

PRACTICAL

# ELECTRONICS

OCTOBER 1973

20p



## SEMICONDUCTOR TESTER

**FREE INSIDE!**

**P.E. AUDIO I.C.  
IDENTICHART**

ALSO: **PE RONDO** QUADRAPHONIC SYSTEM  
Important New Series: PHASE LOCKED LOOPS

# NEW EDU-KIT MAJOR

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BUILD THESE PROJECTS WITHOUT SOLDERING IRON OR SOLDER

- 4 Transistor Earpiece Radio
- Signal Tracer
- Signal Injector
- Transistor Tester NPN — PNP
- 4 Transistor Push Pull Amplifier
- 5 Transistor Push Pull Amplifier
- 7 Transistor Loudspeaker Radio MW/LW.
- 5 Transistor Short Wave Radio
- Electronic Metronome
- Electronic Noise Generator
- Batteryless Crystal Radio
- One Transistor Radio
- 2 Transistor Regenerative Radio
- 3 Transistor Regenerative Radio
- Audible Continuity Tester
- Sensitive Pre-Amplifier
- Complete with parts price list and plans.

TOTAL BUILDING COSTS

**£7.23** P.P. & INS. 44p  
(Overseas P.P. £1.05p)

## NEW ROAMER NINE

WITH V.H.F. INCLUDING AIRCRAFT

Nine Transistors, 9 Tunable wavebands as Roamer Ten

Built in ferrite rod aerial for MW/LW. Retractable chrome plated telescopic aerial for VHF and SW. Push Pull output using 600 mW transistors. 9 Transistors and 3 diodes, tuning condenser with VHF section, separate coil for aircraft, moving coil loudspeaker, volume ON/OFF and wavechange. Attractive all white case with red grille and carrying strap. Size 9 1/2" x 7 1/2" x 2 1/2" approx. Parts price list and plans 30p (FREE with parts)

TOTAL BUILDING COSTS **£6.95** P.P. & INS. 44p (OVERSEAS P. & P. £1.05)

## POCKET FIVE

3 Tunable wavebands. MW/LW and Trawler Band 7 stages, 5 transistors and 2 diodes, supersensitive ferrite rod aerial, moving coil loudspeaker, attractive Black and Gold Case. Size 5 1/2" x 1 1/2" x 3 1/2" approx. Plans and parts price list 15p (FREE with parts)

Total Building Costs

**£2.28** P.P. & Ins. 24p (Overseas P.P. 65p)

## TRANSONA FIVE

Wavebands, transistors and speaker as Pocket Five. Larger Case with Red Speaker Grille and Tuning Dial. Plans and parts price list 15p (FREE with parts)

Total Building Costs **£2.50** P.P. & Ins. 25p (Overseas P. & P. 65p)

## TRANS EIGHT 8 TRANSISTORS AND 3 DIODES

6 TUNABLE WAVEBANDS. MW, LW, SW1, SW2, SW3 AND TRAWLER BAND. Sensitive ferrite rod aerial for MW and LW. Telescopic aerial for short waves. 3in speaker. 8 improved type transistors plus 3 diodes. Attractive case in black with red grille, dial and black knobs with polished metal inserts. Size 9 1/2" x 5 1/2" x 2 1/2" approx. Push-pull output. Battery economiser switch for extended battery life. Ample power to drive a larger speaker. Parts price list and plans 25p (FREE with parts)

TOTAL BUILDING COSTS

**£4.48** P.P. & INS. 33p (OVERSEAS P. & P. £1.05)

## ROAMER SIX 6 TUNABLE WAVEBANDS: MW, LW, SW1, SW2, TRAWLER BAND PLUS AN EXTRA MW BAND

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

TOTAL BUILDING COSTS

**£3.98** P.P. & IN. 31p (OVERSEAS P. & P. £1.05)

## NEW EVERYDAY SERIES

Build this exciting New series of designs

**EV5** 5 Transistors and 2 diodes MW/LW. Powered by 4 1/2 volt Battery. Ferrite rod aerial, tuning condenser, volume control, and loudspeaker. Attractive case with red speaker grille. Size 9 1/2" x 5 1/2" x 2 1/2" approx. Parts price list and plans 15p (FREE with parts)

TOTAL BUILDING COSTS **£2.73** P.P. & INS. 30p (OVERSEAS P. & P. 70p)

**EV6** Case and looks as above. 6 Transistors and 3 diodes. Powered by 9 volt Battery. Ferrite rod aerial, loudspeaker, etc., MW/LW coverage. Push Pull Output. Parts price list and plans 15p (FREE with parts)

TOTAL BUILDING COSTS **£3.60** P.P. & INS. 30p (OVERSEAS P. & P. 85p)

**EV7** Case and looks as above. 7 transistors and 3 diodes. Six wavebands. MW/LW, Trawler Band, SW1, SW2, SW3, powered by 9 volt Battery Push Pull Output. Telescopic Aerial for Short Waves. Parts price list and easy build plans 20p. Free with parts

TOTAL BUILDING COSTS **£4.08** P.P. & INS. 31p (OVERSEAS P. & P. £1.05p)

## ROAMER EIGHT Mk. I

NOW WITH VARIABLE TONE CONTROL

7 TUNABLE WAVEBANDS:

MW1, MW2, LW, SW1, SW2, SW3 AND TRAWLER BAND. Built-in ferrite rod aerial for MW and LW. Retractable chrome plated telescopic aerial for short waves. Push-pull output using 600mW transistors. Car aerial and tape record sockets. Selectivity switch, 8 transistors plus 3 diodes. Fine tone moving coil speaker. Air spaced ganged tuning condenser. Volume/on/off, tuning, wave change and tone controls. Attractive case in rich chestnut shade with gold blocking. Size 9 1/2" x 7 1/2" x 4 1/2" approx. Easy to follow instructions and diagrams. Parts price list and plans 25p (FREE with parts)

TOTAL BUILDING COSTS **£6.98** P.P. & INS. 47p (OVERSEAS P. & P. £1.05)

## ROAMER TEN WITH VHF INCLUDING AIRCRAFT

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

Built-in ferrite rod aerial for MW/LW. Retractable, chrome plated 7 section telescopic aerial, can be angled and rotated for peak short wave and VHF listening. Push-pull output using 600mW transistors. Car Aerial and tape record sockets. 10 transistors plus 3 diodes. Fine tone moving coil speaker. Ganged tuning condenser with VHF section. Separate coil for Aircraft Band. Volume/on/off, wave change and tone controls. Attractive case in black with silver blocking. Size 9 1/2" x 7 1/2" x 4 1/2". Easy to follow instructions and diagrams. Parts price list and plans 30p (FREE with parts)

TOTAL BUILDING COSTS **£8.50** P.P. & INS. 52p (OVERSEAS P. & P. £1.05)

## EDU-KIT

Built Radios, Amplifiers, etc., from easy stage diagrams. Five

units including master unit to construct.

Components include: Tuning Condenser: 2 Volume Controls; 2 Slider Switches; Fine tone moving coil Speaker; Terminal Strip; Ferrite Rod Aerial; 2 Plugs and Sockets; Battery Clips; 4 Tag Boards; 10 Transistors; 4 Diodes; Resistors; Capacitors; Three 1/2in Knobs. Units once constructed are detachable from Master Unit, enabling them to be stored for future use. Ideal for Schools, Educational Authorities and all those interested in radio construction. Parts price list and plans 25p (FREE with parts)

TOTAL BUILDING COSTS **£5.50** P.P. & INS. 33p (OVERSEAS P. & P. £1.05)

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# PRACTICAL ELECTRONICS

VOLUME 9 No. 10 OCTOBER 1973

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## CONSTRUCTIONAL PROJECTS

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Construction of pre-amplifiers, tone and balance controls and 20W amplifiers
- P.E. SOUND SYNTHESISER—9** *by G. D. Shaw* 882  
Voltage controlled output amplifiers and differential amplifier
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- INDUSTRY NOTEBOOK** 897  
What's happening inside industry
- READOUT** 898  
More on the P.E. Sound Synthesiser—Back Numbers Wanted

## SPECIAL DATA SHEET

- AUDIO I.C. IDENTICHART**  
At-a-glance information on over 80 different devices

Our November issue will be published on Friday, October 12, 1973

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like this for  
less than £18?

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Just think—In only a few days you could be giving your ears the treat of a lifetime—AND introducing your envious friends to STEREO 21!

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# RTVC VISCOUNT III

## a boost in the output.

VISCOUNT III now gives you an imposing 20 watts per channel—and the price quoted is actually **'INCLUSIVE OF VAT'**

The money's important, of course, but not nearly so important as *value for money!* And that's something you get in abundance with VISCOUNT III. We design it... we make it... we sell it direct to you—passing on all the economies that come from cutting out middle-men! That's the only way you can get so much quality for so little money!

The unique VISCOUNT III amplifier, plus the Garrard SP25 Mk III deck, plus the magnificent Duo Type III matched speakers (or Duo Type II for a small room) give you an audio installation that will prove unbeatable for listening pleasure! On the brushed aluminium front panel of the amplifier you'll find all the facilities you need—volume, bass, treble and balance controls, plus switches for mono/stereo, on/off function and bass and treble filters. Plus headphone socket on the back. And the teak finish will harmonise and enhance virtually any style of interior decor!

The heart-stopping timbre of Tom Jones at his most virile... the last lingering harmonics of a solo performance by Helfetz or Menuhin... the pathos and the panache of Liza Minelli... the majestic sonorities of the brass band and the elfin subtleties of the virtuoso clavichordist—hear every nuance with a fidelity that you have *never* experienced before!

Come and hear VISCOUNT III! If it's inconvenient to travel, buy by post in the confidence that you won't be disappointed (and with a 24-carat Money-Back Guarantee to give you extra reassurance). Don't settle for second-best!

**SPEAKERS:** Duo Type II Size approx. 17in x 10½in x 6½in. Drive unit 13in x 6in with parasitic tweeter. Max. power 10 watts 8 ohms. Simulated Teak cabinet. £14.00 a pair, £2.20 p. & p. Duo Type III Size approx. 23in x 11½in x 9½in. Drive unit 13½in x 8½in with HF speaker. Max. power 20 watts 8 ohms. Freq. range 20Hz to 20kHz. Teak veneer cabinet. £32.00 a pair + £3.30 p. & p.

### PRICES: SYSTEM 1

Viscount III R 102 amplifier	£24.20 + £1 p. & p.
2 Duo Type II speakers	£14.00 + £2.20 p. & p.
Garrard SP25 Mk III with	
MAG. cartridge plinth & cover	£18.00 + £1.75 p. & p.
<b>total</b>	<b>£56.20</b>

Available complete for only £49.00 + £3.50 p. & p.

### PRICES: SYSTEM 2

Viscount R 102 amplifier	£24.20 + £1 p. & p.
2 Duo Type III speakers	£32.00 + £3.30 p. & p.
Garrard SP25 Mk III with	
MAG. cartridge plinth & cover	£18.00 + £1.75 p. & p.
<b>total</b>	<b>£74.20</b>

Available complete for £65.00 + £4 p. & p.

STILL ONLY **£49** COMPLETE

### THE TOURIST PUSH-BUTTON CAR RADIO KIT £6.60

The Tourist PB is suitable for 12 volt working on both negative and positive earth vehicles it covers the full medium and long wave bands. It is permeability tuned and sturdily constructed. Output is a full 2.5 watts into an 8 ohms speaker. But the Tourist PB will operate into any loudspeaker from 8 to 15 ohms.

Apart from the output stage, which is an integrated circuit, the only other electronic components that need soldering are some capacitors, resistors, etc. The kit includes a pre-built RF tuner unit, and fully modularised IF stages which are pre-aligned before despatch. As well as electronic components this kit also contains 2 diamond-spun aluminium knobs, elegant matching front panel, dial, washers, screws and wire.

The Tourist PB can be mounted in any standard size dash panel and it has an illuminated tuning scale. Chassis size is: 7in wide, 2in high and 4½in deep.

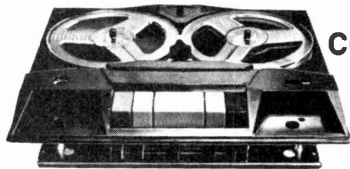
\* Circuit diagram and comprehensive instructions 55p free with parts.

\* Fully retractable and lockable car aerial £1.37 post paid.

### CAR RADIO KIT £6.60 p. & p. 55p

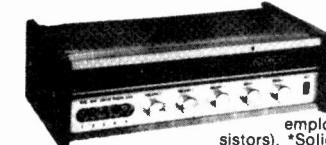
Speaker with baffle and fixing strips £1.65. 23p p. & p., post free if bought with the kit. Send stamped addressed envelope for leaflet.

If you can solder on printed circuit board, you can build this push-button car radio kit. It's simple—just follow the step-by-step instructions.



### PE TAPE LINK CONSTRUCTORS

Suitable 3 speed tape deck, **less heads**. Caters up to 5½ins. spools. 240V AC mains. Unused but store soiled hence no warranty. **£4.00** £1 p. & p.



### RELIANT Mk IV £13.50

\*5 Electrically Mixed Inputs. \*3 Individual Mixing controls. \*Separate bass and treble controls common to all 5 inputs. \*Mixer employing F.E.T. (Field Effect Transistors). \*Solid State Circuitry. \*Attractive Styling.

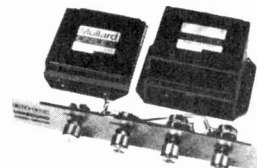
INPUTS 1. Crystal Mic or Guitar 9mV. 2. Moving coil Mic. or Guitar 8mV. Inputs 3, 4 & 5 are suitable for a wide range of

medium output equipment (Gram. Tuner, Monitor, Organ, etc.). All 250mV sensitivity. Output 20 watts into 8 ohms (suitable for 15 ohms). Size approx. 12½ x 6 x 3½ ins. **£13.50 p. & p. 60p.**

### UNISOUD MODULES

ONLY £7.64 + 55p p. & p.

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



### IN-CAR ENTERTAINMENT AT HOME

With this elegant stereo 8 track add on unit, audio enthusiasts now have the opportunity to extend their systems to include the playing of 8 track cartridges. Simply select your channel, by push button, four digital lamps indicate channel selected. Mains operated.



The Viscount III, the fabulous Stereo 21 and the Unisound Modules will all accept this unit. **£9.90 p. & p. 80p** simply connect up.

**ALL PRICES INC. VAT**

**SEE OPPOSITE PAGE FOR ADDRESS DETAILS**

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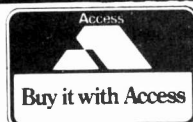
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**ADD A TOUCH OF PRECISION TO V.C.O.'s, ETC., BY INSTALLING 10 TURN POTS AND COUNTING DIALS.**

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10 turn indicating dial and knob by **AMPHENOL**. 22mm dia. Resolution better than 0-1%. With brake and zero backlash gearing. £2 each.

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Red L.E.D. 30p; Green L.E.D. 75p (approx. 5mm diam.). Minitron 7-segment display, £1-50 OR complete with a 7447 decoder-driver £2-50

**Integrated circuits in 8-14 pin D.I.L. packages**

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BC182L 9p	BC212L 11p	BFY51 19p
TIP29B 50p	TIP30B 60p	TIP41A 70p
TIP42A 85p	TIP35C £3	TIP36C £4
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### Zeners 400 mw 5% full range 12p

Slide Switch DPDT 10p | P.C. Mounting Stereo  
TO5 Heat Sinks 10 for 40p | Pots 100K Lin. 100K Log.  
10K Log. all at 35p

TO3 Heat Sinks 25p

### Bridge Rectifiers

W005 50 P.I.V. 1A 23p  
W02 200 P.I.V. 1A 25p  
W04 400 P.I.V. 1A 27p  
W08 800 P.I.V. 1A 34p

### Miniature Toggle Switch

S.P.C.O. at 35p  
Neon, panel mounting  
amber, mains voltage 15p

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Digital Frequency Meters/Counters  
Multimeters—Please state requirements

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Spend £4 and receive **FREE** a red L.E.D.

Please add 10% VAT to total cost

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## THOUSANDS OF MILES REDUCED TO INCHES? 1973 RUSSIAN RADIO TECHNOLOGY SHRINKS THE WORLD! COMPUTERISED?

**THIS FANTASTIC  
EARTH SHRINKER**



**YES, 24,901 miles  
SHRUNK TO ONLY 13 x 10 x 4 1/2  
inches approx?**

**BRAND NEW  
FABULOUS ASTRAD 17**  
PORTABLE RADIO & COMMUNICATIONS  
RECEIVER



**\*MUST  
YOU PAY UP  
TO £80?**

**FIRST TIME EVER!**  
\*NOW AVAILABLE WITH  
fabulous **COMPUTERISED**  
**WORLD TUNING GUIDE!**  
NO MORE GUESSWORK!  
INSTANT DATA at your fingertips—  
enables you to **TUNE IN A FLASH** to  
transmissions the world over!

**THIS  
OFFER  
ONLY  
FROM  
US!**

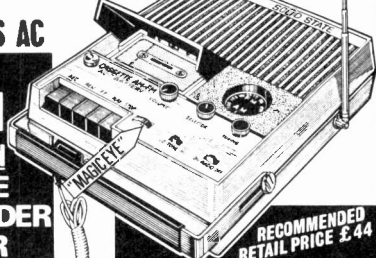
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AND DIODES!**  
**WAVEBANDS:**  
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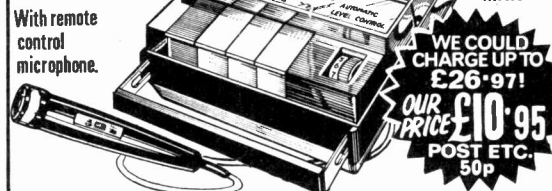
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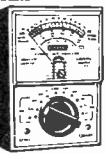
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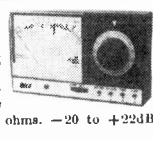
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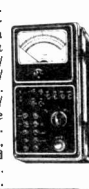
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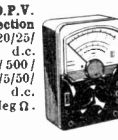
## MODEL FL436

20KΩ/V d.c. 8KΩ/V a.c. Mirror scale. 0-6/3/12/30/120/600V d.c. 3/30/120/600V a.c. 50/500µA/160/600mA. 10/100K/1 Meg/10 MegΩ. -20 to +46dB. £2-97. Post 12p.



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mirror scale 0/0-2/5/20/25/100/250/500/1,000V d.c. 0/2.5/10/25/100/250/500/1,000V a.c. 0/50µA/5/50/500mA. 12 amp. 0/60K/6 Meg/60 MegΩ. £9-95. Post paid.  
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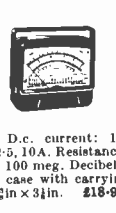
## 870 WTR MULTIMETER

Features a.c. current ranges. 20,000 O.P.V. 0/0-5/2-5/10/150/250/500/1,000V d.c. 0/2-5/10/50/250/500/1,000V a.c. 0/50µA/1/10/100mA/1/10 amp. d.c. 0/100mA/1/10 amp. a.c. 0/5K/50K/500K/5MEG/50MEG. -20 +62dB. £15. Post 25p.



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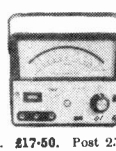
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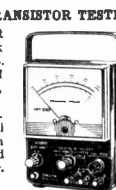
## MODEL 449A IN-CIRCUIT TRANSISTOR TESTER

Checks true a.c. beta in/out. Checks Ico. Checks diode in/out. Checks SCR, etc. Beta HI 10-500 LO 2-50 Ico 0-5000µA. 220/240V a.c. operation. £17-50. Post 25p.



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High quality instrument to test Reverse Leak current and D.C. current. Amplification factor of NPN, PNP, transistors, diodes, SCR's, etc. 4" x 4 1/2" clear scale meter. Operates from internal batteries. Complete with instructions, leads and carrying handle. £12-50. Post 30p.



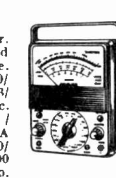
## TE-55 VALVE VOLTMETER

28 ranges. D.C. volts 1-5-1,500V a.c. volts 1-5-1,500V. Resistance up to 1,000 megohms. 200/240V a.c. operation. Complete with probe and instructions. £17-50. Post 30p. Additional probes available: R.F. £2-12; H.V. £2-50.



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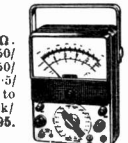
## MODEL U4311 SUB-STANDARD MULTI-RANGE VOLT AMMETER

Sensitivity 330 ohms/Volt a.c. and d.c. Accuracy 0-5% d.c. 1% a.c. Scale length 165mm. 0/300/750µA/1-5/3/7-5/15/30/75/150/300/750mA/1-5/3/7-5 amp. d.c. 0/37-5/15/30/75/150/300/750mA/1-5/3/7-5 amp. a.c. 0/75/150/300/750mV/1-5/3/7-5-15-30/75/150/300/750V d.c. 0/750mV/1-5/3/7-5-15/30/75/150/300/750V a.c. Automatic cut out. Supplied complete with test leads, manual and test certificates. £48. Post 50p.



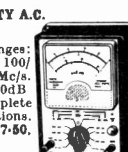
## KAMODEN HM720B F.E.T. V.O.M.

Input impedance 10MΩ. Ranges: 0/0-25/1-2-5/10/50/250/1,000V a.c. 0/2-5/10/50/250/1,000V a.c. 0/25µA/2-5/25/250mA d.c. -20 to +62dB. 0/5K/50K/500K/5MΩ/500Ω. £14-95. Post 30p.



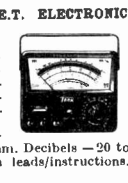
## TE-40 HIGH SENSITIVITY A.C. VOLTMETER

10 meg. input 10 ranges: 0/1-003/1-3/1-3/10/30/100/300V. R.M.S. 4cps-1-2 Mc/s. Decibels -40 to +50dB. Supplied brand new complete with leads and instructions. Operation 230V. a.c. £17-50. Carr. 25p.



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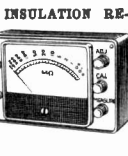
## MODEL L-55 FET V.O.M.

Input impedance 10 meg ohms. 0/0-3/1-2/6/30/120/600V d.c. 0/3/12/60/120/600V a.c. 0/120µA/120mA d.c. 0/1K/100K/10 meg/100 meg ohms. £15-97. Post 25p.



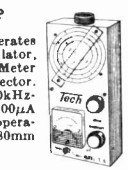
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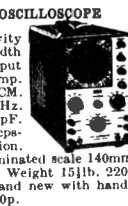
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Transistorised. Operates as Grid Dip, Oscillator, Absorption Wave Meter and Oscillating Detector. Frequency range 440kHz-280MHz in 6 coils. 500µA meter. 9V battery operation. Size 180mm x 80mm x 40mm. £12-50. Post 20p.



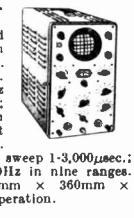
## TO-3 PORTABLE OSCILLOSCOPE

8in tube. Y amp. Sensitivity 0-1V p-p/CM. Bandwidth 1-5cps-1.5MHz. Input Imp. 2 megΩ 25pF X amp. sensitivity 0-9V p-p/CM. Bandwidth 1-5cps-800kHz. Input Imp. 2 megΩ 20pF. Time base. 5 ranges 10cps-300kHz. Synchronisation. Internal/external. Illuminated scale 140mm x 215mm x 330mm. Weight 15lb. 220/240V a.c. Supplied brand new with handbook. £52-50. Carr. 50p.



## CI-5 PULSE OSCILLOSCOPE

For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth 10MHz. Sensitivity at 100kHz V. RMS/mm. 0-1-25; HOR. AMP. Bandwidth 500kHz. Sensitivity at 100kHz V. RMS/mm. 0-3-25; Pre-set triggered sweep 1-3,000µsec.; free running 20-200,000Hz in nine ranges. Calibrator pips. 220mm x 360mm x 430mm, 115-230V a.c. operation. £28. Carr. paid.



## RUSSIAN CI-16 DOUBLE BEAM OSCILLOSCOPE

5MHz Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5in x 4in C.R.T. Calibrated triggered sweep from 0-2µsec to 100 milli-sec per cm. Free running time base 50 Hz-1MHz. Built-in time base calibrator and amplitude calibration. Supplied complete with all accessories and instruction manual. £87. Carr. paid.



## TE-20D RF SIGNAL GENERATOR

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



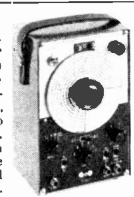
## TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20cps to 200 kc/s on 4 bands. Square wave: 20cps to 30 kc/s. Output impedance 5,000 ohms. 200/250V a.c. Supplied brand new and guaranteed with instruction manual and leads. £17-50. Carr. 37p.



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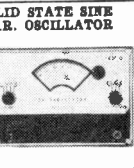
## MODEL AT201 DECADE ATTENUATOR

Frequency range 0-200kHz. Attenuator 0-11dB. 0-1dB step. Impedance 600 ohms. Max. Input power 30dBm. Size 180mm x 90mm x 55mm. £12-50. Post 37p.



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Sine 18-200,000 Hz. Square 18-50,000 Hz. Output max. +10dB (10 K ohms) Operation internal batteries. Attractive 2-tone 74in x 3in x 2in. Price £17-50. Carr. 17p.



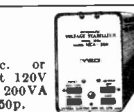
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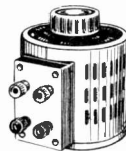
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12 amp.	£23.60
20 amp.	£49.00
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100µA	£3.95
100-0-100µA	£3.90
500µA	£3.70
1mA	£3.60
20V d.c.	£3.60
50V d.c.	£3.60
300V d.c.	£3.60
1 amp. d.c.	£3.60



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100µA	£3.35
100-0-100µA	£3.35
500µA	£3.30
1mA	£3.15
5V d.c.	£3.10
50V d.c.	£3.10
300V d.c.	£3.10
1 amp. d.c.	£3.10
50µA	£3.40
50-0-50µA	£3.40
100µA	£3.35
100-0-100µA	£3.35
500µA	£3.30
1mA	£3.15
5V d.c.	£3.10
50V d.c.	£3.10
300V d.c.	£3.10
1 amp. d.c.	£3.10

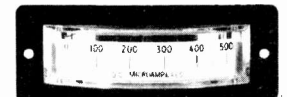


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100µA	£3.00
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50V d.c.	£2.90
300V d.c.	£2.90
1 amp. d.c.	£2.90
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50-0-50µA	£3.05
100µA	£3.00
100-0-100µA	£3.00
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1mA	£2.90
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1mA	£2.60
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50V d.c.	£2.60
300V d.c.	£2.60
1 amp. d.c.	£2.60
50µA	£2.80
50-0-50µA	£2.80
100µA	£2.75
100-0-100µA	£2.75
500µA	£2.70
1mA	£2.60
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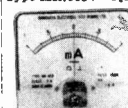


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10-0-1mA	£3.90
5mA	£3.90
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100µA	£3.00
100-0-100µA	£2.95
500µA	£2.85
1mA	£2.80
10-0-1mA	£2.80
5mA	£2.80
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### TYPE MR.65P. 3 1/2 in. x 3 1/2 in. Fronts

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100µA	£3.15
100-0-100µA	£3.10
500µA	£3.05
1mA	£2.95
10-0-1mA	£2.95
5mA	£2.90
10mA	£2.90
50µA	£3.70
50-0-50µA	£3.15
100µA	£3.15
100-0-100µA	£3.10
500µA	£3.05
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10V d.c.	£2.25
15V d.c.	£2.25
20V d.c.	£2.25
50V d.c.	£2.25
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300V d.c.	£2.25
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1-0-1mA	£2.25
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100-0-100µA	£2.50
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5mA	£2.40
10mA	£2.40
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100µA	£2.60
100-0-100µA	£2.50
500µA	£2.40
1mA	£2.40
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10V d.c.	£2.60
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100-0-100µA	£3.00
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10mA	£2.60
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50-0-50µA	£3.05
100µA	£3.00
100-0-100µA	£3.00
500µA	£2.70
1mA	£2.60
1-0-1mA	£2.60
5mA	£2.60
10mA	£2.60
50µA	£4.60
50-0-50µA	£3.05
100µA	£3.00
100-0-100µA	£3.00
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50V d.c.	£3.00
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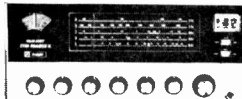
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BFO Built-in Speaker 220/240V  
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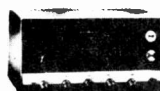
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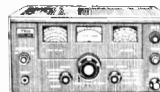
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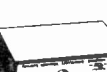
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with in-  
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built in ampli-  
fiers giving 22  
+ 22W r.m.s.  
output. Push-  
button track  
selector. Illu-  
minated track indicators, slider  
controls for volume, balance and  
tone. Attractive cabinet with  
black and silver trim. Output  
impedance 8 ohms. 220/240V a.c.

