASKY'S PRICE £8.35** Post 13p

## ADC 40 PRECISION PICK-UP ARM

The ADC 40 Mk II is a complete low inertia arm with side thrust compensator and anti-drag lead out arrangement. Single-thrust ball bearings used at four points. Accurately machined walnut non-resonant arm. Adjustable counter-weight. Plug-in head shell accommodates nearly all cartridges. Easy installations. Built-in arm rest. Arm length 10 1/4 in. overall. Pivot to stylus tip 9 in. Rear overhang 1 1/4 in.

List Price **£19.41**

OUR PRICE

**£6.95**

Post 18p



## AUDIO DEVELOPMENT

### AD-309K

PRECISION PICK-UP ARM COMPLETE WITH AD-76K MAGNETIC CARTRIDGE

The new AUDIO DEVELOPMENT precision counter-balanced pick-up arm — ready fitted with the outstanding AD-76K magnetic

cartridge is constructed of brass throughout, heavily chrome-plated; uses needle and miniature ballrace bearings; both coarse and fine balance adjustment is provided. The fixed head has standard jin, mounting centres and is finished in black enamel with chrome lifting spur. Completely wired, with all fixing nuts and washers. Arm rest also supplied. Tech. details: Overall length 285mm; needle to pivot length 223mm; offset angle 24°; overhang 10mm. Requires single 7/16in. dia. mounting hole.

**LASKY'S PRICE £8.50** Post Free

### AUDIO DEVELOPMENT AD-76K

Stereo Magnetic Cartridge. Frequency response 20-20,000Hz. Output: 5mV. Stylus: Diamond LP. Tracking force: 2 gms — 0.5 gm. Replacement stylus type JS.P1 £2.05 post free. **£4.50** Post Free

### AUDIO DEVELOPMENT AD-96K

Stereo Magnetic Cartridge. Frequency response 20-20,000Hz. Output: 5mV. Stylus: Diamond LP. Tracking force: 2 gms. Replacement stylus type Y.960S £2.57 post free. **£5.93** Post Free

## Lasky's COMPACT CASSETTES

C60 • C90 • C120

Exclusively made for us in USA Great Savings.

	Each	Post	Five for	Post	Ten for	Post
C60—	37p	5p	£1.65	20p	£5.95	25p
C90—	57p	5p	£2.75	20p	£9.90	25p
C120—	87p	5p	£3.75	20p	£12.10	25p

U.S.A. Cassette head cleaner, 53p Post 5p



## INTERNATIONAL

MAGNETIC RECORDING TAPE FROM THE U.S.A. AT LASKY'S RECORD LOW PRICES

3in	Message tape, 150ft.	13p	5 1/2in	Long play, 1200ft. Mylar	75p
3in	Message tape, 225ft.	19p	5 1/2in	Triple play, 2400ft.	£1.75
3in	Message tape, 300ft.	38p	7in	Standard play, 1200ft.	63p
3 1/4in	Triple play, 600ft. Mylar	50p		Acetate	
5in	Double play, 1200ft.	75p	7in	Standard play, 1200ft.	63p
5in	Long play, 900ft. Acetate	50p		Mylar	
5in	Standard play 600ft.	40p	7in	Long play, 1800ft. Mylar	98p
5 1/2in	Double play, 1800ft. Mylar	£1.13	7in	Double play, 2400ft. Mylar	£1.25
5 1/2in	Long play 1200ft. Acetate	75p	7in	Long play 1800ft. Acetate	75p
5 1/2in	Standard play 900ft. PVC.	63p	7in	Triple play 3600ft. Mylar	£2.50

P. & P. 5p extra per reel, 4 reels and over Post Free. Special quotes for quantities.

# SONY FM-8030L

**BARGAIN SCOOP**

## HIGH PERFORMANCE 11 TRANSISTOR THREE WAVEBAND PORTABLE BATTERY MAINS RADIO

This is a really top performance, top quality solid state receiver packed with SONY know-how and backed by the outstanding reliability for which SONY are renowned. Now this outstanding set is available from Laskys at over 27% below the manufacturers list price making it without a doubt the NUMBER ONE SCOOP of 1971! Just look at these outstanding features: Covers MW, LW and FM (VHF). 11 transistor circuit for high sensitivity and stability. Powerful output to 5" P.M. Dynamic speaker with rich clear tone quality. AFC for drift free VHF reception. Push button wavechange selectors and tone control.

Choice of three power sources—9V battery, household mains or car battery with suitable adaptors. Dial light for use in the dark. External jacks for earphone, tape recording, external power input and car aerial. Ultra modern styling and superb finish with padded leatherette covered cabinet for superior sound damping with chrome trim, strong carrying handle.

The SONY FM 8030L will enliven your leisure hours anywhere, anytime with exciting sound, news, sport, music, etc. Technical specification: Freq. range, FM 87-108MHz, LW150-285kHz, MW530-1, 605kHz. Circuit: 11 transistors, 7 diodes and 2 thermistors. Aerial System: Directional telescopic for FM, internal ferrite bar for LW/MW. Power Output: 1.85W max. Speaker PM Dynamic—4Ωimp. Power Source: 9v power pack battery (Ever-Ready PP9 or equiv.), AC mains with adaptor, Car battery with adaptor. Size: 9½(W) x 8½(H) x 3½(D). Complete with earphone and battery and full instruction manual.

MANUFACTURERS LIST PRICE £29.75

LASKY'S SPECIAL OFFER PRICE **£21.50**

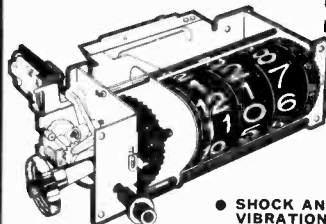
Optional Extras. SONY AC-90e AC adaptor £4.00 DCC-126 stabilised car battery £6.00. Both post FREE if purchased with radio.

Post 35p



# EXCLUSIVE McDONALD

## DIGITAL CLOCK SCOOP!



SPECIAL QUOTATIONS FOR QUANTITIES

- SHOCK AND VIBRATION PROOF
- BUILT IN ALARM BUZZER

- MADE ESPECIALLY FOR LASKY'S BY FAMOUS MAKER
- MAINS OPERATION
- 12 HOUR ALARM
- AUTO "SLEEP" SWITCH
- HOURS, MINUTES AND SECONDS READ-OFF
- FORWARD AND BACKWARD TIME ADJUSTMENT
- SILENT OPERATION SYNCHRONOUS MOTOR

This unique DIGITAL CLOCK is now available EXCLUSIVELY FROM LASKY'S in chassis form for you to mount in any housing that you choose. All settings are achieved by two dual-concentric controls at the front including: ON-OFF-AUTO and AUTO ALARM, "sleep" switch, 10 minute division "click" set alarm (up to 12 hour delay), time adjustment. Ultra simple mechanism and high quality manufacture guarantee reliable operation and long life.

The sleep switch will automatically turn off any appliance—radio, TV, light, etc., at any pre-set time up to 60 min. and in conjunction with the AUTO setting will switch on the appliance again next morning.

The clock measures 4½W x 1½H x 3½D (overall from front of drum to back of switch). SPEC: 210/240V AC, 50Hz operation; switch rating 250V, 3A. Complete with instructions. HUNDREDS OF APPLICATIONS.

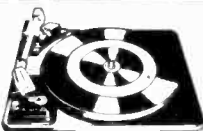
COMPLETE WITH KNOBS.

LASKY'S PRICE **£6.95** Post 18p

## GARRARD SP25 Mk III

The SP 25 series record deck has proved to be one of the most popular of its type in the world. Styled in black and silver, this moderately priced three-speed unit complies with the Din 45-500 Hi-Fi performance standard. The tubular low resonance aluminium pick-up arm is counter-balanced by a resiliently mounted weight. Stylus force is adjusted by an optical-type knurled knob, finely calibrated from 0.5 grm. in steps of 1 grm. Bias compensation is set with a finger-tip adjustment, the scale being calibrated to correspond with the stylus force. The viscous damped cue control facilitates raising and lowering the pick-up arm onto the track required without damage to either the record or stylus. The 10½in. aluminium turntable is driven by the well-proven Garrard 4-pole high and low voltage induction motor. Actual size including max. rear and side overhang of pick-up arm 15¼in. wide x 12½in. front to rear x 12½in. above and 2½in. below edge of unit plate.

LASKY'S PRICE **£12.50** WITH 9TA CARTRIDGE Post 35p



## PROFESSIONAL SERIES FOUR-SPEED SINGLE PLAY UNIT

### MP60

High-precision low-mass fully counterbalanced pick-up arm, heavy balanced turntable, simple to operate controls, viscous cueing device, slide-in cartridge carrier, four pole motor.



LASKY'S PRICE **£12.50** Post 35p

complete with plinth and cover **£15.75**

Post 40p

## 610 AUTOMATIC TURNTABLE

Same specifications as the MP60 but with synchronous four pole motor and full automatic change facilities.

LASKY'S PRICE **£15.45** Post 35p

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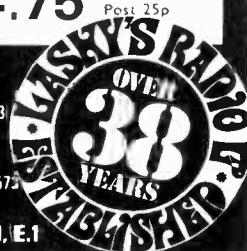
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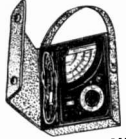
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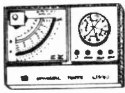
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20,000 Ω per volt;  
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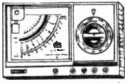
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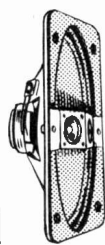
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(30,000 Ω/V). D.C. Current: 0, 0.03, 3, 30,  
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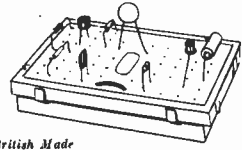


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2N726	30p	2N2906	40p	2N3855A	30p	2N3367	37p	ACY40	20p	BC149	17p	BF163	35p	BFW60	25p	MAT100	30p	NKT403	75p	OC46	15p
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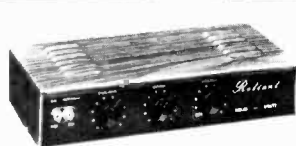
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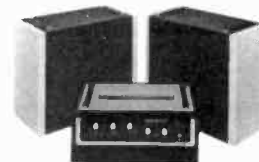
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**Output Power:** 45 watts R.M.S. (Sine wave drive). Frequency response:—3dB points 30Hz at 18kHz. Total distortion: less than 2% at rated output. Signal to noise ratio: better than 60dB.

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Specification same as Mk. I, but with the following inputs: Mag. P.U. CER. P.U. Tuner.

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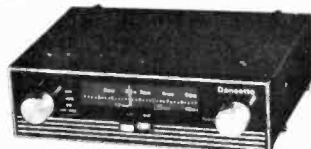
Beautifully designed to blend with the interiors of all cars. Permeability tuning and long wave loading coils ensure excellent tracking, sensitivity and selectivity on both wave bands. R.F. sensitivity at 1 MHz is better than 8 micro volts. Power output into 3 ohm speaker is 3 watts. Pre-aligned I.F.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

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## ONE GOOD REASON

**T**HERE are all sorts of reasons why people build electronic equipment for themselves. A very good one is, simply, that unless they do, they go without!

No wild exaggeration, this. While the semiconductor industry can turn out vast quantities of thought-provoking circuit devices—originally developed for professional applications, it is true—is it not strange that equipment manufacturers have not seized upon these to embody in a host of imaginative functional products for the domestic consumer?

Oh yes, for sure the radio, television, and audio equipment business is well saturated, as the shop windows and showrooms in every high street testify. But the very proliferation of traditional entertainment products from both home and overseas factories induces a lop-sided view of electronics and what it can do for everyman and his wife. For instance, light and heat sensitive semiconductors, and power switching thyristors and triacs, are all crying out for more general use; to say nothing of logic systems based on miniature integrated circuits which offer possibilities for programming routine switching operations within the home.

There has been plenty of pie-in-the-sky talk of the electronics-run home of the future. When will the big breakthrough occur?

While prodding the commercial world to venture into these unusual and as yet scarcely explored domestic regions, we do see that this is not so simple nor (perhaps) as profitable as satisfying mass market needs for standardised conventional products like radio and audio equipment. Many installed automatic systems, such as intruder detectors, and environment sensing and controlling equipments, have to be tailored to suit specific needs and situations. And coping with a number of possible combinations from a wide range of units in order to build up an ideal installation for one customer would give the retailer some headaches, no doubt.

This is, of course, where we came in: if you do require something rather special in this particular line of electronics, the chances are you will have to build it yourself. This is just one further demonstration of the paradoxical situation we now have, and which arises directly from the highly productive semiconductor industry: the general availability of mass produced, efficient and versatile devices is helping in the preservation of individual craftsmanship. F.E.B.

### PRICE INCREASE

As from next month, the price of PRACTICAL ELECTRONICS will be 20p (4s). We regret the necessity for this increase, which is due to rising production costs.

## THIS MONTH

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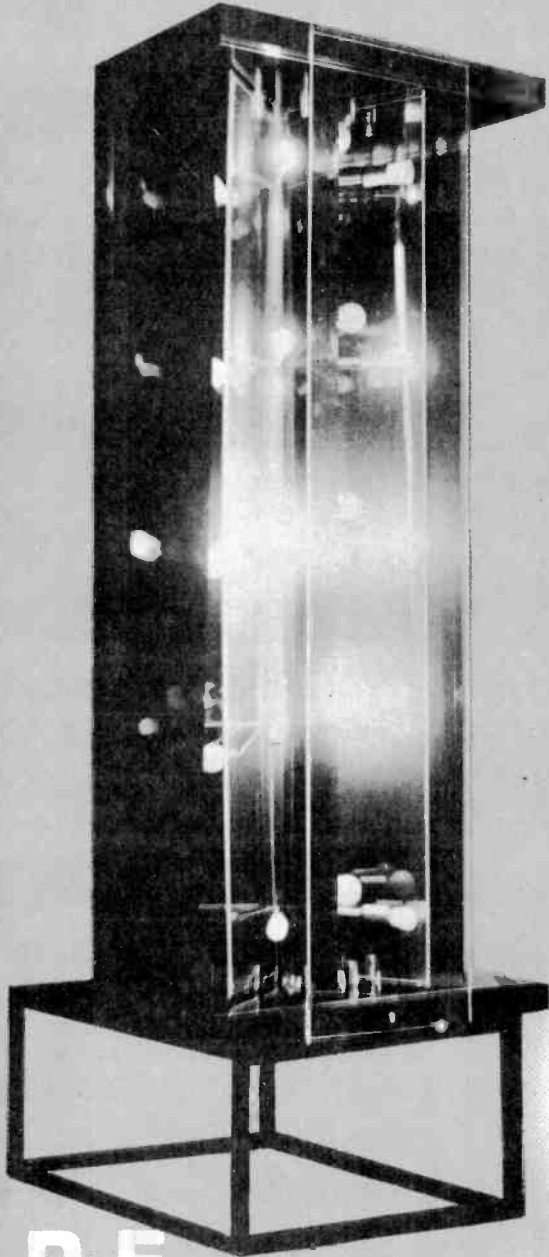
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*Our May issue will be published on Friday, April 16*

Create living colour that "moves" with the mood of your music.

**P.E. AURORA** is a controlled lighting system that can be as simple or as complex as you like to make it.

The selected audio frequency ranges can be "coloured" and the lighting arranged in whatever domestic decor you choose.



**S**OUND controlled colour light displays can be arranged to provide several kinds of visual effects some of which have been exploited for television and discotheques. The growing interest in this idea among amateurs and professionals was obvious at the recent Audio and Music Fair, when PRACTICAL ELECTRONICS presented to the public a versatile system called "P.E. Aurora".

This is a do-it-yourself design capable of exploitation to provide domestic mood lighting appropriate to any kind of music (serious, classical, jazz, or pop), and can be controlled from any audio amplifier or pre-recorded sequencer programme.

Any such system calls for three basic pieces of equipment:

1. A source of instructions to provide the light control information;
2. A piece of equipment which will convert these instructions into controlled power which is then applied to the lights;
3. The light system itself.

This series of articles describes an overall system which is driven by the signal from an audio amplifier; describes other methods of providing the initial instructions to drive a single general purpose power controller, and a novel technique for displaying the final effect.

At the end of the constructional series several alternative application systems will be described—some which have been successfully used by the designer and others, which are food for thought for further experimentation.

**MUSIC  
INSPIRED  
AND LIGHT  
COLOUR**

**P.E.  
AURORA**

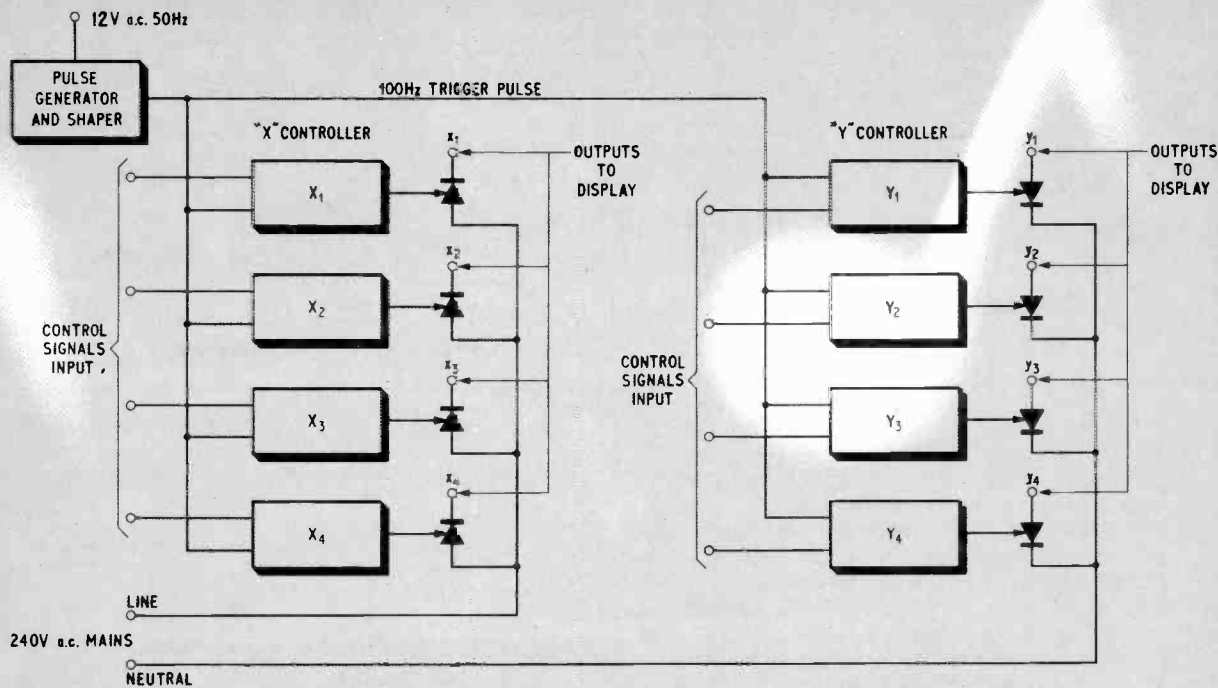
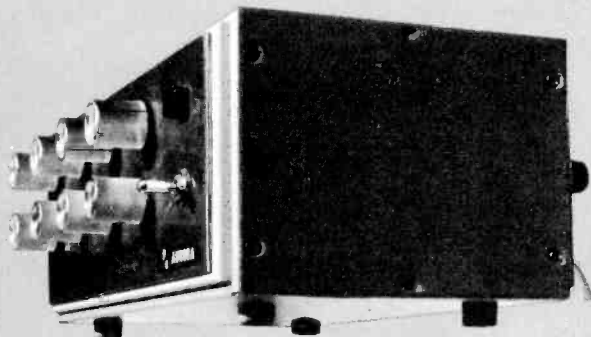


Fig. 1. Basic eight channel thyristor switching system used to operate a 16-lamp matrix of P.E. Aurora



## PART 1 BY M. J. HUGHES M.A.

The P.E. Aurora system was specially commissioned by Practical Electronics and is the result of close collaboration with M. J. Hughes, M.A., who designed the electronics, and M. Leonard, A.R.J.B.A., who was responsible for the artistic presentation of this light display shown at the "Audio & Music Fair" and the "Electric Theatre" exhibition.

### THYRISTOR OR TRIAC CONTROL

The heart of the system to be described is a d.c. voltage controlled phase shifter, coupled to a trigger circuit, which in turn fires either triacs or thyristors early or late within the mains a.c. waveform. The controller's input is of high impedance and has a linear control over input voltages ranging from 0.5V to 1.0V d.c.

The input is 100 per cent isolated from the output, thus the control voltages can be derived with safety from many forms of semiconductor circuitry. Two such circuits will be described in detail: a narrow band filter unit—for sound to light control, and a self programming digital unit which provides constantly changing light patterns.

Other input circuits, which will be discussed later, include tape control (using a conventional  $\frac{1}{4}$  in or cassette tape recorder) and several types of optical feedback control.

The system to be described will be based on eight individual control channels supplying a matrix of 16 lamp nodes, but individuals can tailor their systems to suit the application or their pockets. The basic system is shown in block form in Fig. 1.

### DESIGN SPECIFICATIONS

As the original intention was to make the "P.E. Aurora" a versatile piece of equipment the following design parameters were self-imposed:

1. Ultimate a.c. power control should be by readily available thyristors or triacs and the

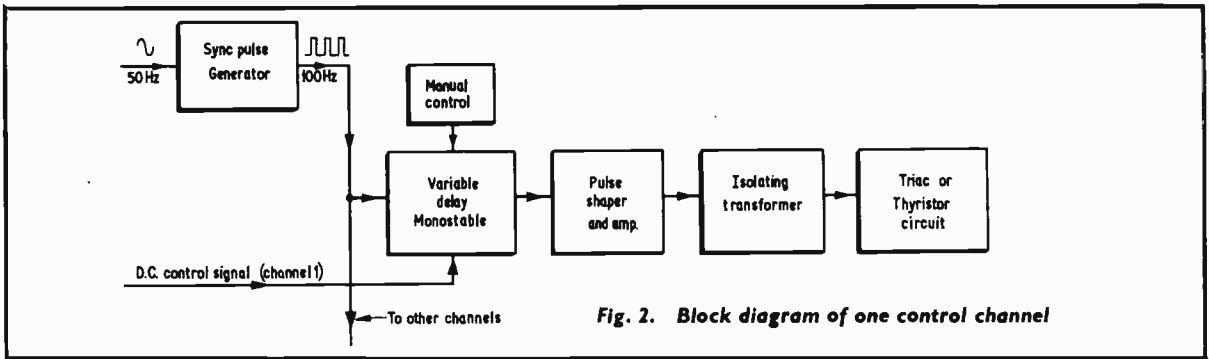


Fig. 2. Block diagram of one control channel

equipment should interface with as wide a range of trigger requirements as possible, in conjunction with the a.c. mains frequency.

2. Either triacs or thyristors could be used without any change in circuitry, provided they are capable of operation from the voltage and current source of the switching circuit.
3. The power side of the controller should be isolated from the input for safety reasons—this isolation should not be by optical means (which is quite often specified) because it presents difficulties in producing a simple mechanical construction.
4. Phase angle control should be over a range of as near 180 degrees as possible to obtain full lamp brightness and as near full extinction as possible.
5. Input signal requirements should be as wide as possible and be such that the equipment can be used with semiconductor circuitry.
6. Simple unstabilised power supplies should be used. All circuitry should be simple, should use low price components, and should need no specialised test equipment for setting up, apart from a multimeter and possibly an audio signal generator.

7. Perhaps the most difficult of the specifications to achieve; that the lamp brightness should appear linearly related to the input control signal.

All the above parameters have been met in the equipment to be described.

### FREQUENCY LOCKED SWITCHING

Fig. 2 shows a block diagram of a single control channel. All thyristor or triac phase control systems should be accurately locked to the mains frequency so that linear control may be effected by firing the device early or late within a single mains frequency cycle or half-cycle.

The triacs require a trigger pulse every positive and negative half-cycle of the mains while a thyristor—a unidirectional switching device—requires trigger pulses during positive half-cycles only. The sync pulse generator produces a single positive going pulse at the start of every positive and negative going half-cycle of the mains frequency. This pulse is applied to all channels in parallel (the present generator will satisfactorily drive up to 10 control channels).

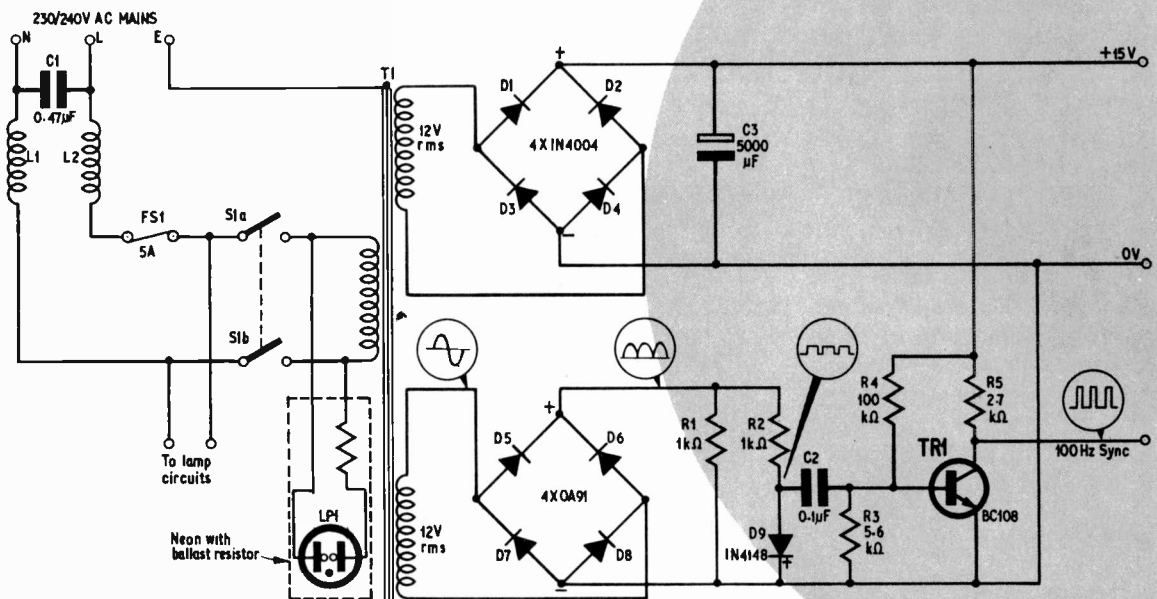


Fig. 3. Circuit diagram of the power supply and sync pulse generator





Considering a single channel; the arrival of this pulse fires the monostable multivibrator, the output of which rises to approximately +10V and dwells at this level for a period which is set either by the manual control or the input d.c. control signal. It is this dwell time that controls the phase angle of the final trigger pulse and is designed to be in the range of 2 to 9ms (this gives a range of firing angles of approximately 36 to 160 degrees).

After the dwell period the output of the monostable falls back to zero volts and this negative going transition is detected and amplified by the pulse shaper, which is coupled to the primary winding of a simple pulse transformer. This provides isolation between the mains and low voltage parts of the circuit. The secondary of this transformer is directly coupled across the cathode and gate of the thyristor or main terminal 1 and gate of the triac.

Trigger pulses will arrive at the transformer every 0.01sec and thus will fire a triac on every half-cycle. If a thyristor is used only alternate pulses will fire the device—pulses arriving during negative excursion half-cycles will be ignored.

### POWER SUPPLY AND SYNC PULSE GENERATOR

As the power supply and sync generator are closely coupled to the mains transformer, both units are shown in Fig. 3. T1 is a straightforward mains transformer having two separate secondary windings each providing 12V a.c. One of the windings rated at 500mA is connected to a standard bridge rectifier comprising diodes D1, 2, 3, and 4. The smoothed output of this supplies sufficient power to drive all the circuitry required for the eight channels.

The inductors L1 and L2 together with C1 provide a satisfactory degree of interference suppression. The rating of fuse FS1 will depend on the total power the controller will eventually be driving. In the case of the prototype a 5A fuse was sufficient. Later we will deal with modifications necessary for higher power operation.

The main switch S1 only serves to isolate the electronics from the mains—it does not disconnect the main power to the lamps owing to problems in obtaining a suitably rated panel switch of reasonable mechanical proportions.

The second winding of T1 is connected to a bridge comprising four germanium diodes—D5, 6, 7, and 8. This provides a full wave rectified signal across the nominal load R1.

For those constructors having access to an oscilloscope, approximate waveforms are shown on the circuit diagram. Diode D9 is a small signal silicon type connected in a forward biased direction. The 600mV forward drop across this device serves to clamp the full positive excursion of the bridge producing a waveform closely resembling a square wave with fairly fast negative going edges. This waveform is inverted and its level restored to approximately 10V (off load) by transistor TR1.

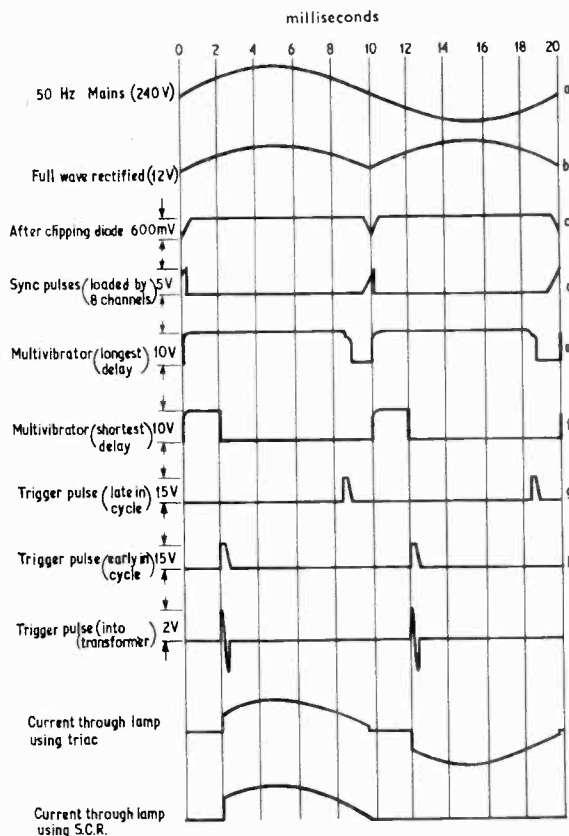


Fig. 4. Waveform timing diagram as measured on an oscilloscope. Typical amplitudes are shown. All levels are measured relative to the zero voltage rail. Waveforms (g) and (h) show the extremes of firing angle, 36 to 160 degrees

The output is a 100Hz sync pulse which is then applied to all the monostable stages for triggering the thyristors. On full load the amplitude of the positive going pulses at the collector of TR1 falls to approximately 5V.

The waveform timing diagram shown in Fig. 4 shows the relationship of sync pulses to the original mains waveform (a, b, c, and d).

However, due to the trigger sensitivity of the monostables (which require approximately 4 volts for reliable triggering) the monostable does not fire until the sync pulse reaches this voltage which occurs almost exactly at the moment the mains waveform crosses the zero voltage line (Fig. 4c).

## MONOSTABLE AND TRIGGER CIRCUIT

Fig. 5 shows the circuit of the monostable and trigger for a single channel. In this system eight such circuits are required; for other systems more or fewer can be built.

TR3 and TR4 form the main monostable, these being cross coupled by C5 and R11. Sync pulses are applied to the base of TR3 via C4 and D10. In the absence of such pulses TR4 is normally "on", its base being returned to the positive rail by R9 and the parallel combination of VR1 (a preset potentiometer), VR2 (the manual control) and TR2.

On the arrival of a sync pulse at TR3 this transistor switches on rapidly; the negative going transition at its collector is transmitted via C5 to TR4 which turns off and stays off for the duration of the time constant of C5 together with R9, VR1, VR2, and TR2. R9 guarantees a minimum dwell time (in this case approximately 2ms); as will be seen later this corresponds to maximum lamp intensity.

This resistor can be safely reduced to 22kΩ if absolute maximum brightness is required, but if this

is done the circuit begins to operate on the edge of stability. In actual fact, very little increase of light output was apparent by firing earlier in the cycle than 36 degrees which is what 2ms represents.

The maximum dwell time is set by VR1. This is necessary to prevent the possibility of the monostable "hanging on" into the next mains half-cycle. The effect of deliberately causing this to happen will be described during the setting up procedure. Maximum dwell time should be approximately 9ms for stability—this also allows for variations in mains frequency.

Having set the minimum and maximum dwell times, intermediate periods can be set by adjusting VR2 (the front panel control) or by causing TR2 to draw current. Voltage control of this dwell time is effected by drawing base current through TR2 by a voltage applied to the input of R6. It is important to note that the control voltage must be negative with respect to the positive rail as TR2 is a *pnp* transistor.

No control is effected until the input voltage exceeds the emitter-base forward voltage drop (500–600mV). As the input voltage increases the collector current of TR2 increases in proportion and thus linearly reduces the dwell time of the monostable. See Fig. 4e and 4f.

As it is the dwell time which determines the position of the ultimate trigger pulse within the mains half-cycle, it is the negative going excursion of the collector of TR4 that is used. This is differentiated by C6 and R13 before being applied to TR5 which provides the trigger pulse drive into the isolating transformer T2.

The output of T2 is directly connected across the cathode and gate of the thyristor or triac. The amount of gate current to the thyristor is determined by the tuned circuit C7 and T2 primary. If this gate current is insufficient for the device used C7 can be

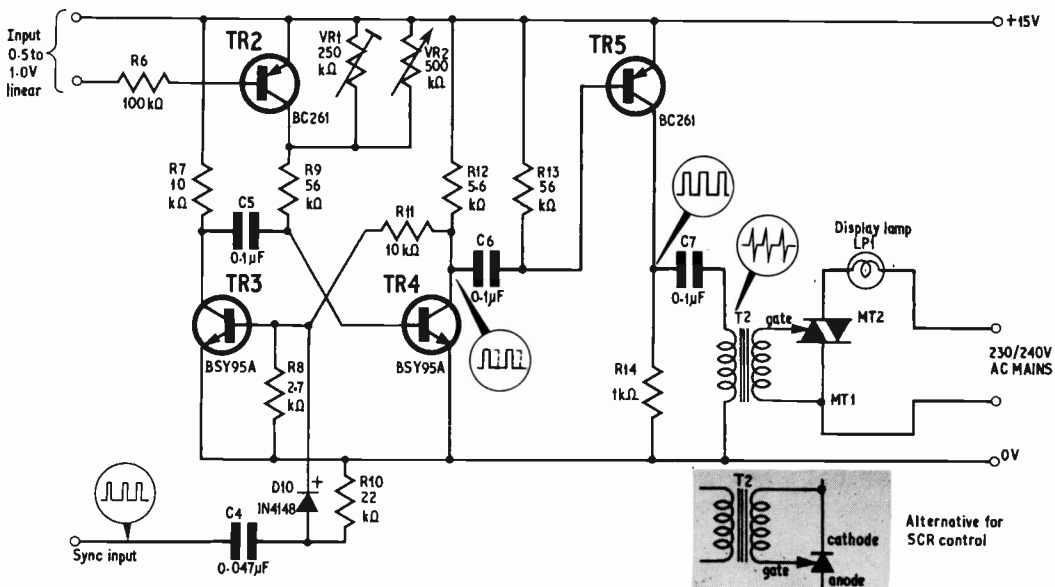


Fig. 5. Circuit diagram of the monostable timing and trigger for one channel

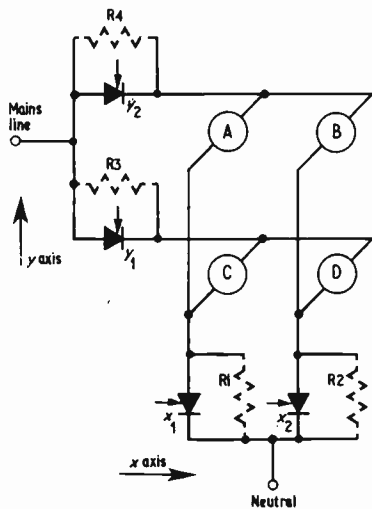


Fig. 6. Simple thyristor matrix of two by two. It is necessary to include the ballast loads (R1 to R4 shown dotted) in the form of 15 watt lamps. These will have a higher resistance than the lamps at the matrix nodes, but still low enough to provide at least 20mA holding current for the thyristors. Each lamp node should not be less than 40 watts to minimise interaction

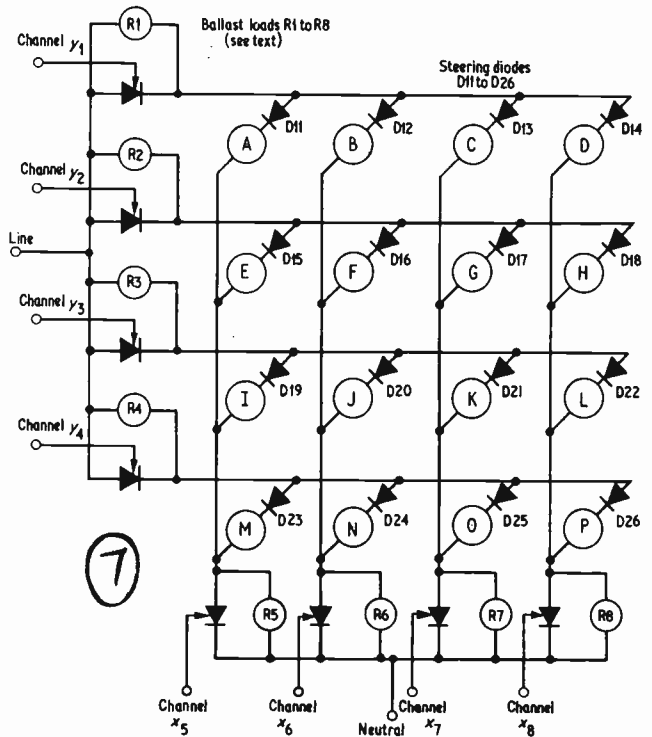


Fig. 7. A complete four-by-four matrix where symbols A to P represent the lamp nodes (40 watts each), symbols R1 to R8 represent the ballast loads (15 watt bulbs), D11 to D26 steering diodes to avoid interaction are rated at 600V 1A for each lamp node. Thyristors for channels 1 to 8 must each be rated at four times the current through each node.

increased to a value up to 0.2 $\mu$ F. Trigger current for the thyristors or triacs is not greater than 30mA 3V. Polarity of the output of T2 is not important owing to differentiation of the waveform.

### TRIAC AND THYRISTOR MATRIX

It was mentioned earlier that a novel type of output was available from the controller, and it is worth discussing at this point as it requires a slight variation in thyristor orientation. If it is desired, each control channel can be used independently of any other, thus one can control up to eight lamp circuits. If this is all that is required then the following details can be ignored and the circuits wired up exactly according to Fig. 5.

Provided one is prepared to use thyristors, it is possible to obtain up to 16 lamp control channels from the eight basic trigger circuits. This is done by matrixing four of the channels against the remaining four.

The principle of the matrix is shown in Fig. 6, which represents four lamp circuits controlled by four thyristors (x1, x2, y1, and y2). One side of lamps A and B are commoned and taken to the cathode output of thyristor at y2; similarly one side of C and D is taken to y1. Conversely the free side of A is commoned with C and taken to x1; similarly with B and D to x2.

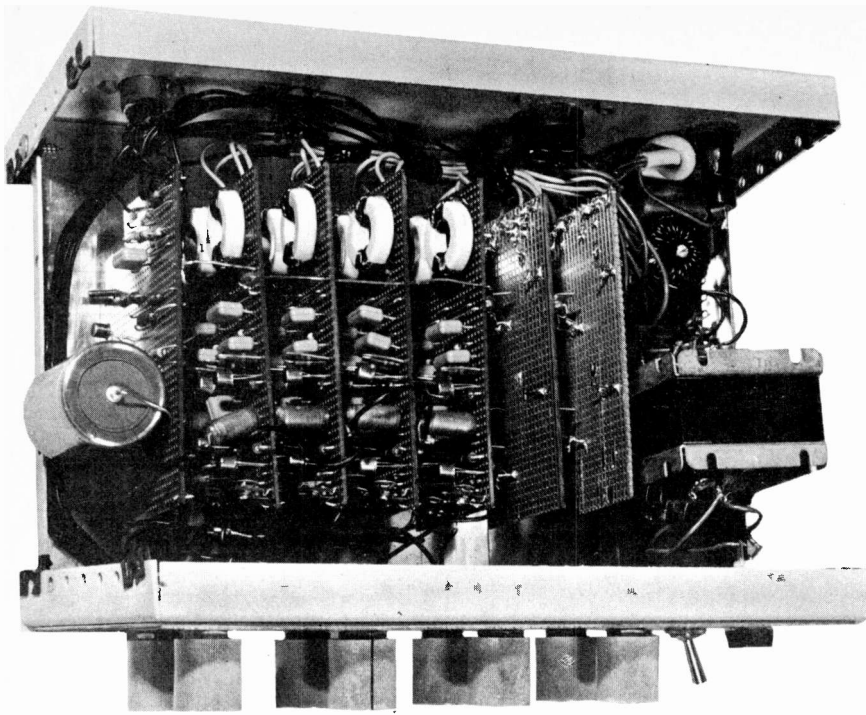
Note, however, that the commoned sides of A and C with B and D go to the anode ends of thyristors x1 and x2. The anodes of the thyristors on the Y axis are both taken to one side of the mains (say "line") and the cathodes of those on the X axis to "neutral". All the thyristors can be individually controlled by trigger pulses from the control channels.

If one ignores the fact that a thyristor needs a holding current to sustain conduction, one can simply say that if y1 and x1 are triggered, lamp A will go on; y2 with x1 and x2 will light A and B and so on. In practice, however, this simple concept will not work unless trigger pulses arrive at the x and y thyristors simultaneously.

Assume that y2 is triggered but neither x1 or x2; no current will flow through y2 and hence it will immediately extinguish at the end of the trigger pulse. If a trigger pulse was to arrive at x1 or x2 later but within the same half-cycle, neither of these would hold on.

### HOLDING CURRENT

For the matrix to work we must provide some holding current when either axis switches. This holding current can be provided by the resistors shown dotted as R1 to R4 (Fig. 6). If either of the thyristors on the Y axis are now triggered they will



Top view of the controller chassis showing the circuit boards and power unit

draw current through either R1 or R2. Likewise for devices on the X axis through R3 or R4.

The values of these resistors must be carefully chosen so that they pass sufficient holding current, but not sufficient current for any apparent illumination of the main lamps A, B, C, and D, which are in effect in a complicated series parallel arrangement with the resistors. In operation the thyristors work by bypassing the resistors rather like toggle switches.

A few moments puzzling over a network analysis of the equivalent circuit under all combinations of switching will show that the problem is extremely complex. If the circuit was scaled up to a four-by-four matrix the problem could only be satisfactorily solved by computer.

Without going into the complicated mathematics it is sufficient to say that the problem can be solved in two ways:

1. The holding current resistors should be of very high resistance compared with the lamps, or
2. We allow current only to flow in one direction through the main lamps by using steering diodes.

The author has used both methods and quite definitely the diode solution, although more expensive, is by far the best.

Even with diodes one still has to provide holding current and the simplest solution to obtaining resistors of sufficient power rating is to use low power mains rated lamps (these can ultimately be incorporated as part of the display). This holding current is provided by 15W bulbs which allow a reasonable matrix effect if the main display lamps are not less than 40W each.

If diodes (of sufficient voltage and current rating) are also used they should be connected in series with each main lamp in the same direction as the thyristors.

## LAMP LOADS

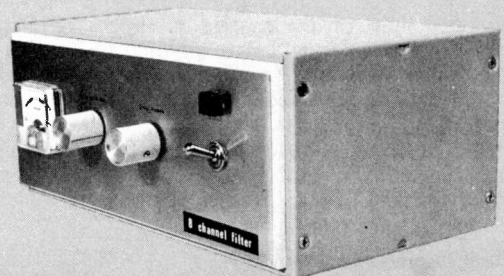
Using 40W bulbs in the main display, a perfect matrix display, with no parasitic interaction, is obtained. Fig. 7 shows the complete circuitry for the four-by-four matrix using diodes as recommended.

It is important to note that each thyristor on each axis must be capable of handling the load of all four lamps to which it is commoned. In this article we shall be considering 1A thyristors without heat sinks, thus the maximum current that may be drawn by each lamp node is 250mA (i.e. approximately 60W). This can easily be extended by using higher current rated thyristors mounted on heat sinks; however, for domestic use 16 lamps of 60W each are more than adequate.

No advantage is obtained by using triacs in the matrix when diodes are in use. They will, of course, increase the available light in the simple resistor only matrix but will exaggerate the interaction of current paths.

## Next month: construction of the lamp control unit

P.E. AURORA AUDIO BAND SPLITTING FILTER UNIT FOR OPERATION WITH SOUND WILL BE DESCRIBED IN PART THREE





## F.E.T. INPUT

The circuit of the touch switch is shown in Fig. 1. A field effect transistor, TR1, is used at the input to provide a very high input impedance, to the noise voltages developed across the resistor chain R1-R6 through contact with the touch plate.

The source, gate and drain electrodes of the n-channel f.e.t. are closely analogous to the cathode, grid and anode of the triode valve. The voltage drop across source load R2 biases the gate negative with respect to the source. With the values shown, the f.e.t. is biased close to pinch-off, corresponding to valve cut-off.

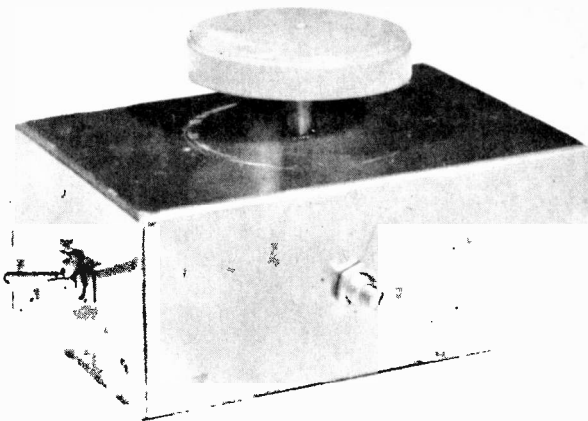
## TOGGLE ACTION

On touching the touch plate, the stray noise introduced raises the mean drain/source current and the potential across C1 rises. When the touch is removed the potential falls. This negative swing is passed by C3 and C5 to cause the bistable circuit of TR2 and TR3 to change state.

When TR2 is conducting, its collector is close to earth potential and TR3 is biased off via VR1. TR2 is held in conduction by current through R10 and therefore this state is stable. The small current through the relay is insufficient to energise it.

If now a negative pulse is fed to TR2 base via C3 and D1, TR2 turns off. Its collector goes positive and TR3 is turned on via VR1. The collector of TR3 swings towards earth so that TR2 is no longer biased on. The circuit is now in its other stable state where there is sufficient current in the relay to energise it.

A negative pulse fed to TR3 base via C5 and D2 causes the circuit to change state again. The relay contacts switch the power to the equipment to be controlled. Thus the switch provides a touch-on, touch-off operation.



As TR3 has an inductive load, its turn on time has to be speeded up by the addition of C4. It is also protected by diode D3 against transient voltages induced in the relay.

The a.c. gain of TR2 is reduced by C2 to prevent relay chatter.

The times taken for C3 and C5 to charge through R9 and R11 respectively affect the rate at which the bistable states can be changed and these time constants are made large to ensure stable operation.

## RESISTOR CHAIN

The large total value of the resistor chain R1-R6 was found to give good sensitivity. It is obtained by connecting six, 10 megohm carbon resistors in series and arranging for them to be self supporting to avoid leakage problems.

Higher resistance values will provide a higher input impedance and hence more sensitivity but there is a diminishing return as the f.e.t. gate impedance becomes more significant in comparison. If the resistance of R1 is made infinite, or in other words R1 is just an open circuit, the input impedance is so high that the f.e.t. responds to static charges.

Electrolytic capacitors cannot be used for C3 or C5 as these capacitors receive charges of opposite polarity in the two bistable states. Small paper or polyester types are suitable.

## CONSTRUCTION

The circuit components are arranged on a small piece of Veroboard (Fig. 2) mounted inside an aluminium chassis as shown in Fig. 3. The chassis is connected to battery negative to provide screening for the circuit. Layout is not critical and the unit can be made smaller provided it is fully screened.

If mains equipment is to be controlled a piece of metal, bolted to the chassis, should be used to screen the relay contacts from the rest of the circuit.

The supply is made up of three 9V batteries connected in series to give 27V; the circuit will work well on any voltage between 18V and 30V.

A tin lid can be used for the touch plate. This is supported above the chassis by a short piece of Bakelite tube as it is important to maintain a high insulation and a low capacity between the touch plate and the chassis.

## COMPONENTS . . .

### Resistors

R1-R6	10M $\Omega$ (6 off)
R7	6.8k $\Omega$
R8	10k $\Omega$
R9	470k $\Omega$
R10	1M $\Omega$
R11	470k $\Omega$
All $\pm 10\%$ $\frac{1}{2}$ watt carbon	

### Capacitors

C1	64 $\mu$ F elect. 40V
C2	0.1 $\mu$ F polyester
C3	1 $\mu$ F polyester
C4	0.01 $\mu$ F ceramic
C5	1 $\mu$ F polyester

### Transistors

TR1	2N3819
TR2-TR3	ZTX302 (2 off)

### Diodes

D1-D3	OA81 (3 off)
-------	--------------

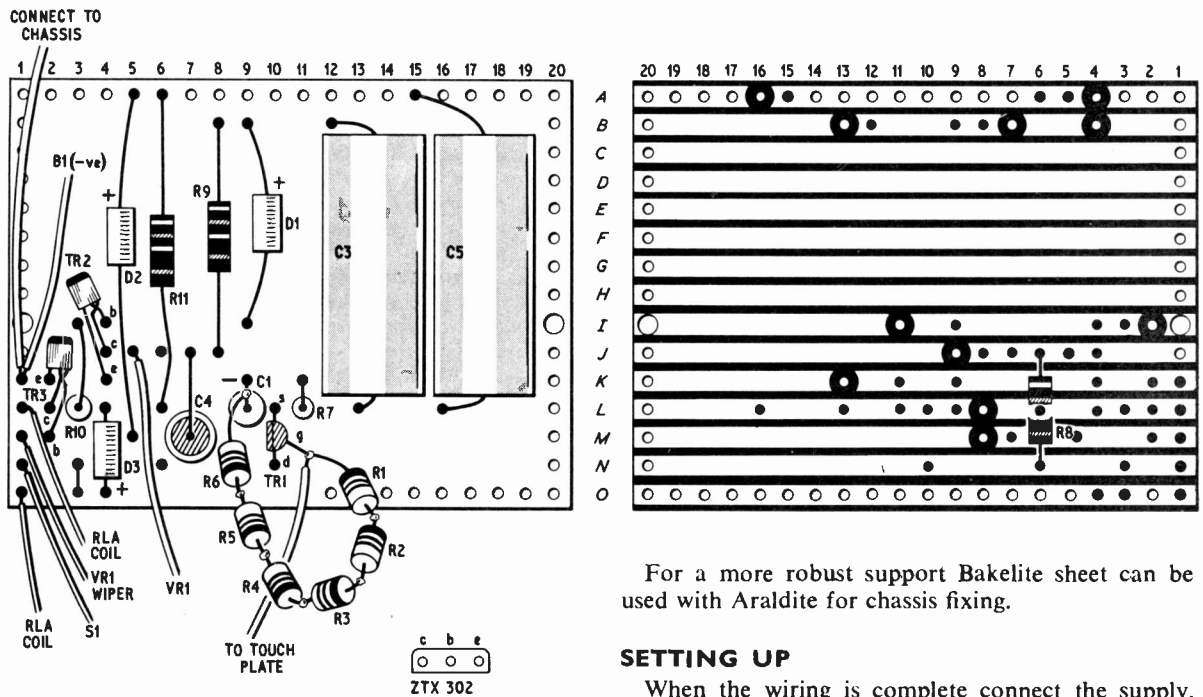
### Relay

RLA	700 $\Omega$ , 2-pole C/O relay type 43 (Radiospares) or type MH2 (Omron)
-----	--

### Miscellaneous

BY1-9V batteries (3 off), Veroboard $2\frac{1}{2}$ in $\times$ 3in 0.1in matrix, 6in $\times$ 4in $\times$ $2\frac{1}{2}$ in aluminium.	
--	--





**Fig. 2.** Assembly and wiring details of topside and underside of Veroboard sub-assembly. Resistor R8 is shown on the underside, broken to reveal the connection at hole 6L for R11

For a more robust support Bakelite sheet can be used with Araldite for chassis fixing.

### SETTING UP

When the wiring is complete connect the supply. Set VR1 to mid-position and switch on. The bistable will immediately go into one of its two stable states and the relay may energise.

Touch the touch plate to see if this will trigger the bistable. VR1 must be carefully adjusted to give proper action and equal "on" and "off" sensitivity and stability. If the resistance is set too high, TR3 will not conduct hard enough to keep the relay energised.

As VR1 resistance is reduced, a point may be reached where touching the touch plate causes the relay to chatter. Reducing the resistance a little more will give the proper operating point. If the resistance is too low the relay will remain permanently energised; if this should happen for all settings of VR1 it may be necessary to reduce R5 to 820k $\Omega$  or 680k $\Omega$ .

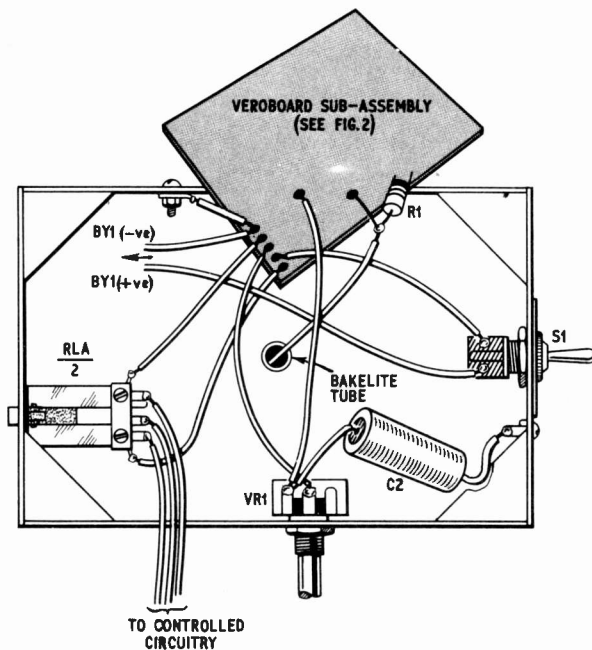
If the circuit fails to work, the f.e.t. stage can be checked by connecting a voltmeter across C1. Touching the plate should cause an increase in deflection.

The bistable can be checked by connecting a lead to battery negative and touching it to the base of whichever of TR2 and TR3 is conducting. This should cause the bistable to change state.

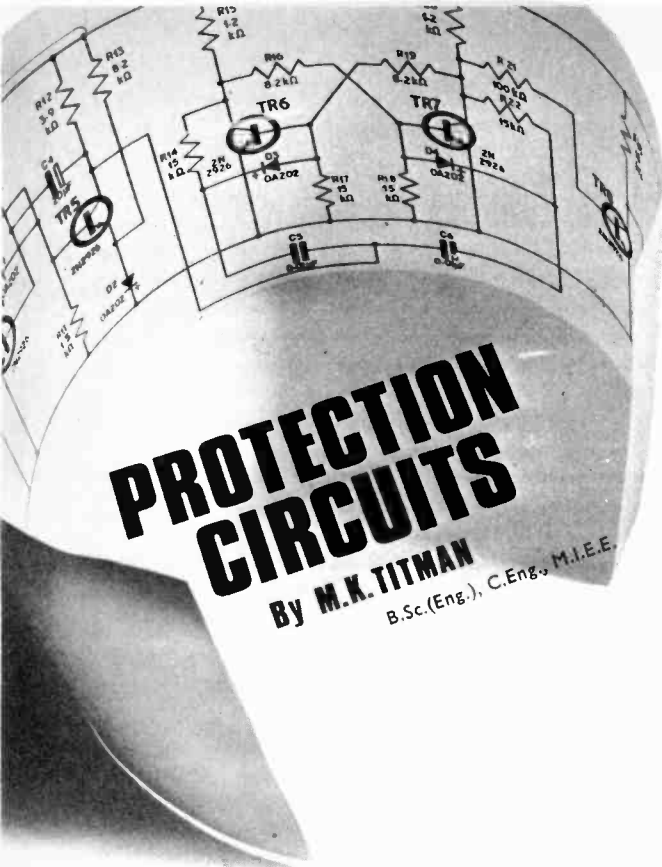
### SENSITIVITY

When the switch is used in a building, it responds to the mains radiation transferred by bodily contact with the touch plate. When used away from mains wiring it responds to radio frequencies and is somewhat less sensitive. It will not work in a completely screened room or react to the touch of a person who is well "earthed".

If C2 is reduced in value or removed, the touch switch becomes slightly more sensitive and mere body proximity may be enough to cause switching. But under these conditions the setting of VR1 is extremely critical and the switch is less stable. ★



**Fig. 3.** Chassis mounted components and Veroboard wiring details. The precise details of connecting the relay contacts will depend on the circuit application



where  $I_{Dp}$  = maximum diode current  
 $V_{in}$  = supply voltage  
 $V_{Dp}$  = Zener voltage  
 $R_s$  = series resistance in ohms

Assuming an integrated circuit supply having an input voltage of 12V and an output rating of 5.1V at 1A, the resistor  $R_s$  would normally have a value of 4 ohms. Consequently the 6.2V protection Zener should be capable of carrying 1.5A continuously, and therefore a 10W, 6.2V Zener diode mounted on a heatsink would be required.

It should be noted that the power rating of the series resistor must be capable of 9W continuous dissipation.

From this it can be seen that the protection Zener diode must be capable of holding and dissipating the full output power of the supply, therefore it is only suitable for low power stabilised supplies.

As an example a 24V d.c. supply capable of delivering 1A would require a protection diode of 26 to 30W rating and clearly this is impractical. For higher power circuits, therefore, crowbar protection circuits are utilised.

### CROWBAR PROTECTION

Crowbar protection circuits operate by effectively causing a short circuit across the supply until the line fuse ruptures. Unlike Zener protection where an intermittent fault would result in a return to normal working after the fault cleared, crowbar circuits positively isolate the faulty power supply.

This can be an advantage in very complex systems. Any failure condition can be used to operate the crowbar circuit and these include overvoltage, overcurrent and overpower.

WITH the increasing complexity of modern semiconductor circuitry, any form of power supply failure can be extremely costly. To forestall this, power supply and circuit failure protection circuits are commonly employed.

In general, overvoltage protection prevents damage to the fed circuit if the power supply voltage increases. Overcurrent and overpower protection prevents damage to the power supply if the fed, or external, circuit fails.

The two forms of protection circuit presented here are the self-resetting and crowbar circuits.

### ZENER DIODE PROTECTION

Of the self-resetting overvoltage protection circuits, the simplest relies on a Zener diode. Fig. 1 shows a typical low power stabilised supply circuit used to power integrated circuits.

The output voltage is held at 5.1V and the supply current of 175mA is limited by the series resistor  $R_s$ .

If the stabiliser diode  $D_s$  failed and went open circuit, this would normally result in an increase in output voltage towards a peak value of 12V. However, with the protection Zener diode  $D_p$  connected the output voltage is held at 6.2V.

### DIODE POWER RATING

For overvoltage protection of larger current stabilised supplies the power rating of the protection diode must be calculated.

In Fig. 1, the maximum current  $I_{Dp}$  likely to be taken by  $D_p$  is determined by the value of  $R_s$ . To evaluate this the following equation should be used.

$$I_{Dp} = \frac{V_{in} - V_{Dp}}{R_s}$$

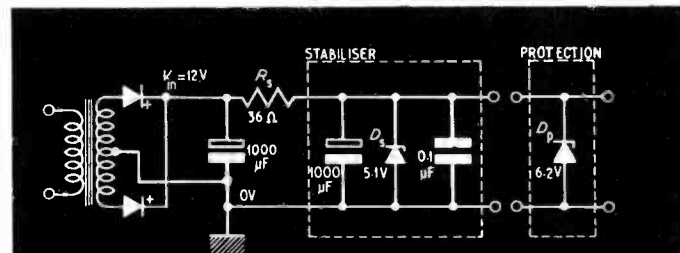


Fig. 1. Zener diode overvoltage protection

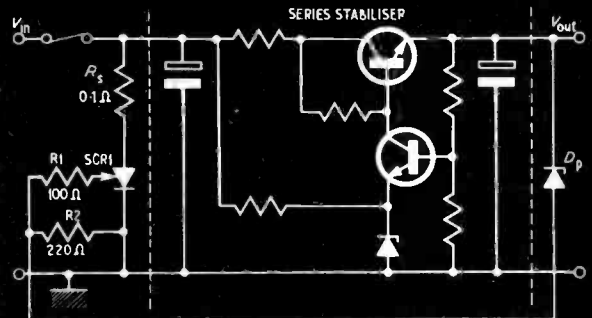


Fig. 2. Overvoltage crowbar protection

## OVERVOLTAGE CROWBAR

In Fig. 2 is shown a typical overvoltage crowbar system operating in conjunction with a high power series stabiliser.

Any overvoltage at the output causes the sensing Zener diode  $D_p$ , to conduct, so passing current to the thyristor gate. The thyristor SCR1 switches on and causes a heavy current to flow through the fuse until it ruptures.

Since the circuit operates only for a very short period the Zener diode can be of 100mW rating as can the thyristor gate resistor.

The thyristor is chosen for its peak transient current rating which can be 25A to 100A for a TO-5 case thyristor. The series resistor  $R_s$  is a low value wire-wound resistor which simply limits the peak transient current.

Whilst an actual overvoltage condition must occur before the crowbar circuit operates, the overvoltage acts for a very short period.

Since the turn-on time of the thyristor is 10 to 20 $\mu$ s and following this a large current flows through the fuse, the supply voltage reduces almost immediately. Consequently the circuitry operated from the power supply receives an overvoltage transient of only 10 to 20 $\mu$ s duration which is usually insufficient time to cause circuit failure.

Because the ratings are based on transient effects, low cost components can be used.

## OVERCURRENT CROWBAR CIRCUIT

One form of overcurrent crowbar circuit is illustrated in Fig. 3 and it can be seen that a certain amount of increased complexity, and therefore expense, is involved.

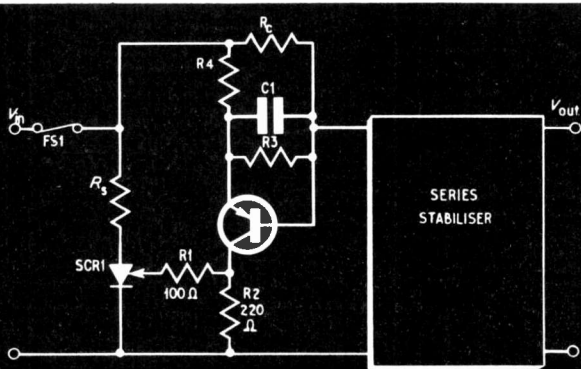


Fig. 3. Overcurrent crowbar protection

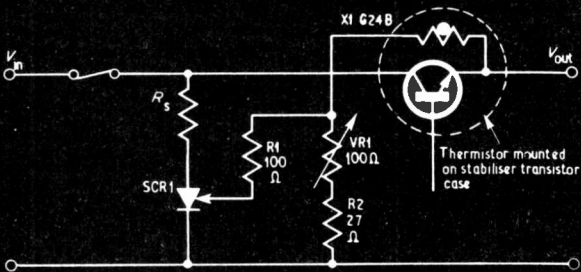


Fig. 4. Overpower crowbar circuit

The current level is sensed by resistor  $R_e$  which is chosen to give approximately 0.5 to 0.75 voltage drop at the fusing current. Generally the fusing current is chosen to be 150 to 200 per cent of full load current. When the current reaches this level the transistor conducts and operates the crowbar thyristor.

The resistor capacitor combination  $R_4$ ,  $R_3$ , and  $C_1$  are incorporated to limit the speed of response of the circuit. This is a vital precaution since the capacitors in the stabiliser and following circuitry usually require a heavy switch-on charging current, consequently the time constant  $C_1R_4$  must be longer than any switch-on surge current periods.

Typical component values using a transistor series stabiliser are  $R_4 = 680\Omega$ ,  $R_3 = 1.8k\Omega$ ,  $C_1 = 10\mu F$ .

## COMPARISON WITH A FUSE

With the increased complexity and difficulties inherent in the design of overcurrent trip circuits, the usefulness of this type of circuit is doubtful. For the vast majority of applications the simple fuse is adequate. However, occasionally this form of circuit is necessary for the protection of complex power equipment.

The main advantages over the simple fuse are a more definite fuse current, increased speed of response and greater reliability.

Reliability is perhaps the most important aspect, since the fuse incorporated with the crowbar circuit can be two or three times the rated current. This increased rating could well increase fuse life by three to ten times above the 1,000 hours usually quoted.

## OVERPOWER CROWBAR CIRCUIT

The overpower crowbar circuit is seldom employed but can have very useful applications. The simplest form of circuit is given in Fig. 4 and consists of a thermistor for temperature sensing together with the thyristor crowbar.

In this example, the directly heated bead type thermistor is located on the surface of the series transistor of the stabiliser. Any excess power dissipation in the series transistor, such as produced by a short circuit, would result in overheating and consequent reduction in thermistor resistance. After a thermal delay period the minimum gate voltage will be exceeded and the thyristor triggers.

Since the body of the thermistor is isolated, any critical or expensive component in any part of the circuit can be monitored. Therefore this form of protection is extremely versatile.

Unfortunately, this form of protection requires a fairly large temperature change for reliable operation and is suitable only for non-critical operation. For more critical operation a single transistor comparator circuit can be used to give an accuracy of temperature measurement to  $\pm 5$  degrees Centigrade.

## APPLICATIONS

The Zener diode protection circuits are only suitable for low power supplies, although they are useful for high current low voltage integrated circuit power supplies.

The thyristor crowbar circuits can be used for any size power supply, and it can be arranged for any type of fault condition to fire the thyristor. The crowbar circuits given can be combined to give a comprehensive protection device using a single thyristor, sensing Zener diode, thermistor and transistor. All the circuits are separate to the basic power supply and modifications to this are not required. ★

# 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.

## STEREO TAPE CARTRIDGE

Offering 40 minutes and 80 minutes recording time, compared with the 30 and 60 minute version currently available, is the main feature of the new Scotch 8-track tape cartridges, type S-8TR-40 and S-8TR-80, from the **3M Company**.

The Scotch 8-track cartridges may be used in any cartridge system having recording facilities and may, of course, be played back on any 8-track stereo equipment. The extra 10 minutes on the S-8TR-40 permits the complete recording of an average 12in. LP record.

Recommended retail prices are £1.50 for the 40 minute cartridge, and £1.80 for the 80 minute version.

## MOULDED TRACK POTENTIOMETER

Potentiometers, types T and TS, of all-moulded construction, including the bush and fixing nut, are announced by Plessey.

The type TS is identical to the Type T except that it incorporates a single-pole switch which is suitable for low voltage battery circuits.

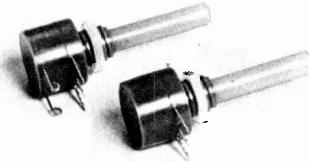


Scotch 8-track stereo tape cartridge from the 3M Company

The case is in two halves and is ultrasonically welded together to provide a completely insulated potentiometer.

These potentiometers are particularly suitable for portable transistor receivers and other equipment where a miniature moulded track potentiometer is required.

Full details and technical specifications can be obtained from Painton Electronic Components, Kingsthorpe, Northampton, NN2 6NA.



Plessey type TS and T miniature moulded potentiometers

## FLASH TUBE

A new photographic flash tube, the Type CD13, has been introduced by the Electronic & Display Equipment Division of Ferranti as an addition to its range of tubes for photographic and similar applications.

A high intensity xenon-filled flash tube for electronic flash equipment, the CD13 produces a white light which is a good match to daylight and is suitable for "daylight" colour films. This device is a straight tube 210mm long.

Operating voltage of the tube ranges between a minimum 400V and a maximum 1,000V, and the typical operating level is 900V. The CD13 is not polarised and the charging voltage and discharge capacitor may be connected across the leads without regard to polarity.

Details of price and local stockists can be obtained from Ferranti Ltd., Electronic and Display Equipment Division, Gem Mill, Chadderton, Oldham, Lancashire.

## CIRCUIT BOARDS

Quality printed circuit boards are now available for the circuits shown in the Mullard book "Transistor Audio and Radio Circuits". The boards manufactured by **Bribond Printed Circuits Limited**, Terminus Road, Chichester, Sussex, are made to the same standards as their industrial boards.

The boards are manufactured from high electrical grade s.r.b.p. laminate clad with 0.0015in copper. The copper tracks are tinned to aid soldering and give protection against oxidation. To aid construction, the

component identification is printed on the reverse in white.

At the moment the following circuits are available:—

- 10W high quality audio amplifier (p. 102) 66p
  - 25W high quality audio amplifier (p. 106) 70p
  - 10/25W high quality audio pre-amplifier (p. 108) 73p
  - 10W audio amplifier (p. 39) 66p
  - 10W audio preamplifier (p. 42) 69½p
- Price each including postage and packing.

## LITERATURE

The new component catalogue from **A. Marshall & Son (London) Ltd.**, is now available to readers. The catalogue lists many new items but probably the most interesting, to our readers, is the section on integrated circuits. This section contains one of the largest selections of I.C.'s available to the amateur we have seen. Apart from the English manufacturers there is a large range from American firms.

Request for copies should be addressed to, A. Marshall & Son (London) Ltd., 28 Cricklewood Broadway, London, N.W.2.

All the new editions of the component catalogues from **Henry's Radio, Home Radio (components), G. W. Smith & Co. (Radio), and LST Components** are up to their usual high standard and make a useful reference for the workshop.

Of particular interest to designers is a revised designers' guide to mercury and alkaline manganese primary power systems published by **Mallory Batteries**.

In addition to describing the two primary cell systems, the guide explains their advantages under widely differing environmental conditions.

It provides detailed specifications of over 100 different cells with the object of giving designers such basic information as capacity, nominal voltage and dimensions.