**OUR PRICE £17.25** P. & P. 50p, plus V.A.T.

### AHP8D 8 TRACK STEREO TAPE DECK

Can be used  
with most hi-fi  
amplifiers.  
Push button  
track selector  
and illuminated  
track indicators. Attractive  
cabinet with black and silver trim.  
Output level 750mV. 220/240V a.c.

**OUR PRICE £11.95** P. & P. 50p, plus V.A.T.

### STEREO HEADPHONES

LSH20. Individual  
volume controls.  
Stereo mono switch.  
8 ohms. 40-  
19,000Hz.  
£3.50 P. & P. 30p

LSH30. Open back  
type. Individual  
tone and volume  
controls. 8 ohms.  
30-20,000Hz.  
£5.50 P. & P. 30p

LSH40. Two way  
speaker system.  
Individual volume  
controls. 8 ohms.  
20-20,000Hz.  
£6.95 P. & P. 30p

LSH60. 3in speaker  
units. 8 ohms.  
20-20,000Hz. Com-  
plete with zipped  
carrying case.  
£8.50 P. & P. 30p

LQ1400. 4-channel  
dynamic head-  
phones. Each ear-  
piece has 4 drive  
units. 4-32 ohms.  
20-20,000Hz.  
£9.95 P. & P. 30p

LSH50. Electro-  
static with self  
powered energiser  
and control unit  
with headphone/  
speaker selector.  
4-32 ohms. 20-  
24,000 Hz.  
£15.95 P. & P. 30p

## RANGE OF HIGH QUALITY EQUIPMENT

### DOLBY 'B' NOISE REDUCTION UNITS



Reduce tape hiss by 3dB at  
600Hz, 6dB at 1200Hz and 10dB  
for all frequencies above 3000Hz.  
Size 16 1/2 in x 8 in x 3 1/2 in. a.c.  
00/250V2.

### PROCESS TWO

For use with cassette and tape  
recorders. Freq. res. 301Hz-  
20kHz-2dB. Off tape monitoring.  
Switchable multiplex filter. Two  
Dolby calibration meters. S/N  
better than 70dB.  
Supplied with test cassette or  
tape as required.

**OUR PRICE £34.50** P. & P. 50p

### PROCESS FOUR

For use with semi professional tape  
recorders. Freq. res. 30Hz-  
20kHz ±2dB. S/N better than  
70dB. Full source tape monitoring.  
Record/Replay metering. Switch-  
able multiplex filter. Supplied  
with test tape.

**OUR PRICE £50.00** P. & P. 50p

### ACR14 BATTERY MAINS CASSETTE RECORDER

Portable (two  
track) mono  
recorder with  
auto auto  
recording level  
control. Built  
in speaker.  
Ear piece  
socket. Input  
for radio or  
record player.  
Fast forward and rewind. Output  
500mW. 220/240V a.c. or 6V d.c.  
operation. Complete with remote  
control microphone, mains lead,  
earpiece and batteries.

**OUR PRICE £10.50** P. & P. 50p

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## AR1000 Sportsman AM/FM Portable

5 wavebands  
covering A.M.:  
535 - 1065kHz  
F.M.: 88-  
108MHz; A.I.R.:  
108 - 135MHz;  
P.B.: 147-  
174MHz; W.B.:  
162-5MHz Large  
horizontal slide  
dial with logging  
scale. Slider  
volume and  
switch controls.  
7 section tele-  
scopic aerial for F.M. and built in  
ferrite bar for A.M. A.P.C. 3in  
speaker. Earpiece socket. Green  
leatherette covered cabinet with  
metal slide panels. Size 15 1/2 x 7 1/2  
x 2 1/2 in. Battery/mains operation.  
**OUR PRICE £11.50** P. & P. 35p



## AMB500 MULTI BAND RADIO

5 wavebands  
covering MW 535  
- 1065kHz and  
F.M. 88-175MHz.  
All transistor.  
Battery or mains  
operation. Built-  
in aerial and 8  
section telescopic  
aerial. Complete  
with batteries,  
shoulder strap  
and earpiece.  
**OUR PRICE £6.95** P. & P. 35p



## AMR-9000 GLOBAL AM/FM PORTABLE

10 wavebands  
covering A.M.:  
535-1065kHz;  
L.W.: 150-350kHz;  
M.B.: 1.6-4.0MHz;  
S.W.1: 4.0-8.0MHz;  
S.W.2: 8.0-16MHz;  
S.W.3: 16-24MHz;  
P.S.B.1: 30-50MHz;  
P.S.B.2: 148-  
174MHz; F.M. 88-108MHz; A.I.R.:  
108-135MHz. Features time zone  
map and timing dial. Large clear  
scale. Telescopic aerial and built-  
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Battery/mains operation. Size  
3 1/2 x 13 1/2 x 3 1/2 in.



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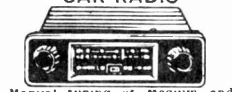
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CASSETTE TAPE HEAD CLEANER 30p each. P. & P. 50p.

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Manual tuning of Medium and  
Long waves. 12V pos. or neg.  
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mounting brackets and instructions.  
**OUR PRICE £6.50** P. & P. 50p

## ACP8 8-TRACK CAR PLAYER



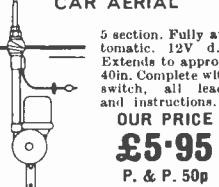
12V neg. earth. Slider controls for  
Volume, Tone and Balance.  
Channel selector button with pilot  
lamp. With speakers, mounting  
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Push button tuning of one LW  
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choice. 12V pos. or neg. earth.  
Complete with speaker, mounting  
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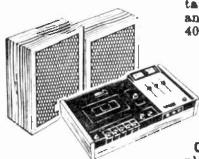
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5 section. Fully au-  
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Extends to approx.  
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For conventional or Chromium Dioxide tape. 4 track record/playback. Volume and tone controls. Frequency response 40-16kHz (using CrO2 tape), distortion better than 2%, wow and flutter better than 0.2% RMS. Complete with pair of matching Akai CS88 speakers. Rec. Price £96-10. OUR PRICE £56-50 P. & P. 50p.

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## RECORD DECK PACKAGES



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Complete unit with Stereo Carriage ready wired in plinth and cover.

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### B.S.R. McDONALD

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Super	£70-35
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Famous BSR 8 track chassis as used in Model T D 8 S complete with silver and black escutcheon ready to fit into cabinet. Output 125mV A.C. 240V. Overall size approx. 185 x 215 x 80mm.	
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## RECORD DECKS



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GL72	£25-45
GL72/P	£33-75
GL75	£32-20
GL75/P	£41-65
GL78 P/C	£35-25
GL85/P/C	£72-00

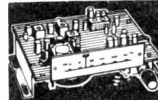
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Moving coil. Headphone imp. 16 ohms. Mike imp. 200 ohms. Ideal for language teaching, communications etc. Complete with leads and plugs.	
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Sensitive magnetic headset with soft earpads. Impedance 2,500 ohms (d.c. 500 ohms). Frequency response 200-4,000 Hz.	
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6 TRANSISTOR HIGH QUALITY TUNER. SIZE ONLY 6in x 4in x 2 1/2in 3 I.F. stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9V battery. Coverage 88-108MHz. Ready built ready for use.

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### FERGUSON EXPORT MODELS



## 3408 STEREO TUNER AMP.

Covers FM 88-108 MHz. Five push button tuning scales. 8+8 watts rms. Inputs for stereo ceramic cartridge and tape, etc. Separate bass, treble, balance and volume controls.

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4 track. 7 1/2, 3 1/2, 1 1/2 i.p.s. Stereo/mono record/play. 7in reels. Inputs for dynamic mikes, radio gram. Complete with cover.

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Outstanding value. Soft earpads, adjustable headband. 8-16 ohms. 20-20,000 Hz. Complete with lead and stereo plug.	
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4 speed autochanger unit fitted with stereo ceramic cartridge.

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4 speed single record player fitted with Acos GP104 stereo ceramic cartridge.

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Model No.	Description	RRP Excluding V.A.T.	V.A.T.	Total RRP incl'd. V.A.T.
AF20	Mono Transistor Amplifier	4.80	0.48	5.28
AF30	Mono Transistor Pre-Amplifier	2.61	0.26	2.87
AF310	Mono Amplifier (for Stereo use two)	5.91	0.59	6.50
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AT70	Photo Cell Switching Unit	5.70	0.57	6.27
AT50	400W Triac Light Dimmer Speed Control	4.80	0.48	5.28
AT55	1,300W Triac Light Dimmer Speed Control	5.70	0.57	6.27
AT56	2,200W Triac Light Dimmer Speed Control	6.90	0.69	7.59
AT60	Psychedelic Light Control, Single Channel	7.80	0.78	8.58
AT65	Psychedelic Light Control, 3 Channel	14.55	1.45	16.00
HF61	Medium Wave Transistor Radio	3.33	0.33	3.66
HF75	F.M. Transistor Receiver	2.88	0.28	3.16
HF310	F.M. Tuner Unit	15.81	1.58	17.39
HF325	De-Luxe F.M. Tuner Unit	24.12	2.41	26.53
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HF395	Aerial Amplifier for AM/FM Bands I, II and III	1.77	0.17	1.94
GP310	Stereo Pre-Amp to use with 2, AF310	21.27	2.12	23.39
GU330	Tremolo Unit for guitars, etc.	7.50	0.75	8.25
NT10	Power Supply 100mA 9V Stabilised, 12V Unstabilised	6.15	0.61	6.76
NT300	Professional Stabilised Power Supply 2 x 30V, 2.2A	12.51	1.25	13.76
NT305	Transistor Converter 12/15V, a.c./d.c. to 6V, 7.5V, or 9V d.c.	4.50	0.45	4.95
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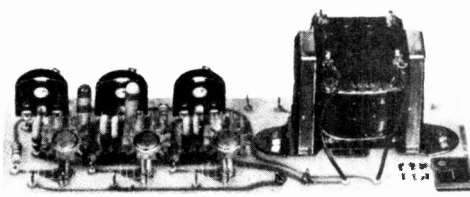
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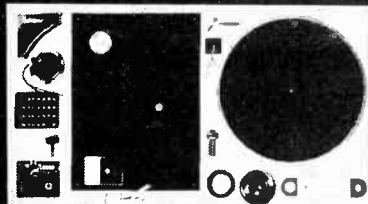
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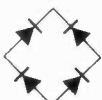
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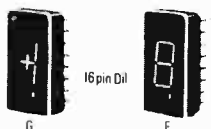
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33in x 33in	26p 23p
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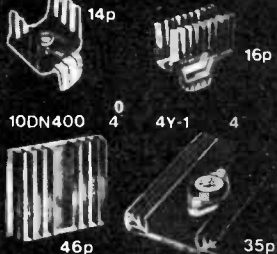
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# CHROMASONIC electronics

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1/2 watt	Carbon Film	±5%	E24 Series 510 to 330KΩ	11p
1 watt	Metal Oxide Film	±2%	E24 Series 100 to 1MΩ	41p
1 watt	Cermet Thick Film	±2%	E12 Series 560 to 150KΩ	8p
1 watt	Carbon Film	±5%	E24 Series 100 to 10MΩ	14p
1 watt	Carbon Composition	±0.5Ω	2.2Ω, 2.7Ω, 3.3Ω, 3.9Ω, 4.7Ω	44p
1 watt	Carbon Composition	±0.5Ω	5.6Ω, 6.8Ω, 8.2Ω	54p
1 watt	Carbon Film	±10%	E12 Series 100 to 10MΩ	3p
2 watt	Carbon Film	±5%	E12 Series 100 to 10MΩ	6p
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2 1/2 watt	Wire Wound	±10%	E12 Series 10 to 270Ω	10p
5 watt	Wire Wound	±5%	E12 Series 0.5Ω to 8.2KΩ	10p
10 watt	Wire Wound	±5%	E12 Series 0.5Ω to 6.8KΩ	11p
15 watt	Wire Wound	±5%	10KΩ, 15KΩ, 20KΩ, 25KΩ	17p
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5p, 0.2μF, 63p.  
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0.033μF, 0.047μF, 33p, 0.068μF,  
5p, 0.1μF, 0.15μF, 41p, 0.22μF,  
12p, 0.33μF, 7p, 0.47μF, 9p, 0.68μF,  
12p, 1.0μF, 14p, 1.5μF, 22p,  
2.2μF, 26p.

## TRANSISTORS and DIODES

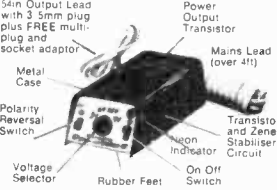
AC107	16p	AF179	71p	BC214L	11p	BF177	26p	BSX20	18p	TC144	46p
AC126	16p	AF236	41p	BC268	11p	BF178	26p	BSX21	22p	TC226D	91p
AC127	13p	ASV26	33p	BC327	26p	BF179	33p	BSY55A	13p	TP141A	81p
AC128	13p	BC107	9p	BC328	26p	BF180	33p	BU105	17p	TP42A	99p
AC176	15p	BC108	9p	BCY70	17p	BF181	35p	BU105/02	17p	TS143	36p
AC187	22p	BC109	9p	BCY72	17p	BF184	27p	D13V	53p	TS173	42p
AC187K	20p	BC114	153p	BC210	29p	BF185	27p	MAJ000	11p	TS191	33p
AC188	22p	BC117	22p	BC211	29p	BF194	15p	MAJ010	11p	TS197	16p
AC188K	20p	BC147	9p	BD115	74p	BF195	17p	MAJ540	52p	TS198	16p
ACV17	24p	BC148	9p	BD133	42p	BF196	16p	MAJ255	36p	TS208	16p
ACV18	21p	BC149	9p	BD131	42p	BF197	16p	MAJ565	82p	TS214	24p
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AD162	25p	BC171	20p	BD137	57p	BF272	£1.21	OC28	33p	TS219	24p
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AF125	22p	BC184	9p	BF109	75p	BFX88	26p	OC81	13p	TS219	24p
AF126	22p	BC184L	9p	BF115	25p	BFY50	18p	OC83	22p	TS219	24p
AF127	22p	BC187	27p	BF160	25p	BFY51	18p	OC84	22p	TS219	24p
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P. & P. on all models 16p.

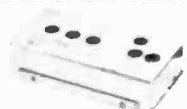
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All 5% tolerance

BZY88, 400mW, 3.3V to 33V	11p
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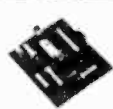
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20 - 20 Watt Amplified Stereo Amplifier Kit. Superb state-of-the-art design by engineers of Texas Instruments. £31-35 + P & P 49p.



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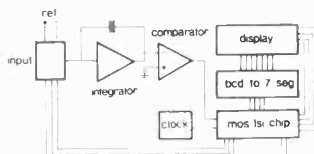
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MC1312 decodes CBS. SQ. Free leaflet No. 11 gives full circuit and details.

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709	34p	40p
710	35p	40p
711	45p	39p
723	45p	96p
741	45p	43p
747	42p	95p
748	42p	43p

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ZTX302 17p  
ZTX303 14p  
ZTX304 21p  
ZTX310 9p  
ZTX311 10p  
ZTX312 10p  
ZTX313 11p  
ZTX314 13p  
ZTX108 8p  
ZTX109 11p  
ZTX212 14p  
ZTX213 14p  
ZTX214 15p  
ZTX300 12p  
ZTX301 13p

ZTX450 17p  
ZTX501 13p  
ZTX502 17p  
ZTX503 14p  
ZTX504 43p  
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KSO30A Zener Series as BZY88 Series 11p each.

## ELECTROLYTICS

µF	4V	6.3V	10V	16V	25V	40V	63V	100V
1							6pF	8p
1.5							6pF	
2							6pF	
2.2							6pF	
3							6pF	
3.3							6pF	
4							6pF	
4.7							6pF	
6							6pF	
6.8							6pF	
10							6pF	9p
15							6pF	
22							6pF	
33							6pF	11p
47	6pF	6pF	6pF	6pF	6pF	6pF	6pF	
68	6pF	6pF	6pF	6pF	6pF	6pF	6pF	
100	6pF	6pF	6pF	6pF	6pF	6pF	6pF	
150	6pF	6pF	6pF	6pF	6pF	6pF	6pF	
220	6pF	6pF	6pF	6pF	6pF	6pF	6pF	
330	6pF	6pF	6pF	6pF	6pF	6pF	6pF	
470	6pF	6pF	6pF	6pF	6pF	6pF	6pF	
680	6pF	6pF	6pF	6pF	6pF	6pF	6pF	
1000	6pF	6pF	6pF	6pF	6pF	6pF	6pF	
1500	6pF	6pF	6pF	6pF	6pF	6pF	6pF	
2200	6pF	6pF	6pF	6pF	6pF	6pF	6pF	
3300	6pF	6pF	6pF	6pF	6pF	6pF	6pF	
4700	6pF	6pF	6pF	6pF	6pF	6pF	6pF	
6800	6pF	6pF	6pF	6pF	6pF	6pF	6pF	
10000	6pF	6pF	6pF	6pF	6pF	6pF	6pF	

## Potentiometers

5kΩ	250kΩ
10kΩ	500kΩ
25kΩ	1MΩ
50kΩ	2MΩ
100kΩ	

Log or lin less switch (and 1kΩ lin) 13p  
Log or lin with switch 26p  
Dual less switch 44p  
Dual with switch 10kΩ, 100kΩ and 1MΩ. log only 57p  
10kΩ log + 10kΩ antilog less switch 44p

10kΩ	Single
25kΩ	33p
50kΩ	Dual
100kΩ	55p

New Silver and Black Knob 16p

## Presets

Vertical or Horizontal  
0.1 watt 5p 0.25 watt 7p  
100Ω 1kΩ 10kΩ 100kΩ 1MΩ  
250Ω 2.5kΩ 25kΩ 250kΩ 2.5MΩ  
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CZ19	14p	VA1026	14p
E298DC A258	11p	VA1033	11p
E298ED A258	11p	VA1034	11p
E298ED A260	11p	VA1039	16p
E298ED A262	11p	VA1040	11p
E298ED A265	11p	VA1053	11p
E298ED P268	11p	VA1055S	11p
E298ZT 05	13p	VA1056S	11p
E298ZT 06	11p	VA1066S	11p
E298DD P336	11p	VA1067S	16p
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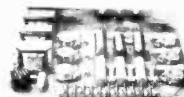


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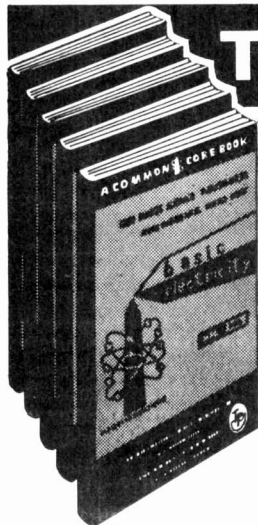
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8N7435N	43 43	37	8N7495N	7.5 7.0	6.3
8N7438AN	57 57	50	8N7496N	1.00 90	80
8N7437N	43 43	37	8N74100N	2.16 1.89	1.63
8N7438N	43 43	37	8N74104N	6.0 5.5	4.5
8N7438BN	57 57	50	8N74105N	6.0 5.5	4.5
8N7440N	20 18	16	8N74107N	5.1 5.1	4.5

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£p	£p	£p	£p	£p	£p
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AC107	35 BC182	12 BY127	15 OC44	18 ZTX108	10 2N3702
AC128	20 BCY32	85 BYZ13	35 OC45	18 ZTX300	14 2N3714
AC187	20 BCY39	1-00 C1060	35 OC71	15 ZTX302	18 2N3771
ACV17	35 BCY55	2-50 GET111	35 OC72	25 ZTX500	15 2N3773
ACV39	65 BCY70	15 GET115	75 OC77	55 ZG301	40 2N3790
AD149	50 BCY71	20 GET880	55 OC81	28 ZN697	15 2N3819
AD161	39 BCY72	13 LM309K	1-87 OC83	25 2N706	10 2N3866
AD162	39 BD124	80 MAT121	25 OC140	65 2N930	20 2N3903
AF117	20 BD131	45 MJE340	50 OC170	25 2N987	45 2N4062
AF118	50 BF115	22 MJE520	65 OC200	55 2N1132	25 2N4126
AF139	33 BF180	33 MJE305S	75 OC202	90 2N1304	22 2N4271
AF186	40 BF194	13 MPF105	46 OC271	1-00 2N1613	20 2N4547
AF239	44 BFX13	25 NKT217	45 OC215	55 2N1671	1-00 2N5001
AS271	30 BFX34	55 NKT404	60 OC260	45 2N2147	75 2N5026
BA115	10 BFX88	12 OA5	60 P346A	20 2N2160	69 2N5303
BAX13	5 BFY50	20 OA80	10 TIL209	25 2N2926	10 40250
BC107	12 BFY51	20 OA100	8 TIP29A	49 2N3053	20 40361
BC108	12 BFY64	45 CA202	10 TIP30A	58 2N3054	45 40412
BC109	12 BFY90	75 OC16	85 TIP31A	61 2N3055	45 40408
BC109C	14 BLY36	6-25 OC20	1-25 TIP41A	74 2N3440	50 40486
BC113	16 BSX20	15 OC28	65 TIP42A	90 2N3442	1-00 40636
BC147	12 BU105	2-20 OC35	55 TIS43	26 2N3525	80 40430

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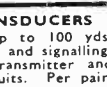
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723C (DIL)	90
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728C (T09)	45
741C (T05)	30
741C (DIL)	50
747C (T09)	1-00
747C (DIL)	1-00
748C (DIL)	61

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B025/05 50	16p
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B05/60 600V	27p

## 1/2 x 1/2 x 1/2 in. dia.

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B1/10 100V	25p
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B1/60 600V	30p

## 1/2 x 1/2 x 1/2 in. dia.

W005 50V	29p
W01 100V	30p
W02 200V	32p
W06 600V	35p

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B2/20 200V	45p
B2/60 600V	50p
B2/100 1000V	55p

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B6/10 100V	70p
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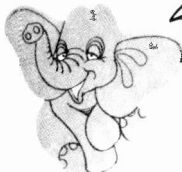
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Model 500 30k/V, £9.95

## OTHER EQUIPMENT

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TE15 Grid Dip Meter 440kHz—280MHz, £13.45.  
Carr. 30p  
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TE65 28 Range Valve Voltmeter, £19.25. Carr. 40p  
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Carr. 40p  
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Carr. 40p  
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Carr. 20p

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B2004 2 Ch. stereo mixer, £4.75. P. & P. 15p

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**PORTABLE MW/LW  
RADIO KIT** using Mullard  
RF/IF module. Features  
MW—bandspread for extra  
selectivity. Slow motion  
tuning. Fibre glass PVC cabinet. 600MW output.  
All parts £7.98 (battery 22p). Carr. etc. 32p.



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MW/LW Radio tuner to use with any amplifier.  
Features Mullard RF/IF module Ferrite aerial, built  
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## KITS BY



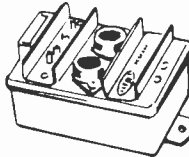
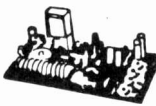
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GARRARD 2 speed 9 volt tape decks. Fitted record/  
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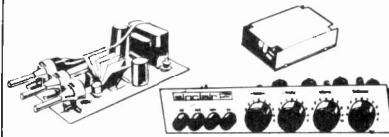
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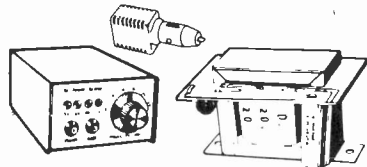
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**Henry's** RADIO  
LIMITED  
EDGWARE ROAD, W2

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AA5500	78.50
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AMSTRAD: IC2000 Mk. II	29.50
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TSA151	34.85
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Built	24.95
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PIONEER: TX500A	48.75
ROTEL: RT320	36.95
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SINCLAIR: 2000	26.95
3000	26.95
TELETON: GT202	30.50

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EAGLE: AA10	12.00
AA26	16.35

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TATE 3 Chassis	15.75
TATE 4	19.95
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Recommended pairs 8 ohms

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200, 20W	33.50 pair

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Linton 2, 20W	31.00 pair
Triton, 25W	37.75 pair

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150, 18W	33.50 pair
250, 18W	42.50 pair

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I20/20W	35.95 pair
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complete with speakers

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	19.95

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(With MW/FM stereo radio).	

### PORTABLE TV BATTERY—

### MAINS

(Carr./packing £1 00)	£
Elizabethan TV (9in)	43.50
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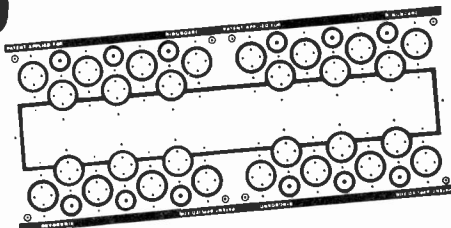
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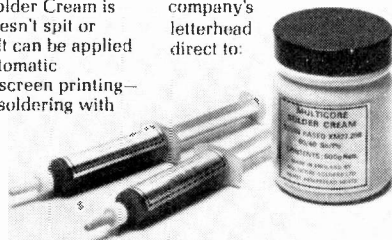
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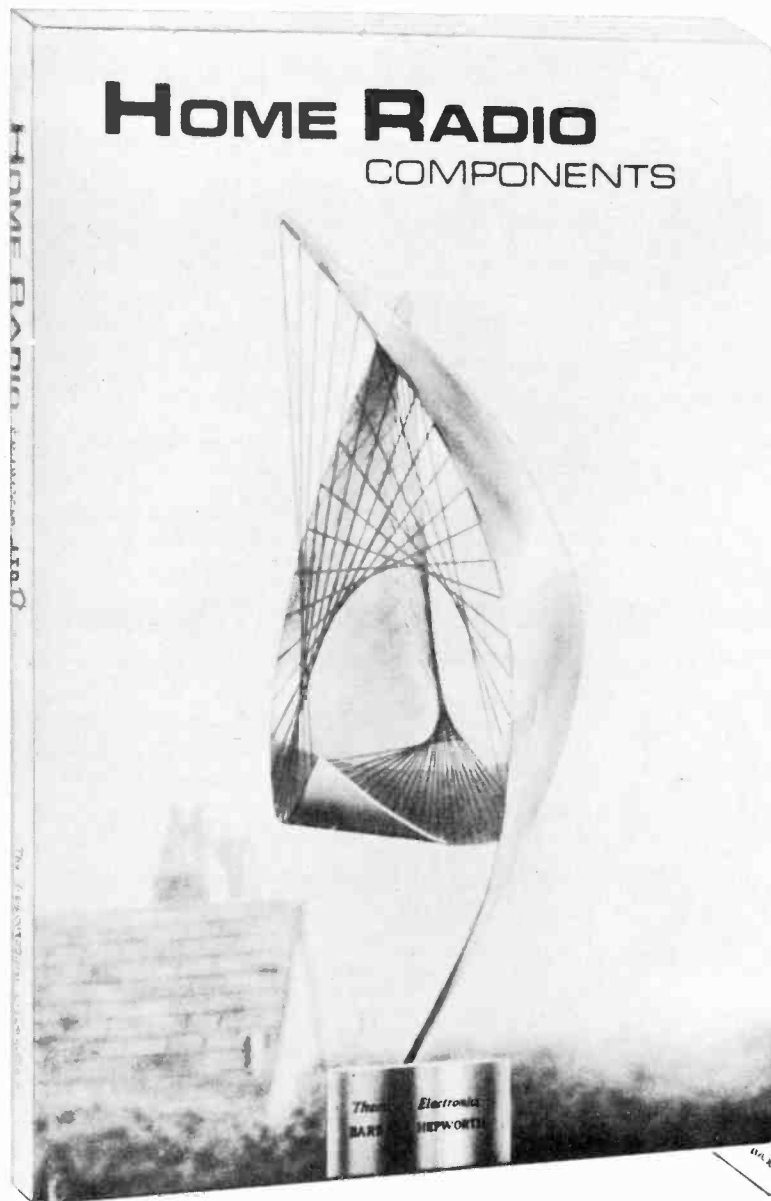
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No doubt the community spirit engendered through contacts established by wireless between individuals and groups was responsible for the rapid formation of wireless clubs throughout the country. On September 23, 1913 the London Wireless Club held its first general meeting in London. This was a momentous event, because this body was later to be reconstituted as the Radio Society of Great Britain.

At this time when the RSGB is celebrating its Diamond Jubilee, it is well to record the event and acknowledge the vital part this body has played in furthering the interests of the radio amateur, not only within the U.K., but on an international level as well.

It has to be admitted that, in the popular eye, the radio amateur has become typified as a somewhat odd character living for much of his time in a peculiar world of his own, peopled only by other kindred spirits identified by call signs rather than names. That he *can* become so totally engrossed in his hobby as to be oblivious of all other affairs is a fact that many wives and acquaintances will affirm! It is also a fact that in recent times he has succumbed more and more to the sophisticated products offered by the communications equipment manufacturers, and his chief role now is likely to be that of an operator of a radio station equipped largely with commercial apparatus.

Nowadays the opportunities for making significant contributions to radio science are limited. Commercial interests have always quickly and eagerly followed up past pioneering achievements by amateurs (often to the latter's ultimate cost). Exploitation of all kinds of radio communication with the very latest electronic techniques has for long been a prime concern of professionals working for industry and government agencies.

But the radio amateur still has his own fascinating hobby. No one who has experienced the thrill of that first over-the-air contact will dispute the attractive force of electromagnetic waves. When the bug bites, it usually bites deep. And, of course, not all amateurs are as single-minded as we might have suggested. Not for all the time, at any rate! Most are likely to be avid followers of electronics in its widest sense, and no doubt become involved from time to time in the building of equipment entirely foreign to a radio shack.

Today's amateur constructor and experimenter, whatever his field of specialisation within electronics, is continuing a fine tradition of individual enterprise where financial gain is not the goal; a tradition established by that pioneering band in the early days of wireless. We offer best wishes to the Radio Society of Great Britain and to their members, a fraternity which through usage over the last 60 odd years has acquired its own special kind of proprietary right to that honourable term "amateur."

F.E.B.

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# Semiconductor TESTER

BY J. H. PERKIN



**T**HE semiconductor tester is an invaluable aid to the experimenter since it allows him to not only detect faulty components in both building and servicing but to select or match components for specific circuit requirements and, bearing in mind the availability of untested components, purchase and sort such devices.

However, to effect all these usually requires a number of different instruments because of the inherent differences between the devices to be tested.

The present tester removes this objection to a great extent by being able to cope with a wide range of discrete components and identify their main parameters.

It was designed so as to be of low cost and reasonable ease of construction, to be portable and easy to operate, and of course to be as versatile as possible.

## SEMICONDUCTOR THEORY

### Transistors

These have the ability to provide current gain, i.e. the application of a small change in base current of a transistor gives a larger change in collector current, giving current amplification. This may be converted to voltage amplification by use of external components.

The magnitude of this amplification is referred to as  $h_{te}$  where:—

$$h_{te} = \frac{\text{The change in collector current}}{\text{The change in base current}}$$

Ideally, when no base current flows no collector current should flow but in fact this is not so in practice. Even when the base is completely disconnected a small amount of current flows in the collector/emitter circuit. This current is known as  $I_{ceo}$  or leakage current.

### Diodes

Basically a diode is a device which allows current to flow in one direction only. Again, as with

the transistor, such devices are not perfect and, under some conditions of applied voltage, current can indeed flow in either direction through a diode.

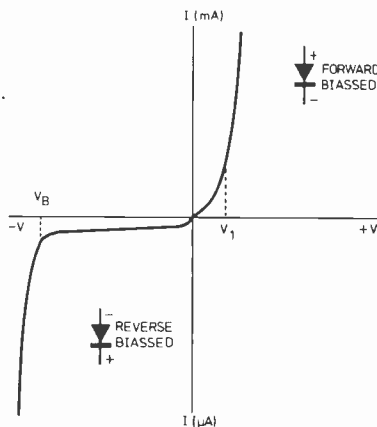
Fig. 1 shows the curve of current to voltage for a diode, identifying the two conditions of forward and reverse bias.

When the diode is forward-biased very little current flows until voltage  $V_1$  is reached. In practice the value of  $V_1$  depends very largely on the nature of the semiconductor. If it is germanium  $V_1$  will be 0.2 volts and if silicon it will be 0.6 volts.

Incidentally, this holds true of the base/emitter junction of a transistor.

When  $V_1$  is exceeded the current rises rapidly for small increases in voltage and the slope of the graph (a tangent to the line at any given point) is the forward a.c. resistance of the diode which is approximated by using the formula:—

$$R_{tac} = \frac{26}{I_e} \text{ where } I_e \text{ is the diode current in mA.}$$



**Fig. 1 Graph showing a typical voltage/current relationship for a diode**

When the diode is reverse-biased little current flows and it is called the leakage current. This increases as the breakdown voltage  $V_B$  is reached and exceeded. Above  $V_B$  the current increases rapidly for small increases in voltage.

This region of the curve is known as the Zener region and the slope of the curve in the Zener region is known as the a.c. resistance or  $R_{ac}$ .

### Thyristors

Basically a thyristor is an electrically controlled switch in which a small gate current can trigger a very much larger anode/cathode current. One drawback of this device is that once anode current is flowing it can be turned off only by either removing the voltage or breaking the circuit externally to the thyristor.

The current through the thyristor in its untriggered state is known as the leakage current,  $I_{l0}$  when the thyristor is forward-biased and  $I_{r0}$  when it is reverse biased.

The magnitude of the current required to "trigger" the thyristor via the gate is known as the "gate trigger current" and the magnitude of the current required to switch the thyristor "on" is known as the "gate trigger voltage," measured with respect to the cathode.

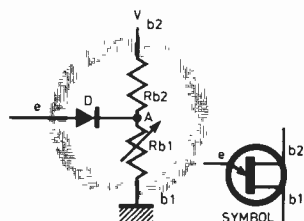


Fig. 2. Diagram of the equivalent circuit of a unijunction transistor with its usual symbol

As the current through a thyristor is reduced it reaches a state where further reduction would switch the thyristor "off." This level of current is known as the "holding" current.

### Unijunction Transistors

The diagram of Fig. 2 shows the pictorial representation of a unijunction transistor.

The voltage at point A with the emitter disconnected is given by the formula:—

$$\frac{V \times R_{b1}}{R_{b1} + R_{b2}}$$

where the ratio  $\frac{R_{b1}}{R_{b1} + R_{b2}}$  is known as  $\pi$ , the intrinsic standoff ratio (considering  $R_{b1}$  and  $R_{b2}$  in series).

The emitter connection is isolated from b2 and b1 unless the potential at the emitter (e) is greater than  $A + 0.6V$ , when the diode will be forward-biased and thus conduct. In this condition the resistance  $R_{b1}$  decreases and the voltage at A drops as the current increases, thus producing a negative resistance region.

A point is reached where the emitter current ceases,  $R_{b1}$  returns to its initial value and the diode is reverse-biased until it attains a sufficiently high potential for the process to repeat.

## CIRCUIT OPERATION

### Transistor Testing

The block diagram of the system used to test transistors is as shown in Fig 3. To measure  $I_{ceo}$  only a meter and a meter switch S2 (see Fig. 4 which is the complete circuit diagram) are used, and the meter monitors the current through the transistor with the base disconnected. R12 is a meter shunt which is switched out by the f.s.d.  $\div 20$  switch S4. (See Fig. 4.)

$h_{fe}$  is measured as follows. The output of a multi-vibrator consisting of components R1, R2, R3, R4, C1, C2, TR1, TR2, oscillating at approximately 400Hz is fed via R5 to a calibrated attenuator VR1 and also to the comparator circuit. VR1 is calibrated to read  $h_{fe}$  directly and R15 is included to expand the  $h_{fe}$  scale.

The attenuated oscillation from the slider of VR1 is fed via R19 which compensates for differing input impedances of the transistors to be checked. The signal is then fed via C5, a d.c. blocking capacitor through S1e and S2d to the base of the transistor under test.

The transistor connected in the common emitter mode amplifies and inverts the signal at its base. The amplified signal is fed via R7 and C4 to the base of TR3 where it combines with the non-inverted

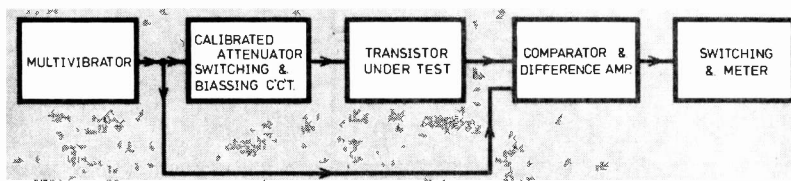


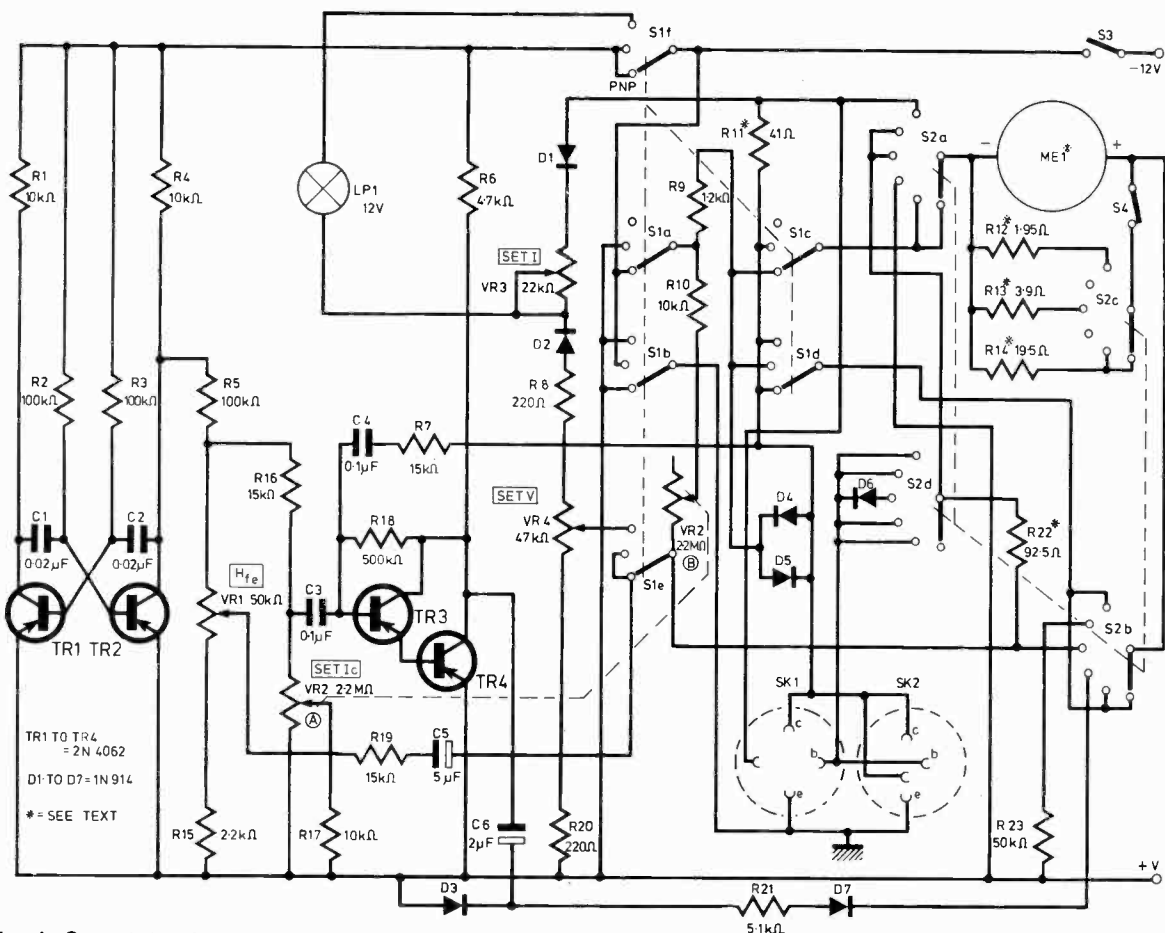
Fig. 3. Block diagram of the Semiconductor Tester as used to measure transistor characteristics

oscillation from the multivibrator which has been fed via R16 and C3; VR2a and R17 compensate for attenuation made by the network R19, VR2b and R10. If VR1 is correctly adjusted the two signals cancel at the base of TR3. Any uncanceled oscillation is amplified by TR3, TR4 and R6, R18 biasing TR3. The amplified signal is passed by C6 and R21, rectified by D7 and D3 and causes a deflection on the meter when the meter switch is set to  $h_{fe}$ . VR2 is set to the required no signal current in the transistor which is being checked. D4 and D5 provide a path for collector current when  $I_c$  is not being monitored.

### Diode and Zener Testing

Diode testing is accomplished by connecting the diode to the power supply through an internal resistor R11. The current through the diode is monitored by the meter both when the diode is forward and reverse biased. Reverse biasing is accomplished by reversing the polarity of the supply voltage.

The voltage across the diode can be measured by utilising a meter as a voltmeter, this is accomplished using the meter switch and a multiplier resistor R23, which converts the meter to read 25V f.s.d. The breakdown voltage (Zener voltage) of a Zener diode can be measured using the meter as a voltmeter. A



**Fig. 4. Complete circuit diagram of the Semi-conductor Tester.** The resistors marked with an asterisk are made from two or more in parallel. Switch S1 is shown in the PNP position and S2 in the  $I_{FO}$ ,  $I_{RO}$  position, other switch positions being shown right

## COMPONENTS . . .

### Resistors

R1	10k $\Omega$	R6	4.7k $\Omega$
R2	100k $\Omega$	R7	15k $\Omega$ 2%
R3	100k $\Omega$	R8	220 $\Omega$
R4	10k $\Omega$	R9	1.2k $\Omega$
R5	100k $\Omega$	R10	10k $\Omega$
R11	41 $\Omega$ (43 $\Omega$ 2% in parallel with 910 $\Omega$ 2%)		
R12	1.95 $\Omega$ (5.4 $\Omega$ in parallel with 5.1 $\Omega$ and 8.2 $\Omega$ all 2%)		
R13	3.9 $\Omega$ 2%		
R14	19.5 $\Omega$ (22 $\Omega$ 2% in parallel with 180 $\Omega$ 2%)		
R15	2.2k $\Omega$	R18	500k $\Omega$
R16	15k $\Omega$ 2%	R19	15k $\Omega$ 2%
R17	15k $\Omega$ 2%	R20	220 $\Omega$
R22	92.5 $\Omega$ (100 $\Omega$ 2% in parallel with 1.2k $\Omega$ 2%)		
R23	50k $\Omega$ 2%		

All  $\frac{1}{2}$ W 5% carbon unless otherwise stated

### Potentiometers

VR1	50k $\Omega$ log moulded track
VR2	2.2M $\Omega$ + 2.2M $\Omega$ linear double ganged
VR3	22k $\Omega$ linear
VR4	47k $\Omega$ linear

### Capacitors

C1, C2	0.02 $\mu$ F (2 off)	C5	5 $\mu$ F 25V elect
C3, C4	0.1 $\mu$ F (2 off)	C6	2 $\mu$ F 35V elect

### Diodes

D1 to D7 1N914 or similar (7 off)

### Transistors

TR1 to TR4 2N4062 or similar high gain pnp silicon (4 off)

### Switches

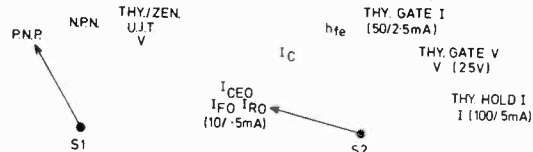
- S1 6-pole 3-way (R.S. Components Miniature Maka-switch. Shaft assembly plus 2  $\times$  4-pole 3-way wafers)
- S2 4-pole 6-way (Maka-switch shaft assembly plus 2  $\times$  2-pole 6-way wafers)
- S3 Single pole on/off
- S4 Single pole on/off biased on

### Plugs and sockets

- SK1 4 pin transistor socket
- SK2 3 pin DIN socket
- PL1-3 3 pin DIN plugs (3 off)

### Miscellaneous

- ME1 500 $\mu$ A f.s.d. (SEW type MR45P)
- LP1 12V 0.1A (with holder)
- B1, B2 6V PP1 or equivalent with battery connectors
- West Hyde MOD303 case with rubber feet
- Veroboard 3 $\frac{1}{2}$ in  $\times$  1 $\frac{1}{2}$ in 0.15in matrix
- 4BA  $\frac{1}{2}$ in bolts, nuts and washers (4 off)
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- Crocodile clips (7 off)
- Screened double cored cable (6ft)





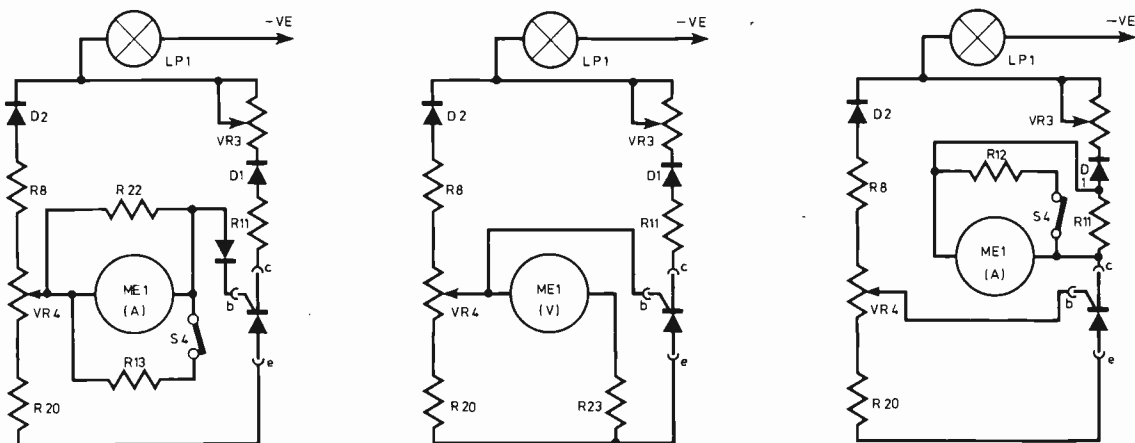


Fig. 5 (a) (left). The equivalent circuit when the switch is set to measure gate trigger current, (b) (centre) shows the switch in the gate trigger voltage position and (c) (right) in the holding current position

measure of  $R_{ac}$  and  $R_{tac}$  can be found by varying the current through the diode by adjusting VR3 and monitoring the change in voltage across the diode.

#### Thyristor testing

The circuits used in thyristor testing are as shown in Fig. 5a, b and c. The "gate trigger current" is found by increasing the voltage applied to the gate with respect to the cathode by adjusting VR4 until the thyristor switches on. The thyristor "ON" condition is indicated by the meter reading falling to zero and the lamp LP1, lighting (if VR3 is set to minimum resistance). R13 and R22 act as meter shunts and S4 is the f.s.d.  $\div 20$  switch. Diode D6 protects the meter from reverse currents which would flow through the meter when the thyristor is in the "ON" condition. The gate trigger voltage is found by setting the meter switch S2 so that the meter plus the multiplier resistor are connected across the gate and the positive supply line.

The leakage currents  $I_{to}$  and  $I_{ro}$  through the thyristor can be found in the same way as the leakage currents for *nnp* and *pnp* transistors.

Thyristor holding current is found by setting the meter switch to THY HOLD I which places the meter in the cathode circuit of the thyristor. Increasing VR4 (SET I) towards maximum decreases the current through the thyristor until a point is reached

where the thyristor switches off. The diodes D1 and D2 isolate the resistor line VR3, R8, VR4, R20 to 0V when the semiconductor tester is operating in the *pnp* or *nnp* mode. Resistors R11 and R12 act as meter shunts giving two holding current ranges of 5mA and 100mA.

#### Unijunction Testing

The basic circuit used to test unijunction transistors is shown in Fig. 6. The voltage with respect to base of the emitter can be increased by VR4 (SET V) by adjusting it from maximum to minimum until at a certain point the unijunction and the semiconductor components behave as an oscillator; this point is indicated by a rise in the meter voltage.

#### Voltmeter and Ammeter

The above semiconductor tester components are used in this mode of operation. Resistor R23 acts as a meter multiplier.

When the meter switch is set to THY HOLD I the meter can be used as a two range ammeter when the ammeter plug is used, R11 and R12 acting as meter shunts.

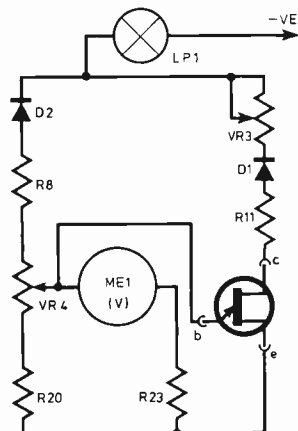
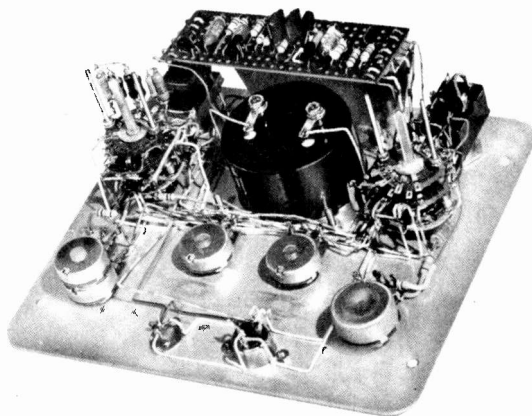


Fig. 6. The circuit used when the switches are set to measure intrinsic standoff ratio



Next month: Constructional details and operating instructions.

## Automobile Integrated Circuit



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

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

JUST coming on to the market are two integrated circuits from Fairchild, both designed with the Automobile market in mind. The first is the  $\mu A7350$  a complete tachometer subsystem, and the second is a triple operational amplifier, the  $\mu A7351$ .

The  $\mu A7350$  is a monolithic i.c. which includes a tachometer, an operational amplifier and two comparators. The tachometer produces fixed width pulses at the zero crossings of a ground reference a.c. input signal.

Each pulse width is individually determined by the choice of an external resistor and capacitor. The output stage of the tachometer section is a common emitter *npn* transistor with an uncommitted collector.

The operational amplifier and comparators are of identical design except that the comparators have no provision for external compensation. Their output stages consist of class A *pnp* amplifiers with uncommitted collectors which allow a variety of loads for general purpose applications.

In addition, the outputs of the comparators may be wired-OR for use as a dual level sense device.

Typical applications of this chip include over- and under-speed and frequency sensing, servo control, tone detection and a variety of timing functions.

Power requirements can be met by a single or a dual supply with an absolute supply voltage maximum of 24V. The chip is short-circuit protected.

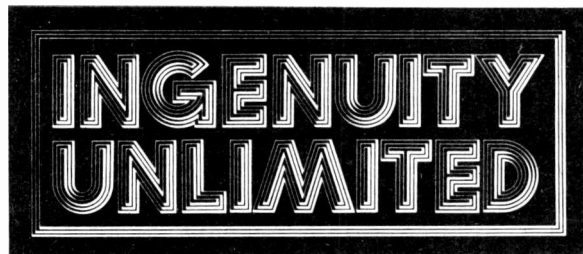
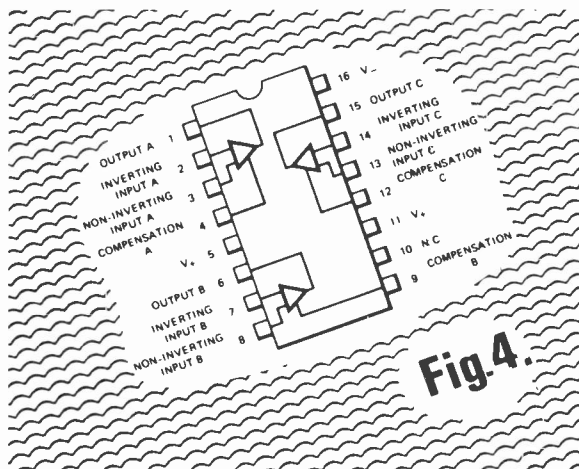
Figure 1 shows the block schematic of the 7350 whilst Fig. 2 is a circuit of the tachometer section in application.  $R_A$  and  $R_B$  are 27k $\Omega$  and  $C_A$  and  $C_B$  are 5.670pF (all at 1%) for an output pulse width of between 900 $\mu$ s and 110 $\mu$ s. Fig. 2b shows the output in graphic form.

Figure 3 shows the block diagram of a complete system.

### TRIPLE OPERATIONAL AMPLIFIER

The second i.c. the  $\mu A7351$  shown in block form in Fig. 4, is again a monolithic device carrying three identical operational amplifiers. Each two-stage amplifier uses a class A *pnp* common emitter output stage with an uncommitted collector, providing a variety of loads for general-purpose applications.

The chip is designed specifically to operate from a single supply and is thus ideal for automotive applications or any portable battery-type environment. In fact, the power requirements run from +4V to +16V single supply or  $\pm 2V$  to  $\pm 8V$  double.



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

### SERIES REGULATOR

IN Fig. 1, the operational amplifier acts as a differential amplifier controlling the base current of the Darlington pair arrangement in series with  $V_{in}$ . The Darlington pair used came in one package (TIP140). This has a high gain and a current capability of 10A.

TR2 across R2 acts as a current limit. When the voltage across R2 is greater than  $V_{BE}$  of TR2, it will conduct and cause TR1 to turn off until the voltage across R2 is equal to  $V_{BE}$ .

The present circuit is capable of withstanding a continuous short circuit across its output. The line voltage used was 12V and was adjusted for 5V output. The circuit will regulate the output to 5V from anything from the maximum operating voltage of the op-amp down to 7V.

A very simple input can be used consisting of just a transformer, bridge rectifier and smoothing capacitor.

A. Belka,  
Bletchley.

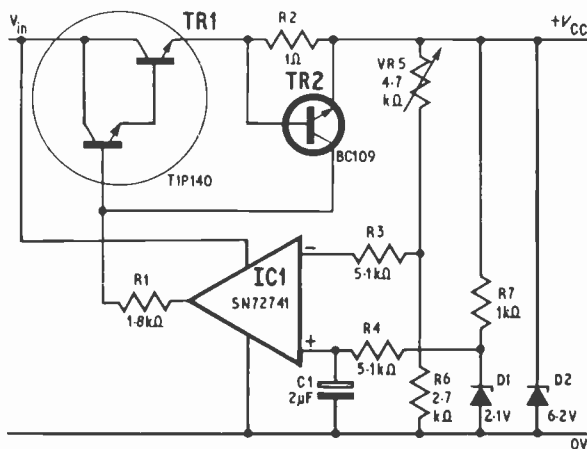
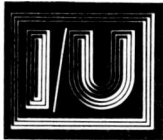


Fig. 1. Circuit diagram of Series Regulator using a Darlington pair transistor



## EVENTS TIMER WITH READOUT

THE TIMER in Fig. 1 uses an electromechanical readout device which is not capable of actuating faster than 10 times per second. Thus the speed of operation is similarly limited.

In basis, an oscillator section, TR1 and TR2 form a multivibrator which can run at 1 or 10Hz dependent on the selection of C1 and C3 or C2 and C4.

Thus C1 and C3 are made 10 $\mu$ F for 10Hz and R2, R3 about 7k $\Omega$  each. The exact value is adjusted by VR1. A lower value of C1, C3 may be necessary as the voltage change produced at the base of TR3 may be insufficient to turn the counter off.

For the second range S1 is switched to bring in C2, C4, 100 $\mu$ F to give a frequency of 1Hz and again VR1 may need to be adjusted.

In practice capacitance adjustment was found to be much better than varying R2, R3 as too high a value for these resistors when lowering the frequency can reduce the voltage at the base of TR3 too far.

The output via TR3 is straightforward; a positive pulse at the base causes a large change in voltage at the emitter to activate the counter.

The diode D1 deals with back e.m.f. induced in the counter coil.

Basically the current drawn depends on the counter coil resistance as very little is drawn by TR1 and TR2. Indeed this can be further reduced by increasing R1, 4.