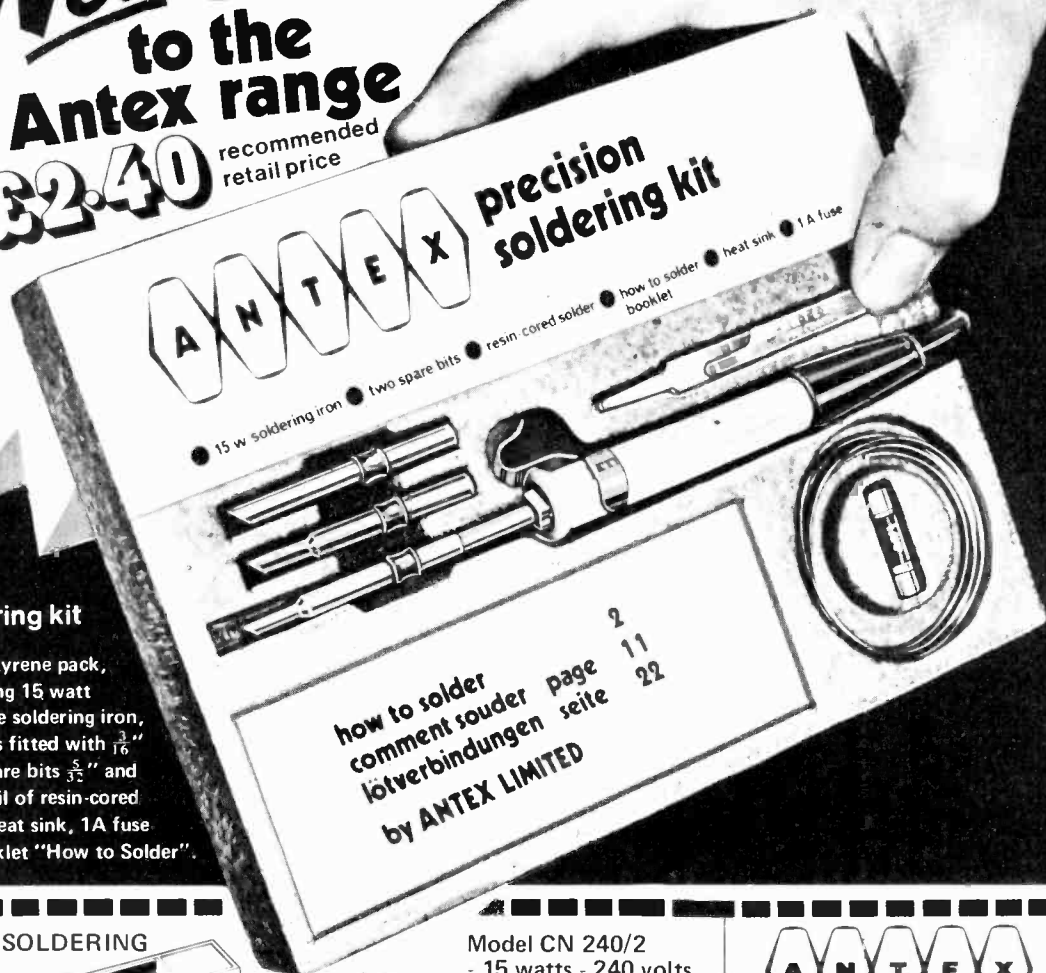
The designers' guide is also available in French and German and full details can be obtained from **Mallory Batteries Ltd.**, Gatwick Road, Crawley, Sussex.

Containing more than 70 new products, ranging from an 8-track stereo cartridge player for cars to a multi-meter for test engineers, **Eagle International's** new 45-page catalogue is now available from **Eagle International**, Coptic Street, London, WC1A LNR, price 20p.

Divided into sections on hi fi equipment, hi fi accessories and peripherals, radio and tape equipment, office intercoms, public address, test equipment, electronics and accessories, the catalogue carries illustrations, detailed specifications and prices of over 400 products.

# introducing the New SK2 KIT to the Antex range

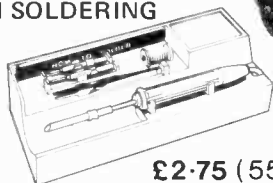
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## SK2 Soldering kit

In polystyrene pack, containing 15 watt miniature soldering iron, 240 volts fitted with  $\frac{3}{16}$ " bit, 2 spare bits  $\frac{5}{32}$ " and  $\frac{1}{8}$ ". Coil of resin-cored solder, heat sink, 1A fuse and booklet "How to Solder".

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Model CN 240/2  
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Fitted with nickel plated  $\frac{3}{32}$ " bit and packed in handy transparent box.



Model G - 18 watts. Fitted  $\frac{3}{32}$ " bit. Spare bits  $\frac{1}{8}$ ",  $\frac{3}{16}$ " and  $\frac{1}{4}$ " available. For 240 or 220 volts. £0.87 (17/5).



Model F - 40 watts. Fitted  $\frac{5}{16}$ " bit. Spare bits  $\frac{3}{32}$ ",  $\frac{1}{8}$ ",  $\frac{3}{16}$ " and  $\frac{1}{4}$ " available. For 240, 220, 110, 20 volts. From £2.35 (47/-).

Model E - 20 watts. Fitted  $\frac{1}{4}$ " bit. Spare bits  $\frac{3}{32}$ ",  $\frac{1}{8}$ " and  $\frac{3}{16}$ " available. For 240, 220 or 110 volts. From £1.80 (36/-).

Model ES - 25 watts. Fitted  $\frac{1}{8}$ " bit. Spare bits  $\frac{3}{32}$ ",  $\frac{3}{16}$ " and  $\frac{1}{4}$ " available. For 240, 220 or 110 volts. From £1.80 (36/-).



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1N253	0-60	AC188	0-30	BF185	0-25	HG1005	0-60	OC45	0-15
1N256	0-60	ACV17	0-30	BF194	0-18	H8100A	0-20	OC45M	0-18
1N645	0-25	ACV18	0-25	BF195	0-15	MAT100	0-25	OC46	0-28
1N725A	0-20	ACV19	0-25	BF196	0-25	MAT101	0-30	OC47	0-20
1N914	0-08	ACV20	0-25	BF197	0-25	MAT120	0-25	OC58	0-60
1N4007	0-23	ACV21	0-23	BF861	0-28	MAT121	0-30	OC59	0-65
18021	0-20	ACV22	0-18	BF898	0-28	MJE520	0-88	OC66	0-50
18113	0-15	ACV27	0-25	BFX12	0-28	MJE2955	1.75	OC70	0-13
18130	0-13	ACV28	0-18	BFX13	0-23	MJE3055	0-88	OC71	0-15
18131	0-13	ACV39	0-25	BFX29	0-30	NKT128	0-30	OC72	0-25
18202	0-23	ACV40	0-15	BFX30	0-28	NKT129	0-30	OC73	0-25
2G240	0-08	ACV41	0-25	BFX35	0-08	NKT211	0-25	OC74	0-30
2G301	0-18	ACV44	0-38	BFX63	0-50	NKT213	0-25	OC75	0-25
2G302	0-23	AD140	0-50	BFX84	0-30	NKT214	0-15	OC76	0-25
2G306	0-30	AD149	0-50	BFX85	0-40	NKT216	0-38	OC77	0-40
2G371	0-23	AD161	0-38	BFX86	0-33	NKT217	0-40	OC78	0-20
2G381	0-25	AD162	0-38	BFX87	0-33	NKT218	1.13	OC78D	0-13
2G414	0-30	AF106	0-30	BFX88	0-38	NKT219	0-30	OC79	0-25
2G417	0-23	AF114	0-30	BFY10	1.00	NKT222	0-20	OC81	0-25
2N214	0-43	AF115	0-30	BFY11	1.25	NKT224	0-23	OC81D	0-20
2N247	0-25	AF116	0-33	BFY17	0-25	NKT251	0-24	OC81M	0-20
2N260	0-50	AF117	0-25	BFY18	0-25	NKT271	0-25	OC81DM	0-18
2N404	0-23	AF118	0-23	BFY19	0-25	NKT272	0-25	OC81Z	0-55
2N897	0-18	AF119	0-20	BFY24	0-45	NKT278	0-30	OC82	0-50
2N298	0-43	AF120	0-25	BFY44	1.00	NKT274	0-20	OC82D	0-15
2N706	0-10	AF123	0-30	BFY50	0-23	NKT275	0-25	OC83	0-25
2N706A	0-13	AF126	0-18	BFY51	0-20	NKT277	0-20	OC84	0-25
2N708	0-15	AF127	0-18	BFY52	0-23	NKT278	0-25	OC114	0-38
2N709	0-03	AF139	0-30	BFY53	0-18	NKT301	0-30	OC122	0-50
2N711	0-38	AF178	0-48	BFY64	0-43	NKT304	0-35	OC129	0-50
2N897	0-43	AF179	0-48	BFY90	0-48	NKT349	0-75	OC139	0-25
2N1090	0-30	AF180	0-53	BX27	0-50	NKT404	0-63	OC140	0-38
2N1091	0-33	AF181	0-43	BX260	0-93	NKT678	0-30	OC141	0-63
2N1131	0-30	AF186	0-40	BX276	0-15	NKT713	0-25	OC169	0-20
2N1132	0-30	AFY19	1.13	BX266	0-18	NKT773	0-25	OC170	0-25
2N1302	0-20	AFZ11	0-63	BX277	0-20	NKT777	0-38	OC171	0-30
2N1303	0-23	AFZ12	-0.75	BY51	0.50	OT873	0-35	OC200	0-38
2N1304	0-25	AFY28	0-25	BY95A	0.15	OA5	0-15	OC201	0-48
2N1305	0-25	ASY27	0-33	BY95	0.15	OA6	0-13	OC202	0-63
2N1306	0-25	ASY28	0-25	BT102/500R	0-25	OA47	0-10	OC203	0-38
2N1307	0-25	ASY29	0-30	0.75	OA70	0.10	OC204	0-40	
2N1308	0-30	ASY36	0-25	BTY42	0.75	OA71	0.10	OC205	0-63
2N1309	0-25	ASY50	0.18	BTY79/100R	0.75	OA73	0.10	OC206	0.75
2N1420	0-20	ASY51	0.20	0.75	OA74	0.10	OC207	0.75	
2N1507	0-28	ASY53	0-20	BTY79/400R	0-20	OA79	0.10	OC460	0-20
2N1526	0-38	ASY55	0-20	1.75	OA81	0.10	OC470	0-30	
2N1909	0-25	ASY62	0-25	BY100	0-18	OA85	0-13	OCP71	0-28
2N2147	0-75	ASY66	0-33	BY126	0-15	OA86	0-15	ORP12	0-50
2N2148	0-60	ASZ21	0-43	BY127	0-20	OA90	0-10	ORP60	0-40
2N2149	0-63	ASZ23	0-25	BY182	0-75	OA91	0-08	ORP61	0-43
2N2218	0-30	AY10	0-40	BY213	0-25	OA95	0-08	S19T	0-30
2N2219	0-33	AU101	1.50	BY213	0-25	OA200	0-08	SAC40	0-25
2N2287	1-03	BC107	0-25	BYZ10	0-40	OA202	0-10	SFT308	0-38
2N2297	0-30	BC108	0-25	BYZ11	0-35	OA210	0-25	SFT72	0-38
2N2309A	0-20	BC109	0-25	BYZ12	0-30	OA211	0-25	STX231	0-63
2N2613	1-25	BC113	0-25	BYZ13	0-25	OA2300	0-55	SX560	0-20
2N2646	0-53	BC115	0-25	BYZ15	1.00	OA2201	0-43	SX631	0-20
2N2712	0-25	BC116	0-40	BYZ15	1.00	OA2202	0-43	SX635	0-30
2N2784	0-60	BC116A	0-45	BYZ16	0-63	OA2208	0-43	SX640	0-25
2N2846	2-25	BC118	0-38	BY288C8V3	0-38	OA2204	0-43	SX641	0-25
2N2848	0-43	BC121	0-20	C111	0-18	OA2205	0-43	SX642	0-38
2N2904	0-30	BC122	0-20	CR81/05	0-65	OA2206	0-43	SX644	0-38
2N2904A	0-30	BC123	0-65	CR81/40	0-48	OA2208	0-48	SX645	0.75
2N2906	0-30	BC126	0-25	CS4B	2.50	OA2209	0-33	V15/30P	0-38
2N2907	0-38	BC140	0-55	CS10B	3-13	OA2210	0-33	V30/201P	0-38
2N2924	0-23	BC147	0-18	DD000	0-15	OA2211	0-33	V60/201P	0-38
2N2925	0-18	BC148	0-13	DD003	0-15	OA2222	0-40	XA101	0-10
2N2926	0-13	BC149	0-20	DD006	0-18	OA2223	0-40	XA102	0-18
2N3055	0-75	BC157	0-20	DD007	0-40	OA2224	0-38	XA151	0-15
2N3702	0-13	BC158	0-20	DD008	0-38	OA2241	0-22	XA152	0-15
2N3705	0-15	BC160	0-83	GD3	0-33	OA2242	0-22	XA161	0-25
2N3706	0-23	BC169	0-13	GD4	0-05	OA2244	0-23	XA162	0-25
2N3707	0-15	BCY31	0-30	GD5	0-33	OA2246	0-22	XB101	0-43
2N3709	0-13	BCY32	0-50	GD8	0-25	OA2249	0-38	XB102	0-10
2N3710	0-13	BCY33	0-20	GD12	0-05	OC16	0-38	XD103	0-25
2N3711	0-13	BCY33	0-20	GET102	0-30	OC16T	0-38	XB113	0-10
2N3819	0-35	BCY34	0-25	GET103	0-23	OC19	0-38	XB121	0-43
2N3820	0-88	BCY38	0-30	GET113	0-20	OC20	0-98	ZR24	0-63
2N3823	0-75	BCY39	0-48	GET114	0-15	OC22	0-48	ZR24	0-63
2N3927	0-53	BCY40	0-48	GET115	0-45	OC23	0-60	ZR170	0-10
2N3988	0-30	BCY42	0-45	GET116	0-50	OC24	0-50	ZR271	0-18
28005	0-75	BCY70	0-20	GET120	0-25	OC25	0-38	ZT21	0-25
28301	0-43	BCY71	0-30	GET872	0-30	OC26	0-25	ZT43	0-25
28304	0-63	BCZ10	0-30	GET875	0-25	OC28	0-63	ZTX107	0-15
28501	0-38	BCZ11	0-38	GET880	0-38	OC28	0-63	ZTX108	0-15
28703	0-63	BD121	0-65	GET881	0-25	OC29	0-63	ZTX300	0-13
AA129	0-20	BD123	0-63	GET882	0-25	OC30	0-40	ZTX304	0-18
AA212	0-30	BDY11	1.63	GET885	0-20	OC35	0-50	ZTX500	0-15
AA213	0-13	BF115	0-25	GEX44	0-08	OC36	0-63	ZTX503	0-20
AC107	0-88	BF117	0-50	GEX45/1	0-15	OC41	0-25	ZTX531	0-30
AC126	0-25	BF167	0-25	GJ3M	0-25	OC42	0-30		

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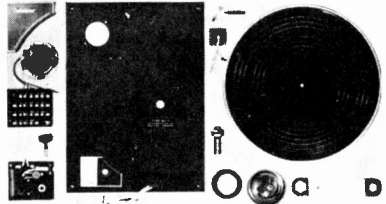
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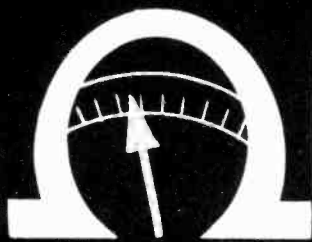


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# DESIGN OF OHMMETERS

BY H.A. COLE, C.ENG. M.I.E.R.E.

THERE are many ways of making an ohmmeter circuit; the most popular circuits can be reduced to either of two basic types which, for convenience, we will designate A and B.

In the A-type circuit (Fig. 1), a battery is connected in series with a fixed resistor ( $R_1$ ), a variable resistor ( $VR_1$ ), and the indicating meter ( $M_1$ ).  $R_m$  is the internal resistance of the meter and  $R_t$ , the total resistance in the circuit, is equal to  $R_1 + R_{VR} + R_m$ .

## SIMPLE MEASUREMENT

The unknown resistor ( $R_x$ ) is connected between the two ohmmeter terminals X and Y, which places it in series with the rest of the circuit. To determine the value of  $R_x$ , the X and Y terminals are first shorted together (so as to simulate  $R_x = 0$  ohms);  $VR$  is then carefully adjusted so that  $M_1$  just indicates full-scale-deflection (f.s.d.). This procedure is called zeroing the ohmmeter, and is necessary to compensate for ageing of the battery.

The short-circuit between X and Y is then replaced with  $R_x$  and the meter indication, which will now be less than f.s.d., gives an indication of the value of  $R_x$ ; the greater the value of  $R_x$ , the smaller the deflection.

## CALIBRATION

To illustrate how this circuit works, let the battery voltage  $V_b$  equal 1.5V and let the f.s.d. of  $M_1$  equal  $50\mu A$ . When the ohmmeter is zeroed,  $VR_1$  must be adjusted so that the meter current ( $I_m$ ) equals  $50\mu A$ , which means that  $R_t = \frac{1.5V}{50\mu A} = 30k\Omega$ . Leaving  $R_t$  set at  $30k\Omega$ , now connect to the X and Y terminals, an unknown resistor ( $R_x$ ) of such a value that  $I_m$  is reduced to  $25\mu A$  (mid-scale). From Ohms law,

$$I_m = \frac{V_b}{R_x + R_t} \quad (1)$$

$$\text{or} \quad R_x = \frac{V_b}{I_m} - R_t \quad (2)$$

$R_x = \frac{1.5}{25 \times 10^{-6}} - 30 \times 10^3 = 30,000$  ohms which is the same as  $R_t$ .

This is the first important point to notice about the A-type circuit; the mid-scale resistance value is equal to the value of  $R_t$  corresponding to  $R_x = 0$ .

Knowing that  $V_b$  equals 1.5V, and that  $R_t$  equals  $30k\Omega$  for  $I_m = 50\mu A$  ( $R_x = 0$ ), a table of  $R_x$  for corresponding values of  $I_m$  can be compiled by substituting values of  $R_x$  in equation 1 above (Table 1).

From this table a suitable ohms scale may be produced, which can then be marked on the meter dial face; this is illustrated in Fig. 2, for a few values of  $R_x$ .

TABLE 1

Resistor on test $R_x$ (ohms)	Meter current $I_m$ ( $\mu A$ )
0	50 (f.s.d.)
100	49.8
1k	48.4
10k	37.5
30k	25
100k	11.52
1M	1.5
Infinity	0

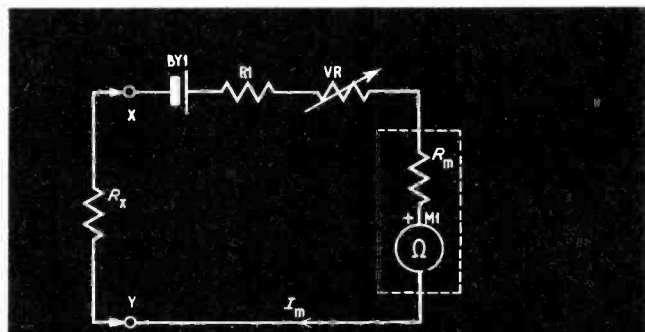


Fig. 1. "A"-type circuit where the battery, meter and variable resistor are all in series

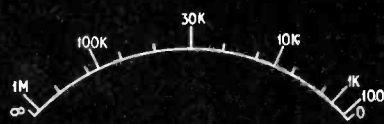


Fig. 2. Typical dial calibration for the example described with Table 1

## SCALE CRAMPING

Note that zero ohms ( $I_m = 50\mu\text{A}$ ) occurs at the right-hand end of the scale, and that infinite resistance ( $I_m = 0\mu\text{A}$ ) corresponding to  $R_x = \text{open-circuit}$ , occurs at the left-hand end.

The scale is also non-linear, following a line of  $1/R$ . It appears severely cramped at the high-resistance end and open at the low resistance end. In fact, if we assume  $1\mu\text{A}$  to be the smallest discernible deflection of the meter pointer (corresponding to 2 per cent of f.s.d.), then we can say that the largest measurable resistance with this particular circuit is about  $1.5\text{M}\Omega$ , using equation 2. Even so, cramping is so severe in this region of the scale that anything greater than about  $1\text{M}\Omega$  is almost unmeasurable.

To measure greater resistance values with this particular circuit (without changing to a more sensitive meter), it is necessary to increase the value of  $V_b$ .

## INCREASING RANGE

Increasing  $V_b$  from 1.5V to 15V increases the measurable resistance by ten times, and also the value of  $R_t$  required for the zero-ohms setting from  $30\text{k}\Omega$  to  $300\text{k}\Omega$ , as is the mid-scale resistance indication.

The advantage of providing a tenfold increase in the value of  $V_b$  means that a single ohms scale can be used for a two-range ohmmeter, the readings corresponding to the higher range being multiplied by ten by the user. This is common practice; typical basic two-range ohmmeter circuits might look like those shown in Fig. 3.

In Fig. 3a, separate VR controls are provided, whereas in Fig. 3b a single VR control is shared by the two ranges. The advantage of having separate controls means that once the two ranges have been zeroed properly it is possible to change from one range to the

other without having to re-zero each time. The only disadvantages of having two controls are additional expense and greater panel space needed to accommodate them.

In the case of one control types of circuit, it is usually fairly coarse in operation, i.e. small adjustments bring about comparatively large changes in the meter indication, which makes zeroing rather difficult.

We have recently seen that the required value of  $R_t$  for the  $\text{OHMS} \times 1$  range ( $V_b = 1.5\text{V}$ ) is  $30\text{k}\Omega$ , and that for the  $\Omega \times 10$  range ( $V_b = 15\text{V}$ ) it is  $300\text{k}\Omega$ . The value of VR1 in Fig. 3b should be made as small as possible for the  $\text{OHMS} \times 10$  range, so that it is no larger than absolutely necessary when it is used for the  $\text{OHMS} \times 1$  range (a resistance value which is small compared with  $300\text{k}\Omega$  is likely to be large when compared with  $30\text{k}\Omega$ ).

## BATTERY AGEING

The batteries used in most ohmmeter circuits are of the carbon-zinc type, a type which is notorious for the variations which occur in its terminal p.d. throughout its life. Because of this, when a new battery is purchased, its terminal p.d. is quite likely to be higher than its nominal voltage, even when delivering a small load current.

In time, however, even if not used, its p.d. will fall and its internal resistance will increase considerably—so much so that it will be unable to deliver the required voltage for the circuit. When it has reached this state the battery is considered as being fully discharged and should be replaced.

## AGEING COMPENSATION

In view of this, the resistance of VR1 must be sufficient to compensate for changes in  $V_b$  ranging from about 13V to 16V on the  $\text{OHMS} \times 10$  range, and from about 1.3V to 1.6V on the  $\text{OHMS} \times 1$  range.

Taking the  $\text{OHMS} \times 10$  range first; when  $V_b$  is 16V, the value of  $R_t$  required to limit  $I_m$  to f.s.d. ( $50\mu\text{A}$ ) when zeroing the ohmmeter is

$$R_{t(\text{max})} = \frac{16\text{V}}{50\mu\text{A}} = 320\text{k}\Omega.$$

Similarly, when  $V_b = 13\text{V}$

$$R_{t(\text{min})} = \frac{13\text{V}}{50\mu\text{A}} = 260\text{k}\Omega.$$

It is the difference between these two required values of  $R_t$  which must be compensated for by VR1; the value of VR1 should therefore be  $60\text{k}\Omega$ .

Since this is not a standard value for a potentiometer, we must either accept a value of  $50\text{k}\Omega$ , which means we won't be able to compensate completely for all changes in  $V_b$ , or one of  $100\text{k}\Omega$ , which would be much too coarse when used on the  $\text{OHMS} \times 1$  range ( $R_t$  for the  $\text{OHMS} \times 1$  range is only  $30\text{k}\Omega$ ). The sensible thing to do then is to select the  $50\text{k}\Omega$  value and to accept the limitation on  $V_b$  compensation.

## RANGE RESISTOR

The next thing to do is select suitable values for R1 and R2. Now, since  $R_{t(\text{max})}$  for the  $\text{OHMS} \times 10$  range is  $320\text{k}\Omega$ , and VR1 is  $50\text{k}\Omega$ , then  $R_2 = (320 - 50)\text{k}\Omega = 270\text{k}\Omega$ —which happens to be a preferred value resistor.

Unfortunately, we run into another problem here, and that is the selection tolerance of R2. For cheapness a  $\pm 20\%$  type could be used, but the value of VR1 (which itself will have a tolerance of  $\pm 10\%$ ) would have to be large enough to compensate for tolerance differences in R2 ( $\pm 20\%$  of  $270\text{k}\Omega = \pm 54\text{k}\Omega$ ), as well as for changes in  $V_b$ .

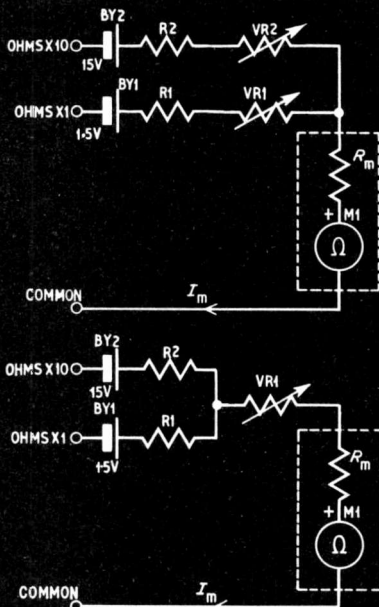


Fig. 3. Basic two-range ohmmeter circuit with (a) two separate controls and (b) one common control

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2G303	20p	2N3420	22p	40311	30p	BC180	12p	88X21	17p	NKT241	27p
2G306	42p	2N3416	37p	40312	47p	BC183	12p	88X21	37p	NKT242	27p
2G308	30p	2N3417	37p	40314	37p	BC184	15p	88X26	45p	NKT243	62p
2G309	30p	2N3570	11-25	40320	47p	BC212L	12p	88X27	47p	NKT244	17p
2G371	15p	2N3572	97p	40323	32p	BCY30	27p	88X28	32p	NKT245	20p
2G374	20p	2N3605	27p	40324	47p	BCY31	27p	88X60	82p	NKT261	20p
2G381	22p	2N3606	27p	40326	37p	BCY32	37p	88X61	62p	NKT262	30p
2G384	22p	2N3607	22p	40329	30p	BCY33	20p	88X76	22p	NKT264	20p
2N696	20p	2N3702	12p	40344	47p	BCY34	22p	88X77	27p	NKT271	20p
2N697	20p	2N3703	12p	40347	57p	BCY38	22p	88X78	27p	NKT272	20p
2N698	25p	2N3704	17p	40348	57p	BCY39	52p	88X79	27p	NKT273	20p
2N706	12p	2N3705	15p	40360	47p	BCY40	37p	88Y10	27p	NKT275	27p
2N708	12p	2N3707	12p	40361	47p	BCY42	15p	88Y11	27p	NKT281	27p
2N709	15p	2N3707	15p	40362	57p	BCY43	15p	88Y24	15p	NKT401	87p
2N709	62p	2N3708	9p	40370	32p	BCY54	32p	88Y25	15p	NKT402	90p
2N718	25p	2N3709	10p	40406	57p	BCY58	22p	88Y26	17p	NKT403	75p
2N726	30p	2N3710	11p	40407	40p	BCY59	22p	88Y27	17p	NKT404	62p
2N727	30p	2N3711	12p	40408	52p	BCY60	27p	88Y28	17p	NKT405	75p
2N914	17p	2N3715	22-25	40410	62p	BCY70	20p	88Y29	17p	NKT406	62p
2N916	15p	2N3720	22-25	40467A	57p	BCY71	42p	88Y32	25p	NKT451	62p
2N919	30p	2N3791	22-25	40468A	30p	BCY72	17p	88Y33	22p	NKT452	62p
2N929	27p	2N3819	35p	40600	57p	BCZ10	27p	88Y37	25p	NKT453	47p
2N930	27p	2N3823	97p	40601	42p	BCZ11	42p	88Y38	22p	NKT603F	32p
2N1090	22p	2N3854	27p	40602	15p	BD116	11-12p	88Y39	22p	NKT613F	32p
2N1091	22p	2N3854A	27p	40603	15p	BD121	65p	88Y40	32p	NKT674F	32p
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2N1302	15p	2N3856	27p	40606	30p	BD131	37p	88Y53	37p	AA129	10p
2N1303	17p	2N3856A	35p	40607	22p	BD132	37p	88Y54	40p	AAZ13	10p
2N1304	22p	2N3858	25p	40608	25p	BDY10	11-37p	88Y56	90p	NKT10439	37p
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2N1638	30p	2N3902	37p	40619	20p	BF117	25p	C428	37p	NKT80216	92p
2N1639	27p	2N3904	35p	40620	40p	BF163	37p	C744	30p	NKT80216	92p
2N1711	25p	2N3905	37p	40621	52p	BF167	32p	D16P1	37p	OC20	75p
2N1889	32p	2N3906	37p	40622	52p	BF173	32p	D16P2	37p	OC21	50p
2N1893	37p	2N405X	17p	40623	37p	BF177	32p	D16P3	37p	OC22	50p
2N2147	82p	2N4059	10p	40624	42p	BF178	32p	D16P4	40p	OC23	50p
2N2148	57p	2N4060	12p	40625	42p	BF179	78p	GET102	30p	OC24	50p
2N2160	57p	2N4061	12p	40626	42p	BF180	35p	GET113	20p	OC25	50p
2N2193	40p	2N4062	12p	40627	42p	BF181	32p	GET114	20p	OC26	50p
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2N2539	25p	2N5175	52p	40643	62p	BFW60	25p	GET130	12p	OC49	12p
2N2540	22p	2N5176	42p	40644	32p	BFX11	22p	GET131	12p	OC50	12p
2N2613	35p	2N5232A	30p	40645	25p	BFX12	22p	GET132	12p	OC51	12p
2N2614	30p	2N5245	45p	40646	25p	BFX13	22p	GET133	12p	OC52	12p
2N2646	57p	2N5246	42p	40647	27p	BFX29	30p	GET134	12p	OC53	12p
2N2696	32p	2N5249	67p	40648	25p	BFX30	30p	GET135	12p	OC54	12p
2N2711	25p	2N5256	27-75	40649	25p	BFX43	37p	GET136	12p	OC55	12p
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2N2904A	32p	2N5308	37p	40654	27p	BFX86	27p	GET141	12p	OC60	12p
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2N2905A	40p	2N5310	42p	40656	27p	BFX88	25p	GET143	12p	OC62	12p
2N2906	25p	2N5354	27p	40657	27p	BFX89	62p	GET144	12p	OC63	12p
2N2906A	27p	2N5355	27p	40658	27p	BFX90	62p	GET145	12p	OC64	12p
2N2907	30p	2N5356	32p	40659	12p	BFY11	12p	GET146	12p	OC65	12p
2N2923	15p	2N5365	47p	40660	12p	BFY17	12p	GET147	12p	OC66	12p
2N2924	15p	2N5366	47p	40661	12p	BFY18	12p	GET148	12p	OC67	12p
2N2925	15p	2N5367	57p	40662	12p	BFY19	12p	GET149	12p	OC68	12p
2N2926	15p	2N5457	37p	40663	12p	BFY21	12p	GET150	12p	OC69	12p
.. Green	14p	28005	75p	40664	12p	BFY24	12p	GET151	12p	OC70	12p
.. Yellow	12p	28020	42p	40665	12p	BFY25	12p	GET152	12p	OC71	12p
.. Orange	12p	28102	50p	40666	12p	BFY26	12p	GET153	12p	OC72	12p
2N3014	32p	28103	25p	40667	12p	BFY27	12p	GET154	12p	OC73	12p
2N3014	32p	28104	25p	40668	12p	BFY30	12p	GET155	12p	OC74	12p
2N3033	25p	28501	32p	40669	12p	BFY41	12p	GET156	12p	OC75	12p
2N3054	25p	28502	35p	40670	12p	BFY43	12p	GET157	12p	OC76	12p
2N3055	75p	28503	27p	40671	12p	BFY50	12p	GET158	12p	OC77	12p
2N3133	30p	3N83	40p	40672	12p	BFY51	12p	GET159	12p	OC78	12p
2N3134	25p	3N128	70p	40673							

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230	6-12	2 c/o	63p*	1250	36-48	6M	63p*	
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To be able to do this, VR1 would have to be made 100k $\Omega$ , which is unacceptably large for the OHMS  $\times$  1 range. The simplest solution would be to use a closer tolerance resistor for R2 and accept a reduction in the compensating ability of VR1. Ideally, this should be of  $\pm 1\%$  tolerance before an acceptable result is obtained.

### OHMS $\times$ 1 RANGE RESISTOR

Having settled on the value of R2 in Fig. 3b, we must now turn our attention to the OHMS  $\times$  1 range and determine the value of R1.

Since  $V_{b1}$  is one-tenth of  $V_{b2}$ , then the corresponding values of  $R_{t(max)}$  and  $R_{t(min)}$  for maximum and minimum values of  $V_{b1}$  will be one-tenth of those values determined for  $R_{t(max)}$  and  $R_{t(min)}$  for  $V_{b2}$ . For the OHMS  $\times$  1 range then,  $R_{t(max)} = 32k\Omega$  and  $R_{t(min)} = 26k\Omega$ .

This means that VR1 for this range, should ideally be equal to the difference between these two values, i.e. 6k $\Omega$ . However, VR1 has already been selected as being 50k $\Omega$  which is nearly ten times greater than 6k $\Omega$  and VR1 is already greater than the largest value ever required for R1.

In this case we don't need R1 at all since VR1 (50k $\Omega$ ) is more than big enough to cope with all required values of  $R_t$ . However, if R1 is dispensed with altogether, there would be no built-in protection for the meter if VR1 should inadvertently be set to zero. By insertion of a large value for R1, the operation of VR1 is even coarser than it is already (it is almost ten times greater than it need be).

Resistor R1 must be made large enough to provide a substantial degree of overload protection for the meter, and yet small enough to have little effect on the sensitivity of VR1.

If the meter current is limited to a value equal to ten times the f.s.d. current (most meters will just about stand a 10 : 1 instantaneous overload) then the overload current will be 500 $\mu$ A and the corresponding value for  $R_t$  (assuming VR1 is set to zero, and  $V_{b1}$  is at its highest value of 1.6V) will be equal to  $\frac{1.6V}{500\mu A} = 3.2k\Omega$ .

Then,  $R_1 = R_t - R_m = 1.7k\Omega$ . The nearest preferred value is 1.8k $\Omega$ .

### INDICATION ACCURACY

Before leaving the A-type ohmmeter circuit, it is important to note a very serious drawback concerning its indication accuracy. The validity of the mid-scale indications (the OHMS  $\times$  1 range is 30k $\Omega$ , and on the OHMS  $\times$  10 range it is 300k $\Omega$ ) only applies when the battery voltages are 1.5V and 15V, respectively. See what happens to the indications when the battery voltages are first high, and then low; this need only be done for one ohmmeter range because the overall effect will be the same for both ranges.

Taking the OHMS  $\times$  1 range, and a  $V_{b(min)}$  value of 1.3V, the value of  $R_t$  required to achieve f.s.d. (50 $\mu$ A) is 26k $\Omega$ . The value of VR1 will be adjusted during the zeroing procedure so that it equals 26k $\Omega$ .

From earlier deductions, the value of  $R_t$  required to bring about f.s.d., is also equal to the value of an external resistor ( $R_x$ ) required to bring about half-f.s.d. (25 $\mu$ A). Consequently, the mid-scale indication of the OHMS  $\times$  1 range when  $V_b$  is 1.3V (instead of 1.5V) is 26k $\Omega$ , instead of 30k $\Omega$ , i.e. 4k $\Omega$  below normal. This represents an indication error of about -13%, which is almost the same as the corresponding reduction in the value of  $V_b$ .