Several counters are available but if the resistance falls below 500 $\Omega$ , R5 should be reduced, increasing current drain.

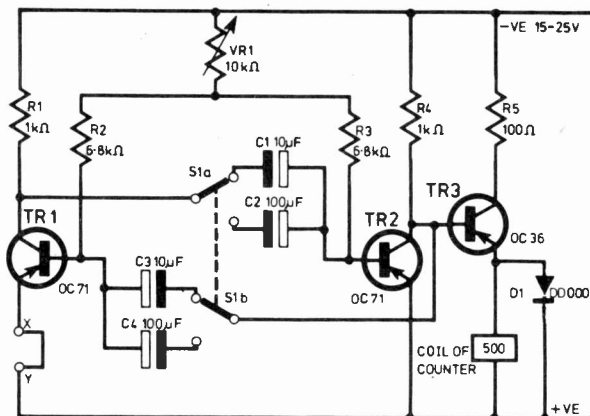


Fig. 1. Events Timer with Readout

For accuracy of timing the supply should be stabilised. Calibration could be by comparison with the Greenwich "pips" and resetting is not needed if a note is made of the reading each time it is used.

If it is required to synchronise the timer to some event such as a photocell switch then the trigger should be connected between X and Y in the emitter lead of TR1. This holds one capacitor discharged when the circuit is not oscillating so as to ensure fast and short-lived events can be handled.

Accuracy is not up to crystal-controlled standards and probably most applications will require only, say, about 5 per cent accuracy. However, the original exhibited a loss of only 3 seconds during one hour, an accuracy of better than 1 per cent.

G. Bachelor,  
Coventry.

## TWO-TONE AUDIO ALARM OSCILLATOR

FIGURE 1 shows the circuit diagram for a two-tone audio alarm oscillator, using two TTL i.c. packages.

IC1 is an SN7404N, its inverters wired in pairs to form three astable multivibrators, two oscillating at different audio frequencies, the other switching at a slow rate.

The output of one audio oscillator is gated with an output of the switching oscillator, the complementary output of the latter being separately gated with the second audio frequency. The two resultant outputs pass through a third gate, which drives a single transistor amplifier. The three NAND gates are contained in the SN7410 package.

If the two unused inputs to the first two gates are linked, a logical 1 at point X will cause the alarm to sound; a logical 0 turning it off. If these inputs are left open, the alarm sounds on connection of the power supply. The latter should be between 4.5 and 6V.

To alter the frequencies of the audio oscillators, change the values of C1 and C2; C5 and C6. Their associated resistors must NOT be altered.

This circuit was intended for use as an alarm in a digital clock, but for other purposes where a greater output is required a more powerful amplifier is needed.

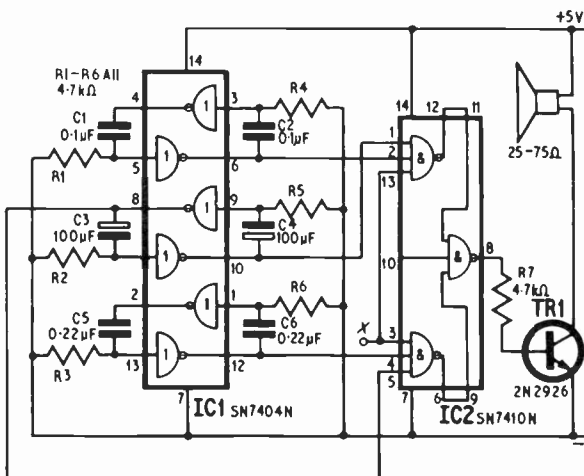


Fig. 1. Circuit diagram of the Two-tone Audio Alarm

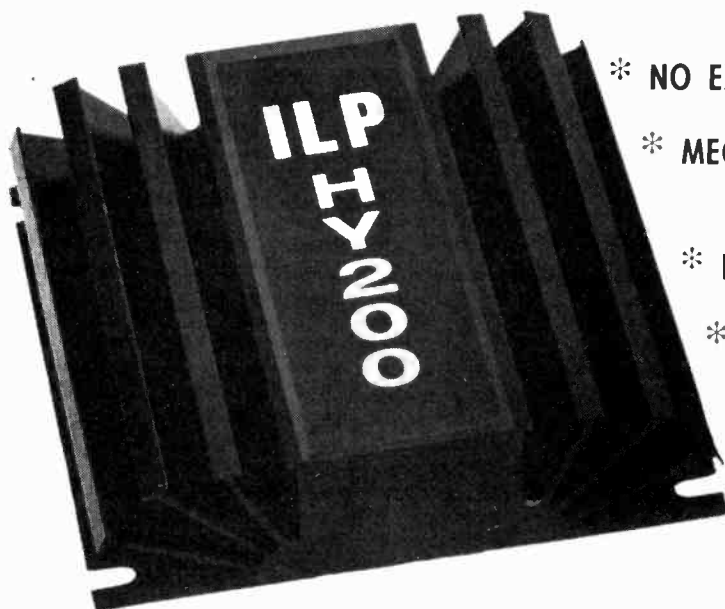
If a transformer is to be used to power the alarm, then its output must be Zener stabilised.

B. Woodland,  
London, S.W.6.



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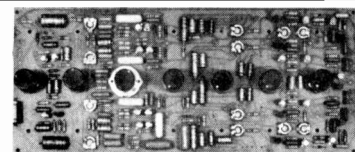
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**A. F. SIGNAL GENERATOR**  
(PE Nov. 72) S/c's, Rs, Cs, Pots, Sw's, PCB (2 1/2in x 4in) also holds Sw's, £3.15.

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DETAILS ON REQUEST

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(PE Nov. 70/Mar. 71) Stereo Sets & PCB's. Pre-amp—Rs, Cs, Pots, Maka-Sw's—with 1W MO Rs, £10.90—with 1W or 1W CF Rs, £8.90. PCB (3 1/2in x 10 1/2in) for sets with MO and 1W Rs, also holds rotary or slider pots and Maka-Sw's, £1.90. Main Amp—Rs, Cs, Pots, £5.20. PCB (3 1/2in x 5in), £1.15. PSU—Rs, Cs, Pot, £3.70. PCB (2in x 4in), 65p.

**LOGICAL RADIO CONTROL**  
(PE Apr./Jun. 72)—Details in lists

**GEMINI STEREO TUNER**  
(PE Apr./Jun. 72). Rs, Cs, Pot, £3.80. PCB as publ., £1.50.

**MICROPHONE MIXER**  
(PE Apr. 69). S/c's, Rs, Cs, Pots, £2.60. PCB (3 1/2in x 4 1/2in) also holds 6 rotary or 4 slider pots, £1.10.

### BIOLOGICAL AMPLIFIER

(PE Jan./Feb. 73). P/A Set—S/c's, i.c's, Rs, Cs, Pots, PCB (1 1/2in x 3 1/2in), £3.50. O/P Stages (S/c's, Rs, Cs, Pots and Sw's as req'd.), Alphaphone 53p, Cardiophone 66p, Freq. Meter £1.60, Vis-Feedback 55p. Audio Amp PC7 avail to order £5.20.

### ELECTRONIC PIANO

(PE Sep. 72/Jan. 73). PCB PRICES DOWN. Details in lists.

### MODEL SERVO CONTROL

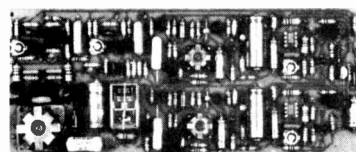
(PE Feb./Mar. 72)—Details in lists

### 8 WATT AMPLIFIER

(PW Nov./Dec. 72). Pre-amp—S/c's, Rs, Cs, Pots, Sw—Mono. £2.50; Stereo, £5.20. PCB (3 1/2in x 7 1/2in) (Stereo) also holds rotary or slider pots and Sw, £1.50. Main Amp—S/c's, Rs, Cs, Pot—Mono, £3.65; Stereo, £7.30. PCB (2 1/2in x 3in) Mono, 60p.

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### VIBRASONIC GUITAR

(PW Sept. 70). Incl. Mic P/A, 2-Guitar P/A, Trem and Tone Controls, Master Volume. S/c's, Rs, Cs, LDR, Rotary Pots, Lamp, Coupling T/fmr, £6.65. PSU, £2.80. PCB (3 1/2in x 10 1/2in) Mk. 2, also holds 7 rotary or slider pots, £1.75.

### ULTRASONIC

**TRANSMITTER-RECEIVER**  
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### ALSO

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DIGITAL PSU (PE Aug. 72), 50p  
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SCORPIO (PE Nov./Dec. 71), 60p  
TRIFFID (PE Feb. 73), 60p

### AND

DIGITRONIC (PW Mar. 73). Read-out PCB (1 1/2in x 3 1/2in), 60p.

### TAPE NOISE LIMITER

(PE Feb. 72). S/c's, Rs, Cs, Pot, PCB (1 1/2in x 3in), £2.20. Reg. PSU and PCB (1 1/2in x 2 1/2in), £3.10.

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(PE 1973)  
Details of PCB's & Components in lists. SOME PRICES DOWN.

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AC128	20p	ZTX531	22p
AC176	20p	2N706	13p
AD161	40p	2N914	22p
BC107	9p	2N1304	20p
BC108	9p	2N2905	23p
BC109	9p	2N2907	22p
BC147	11p	2N3702	10p
BC148	11p	2N3704	10p
BC149	11p	2N3823E	31p
BC157	12p	2N5777	40p
BC158	12p	IN914	4p
BC159	12p	IN4001	6p
BC204	14p	IN4002	7p
BCY71	22p	IN4004	8p
BFY51	16p	IN4005	10p
BSY95A	12p	BA145	17p
OC28	45p	OA91	7p
OC71	12p	OA200	6p
OC84	24p	Z1J	50p
OC912	48p	741s	36p
TIS4	24p	(8-p DIL)	
ZTX107	9p	µA7815	£2.47
ZTX503	14p	(TO3 can)	

### ELECTROLYTIC

1 0/63	6p	220 10	6p
2 2/63	6p	220 16	6p
4 7/63	6p	220 25	10p
10/25	6p	220 40	12p
10/63	6p	226 63	18p
15/40	6p	330 10	6p
22/10	6p	470 6.3	6p
22/25	6p	470 25	12p
33/16	6p	470 40	16p
33/16	6p	500/64	40p
33/16	6p	680/6.3	40p
33/40	6p	680/25	18p
47/6.3	6p	1000/10	12p
47/25	6p	1000/25	20p
47/40	6p	1000/40	40p
47/63	6p	2200/25	45p
100/10	6p	2200/40	50p
100/25	6p	3300/63	110p
100/40	6p	3300/100	£3
100/63	6p	4700/16	60p
150/16	6p	4700/25	75p
150/63	12p	4700/40	93p

### CAPACITORS

(μF/V)	TANTA BEAD
6p	0.1/35
10p	0.22/25
12p	0.47/35
18p	1.0/25
6p	1.0/35
6p	1.5/35
12p	2.2/16
16p	2.2/25
40p	2.2/35
10p	4.7/35
18p	10/16
12p	10/25
20p	15/6.3
40p	22/16
45p	47/6.3
50p	47/16
110p	
£3	
6p	
75p	
93p	
	RESIST
	1W 5% C

### POLYESTER

C280AE	3p
250V(µF)	3p
0.01	3p
0.022	3p
0.033	3p
0.047	3p
0.068	3p
0.1	4p
0.15	5p
0.22	5p
0.33	7p
0.47	9p
0.68	11p
1.0	14p

### POLYSTYRENE

63V 5% (pF)	3p
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3300 to 8200	4p
10000	5p

### RESISTORS (E24 SERIES)

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Reed Relay	85p
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### POTENTIOMETERS

Rotary:		Sliders—	
10k	12p	as and when available—	
Dual	40p	most popular values with PCB mounting pins.	
Preset:			
Knobtrim	or		
Mouldtrim			
100Ω to 470Ω			
1K to 1M	31p		
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Cermet Horiz.		Dual	60p
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## RED PLANET PROBES

MARS is again coming to the forefront of space exploration. With the two new probes from Russia now well on their way, the plans for the fly-by by the USA in 1976, and the final *Viking* missions of landing craft as a prelude to the manned missions in the next decade, there is much to be done in preparation. A number of problems will need to be resolved for distant direct control of landed vehicles. If it is the case that the Russians intend to land a similar vehicle on Mars as they did on the moon, then the control from a distance will be somewhat difficult. Even at a close approach between the earth and Mars the controllers will be seeing their vehicle on the surface as it was four minutes earlier. Any guidance or correction will take a similar time to reach operation points.

There will be some areas which, though of great scientific interest, are too hazardous for landings. It therefore follows that the majority of the experiments will be automatic. Already a number of ingenious instruments have been designed for the *Viking* landing craft. These will sample the soil for biological activity.

The very ambitious search for life on Mars can only begin with instrumental techniques. Even so the instruments devised will only work if the basic chemistry of any Martian life that there may be, is similar to the basic chemistry of earth life. Should it be of a different chemistry then it may well be that any realistic search for life will have to wait until the 1980's for manned exploration. No one has succeeded in establishing a model of life chemistry that is entirely different from the carbon based system of earth life.

The final goal must of course be by manned exploration. The *Apollo* missions to the moon have more than made this point. It is only by this means that it will be possible to determine the other puzzles that need to be resolved. For example whether life on Mars may have developed from non living chemicals and whether the apparently lifeless planet may once have enjoyed a rich variety of life that has disappeared. Any relics of this could only be determined by live exploration.

## SPECULATIONS

There are a number of people who believe that there was once an abundance of water on the planet, though it is dry today. It is therefore possible that any form of life that developed, when the conditions were warm and the climate resembled that of the earth, would have had millions of years in which to grow hardy. Sufficiently so, in fact, that as the vital gases in the



atmosphere escaped from the surface including water vapour, the life adapted to the severe conditions. As on earth the successive generations would exhibit the survival of the fittest and it could well be that there does exist a hardy plant life or something similar.

Some who have been thinking on these lines feel that with the possible colonisation of Mars the first platform will have been reached in space travel. Meanwhile Professor Carl Sagan has speculated that Mars is not dead but sleeping, and suggests that the climatic variations might well be extreme enough for there to be running water at times and the means for life, as we know it on earth, a possibility. These ideas are based on the presence of huge amounts of carbon dioxide frozen into the polar caps. Released as gas the density of the atmosphere would increase. The result could be a greenhouse effect which, with the prevailing meteorological conditions, could well support life.

## THE LUSTROUS PLANET

Venus will be having a visit from a USA probe in early 1978. This will be some 840 pounds in weight. When it arrives at Venus the four smaller vehicles will be ejected to penetrate the Venusian atmosphere. These four probes will consist of one large one with a 60 pound payload and three smaller ones of about 3 pounds. The big one will take about an hour and a half to reach the surface of the planet and the smaller ones about 75 minutes. The carrying vehicle will enter the atmosphere of the planet sending back data until it burns up. While all this is going on a sister probe will have been launched to arrive and orbit the planet at about the same time as the multiple probe. Thus the benefits of two observa-

tion vehicles will be available.

The discovery that there are vast vertical movements of the atmosphere of Venus presents another problem for astronomers. This pulsing of the clouds was detected by infra red telescopes. The indications are that the distance over which this pulsing takes place is about one kilometre.

At the present time there is no clue to the mechanism of this activity. Certainly enormous energy is indicated but where it originates is not known. Some further information may well be gathered by the spacecraft which will fly-by on its way to Mercury sometime next year.

## SOVIET AND FRENCH CO-OPERATION

The co-operation between France and Russia in some of the lunar activities is having a special orientation to geodesy. The laser reflectors, placed on the moon and on the earth in an attempt to measure accurate distances and changes, have provided important data. In consequence the techniques of this system has been developed to a stage where the satellites are to be brought into the picture.

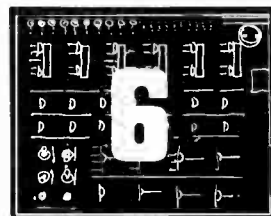
Next year a launch is planned for a special satellite which will carry 60 corner reflectors for use with laser beams. It will have a purely passive role to play being in fact an orbiting reflector with a known position. The satellite will be known as *Starlette* with reflectors that will be grouped in threes on the outer surface on twenty plates making a total of sixty. It will have a very high density of 18.7 to ensure good dynamic stability. It will be some 26cm in diameter and be made largely of uranium. The orbit will be 50 degrees at a height of between 800 and 1,000km. It is hoped that the accuracy of the measurements will be of the order of 20cm over a period of 12 hours.

## SKYLAB RESULTS

One of the principal activities designed for *Skylab* was the detailed photography of the Sun. The results obtained in the first mission have been rewarding. In fact it would seem that the same situation exists on this venture as on so many others in space exploration, namely that a whole new vista opens up. In the case of these preliminary solar results the films show detailed structure of the Sun's atmosphere and the special changes that have been brought about by the magnetic field and the plasma which streams out from the Sun. In the X-ray part of the spectrum many small flares that were observed, developed in a few seconds. None of this type of phenomenon is observed from the ground.

# LOGIC TUTOR EXPERIMENTS..

## WIRED OR



THE problem of last month was of rather a theoretical nature—to prove that the output of the four NAND gates (Fig. 5.4) was EXCLUSIVE OR. From the circuit layout and writing down the functions at each node we arrived at an output which was:

$$Q = \overline{\overline{A(\overline{A.B})}} + \overline{\overline{B(\overline{A.B})}}$$

The two double negatives cancel and we are left with:

$$Q = A(\overline{A.B}) + B(\overline{A.B})$$

By applying De Morgan's Theorem to the  $A.B$  terms we get

$$Q = A(\overline{A} + \overline{B}) + B(\overline{A} + \overline{B})$$

There is a rule in Boolean Algebra known as the Distributive Rule which allows us to expand bracketed functions—rather like multiplying out brackets in conventional algebra:

$$Q = A.\overline{A} + A.\overline{B} + B.\overline{A} + B.\overline{B}$$

But  $A.\overline{A}$  is always 0—if  $A$  is 1, NOT  $A$  must be 0; 1 AND 0 gives 0. We would get nought if  $A$  was nought and NOT  $A$  was one. Likewise  $B.\overline{B}$  is always 0; so our expression becomes:

$$Q = (0 + 0) + (A.\overline{B} + B.\overline{A})$$

Note we have changed the sequence of the terms—this is permitted by the Boolean Commutative Rule—and grouped the functions (Associative Rule). Nought OR nought is always nought so the expression now becomes:

$Q = (0 + A.\overline{B}) + B.\overline{A}$  (again we have done a bit of re-grouping) 0 OR  $A.B$  is always  $A.\overline{B}$ —you can prove this with a little truth table so we are left with the final expression that:

$Q = A.\overline{B} + B.\overline{A}$ —the EXCLUSIVE OR expression we arrived at last month.

### WIRED OR

The WIRED OR function is extremely valuable for economising on the number of gates used in a piece of equipment. To use the function you are limited to a logic type that uses passive pull up resistors in the output stages (such as DTL); it is not possible to apply the principle to conventional TTL gates which use the two output transistors in totem pole configuration but there are a number of TTL modules now available with open collectors and passive pull up which can be used. If you have made the Logic Tutor exactly as specified you will have used DTL and so can carry out this month's experiment; if you have used standard TTL please do not attempt the experiments as you will damage your gates.

Fig. 6.1. shows that WIRED OR is obtained by shorting together the outputs of two gates. If points  $X$  and  $Y$  were both at level 1 the output at node  $Q$  will obviously be 1.

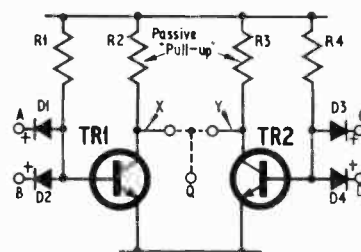


Fig. 6.1. The WIRED OR function is obtained by shorting the outputs of two NAND gates together

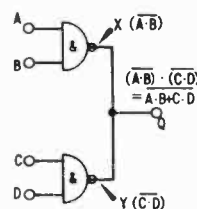


Fig. 6.2. The NAND gates showing the Boolean expressions at each node

If, however, the inputs  $A$  with  $B$  were such that  $TR1$  was non conducting (i.e. the output from the left hand gate wanted to go to 1) but the inputs  $C$  with  $D$  forced an output of 0 from the right hand gate the combined output  $Q$  will have to be 0 because  $TR2$  will act as a sink for current flowing through  $R2$ .

If you think about it you should see that the output  $Q$  has a level that can be specified by ANDing the levels the individual gates would have given had they not been connected together. If  $X$  wanted to be 1 but  $Y$  was 0  $Q$  is nought and vice versa.  $Q$  will be 1 only when both  $X$  and  $Y$  want to be 1. Thus shorting the outputs of two DTL gates together effectively gives an AND function between the two outputs—a logic function obtained with no extra gates.

It might seem strange to call this WIRED OR but the name is derived from the overall function from inputs  $A$  with  $B$  and  $C$  with  $D$  to the output  $Q$ . Fig. 6.2 shows the functions  $X$  and  $Y$  would like to go to and then shows these functions ANDed for the combined output. The final expression is an INVERTED OR of the ANDed forms of the two pairs of inputs.

This function could be obtained by using the basic logic gates shown in Fig. 6.3—AND followed by OR followed by INVERT. The effect produced by wiring together two outputs of two NANDS to give WIRED OR is sometimes called

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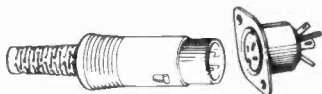
Other semiconductors: AC128, 17p; AF117, 32p; BFY51, 19p. Full lists and technical data will be found in Catalogue No. 6. See also amendments list.

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

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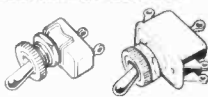
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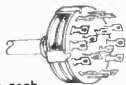


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4.7	—	—	—	10p	—	7p	8p	7p
10	—	—	7p	—	7p	8p	7p	8p
22	—	—	—	7p	—	—	7p	9p
47	7p	—	7p	8p	8p	7p	9p	12p
100	8p	7p	7p	7p	7p	9p	11p	19p
220	7p	8p	8p	8p	9p	10p	17p	27p
470	8p	9p	9p	10p	12p	17p	24p	43p
1,000	10p	12p	12p	17p	20p	24p	40p	—
2,200	14p	17p	22p	25p	36p	40p	—	—
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10,000	40p	43p	—	—	—	—	—	—

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Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99 (see note below)	100 up
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C	1/8W	5%	4.7 $\Omega$ –470K $\Omega$	E24	1	0.9	0.75 nett
C	1/4W	5%	4.7 $\Omega$ –10M $\Omega$	E12	1	0.9	0.75 nett
C	1/2W	5%	4.7 $\Omega$ –10M $\Omega$	E24	1	1	0.95 nett
C	1W	5%	4.7 $\Omega$ –10M $\Omega$	E12	2.5	1	1.6 nett
MO	1/2W	2%	10 $\Omega$ –1M $\Omega$	E24	4	3	2 nett
WW	1W	10%	1/20 $\Omega$ –3.9 $\Omega$	E12	7	7	6
WW	3W	5%	1 $\Omega$ –10K $\Omega$	E12	7	7	6
WW	7W	5%	1 $\Omega$ –10K $\Omega$	E12	9	9	8

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

WW = wire wound, Plessey.

Values:

E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82

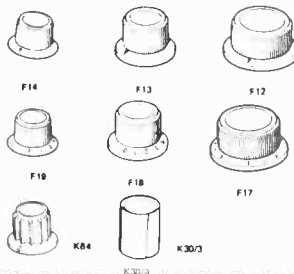
and their decades.

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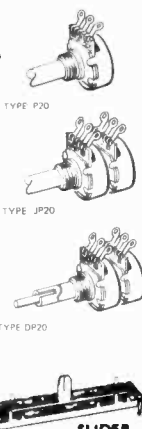
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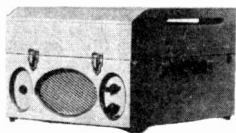


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Quality Control	<input type="checkbox"/>	Inst.	<input type="checkbox"/>
Salesmanship	<input type="checkbox"/>	Farm Science	<input type="checkbox"/>
Storekeeping	<input type="checkbox"/>	General Educat.	<input type="checkbox"/>
Work Study	<input type="checkbox"/>	Gen. Plastics	<input type="checkbox"/>
Works	<input type="checkbox"/>	Pract. Maths	<input type="checkbox"/>
Management	<input type="checkbox"/>	Pract. Slide Rule	<input type="checkbox"/>
<b>DRAUGHTSMANSHIP</b>	<input type="checkbox"/>	Pure & Applied	<input type="checkbox"/>
A.M.I.E.D.	<input type="checkbox"/>	Maths	<input type="checkbox"/>
Design of Elec.	<input type="checkbox"/>	Refrigeration	<input type="checkbox"/>
Machines	<input type="checkbox"/>	Rubber Tech.	<input type="checkbox"/>
Die & Press Tool	<input type="checkbox"/>	Sales Engineers	<input type="checkbox"/>
Design	<input type="checkbox"/>	Tech. Report	<input type="checkbox"/>
Electrical	<input type="checkbox"/>	Writing	<input type="checkbox"/>
Draughtsman-	<input type="checkbox"/>	Timber Trade	<input type="checkbox"/>
ship	<input type="checkbox"/>	University Ent.	<input type="checkbox"/>
Gen. Draughts-	<input type="checkbox"/>		
manship	<input type="checkbox"/>		
Jig & Tool Des.	<input type="checkbox"/>		
Techn. Drawing	<input type="checkbox"/>		
<b>RADIO &amp; TELE-</b>	<input type="checkbox"/>		
<b>COMMUNICATIONS</b>	<input type="checkbox"/>		
Colour TV	<input type="checkbox"/>		
C & G Radio/TV	<input type="checkbox"/>		
Electronics	<input type="checkbox"/>		
C & G Telecomm.	<input type="checkbox"/>		
Tech.	<input type="checkbox"/>		
Prac. Radio Elec.	<input type="checkbox"/>		
(with kit)	<input type="checkbox"/>		
Radio Amateurs	<input type="checkbox"/>		
Exam.	<input type="checkbox"/>		

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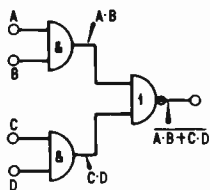


Fig. 6.3. Basic AND-OR-NOT configuration of circuit in Fig. 6.2 showing the economy effected by WIRED OR

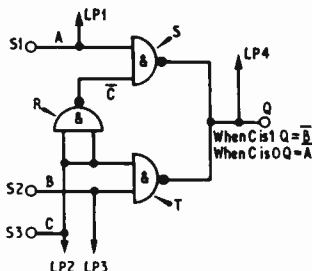


Fig. 6.4. Practical application of the AND-OR-NOT function for steering signals

an AND-OR-NOT gate—a frequently used function to enable two sources of digital waveforms to be selected alternately and fed (in an inverted form) into a common line.

Fig. 6.4 shows how you can demonstrate this on the Logic Tutor. The signal lines are A and B and digital waveforms can be simulated with switches S1 and S2; input C is the control line that selects the line we want to appear at the output Q. When C is 1 the output of gate S always wants to stay at 1 but the output of gate T wants to give an inverted form of input B. AND the output of S with that of T and you get B. Waggle S2 and you will see the inverted signal appear at the output but signals from S1 (line A) will be inhibited. Make C go to 0 and the signal from A will pass while that from B will be inhibited.

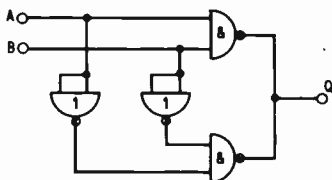


Fig. 6.5. The four gates plus the WIRED OR function in this circuit provide a well-known logic function. What is it?

Could you do this as economically without using the WIRED OR function? As an exercise try and sort out the logic of Fig. 6.5. The output of the gate configuration is quite well known; what is it?

by M. J. Hughes

Next month: The Half Adder.

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**PE**

# PERONDO PART 2

## AUDIO AMPLIFIERS

BY R.A. COLE

### PRE-AMPLIFIERS

### POWER AMPLIFIERS

### TONE AND BALANCE CONTROLS

**I**N the first part of the RONDO series we described the subject of quadraphonics in general, its abilities, and the various systems available. In addition the construction of a CBS SQ quadraphonic decoder was explained in detail. Now we come to the power and pre-amplifiers and tone controls.

The Rondo system shown in block diagram Fig. 1.15 in Part 1 of the series uses integrated circuits extensively throughout. There are a total of 13 in the basic system, of which eight are in the power amplifier, tone control and pre-amplifier stages. The balance are two in the f.m. tuner, one in the a.m. tuner, one in the stereo multiplex decoder and one in the CBS SQ matrix decoder. An additional four are required for the full logic enhancement board.

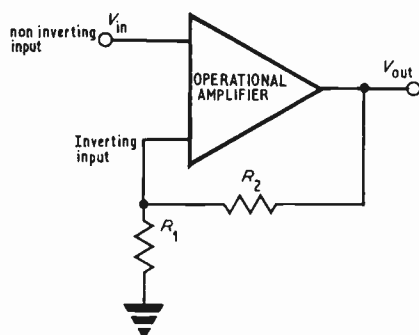


Fig. 2.1. Simplified schematic of an operational amplifier used in an audio application

Some of these integrated circuits perform specific complex functions, whilst others are used as "gain blocks". The eight used in the amplification stages fall in this latter category and are, in fact, operational amplifiers.

The Rondo power and pre-amplifiers use operational amplifiers of the 748 series which are available from many device manufacturers in a number of DIL and TO packages. The Rondo PC boards are drawn so as to accept either the 14 pin dual-in-line package or the 8 pin dual-in-line package.

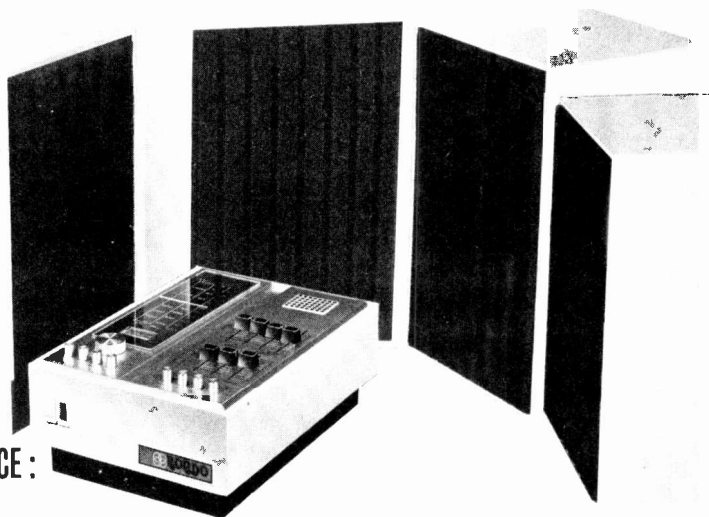
Operational amplifiers have a number of points in their favour in amplifier design. For example, they replace quite complex discrete voltage gain circuits and require only a few external components and they can operate from a balanced supply which permits d.c. connection of some stages, thus reducing the use of electrolytic capacitors.

As they have a very high mid-band gain they can be very accurately equalised and yet have a good loop gain margin for reducing distortion. An inherently high ripple rejection allows them to work well on unregulated power supplies and reduces the chances of l.f. instability so often found in stereo systems due to large circulating earth currents.

High input and low output impedances simplify the design of feedback networks and a good common mode rejection, the ability to ignore spurious voltages which appear at both inputs rather than the differential signal inputs, is advantageous.

Fig. 2.1 is a simplified schematic of a typical operational amplifier, showing the two inputs and its application to audio amplification. The closed loop gain is determined as follows

$$\frac{V_{OUT}}{V_{IN}} = \frac{R_1 + R_2}{R_1}$$



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### THE PRE-AMPLIFIERS

Two 748 operational amplifiers are used, one for each channel of the basic stereo system, one channel of which is shown in Fig. 2.3. The 748 (IC1) amplifies the incoming signal to around 100mV, whilst providing equalisations for the appropriate input signal.

There are four inputs selected by the selector switch bank.

The "Gram" input is compensated for RIAA disc characteristic, see Fig. 2.2, and requires an input of 3mV for full output. The compensation is carried out by the network R7, R9, C6, C7.

The other three inputs have a linear response, the gain of which is set by R8.

It will be noted that R7, which is in fact part of the RIAA network, is permanently in circuit. This is to reduce the switching transient caused by open-circuiting the feedback loop when using push-button switches. These switches are break-before-make types and if this precaution is not observed a momentary, but startling, screech will ensue. R7 and R8 are in parallel for all linear response inputs but as R7 is very large in comparison with R8 the resultant value is virtually the same as R8.

An output from the i.c. is taken via a 0.22 $\mu$ F capacitor from each channel to provide an isolated signal (prior to volume and tone controls) for tape recording.

### TONE CONTROL, VOLUME AND BALANCING

The tone controls, also shown in Fig. 2.3, are of the standard Baxandall type. The 748 integrated circuit IC2 provides the necessary loop gain requirements. There is only small interaction between the bass and treble controls and R12, R15 and R11, R14 provide the end stops for bass and treble controls respectively and limit their range (see Fig. 2.4).

A 10 $\mu$ F tantalum capacitor C11 is used at the output of the tone control stage before the master volume control. As the output voltage of the i.c. depends upon the input offset voltage, it can be of

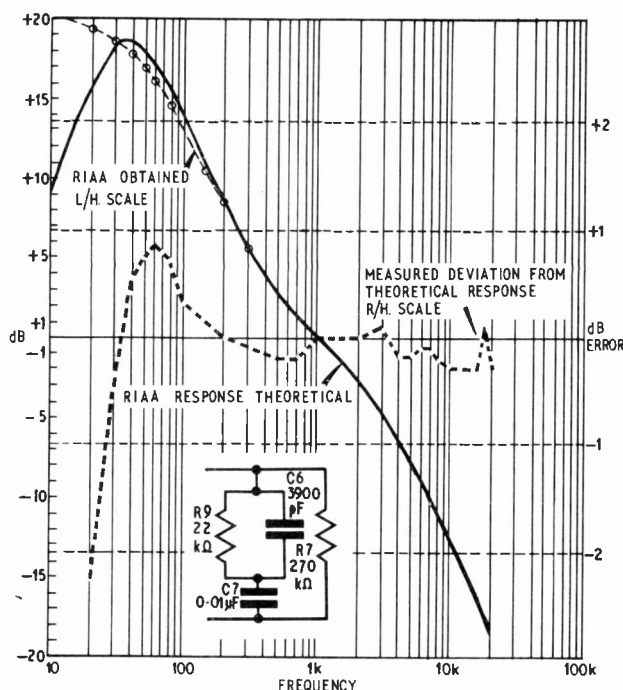
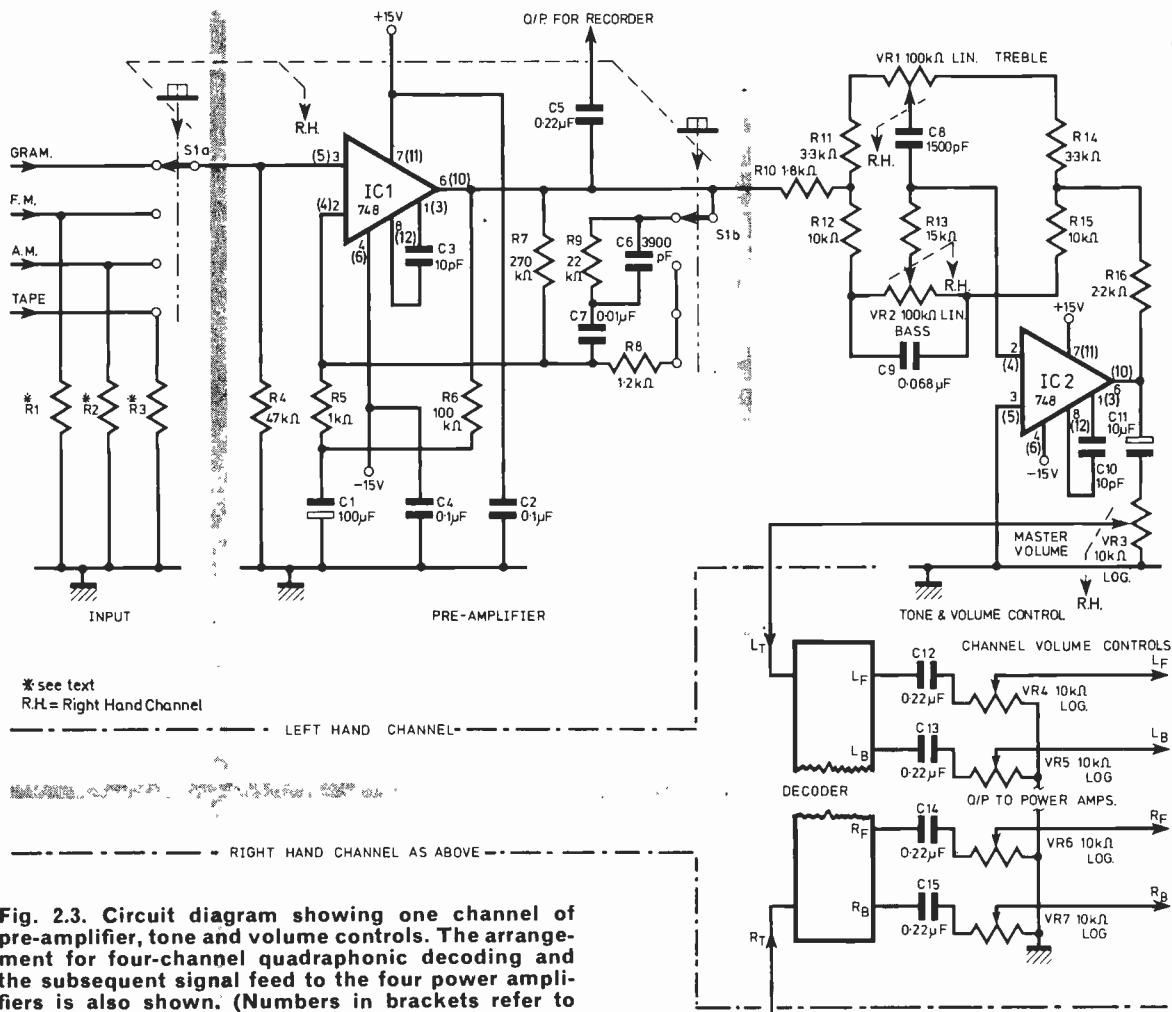
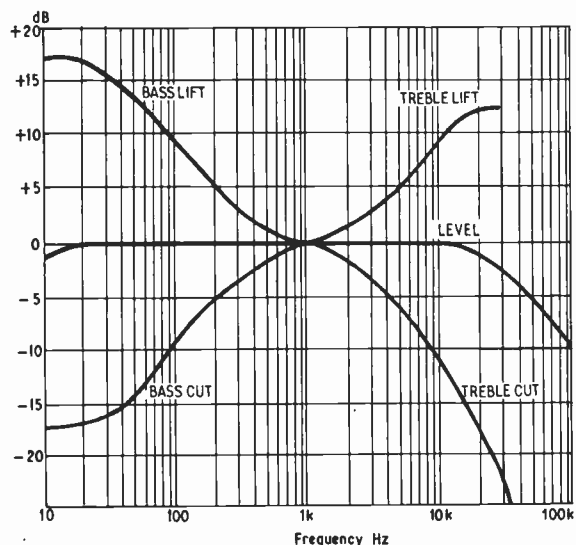


Fig. 2.2. Graphic representation of the playback response obtained for RIAA correction in disc playback and the filter network used



**Fig. 2.3.** Circuit diagram showing one channel of pre-amplifier, tone and volume controls. The arrangement for four-channel quadraphonic decoding and the subsequent signal feed to the four power amplifiers is also shown. (Numbers in brackets refer to 14-pin i.c.)



**Fig. 2.4.** Overall response of each tone control circuit

either polarity. The tantalum capacitor can withstand the maximum reverse polarity likely to be reached at any setting of the controls.

Fig. 2.5d shows a 1kHz square wave response of the pre-amplifier combined with the tone control stage with controls set level.

Signals have been processed as stereo signals up to the output from the master volume control. The signals are now passed through the quadraphonic decoder and are henceforth four channel signals; these pass, via 0.22μF capacitors C12 to C15, through the four balance controls VR4-VR7 to the power amplifiers.

The balance controls provide total control over the level of each of the four channels and each can be faded to zero independently. This is considered to be superior to the normal left-right and front-back balance controls as fully independent control of each channel is far more flexible and fine control of low level listening can be obtained using the full swing of the master volume control VR3.





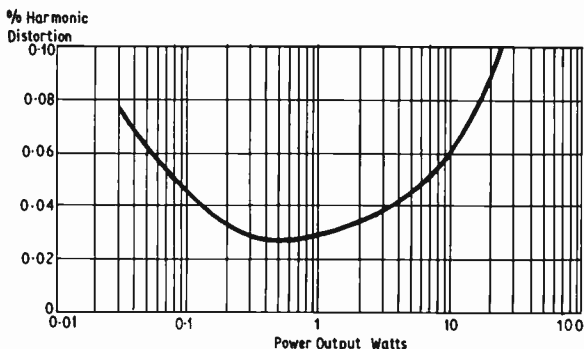


Fig. 2.7. Total harmonic distortion of power, tone, and pre-amplifier combination against power (log scale)

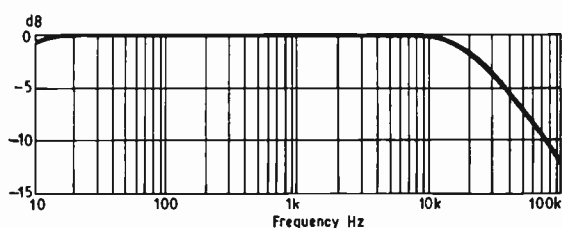


Fig. 2.8. Frequency response of the system at 1W into 8 ohms

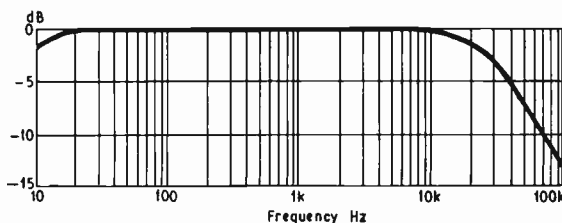


Fig. 2.9. The rated power bandwidth at 20W into 8 ohms

Although the open loop gain of the 748 i.c. op-amp is typically around 95dB, a stable closed-loop gain of some 20dB is utilised to give low harmonic distortion, see Fig. 2.7, and intermodulation products. It is therefore necessary to provide additional gain elsewhere.

This is achieved by use of a modified Darlington output stage in which resistors R26, R23 and R27, R24 apply attenuation of the feedback path in the Darlington pairs TR2, TR4 and TR3, TR5, giving a voltage gain of 20dB. The drivers TR2 and TR3 are fed by a phase splitter TR1 which also controls the bias conditions.

## QUIESCENT CURRENT

The quiescent current in the output stage, around 20mA, is controlled by the network R19 and VR8. VR8 is in the base-collector half and is preset for the correct quiescent current. Placing the preset in

this half of the network ensures that if the preset goes open circuit (the most common fault) the quiescent current in the output stages drops to a minimum and not, as so often happens, to a damaging maximum.

TR1 and TR2 are placed in contact with each other to provide a thermal path which enables the biasing to "track" easily so that, after prolonged full output, the quiescent current falls back to near normal in a much shorter time.

Two power amplifier channels are provided on each circuit board with a common heat sink. As much lower power is transmitted to the back channels from many quadraphonic recordings, one front and one back channel are routed to each board to balance the heat dissipation.

Fig. 2.8 shows the overall frequency response of the power amplifiers at 1W output into 8 ohms.

Fig. 2.9. The rated power bandwidth graph shows that, at full output, the frequency response is virtually the same as at lower outputs.

## DISTORTION

Reference back to Fig. 2.7 shows the small increase in harmonic distortion at low outputs. When drawn on a linear power scale (a very common way) this rise is masked and power outputs of 50mW or so are conveniently ignored.

Fig. 2.5a shows the sine waveform at 1kHz just at the onset of clipping (21W into 8 ohms), the condition being indicated by the bright-up at the crest of the waveform.

## CONSTRUCTION DETAILS

### Pre-amplifiers

Figs. 2.10a and b show the layout of the pre-amplifier board copper and components. Assembly follows normal practice. A space of  $\frac{1}{16}$ in is left between the plastic switch bodies and the board to prevent capillary action drawing the solder up into the switch mechanism.

### Tone, Volume and Balance Controls

Figs. 2.11a and b show the layout of this board. The slider controls should be soldered into the board after all other components have been assembled and soldered.

When the slider controls are mounted care should be taken to ensure that they are well seated onto the board surface so that the wiper levers are all parallel.

### Power Amplifiers

Figs. 2.12a and b show the layout of one of the stereo power amplifier boards. As mentioned earlier there is a common heat sink for the two amplifiers on each board.

The Motorola devices are supplied with a compression washer which should be tightened by the screw until the washer just deforms.

The Texas devices are supplied with a stepped insulating bush which should be inserted between the head of the screw and the fixing hole in the metal tab. The smaller mica insulating washer should have a thin smear of silicone grease applied to both sides to improve thermal conductivity between transistor and heat sink.

# PRE-AMPLIFIER MODULE

## COMPONENTS . . .

### PRE-AMPLIFIER

#### Resistors

R1, R101	Input matching	(2 off)
R2, R102	resistors, to be	(2 off)
R3, R103	discussed in	(2 off)
	future article	
R4, R104	47k $\Omega$	(2 off)
R5, R105	1k $\Omega$	(2 off)
R6, R106	100k $\Omega$	(2 off)
R7, R107	270k $\Omega$	(2 off)
R8, R108	1.2k $\Omega$	(2 off)
R9, R109	22k $\Omega$	(2 off)

All  $\pm 5\% \frac{1}{4}W$  Hi-Stab carbon film

#### Capacitors

C1, C101	100 $\mu F$ 3V tantalum	(2 off)
C2	0.1 $\mu F$ polyester	(1 off)
C3, C103	10pF 30V polystyrene	(2 off)
C4	0.1 $\mu F$ polyester	(1 off)
C5, C105	0.22 $\mu F$ polyester	(2 off)
C6, C106	3900pF 30V polystyrene	(2 off)
C7, C107	0.01 $\mu F$ polyester	(2 off)

#### Integrated Circuits

IC1, IC101	ML748, $\mu 748$ or SN72748P	(2 off)
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#### Switch

S1	4-pole 4-way Special (Lipar Isostat) selector switch—Sonax Electronics
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#### Miscellaneous

Printed circuit board, link wire and connecting wires

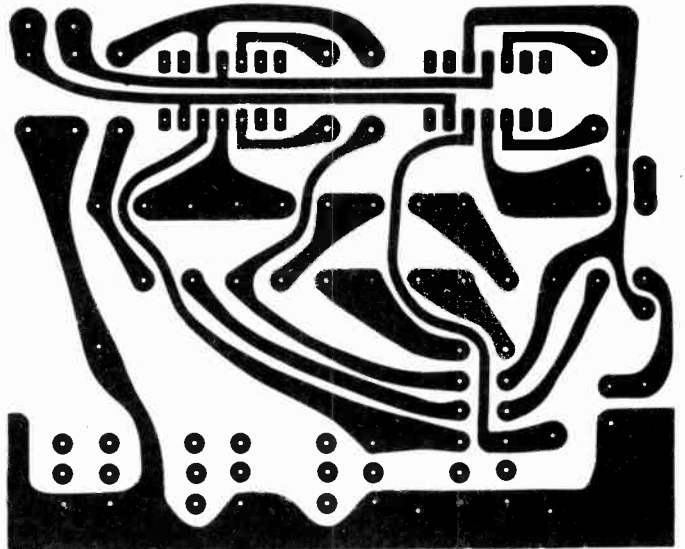
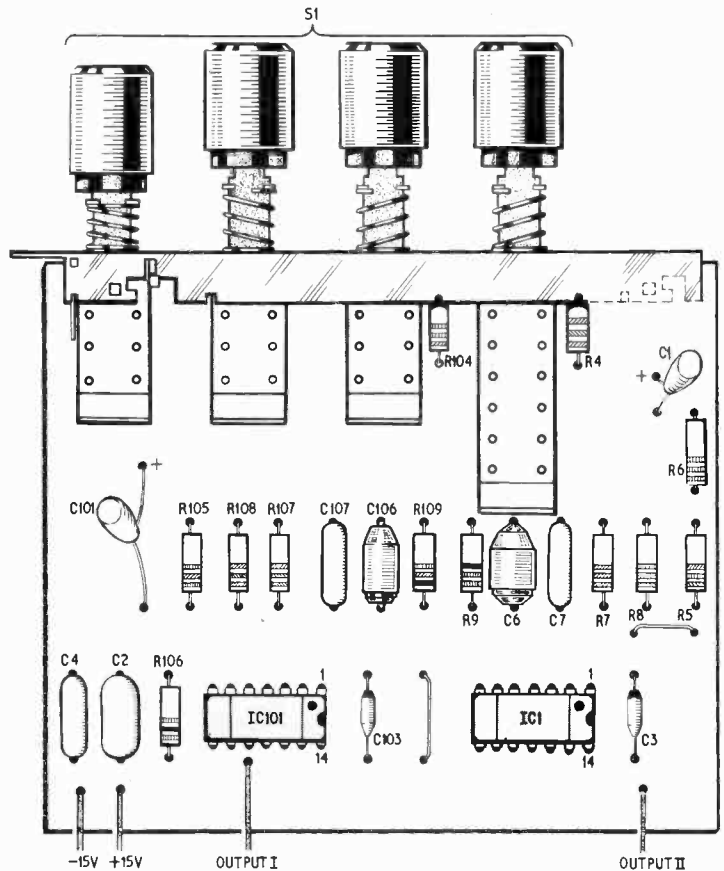
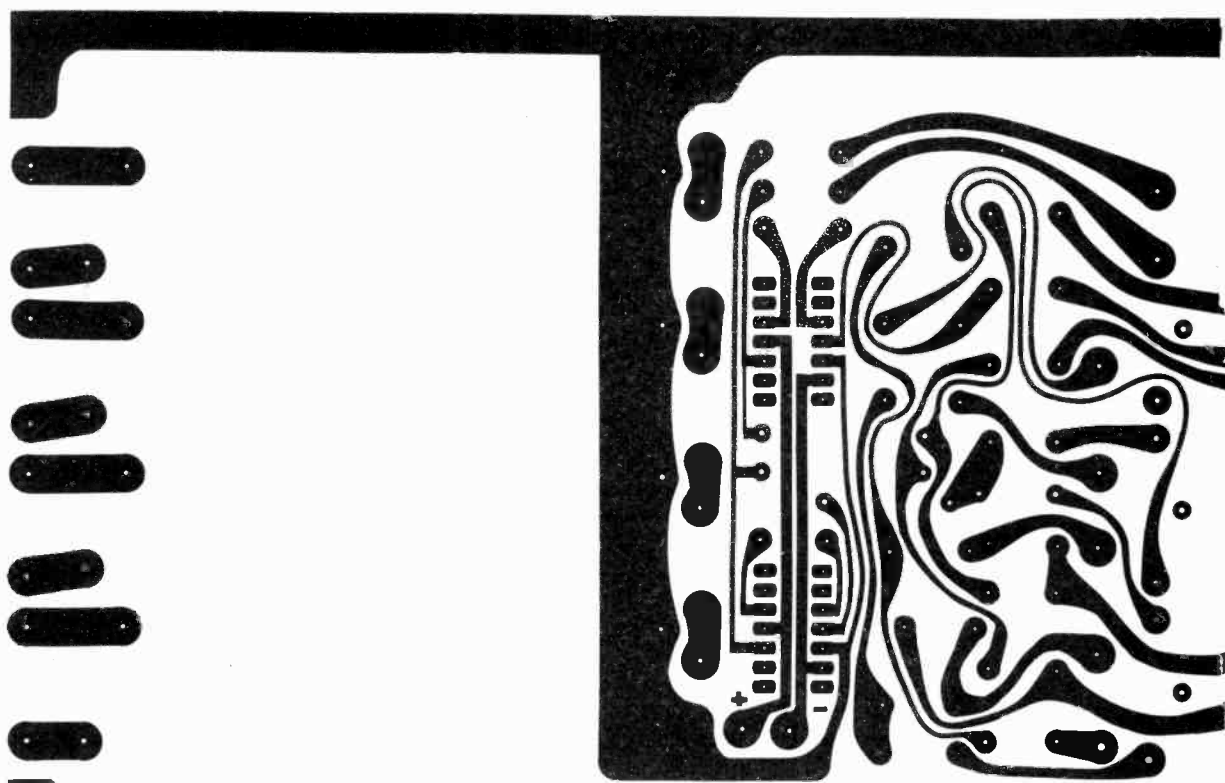
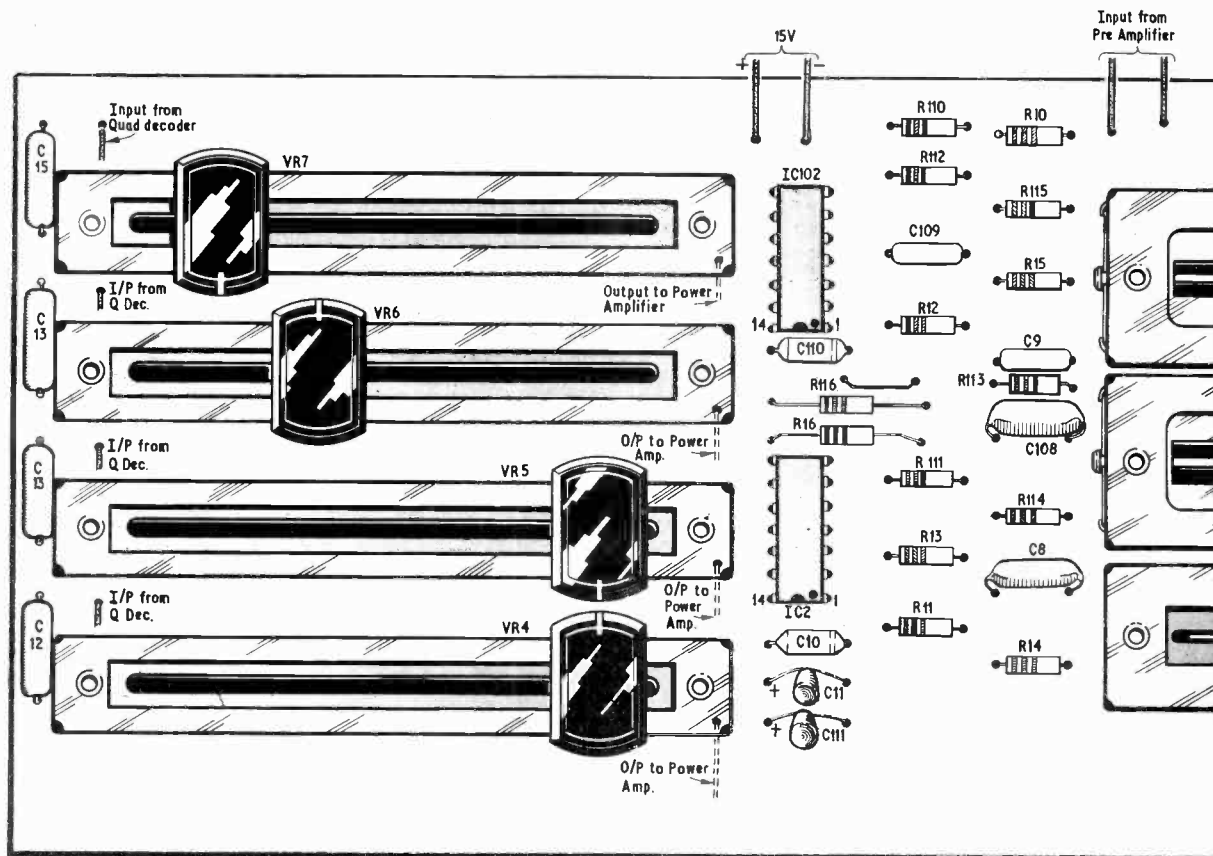


Fig. 2.10. Component layout and printed circuit master (full size) for the pre-amplifier board

# TONE, BALANCE AND VOLUME CONTROL MODULE



## COMPONENTS . . .

### tone and volume controls

#### Resistors

R10, R110	1.8k $\Omega$	R14, R114	3.3k $\Omega$
R11, R111	3.3k $\Omega$	R15, R115	10k $\Omega$
R12, R112	10k $\Omega$	R16, R116	2.2k $\Omega$
R13, R113	15k $\Omega$		
All 5% $\frac{1}{4}$ W Hi-Stab carbon film (2 off each required)			