For a  $V_{b(max)}$  value of 1.6V (about 7% above the 1.5V normal value), the indication inaccuracy will be about +7%.

From these calculations we may deduce that the indication accuracy of the A-type ohmmeter circuit (quoted at mid-scale) is correct only when  $V_b$  is equal to 1.5V, and that the inaccuracy of this indication will vary from about +7% when the battery is new, to about -13% when it is ready for replacement. These facts are worth knowing, especially when using the ohmmeter to select a close tolerance resistor.

This completes the examination of the A-type ohmmeter. The reasons for going into its circuit in such detail were to illustrate the difficulties in reaching a suitable compromise for the component values, and to highlight its undesirable indication inaccuracies.

### PARALLEL POTENTIOMETER OHMMETER CIRCUIT

The B-type of circuit (Fig. 4) is basically very similar to the A-type circuit shown in Fig. 1, except that the variable resistor VR1 is connected in parallel with the meter (M1) instead of in series with it. The zeroing procedure is exactly the same except that, in this case, the meter current ( $I_m$ ) is adjusted to f.s.d. by shunting the excess current ( $I_s$ ) through VR1.

The total circuit current ( $I_t$ ) is equal to the sum of  $I_s$  and  $I_m$  ( $I_t = I_s + I_m$ ), and is therefore greater than the corresponding value of  $I_t$  for the A-type circuit in which  $I_t$  was always equal to  $I_m$ . This type of circuit therefore consumes more power than the previous type.

The B-type circuit, for the same number of components, is much more flexible than the A-type and the zeroing control VR1 is much smoother in operation. The reason for this, as you will see, is that almost any value can be chosen for VR1, which means that it may

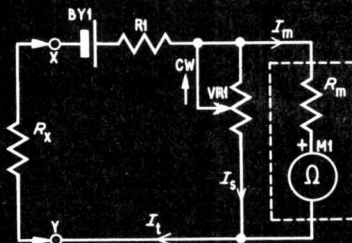


Fig. 4. "B"-type circuit where the variable resistor is in parallel with the meter

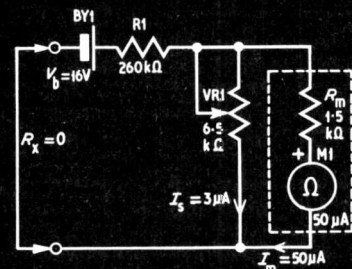


Fig. 5. Component values for the "B"-type circuit to allow for change of battery voltage

be used to determine the overall resistance range of the ohmmeter; in addition to its normal role of compensating for changes in  $V_b$ .

### BATTERY $V_b$ COMPENSATION

Let us first consider the fundamental requirement of compensating for a change in  $V_b$ , assuming a nominal value of 15V for  $V_b$  and a mid-scale resistance indication of 300k $\Omega$  (the same as the corresponding indication for the A-type circuit).

Since the battery voltage  $V_b$  is likely to change from about 13V (for old battery) to about 16V when renewed,  $I_m$  will increase from 50 $\mu$ A (13V/260k $\Omega$ ) to 61.5 $\mu$ A (16V/260k $\Omega$ ). In order to compensate for this change in  $I_m$ , VR1 must be set to such a value that it will bypass the excess 11.5 $\mu$ A at present flowing in  $R_m$ .

The value of VR1 should be 50/11.5 or approximately 4.33 times greater than the value of  $R_m$ ; VR1 should therefore be 6.5k $\Omega$ . This is illustrated in Fig. 5.

What we have just done is to determine the minimum value that VR1 is ever required to have in order to compensate for the maximum likely value of  $V_b$ . One obvious advantage with this type of circuit is that no matter how large  $V_b$  might be, the excess current can always be fully absorbed by VR1 since its value can, if necessary, be reduced to zero—thereby bypassing all the current.

### VR UPPER LIMIT

There is no upper limit for the value of VR1 since we have already shown that  $I_t$  can never exceed 61.5 $\mu$ A (with  $R_1 = 260$ k $\Omega$ ), and that setting VR1 to 6.5k $\Omega$  can take care of that current which is in excess of the 50 $\mu$ A required by the meter.

It is, however, necessary to employ a reasonably large value for VR1 so that when set to its maximum value its shunting effect on  $R_m$  is negligible. This is important in order to ensure that 50 $\mu$ A f.s.d. is still possible when  $V_b$  is approaching its minimum value of 13V. If VR1 is set to a maximum value of 10k $\Omega$  (by using a 10k $\Omega$  variable resistor), then  $I_m$  would equal 43.5 $\mu$ A when  $V_b = 13$ V and 6.5 $\mu$ A would flow in VR1, giving a total ( $I_t$ ) of 50 $\mu$ A.

This means that it would not be possible to obtain f.s.d. when  $V_b$  had fallen to 13V. Looking at it another way, we can say that the minimum value of  $V_b$  which can be tolerated with a 10k $\Omega$  value for VR1 is about 15V. The circuit as it stands, therefore, isn't going to be very useful because the battery will need replacing as soon as its potential has fallen to 15V; a value which is only a little less than its value when new.

### COMPROMISE

The alternatives are to reduce the value of  $R_1$ , or increase the value of VR1. If the value of  $R_1$  is reduced, then the mid-scale indication of the ohmmeter will also be reduced. On the other hand, if VR1 is increased then its rate of adjustment will be more coarse, making it difficult to zero the ohmmeter, particularly when the battery is new and a comparatively low-value setting is required for VR1.

The final choice for VR1 is a compromise between mid-scale resistance indication and ease of zeroing adjustment. A useful rule-of-thumb in selecting a value for VR1 in this type of circuit is that its value should not exceed about ten times the value of  $R_m$  (the resistance of the meter). In the example we have just considered,  $R_m$  is 1.5k $\Omega$ , therefore VR1 should not

exceed 15k $\Omega$ . The initial selection of 10k $\Omega$  for VR1 appears to be quite reasonable; the compromise required in this example must be made with the value selected for  $R_1$ . This may be done as follows.

### SET MID-SCALE INDICATION

If a value of 10k $\Omega$  is selected for VR1, then the maximum acceptable value for  $R_1$  may be determined by assuming a  $V_{b(\min)}$  value of 13V. With  $I_m = 50\mu$ A (f.s.d.), then 7.5 $\mu$ A ( $I_s$ ) will flow in VR1 (determined from  $I_s = R_m \times I_m / R_{VR1}$ , making  $I_t$  equal to 57.5 $\mu$ A.  $R_s$  is determined by  $V_{b(\min)} / I_t$ , which equals 13V/57.5 $\mu$ A = 226k $\Omega$  (220k $\Omega$  is a preferred value).

The mid-scale indication of the ohmmeter is thus 220k $\Omega$ , which is not very different from the corresponding indication of 260k $\Omega$  determined for the A-type circuit when  $V_b$  equalled 13V.

In the B-type circuit, however,  $R_1$  is fixed at 220k $\Omega$  irrespective of the variations which occur in  $V_b$ , since the parallel combination of VR1 and  $R_m$  is always small enough to be neglected. This is very different from the A-type circuit in which the mid-scale indication changed from 320k $\Omega$  to 260k $\Omega$  (due to adjustment variations in VR1) when  $V_b$  changed from 16V to 13V.

This is a very important observation since it shows that the B-type circuit is inherently more accurate than that of the A-type. Actually, this statement ignores the relative abilities of the two circuits to compensate for variations in the internal resistance ( $R_b$ ) of the batteries. However,  $R_b$  is relatively small in the low-current circuits considered so far, and may therefore be ignored.

### RANGE SELECTION

Now consider the second feature of the B-type circuit—the ability to select a particular resistance range by suitable choice of VR1.

We have just seen that a 10k $\Omega$  value for VR1 sets the mid-scale resistance indication at 220k $\Omega$ . Assuming a low-resistance range with a mid-scale indication of about 1k $\Omega$  (30 times smaller than that obtainable with the corresponding A-type circuit) when  $V_{b(\min)} = 1.3$ V, then  $I_t = \frac{V_{b(\min)}}{(R_1 + R_p)}$  where  $R_p = \frac{R_m \times R_{VR1}}{(R_m + R_{VR1})}$ .

The value  $R_p$  is now comparable with  $R_1$  and cannot be ignored; at least, not just yet. Since the mid-scale indication is 1k $\Omega$ , then  $(R_1 + R_p)$  must equal 1k $\Omega$ .

Thus,  $I_t = \frac{1\text{k}\Omega}{1.3\text{V}} = 1.3\text{mA}$ . When the meter is indicating f.s.d. ( $I_m = 50\mu$ A), the current ( $I_s$ ) which flows in VR1 must equal  $(I_t - I_m)$ , i.e.  $I_s = 1.3\text{mA} - 50\mu\text{A} = 1,250\mu\text{A}$ . The value of VR1 required to absorb this amount of current is therefore equal to  $I_m \times R_m / I_s = 60$  ohms.

This is the maximum value that VR1 is ever likely to require. Now, since this value is so small compared with  $R_m$  (1,500 $\Omega$ ), the value of  $R_p$  can be assumed to equal 60 ohms. Furthermore, since  $R_p$  is also very small compared with  $R_1 + R_p$ , i.e. 1k $\Omega$ , we may further assume that  $R_1$  equals 1k $\Omega$ . The value required for VR1 when  $V_{b(\max)} = 1.6$ V and when  $I_m = \text{f.s.d.}$  (50 $\mu$ A) is equal to  $I_m \times R_m / I_s = 48$  ohms.

This is the minimum value that VR1 is ever likely to require. From these two sets of calculations, VR1 is required to vary between 48 and 60 ohms, depending upon the value of  $V_b$ ; a 100 ohms variable resistor would therefore be a very satisfactory choice.

When using such a resistor value, the minimum setting of 48 ohms would represent a setting of 48 per cent of maximum, which would yield very smooth adjustment during the zeroing procedure. The circuit for this particular ohmmeter is shown in Fig. 6.

### TWO-RANGE OHMMETER CIRCUIT

The B-type circuit can also be used to provide two resistance ranges and, like the A-type circuit, this may be achieved by using two batteries and a single zero-adjustment control. In order to make a more direct comparison with the A-type circuit (Fig. 3), a B-type two-range circuit will be designed using battery voltages of 15V and 1.5V, attempting to achieve the same approximate mid-scale indications.

The mid-scale indication for the OHMS  $\times 10$  range of the A-type circuit, using  $V_b = 15V$ , was found to be  $300k\Omega$ . The nearest approach to this figure using the corresponding B-type circuit, and a value of  $10k\Omega$  for  $VR_1$ , was  $220k\Omega$ .

By replacing  $V_b$  of the B-type circuit with a battery of 1.5V, so as to produce an OHMS  $\times 1$  range, then the mid-scale indication will be reduced by a factor of ten, making  $R_1 = 22k\Omega$ . The mid-scale indications are, therefore, not widely different from those of the A-type circuit.

However, as was explained when the A-type circuit was examined, the zeroing adjustment of  $VR_1$  on the OHMS  $\times 1$  range of that circuit was expected to be very coarse, because of the compromise which had to be made concerning the choice of value for  $VR_1$ . Let us now see what the sensitivity of the zeroing adjustment is like in the B-type ohmmeter.

The sensitivity is all right on the OHMS  $\times 10$  range because  $VR_1$  was selected to make it so.

### LOW RESISTANCE SETTING

On the OHMS  $\times 1$  range, the lowest resistance setting required for  $VR_1$  occurs when  $V_{b(max)} = 1.6V$ ; the total current ( $I_t$ ) in the circuit during the zeroing procedure is equal to  $V_{b(max)}/R_1 \approx 73\mu A$ . In this condition, therefore, the value of  $VR_1$  must be adjusted so that it absorbs the  $23\mu A$  which is in excess of  $I_m$ , the f.s.d. current of the meter.

Since  $I_s = 23\mu A$ , and  $I_m = 50\mu A$ , then the required value of  $VR_1$  must equal  $I_m \times R_m / I_s = 3,260$  ohms. A setting of this value represents 33 per cent of  $R_{VR(max)}$ , which represents a substantial angular rotation of the control shaft: the zeroing adjustment will, therefore, be quite smooth in this worst-case condition, and will be even better when the battery is relatively new. The circuit diagram of this particular two-range ohmmeter is shown in Fig. 7.

### SHUNT OHMMETER

In the shunt ohmmeter (Fig. 8), the indicating meter  $M_1$ , is connected directly across the input terminals in parallel with the unknown resistor ( $R_x$ ). The circuit is normally used for measuring very low resistance values (typically 0.01 to 2,000 ohms), and is therefore ideally suitable for measuring the winding resistances of coils and transformers.

The resistance scale differs greatly from the other types of ohmmeters so far examined in that it reads from left-to-right instead of from right-to-left, i.e. zero ohms corresponds to zero deflection and infinite resistance corresponds to f.s.d.

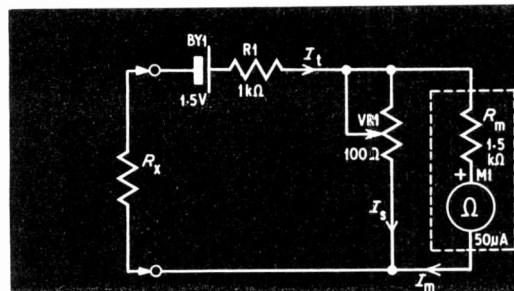


Fig. 6. Single-range parallel control ohmmeter circuit

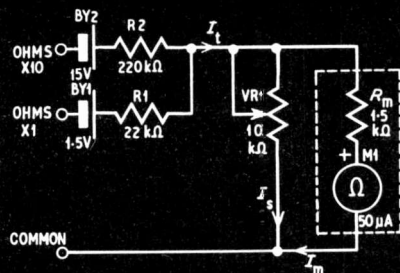


Fig. 7. Two-range parallel control ohmmeter circuit

### SET ZERO

The zeroing procedure is very similar to that adopted for previously described circuits, except that it is carried out with the input terminals open-circuit (corresponding to infinite resistance) instead of with them short-circuit.

To zero this type of ohmmeter, the input terminals are left open and  $VR_1$  is adjusted until the meter indicates f.s.d. ( $VR_1$  and  $R_1$  have the same purpose as in previously described circuits, and their values are determined by the same procedures.) Having done this the unknown resistor ( $R_x$ ) is then connected to the input terminals. This causes the meter current ( $I_m$ ) to be bypassed to some extent and a reduced indication results; the degree of the reduction depending upon the value of  $R_x$ . If a short-circuit is connected to the terminals then all of  $I_m$  is bypassed and zero indication results.

### RANGE SELECTION

The range of the ohmmeter may be changed by connecting an internal resistor across the meter. This reduces the effective sensitivity of the meter and hence more total current ( $I_t$ ) is required to achieve f.s.d.

On the OHMS  $\times 1$  range no ranging resistor is added and the mid-scale resistance indication is equal to the meter resistance  $R_m$ , i.e. 1,500 ohms. Thus, if a resistor ( $R_x$ ) of the same value as  $R_m$  is connected to the terminals, then  $I_t$  will be shared equally between  $R_x$  and the meter;  $25\mu A$  will flow in each.

In order to produce the OHMS  $\div 10$  range provided for in Fig. 8, an internal resistor  $R_2$  must be connected across the meter so that the parallel combination of  $R_2$  and the meter is equal to  $R_m/10$ , or  $\frac{R_2 \times R_m}{R_2 + R_m}$ . Rearranging this expression and substituting known values, we get  $R_2 = R_m/9 = 1,500/9 = 166.6$  ohms.

# NEWS BRIEFS

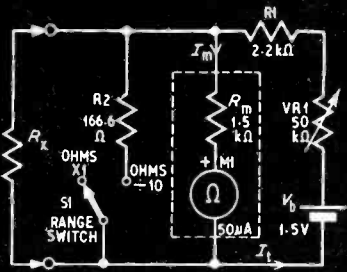


Fig. 8. Shunt ohmmeter in which the meter is connected directly across the terminals and the range selector

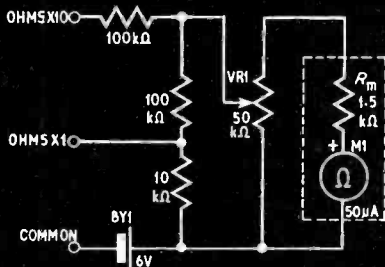


Fig. 9. Constant resistance ohmmeter

## Silicon Pictures

A NEW TV camera tube incorporating a silicon target is being developed by English Electric Valve Co. Ltd. The target of this tube—The Sidicon—is in the form of a mosaic of isolated silicon diodes and its production follows a sequence of modified micro-circuit practices resulting from improved microlithographic techniques.

Results of developments so far, have shown these tubes, which are interchangeable with 1 inch vidicons, to be mechanically, thermally and electrically very rugged, with high sensitivity throughout the visible and infra-red range. The Sidicon has considerably less lag than conventional vidicons and much higher sensitivity. The nature of the targets allows full high-vacuum processing, so ensuring a long life expectancy.

## Brain Box

A SMALL sensitive electronic amplifier no larger than a packet of cigarettes is helping surgeons at the London Hospital, Whitechapel, to trace brain activity during operations for Parkinson's disease.

This is achieved by picking up and monitoring very small signals from the brain through an electrode implanted in it. The amplifier enables the surgeon to track with greater accuracy the exact portion of the brain in which he is working while carrying out this extremely delicate operation.

Made by the British company, Fenlow Electronics Ltd., it is the first miniature data amplifier the firm has produced for medical use. Using f.e.t.'s the amplifier is constructed to stringent safety specifications and costs only £40.

## Transportable Tactical Centre

THE photograph below shows test pattern symbols on the screen of a lightweight display console being checked with a microscope at Hughes Aircraft Company, America, to verify their sharpness and clarity. The console, along with high-speed computers and other electronic equipment, is being built by Hughes for the U.S. Air Force Electronic Systems Division's 407L programme, an advanced concept of tactical air control.

The equipment will be housed in inflatable, modular operations centres that can be transported anywhere in the world and set up in a matter of hours. Hughes is producing 31 of these tactical centres along with two training systems designed to give the Air Force flexible and mobile response to fast-changing battlefield situations.



The same result may be achieved by using the expression

$$R_2 = \frac{R_m}{n - 1}$$

where  $n$  is the number of times that the f.s.d. is to be multiplied. When operating on this range,  $I_t$  is increased by a factor of ten ( $500\mu A$ ), 90 per cent of which flows in  $R_2$ , and the mid-scale indication equals  $R_m/10$  or 150 ohms.

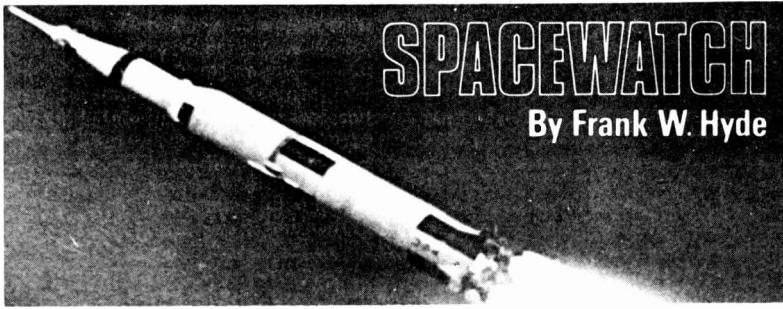
## CONSTANT RESISTANCE OHMMETER

In the constant resistance type of ohmmeter (Fig. 9), the variable resistor VR1 is connected in such a way that the total resistance of the circuit is maintained near-constant as VR1 is adjusted to compensate for changes in  $V_b$ . This is accomplished by connecting VR1 across the meter in such a way that it is used as a potentiometer.

Adjusting VR1 in one direction causes more resistance to be added in series with the meter and a lower value of resistance to be connected in parallel with  $R_x$ ; the reverse occurs when VR1 is adjusted in the opposite direction. This arrangement maintains an almost constant total circuit resistance, and hence the accuracy of the indication is very little affected by the setting of VR1.

Fig. 9 shows a two-range ohmmeter based upon this type of circuit. Only one battery is used and the mid-scale indications on the OHMS  $\times 1$  and OHMS  $\times 10$  ranges are 10k $\Omega$  and 100k $\Omega$ , respectively. The zeroing procedure is conventional and is carried out with the input terminals short-circuited; the ohmmeter scale reads from right-to-left.

This completes this examination of various ohmmeter circuits; there are a great many other types of circuits but these are, in many cases, simply variants of those just described. ★



## WHAT THE ASTRONAUTS SAW

All crews of the *Apollo* missions reported seeing flashes and streaks before their eyes even when closed. It is supposed that this is the result of the passage of ionised cosmic ray particles through the head.

It has been suggested that the light comes from the passage of the high energy particles through the jelly-like medium in the eyeball where light has a lower velocity. Another explanation is that it is the impact of the particles on the retinal cells.

The particles also affect the astronauts' space helmets which are made of a polycarbonate plastic. This plastic is of the long-chain polymer class and as a result of radiation the molecules are broken up. It is known in biological systems that ionising radiations damage cells by disturbing the replication of long-chain molecules.

It has been found that the damage to the space helmets can be studied by etching the streaks caused by the particles. Silicone casts can be made of the holes in the plastic and the rate of etching indicates the degree of ionisation that takes place. The shape of the rubber allows the measurement of the ionisation from point to point along the track. Comparison with the effects of known ions enables the particular particle to be identified.

## RADIO TELESCOPE

Germany's new 100m radio telescope, the largest steerable dish in the world, is nearing completion at Effelsberg some 40km from Bonn. The site is a deep valley in an area of minimum interference.

The design of this telescope has made use of the most advanced principles of structural engineering to ensure that in all positions of the dish the effects of loading both static and variable cause the least departure from paraboloid form. It is expected that the surface accuracy will hold to less than 1mm.

The actual construction of the reflecting surface is interesting, the inner section of 60m diameter is formed from an aluminium sandwich with a honeycomb inner unit bonded to the outer formed sheets. Trial measurements show that the r.m.s. accuracy of the surface of this construction is of the order of 0.22mm.

The next 20m of the surface is covered by formed sheets of aluminium supported by aluminium sections. The standard of accuracy reached in this section of the dish is 0.27mm. The outer section of this ring of panels is connected to the rest of the surface, made up of 6mm square stainless steel mesh panels, by perforated aluminium panels to maintain the aerodynamic conditions required. The accuracy of the outer mesh is about 0.55mm.

The overall efficiency of the telescope is expected to be capable of operation down to a wavelength of 5cm. The central 60m section will, it is hoped, enable wavelengths of 8mm to be used.

Round the outer rim of the dish a collar has been added to reduce the effects of local interference.

## FOCUSING ACCURACY

The focus to diameter ratio is midway between that of the Jodrell Bank and Parkes telescopes. Jodrell Bank Mk1 is 0.25 and Parkes 0.41 with the German dish at 0.3.

The Gregorian system has been adopted which enables both prime focus and secondary focus work to be carried out. For prime focus operation a tube will project through the centre of the sub-reflector to house a prime focus receiver. The intention is to use multibeam methods of observation and as many as nine feeds will be available at the secondary focus. Space receivers at wavelengths of 6cm, 11cm, and 13cm will be provided at the secondary focus.

With such a sophisticated type of radio telescope it is not surpris-

ing that the receiving installation is very elaborate. Cryogenically cooled amplifiers and low noise front ends are being provided.

The timing system will use a rubidium clock as reference for the universal oscillator in line measurements for Pulsar timing and very long base line observations. Continuum measurements will be made by Radiometers.

## COMPUTER CONTROL AND PROCESSING

Data processing is also very elaborate and the basic data processor and steering computer is an ARGUS 500 by Ferranti. This digital computer will co-ordinate transformations, control the telescope drive and process real time data.

From a control desk an observer can choose the astronomical coordinates he needs and the method of scanning. The computer will then carry out the transformations and instruct the drives of the telescope in the necessary velocities in azimuth and elevation.

Since this occupies only a portion of the computer cycle, time is available for storing of data on magnetic tape, operate a fast line printer and Calcomp plotter and have time available for some on-line data processing.

## SUPPORT FOR THE GENERAL THEORY OF RELATIVITY

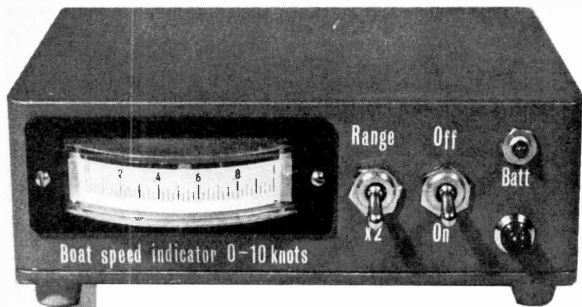
Working with *Mariners 6* and 7 probes, the team at the Jet Propulsion Laboratory led by Dr J. Anderson have obtained data which, they claim, confirms Einstein's predictions with an accuracy of 2 to 4 per cent.

Previous work by Muhleman and Shapiro using the passive radar technique by bouncing signals off planets close to the sun's limb showed an accuracy of 5 per cent.

The first results with active radar are now available from the 210ft dish at Goldstone. A narrow beam of radio signals at 250kW is sent out to impinge on *Mariner 6* or 7, which are now some 250 million miles beyond the sun. The spacecraft collect the signals, amplify them, and transmit them to the dish at Goldstone. The round trip takes about 43 minutes and can be timed within a microsecond.

The most important source of error is the very considerable dispersion of radio waves by the sun and the results depend on the type of model of the sun's atmosphere that is used.

Dr Anderson's results conflict with the gravitational theories which show about 7 per cent error.



# BOAT SPEED INDICATOR

By M. KENWARD

**O**WNERS of small boats, both power and sail, often find the need for a boat speed indicator. The speed indicator is useful for a variety of reasons including engine tuning, propeller selection, water skiing, sail trimming, arrival time estimation, and the observance of speed limits. The device described here uses a potentiometric transducer in a simple circuit to produce a linear speed reading on a moving coil meter.

## TRANSDUCER DESIGN

One of the most difficult problems when designing and building a speed indicator is to arrive at a transducer design that is effective, reasonably accurate, yet easy to construct, using limited resources. The design finally arrived at uses a horizontal underwater probe that is turned about its fixed end by the pressure of water moving past it. The probe rotates the shaft to which it is affixed which in turn revolves a potentiometer (VR1) in Fig. 1 by means of two gears. These gears are used to increase the angle by which VR1 revolves, thus decreasing wear on the potentiometer and making for greater accuracy; the probe will only turn through 90 degrees.

A spring is used to give torsional resistance to the probe. Providing this spring has a good number of turns, the torsional resistance will be similar at all probe angles.

The transducer is housed in a suitable round plastics container, the top of which is screwed to a brass plate that is soldered or brazed to the shaft. This gives some degree of water protection to the unit, although the transducer will not be completely waterproof unless the container is carefully sealed after installation. A high quality sealed, carbon track potentiometer is used for VR1.

## CIRCUIT THEORY

From the description of the transducer it will be noted that the resistance of VR1 is varied with the speed of the boat. The variation of resistance will not be linear as the area of the probe exposed to the flow of water effectively reduces as the probe revolves about the shaft; this gives a variation corresponding to  $\text{Cos}^2\theta$  (where  $\theta$  is the rotated probe angle).

With the boat stationary, and the probe at right angles to the fore and aft axis of the boat, the maximum value of resistance will be across output leads a and b (Fig. 1) from the transducer. As the boat speeds up the resistance will be reduced and reach its lowest possible value when the probe is in line with the fore and aft axis of the boat. By inserting potentiometer VR1 in the circuit shown in Fig. 1, the variation can be arranged to give an almost linearly increasing reading, directly proportional to boat speed, on meter M1. However, this reading is only proportional to speed for probe angles up to 45 degrees—due to the shape of the  $\text{Cos}^2\theta$  curve. Thus the transducer is only used in this range of angles.

As stated, the resistance of VR1 is varied as  $\text{Cos}^2\theta$ . The curve of  $\text{Cos}^2\theta$  is shown in Fig. 2 as graph (a). If we arrange for the circuit to give a meter reading that varies to  $\text{Sine}^2\theta$ , the two variations will cancel and give a meter reading corresponding linearly to boat speed. Graph (b) is the actual graph of meter reading against probe angle, taken from 0 to 45 degrees; graph (c) is the result of (a) minus (b). Graph (c) is not quite a straight line—as it should be for complete accuracy—but is within 0.3 of a knot or 5 per cent of the true reading, whichever is the greater, and it is felt that this is sufficiently accurate for most purposes.

The boat speed indicator circuit could, of course, have been made to give a perfect straight line for



(c), but this would make it more complicated and expensive to build. If greater accuracy is required a graph such as (c) can be plotted for the completed unit over the full range of speeds, and this graph used for correcting the speed indicated.

A times 2 range is provided to give greater meter movement at low boat speeds and in this mode the accuracy of the unit will depend mainly on the transducer construction.

### CIRCUIT OPERATION

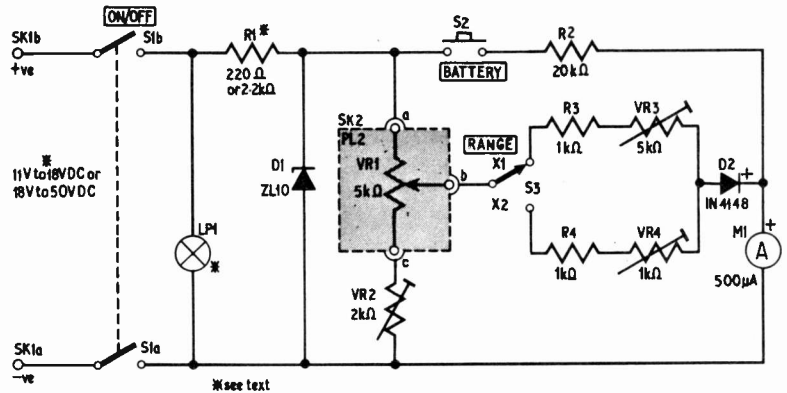
The input voltage is stabilised by R1 and Zener diode D1 so that variations in battery voltage will not affect the circuit function unduly.

The resulting 10V is applied across VR1 and VR2 and the varying voltage at VR1 wiper is taken via

range switch S3 to a voltmeter circuit. The voltmeter circuit consists of the appropriate range resistors—R3 and VR3 or R4 and VR4—diode D2 and the 500 $\mu$ A f.s.d. moving coil meter M1. The diode is used as a low voltage Zener; its breakdown voltage in the forward bias condition is 0.6V. This means that up to 0.6V can be present across D2 without the meter indicating any current. Once the breakdown voltage is exceeded the diode resistance drops to a low value and the circuit acts essentially as a normal voltmeter.

Potentiometer VR2 is preset to give a reading of 0.01 milliamps on M1 with the wiper of VR1 turned towards VR2 end; this indicates that D2 is just beginning to conduct and as soon as VR1 is varied M1 will indicate the voltage present at its wiper.

Fig. 1. Circuit diagram of the boat speed indicator. Reference is made in the text to the supply voltage, R1 and LP1. The tinted panel indicates the potentiometer used in the transducer.



## COMPONENTS . . .

### Resistors

- R1 220 $\Omega$  or 2.2k $\Omega$  (see text)
- R2 20k $\Omega$
- R3 1k $\Omega$
- R4 1k $\Omega$
- All  $\frac{1}{4}$ W,  $\pm$  10% carbon

### Potentiometers

- VR1 5k $\Omega$  high quality sealed carbon lin (see text)
  - VR2 2k $\Omega$
  - VR3 5k $\Omega$
  - VR4 1k $\Omega$
- } wirewound trimmers

### Diodes

- D1 ZL10 1.5W, 10V Zener
- D2 IN4148 silicon

### Switches

- S1 D.P.D.T. toggle
- S2 S.P.S.T. pushbutton
- S3 S.P.D.T. toggle

### Miscellaneous

- M1 500 $\mu$ A f.s.d. moving coil meter (S.E.W. edge-wise type)
- SK1/PL1 Two pin DIN plug and socket
- SK2/PL2 Three pin DIN plug and socket
- LPI Miniature indicator lamp and holder (voltage to suit supply)
- Veroboard 2 $\frac{1}{2}$ in  $\times$  3 $\frac{1}{2}$ in  $\times$  0.15in matrix
- Diecast case 6 $\frac{1}{2}$ in  $\times$  4 $\frac{1}{2}$ in  $\times$  2 $\frac{1}{4}$ in
- Connecting wire, transducer connection wire—3 core plastics covered mains lead; supply connection wire—2 core plastics covered mains lead.
- 6B.A. fixings
- Foam rubber, paint and Letraset

The action of D2 provides the required circuit response to variation of VR1.

Switch S2 and resistor R2 provide a circuit voltage checking position that will indicate, by way of M1, when the battery voltage is too low to operate the circuit. Resistor R1 will be either 220 ohms or 2.2 kilohms to accommodate supplies of 11V to 18V or 18V to 50V d.c. respectively; LP1 will, of course, have to be the correct voltage for the supply.

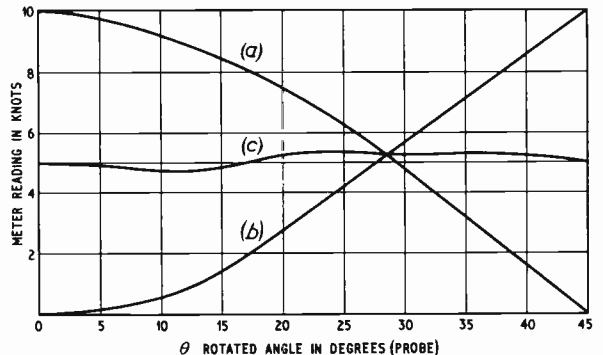
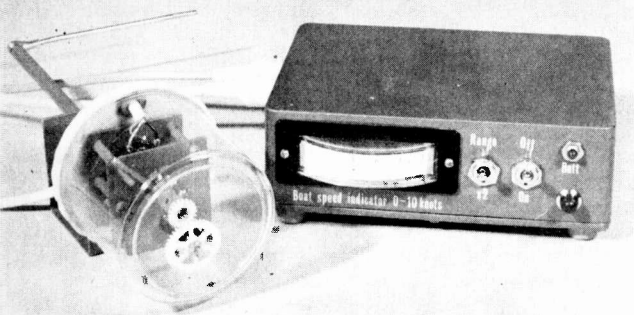


Fig. 2. Graph of probe rotation against meter reading (b) subtracted from the  $\text{Cos}^2\theta$  graph (a) to give the resultant curve (c). For an accurate instrument curve (c) should be a straight line



### TRANSDUCER CONSTRUCTION

The transducer must be constructed of materials that will not be affected by water; in the prototype brass was used throughout. The shaft is a model boat propeller shaft and the gears are nylon, 2 to 1 ratio, also supplied for model making. The torsion spring can be any  $\frac{1}{8}$  in diameter coil spring that is of fairly light construction. Particular attention should be paid to accuracy since any unnecessary friction or play in the unit will result in inaccurate and erratic readings when in use.

The gears should be arranged to mesh closely and there should be as little play in the potentiometer bearings as possible; because of this a metal encased potentiometer may prove best in this application—this can be sealed with epoxy resin or paint if necessary. Before using the transducer all surfaces should be protected with paint or varnish, the shaft and potentiometer bearing packed with grease and the container sealed with a rubber ring.