#### Capacitors

C8, C108	1500pF 30V polystyrene	(2 off)
C9, C109	0.068 $\mu$ F polyester	(2 off)
C10, C110	10pF 30V polystyrene	(2 off)
C11, C111	10 $\mu$ F 16V bead tantalum	(2 off)
C12-C15	0.22 $\mu$ F polyester	(4 off)

#### Potentiometers

VR1/101	100k $\Omega$ lin.	2-gang (Alps) Sonax Electronics	(1 off)
VR2/102	100k $\Omega$ lin.		(1 off)
VR3/103	10k $\Omega$ log.		(1 off)
VR4-VR7	10k $\Omega$ log. (Alps)		(4 off)

#### Integrated Circuits

IC2, IC102	ML748, $\mu$ 748 or SN2748P	(2 off)
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#### Miscellaneous

Printed circuit board, connecting wires

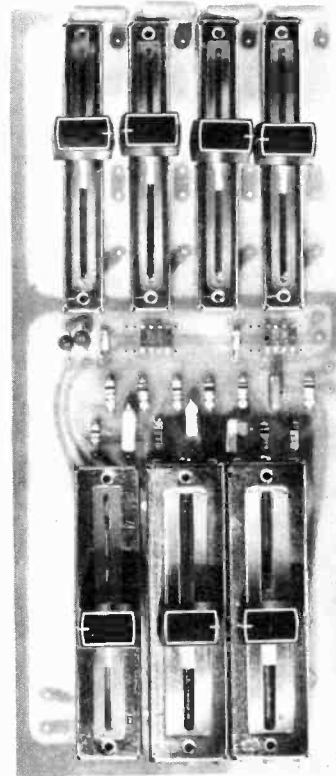


Fig. 2.11. Component layout and printed circuit master (full size) for the tone control and balance board. A photograph of a prototype board is also shown

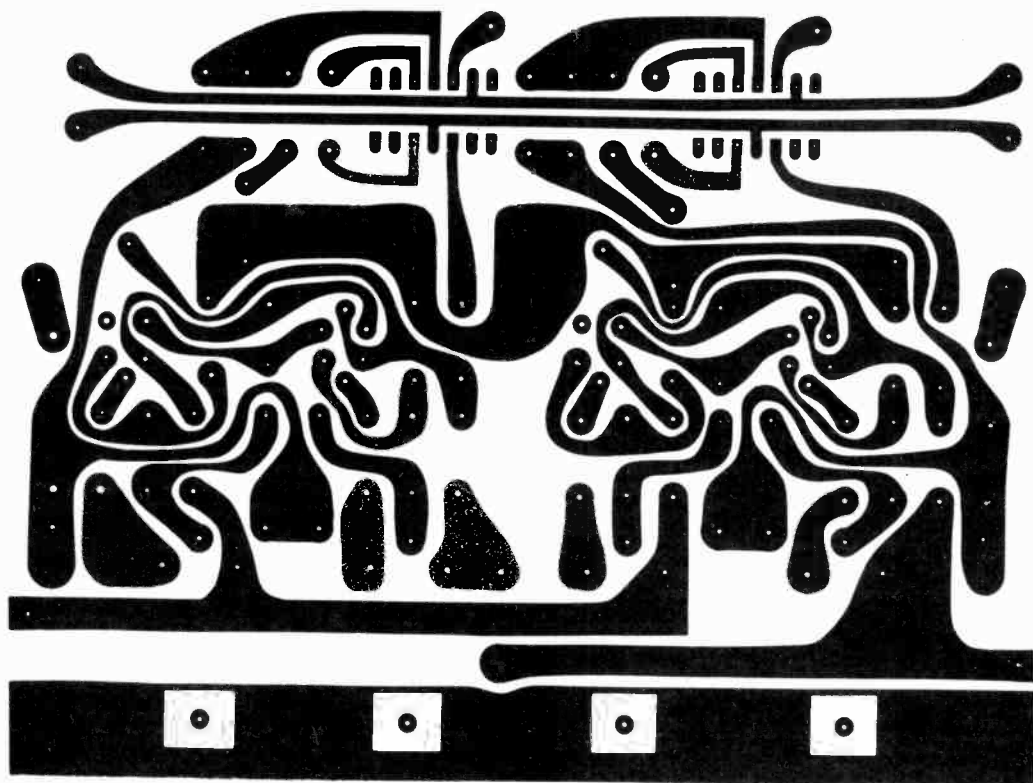
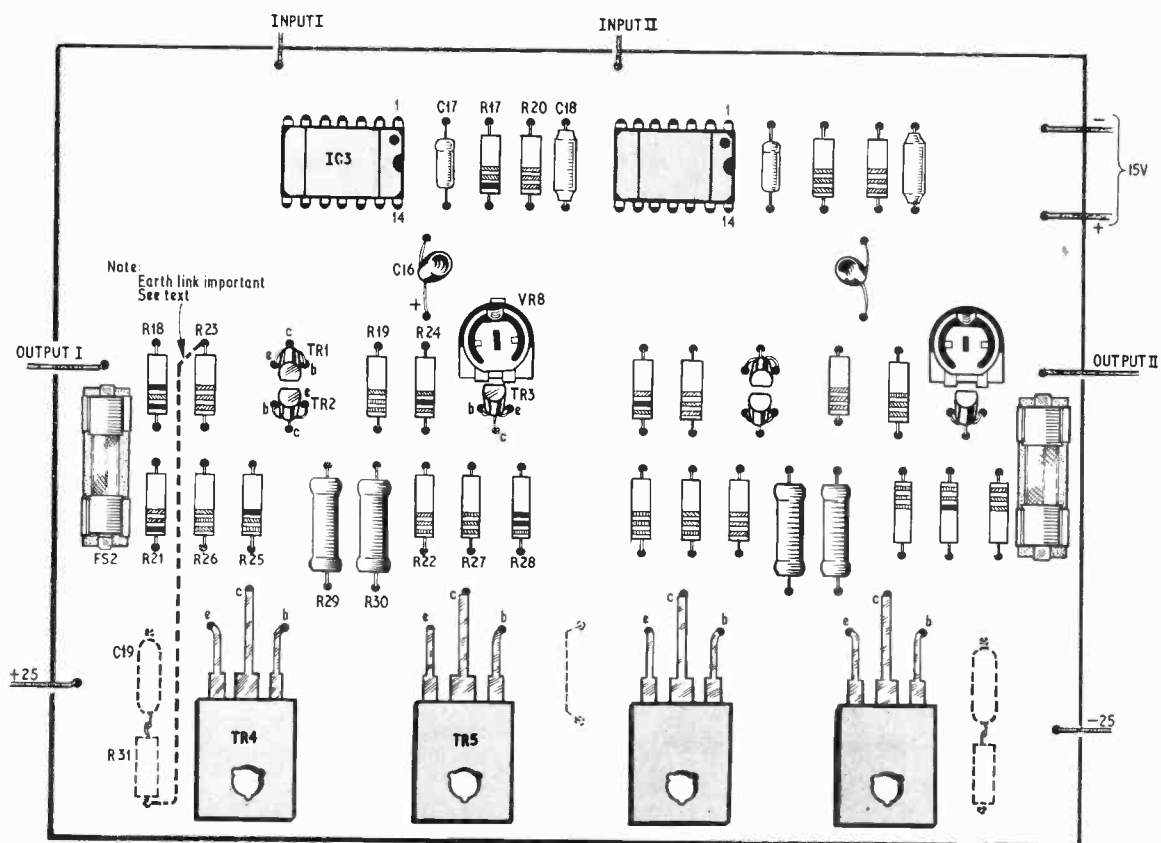
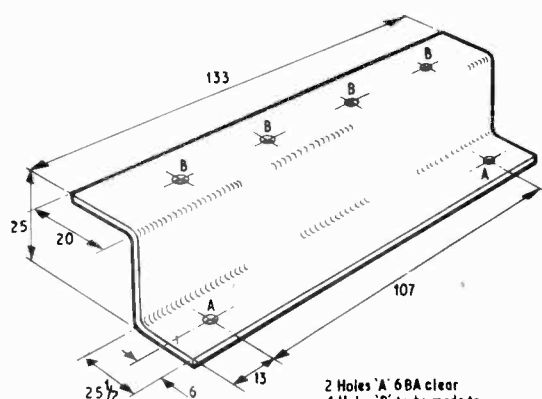


Fig. 2.12. Component layout and printed circuit master (full size) of one of the two power amplifier boards. Components on the right are similar to the left channel





2 Holes 'A' 6 BA clear  
4 Holes 'B' to be made to  
suit power transistors  
on Component Board  
Material: 16 SWG Aluminium  
All dimensions in mm

**Fig. 2.13.** Details of one of the heat sinks for the power amplifiers. A photograph of the amplifier board is shown opposite with a heat sink in position ready for marking for drilling

Fig. 2.13 shows the dimensions and form of the heat sink. Reference to the layout drawing Fig. 2.12 shows two links (dotted lines) on the copper side. R31 (10 ohm) and C19 (0.01  $\mu$ F) are also fitted on the copper side. These last components are high frequency compensation networks provided to ensure stable performance into difficult loads.

## COMPONENTS . . .

### POWER AMPLIFIERS

(two boards required, two amps per board)

#### Resistors

R17 680 $\Omega$	R25 150 $\Omega$
R18 100 $\Omega$	R26 220 $\Omega$
R19 470 $\Omega$	R27 220 $\Omega$
R20 82k $\Omega$	R28 150 $\Omega$
R21 4.7k $\Omega$	R29 0.5 $\Omega$
R22 4.7k $\Omega$	R30 0.5 $\Omega$
R23 22 $\Omega$	R31 10 $\Omega$
R24 22 $\Omega$	

All 5%  $\frac{1}{4}$ W Hi-Stab carbon film (4 off each required)

#### Potentiometer

VR8 470 $\Omega$  Skeleton preset (Piher) Sonax (4 off)

#### Capacitors

C16 100 $\mu$ F 3V bead tantalum  
C17 10pF 30V polystyrene  
C18 see text  
C19 0.1 $\mu$ F polyester  
Four of each capacitor required

#### Integrated Circuits

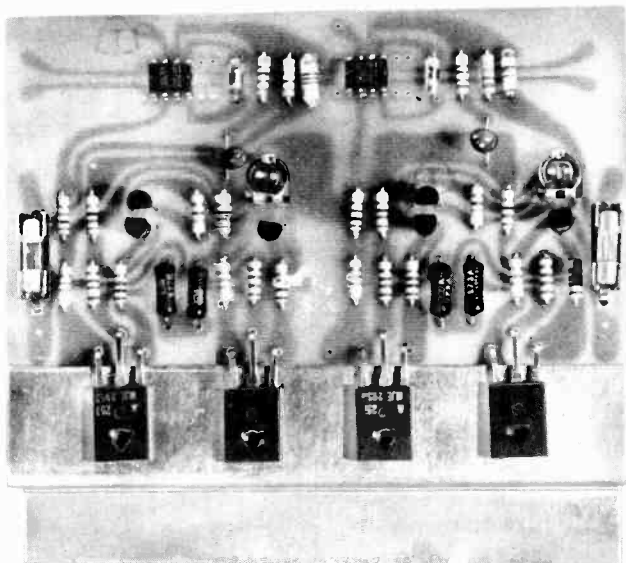
IC3 ML748,  $\mu$ 748 or SN72748P (4 off)

#### Transistors

TR1, TR2, BC182LB (8 off) TR3 BC212LB (4 off)  
TR4 MJE 2955 (4 off) TR5 MJE 3055 (4 off)

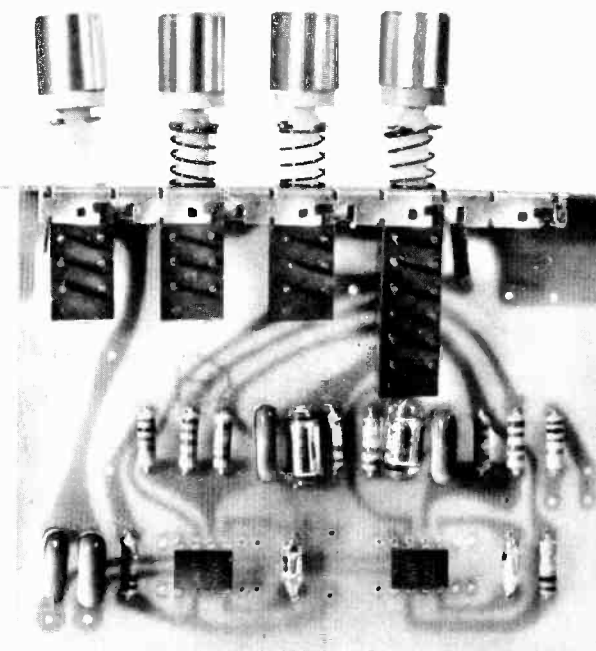
#### Miscellaneous

FS2 2A Fuseholder and fuse (4 off)  
Printed circuit boards (2 off), connecting and link wires, set of mica washers for power transistors



C18 can be either 37pF or 68pF. A greater rate of roll off in frequency response is obtained by use of the 69pF, which in some circumstances can help reduce r.f. breakthrough. This is rather rare, but some constructors close to transmitters, or sources of r.f. interference, may experience this trouble.

**Next month: Power supply and mechanical details and wiring**



**An almost completed pre-amplifier board**

# PHASE LOCKED LOOPS

BY J.B. DANCE M.Sc.

**D**URING the past two or three years a type of circuit known as the phase locked loop has aroused enormous interest in a number of fields, especially in that of radio receiver design. These articles will provide readers with a simple explanation of the operation of phase locked loops, their advantages and limitations, together with some of their practical applications.

The phase locked loop offers certain advantages over the other types of detector used in radio receivers. It can also be employed in a wide variety of other applications such as in frequency synthesisers, in frequency shift keying demodulators, in f.m. generators, in tape recorder flutter meters, for electric motor speed control, etc.

## SINGLE INTEGRATED CIRCUITS

The principles of the phase locked loop have been known for many years (an account of the synchronous reception of radio signals was published as long ago as 1932). However, the circuits are so complex that it has not been very economical to construct them with discrete components. In the past three years, however, complete phase locked loops have become available as single integrated circuits. Their potential possibilities have stimulated great interest especially in radio receiver circuitry.

Currently available phase locked loops can replace nearly all of a receiver intermediate frequency strip (including the detector) with a single integrated circuit. The frequency of operation is set by a single component connected to the integrated circuit, whilst another component can be used to control the selectivity.

## THE PHASE LOCKED LOOP

The phase locked loop contains an electronically controlled oscillator which can be synchronised with an incoming signal.

The basic operation of the phase locked loop may be illustrated by the block diagram of Fig. 1.1.

In subsequent parts we shall see that this basic system can be employed as a demodulator for f.m. signals, and with some additional stages, it can be employed to demodulate a.m. signals.

## FREE-RUNNING FREQUENCY

If no input signal is fed to the phase locked loop of Fig. 1.1, the voltage controlled oscillator operates at a frequency known as the "free-running" or "centre" frequency. This frequency can be controlled by changing the value of certain components external to the integrated circuit phase locked loop.

In the free-running condition, the phase detector provides no output signal (or error signal). There is therefore no control voltage fed to the voltage controlled oscillator.

If an input signal is now applied to the system of Fig. 1.1, the phase detector will compare the phase of the input signal with that of the signal generated by the voltage controlled oscillator. The error voltage at the output of the phase detector is dependent on the phase difference between the two signals. It may be either positive or negative, according to which of the signals is leading or lagging the other in phase.

The error signal is passed through a low-pass filter, after which it is amplified to produce the signal which is used to control the frequency of the oscillator. The control voltage alters the frequency of the voltage controlled oscillator and can make it approach the frequency of the input signal. If the input frequency is close enough to the free-running frequency of the voltage controlled oscillator, the latter will become locked to the input frequency.

## PHASE DIFFERENCE

When the phase locked loop is "in lock", the voltage controlled oscillator frequency is identical with that of the input signal, but in general there is a

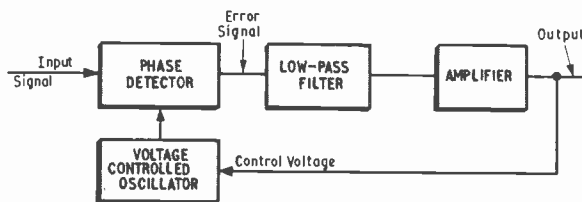


Fig. 1.1. Basic block diagram of a phase locked loop

certain finite phase difference between the signals. This phase difference must be present in order to generate the error voltage which is required to change the voltage controlled oscillator frequency from its free-running value to the input signal frequency.

## FEEDBACK SYSTEM

The feedback system employed in a phase locked loop enables the frequency of the voltage controlled oscillator to change automatically as the input frequency changes. A slight change in the input frequency will result in a phase change between the input signal and the signal from the voltage controlled oscillator. The error signal produced by the phase detector will automatically adjust itself so that the voltage controlled oscillator frequency is kept the same as the input frequency.

## PHASE COMPARATOR

It is instructive to note that the phase comparator is essentially a multiplier circuit which acts like a frequency changer. It operates on the input and voltage controlled oscillator signals so as to generate the sum and difference of these frequencies.

The sum frequency is unable to pass through the low-pass filter of Fig. 1.1. However, when the loop is locked the difference frequency is zero (since the two frequencies being fed to the phase comparator are the same) and a d.c. voltage is produced which can pass through the low-pass filter and keeps the loop locked.

If the input frequency is changing with time (as in an f.m. signal), the error signal will contain some frequencies which are much lower than the input frequency. The low-pass filter may transmit these frequencies almost unattenuated, in which case the voltage controlled oscillator will track the input frequency and the loop will remain locked.

Most phase detectors are also sensitive to the amplitude of the signals.

## LOCK RANGE

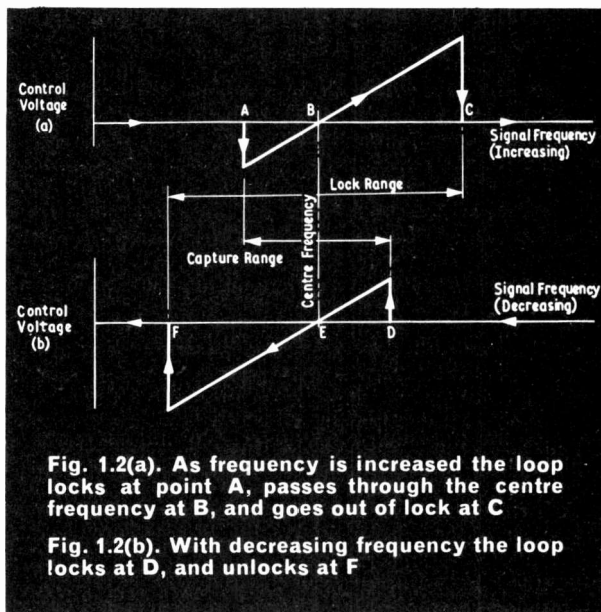
The lock range of a phase locked loop is the range of input frequencies over which the loop remains locked to the input signal. The lock range is also known as the tracking range.

The term "hold-in" range is sometimes used to denote the maximum allowable difference between the centre frequency and the signal frequency at which the loop just remains locked. It is one half of the lock range, since the latter extends on each side of the centre frequency.

In a loop which is locked to the input frequency, the error voltage is of zero frequency and will therefore always be transmitted by the low-pass filter. The lock range is therefore not affected by the characteristics of this filter.

The lock range is limited by the maximum value of the control voltage which can be generated in the loop and thus the corresponding frequency of the voltage controlled oscillator.

The lock range can be many times the bandwidth of the signals accepted by the loop. This means that if the frequency of the input signal varies somewhat, the voltage controlled oscillator frequency will follow it, but at all times the bandwidth will be narrow so that the amount of noise is small. Effectively this means that the tuning of the receiver is automatically corrected as the input frequency changes.



**Fig. 1.2(a).** As frequency is increased the loop locks at point A, passes through the centre frequency at B, and goes out of lock at C

**Fig. 1.2(b).** With decreasing frequency the loop locks at D, and unlocks at F

## CAPTURE RANGE

The capture range is the range of input signal frequencies which can cause the loop to become locked. The capture range is generally smaller than the lock range. In other words, if a signal near to one of the ends of the lock range is applied to an unlocked loop, it will not bring the loop into lock. However, a loop to which this signal is being fed will remain in lock.

The capture range never exceeds the lock range. It is a measure of how close the input signal frequency must be to the centre frequency of the loop for locking to take place.

If the signal frequency in Fig. 1.2(a) is slowly increased, the loop will suddenly become locked at point A which is the edge of the capture range. As the frequency is increased further, the control voltage applied to the voltage controlled oscillator decreases linearly with frequency and passes through a value of zero at the free-running frequency, B. The loop remains in lock until the frequency reaches point C, the edge of the lock range. The control voltage returns to zero when the system comes out of lock.

If the frequency is now reduced, one obtains the characteristic illustrated by Fig. 2(b). The loop does not come into lock until point D is reached, the edge of the capture range. The centre frequency, point E, is reached when the control voltage is zero and the loop finally comes out of lock at point F.

## THE CAPTURE PROCESS

The mechanism of the capture process may be examined by first considering a loop which is not yet locked to the input frequency. The phase detector produces sum and difference frequencies of the two signals being fed to it, but both of these frequencies are so high that they cannot pass through the low-pass filter. The voltage controlled oscillator therefore continues to operate at its free-running frequency.

If the signal frequency now approaches the free-running frequency, the difference frequency decreases until it falls within the pass band of the

low-pass filter. The part of the difference frequency voltage which passes through the low-pass filter causes the voltage controlled oscillator frequency to move towards the input signal frequency. This reduces the difference frequency further so that it is transmitted more easily through the low-pass filter and exercises a greater effect on the oscillator.

The mechanism is essentially one of positive feedback. It has the effect of causing the voltage controlled oscillator frequency to suddenly become the same as that of the input signal.

Capture occurs when the difference frequency between the input and the voltage controlled oscillator signals can pass through the low-pass filter without being attenuated so much that it cannot produce an adequate control voltage. The capture range is therefore determined mainly by the maximum frequency which can pass through the low-pass filter.

The capture effect determines the selectivity of the phase locked loop circuit. Thus selectivity is determined by the characteristic of the low-pass filter.

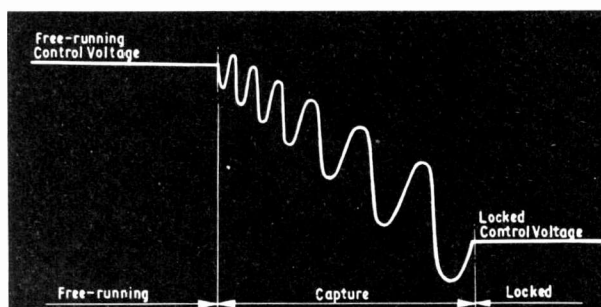


Fig. 1.3. Diagram showing transient locking characteristic

## THE LOCKING TRANSIENT

When the voltage controlled oscillator is free-running and as the loop approaches lock, the output from the phase detector contains a sinusoidal frequency equal to the difference frequency between the two signals. When the input frequency moves to a point within the capture range of the loop, the difference frequency is fed through the low-pass filter to the voltage controlled oscillator.

This oscillator frequency is modulated for a moment by the difference frequency and the latter will therefore vary with time. Once locking has occurred, the output from the phase comparator is of zero frequency.

The control voltage thus changes from the constant zero voltage in the unlocked state through an oscillating signal containing the difference frequency to a non-zero constant voltage when the loop is locked to the input frequency.

In the intermediate state during the capture process, the control voltages consists of a non-sinusoidal asymmetrical waveform containing a steady (or d.c.) component, as shown in Fig. 1.3.

The steady component causes the voltage controlled oscillator frequency to move towards the signal frequency. The difference frequency component in the control voltage gradually increases during the capture transient, as shown by the increasing width of the peaks in Fig. 1.3.

## PULL-IN TIME

The pull-in time of a phase locked loop is the time taken for the loop to become locked to the input frequency. In some systems the pull-in time can be very short—even less than the time for one oscillation of the difference frequency; in this case lock can be established without any oscillations in the frequency of the voltage controlled oscillator occurring.

The pull-in time depends on the difference between the initial free-running frequency and the signal frequency, the bandwidth of the low-pass filter and the overall gain around the loop. In general locking will take place more rapidly when the frequency of operation is relatively high, since a given number of cycles of the waveforms occur in a shorter time.

One might expect that locking would be instantaneous when the input frequency is exactly equal to the free-running frequency. This is not necessarily true, however, since although the frequencies are the same, the phases of the waveforms may be different and it is the phase differences which are detected.

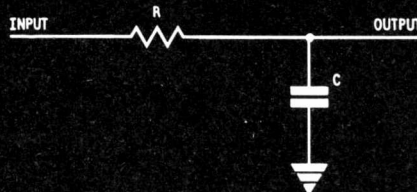


Fig. 1.4. The simplest low-pass filter circuit

## THE LOW-PASS FILTER

The low-pass filter is often extremely simple — merely a resistor and capacitor, as shown in Fig. 1.4, however, it has a very profound effect on the performance of the phase locked loop.

We have already seen how the characteristics of the low-pass filter can control the capture range. This filter also increases the pull-in time, since a rapid change of the output voltage from the phase comparator will produce a slower change in the output from the filter.

The use of the low-pass filter improves the noise rejection characteristics of the phase locked loop. If an interfering noise signal reaches the input of the phase comparator, the output will change almost instantaneously. However, the low-pass filter will delay any change in the oscillator frequency. The filter therefore acts as a short term memory which keeps the voltage controlled oscillator locked to the input frequency during a short noise pulse. Similarly, the loop remains locked during a short period when fading of the signal occurs.

## SELECTIVITY

The selectivity of the whole phase locked loop is controlled by the characteristics of the low-pass filter. Although the low-pass filter operates at a

relatively low frequency, its characteristics are effectively imposed on the high frequency response of the phase locked loop. A simple low-pass filter can provide selectivity which is equivalent to that of a conventional superheterodyne receiver containing six tuned circuits at the intermediate frequency.

Phase locked loops are especially useful for receiving radio signals which are "buried" in noise. Their pass band can be made almost ideal for this purpose.

If the bandwidth of the low-pass filter is sufficiently narrow, the signal-to-noise ratio at the output of the voltage controlled oscillator can be considerably better than that at the input. The use of a low-pass filter with a large time constant will provide greater noise rejection and immunity to a momentary loss of the input signal, but it does result in a lower tracking rate, a reduced capture range and a longer pull-in time.

The low-pass filter limits the rate at which the voltage controlled oscillator can track the input signal. If the frequency of the latter changes at a greater rate than the maximum rate for the loop used, the loop will not remain locked. Capture will not occur at the new input frequency if this is outside the capture range. A low-pass filter with a relatively high cut off frequency will produce a higher tracking rate, but the ability of the loop to reject short term noise will be reduced.

## THE INPUT LEVEL

If the input signal is relatively large, its amplitude will be limited either in the phase locked loop or in the preceding circuits. The capture range and the lock range are then independent of the signal amplitude.

Although a phase locked loop can act as its own limiter, greater freedom from noise and from spurious signals can be obtained when the input level is below the threshold at which limiting occurs. When the amplitude is high enough to drive the system outside the limit for linear operation, there are more cross modulation signals formed. However, higher input levels do result on a reduced pull-in time.

**Next month: f.m. and a.m. demodulation techniques will be described.**

## PRACTICAL ELECTRONICS

### ● INDEX

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

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# POINTS ARISING

## WIDE RANGE PULSE GENERATOR (June 1973)

Capacitor C1 should be positioned in the circuit adjacent the contact of S1 and not, as shown in Fig. 2, in the direct connection from pins 2 and 3 to C2. It is shown correctly in the wiring diagram of Fig. 3.

## THE 555 TIMER IC (June 1973)

It has been pointed out by a reader that any constructor attempting to use this chip to construct a 1:1 mark-space ratio monostable as described on pages 486 and 515 may run the risk of damaging TR1 because of a reduction of RA below a suggested value of 1 kilohm. The manufacturers have, in fact, not considered taking the resistance value below 1 kilohm.