Details of the transducer are given in Fig. 3. Three  $\frac{1}{8}$  in diameter brass rods are used to position the two plates; one of these rods forms a locating pin to ensure correct orientation of the probe with respect to boat axis.

The other two pins form rotation limiters for the arm connected to VR1 and a spring anchoring point. The locating pin slides into a hole in the mounting bracket (shown in Fig. 3), that is fixed to the transom of the boat. The complete transducer can be lifted clear of the water, for breaching purposes or mooring, without completely removing the unit.

### TRANSDUCER ASSEMBLY

Assembly of the transducer may prove slightly tricky, but is fairly easy once the correct sequence is known. When all parts have been made to the details shown in Fig. 3 the three rods can be soldered or brazed to the lower plate—the one with no potentiometer mounting hole. The locating pin should be affixed so that its top end is about  $\frac{1}{16}$  in above the position of the upper plate—determined by the depth of VR1. The remaining two pins are mounted so that their lower end is flush with the underside of the lower plate.

Next, VR1 should be mounted on the upper plate approximately in the centre of the slightly elongated hole. It is not necessary to tighten the fixing fully at this stage since the horizontal position of VR1 will have to be adjusted. Fit the spacers over the pins and place the two plates together, holding them with the two screws and two further spacers; the case lid should not be included under the screw heads at this stage.

The next operation is to mount the small gear on the potentiometer using the spindle coupler. The shaft can then be inserted through the two plates and the larger gear attached by tapping the brass bush 4B.A. and screwing it to the spindle.

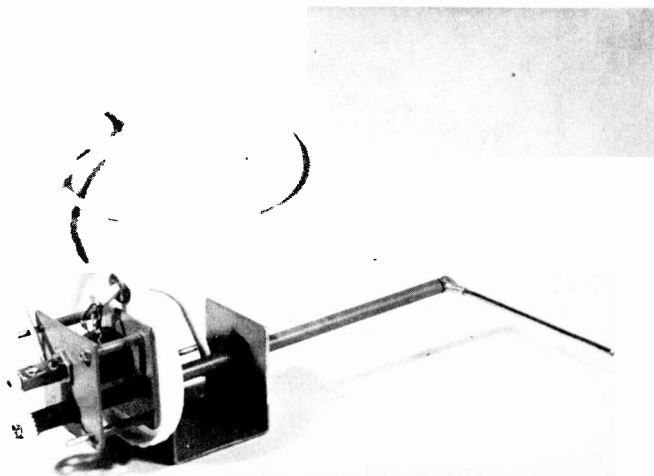
### SHAFT ALIGNMENT

The vertical position of the shaft can now be adjusted so that the two gears align—a small washer should be inserted under the large gear—the shaft is then soldered or brazed to the lower plate. The two screws can be removed and the case lid slid over the shaft and locating pin and the whole thing screwed together. The rotation limit arm is inserted so that with the arm touching the anti-clockwise limit pin, VR1 is turned so that it is a few degrees off its fully anti-clockwise position. VR1 can now be adjusted so that the two gears mesh correctly and its fixing tightened fully.

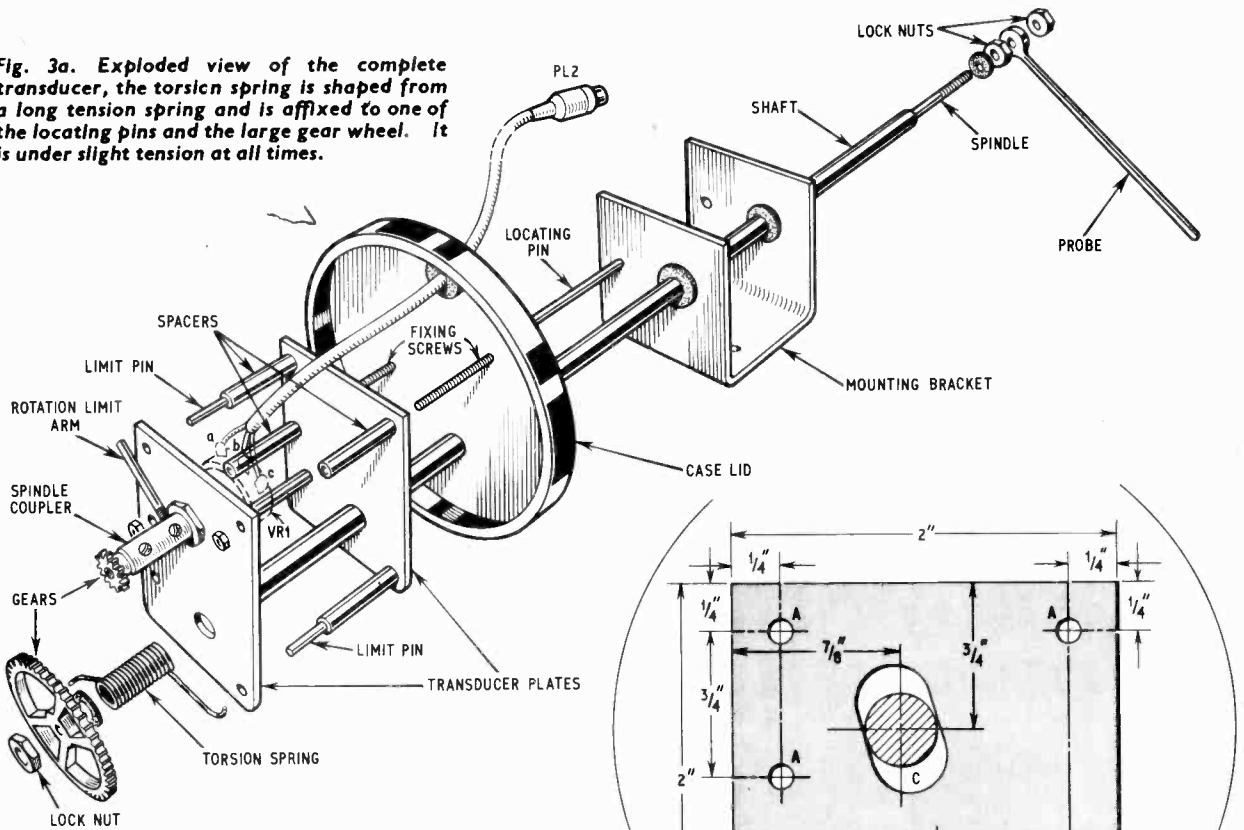
The torsion spring can now be fixed, the spindle revolved so that slight torsion is applied and, with the mounting bracket in place, the probe bolted in position. A washer should be included between the shaft and the probe and the probe fixed so that there is no vertical play on the spindle. The probe is made by hammering flat one end of a  $\frac{3}{16}$  in diameter brass rod, shaping and drilling the flattened end.

### INDICATOR CONSTRUCTION

The four resistors, the two diodes, D1, D2 and VR2, VR3 and VR4, are mounted on a small piece of Veroboard, as shown in Fig. 4. Veroboard is used as it provides good support to the components and is not badly affected by water, as some tag panels are.



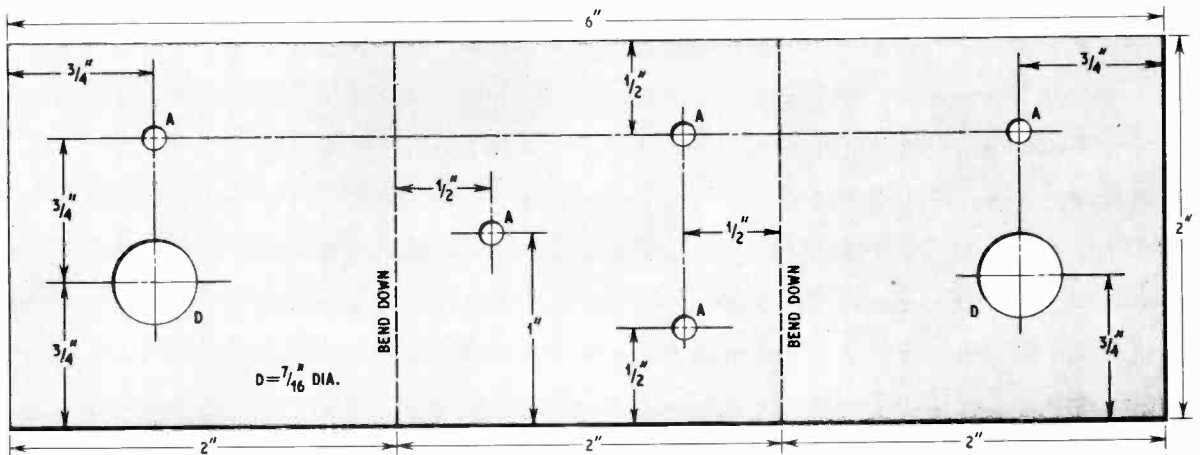
**Fig. 3a. Exploded view of the complete transducer, the torsion spring is shaped from a long tension spring and is affixed to one of the locating pins and the large gear wheel. It is under slight tension at all times.**



## TRANSUCER MATERIALS. . .

- 16 s.w.g. brass plate, 2in x 10in—for plates and bracket;  $\frac{1}{8}$ in diameter brass rod, 8in—for pins;  $\frac{3}{16}$ in diameter brass rod, 6in—for probe
- Model boat propeller shaft and spindle—see text
- Model makers' nylon gears 2 : 1 reduction with  $\frac{1}{4}$ in diameter brass bushes
- Spindle coupler  $\frac{3}{4}$ in long, for  $\frac{1}{4}$ in diameter spindles
- Spacers  $1\frac{1}{2}$ in x  $\frac{1}{4}$ in internal diameter, brass (4 off)
- 6B.A. screws  $1\frac{1}{2}$ in long (3 off) for fixing screws and rotation limit arm
- Case, 3in internal diameter plastics container with flat screw top
- Spring  $\frac{1}{2}$ in diameter tension spring of light construction at least  $1\frac{1}{2}$ in long.
- Grommets (3 off)—2 to suit shaft and 1 for connection lead; 4BA and 6BA nuts and washers

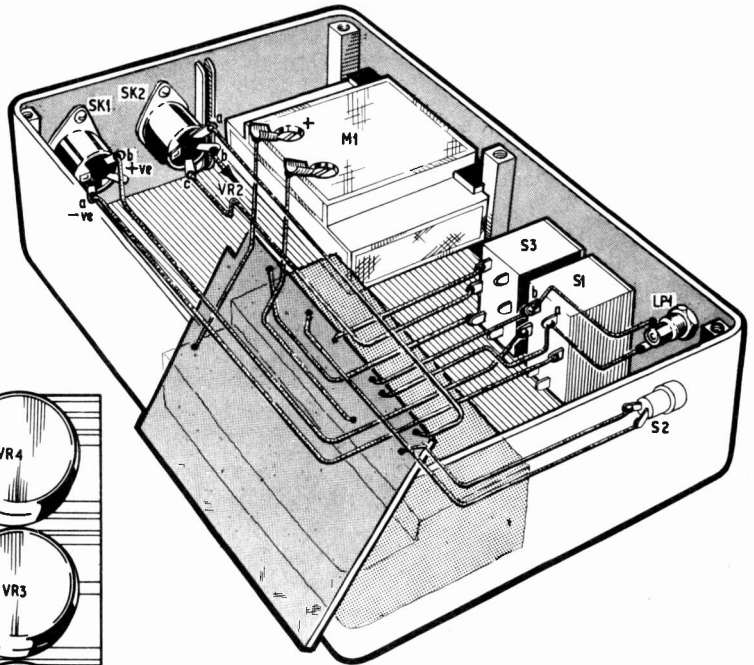
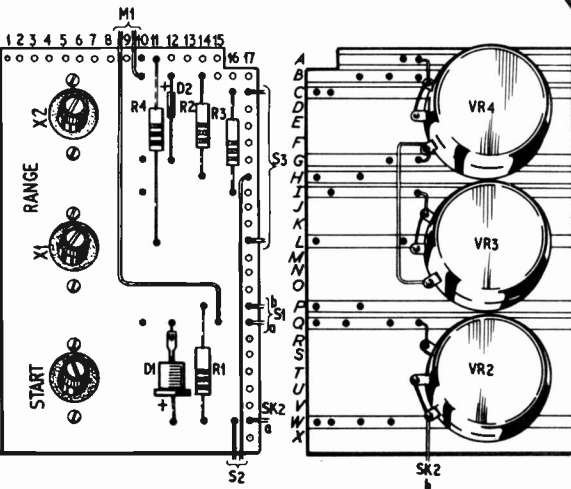
**Fig. 3b. Drilling details of the transducer plates. The distance between the two plates is determined by the depth of the potentiometer body—thus rod and spacer length will vary. Two plates are required and these should be drilled while clamped together. The elongated hole is only drilled through one plate. The position of the plates when mounted inside the case is indicated**



**Fig. 3c. Transducer mounting bracket details. Holes marked "D" must line up when the bracket is bent, their size will depend on the shaft and grommet diameter**

**Fig. 4. Veroboard layout and wiring diagram. The potentiometers may be designated as shown on the board, for easy identification during setting up and calibration**

**Fig. 5. Layout and wiring diagram of all components mounted in the die-cast case. The lid to the case forms the base of the unit and the view shown is of the underside with the base plate removed**



The remainder of the components are mounted directly to the die-cast case used to house the unit, see Fig. 5. This case should be carefully painted inside and out, after drilling, to prevent it being corroded by salt water; the base plate should be sealed with rubber strips. Sockets are provided for the leads to the transducer and the supply; these leads should be of good quality plastics insulated flex.

The meter is mounted on a rubber pad to provide some shock protection and prevent water from entering the case. The meter specified has no external apertures and the mechanical zero is adjusted through a hole in the top of the case which is plugged with a small piece of rubber when not in use. The Veroboard is mounted by sandwiching it between two pieces of foam rubber.

Layout and wiring of all components mounted in the indicator case is shown in Fig. 6. Internal batteries may be used if a larger housing is provided; in this case LP1 should be omitted to conserve the battery.

## INSTALLATION

The mounting bracket is fitted to the transom of the boat so that the lowest part of the bracket is about 1in above the highest possible water line. The bracket should be fitted well away from propellers on power craft or any obstruction that could interfere with the water flow.

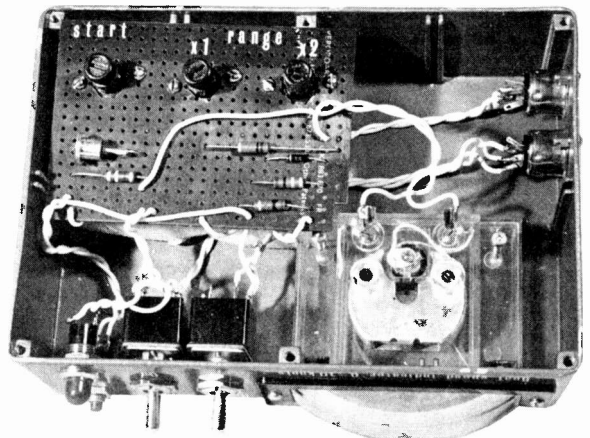
The length of the shaft used will depend on the type and speed of the boat. The prototype, which was intended for a sailing dinghy, used a 9in shaft,

but power yachts may require a greater length to keep the probe below and the unit above, the water level at all speeds (the transducer body should also be clear of the water when going astern).

The indicator unit can be fitted in a convenient position and a good quality piece of 3 core mains lead made the correct length and wired to PL2. The transducer could be fitted through the bottom of larger craft but a special adaptor will have to be manufactured for this.

## CALIBRATION

The first step in calibration of the unit is to mark the correct supply level on M1. To do this a d.c. voltmeter is used to measure the voltage across D1; this voltage should be 10V—providing the battery is in good condition and D1 is functioning. Once this has been checked S2 can be depressed and the reading of M1 noted and marked on the scale or meter face; VR1 should be in circuit at its stationary position for this operation.



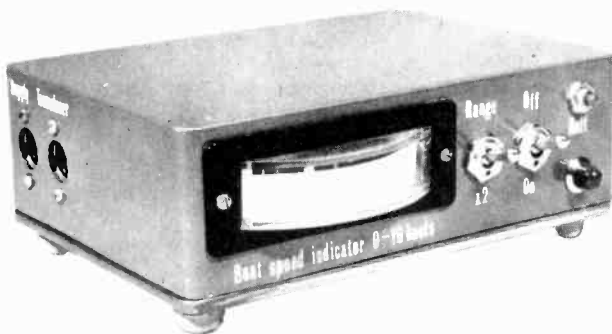
Switch S3 can then be set to the first range ( $\times 1$ ) and VR2 adjusted so that the meter shows a reading of  $10\mu\text{A}$ . Once this is done the meter can be zeroed when the circuit is energised, using the mechanical zero adjustment.

The maximum possible speed of the boat should be estimated and this speed marked at the full scale deflection point on M1. The scale should then be divided equally to indicate the intermediate speeds. With the probe rotated through 45 degrees, VR3 should be set to indicate full scale deflection on M1.

### INITIAL SETTING

Initial setting of VR3 can be made without installing the unit. Once this is completed the unit should be installed for further calibration in the boat in which it is to be used, in the correct position with the transducer lead of the required length.

Initial calibration is by means of variation of probe length and diameter (prototype used a 4in shaft of  $\frac{3}{16}$ in diameter brass) and torsion spring. Probe diameter may easily be increased by sliding a length of plastics flex insulation over it. Fine calibration may be effected by adjustment of VR3. The unit should be calibrated as near the maximum speed as possible, since this is the point at which the circuit is most accurate (refer to Fig. 2).



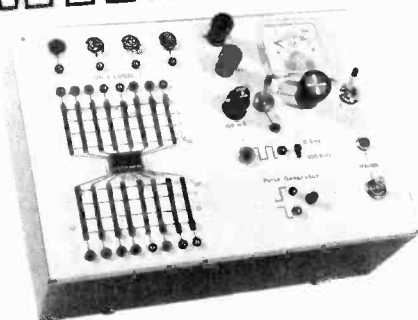
There are two ways of speed calibrating the unit: by comparison with another speed indicator or by timing the boat over a measured distance. If the second method is used the measured distance should be as large as practicable and the boat speed held constant by means of the indicator, any error can then be adjusted after a second run in the opposite direction.

To calibrate the times 2 range it is only necessary to hold the probe in such a position that half full scale deflection is indicated with S3 in the  $\times 1$  position; then switch S3 to  $\times 2$  (with the probe in the same position) and adjust VR4 to give full scale deflection on M1. When this has been done the probe fixing can be soldered over, to protect it and prevent it becoming corroded, and finally painted.

Designations may then be added to the unit as required, using Letraset, and given a coat of clear varnish to protect them. The unit is then ready for use.

If it is found that the meter is too sensitive to slight variations in speed or that the needle tends to flicker in use, the movement can be damped by placing a 2,000 $\mu\text{F}$  15V electrolytic capacitor directly across the meter terminals—observing polarity. ★

# MAY '71



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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 merit.

## DIGITAL DICE

PERHAPS your readers would be interested in the following circuit for an Electronic Dice.

The circuit is basically three binary stages with feed-back to give a count of six, being driven at high frequency by a free running multivibrator. When the count is stopped by pressing the display button S1 the output of the six counter is fed via gates to light lamps LPI to LP6, giving a display in the familiar dice combinations, i.e. with the centre lamp only lit for a "one", the six outer lamps for a "six", etc. The dice requires only four decoding circuits;

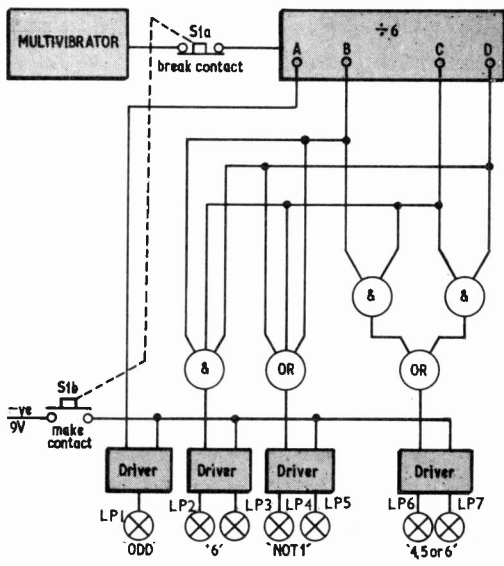


Fig. 1. Block diagram of the electronic dice

the first of these decides "even or odd"—if the count is odd only the centre lamp lights. The next gate decides "not one" which lights two diagonally opposite lamps (except during a one). A third gating circuit decides four, five or six and lights the two remaining diagonally opposite bulbs on these counts. The final gate decides "six" and lights the two remaining bulbs on this count. A little thought will show that these combinations will automatically light the proper number of bulbs in the correct pattern for each dice position. The block schematic diagram of the dice is shown in Fig. 1; Figs. 2, 3, 4 and 5 show the sections of circuitry, Fig. 2 being the driving multivibrator; Fig. 3 is the divide by 6 counter; Fig. 4 shows the five gates that together form the three gating circuits and Fig. 5 shows the lamp driver circuits.

The display panel is made up of a square of holes drilled in the positions shown in Fig. 6. A piece of coloured translucent perspex is fitted over a blanking panel, so that only the illuminated lamps can be seen as spots of light on the perspex.

If required, the dice may be built up as a double unit in which case the divider board, gates and lamp display should be duplicated and the second divider board input driven from point "D" on the first divider board; this ensures independent displays on the two dice.

The circuit may be powered either by a nine volt dry battery or by a d.c. nine volt, one amp, mains power supply. The mains power supply is preferable due to the current drain of the lamp display.

J. D. CROFT,

Warrington, Lancashire.

Count	Output from ÷ counter				Binary
	A	B	C	D	
1	NEG	POS	POS	POS	0 0 0
2	POS	NEG	POS	POS	0 0 1
3	NEG	POS	NEG	POS	0 1 0
4	POS	NEG	NEG	POS	0 1 1
5	NEG	POS	NEG	NEG	1 1 0
6	POS	NEG	NEG	NEG	1 1 1

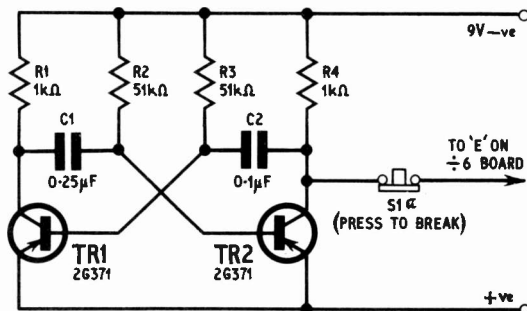


Fig. 2. Multivibrator driver for the dice



Fig. 3. The divide by six counter

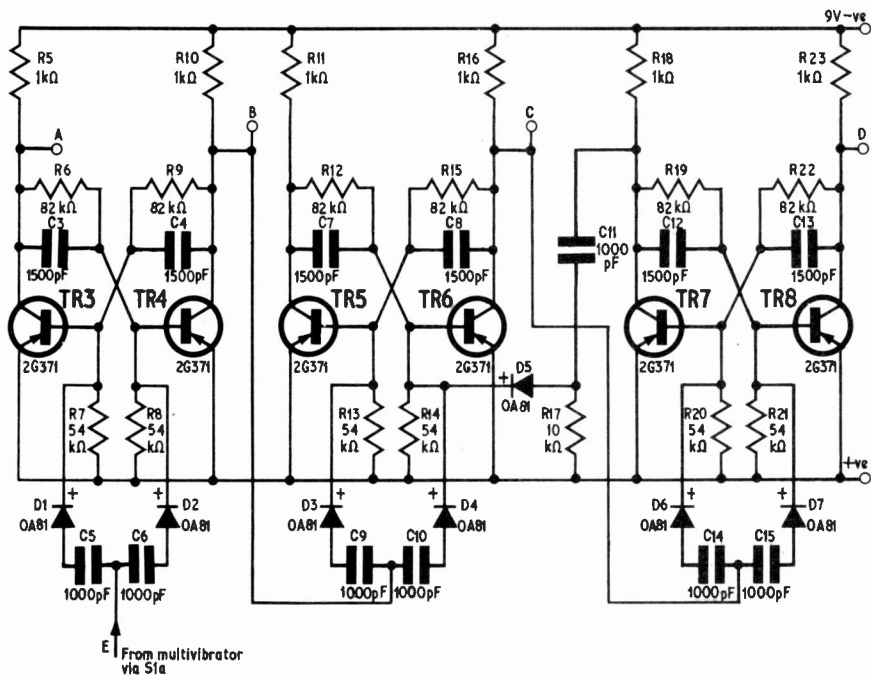


Fig. 4. Gate circuits used in the dice

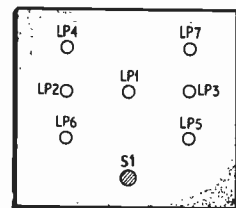
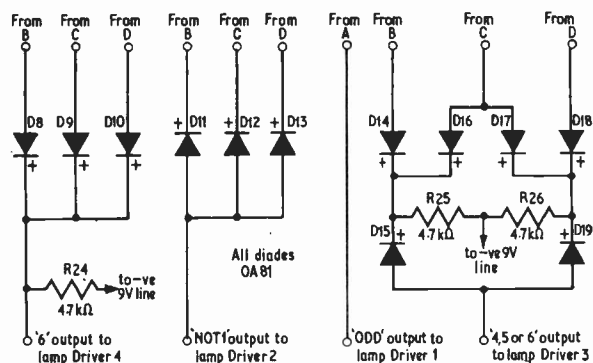
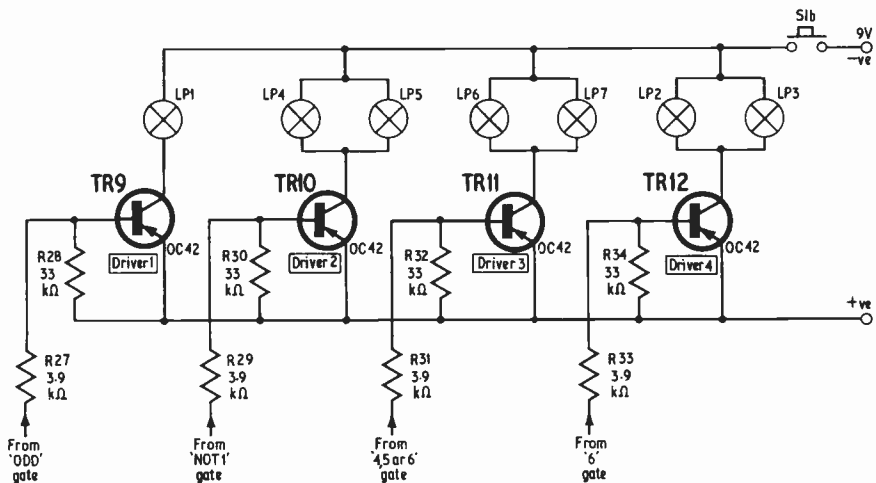


Fig. 6. Lamp and switch positions

Fig. 5. Lamp driver circuits; all lamps 6.3V 0.04A



# DIGITAL TO ANALOGUE CONVERSION

It is often required to obtain a staircase waveform output from 1, 2, 4, 8 counter or logic outputs. The methods usually used are combinations of integrators and diode pumps of various descriptions. The circuit used here, however, is purely digital and the minimum of design application and components are required. The components used may be four transistors, used as single input gates, four Zener diodes and a load resistor. All of the components could probably be incorporated economically on a single i.c.

For operation of this circuit, I will refer to the circuit diagram (Fig. 1) where the resistors R1, R2, R3, and R4 ensure that the transistors TR1, TR2, TR3 and TR4 are saturated when the inputs 1, 2, 4, and 8 are at logic "1", (which must be 10V or more in this circuit).

In "0" output condition the transistors TR1, TR2 and TR3 and TR4 will all be saturated and the output will be at a level of  $V_{ce(sat)} \times 4$  above zero volts or ground, this gives a level of approximately 1.2V. Now assume input 1 is taken to zero volts or ground, TR1 will thus switch off; the voltage across which will rise until D1 Zener diode break-down level is reached. This break-down voltage level is selected to be 1 volt plus the  $V_{ce(sat)}$  of TR1, this will give a step of 1 volt at the output. The voltage  $1 \times V_{ce(sat)}$  is added to each Zener voltage to maintain linear 1 volt steps at the output, as without taking this into account the voltage output will vary depending on the number of transistors saturated or not.

Assume the inputs to be obtained from a binary counter then input 2 will become zero and input 1 will

go to a positive voltage. Thus TR1 will saturate shorting out Zener diode D1, but TR2 is now switched off—the voltage across which rises to the Zener break-down voltage of D2. This has been selected as 2 volts plus  $V_{ce(sat)}$  of TR2 which gives an output level of 2 volts above the zero level of  $V_{ce(sat)} \times 4$ .

This is continued for inputs 1 and 2 where both TR1 and TR2 are switched off which allows the output to rise by 3 volts i.e., D1 plus D2, and like-wise all the way along the chain of a 1, 2, 4, 8 counter or other input.

The output will start at  $V_{ce(sat)} \times 4$  (which is zero) and ascend in one volt steps until the output voltage reaches ten volts, our count of ten plus  $V_{ce(sat)} \times 4$ , this gives a total of 11.2 volts, and it goes without saying the steps may ascend in level by reversing the logic input levels.

The beauty of this circuit is that it is entirely independent of frequency and voltage levels, providing  $V_{CC}$  does not fall to below the sum of the total Zener voltage levels, i.e.  $V_{CC}$  may be 100 volts (if the components will take it) and the output levels obtained will not vary considerably from those when  $V_{CC}$  was at 12 volts. So it can be seen that the only design consideration is one of upper operating frequency which is dependent upon the components used and not so much the circuit; by selecting the appropriate Zener voltage levels this circuit may be used on various coded outputs quite easily.

D. W. Lloyd,  
Stotfold, Herts.

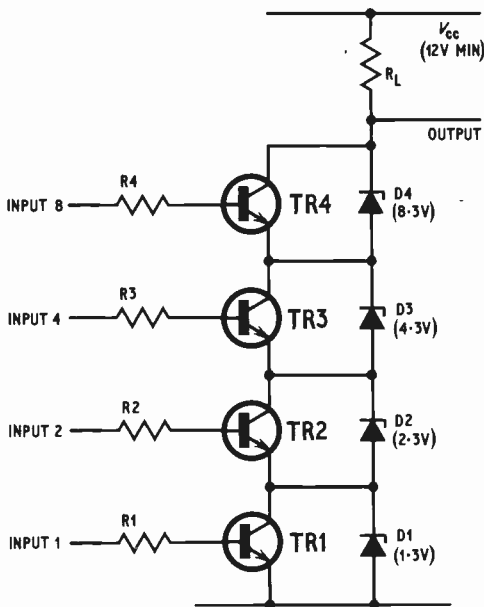


Fig. 1.

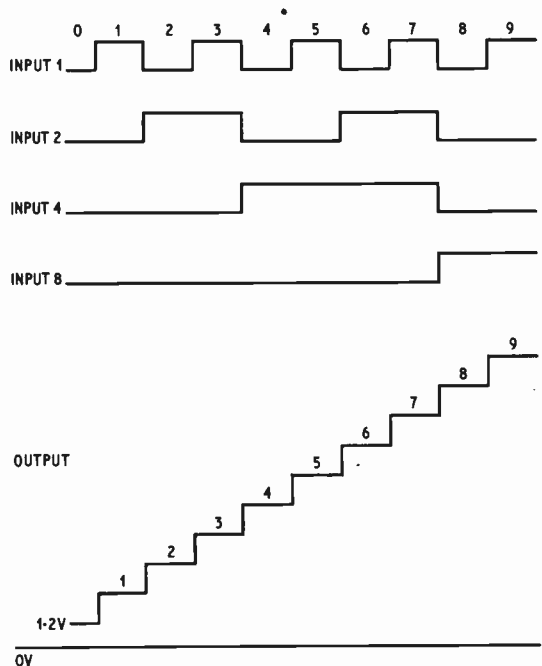
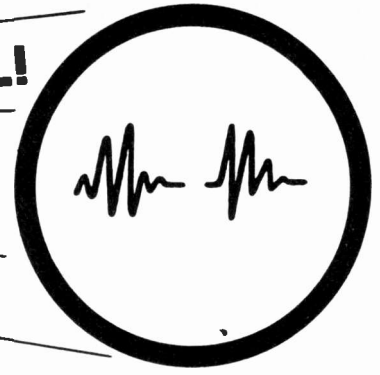


Fig. 2.

# LOOK!

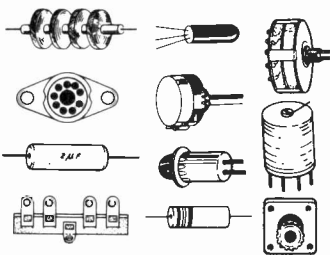
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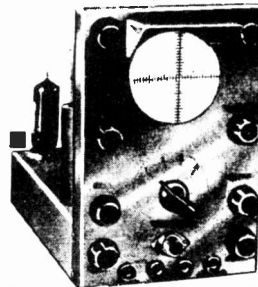
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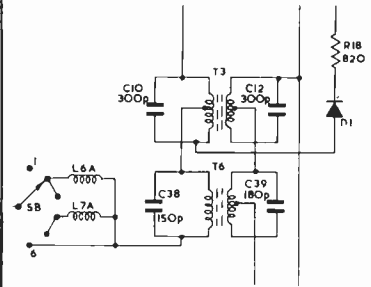
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# MARKET PLACE

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.

## LOUDSPEAKERS AND ENCLOSURES

An increasing number of cost conscious hi fi enthusiasts are home constructing loudspeaker systems from the expanding range of multi-unit kits and individual loudspeakers now available.

One of these multi-unit kits is the Peerless 20-3 from P. F. & A. R. Helme. This is a 3-way system consisting of a low frequency "woofer" loudspeaker with rubber roll surround, a mid-range speaker, a "tweeter" high frequency speaker and a printed circuit board crossover unit.

Recommended for amplifiers of 10 to 40 watts, the maximum power input of the system is 40 watts. The frequency range is claimed to be 40 to 20,000Hz and the crossover frequencies are 1,500 and 6,000Hz. All speakers have voice coils wound on an aluminium coil former and have standard impedances of 4, 8 or 16 ohms.

The Peerless 20-3 kit costs approximately £18.87 and full details will be supplied by A. F. & A. R. Helme, Summerbridge, Harrogate, Yorkshire, HG3 4DR.

For those readers who do not feel sufficiently proficient to make their own enclosures, Messrs. Omar Skinner & Sons produce ready built enclosures to makers' specifications for the more popular systems.

The enclosures are soundly constructed and available in a variety of finishes. The baffle boards are cut to order and they claim they can supply an enclosure for every need.

Our photograph shows the Omar Skinner enclosure for the four loudspeaker EMI 750 kit. The 750 kit consists of a bass, mid-range and two treble speakers, which together are capable of handling 20 watts and cover the frequency range of approximately 30-20,000Hz. A crossover unit with a choice of switching frequencies, wiring harness and full instructions is included and the complete EMI 750 kit costs £27.50.

Details of enclosures may be obtained from Messrs. Omar Skinner & Sons, Warfield Park

Workshops, Warfield Park, Bracknell, Berkshire, and enquiries for information on EMI loudspeaker kits and enclosures should be addressed to EMI Sound Products Ltd., Blythe Road, Hayes, Middx.

## TOOL KITS

During the last few years manufacturers have been gradually gearing themselves to continental specifications and component practices when designing equipment. The result of this gradual changeover has meant that numerous pieces of equipment have contained both U.K. and continental components, i.e. Phillips, Allen, and standard screws.

One of the problems encountered by this situation is the lack of necessary tools when carrying out service repair work. **Special Products Distributors** seem to have recognised this problem and are now introducing the well-known Xcelite tools from America to the British market.

The first tools to be marketed are a 19-piece screwdriver kit, 14-piece socket set and a 5-piece screwdriver kit.

The XL-70 19-piece kit contains a selection of Allen keys, slotted and Phillips screwdrivers, reversible ratchet and extension handle. The ratchet can be attached to the extension handle for added torque if required. This kit is particularly useful for television service engineers.

The 1001 14-piece socket set includes sockets from  $\frac{1}{8}$ in. to  $\frac{1}{2}$ in., 2in. extension, reversible ratchet and extension handle.

Included amongst the sockets are two 10-point sockets,  $\frac{1}{4}$ in. and  $\frac{3}{8}$ in., which are dual purpose to fit both square and hexagonal nuts. The reversible ratchet in this kit is fully enclosed to keep out dirt and grit.

The XL75 5-piece kit is contained in a plastics wallet and is a small set of slotted and Phillips screwdrivers with an offset ratchet handle, again extremely useful for working in awkward and confined spaces.

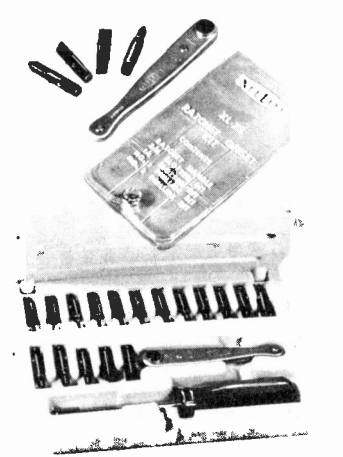
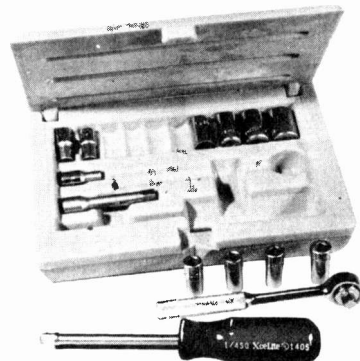
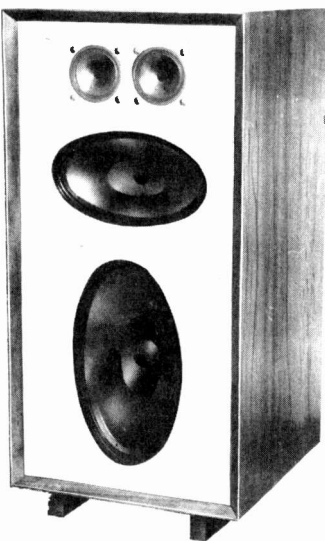
The XL70 screwdriver kit costs £6.25, the 1001 socket set costs £7.18 and the XL75 costs £2.10.

Both the XL70 and the 1001 kits are housed in moulded high impact plastics cases. Full particulars of these tools are available from Special Products Distributors Ltd., 81 Piccadilly, London, W1V 0HL.

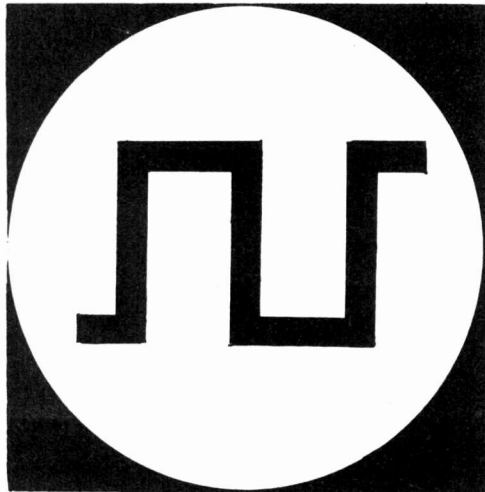


Peerless 20-3 kit from P. F. & A. R. Helme

EMI 750 kit housed in an Omar Skinner enclosure



The 1001, XL75 and XL70 kits marketed by Special Products Distributors



# DOORBELL YODELLER

K. J. Turvey, B.Sc.(Eng.)

**T**his article describes the construction of a completely electronic door bell which is simple, cheap, and does not require accurate adjustment. The rhythm and melody are continually changing so that each time the bell push is depressed a different sound is produced.

## CIRCUIT BLOCKS

In the block diagram of the unit shown in Fig. 1, the 250Hz multivibrator produces the basic note. The base resistors controlling the frequency are divided into two so that the two low frequency (1Hz) multivibrator circuits can short circuit the upper resistors. A total of four notes is thus obtained using only three switching circuits.

Since the multivibrator circuits run asynchronously the rhythm will be continually changing which means that a different tune will be obtained each time the bell push S1 is depressed.

The output from the 250Hz multivibrator is fed via an AND gate to amplifier A2 to drive the loudspeaker LS1. The signal is allowed through the gate when the monostable is pulsed, the duration of which may be adjusted between 0.5 and 12 seconds.

A buffer amplifier, A1, precedes the monostable stage and provides the triggering action when the bell push is used.

## DETAILED OPERATION

Transistors TR3 and TR4 in Fig. 2 form the main astable circuit which provides low frequency calculated by  $1/0.7[C_3(R_6 + R_7) + C_4(R_8 + R_9)]Hz$ .

In order that diodes D1 and D2 effectively short circuit R6 and R8, R7 must be greater than R6 and R9 must be greater than R8.

TR5 and TR6 form another astable circuit working at a very low frequency of about 1Hz. With  $R_{12} = R_{13}$  and  $C_5 = C_6$  the frequency is given by  $1/1.4 C_5 R_{12} Hz$ .

When TR5 is hard on, the collector is almost zero volts and diode D2 is back biased since the junction of R8 and R9 is always positive. When TR5 is cut off the collector is +6V and D2 is forward biased which effectively short circuits R8 and consequently changes the operating frequency of the 250Hz astable.

The action of TR1/TR2 astable circuit is identical to this but is applied to D1.

## GATING THE OUTPUT

The output is taken from TR3 collector and gated at the input of the amplifier A2 by diode D3. With the bell switch not made TR11 in the monostable circuit will be normally hard on and thus the collector will be nearly at zero volts. Here the diode D4 is forward biased and the junction of R28 and R29 will be held at zero volts irrespective of the input to D3.

TR9 is held on by the positive voltage appearing at the junction of R19 and the lamp. When the bell push is depressed the base of TR9 is brought to nearly zero volts so that it switches off.

With TR9 cut off, the collector will change from zero volts to +6V. This positive going voltage turns TR10 on via C10 and R23 thus triggering the monostable action of TR10 and TR11. TR11 is turned off and the collector changes to +6V which reverse biases diode D4, so allowing D3 to pass the output of TR3 to the amplifier A2.

Irrespective of whether the bell push is maintained depressed or not the monostable action will end after a time given by  $0.7 \times C_{11} \times (VR1 + R_{25})$ . In this period a short burst of notes will be obtained. With VR1 set to zero the duration will be approximately 0.5 seconds. Set to maximum resistance it will be about 12 seconds.

R21 is included to reduce the voltage to the astable and monostable circuits so that 6V working capacitors can be used. C9 decouples the astable circuits.

## POWER SUPPLY

The circuit diagram of the power supply is shown in Fig. 3. Here the total current required will depend, in the main, on the rating of LP1.

If a Friedland bell push is used the lamp voltage will probably be 8-15 volts. Thus a 12 volt transformer would be suitable.

The prototype was powered from a 12-0-12 volt transformer and using a Friedland Type 'A' lamp the following measurements were made.

Normal current	150 mA
Bell operating	500 mA
Bell push held depressed	1.2 amps

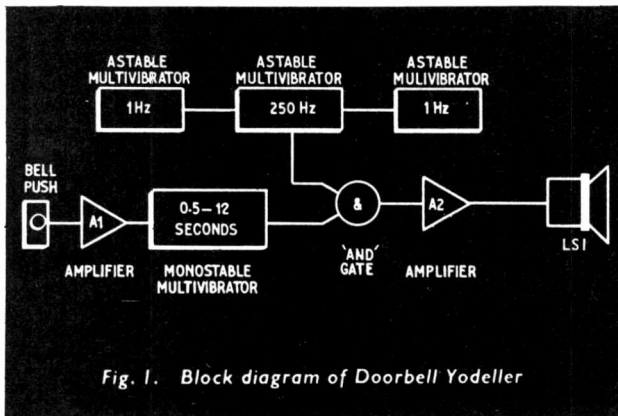


Fig. 1. Block diagram of Doorbell Yodeller



# Components . . .

## Resistors

R1 1k $\Omega$	R11 1k $\Omega$	R21 220 $\Omega$ $\frac{1}{2}$ W
R2 22k $\Omega$	R12 22k $\Omega$	R22 1k $\Omega$
R3 22k $\Omega$	R13 22k $\Omega$	R23 100k $\Omega$
R4 1k $\Omega$	R14 1k $\Omega$	R24 1.8k $\Omega$
R5 3.3k $\Omega$	R15 6.8k $\Omega$	R25 2.2k $\Omega$
R6 22k $\Omega$	R16 150 $\Omega$	R26 22k $\Omega$
R7 33k $\Omega$	R17 10 $\Omega$ 2W	R27 1.8k $\Omega$
R8 27k $\Omega$	R18 15 $\Omega$ 2W	R28 1k $\Omega$
R9 33k $\Omega$	R19 15 $\Omega$ 10W	R29 1k $\Omega$
R10 3.3k $\Omega$	R20 5.6k $\Omega$	

All 10%,  $\frac{1}{4}$ W carbon except where stated

## Potentiometers

VR1 47k $\Omega$ Vertical preset
VR2 25 $\Omega$ Preset

## Transformer

T1 12V 2A centre tapped (Douglas MT71)

## Capacitors

C1 32 $\mu$ F elect. 6V	C7 250 $\mu$ F elect. 15V
C2 32 $\mu$ F elect. 6V	C8 250 $\mu$ F elect. 15V
C3 0.01 $\mu$ F	C9 250 $\mu$ F elect. 6V
C4 0.01 $\mu$ F	C10 0.1 $\mu$ F
C5 32 $\mu$ F elect. 6V	C11 250 $\mu$ F 6V
C6 32 $\mu$ F elect. 6V	C12 5,000 $\mu$ F elect. 15V

## Transistors

TR1-TR7 BC108 (7 off)  
 TR8, OC28  
 TR9-TR11 BC108 (3 off)

## Diodes

D1-D4 OA90 (4 off)      D5-D8 RS50AF (4 off)

## Miscellaneous

S1 (see text), LS1 3-15 ohms loudspeaker,  
 Veroboard 0.1in matrix  $4\frac{1}{2}$ in  $\times$  6in and  $2\frac{1}{2}$ in  $\times$  5in.

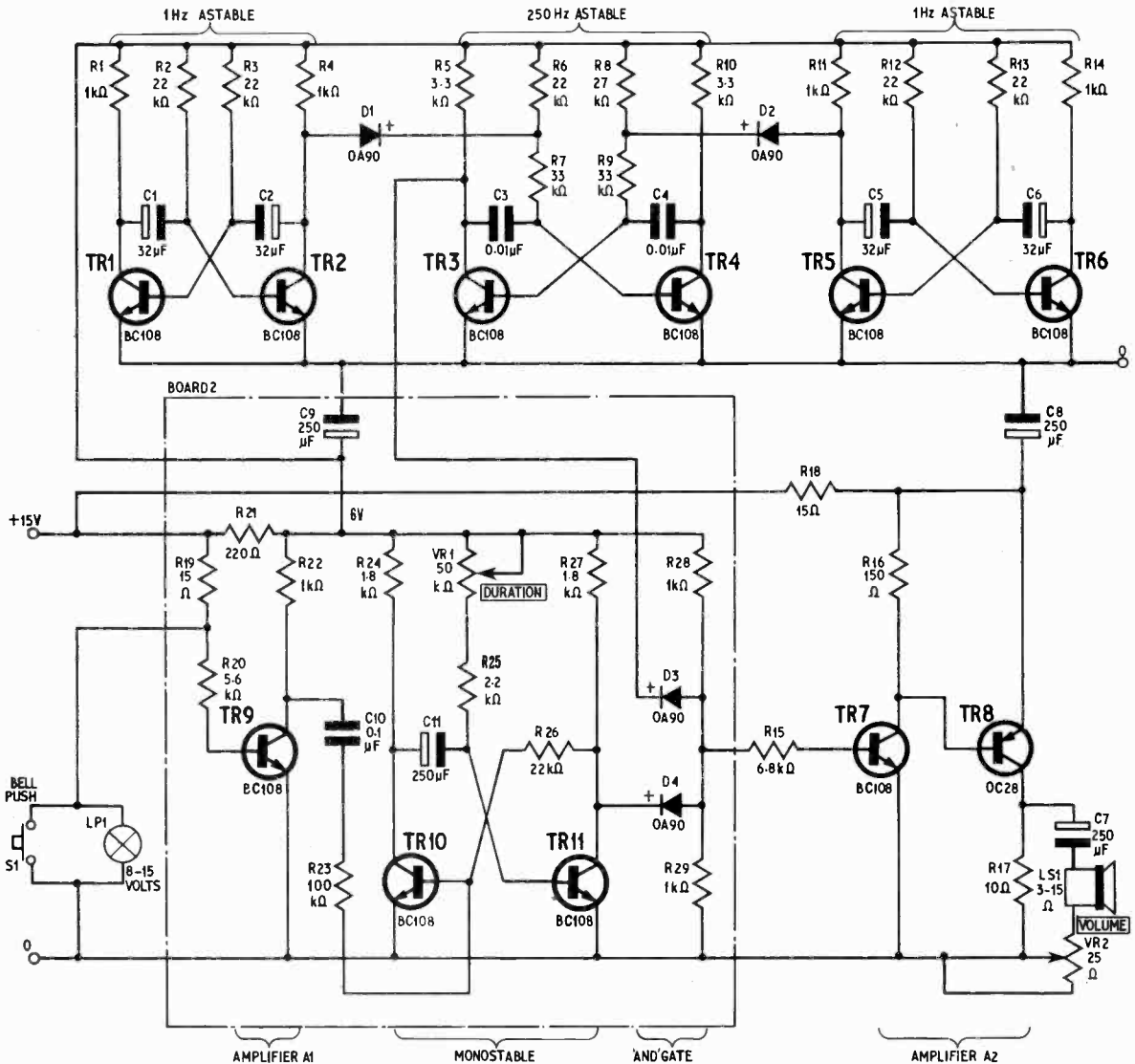
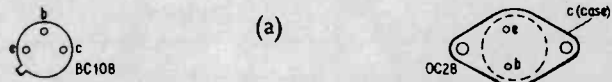
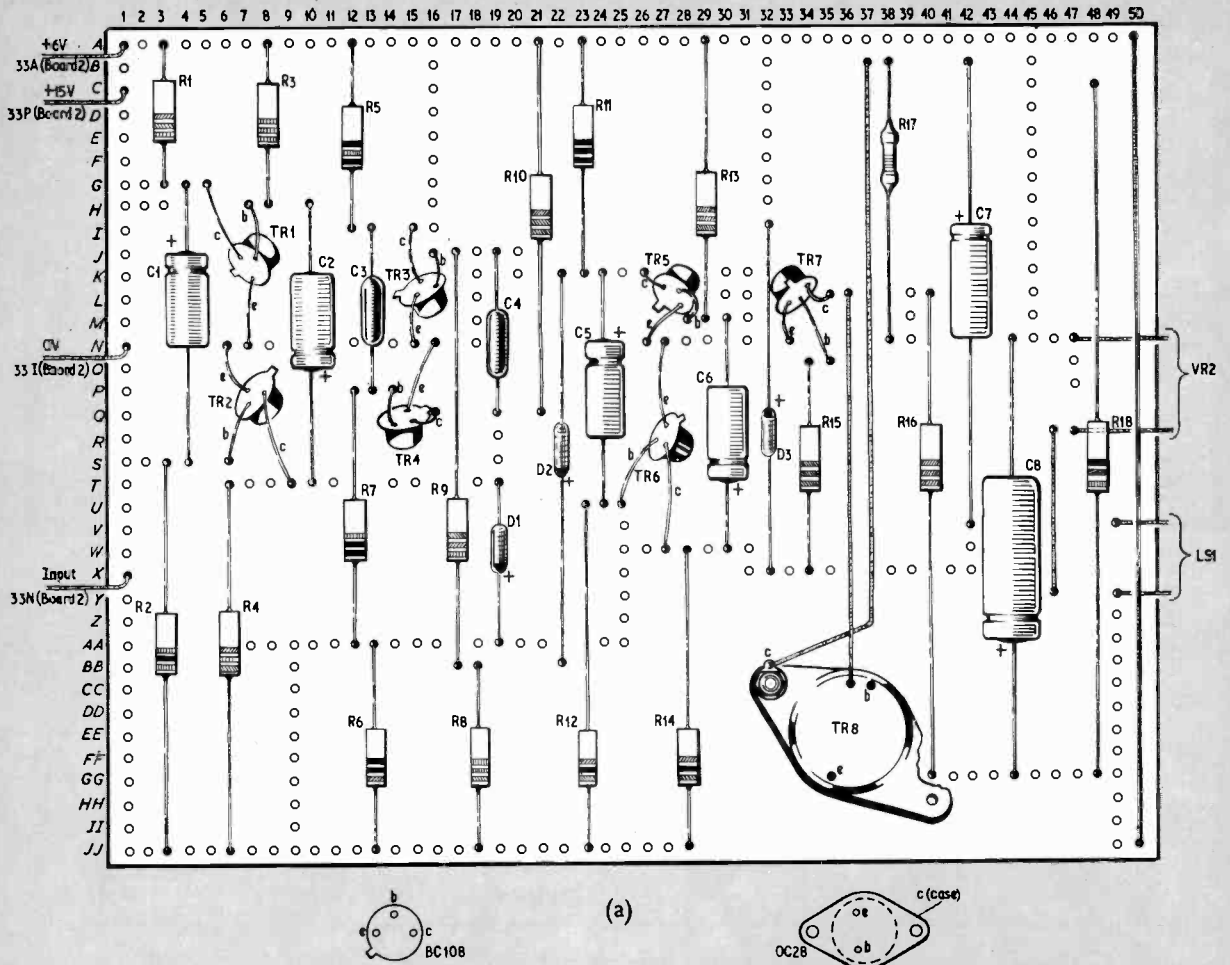
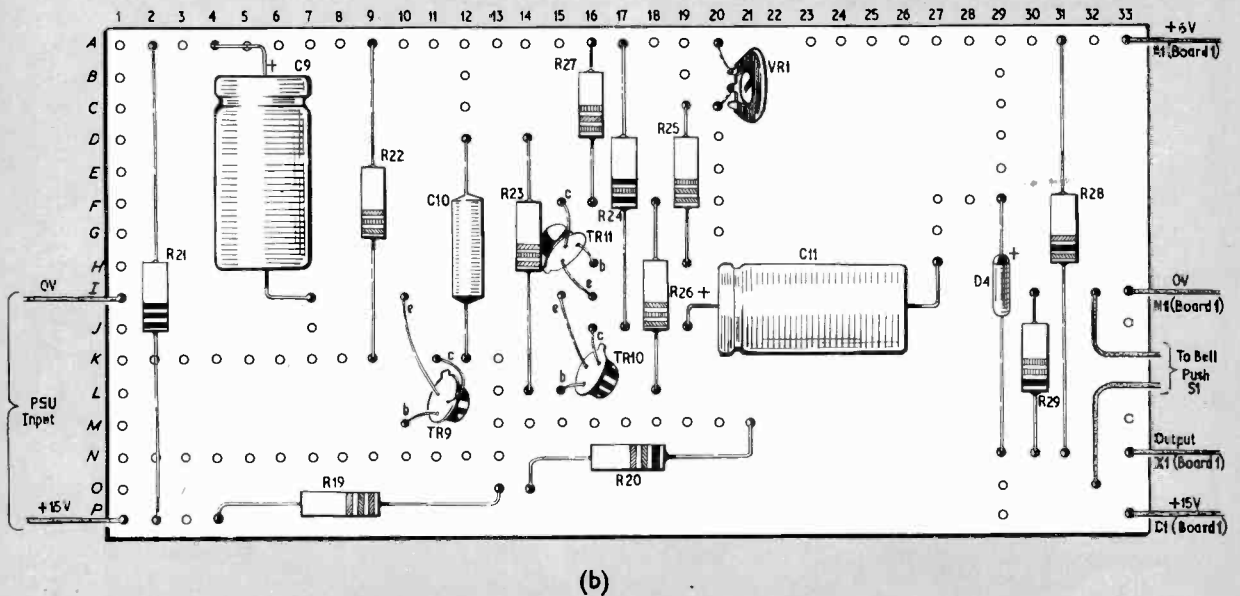


Fig. 2. Circuit diagram of Doorbell Yodeller



**Fig. 4. Component assembly of (a) the astable and amplifier circuit; (b) the monostable and switching amplifier. Assembly may be combined on a single Veroboard**



# NEWS BRIEFS

## Trinitron T.V.

A NEW colour television tube—called the Trinitron has been announced by Sony Ltd. The tube uses only one electron gun that projects three electron beams; the beams are converged and focused through two large diameter electron "lenses" and a pair of deflectors. Because a large diameter single "lens" can be used to focus all three beams from the Trinitron gun, greater brightness and better focus are claimed to be achieved.

The tube (shown below next to a conventional tube) also utilises a new colour selection method named "Aperture Grill" which uses a vertical slotted grill and vertical lines of phosphors rather than the holes and dots of the normal shadowmask tube. The single gun can also be used with either a shadowmask tube, or a chromatron tube, as can be seen from the drawing below.

The new tube has been incorporated in a 13in screen colour television which, when recently demonstrated to the press, gave a good account of itself. The set will be on the market in this country in April '71 and will retail at just under £200. It will be interesting to see if Telefunken A.E.G. are prepared to allow Sony to market this set, if it infringes their patent on the P.A.L. colour system, without a legal fight. It is not yet possible to say if the set infringes P.A.L. patent since Sony will give no technical circuit data, it will also be interesting to see if Sony can make larger screen sets—even if, as they state, they do not wish to market them in this country.

A—CHROMATRON

B—APERTURE GRILL

C—SHADOW MASK

TRINITRON GUN—  
CAN BE USED WITH A,  
B, OR C.

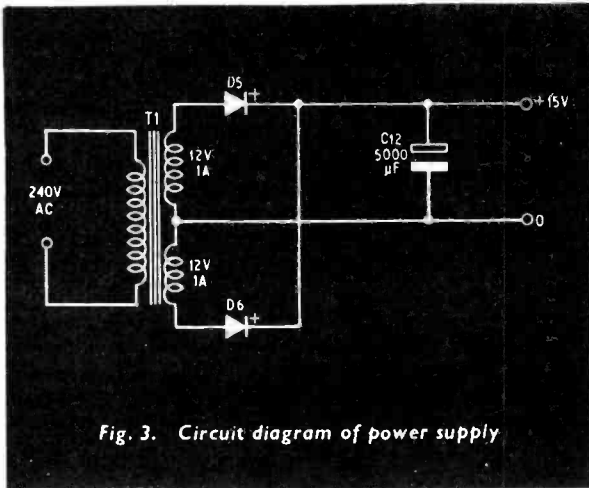
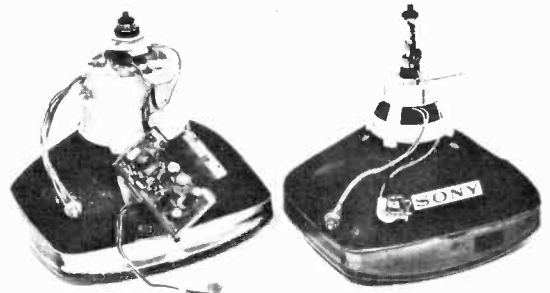
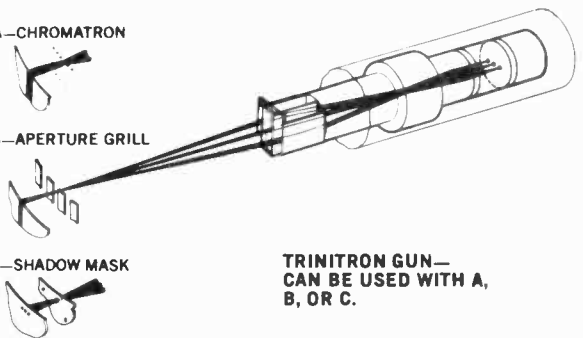


Fig. 3. Circuit diagram of power supply

## CONSTRUCTION

In the prototype the astable and amplifier circuits were built on a piece of 6in by 4½in Veroboard as given in Fig. 4. Here there is ample room for the components and no breaks in the copper strip are required.

A 2½in by 5in Veroboard is used for assembling the monostable circuit and switching transistor TR9. The reason for this separate board construction is because the monostable is dispensable since it only provides an interval of tones, the period of which can be set by VR1.

Since there is nothing critical in the layout, single board construction for the complete circuit, including power supply, can be made.

## CHECK OUT

If the completed unit fails to function with the supply applied, the following check out procedure should be undertaken.

First disconnect D4 to isolate the monostable. If a tone is not apparent, connect a headset via crocodile clips between TR3 collector and emitter. No sound points to either TR3 or TR4 being defunct.

If the stage is alright, apply the 'phones to TR7 and TR8 collectors, in that order, to determine the offending transistor.

To check the operation of the low frequency astables, a voltmeter should be connected to the collectors. This method can be used to establish the switching action at TR9 collector, the swing here being between 0 and 6V when the bell push is depressed.

Once the circuit is functioning correctly R6 can be replaced by a preset potentiometer if any time adjustment is required.

## VARIATIONS

As already mentioned the monostable section could be omitted. Simply omit TR10, TR11 and their associated components. Also omit C10 and R23 and connect the collector of TR9 directly to D4.

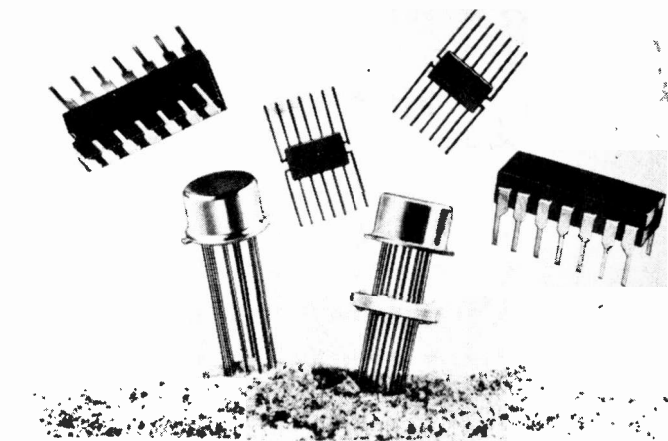
If an illuminated bell push is not used connect a 100 ohm resistor across the bell push contacts. This can be done on the component board.

If the monostable action is not required and a non-illuminated bell push is used, connect TR3 collector directly to R15, the base resistor of TR7. The bell push may then be used to connect the dc supply to the circuit. A 6 volt transformer could be used in this case.

A wooden box, or metal case, can be used for housing the completed circuitry, here the only external control item will be the potentiometer VR2. ★

# MAKING THE MOST

# OF LOGIC IC'S



## PART TEN—By R. W. GOLES

### METAL OXIDE SILICON LOGIC (MOS)

It was mentioned in an earlier article in this series, that a further two logic families have been elevated to positions which rank them alongside the three originally basic groups RTL, DTL, and TTL.

This article concerns itself with the first of these two comparative newcomers, Metal Oxide Silicon Logic, usually referred to simply as MOS.

#### MOS DEVICE CAPABILITY

MOS logic is a very different family from any of the others discussed, both in fabrication and application. Instead of conventional bipolar transistors, insulated gate field effect devices are employed, and in general no linear resistors or diodes are used at all.

MOS is used with negative supply voltages of up to 30V, with consequently large logic swings which render the mixing of this family with, say, TTL a complicated business usually requiring special "interface" circuitry.

Registers and gates in the MOS range will not run at the high speeds associated with TTL either, a limit of 1 MHz being common in the specification of a shift register package.

In the light of all these apparent disadvantages one may well ask why anyone should bother with these devices at all, and the answer to this is that MOS is very simple indeed to produce, an advantage which makes it possible to incorporate vast quantities of logic elements on a single chip, and still achieve an economic yield.

A bipolar device, whether it be a single transistor or an MSI counter, requires well over one hundred process steps in its manufacture from a silicon "chip". An MOS circuit on the other hand is produced in less than forty steps of comparable complexity, which means less chance of manufacturing discrepancies and a correspondingly lower reject rate on circuits of the same magnitude as their bipolar counterparts.

Usually this improvement is used to advantage to enable large logic arrays, such as dual 100-bit serial shift registers, to be built on one chip, rather than duplicate the bipolar circuits. This slant towards large scale integration (LSI) is also helped by the fact that an MOS transistor, being a low current, high impedance device, takes up only about one fiftieth of the chip area that a typical bipolar device needs.

MOS techniques are beginning to revolutionise many areas of logic design because of this capability of producing complete systems in one package. As an example, a recently introduced three digit multi-meter uses a single LSI MOS chip which contains all the analogue-to-digital conversion logic and display decoding required, all in a 16-pin dual in-line package.

#### STRUCTURE

Transistors of the MOS type have been around for some time now, and have appeared in many designs, in particular the "front ends" of communications receivers, and high impedance input stages for audio amplifiers. Readers will be more familiar with them as field effect transistors (f.e.t.).

Just as there are *pnp* and *npn* bipolar devices, so there are *p*-channel and *n*-channel f.e.t.s, but in this case there is a further division into "enhancement" and "depletion" modes of operation, giving four device types in all. MOS logic circuits generally employ *p*-channel enhancement mode devices, although there is a recent form which uses complementary (*p*- and *n*-channel) logic on the same chip. The difference between *p*- and *n*-channel devices will be obvious to most readers, but "enhancement" and "depletion" may call for some explanation.

Fig. 10 shows the operation of these two devices in diagrammatic form. F.e.t.s have three electrodes known as the source, the drain, and the gate, and in the MOSFET the aluminium deposition known



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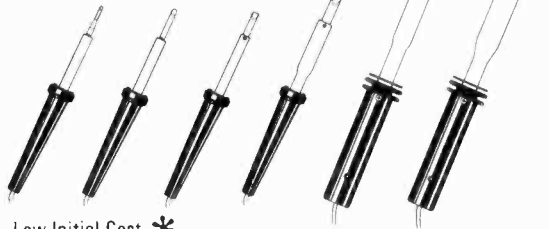
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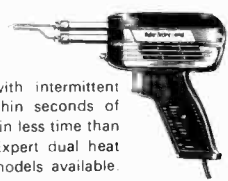
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1R5	0-28 30C17	0-80 DY86	0-28 EM81
185	0-21 30C18	0-87 DY87	0-28 EM84
1T4	0-18 30F3	0-78 EAC80	0-32 EM87
384	0-28 30FL1	0-83 EAF42	0-50 EY51
3V4	0-37 30FL12	0-72 EB91	0-11 EY86
5Y8GT	0-30 30FL14	0-72 EBC33	0-40 EZ40
5Z4G	0-37 30L1	0-32 EBC41	0-52 EZ41
6J0L2	0-58 30L15	0-85 EBC90	0-22 EZ80
6AL5	0-11 30L17	0-73 EBF80	0-33 EZ81
6AM6	0-13 30P4	0-65 EBF89	0-31 GZ32
6AQ5	0-26 30P12	0-77 ECG91	0-18 GZ34
6AT8	0-22 30P19	0-65 ECC82	0-23 K741
6AU6	0-22 30P11	0-83 ECC83	0-35 K761
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6F14	0-45 35Z4GT	0-25 ECH42	0-83 PAB30
6E23	0-73 807	0-45 ECH81	0-28 PC86
6E25	0-82 6053	0-88 ECH83	0-41 PC88
6K7G	0-12 AC/VP2	0-77 ECH84	0-37 PC89
6K8G	0-17 AZ31	0-47 ECL80	0-35 PC87
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6V5G	0-17 H729	0-82 ECL86	0-40 PC84
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10F13	0-60 DAF91	0-21 EY85	0-31 PCF801
12A7	0-25 DAF96	0-28 EL33	0-48 PCF802
12A7U	0-18 DF33	0-38 EY89	0-26 PCF80
12AU6	0-23 DF91	0-16 EY91	0-13 PCF82
12AU7	0-23 DF96	0-36 EY183	0-28 PCF82
12AX7	0-23 DH77	0-22 EY184	0-32 PCF800
19BG6G	0-87 DK32	0-47 EL90	0-42 PCF801
20F2	0-67 DK91	0-28 EL33	0-48 PCF802
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			0-78 UAF42
			0-51 OC170
			0-22 UBC31
			0-60 UBF80
			0-37 UBF89
			0-41 UCL84
			0-45 UCL84
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			0-72 OC81D
			0-12 OC71
			0-24 OC75
			0-12 OC75
			0-72 OC81
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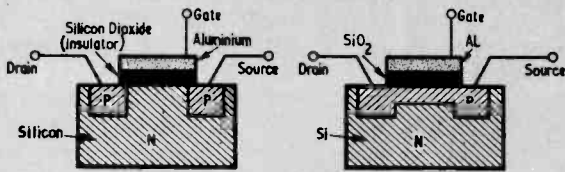


Fig. 10.1a. P-channel enhancement mode device

Fig. 10.1b. P-channel depletion mode device

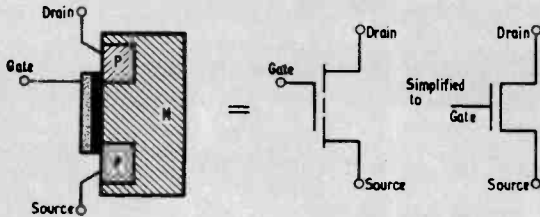


Fig. 10.2. Construction of the f.e.t. in MOS logic (left) with theoretically correct and simplified versions of the circuit symbol

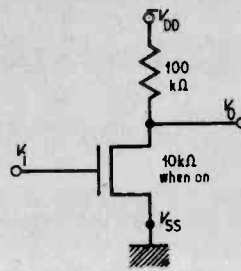


Fig. 10.3a. Logic inverter with discrete resistor as a load

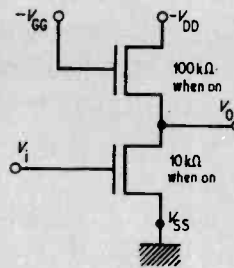


Fig. 10.3b. Using a MOS transistor in place of the resistive load

as the gate is insulated from the other sections of the device by a layer of silicon dioxide. There is therefore no d.c. current flow into or out of the gate, and the input impedance is extremely high, only the field set up by the gate voltage is used to modulate the current flow from source to drain.

When the gate voltage is such that there is a current flow between the other two terminals, a "channel" is said to exist between them. It is the type of bias necessary to form this channel which sets the difference between the enhancement and depletion devices.

### ENHANCEMENT MODE

In the enhancement mode a channel does not exist between source and drain until an appropriate gate bias is applied, whereas in the depletion mode a channel exists with zero gate bias, and a bias has to be applied to cut off current flow. In Fig. 10.1a, for example, the p-channel enhancement mode device requires a negative bias on the gate before it will form a channel, but in Fig. 10.1b the p-channel depletion mode device will have a channel unless the gate is biased positively.