## AUDIO COMPRESSOR (August 1973)

In the base diagram of the 2N3708 transistor in Fig. 2 the base and emitter leads are shown transposed. Copper strip should be broken at F12. Resistor R13 should go to K29 not J29.

## LIGHTING CONTROL UNIT (July 1973)

Page 612, the end of the fourth paragraph under the side heading "THE THYRISTOR" should read "", so that the voltage applied to the load looks like Fig. 2 (c) not 3 (c)." Also, at the end of the section headed "TESTING" Fig. 4 should read Fig. 3.

## PHASING UNIT (September 1973)

Changing the 10kΩ linear dual-gang potentiometer VR2 for a logarithmic type will enhance the performance of the unit.

## P.E. SOUND SYNTHESISER (March 1973)

### POWER SUPPLY REGULATORS

It should be noted that the maximum input voltage for the voltage regulator  $\mu$ A7815 should not exceed 36V. Thus if the 30V Rec. Transformer by R. S. Components is being used in the power supply it is necessary to connect the 25V windings instead of the 30V windings given in March P.E.

Constructors using alternative 30V transformers should protect the regulator by means of an 8.2V 10W Zener diode connected between the bridge and C1 positive (cathode to the diode bridge). The Zener should be mounted on a heatsink, (2in x 2in 14 s.w.g. aluminium would suffice), which can be bolted to the power supply subframe lip above the transformer.

It will be necessary to insulate the heatsink from the subframe and separate heatsinks should be used for each Zener. The Z3B series of Zeners by Semitron would be suitable for use in the suggested circuit.

## 550 VOLT MEGOHMMETER (August 1973)

The function of VR2 was omitted. It should be adjusted so that the meter reads full scale with the leads shorted.

## SOUND SYNTHESISER LECTURE

Our author Mr. G. D. Shaw will present a lecture-demonstration at the coming International Audio Festival and Fair, Olympia, London. The lecture will be given at 2 p.m. on Tuesday, October 23, 1973.

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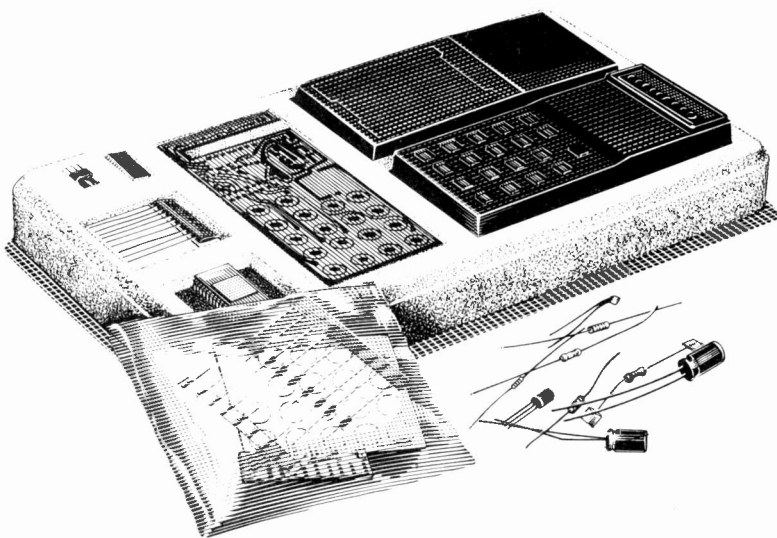


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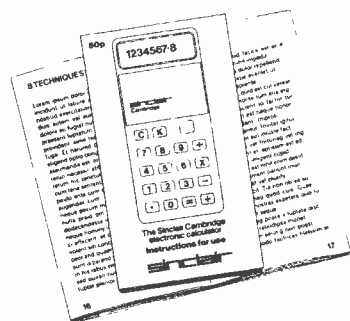
1. Coil.
2. Large-scale integrated circuit.
3. Interface chip.
4. Thick-film resistor pack.
5. Case mouldings, with buttons, window and light-up display in position.
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# PE Sound Synthesiser 9

## VOLTAGE CONTROLLED & DIFFERENTIAL AMPLIFIERS

By G.D. SHAW

THIS part describes the construction and operation of the Voltage Controlled Amplifiers, the Differential Amplifier and finalises the interconnection details outlined in Part 1 of the series.

### OUTPUT AMPLIFIERS

The heart of each of the Voltage Controlled Amplifiers is the Motorola MFC6040 electronic attenuator which was described in Part 7 of the series and which, by means of an externally derived voltage, enables the input signal to be attenuated by 77dB or amplified by 13dB.

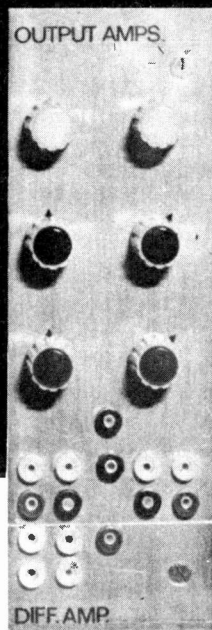
Two Output Amplifiers are employed, each having two stages, and arranged to be operated in parallel with cross-coupling between the final stages by means of panning controls. The general arrangement is shown in block form in Fig. 9.1. The first stage consists of a two input resistive mixer at the front end of the MFC6040 which has, for each channel, a separate control amplifier. Output from the first stage is led to a pan-pot which can route the signal to either of the output stages direct or to both channels at a range of intermediate levels.

Fig. 9.2 shows the theoretical circuit of the left channel Output Amplifier in which IC1 provides the variable gain input mixer, IC2/TR1 the control amplifier and IC3 the final output stage. The right channel is identical in design except that the 'a' side of the pan-pot is coupled to IC3 of the left channel instead of direct to the right channel output stage. This is so that clockwise rotation of the pan-pots will route signals to the right channel and anticlockwise rotation to the left.

### PAN-POTS

The pan-pots themselves are designed to allow the smoothest possible transition when swinging the signal from one channel to the other and in such a way that equal increments of rotation of the pot give approximately equal incremental changes in the level of the signal.

The pots consist of two tracks ganged together and wired back-to-back so that as the output of one track increases the output of the other decreases by a similar amount. The ideal arrangement is when one of the tracks follows a logarithmic law with the other being anti-logarithmic. Unfortunately the manufacture of accurately matched tracks of this type is difficult and purpose built pots having the desired characteristics are not easily available and generally expensive.



The pan-pots in the Synthesiser represent a compromise in that they utilise linear tracks which, for most practical purposes, are made logarithmic in action by the addition of a relatively low value load resistor (R11 and R12 in Fig. 9.2).

### PRACTICAL PROBLEMS

On completion of the module and having checked that each channel's performance characteristics are similar for a given input signal the following procedure should be adopted for determining the electrical centre of rotation of the pan-pots. Set both pots to approximately the mid-point of rotation and apply a signal of about 250mV to the input of one channel only. The remaining inputs should be grounded.

With the gain on the appropriate channel turned full up monitor the output stages of both amplifiers and adjust the appropriate pan-pot until the output signals are exactly equal. With a well matched pot the electrical centre should be quite close to the

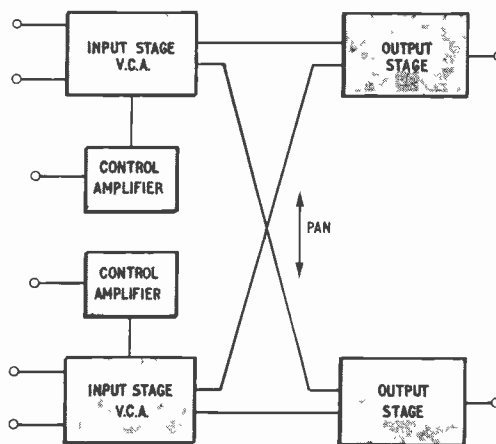
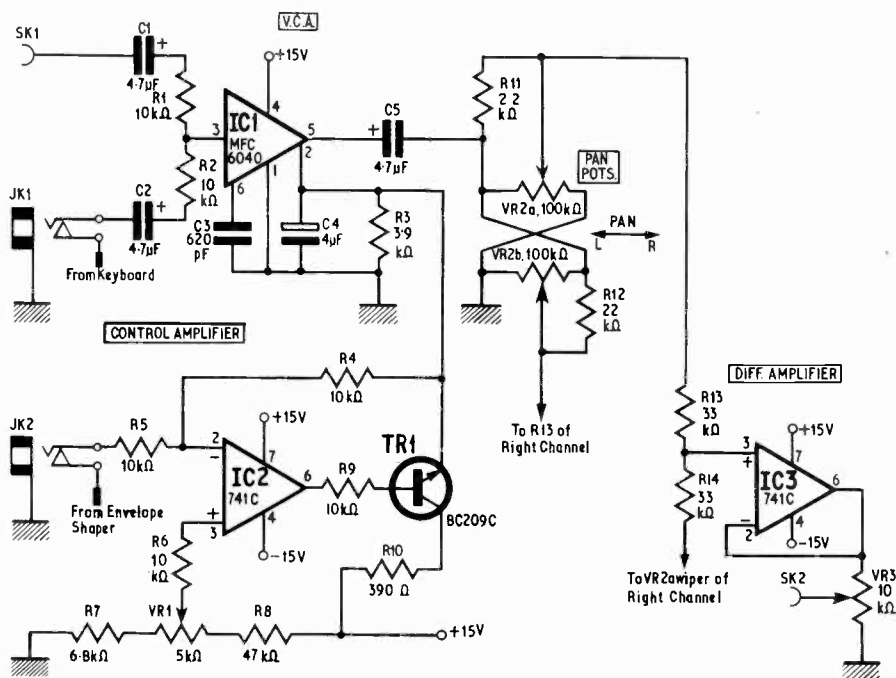


Fig. 9.1. General arrangement of voltage controlled Output Amplifiers



**Fig. 9.2. Output Amplifier for left channel, right channel is identical. Note that if the Envelope Shaper is not connected by prewired link or if auto-programming of gain is not required JK2 must carry a grounded jack plug in order that full range of attenuation gain is achieved**

## COMPONENTS . . .

### OUTPUT AMPLIFIERS (Left and right channels)

#### Resistors

- R1-R2 10k  $\Omega$  (4 off)
- R3 3.9k  $\Omega$  (2 off)
- R4-R6 10k  $\Omega$  (6 off)
- R7 6.8k  $\Omega$  (2 off)
- R8 47k  $\Omega$  (2 off)
- R9 10k  $\Omega$  (2 off)
- R10 390  $\Omega$  (2 off)
- R11-R12 22k  $\Omega$  (4 off)
- R13-R14 33k  $\Omega$  (4 off)
- All 5%  $\frac{1}{2}$  watt carbon

#### Capacitors

- C1-C2 4.7uF tantalum 35V (4 off)
- C3 620pF (2 off)
- C4 4uF elect. 18V (2 off)
- C5 4.7uF tantalum 35V (2 off)

#### Potentiometers

- VR1 5k  $\Omega$  midget linear carbon (2 off)
- VR2 100k  $\Omega$  ganged midget linear carbon (2 off)
- VR3 10k  $\Omega$  midget linear carbon (2 off)

#### Integrated Circuits

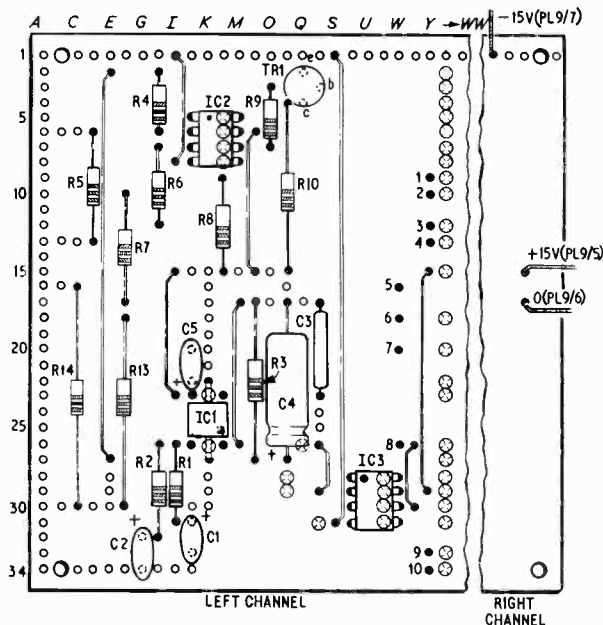
- IC1 MFC 6040 (2 off)
- IC2-IC3 741C (4 off)

#### Transistors

- TR1 BC209C (2 off)

#### Sockets

- SK1-SK2 2mm miniature sockets (4 off)
- JK1, JK2 3.5mm jack sockets (4 off)



**Fig. 9.3. Component layout for Output Amplifiers. As both channels are identical only the left hand is shown**

mechanical centre. If there is more than say 10 to 15 per cent rotation between the two points it may be worth considering the empirical adjustment of one of the loading resistors in order to obtain a better balance or, alternatively, replacing the pot.

Both channels should be checked out in a similar manner and the electrical centres, when satisfactorily determined, marked on the front panel for reference.

## CONTROL AMPLIFIER

In Part 7 of this series the action of the MFC6040 was described and it was shown that the full range of attenuation/gain could be obtained by varying the control voltage applied to pin 2 of the device. Maximum attenuation is associated with a control of +6V whilst maximum gain is obtained when the control falls to +3.5V.

As in the Reverberation Amplifier the control voltages are supplied by a separate amplifier, IC2 in this case, which is operating in the differential mode. Signals normally arrive at the control amplifier, via R5, from the envelope shaper to which it is permanently linked by means of a pre-wired interconnection. This means that R5 is effectively grounded since it is looking into a low impedance whatever the setting of the envelope shaper level control.

The non-inverting input of IC2 is provided with a reference voltage supplied via the divider R8, VR1, R7, which is variable between +1.75V and +3V and which, since the feedback around IC2 is halved due to the coupling on R5, results in the amplifier having an output swing ranging between +3.5V and +6V.

TR1 acts as a follower/current amplifier to ensure that the current sink at the MFC6040 control input has no effect on the output voltage of IC2.

Fig. 9.3 shows the recommended board layout of the output amplifiers.

If the output amplifiers are tested out before making the necessary pre-wired interconnections it is essential to insert a grounded jack plug into the control socket, or otherwise ground the input end of R5, in order to ensure the correct functioning of the circuit.

## ENVELOPE COMPARISON

The rapidity with which the MFC6040 responds to changes in control voltage depends very largely on the value of C4 which has been chosen to present a time constant as close as possible to the fastest rate of attack/decay set by the envelope shaper. However it is prudent to compare the signal envelope at the output of the v.c.a. with the control envelope produced by the envelope shaper.

Fig. 9.4 gives a typical example of such a comparison. The slight rounding off at the corners of the signal envelope is due to the buffering action of C4

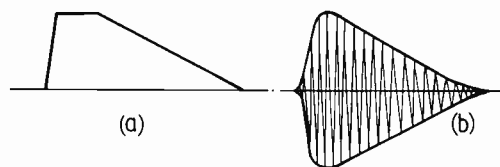


Fig. 9.4. (a) Control envelope—positive going (b) audio signal envelope with rounded edges

and is perfectly acceptable. If the rounding off is too pronounced there is a case for reducing the value of C4 to the next lowest preferred value but it is not recommended that the capacitor be removed entirely.

## DIFFERENTIAL AMPLIFIER

In common with the voltage inverter appearing in Part 3 there is little which need be said concerning the Differential Amplifier which is of the simplest kind. Despite its simplicity however the Differential Amplifier can be made to perform many useful functions in the Synthesiser particularly in connection with the mixing of complex programming waveforms.

Fig. 9.5 gives the circuit diagram of the differential amplifier, while Fig. 9.6 shows the recommended board layout. The front panel component layout and wiring is shown in Fig. 9.7.

## MODULE CONSTRUCTION

Construction of the module should generally follow the pattern already established in the series, that is, with the assembly and wiring of the components to the front panel before the panel itself is mounted to the circuit board support plate.

Wiring from the front panel components should be formed into two harnesses, one containing all leads to the output amplifiers passing out at the top of the front panel to the circuit board which is mounted in the position adjacent to the McMurdo plug. Leads to the differential amplifier should pass direct to the circuit board which is mounted in the lower position adjacent to the front panel.

The board size for this latter circuit should not exceed 17 ways in depth otherwise there may be some difficulty in clearing the ganged pan-pots.

## USING THE MODULE

As was explained last month the Voltage Controlled Amplifiers are principally intended for use with the Envelope Shaper in order that signals passing through them can be amplitude modulated in a variety of ways. However, only the left channel v.c.a. is permanently linked to the Envelope Shaper while the right channel control input is open circuited, that is, it requires a grounded jack plug inserted if control over signal amplitude is to be exercised.

With a jack plug in position the input level control may be operated in a similar fashion to a normal volume control, the characteristics of which were illustrated in graphical form in Part 7.

It is worth bearing in mind that the input level potentiometer is linear and thus the greatest degree of change in volume of the audio signal will occur within the last 30 degrees or so of rotation of the control. Alternatively, the control socket of the right channel may be linked by means of a patch-cord with the positive going envelope socket in order that both channels may be programmed by the envelope shaper. This latter procedure in no way compromises the audio signal and, in fact, with the pan-pots in the full left and right positions respectively the separation between channels is almost perfect.

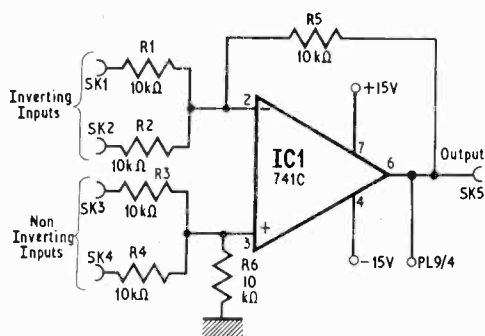


Fig. 9.5. Differential Amplifier circuit

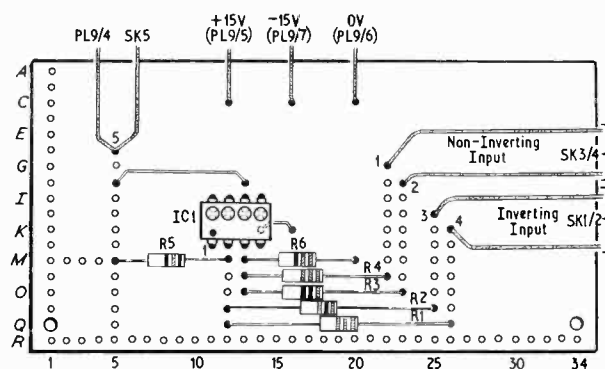


Fig. 9.6. Board layout for Differential Amplifier components

## COMPONENTS . . .

### DIFFERENTIAL AMPLIFIER

#### Resistors

R1-R6 10kΩ (6 off)

#### Integrated Circuit

IC1 741C

#### Sockets

SK1-SK5 2mm miniature sockets (5 off)

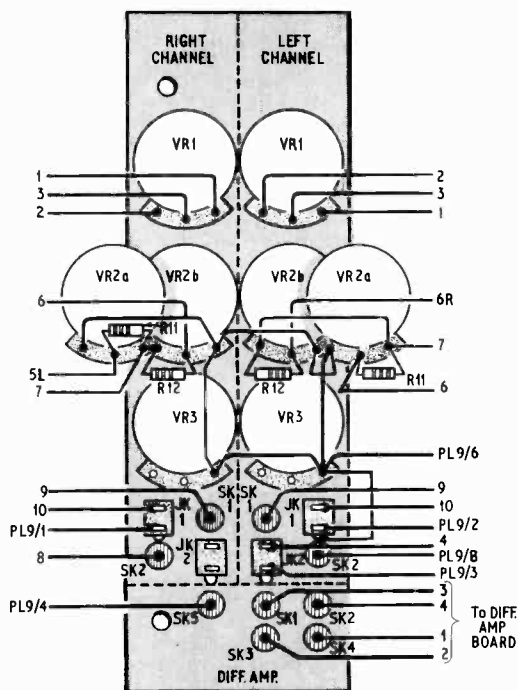
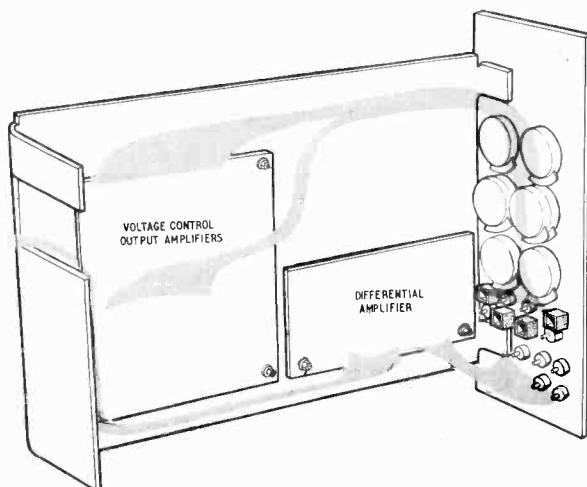
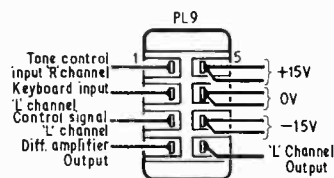


Fig. 9.7. Front panel wiring and inter-board connections. Note: Leads from VR3 as follows: wipers to SK2, unconnected tags to pin 8 on output amplifier board. Board positioning on the module is shown on the left with the McMurdo plug connections above

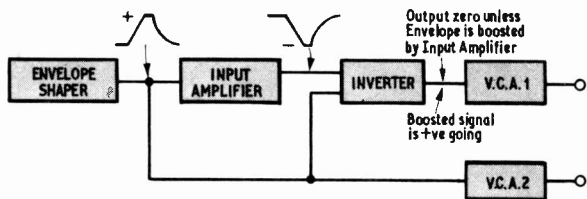


Fig. 9.8. Showing a method of obtaining a differential in envelope level

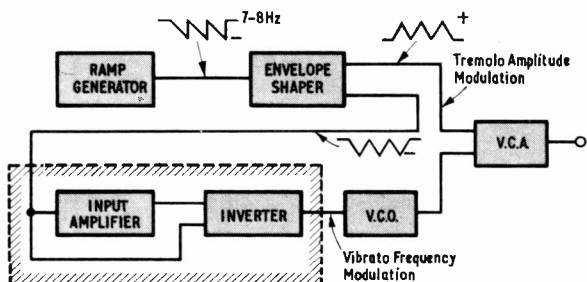


Fig. 9.9. Arrangement for combining tremolo and vibrato modulation

## INPUT LEVEL

The total audio input signal level to the MFC6040 should not exceed 500mV and it is worthwhile ensuring that, if two signals are to be mixed in the v.c.a., each signal does not exceed 250mV peak. The penalty for neglecting this precaution lies in the possibility of damage to the device. The mean output level of the final stages will depend very much on the settings of the pan-pots. However, with 500mV input to the v.c.a. and with the pan-pots in mid-position, the maximum output is unlikely to exceed 2.2V. Output level controls are provided so that the output may be tailored to suit a range of input levels required by external apparatus such as tape recorders, power amplifiers and so on.

When the Envelope Shaper is programming the amplitude of the audio signal it is normal to set the input level control to zero if the full 90dB range of the v.c.a. is to be used. An alternative method is to adjust the input level so that, with a zero level envelope, the signal is just audible. The provision of an envelope under these conditions will serve to emphasise parts of the continuing signal. This technique is useful when one channel is carrying a repetitive rhythm which is to be mixed with another signal derived from, say, the keyboard. In these circumstances it is sometimes possible for the rhythm to be swamped by the keyboard signal unless the former signal is boosted.

If it is required to provide a differential level of positive going envelope for the latter purpose a suitable method is illustrated in Fig. 9.8. Set the envelope shaper signal level to provide the lowest amplitude response required between the two channels. Route the positive-going envelope to an input amplifier set to unity gain and also to the inverter. The output of the input amplifier should similarly be routed to the inverter. Since the inputs to the inverter are now of equal level and opposite polarity, the net output will be zero. Advancing the

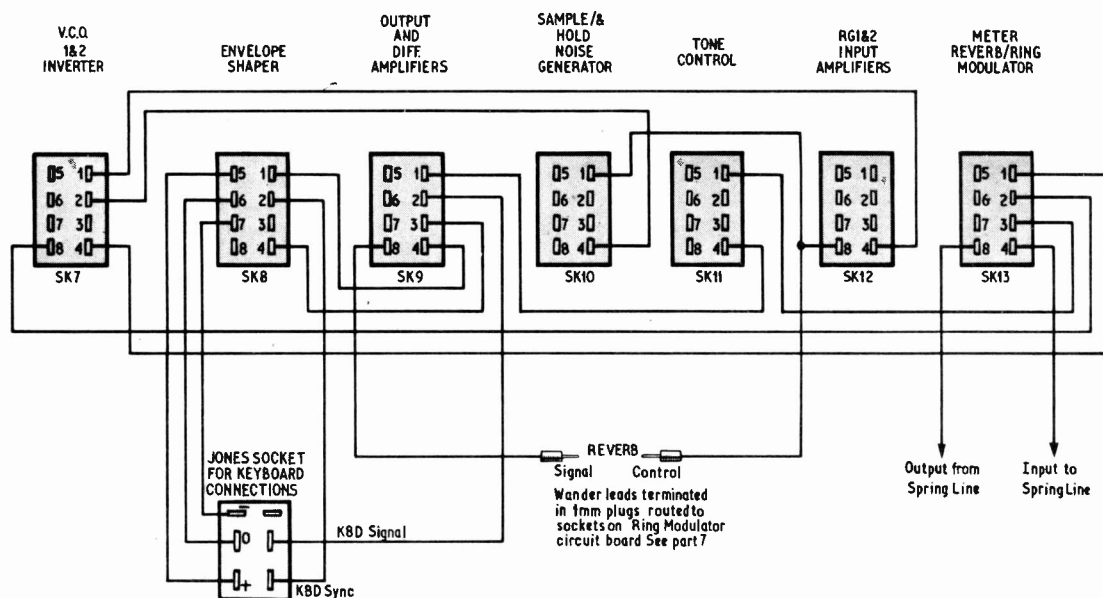


Fig. 9.10. Socket arrangement and wiring on connector mounting rails. Prewired interconnections are shown only



**Table 1: Prewired Connections**

Terminal Number	SK7 V.C.O. 1 & 2 Inverter	SK8 Envelope Shaper	SK9 Output Amplifiers Diff. Amp.	SK10 Sample/ Hold Noise Gen.	SK11 Tone Control	SK12 Ramp Gens. 1 & 2 Input Amps.	SK13 Meter Reverb. Ring Mod.
	Connect to	Connect to	Connect to	Connect to	Connect to	Connect to	Connect to
1	SK12 (4)	SK9 (4)	SK11 (4)	SK12 (8)	SK13 (3)	NC	SK7 (4)
2	SK10 (4)	Jones Skt. kbd. conn. sync.	Jones Skt. kbd. conn. signal	NC	NC	NC	SK7 (8)
3	NC	NC	SK8 (4)	NC	NC	NC	SK11 (1)
4	SK13 (1)	SK9 (3)	SK8 (1)	SK7 (2)	SK 9 (1)	SK7 (1)	Input to Spring Line
5	V+	V+	V+	V+	V+	V+	V+
6	O	O	O	O	O	O	O
7	V-	V-	V-	V-	V-	V-	V-
8	SK13 (2)	NC	Wandering lead	NC	NC	SK10 (1) Wandering lead	Output from Spring Line

gain control of the input amplifier will have the effect of providing a positive going envelope which may be adjusted to suit the requirements of the so-far unprogrammed output channel.

## TREMOLO EFFECTS

An interesting experiment lies in the investigation of tremolo effects. Set a ramp generator to about 7-8Hz programming the envelope shaper direct. Adjust the attack and decay controls so that the resultant envelope is triangular in form and adjust the envelope level so that it provides peak modulation to a v.c.a. Couple a v.c.o. running at about 300Hz to the audio signal input of the same v.c.a. and adjust the input level control so that the sound does not die away completely at zero envelope level. The resultant pulsating sound is known as tremelo modulation.

The next stage is to take the negative going envelope and couple it to the same series of modules described in the previous example. The output of the inverter should be led to the v.c.o. providing the 300Hz signal. If the input level control to the v.c.a. is now turned to maximum and the input amplifier gain carefully increased the resultant sound is known as vibrato or, perhaps more suitably, frequency modulation. Variation of input amplifier gain, in conjunction with v.c.a. input level, can provide an interesting range of sounds in which tremelo and vibrato modulations are mixed. The schematic arrangement of modules for the above experiment is shown in Fig. 9.9.