Of these two types the enhancement device is more suited for use as a logic switch, because it is off until turned on by a negative bias from a previous stage.

Fig. 10.2 compares the construction of the f.e.t.s used in MOS logic with the correct circuit symbol and the simplified version usually employed for logic circuits.

### THRESHOLD VOLTAGE

The MOS device is commonly used in logic circuitry as a switch, and performs very well in this role. On resistance can be varied by the manufacturer by altering the geometry of the device, but is usually chosen to be about 10 kilohms, whereas off resistance is closer to the ideal open circuit than

can be approached with bipolar devices, and is typically  $10^{11}$  ohms.

Fig. 10.3a shows a single MOS used with a discrete resistor to form a logic inverter. As the gate voltage is increased negatively, a point is reached when the device resistance drops to the on value, reducing the output voltage to a low level, which would have the effect of turning off any following stage. The actual voltage at which an MOS turns on is referred to as the "threshold voltage", and it usually lies at about 3V. The threshold is not very abrupt, however, so this is only a nominal value.

Using conventional diffused silicon resistors in an MOS i.c. would unfortunately take up a great deal of space on the chip, losing the size advantage of the MOS active device. A diffused resistor such as is used in TTL circuits would in fact be about 1,000 times larger than a single MOS.

### MOS TRANSISTOR AS A LOAD

To sidestep this problem the arrangement in Fig. 10.3b is employed. Here another MOS transistor is used as a load resistor, only in this case the device geometry is chosen to give an on resistance of the required 100 kilohms. The gate of this load element can either be wired permanently to the  $-V_{DD}$  negative supply, holding the device permanently on, or all the gates of devices used for this purpose can be brought out to a  $-V_{GG}$  common line which is held at a voltage even more negative than  $-V_{DD}$ . This also has the effect of keeping the load on. A third alternative uses these devices as "clock-line" switches as we shall see later.

### BASIC GATE CIRCUITS

Because of the "ideal switch" characteristics of MOS, biasing problems, a feature of bipolar designs, do not arise. MOS devices are used almost as simply as relay contacts or toggle switches in gate circuits,

making them very simple to understand, once the initial unfamiliarity of the symbols is overcome.

Fig. 10.4 shows some examples of gates made with MOS alongside their relay equivalents. With this family there is no "standard" gate, both NOR and NAND logic are used as it suits the designer, though it is normal practice to define gates in the negative logic convention, unlike TTL. There really seems little need to explain the action of the gates in Figs. 10.4a and 10.4b; with the understanding of

an MOS transistor action and the relay version to refer to, readers will be able to work this out for themselves, with the knowledge of logic systems given earlier in this series.

Fig. 10.4c demonstrates how easy it is to expand MOS logic. Here two NAND gates are used in the wired-OR configuration, to generate the AND/OR/INVERT function. Interested readers may like to compare this very simple arrangement with the equivalent TTL circuitry.

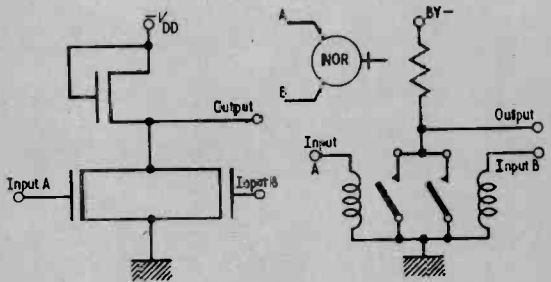


Fig. 10.4a. MOS NOR configuration

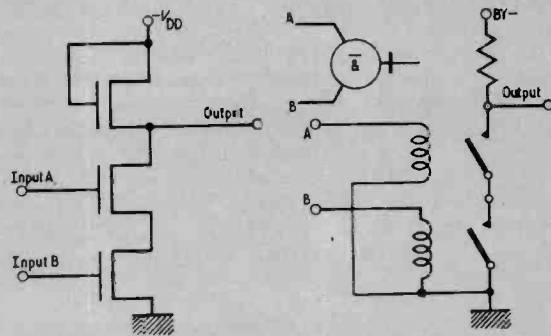


Fig. 10.4b. MOS NAND configuration

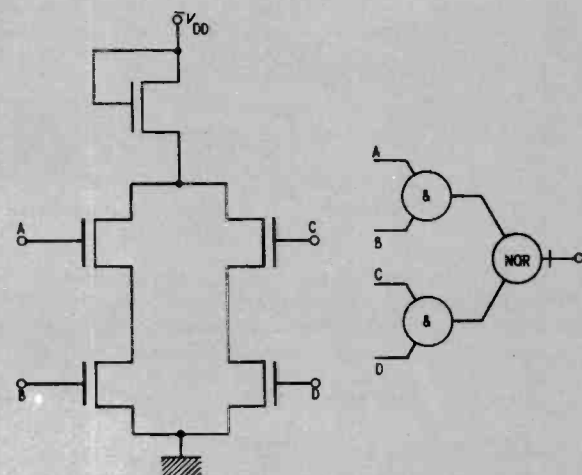


Fig. 10.4c. MOS wired-OR configuration (AND/OR/INVERT)

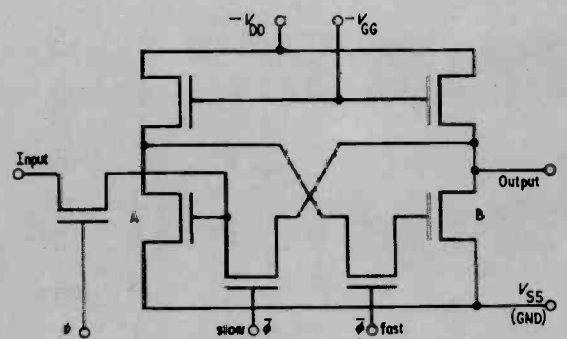


Fig. 10.5. Static shift register cell and clock waveforms

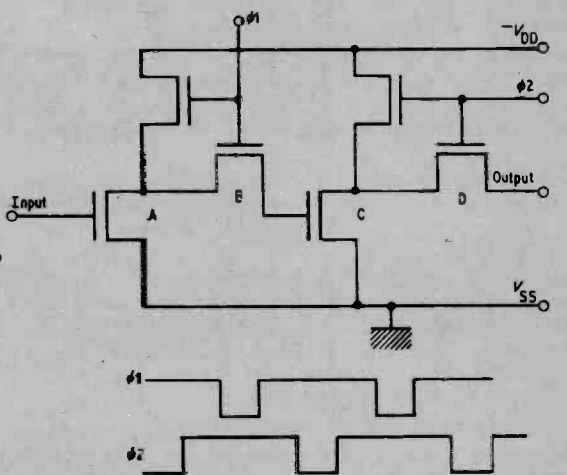
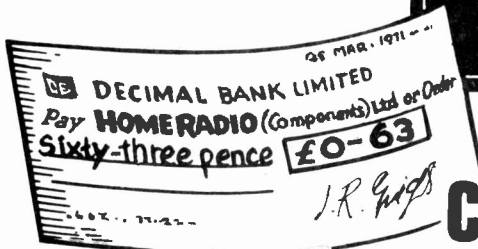


Fig. 10.6. Dynamic shift register cell and clock waveforms

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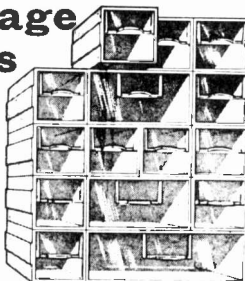
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C	1/2W	10%	4.7Ω-10MΩ	E12	1p	0.8p	0.7p
C	1/4W	5%	4.7Ω-10MΩ	E24	1.5p	1p	0.9p
C	1W	10%	4.7Ω-10MΩ	E12	2.5p	2.5p	1.9p
MO	1/4W	2%	10Ω-1MΩ	E24	4p	3.5p	3p
WW	1W	10% ± 1/20Ω	0.22Ω-3.9Ω	E12	7p	7p	6p
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## SHIFT REGISTERS

MOS is rarely used to build general purpose flip-flops such as the JK type, although a manufacturer's catalogue may contain a single device of this sort to enable a system to be built entirely of MOS. It is included for the sake of completeness, and it is unlikely that these devices could stand on their own merit for economic reasons.

As we have already seen, the strength of MOS lies in its ability to be produced in the LSI form, and this advantage is put to good use in the range of shift registers available. Shift registers in this family are mainly of the "serial-in/serial-out" type, and their operation may be either static or dynamic.

The static type of register uses more devices per stage than the dynamic type, but data is stored by means of cross-coupled flip-flops, and there is no minimum clock rate. Dynamic registers use the capacitor inherent in the gate construction to store data, and are not capable of storing information indefinitely as a result. A minimum clock frequency of about 1kHz at 25°C is common for these registers which are used in continuously circulating applications such as delay lines.

The unit storage cells in both types of register bear little or no relation to the circuitry employed in any of the bipolar logic forms.

## STATIC REGISTER

The emphasis in MOS is on simplicity at the expense of clock circuit complexity. Fig. 10.5 shows the circuit used for a static register cell; the cross coupled flip-flop configuration is immediately apparent.

In all, three separate clock waveforms are necessary to operate this circuit, although in an LSI chip it is usual to have a circuit which generates all these from a single external timing waveform. The  $\phi$  clock corresponds to the external waveform and  $\bar{\phi}$  fast is the  $\phi$  clock inverted,  $\bar{\phi}$  slow comes on sometime after  $\phi$  fast, and usually, although not necessarily, ends before it. Fig. 10.5 shows some typical waveforms.

A negative logic level would be transferred from the input to the gate of device A when  $\phi$  comes on, and this would turn on A, pulling its output to ground. As soon as  $\phi$  goes off,  $\bar{\phi}$  fast comes on and transfers the ground on the output of A to the gate of B which starts to turn off. During this operation  $\bar{\phi}$  slow comes on and the rising negative at the output of B is transferred to the gate of A, holding it on. If the clock is stopped with  $\phi$  off (and hence  $\bar{\phi}$  fast and  $\bar{\phi}$  slow on) data can be stored indefinitely.

The gate of an MOS transistor can be considered to be a capacitor, the insulating silicon dioxide layer acting as the dielectric, and the aluminium and silicon acting as the plates. This capacitor is of very low value, perhaps 0.5pF, but because of the extremely high input impedance of an MOS device any charge stored on this gate capacitor will take quite a long time to leak away. (Remember that time constant equals C times R.)

## DYNAMIC REGISTER

In the dynamic register this effect is used to store digital information, but because the charge will eventually leak away in any event, it is necessary

to quote a minimum clock frequency which is temperature dependent.

Fig. 10.6 shows the circuit of one cell of a dynamic register, and as can be seen there is no cross-coupled flip-flop, only two gated inverters. The load MOS devices are used as switches controlled by the clock, and further devices gate information between stages. The clock waveforms  $\phi 1$  and  $\phi 2$  are in antiphase and must not overlap.

Assuming a negative input to the cell shown, this will be stored on the gate of device A, and will turn it on as soon as the  $\phi 1$  clock comes on. While  $\phi 1$  is present, the output of A will be pulled to ground, and this level will be gated through B to C, the gate capacitor of which will now hold a "ground" charge.

With no negative stored on its gate, C will not turn on when its load is enabled by  $\phi 2$ , and the output gated through D will be the negative we started with delayed by one clock period.

Dynamic registers may seem pretty useless at a first glance because they cannot stand still and must keep their contents moving, but in fact there are many occasions when this is not a disadvantage.

When this is so the dynamic register has several points in its favour. First, it is about twice as fast in operation than the static type; secondly, because the loads are clocked, at low frequencies the power consumption of each cell is extremely low, typically 10 microwatts at 10kHz. This last feature is due to the fact that power is only dissipated when the gate capacitors are charged, which makes the power consumption frequency dependent. At 1MHz a power drain of 1 milliwatt per bit is common.

## APPLICATIONS

MOS circuits are still in their infancy, but are certain to be one of the most important advances ever to be made in the world of data processing and allied fields. Their biggest impact will be in the consumer area, and it will not be long before our homes will have the benefit of a "domestic" computer made possible by the advent of cheap MOS LSI.

A home computer could become adaptable to the telephone (which has push button dialling) so that by ringing our own number from a remote call box, and then dialling a coded message, we could instruct the computer to cook the dinner or turn on the central heating. At work the desk calculator could replace the slide rule, giving answers to all arithmetic problems at the touch of a few keys, and electronic digital test equipment such as frequency counters and digital voltmeters will shrink to pocket size.

On the way home in our car, exhaust emission will be nullified by electronic fuel injection, and the wheels will be unable to lock and skid because of another electronic system. Relaxing in our home we will be able to programme the hi fi system to soothe us in any way we fancy without leaving our armchair or sorting through piles of records.

All these things are possible now, but it will be MOS which makes them economically viable for the many.

## AVAILABLE MOS I.C.'s

Many readers may be hoping for some MOS circuits which are available to do a practical job in

amateur projects right now. Talk of dual 100-bit shift registers in a TO-5 can will, perhaps, only interest those who like to build, or dream about, the amateur built computers of the future.

MOS circuits of simple nature are beginning to appear, and, as an example, look at a couple of Marconi-Elliott i.c.s which are intended for use in electronic organs, the MA60 and the MA70. These two devices are housed in TO-5 cans and operate from -26V. Inputs and outputs are compatible with DTL and TTL.

The MA60 contains six binary dividers arranged as two chains of three, each chain has three outputs, divide-by-two, four, and eight. If the two chains are used in series, a total division of 64 is obtained. The MA60 is shown in Fig. 10.7.

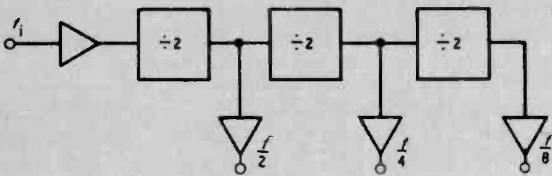


Fig. 10.7. Block diagram of the MA60 i.c. divider

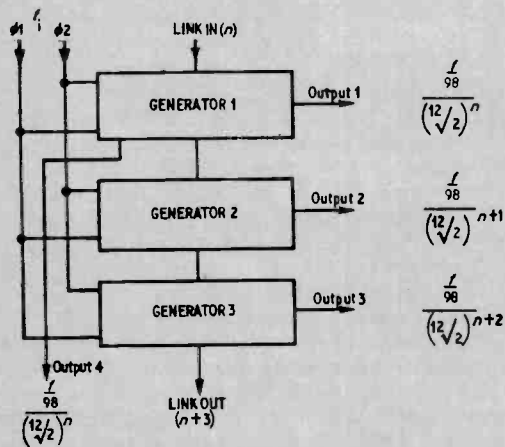


Fig. 10.8. Block diagram of the MA70 i.c. divider

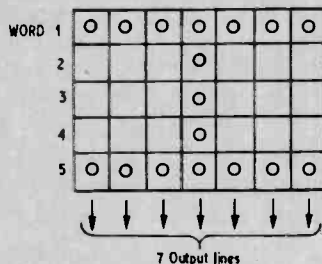


Fig. 10.9. Display programme for one character (letter H) of the Texas read-only memory

The MA70 is rather more complex than the previous device and is intended to produce three separate semitones from a single oscillator. MA70 can be cascaded if required, and when used in conjunction with the MA60 they enable complex organs to be built on a single p.c.b. The block diagram is given in Fig. 10.8.

These are circuits available to amateurs, and they do give a hint of MOS capabilities, but to get a glimpse of advanced applications, it is necessary to return to computer and process control electronics which are finding that MOS memories are becoming increasingly attractive.

## COMPUTER MEMORY CIRCUITS

In the past the main memory in a computer has been built using ferrite core matrices, or core stores. This type of memory is of the "random access" type, as it is possible to address any location and read or write into it immediately.

Another type of memory used is the magnetic drum, which provides bulk storage but which is rather slower to address because the revolving drum may have to make a complete revolution before the correct data location is available.

Some memories are programmed during manufacture by the wiring in of diodes where data is required, these are used as fixed programmes to control computer sub-routines, or sometimes as "tables" to store constants. These memories are of the "read-only" type, and cannot be written into.

MOS LSI techniques are now being used to simulate all three of these memory systems, and the solid state versions are proving to be superior on many counts. As an example, the Texas TMS-2A-4824-MH read-only memory contains 2,240 bits of data which are programmed during manufacture to provide the information necessary to produce 64 alphabetical and numerical characters on a c.r.t. display.

Each character is stored as five seven-bit words which are used to modulate a dot matrix on the tube face. Fig. 10.9 shows how one of the characters is stored and formed. When a particular dot location has to be brightened up on the display a "one" is stored in the memory, each dot position is displayed in sequence, and the information to be displayed is used to address the correct character location.

This type of circuit can also be programmed to customer requirements to contain any information required, a set of sine tables for example, or a sequence programme for an industrial machine.

## DEVELOPMENTS

MOS technology is being continuously improved, and these improvements are making this type of circuit ever more easy to use.

"Silicon gate" MOS devices are now being made with threshold voltages low enough so that they can be driven directly from bipolar logic, without the need for the voltage interface circuits that were necessary with the earlier types. The silicon gate technique uses polycrystalline silicon instead of aluminium for the gate electrode, and apart from giving lower threshold voltages, this also reduces the capacitance inherent in the construction and allows higher operating speeds.



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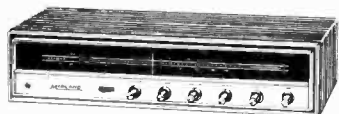
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Function	AM, FM, FM Stereo, Phono (Stereo indicator light)	AM, FM, FM Stereo, Ceramic, Magnetic, Aux.
Size	15" 8 1/2" 3 1/2"	16 1/2" 9 1/2" 3 1/2"
PRICE	<b>£30.45</b> Carr. & Ins. 50p	<b>£44</b> Carr. & Ins. 50p



MODEL 19-520



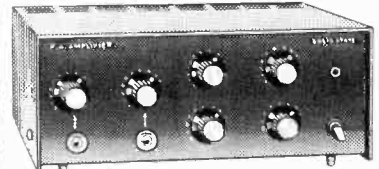
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The latest introduction to the MOS field is a processing system which uses low temperature doping by bombardment with ions. This process is rather complex and expensive at present but it produces circuits which will operate at the same sort of speed as TTL, a great improvement.

### PRACTICAL POINTS

MOS devices come in a wide range of package outlines, especially the more complex circuits which require large numbers of pins. Hermetically sealed packages are almost universally used, because the normal MOS chip needs to be well protected from contamination, and this rules out the simple plastic

d.i.l. packages. The TO-5 can is very popular because this style can provide enough pins, and for the more complex devices a type of ceramic d.i.l. package, or a flatpack is employed.

### PRECAUTIONS WHEN HANDLING

Because of the extremely high input impedance of the MOS, it is possible for a static charge on the gate to exceed the breakdown voltage of about 60V, and so short out the silicon dioxide layer and ruin the device. Some circuits use protective Zener diodes to prevent this, but it is advisable to be sure by consulting the data sheet. Leakage from an un-earthed soldering iron could provide the minute current necessary to destroy a device. It is often recommended that pins should be shorted together whilst in store, to prevent static build up.

### Next month: Emitter Coupled Logic (ECL)



ONE OF the extra pleasures for the electronics enthusiast going abroad is the chance to observe the effect of electronics on daily life abroad, particularly if one can stay for any length of time in a foreign household. This I was privileged to do recently—just over the channel.

It is very interesting to see high-definition French television on 819 or 625 lines and note the clarity and excellence of the picture as well as the fact that the French programme directors are as hard put as ours to fill the screen with sixty minutes of excellence per hour.

It was interesting for me to meet two French clergymen-schoolmasters, who are fervent radio amateurs, and to visit their "shacks" from where they work the world on 2 metres. Incidentally, I did not know before that for this amateur band the French authorities do not require proficiency in morse; merely the equivalent of the City & Guilds written examination.

### APPLIED ELECTRONICS

In the line of applied electronics the Continentals are not slow to make use of the automation made possible by modern techniques. It is probably now well known that in the Renault factories most of the production of major parts, such as the boring of engine cylinder blocks, is performed and controlled by electronically based automative processes.

At the other end of the scale I recently noticed a most effective use for the light-controlled relay that has done so much to automate town-lighting systems, lift doors, car parking lights and the rest. I went into the "Messieurs" in a newly completed and finely appointed hotel in Montreux, Switzerland

and, on approaching the sanitary porcelain, noticed, coming from a metal panel in the wall, the unmistakable "clack" of a well fed relay slamming shut. The noise coincided with a flush of clean water where it would do most good. On looking down, I noticed that my calves had interrupted a light beam aimed at a photo-cell in the side wall and, presumably, the relay thus activated had turned on a plunger-tap

### GAS LIGHTER

Another gadget I noticed in three separate French households I stayed in this year was a new form of gas lighter, driven direct from the mains. The lighter looks like a small, six inch long, plastic torch, with a perforated brass cap where the light bulb should be and a press-button switch on one side. When Madame wishes to light the gas ring, she takes this little "torch", applies the perforated head to the burner and presses the button. The lighter produces a noise like a rattle-snake and a bright spark inside the head immediately lights the gas.

Enquiries in two households as to how this device worked drew shrugs, no solid information, and no enthusiasm in response to my wish to take it to pieces. Finally, in the third family I met sympathy—from the clergyman ham, who affirmed that it worked like an electric bell, but was dissuaded from dismantling it there and then by his sister, who kept house for him. However, I was later able to obtain such a lighter, and no sooner had I returned to my home den than I took it to pieces and found that it does, indeed, work like an electric bell, as my friend had said.

The d.c. resistance of the coil in the specimen examined was 150 ohms, wound from 42 s.w.g. wire. At 230 volt mains a current of about 1.5 amp is broken at the contact bosses and for such slender wire, the sheer temerity of the concept might at first appear alarming. It must be remembered, however, that with such a healthy spark the gas is lit immediately, so that the button switch is released after a few seconds and no fuses blow.

Anyway, these lighters are in use in thousands of French homes, are on general sale at the equivalent of approximately 37 $\frac{1}{2}$ p each and their construction must therefore be presumed to have the approval of Electricité de France, the central electricity authority of France. ★



# BOOK REVIEWS

## TAPE RECORDERS

H. W. Hellyer  
Published by Fountain Press  
239 pages, 8½ in × 5½ in. Price £2.25 (45s)

WRITTEN by the author of the Tape Recorder Servicing Manual, this, in like vein, is an essentially practical book that sets out to educate the reader painlessly into tape recorder techniques and simple maintenance.

From an opening chapter sketching the birth, development and growth prospects, the author embarks on a very readable breakdown on machine principles, naming of parts and functions, all being punctuated with some valuable workshop observations.

Guidelines to recorder and microphone choice will no doubt appeal to prospective buyers although it seems the yardstick axiom of "You only get what you pay for" must eternally prevail.

Chapters on maintenance for both tape and deck are very well illustrated. A final chapter on tests and measurements embraces choice of service equipment, bench tips and typical measurement hook-ups for determining wow and flutter, distortion levels and signal to noise ratios, etc.

All in all, a must for any user of tape recorders, as it affords a useful reference that is very easily dipped into. G.G.

## FOUNDATIONS OF WIRELESS AND ELECTRONICS Eighth edition

By M. G. Scroggie B.Sc., C.Eng., F.I.E.E.  
Published by Iliffe Books  
521 pages, 8½ in × 5½ in. Price £3 (60s)

THERE must be thousands who have built their hobby, or even their career, upon Mr. M. G. Scroggie's "Foundations". First published in 1936, this well known work has re-appeared in new editions from time to time. The present edition, the eighth, is noteworthy for the addition of "electronics" to the title. This is justified by the inclusion of two new chapters providing brief but useful accounts of such subjects as waveform generators and computers.

Apart from this extension of its range, the general character and arrangement of the book has not changed over much, and wireless transmission and reception remains the dominant theme. But much of the material has been completely re-written, and semi-conductors have now nearly, but not entirely, ousted thermionic valves.

Those not already familiar with Mr. Scroggie's classic can be assured that no previous knowledge of radio or electronics is assumed. The text excels in clarity and exposition, and there is little demand upon mathematics. Starting with first principles of electricity and circuit elements, the book proceeds to electronic devices, both thermionic and semiconductor, and explains their function in straightforward descriptive terms. Only in chapter 12 does the going become tough (as the author warns the reader) when transistor and valve equivalent circuits are evolved. Full understanding of this chapter is not, however, vital at the elementary stage.

The application of all the foregoing principles is demonstrated with stage by stage description of the various processes involved in a radio communications system. The principles of cathode ray tubes, television and radar are also outlined.

The two new chapters provide a sound, concise introduction to the many other uses of electronics which stem mainly from pulse switching techniques, as distinct from the generation, detection, and amplification of sinusoidal signals. F.E.B.

## RADIO VALVE AND TRANSISTOR DATA

Compiled by A. M. Ball  
Published by Butterworth & Co. Ltd.  
232 pages, 10½ in × 8½ in. Price £0.75 (15s)

SUBSTANTIALLY revised and added to, this is the ninth edition of a very popular reference on valve and semiconductor electrical characteristics.

Additions to the previous contents list are colour tubes, f.e.t.s, tunnel diodes and i.c.s, the latter including both digital and linear references.

Full marks must be given for the choice of a larger type face in the data presentation. This has meant, inevitably, some considerable pruning in obsolete device information, so don't just throw away that older edition as it will prove to be a valuable complement.

I suppose that in a work of this nature, errors can occur, but those that I found are inexcusable.

In the Amplifier Triodes section, the headings  $g_m$  and  $r_a$  should be transposed. The data for the PCC89 given in the Mullard Valve Data Book includes the description "Variable-mu frame-grid double triode".

In the Integrated Circuits section, the pin layout diagrams (p.199) do not include identification of mode connections. If one has to refer to manufacturers' data for this, then there was little point in including the technical data. It should also be made clear which view is shown in the drawings.

Finally, it would be very much easier to locate transistor types on the data pages if some semblance of alphabetical order were adopted. G.G.

## BEGINNERS GUIDE TO RADIO Seventh Edition

By Gordon J. King  
Published by Newnes-Butterworths  
194 pages, 7½ in × 5 in. Price £1

THIS book is an updated version of an original of the same title by F. J. Camm, it is not just a rewrite in parts but a completely new book. The author's explanations of the basic principles are excellent and this book would prove useful to all studying electronics as well as basic radio. It is unfortunate that most of the work is based on valve theory and practice, however the radio principles are unaffected by this and there is a useful section on transistor theory and function and some transistor circuits are given and described in the text.

Sections 11 and 12 are concerned with "Disc Record Players and Radiograms" and "Hi-Fi Reproduction". Although these items may seem rather out of context under the title of this book they are both worthwhile sections describing the principles involved and giving block diagrams of the systems.

A selection of circuit symbols is given at the front of the book together with a brief description of each and lists of abbreviations and a wavelength/frequency conversion table are given at the back. Also included is an index of words and terms described in the text. M.K.

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### LOW TORQUE HYSTERESIS MOTOR MA23

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### SYNCHRONOUS MOTORS

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Miniature resin encapsulated module. Total delay 50nsec to 10µsec. Tapped at 10% intervals. Impedance 75 ohms to 10 k.Ω. 30V wkg. Attenuation 0.5 dB/µsec. 2 1/2 in x 1 1/2 in x 2 1/2 in. **£1.50.** Post free.

### BATTERY OPERATED TRANSISTOR TESTER

Battery powered for checking leakage current and gain of P.N.P. transistors, meter and audio indication. Siemens Erlawan Type R2925. W. 7 1/2 in, H. 4 1/2 in, D. 2 in. **£5.50.** Post free.

### MEMORY CORE STORES

42 x 22. 2kΩ bit ferrite core store. C/W quantity OAI0 load diodes. Ideal for building computer stores, holding information, teaching experiments, demonstrations, etc. Price **£2.25.** P. & P. 38p.

### NEW ENICRON SHADED POLE MOTORS

240/250V, 50Hz, 2,500 r.p.m. (no load). Shaft 1/2 in dia, x 1 1/2 in long. Suitable record player, blower motor, etc. **65p.** Post free.

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230V, 50Hz, 0.65A, 1/20 h.p., 2,850 r.p.m. Cont. rated. Shaft 1/2 in dia, x 2 1/2 in long. Circular clamp mounting. **£3.50.** Post free.

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Model 48A complete with voltage multiplier for 480V and 3600V. Current shunts for 120A and 480A. A.C. Current transformer for 20A and 60A. In special wooden box. 47A and 48A are Admiralty patterns of the model 40. **£16.75.** P. & P. 75p.

### RESET TIMERS — ACRO TIMER BY HAYDON

Synchronous motor driven timer providing manual adjusted delay. Delay time is set on graduated dial. Press button closes contact and drives motor which drives an arm until it actuates the load switch. The arm then returns to initial position for repeat action. Various ranges available. 230V 50Hz. Load contacts 1.5A 230V. **£5.**

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Instruments by Smiths. Incorporating 4 mechanically selected ranges of 500, 1,000, 5,000 and 50,000 r.p.m. Within 2% accuracy, supplied with accessories and carrying cases. A neat and compact instrument. Bargain at **£19.50.** P. & P. 25p.

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By Sangamo Weston, suitable for D.C. circuit. A high sensitivity relay more sensitive than the electromagnetic type. Single Coil Resistance 310 micro amps. 315Ω. List price **£4.50.** Our price **£1.15.**

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Totalising 240V 50Hz. Viewing window 2 1/2 x 2 1/2 in. Ex-equipment. Price **£2.75.** P. & P. 25p.

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### BERKELEY DECIMAL COUNTING UNIT 0-9

Direct reading octal base plug in unit electronic counter. The number counts received is indicated by one of ten neon lamps behind acetate panel. The unit counts from 0-9, the tenth pulse resetting to zero and simultaneously generating an o/p signal. Circuits can be connected in cascade. Power supply 6.3V d.c. Cut on/Cut off 15V. Price **£3.50** p. & p. free.

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Operates on a rear projection 6.3V pilot lamp. Character size 1/2 in high. 0-9 digits with 0-9 symbol, i.e. (4'). Dimensions 1 in wide, 3/2 in deep, 1 1/2 in high. List price 6 gns. Our price **£2.73.**

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Uses a sensitive moving coil movement to project digits 0-9 on to a viewing screen via an optical lens system. Image height 1/2 in. Lamp 6.3V. Sensitivity 250 micro-amp Dimensions L. 4 1/2 in, W. 2 1/2 in, H. 1 1/2 in. Price **£3.50.** P. & P. 25p.

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Models 40, 47A, 48A. (Models 47A and 48A are Admiralty pattern.) D.C. volts: 0-12, 1.2, 12, 120, 480, 1,200. A.C. volts: 12, 120, 480, 1,200. Amps: 0-0.12, 0-1.2, 1.2, 12. Ohms: 1,000, 10,000. Ohms/Volt when divided by two button is pressed on both a.c. and d.c. ranges. **£18.** P. & P. 75p. Complete with voltage multiplier for 480V and 3,600V. Current shunts for 120A and 480A. A.C. current transformer for 20A and 60A. In special wooden box. **£18.50.** P. & P. £1.

Due to demand it may not always be possible to supply a particular model, and a different type to that ordered may be dispatched. These models are electrically identical.

### STOCK CLEARANCE

All items are sold in as seen condition. **CREED MORSE RECEIVERS.** Model 7B. **£15.** Carriage £3. **OSCILLOSCOPE COSSOR 1038.** £10. Carriage £3. **OSCILLOSCOPE EMI TYPE WM3 PORTABLE.** £15. Carriage £2. **VALVE VOLTMETER.** Fuzehil 3781B/2. 1mV, 5 ranges. **£3.50.** Post free. **UHF SIGNAL GENERATOR.** RCA Type 710-A, I/P 117V, 60Hz, 50W. 370-560 MHz modulation. Carrier (metered) scaled O/P. **£15.** Carriage £1. **VALVE VOLTMETER.** Marconi FT248, a.c./d.c. 5 ranges 1.5V. **£3.** Carriage **£1.50.**

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XN3A	6m/m Lead	(Clear)
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XN23/FA	38m/m Lead	(Amber)
1-3	£1.15 each	
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Electro-Methods Models 901 and 906PL. Permanent magnet d.c. motor. High sensitivity. Ideal for instrument-type servo mechanisms, light loads, driving mechanical counters performing integration, or as small power generators. Will operate directly off a photo-cell or thermocouple, etc. Nominal typical parameter. Starting voltage (no load) 10mV at 0.375mA. Full load speed 1,845 r.p.m. (approx.). Moment of inertia of armature 1.8g. cm/cm. Weight of Motor 300g. (approx.). **£15.** P. & P. included.

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# Sinclair Project 60



the world's most advanced high fidelity modules

**Sinclair Project 60** presents high fidelity in such a way that it meets every requirement of performance, design, quality and value and now that the remarkable phase lock loop stereo FM tuner is available, it becomes the most versatile of high fidelity systems. With Project 60, it is possible to start with a

modest mono record reproducer and expand it to a sophisticated stereophonic radio and record reproducing system of fantastically good quality to hold its own with any other equipment, no matter how expensive. Project 60 is a unique high fidelity module system where compactness and ease of assembly are combined with

circuitry that is far in advance of any other manufacturer in the world. Thus it is extraordinarily easy to assemble any combination of modules using nothing more complicated than the simplest of tools, and you certainly do not have to be experienced to build with complete confidence. The 48 page manual free with Project 60 equipment makes everything easy and you can house your assembly in an existing cabinet, motor plinth, free standing cabinet or virtually any arrangement you wish. Once you have completed your assembly you will have superlatively good equipment to give you years of service and enjoyment. You will have obtained superb value for money because Project 60 is the best selling modular system in Europe and can therefore be produced at extremely competitive prices and with excellent quality control.

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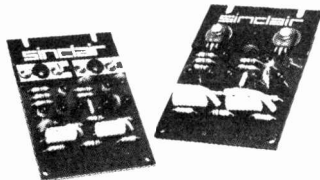
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System	The Units to use	together with	Cost of Units
A Simple battery record player	<b>Z.30</b>	Crystal P.U., 12V battery volume control	<b>£4.48</b>
B Mains powered record player	<b>Z.30, PZ.5</b>	Crystal or ceramic P.U. volume control etc.	<b>£9.45</b>
C 20+20 W. R.M.S. stereo amplifier for most needs	<b>2 x Z.30s, Stereo 60, PZ.5</b>	Crystal, ceramic or mag. P.U., most dynamic speakers, F.M. tuner etc.	<b>£23.90</b>
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F Outdoor P.A. system	<b>Z.50</b>	Mic., up to 4 P.A. speakers controls, etc.	<b>£5.48</b>
G Indoor P.A.	<b>Z.50, PZ.8, mains transformer</b>	Mic., guitar, speakers, etc., controls	<b>£19.43</b>
H High pass and low pass filters	<b>A.F.U.</b>	C, D or E	<b>£5.98</b>
J Radio	<b>Stereo F.M. Tuner</b>	C, D or E	<b>£25.00</b>



# Sinclair Project 60

## Z.30 & Z.50 power amplifiers



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

**SPECIFICATIONS (Z50 units are interchangeable with Z.30s in all applications).**  
**Power Outputs**

Z.30 15 watts R.M.S. into 8 ohms using 35 volts;  
 20 watts R.M.S. into 3 ohms using 30 volts.

Z.50 40 watts R.M.S. into 3 ohms using 40 volts;  
 30 watts R.M.S. into 8 ohms, using 50 volts.

**Frequency response:** 30 to 300 000 Hz  $\pm$  1dB.

**Distortion:** 0.02% into 8 ohms.

**Signal to noise ratio:** better than 70dB un-weighted.

**Input sensitivity:** 250mV into 100 Kohms.

For speakers from 3 to 15 ohms impedance.

Size  $3\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{2}$  in.

Z.30

Built, tested and guaranteed with circuits and instructions manual

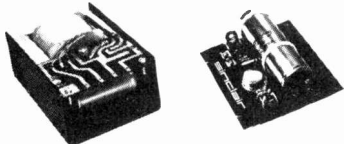
**£4.48**

Z.50

Built, tested and guaranteed with circuits and instructions manual.

**£5.48**

## Power Supply Units



Designed specially for use with the Project 60 system of your choice.

Illustration shows PZ.5 to left and PZ.8 (for use with Z.50s) to the right. Use PZ.5 for normal Z.30 assemblies and PZ.6 where a stabilised supply is essential.

**PZ-5 30 volts un-stabilised £4.98**

**PZ-6 35 volts stabilised £7.98**

**PZ-8 45 volts stabilised**

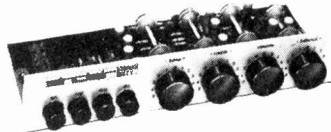
(less mains transformer) **£7.98**

**PZ-8 mains transformer £5.98**

## Guarantee

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

## Stereo 60 pre-amp/control unit



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

### SPECIFICATIONS

**Input sensitivities:** Radio—up to 3mV. Mag. p.u. 3mV; correct to R.I.A.A. curve  $\pm$  1dB; 20 to 25,000 Hz. Ceramic p.u.—up to 3mV; Aux—up to 3mV.

**Output:** 250mV

**Signal-to-noise ratio:** better than 70dB.

**Channel matching:** within 1dB.

**Tone controls:** TREBLE + 15 to -15dB at 10KHz; BASS + 15 to -15dB at 100Hz.

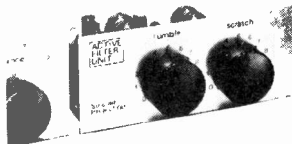
**Front panel:** brushed aluminium with black knobs and controls.

**Size:**  $8\frac{1}{2} \times 1\frac{1}{2} \times 4$  in.

Built, tested and guaranteed.

**£9.98**

## Active Filter Unit



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

Built, tested and guaranteed

**£5.98**

## Stereo FM Tuner



### first in the world to use the phase lock loop principle

Before production of this tuner, the phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio over other systems. Now, for the first time, the principle has been applied to an FM tuner with fantastically good results. Other original features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stereo decoder and squelch circuit for silent tuning between stations. Sensitivity is such that good reception becomes possible in difficult areas. Foreign stations can be tuned in suitable conditions and often a few inches of wire are enough for an aerial. In terms of a high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically as the tuning control is rotated, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with any other high fidelity system.

### SPECIFICATIONS:

**Number of transistors:** 16 plus 20 in I.C.

**Tuning range:** 87.5 to 108 MHz

**Capture ratio:** 1.5dB

**Sensitivity:** 2 $\mu$ V for 30dB quieting; 7 $\mu$ V for full limiting.

**Squelch level:** 20 $\mu$ V.

**A.F.C. range:**  $\pm$  200 KHz

**Signal to noise ratio:** >65dB

**Audio frequency response:** 10Hz—15KHz ( $\pm$ 1dB)

**Total harmonic distortion:** 0.15% for 30% modulation

**Stereo decoder operating level:** 2 $\mu$ V

**Pilot tone suppression:** 30dB

**Cross talk:** 40dB

**I.F. frequency:** 10.7 MHz

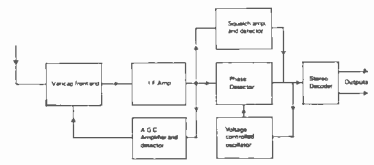
**Output voltage:** 2 x 150mV R.M.S.

**Aerial impedance:** 75 Ohms

**Indicators:** Mains on; Stereo on; tuning indicator

**Operating voltage:** 25-30 VDC

**Size:** 3.6 x 1.6 x 8.15 inches; 91.5 x 40 x 207 mm



Price: **£25** built and tested. Post free

To: SINCLAIR RADIONICS LTD LONDON ROAD ST. IVES HUNTINGDONSHIRE PE17 4HJ

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# Sinclair IC10/Q16/Micromatic

## IC10



### The world's most advanced high fidelity amplifier

This is the world's first monolithic integrated circuit high fidelity power amplifier and pre-amplifier. The circuit itself is a chip of silicon only a twentieth of an inch square by one hundredth of an inch thick, having 5 watts RMS output (10 watts peak). It contains 13 transistors (including two power types), 2 diodes, 1 zener diode and 18 resistors, and is encapsulated in a solid plastic package which holds the metal heat sink and connecting pins. This exciting device is more rugged and has considerable performance advantages, including complete freedom from thermal runaway and a very low level of distortion. The IC10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of such components as tone and volume controls and a battery or mains power supply. It may also be used in other applications including car radios, electronic organs, servo amplifiers (it is dc coupled throughout) etc.

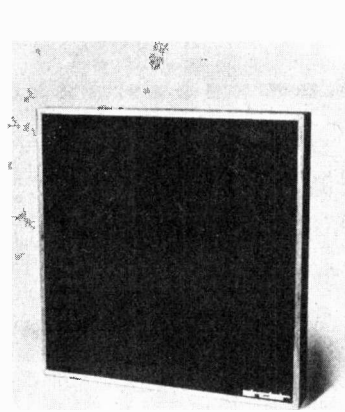
### Circuit Description

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. There is generous negative feedback round both sections and the amplifier is completely free from crossover distortion at all supply voltages, making battery operation eminently satisfactory. Each IC10 is sold with a comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include oscillators, etc. The pre-amp section can be used as an RF or IF, amplifier without any additional transistors.

### Specifications:

Output: 10 watts peak, 5 watts RMS continuous  
 Frequency response: 5Hz to 100kHz  $1 \pm$  dB.  
 Total harmonic distortion: Less than 1% at full output.  
 Load impedance: 3 to 15 ohms.  
 Power gain: 110 dB (100,000,000,000 times) total.  
 Supply voltage: 8 to 18 volts. (A Sinclair power unit, PZ.7 is available for mains operation).  
 Size: 1 x 0.4 x 0.2 in. plus heat sink and tags.  
 Sensitivity: 5 mV.  
 Input impedance: Adjustable externally up to 2.5 Mohms.  
 Price (with manual) **59/6** (£2.97½) post free.

## Q16



### High fidelity loudspeaker

The Q16 employs the well proven acoustic principles specially developed by Sinclair in which a special driver assembly is meticulously matched to the characteristics of the uniquely designed cabinet. In reviewing this exclusive Sinclair design, technical journals have justly compared the Q16 with much more expensive loudspeakers. Its shape enables the Q16 to be positioned and matched to its environment to much better effect than is the case with conventionally styled enclosures. A solid teak surround with a special all-over cellular foam front is used as much for appearance as its ability to pass all audio frequencies.

This elegantly designed shelf mounting speaker brings genuine high fidelity within reach of every music lover.

### Specifications:

Construction: Special sealed seamless sound or pressure chamber with internal baffle.  
 Loading: up to 14 watts TMS.  
 Input impedance: 8 ohms.  
 Frequency response: From 60 to 16,000 Hz, confirmed by independently plotted B and K curve.  
 Driver unit: Special high compliance unit having massive ceramic magnet of 11,000 gauss, aluminium speech coil and a special cone suspension for excellent transient response.  
 Size and styling: 9½ in square on face x 4½ in. deep with neat pedestal base. Black all-over cellular foam front with natural solid teak surround.  
 Price **£8.19.6**. (£8.97½).

## Micromatic



### Britain's smallest radio

Considerably smaller than an ordinary box of matches, this is a multi-stage AM receiver brilliantly designed to provide remarkable standards of selectivity, power and quality for its size. Powerful AGC counteracts fading from distant stations; bandspread at higher frequencies makes reception of Radio 1 easy. The plug-in magnetic earpiece provided matches the Micromatic's output to give wonderful standards of reproduction. Everything including the special ferrite rod aerial and batteries is contained within the minute and attractively designed case. Whether you build a Micromatic kit or buy this amazing receiver ready built and tested, you will find it as easy to take with you as your wrist watch, and dependable under the severest listening conditions.

### Specifications:

Size: 36 x 33 x 13 mm ( $1\frac{1}{5} \times 1\frac{3}{10} \times \frac{1}{2}$  in.)  
 Weight: including batteries, 28.4 gm (1 oz.).  
 Case: Black plastic with anodised aluminium front panel and spun aluminium dial.  
 Tuning: medium wave band with bandspread at higher frequencies. (550 to 1,600 Hz).  
 Earpiece: Magnetic type.  
 On/off switching: By inserting and withdrawing earpiece plug.  
 Kit in pack with earpiece, case, instructions and solder **49/6** (£2.47½).  
 Ready built, tested and guaranteed, with earpiece **59/6** (£2.97½).  
 Two Mallory Mercury batteries type RM675 required. From radio shops, chemists, etc.

To: SINCLAIR RADIONICS LTD LONDON ROAD ST. IVES HUNTINGDONSHIRE PE17 4HJ

Please send \_\_\_\_\_

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5 transistor amplifier complete with volume control, is suitable for 8V d.c. and a.e. supplies. Will give about 1W at 8 ohm output. With high I.M.P. input this amplifier will work as a record player, baby alarm, etc., amplifier.

plus 12½p P. & P.

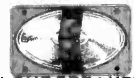


**ACOS STETHOSET.** 200 ohm d.c. Res. stetho- set complete with 5ft. of wire. Ideal for private listening on radio and tape recorder. These stethosets are made to very high standards, they are used but in good condition and are all guaranteed. Well below original Price at 30p plus 7½p P. & P.



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**EMI LOUDSPEAKER 450**  
10W 13in x 8in — two 2½in tweeters and cross-over. All wired and ready for use. This ever-popular 450 in 3-8-15 ohm imp. **£3-25** plus 37½p P. & P. each.

### PSYCHEDELIC LIGHT CONTROL UNIT

Three Channel: Bass—Middle—Treble. 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 600W lamps to the output terminals of the unit, and you produce a fascinating sound-light display. (All guaranteed) **£18-50** plus 37½p P. & P.



If you require more information please send S.A.E.



### SHelf UNIT

Two teak finish shelves on a black frame (overall size: 28in x 25in x 12in). Ideal for hi fi equipment: amplifiers, speaker cabinets, etc. The perfect answer for housing unit audio and equipment. This unit is wall mounting. **£2-50** plus 37½p P. & P.

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10 watts, 13 x 8 base unit. Plus a flared centre cone. Designed to handle the higher frequencies. Please state imp required. 3.8.15Ω. A bargain at **£2-50** plus 37½p P. & P. each.

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Plug your Transistor Radio, Amplifier, Cassette, etc., into the a.e. mains through this compact eliminator. 2½in, 2in, 3in approx. 4½V **£1-50, 6V £1-50, 9V £1-50, 7½V** complete with cable and plug for Philips Cassette. **£2** plus 7½p P. & P. each.



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Keynector connects any Electrical Equipment to the mains supply in seconds. Ideal for bench, garage, demonstrations, etc. Multi connections can be made (max. load 13A fused). **ONLY £2-32½** P. & P. Free on this item.



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28in 8½in 16in high. This modern design TV stand would make an ideal base for a coffee table and is a bargain at: **£1-62½** plus 25p P. & P.

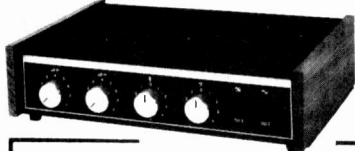


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**NEW IMPROVED MODEL WITH HIGHER OUTPUT AND INCORPORATING HIGH QUALITY READY DRILLED PRINTED CIRCUIT BOARD FOR EASY CONSTRUCTION**

A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors including Silicon Transistors in the first five stages on each channel resulting in even lower noise level with improved sensitivity. Integrated pre-amp with Bass, Treble and two Volume Controls. Suitable for use with Ceramic or Crystal cartridges. Output stage for any speakers from 5 to 15 ohms. Compact design, all parts supplied including drilled metal work, high quality ready drilled printed circuit board, attractive front panel, knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief specification: Power output 14W r.m.s. per channel into 5 ohms. Frequency response —3dB 12-30,000Hz. Sensitivity better than 80mV into 1MΩ. Full power bandwidth ±3dB 12-15,000Hz. Bass boost approx. 10dB. Treble cut approx. —16dB. Negative feedback 18dB over main amp. Power requirements 35V at 1.0 amp. Overall size—12" wide 8" deep × 2 1/2" high. Fully detailed 7-page construction manual and parts list free with kit or send 18p plus large S.A.E.

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3in 4 ohm 50p. P. & P. 13p. 5in 3 ohm 80p. P. & P. 15p. 7 × 4in 3 ohm £1.05. P. & P. 20p. 10 × 6in 3 or 15 ohm £1.90. P. & P. 30p. E.M.I. 8 × 5in 3 ohm with high flux magnet £1.62. P. & P. 20p. E.M.I. 13 1/2 × 8in 3 ohm with high flux ceramic magnet £2.10 (15 ohm £2.25). P. & P. 30p. E.M.I. 13 × 8in, 3 or 8 or 15 ohm with two inbuilt tweeters and crossover network £4.20. P. & P. 30p. E.M.I. 13" × 8" twin cone (parasitic tweeter) 8 ohm £2.25. P. & P. 30p.

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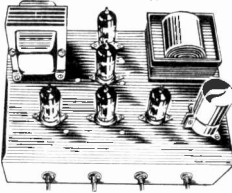
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A top-quality record player amplifier employing heavy duty double wound mains transformer, ECC83, EL84, and rectifier. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. w. × 3 d. × 6 h. Ready built and tested. PRICE £3.75. P. & P. 30p. ALSO AVAILABLE mounted on board with output transformer and speaker ready to fit into cabinet below. PRICE £4.98. P. & P. 38p.

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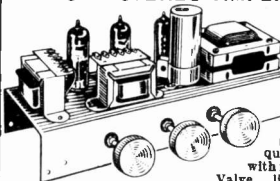
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**HIGH GAIN 4 TRANSISTOR PRINTED CIRCUIT AMPLIFIER KIT**  
**TYPE TAI**  
Peak output in excess of 11 watts. All standard components. Built on printed circuit panel size 6 × 3in. Generous size Driver and Output Transformers. Output transformer tapped for 3 ohm and 15 ohm speakers. Transistors (GFT114 or 81 Mullard AC 128D and matched pair AC128 9p). 9 volt operation. Everything supplied, wire, battery clips, solder, etc. Comprehensive easy to follow instructions and circuit diagram 13p (Free with Kit). All parts sold separately. SPECIAL PRICE £2.48. P. & P. 15p. Also ready built and tested, £2.75. P. & P. 15p.

**3-VALVE AUDIO AMPLIFIER HA34 MK II**  
Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7 1/2 in. × 4 1/2 in. × 4 1/2 in. Incorporates ECC83, EL84, E280 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker. Separate volume control and now with improved wide range tone controls giving bass and treble lift and cut. Negative feedback line. Output 4 1/2 watts. Front panel can be detached and leads extended for remote mounting of controls. Complete with knobs, valves, etc., wired and tested for only £4.75. P. & P. 30p.

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A super quality gram amplifier using a double wound fully isolated mains transformer, rectifier and ECL82 triode pentode valve as audio amplifier and power output stage. Impedance 3 ohms. Output approx. 3 1/2 watts. Volume and tone controls. Chassis size only 7in. wide × 3in. deep × 6in. high overall. AC mains 200/240V. Supplied absolutely Brand New, completely wired and tested with good quality output transformer. FEW ONLY.

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BP53 = 7453	Quad 2-input expandable and-or-invert	0-23	0-20	0-15
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BP 701C—SL701C	TO-5	8	OP Amp	63p	58p	45p
BP 703C—SL703C	TO-5	8	OP Amp Direct OP	63p	58p	45p
BP 702—72702	D.I.L.	14	G.P. OP Amp (Wide Band)	53p	45p	40p
BP 709—72709	D.I.L.	14	High OP Amp	53p	45p	40p
BP 709P—µA709C	TO-5	8	High Gain OP Amp	53p	45p	40p
BP 711—µA711	TO-5	10	Dual comparator	58p	50p	45p
BP 741—72741	D.I.L.	14	High Gain OP Amp (Protected)	75p	60p	50p
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TAA 263—	TO-72	4	A.F. Amp	70p	60p	55p
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	TO-5	TO-66	TO-5	TO-66	TO-5	TO-66	TO-5	TO-66	TO-5	TO-66	TO-5	TO-66
50	0-23	0-25	0-47	0-50	0-47	0-50	0-53	0-53	0-75	0-75	1-13	1-13
100	0-25	0-33	0-53	0-58	0-58	0-63	0-83	0-83	1-40	1-40	1-40	1-40
200	0-35	0-37	0-57	0-61	0-61	0-75	1-60	1-60	1-60	1-60	1-60	1-60
400	0-43	0-47	0-67	0-75	0-75	0-93	1-75	1-75	1-75	1-75	1-75	1-75
600	0-53	0-57	0-77	0-97	0-97	1-25	2-00	2-00	2-00	2-00	2-00	2-00
800	0-63	0-70	0-90	1-20	1-20	1-50	2-50	2-50	2-50	2-50	2-50	2-50

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PIV	300mA		750mA		1A		1.5A		3A		10A		30A	
	TO-5	TO-66	TO-5	TO-66	TO-5	TO-66	TO-5	TO-66	TO-5	TO-66	TO-5	TO-66	TO-5	TO-66
50	0-04	0-05	0-05	0-07	0-14	0-21	0-21	0-47	0-47	0-47	0-47	0-47	0-47	0-47
100	0-04	0-06	0-05	0-13	0-16	0-23	0-75	0-75	0-75	0-75	0-75	0-75	0-75	0-75
200	0-05	0-09	0-08	0-14	0-20	0-24	1-00	1-00	1-00	1-00	1-00	1-00	1-00	1-00
400	0-06	0-13	0-07	0-20	0-27	0-37	1-25	1-25	1-25	1-25	1-25	1-25	1-25	1-25
600	0-07	0-16	0-10	0-23	0-34	0-46	1-85	1-85	1-85	1-85	1-85	1-85	1-85	1-85
800	0-10	0-17	0-13	0-25	0-37	0-55	2-00	2-00	2-00	2-00	2-00	2-00	2-00	2-00
1000	0-11	0-25	0-15	0-30	0-46	0-63	2-50	2-50	2-50	2-50	2-50	2-50	2-50	2-50
1200	—	0-33	—	0-33	0-57	0-75	—	—	—	—	—	—	—	—

## TRIACS

VBOM	2A		6A		10A	
	TO-1	TO-66	TO-1	TO-66	TO-1	TO-66
100	0-50	0-63	1-00	1-00	1-00	1-00
200	0-70	0-90	1-25	1-25	1-25	1-25
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T3 8 2G374A OC81D  
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## MISCELLANEOUS

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because this GPO approved transmitter/receiver kit does not use R.F. and you can get one easily. Your transmissions will be virtually SECRET since they won't be heard by conventional means. Actually it's TWO KITS IN ONE because you get all the printed-circuit boards and components for both the transmitter AND receiver. You're going to find this project REALLY FUN-TO-BUILD with the EASY-TO-FOLLOW instructions. An extremely flexible design with quite an AMAZING RANGE—has obvious applications for HOUSE-TO-HOUSE USE, SCHOOL PROJECTS, LANGUAGE LABORATORIES, SCOUT CAMPS, etc.

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TO: 'BOFFIN PROJECTS'  
DEPT. K2010  
4 CUNLIFFE ROAD  
STONELEIGH, EWELL, SURREY

**FASCIA PANELS**, hi-fi equipment, etc., etched aluminium to individual specifications, S.A.E. details. R. MARSH, 29 Shelbourne Road, Stratford on Avon, Warwicks.

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**WAA-WAA Pedal**. Complete kit of all parts, robust cabinet, mechanism and instructions. Huge sales, well proven design. Only £2.45 complete. Or built and tested £4.75 post free. **Rhythm Box**. Build your own from our pre-built electronic circuit modules, e.g. box giving waltz, foxtro, etc., costs under £17. **Open Percussion units** £14. Bass pedal and other fascinating effects, fuzz, tremolo, etc. Send s.a.e. for list: D.E.W. LTD., 254 Ringwood Road, Ferndown, Dorset

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## MISCELLANEOUS (continued)

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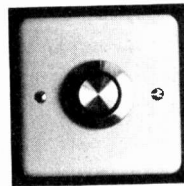
P.O. BOX 148, SHEFFIELD S17 3EX

We stock all those components and materials required by the home Hi-Fi constructor, including speaker grille fabrics, BAF wadding, Peerless speaker kits, Helme Cabinet Kits, cross-over networks, inductors, etc. Special offers also available. Send stamps to value of 10 new pence NOW for your copy of our new fully illustrated catalogue (catalogue cost refunded against purchases over 50p). No callers please, mail-order ONLY.

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Designs by GERRY BROWN and JOHN SALMON  
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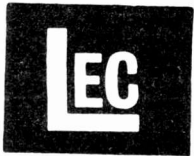
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Postage on Valves: one valve 4p, up to 6 2½p, over 6 post paid.

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RECEIVERS AND COMPONENTS (continued)

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SL402A	£1.80	PA230	92p
7410	28p	D40C1	67p
741	88p	DIL Conn.	30p
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 Marine Tachometer (May 1970) 25p ea. Musical Slave (May 1970) 40p ea. Waa-Waa pedal Vol. 4 No. 7 14p ea. Audio Sig. Gen. (Sine and Square on one board) Vol. 5 No. 10 42p ea.  
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**PANELS** with 2 power transistors similar to OC28 on each board—components 2 boards (4 x OC28) 50p. P. & P. 6p.

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PE 'Gemini' STEREO AMPLIFIER (Dec. 1970)  
 Twin Channel Main Amplifier. Stabilised Power Supply  
 Total price £1.13. P/P. 8p.

All boards are fibreglass, drilled and tin plated with reverse side screen printed for easy component and connection identification.

S.A.E. for PC board list of other current projects.  
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**COMPUTER PANELS.** 5-BC108 diodes, 15p (3/-), post 5p (1/-), 4—50p (10/-), post 15p (3/-), 8-OC76/OC72/OC42, 80A10 diodes, 40p (8/-), post 10p (2/-) per panel. 8-OC170 diodes, 40p (8/-), post 8p (1/7) per panel. 2-OC170, 2-GET875 or 4MDS34, 5-100mfd 12V Electrolytics, pot core, etc. 30p (6/-), post 8p (1/7) per panel.

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25 W high quality audio amplifier	(p.106)	70p
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Price each including postage and packing. Cash with order.

All boards are, tinned to prevent oxidation and to aid soldering and have the component identification printed on the reverse.

**BRIBOND PRINTED CIRCUITS LTD**  
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**SELECTIVE AMPLIFIER MODULE.** The basis of the Wah-Wah pedal. Kit contains all the components to build a 2-transistor circuit module, also the sockets, control, etc., required for the constructor to assemble his own design. £1.75 (35/-). Assembled and tested module £2.13 (42/6).

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Complete kit for Wah-Wah pedal now only £6.50 (£6.10.0). All post free.

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2N696	17p	2N696	17p	2N696	17p
2N697	17p	2N697	17p	2N697	17p
2N706	10p	2N706	10p	2N706	10p
2N706A	12p	2N706A	12p	2N706A	12p
2N930	25p	2N930	25p	2N930	25p
2N1131	30p	2N1131	30p	2N1131	30p
2N1132	30p	2N1132	30p	2N1132	30p
2N1302	20p	2N1302	20p	2N1302	20p
2N1303	22p	2N1303	22p	2N1303	22p
2N1304	25p	2N1304	25p	2N1304	25p
2N1305	25p	2N1305	25p	2N1305	25p
2N1306	25p	2N1306	25p	2N1306	25p
2N1308	30p	2N1308	30p	2N1308	30p
2N1309	25p	2N1309	25p	2N1309	25p
2N1613	22p	2N1613	22p	2N1613	22p
2N1711	25p	2N1711	25p	2N1711	25p
2N2147	75p	2N2147	75p	2N2147	75p
2N2160	65p	2N2160	65p	2N2160	65p
2N2218	30p	2N2218	30p	2N2218	30p
2N2219	30p	2N2219	30p	2N2219	30p
2N2222	30p	2N2222	30p	2N2222	30p
2N2222A	37p	2N2222A	37p	2N2222A	37p
2N2369	20p	2N2369	20p	2N2369	20p
2N2484	35p	2N2484	35p	2N2484	35p
2N2646	50p	2N2646	50p	2N2646	50p
2N2904	30p	2N2904	30p	2N2904	30p
2N2904A	30p	2N2904A	30p	2N2904A	30p
2N2905	37p	2N2905	37p	2N2905	37p
2N2906	30p	2N2906	30p	2N2906	30p
2N2906A	32p	2N2906A	32p	2N2906A	32p
2N2907	37p	2N2907	37p	2N2907	37p
2N2926	12p	2N2926	12p	2N2926	12p
2N3011	25p	2N3011	25p	2N3011	25p
2N3053	25p	2N3053	25p	2N3053	25p
2N3054	50p	2N3054	50p	2N3054	50p
2N3055	75p	2N3055	75p	2N3055	75p
2N3525	£1.10	2N3525	£1.10	2N3525	£1.10
2N3702	12p	2N3702	12p	2N3702	12p
2N3703	12p	2N3703	12p	2N3703	12p
2N3704	17p	2N3704	17p	2N3704	17p
2N3705	15p	2N3705	15p	2N3705	15p
2N3707	15p	2N3707	15p	2N3707	15p
2N3709	12p	2N3709	12p	2N3709	12p
2N3710	12p	2N3710	12p	2N3710	12p
2N3819	35p	2N3819	35p	2N3819	35p
2N3820	60p	2N3820	60p	2N3820	60p
2N4058	17p	2N4058	17p	2N4058	17p
2N4061	15p	2N4061	15p	2N4061	15p
2N4547	35p	2N4547	35p	2N4547	35p
2N4548	37p	2N4548	37p	2N4548	37p
2N4549	50p	2N4549	50p	2N4549	50p
2S301	50p	2S301	50p	2S301	50p
2S302	50p	2S302	50p	2S302	50p
2S303	50p	2S303	50p	2S303	50p
2S304	50p	2S304	50p	2S304	50p
40250	50p	40250	50p	40250	50p
40361	55p	40361	55p	40361	55p
40362	60p	40362	60p	40362	60p
AA30	10p	AA30	10p	AA30	10p
AA42	15p	AA42	15p	AA42	15p
AA113	12p	AA113	12p	AA113	12p
AA217	10p	AA217	10p	AA217	10p
AC107	37p	AC107	37p	AC107	37p
AC126	25p	AC126	25p	AC126	25p
AC127	25p	AC127	25p	AC127	25p
AC128	25p	AC128	25p	AC128	25p
AC176	25p	AC176	25p	AC176	25p
AC187	30p	AC187	30p	AC187	30p
AC188	30p	AC188	30p	AC188	30p
AC17	30p	AC17	30p	AC17	30p
AC18	25p	AC18	25p	AC18	25p
AC19	25p	AC19	25p	AC19	25p
AC20	25p	AC20	25p	AC20	25p
AC21	25p	AC21	25p	AC21	25p
AC22	17p	AC22	17p	AC22	17p
AC23	17p	AC23	17p	AC23	17p
AC24	17p	AC24	17p	AC24	17p
AD140	50p	AD140	50p	AD140	50p
AD149	30p	AD149	30p	AD149	30p
AD161	37p	AD161	37p	AD161	37p
AD162	37p	AD162	37p	AD162	37p
AF14	25p	AF14	25p	AF14	25p
AF15	25p	AF15	25p	AF15	25p
AF16	25p	AF16	25p	AF16	25p
AF17	25p	AF17	25p	AF17	25p
AF18	62p	AF18	62p	AF18	62p
AF124	25p	AF124	25p	AF124	25p
AF125	20p	AF125	20p	AF125	20p
AF126	17p	AF126	17p	AF126	17p
AF127	17p	AF127	17p	AF127	17p
AF139	30p	AF139	30p	AF139	30p
AF178	47p	AF178	47p	AF178	47p
AF179	47p	AF179	47p	AF179	47p
AF180	52p	AF180	52p	AF180	52p
AF181	42p	AF181	42p	AF181	42p
AF186	40p	AF186	40p	AF186	40p
AF239	42p	AF239	42p	AF239	42p
AS26	25p	AS26	25p	AS26	25p
AS27	32p	AS27	32p	AS27	32p
AS28	25p	AS28	25p	AS28	25p
AS29	30p	AS29	30p	AS29	30p
AS297	47p	AS297	47p	AS297	47p
AS21	42p	AS21	42p	AS21	42p
BA15	7p	BA15	7p	BA15	7p
BA16	10p	BA16	10p	BA16	10p
BA13	6p	BA13	6p	BA13	6p
BA15	7p	BA15	7p	BA15	7p
BA17	7p	BA17	7p	BA17	7p
BSY38	17p	BSY38	17p	BSY38	17p
BSY106	12p	BSY106	12p	BSY106	12p
BSY107	12p	BSY107	12p	BSY107	12p
BSY108	12p	BSY108	12p	BSY108	12p
BSY110	12p	BSY110	12p	BSY110	12p
BSY111	12p	BSY111	12p	BSY111	12p
BSY112	12p	BSY112	12p	BSY112	12p
BSY113	12p	BSY113	12p	BSY113	12p
BSY114	12p	BSY114	12p	BSY114	12p
BSY115	12p	BSY115	12p	BSY115	12p
BSY116	12p	BSY116	12p	BSY116	12p
BSY117	12p	BSY117	12p	BSY117	12p
BSY118	12p	BSY118	12p	BSY118	12p
BSY119	12p	BSY119	12p	BSY119	12p
BSY120	12p	BSY120	12p	BSY120	12p
BSY121	12p	BSY121	12p	BSY121	12p
BSY122	12p	BSY122	12p	BSY122	12p
BSY123	12p	BSY123	12p	BSY123	12p
BSY124	12p	BSY124	12p	BSY124	12p
BSY125	12p	BSY125	12p	BSY125	12p
BSY126	12p	BSY126	12p	BSY126	12p
BSY127	12p	BSY127	12p	BSY127	12p
BSY128	12p	BSY128	12p	BSY128	12p
BSY129	12p	BSY129	12p	BSY129	12p
BSY130	12p	BSY130	12p	BSY130	12p
BSY131	12p	BSY131	12p	BSY131	12p
BSY132	12p	BSY132	12p	BSY132	12p
BSY133	12p	BSY133	12p	BSY133	12p
BSY134	12p	BSY134	12p	BSY134	12p
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BSY137	12p	BSY137	12p	BSY137	12p
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BSY192	12p	BSY192	12p	BSY192	12p
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BSY196	12p	BSY196	12p	BSY196	12p
BSY197	12p	BSY197	12p	BSY197	12p
BSY198	12p	BSY198	12p	BSY198	12p
BSY199	12p	BSY199	12p	BSY199	12p
BSY200	12p	BSY200	12p	BSY200	12p

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Part No.	Description	Price	Price	Price	Price
7400	Quad 2-Input NAND Gate	1.49	50-99	100	500
7401	Quad 2-Input NAND Gate Open Collector	25p	2		

# FIND BURIED REAL WORKING ELECTRONIC TREASURE! ORGAN

TREASURE LOCATOR—

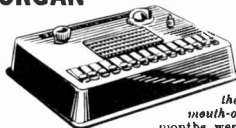
NOW IT'S HERE AT LAST.



after experimenting for four and a half months with a multitude of different circuits and carrying out actual field tests with prototypes, our design team have come up with this real winner. This fully portable transistorised metal locator detects and tracks down buried metal objects—it signals exact location (no phones used—uses only transistor radio which fits inside—no connections needed). **FINDS GOLD, SILVER, LOST COINS, JEWELLERY, KEYS, WAR SOUVENIRS, ARCHAEOLOGICAL PIECES, METALLIC ORE, NUGGETS, ETC.** Extremely sensitive, will signal presence of certain objects buried several feet below ground. Can be built with ease in one short evening with the wonderfully clear, easy to follow, step-by-step, fully illustrated instructions. Fully transistorised—no valves. Uses standard PP3 battery.

ONLY **£2-37** (47/6)

necessary. Size of detector head 13in x 10in x 2in. Great demand expected at this remarkably low price—All parts including detector head case, nuts, screws, wire, simple instructions, etc. Send now **£2-37 + 33p P. & P.** (47/6 + 6/6) (Telescopic handle as illustrated **£1-75** (35/-) extra). Parts available separately. Made up looks worth £15.



ONLY **£2-75** (55/-)

Don't confuse with ordinary electric organs that simply blow air over mouth-organ type reeds, etc. Eight months were spent in creating and testing this superb, revolutionary electronic organ. Fully transistorised, no valves. Proper self-contained loudspeaker. Fifteen separate keys span two full octaves—play the "Yellow Rose of Texas", "Silent Night", "Auld Lang Syne", and lots of similar tunes on this real working electronic organ. Size 13in x 10in x 2in. Uses standard battery. Have the thrill and excitement of building it together with the pleasure of playing a real electronic organ. Play it anywhere. No soldering necessary. Easy as A.B.C. to make following the fully illustrated, step-by-step instructions. **BIG DEMAND ANTICIPATED FOR THIS UNIQUE INSTRUMENT** at our low price. ONLY **£2-75 + 23p P. & P.** (55/- + 4/6) for all parts, including case, loudspeaker, transistors, condensers, resistors, knobs, transformers, volume control, wire, nuts, screws, instructions, etc. (parts available separately). Have all the pleasure of making it yourself, finish with an exciting gift for someone.

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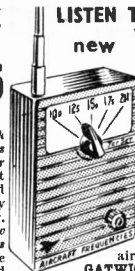


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## SHORTWAVE TRANSISTOR RADIO



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CAN BE BUILT IN ONE EVENING At last! After trying countless circuits searching for easy build, work-first-time short wave. Giving advanced world-wide performance, we chose this "Sky Roma". Anyone from 9 years up can follow the step-by-step, easy-as-A.B.C. fully illustrated instructions. (We built ten prototypes and every one worked first time) no soldering necessary, 76 stations logged on rod aerial in 30 mins.—Russia, Africa, USA, Switzerland, etc. Experience thrills of world wide news, sport, music, etc. Eavesdrop on annual broadcasts. Uses PP3 battery. Transistorised (no valves). Size only 3in x 4in x 1in. As tremendous demand anticipated price held to only **£2-25 + 17p P. & P.** (45/- + 3/6) for all parts incl. cabinet, screws, instr., etc. Parts available separately.

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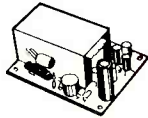


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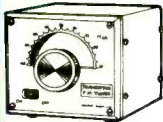
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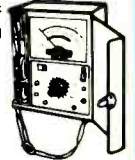
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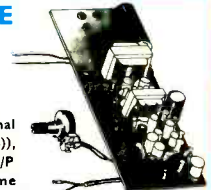
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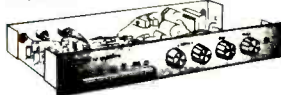
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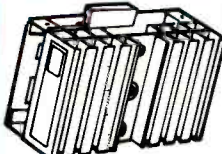
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