Further interest may be provided by variation in the triggering rate of the envelope shaper and variation in the mark-space ratio of the envelope by careful adjustment of the ratio control.

## PRE-WIRED INTERCONNECTIONS

This article concludes with some notes on interconnections which was outlined in Part 1.

Permanently connected interwiring is advocated to reduce the problems associated with external patch cords which, besides being possible sources of hum-pick-up, can often render the front panel controls difficult to operate particularly if a complicated patch is in use.

Table 1 gives the scheme of interconnection, whilst Fig. 9.10 gives a wiring layout based on the original illustration shown in Part 2 of the series. The socket numbers shown correspond to the socket numbers on that illustration which is a view from behind, as it were, of the front panel also depicted in that issue. Those constructors who have changed the arrangement of modules from that shown in Part 2 should note that the wiring on the McMurdo sockets will have been re-routed accordingly and would, perhaps, be well advised to use the table of connections as a guide.

There are two minor changes in the interwiring differing from the block diagram depicted in Part 1. These are:

- V.c.o. 1 is no longer programmed direct from the envelope shaper since the range of sounds which could be produced was not considered wide enough to merit a permanent connection.
- The Envelope Shaper programming of reverberation depth has been replaced by R.G.2 to gain the benefit of the wholly opposite type of effect resulting from the use of negative-going programming signals. At the same time the R.G.2 connection to the envelope shaper has been replaced by a connection from the differential amplifier since it has been found, in practice, to be the more useful of the two.

*Note: See Points Arising this month.*

**Next Month: Commencement of the Keyboard Unit.** This is an independent instrument that can be used for live performance apart from the main Synthesiser.

# WIND and RAIN EFFECTS

By P. J. TYRRELL

**T**his project describes the construction of a simple unit whose output when fed into an audio amplifier produces a sound resembling howling wind or falling rain. The circuit uses an operational amplifier in a dual-in-line package, which simplifies construction and aids stability in the high gain arrangement used. This also means that the circuit layout is less critical than if discrete components were used.

## PRINCIPLE OF OPERATION

The circuit consists basically of an active tuned filter fed from a white noise source. The sound of howling wind is produced by varying the resonant frequency of the filter. By removing one of the capacitors in the filter, the circuit behaves as a broad band amplifier, producing the sound of rain.

Fig. 1 shows the basic filter circuit used. The resonant frequency is determined by the values of  $C_1$ ,  $C_2$  and  $R_1$ ,  $R_2$  determining the gain of the system. Removing  $C_2$  widens the bandwidth of the filter. In the final circuit this function is performed by placing a variable resistor in series with  $C_2$ , permitting the rain to be gradually introduced.

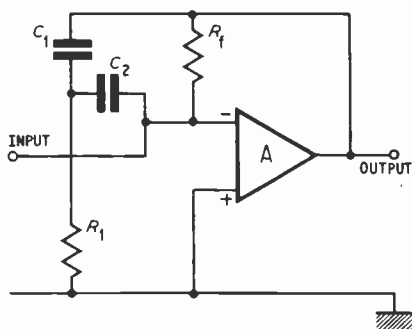


Fig. 1. Basic filter circuit.  $C_1$  and  $C_2$  determine the resonant frequency and  $R_1$  and  $R_2$  determine the gain

## FINAL CIRCUIT

The complete circuit of the unit is shown in Fig. 2. The white noise is generated in TR1 by giving it a reverse bias, then passed via  $R_2$  and  $C_3$  to the input of the filter. VR1 controls the resonant frequency of the filter, and is therefore, the wind control. VR2, in series with  $C_2$ , is the rain control.

The output from the filter passes through  $R_4$  to VR3, the output level control and then to the output socket SK1 via  $C_4$ . VR3 was wired as shown, not with the wiper connected to the output as it was envisaged that other equipment may be connected to the same input of the main amplifier.

The operational amplifier chosen for this circuit is the 741. It was chosen in preference to the 709 as the former requires no external frequency compensation and the greater bandwidth offered by the latter is not necessary in this application. The 741 will work satisfactorily from supply voltages of  $\pm 4$  to  $\pm 15$  volts, making it most suitable for operation from a pair of 9 volt batteries, as is done here. At this supply voltage the open loop voltage gain is over 90dB.

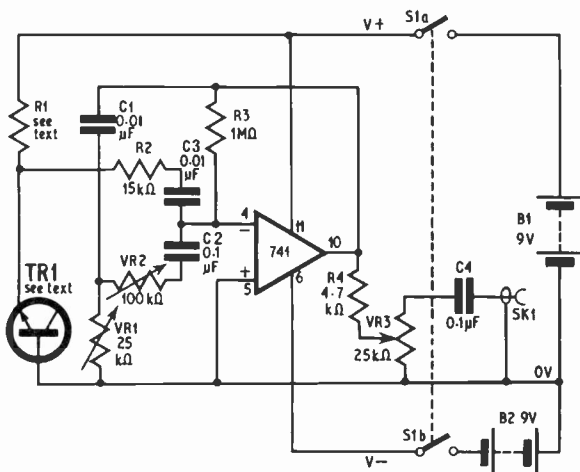


Fig. 2. Complete circuit diagram of the Wind and Rain Effects Unit

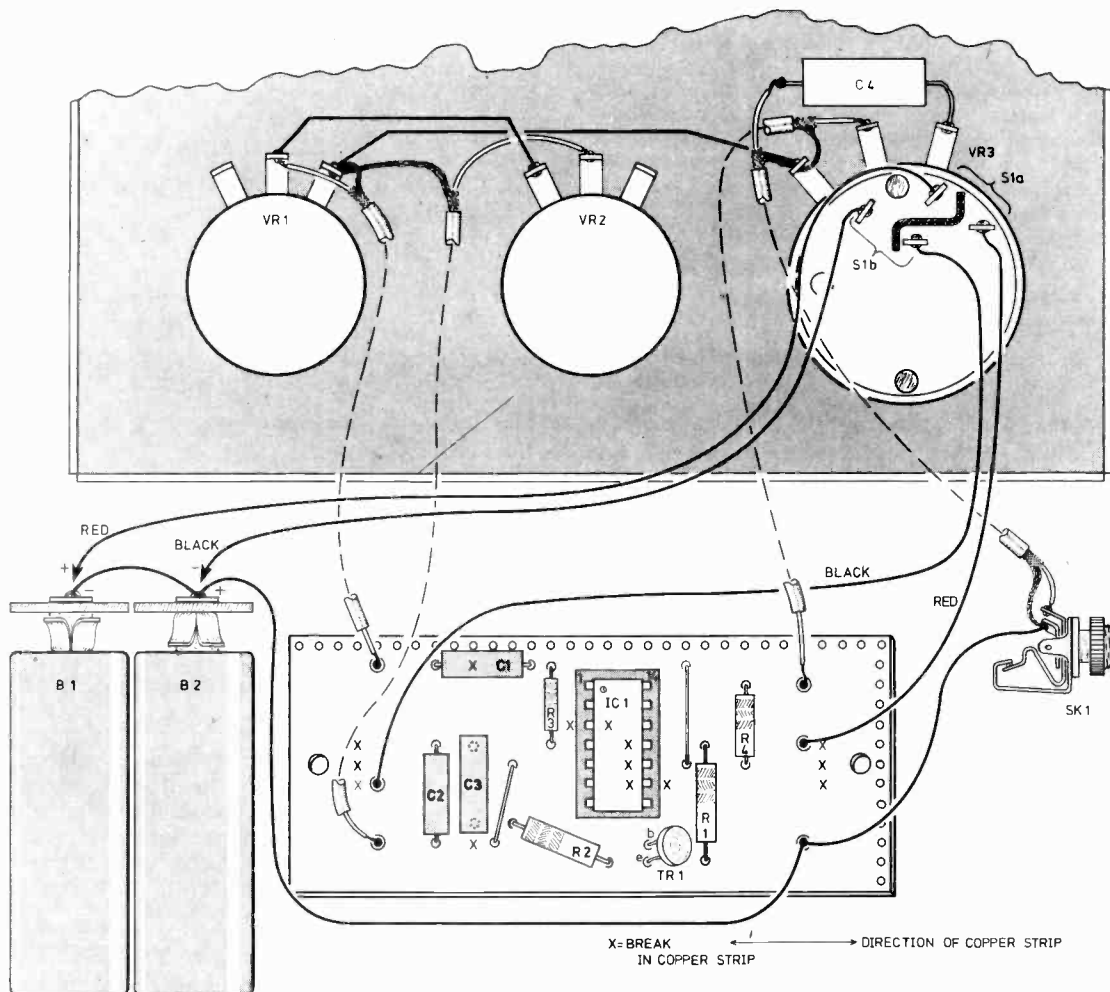


Fig. 3. Construction and interwiring details. All but battery leads should be screened leads

## COMPONENTS . . .

### Resistors

- R1 100k  $\Omega$  nominal (see text)
- R2 15k  $\Omega$
- R3 1M  $\Omega$
- R4 4.7k  $\Omega$
- All  $\frac{1}{4}$  or  $\frac{1}{8}$ W  $\pm 10\%$  carbon

### Potentiometers

- VR1 25k  $\Omega$  linear
- VR2 100k  $\Omega$  linear
- VR3 25k  $\Omega$  linear with double pole switch

### Capacitors

- C1 0.01 $\mu$ F      C3 0.01 $\mu$ F
- C2 0.1 $\mu$ F        C4 0.1 $\mu$ F
- All 160V polyester or polycarbonate

### Semiconductors

- TR1 Any *npn* transistor (see text)
- IC1 SN72741 or equivalent

### Miscellaneous

- Aluminium box 5 $\frac{1}{4}$ in x 4in x 1 $\frac{1}{2}$ in
- B1, B2 9V PP3 batteries (2 off)
- SK1 3.5mm jack socket
- Veroboard 0.1in matrix, 31 holes x 13 strips
- Veropins (6 off)
- Knobs, nuts, bolts, screened wire, aluminium for battery holder

## CONSTRUCTION

The circuit was constructed on a piece of 0.1 inch matrix Veroboard, using a socket for the 741.

Start by cutting the Veroboard to size (31 holes long by 13 strips wide). Next cut the copper strips according to Fig. 3, and then fix the Veropins for attachment of flying leads. All the components except TR1 and R1 should then be soldered in. The integrated circuit socket should be soldered before inserting the i.c. C4 is mounted directly onto VR3 to simplify wiring.

## SELECTING TR1 AND R1

In order to select suitable components for TR1 and R1, flying leads should be temporarily connected to V+, 0V and R2. The 9 volt batteries should be connected up and the output from R4 fed into an audio amplifier. VR2 can be left out of circuit, but VR1 should be temporarily wired in. It facilitates the selection process if a number of leads with insulated crocodile clips on both ends are available.

It is best to have a number of transistors at hand and select a suitably noisy specimen for TR1. Varying R1 alters the noise output from the transistor, but it should not be reduced below about two kilohms. In the prototype R1 was 100k $\Omega$  and TR1 was a silicon *nnp* device obtained from a computer board.

A *pnp* transistor can be used instead, by reversing the base and emitter connections. Alternatively, a noisy Zener diode, reverse biased, may be used. A number of advertisers in this magazine offer untested transistors for sale, cheaply in bulk, and it is worth investing in some of these.

Having chosen R1 and TR1, these should be soldered in place on the Veroboard.

## CASE CONSTRUCTION

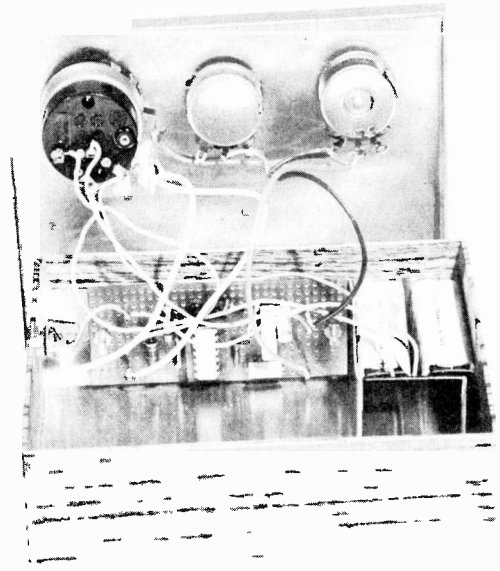
The prototype was constructed in a ready-made aluminium box. Construction and interwiring details for the box and its lid are shown in Fig. 3. A battery retaining clip can be made from a piece of aluminium. The end of this should be wrapped with insulating tape to prevent the battery clips from shorting out.

If it is thought that the batteries may be inadvertently inserted the wrong way round then the inside of the box, next to the Veroboard, can be insulated as well. The Veroboard is mounted with two 6BA bolts and  $\frac{1}{4}$ in spacers. One of the bolts serves to hold the battery retaining clip in position as well.

The prototype box was covered with woodgrain pattern, plastic self-adhesive, and the lid brushed with steel wool. A piece of foam plastic was glued to the inside of the lid, to prevent the batteries from rattling, and Letraset legends applied above the three controls. The front panel was then given a coat of polyurethane varnish, to protect the surface and the lettering. Cellulose varnish should not be used as this dissolves Letraset.

## FINAL WIRING UP

The circuit should be wired up using screened wire, apart from the battery leads, due to the possibility of instability in the high gain arrangement. Do not forget to connect C4, which is mounted on VR3.



Photograph of the internal layout

## TESTING AND OPERATION

With the circuit fully assembled, the current drawn from each battery should be about 1.6mA. With the unit connected to an audio amplifier, VR3 fully clockwise, VR2 and VR1 fully anticlockwise, a low moan should be audible. By advancing VR1 the frequency of the wind should rise up to a scream. With VR1 again fully anticlockwise, as VR2 is advanced, the sound of falling rain is heard, increasing in intensity with rotation of VR1 and VR2.

No detailed description of application is included here, as this is best left to the constructor's imagination. ★

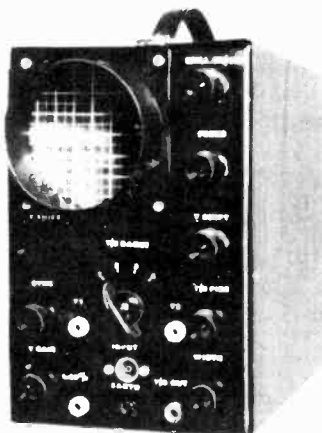
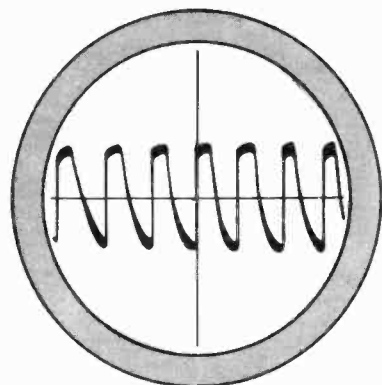


Photograph of the completed Wind and Rain Effects unit

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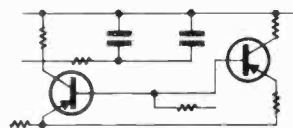
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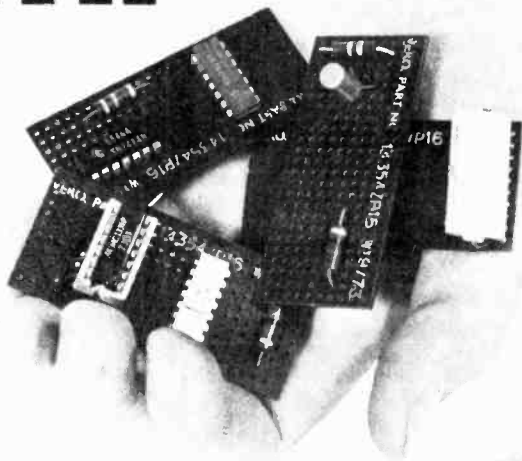
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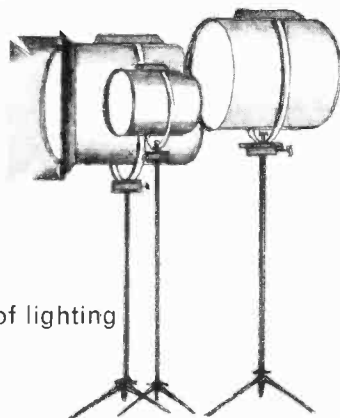
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# ELECTRONICS

NOVEMBER ISSUE ON SALE OCTOBER 12, 1973

# PATENTS REVIEW...

## FOUR CHANNEL VOLUME AND BALANCING CONTROL

In BP1 317 530 Motorola Inc. of Illinois, USA, describe a simple but useful system for balancing 4-channel sound. The patent is concerned mostly with cartridge players for cars.

The basic system diagram is shown in Fig. 1. Four channels drive four speakers i.e., left rear, left front, right rear, right front.

Each of the four speaker driver amplifiers uses a transistor to act as a variable impedance device to control the gain of the audio signal, see Fig. 1. Usually the transistors used are of the *nnp* type with the collector connected to the drive for the speakers and the emitter connected to earth. For *pnp* types the emitter and collector connections are reversed.

Potentiometer VR2 acts as a side balance (left to right) control and has one end connected to the left channels and the other end connected to the right channels. As VR2 slider is moved it thus provides a variable voltage divider network between the respective pairs of channels.

Adjustment of VR2 varies the amount of d.c. voltage delivered to the respective pairs of channels at the bases of their associated transistors. But the total sum of the d.c. applied remains the same; so it follows that although the respective pairs of channels are balanced, a constant volume is maintained with respect to the total output of the pairs of channels. This is because there is no shunting or limiting effect.

Potentiometer VR3 acts as a control for balancing the front and rear sets of speakers. One end is connected to the rear channels and the other to the front channels. VR3 functions in exactly the same manner as VR2 dividing a fixed amount of d.c. voltage between the front and rear channel pairs.

In the circuit shown fixed value resistors are connected in series with the base of each transistor to serve as a bias current limiting device.

The overall gain or volume of the system is controlled by VR1, the slider being connected directly to the sliders of VR2 and VR3 respectively. Once control VR1 has been set to achieve the required overall volume level, this will be maintained whatever balancing

## BP1 317 530

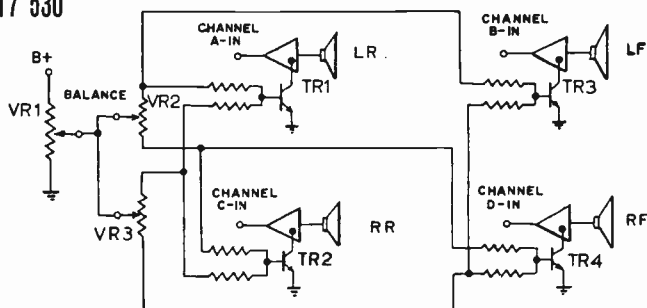


Fig. 1

positions are set on the other controls. Also, the set balance will remain the same as the overall volume level is raised or lowered.

## STEREO AMPLIFIER AVC

Blaupunkt-Werke of Germany in BP 1 307 074 describe an automatic volume control for a stereo amplifier. The idea is to provide a.v.c. with no cross-talk between channels, but without buffer amplifiers.

The output of the first channel amplifier is fed to one end of a potential divider network, the other end of the divider is connected to the positive line. Capacitor C3 connects the junction of resistors R3, R4 to one side of a bridge. The anodes of D2 and D4 connect via VR1 to the base of amplifier transistor TR1 and the cathodes of D3 and D4 are connected to the emitter of TR1. The second channel is connected in exact mirror fashion.

The collector of TR1 is connected through D5 and filter network C7, R12 to the base of TR2.

Its emitter is connected through VR2 to a pair of voltage dividers and transistors TR3 and TR4.

When one of the two channels produces a signal which is too large, the negative going half wave passes through the respective capacitors C3, C4, charged by the positive half wave and action of diodes D1, D3, via either D2 or D4 and VR1 to the base of TR1. The resultant control signal from the collector of TR1 is fed to the base of TR2 and is applied to the variable control VR2 which allows compensation for tolerances of TR3 and TR4.

With correct adjustment of VR2, the voltages on the bases of both TR3 and TR4 will be altered by equal amounts so that the collector/emitter junctions of the transistors are more or less conductive. This will achieve ganged automatic volume control because there will be an alteration in the ratio of the potentiometer in each channel formed by the input resistors R1, R2 and its respective transistors TR3 and TR4, with a resultant change in the fraction of the signal applied to the channel amplifiers.

## BP1 307 074

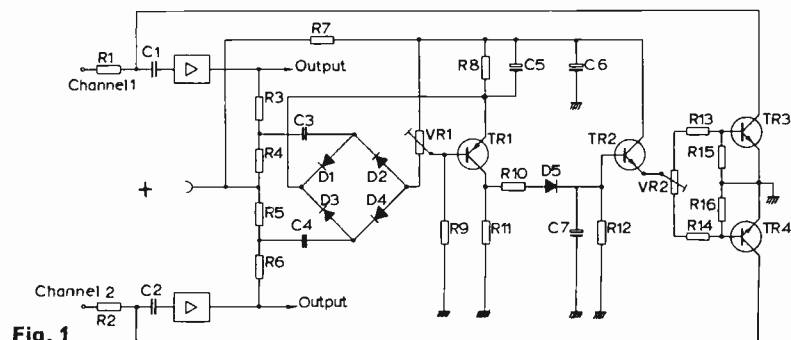


Fig. 1

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## RESISTORS

W Iskra high stability carbon film—very low noise—capless construction.  
W Mullard CR25 carbon film—very small body size 7.5 x 2.5mm.  
W 2% ELECTROSIL TRS

Power watts	Tolerance	Range	Values available	Price 1-99 100+
1/4	5%	4.7Ω-2.2MΩ	E24	0.8p
1/2	10%	3.3MΩ-10MΩ	E12	0.8p
1	2%	10Ω-1MΩ	E24	3.5p
2	10%	1Ω-3.9Ω	E12	0.8p
4	10%	4.7Ω-1MΩ	E12	1p
10	10%	1Ω-10Ω	E12	6p
25	10%	1Ω-10Ω	E12	5.5p

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

## DEVELOPMENT PACK

0.5 watt 5% Iskra resistors 5 off each value 4.7Ω to 1MΩ.  
E12 pack 325 resistors £2.40. E24 pack 650 resistors £4.70.

## POTENTIOMETERS

Carbon track 5kΩ to 2MΩ, log or linear (log 1W, lin 1/2W).  
Single, 12p. Dual gang (stereo), 40p. Single D.P. switch 24p.

## SKELETON PRESET POTENTIOMETERS

Linear: 100, 250, 500Ω and decades to 5MΩ. Horizontal or vertical P.C.  
mounting (0.1 matrix).  
Sub-miniature 0.1W, 5p each. Miniature 0.25W, 6p each.

## TRANSISTORS

AC107 15p	AF125 20p	BD132 75p	OC28 50p	2N3702 13p
AC126 12p	AF126 20p	BD133 75p	OC35 50p	2N3703 12p
AC127 12p	AF127 20p	BF115 25p	OC42 12p	2N3704 13p
AC128 12p	AF139 32p	BF173 20p	OC44 12p	2N3705 12p
AC131 12p	AF178 32p	BF177 28p	OC45 12p	2N3706 11p
AC132 12p	AF180 40p	BF178 32p	OC70 12p	2N3707 12p
AC176 12p	AF181 40p	BF179 32p	OC71 12p	2N3708 10p
AC187 22p	BC107 9p	BF180 32p	OC72 12p	2N3709 11p
AC188 22p	BC108 9p	BF181 32p	OC81 12p	2N3710 11p
AD140 50p	BC109 9p	BF194 15p	OC82D 12p	2N3711 11p
AD149 45p	BC147 13p	BF195 15p	2N2904 20p	2N4062 12p
AD161 33p	BC148 13p	BF197 15p	2N2926R 9p	40360 35p
AD162 36p	BC149 13p	BF200 32p	2N2926Y 9p	40361 35p
AF114 20p	BC157 14p	BFY50 20p	2N2926Y 9p	40362 40p
AF115 20p	BC158 14p	BFY51 20p	2N2926G 10p	40408 40p
AF116 20p	BC159 14p	BFY52 20p	2N3054 50p	ZTX302 15p
AF117 20p	BC187 22p	BU105 225p	2N3055 60p	ZTX500 15p
AF124 22p	BD131 75p	OC26 45p		

## ZENER DIODES

400mW 5% 3.3V to 30V, 12p.

## WIRE WOUND POTS, 3W, 10, 25,

50Ω and decades to 100kΩ, 35p.

## DIODES

### RECTIFIER

BY127 1250V	1A	12p
BZ10 800V	6A	25p
BZ13 200V	6A	20p
IN4001 50V	1A	7p
IN4004 400V	1A	8p
IN4007 1000V	1A	10p

### SIGNAL

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

## BRUSHED ALUMINIUM PANELS

12in x 6in=25p, 12in x 2in=10p, 9in x 2in=7p

## SLIDER POTENTIOMETERS

86mm x 9mm x 16mm, length of track 59mm.

SINGLE 10K, 25K, 100K log. or lin. 40p.

DUAL GANG, 10K + 10K etc. log. or lin. 60p.

KNOB FOR ABOVE 12p.

## FRONT PANEL 65p

18 Gauge panel 12in x 4in with slots cut for use  
with slider pots. Grey or matt black finish com-  
plete with fixings for 4 pots.

## THERMISTORS

VA10555 15p
VA10665 15p
VA1077 15p
RS3 15p

## THYRISTORS

2N5060 50V 0.8A 30p.
2N5064 200V 0.8A 47p.
CRS1/40 400V 1A 25p.
106F 50V 4A 40p, 106D
400V 4A 55p.

## MULLARD POLYESTER CAPACITORS C196 SERIES

400V: 0.001μF, 0.0015μF, 0.0022μF, 0.0033μF, 0.0047μF, 21p. 0.0068μF, 0.01μF,  
0.015μF, 0.022μF, 0.033μF, 3p. 0.047μF, 0.068μF, 0.1μF, 4p. 0.15μF, 6p. 0.22μF, 7p.  
0.33μF, 11p. 0.47μF, 13p.

160V: 0.01μF, 0.015μF, 0.022μF, 0.033μF, 0.047μF, 0.068μF, 3p. 0.1μF 3p. 0.15μF 4p.  
0.22μF, 5p. 0.33μF, 6p. 0.47μF, 7p. 0.68μF, 11p. 1.0μF, 13p.

## MULLARD POLYESTER CAPACITORS C280 SERIES

250V P.C. mounting: 0.01μF, 0.015μF, 0.022μF, 3p. 0.033μF, 0.047μF, 0.068μF,  
31p. 0.1μF, 4p. 0.15μF, 0.22μF, 5p. 0.33μF, 6p. 0.47μF, 8p. 0.68μF, 11p. 1.0μF, 13p.  
1.5μF, 20p, 2.2μF, 24p.

## MYLAR FILM CAPACITORS 100V

0.001μF, 0.002μF, 0.005μF, 0.01μF, 0.02μF,  
21p. 0.04μF, 0.05μF, 0.068μF, 0.1μF, 31p.

## CERAMIC DISC CAPACITORS

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

## ELECTROLYTIC CAPACITORS—MULLARD O15/6/7 RANGE REPLACES C426,

C457 RANGES.  
(μF/V) 1/0.63, 1.5/63, 2.2/63, 3.3/63, 4.7/63, 6.8/80, 10/25, 10/63, 15/16, 15/40, 15/63,  
22/10, 22/25, 22/63, 33/6.3, 33/40, 47/40, 47/25, 47/40, 47/63, 68/6.3, 68/16, 100/4,  
100/10, 100/25, 100/40, 150/6.3, 150/16, 150/25, 220/4, 220/10, 220/16, 330/4, 330/10,  
470/6.3, 5p each. 68/63, 150/40, 220/25, 330/16, 470/10, 680/6.3, 1,000/4, 9p. 100/63,  
150/63, 220/40, 470/25, 680/16, 1,000/10, 1,500/6.3, 12p. 220/63, 470/40, 680/25,  
1,000/6.3, 1,500/10, 2,200/6.3, 15p. 330/63, 680/40, 1,000/25, 1,500/16, 2,200/10,  
3,300/6.3, 4,700/4, 18p.

## SOLID TANTALUM BEAD CAPACITORS

0.1μF 35V	2.2μF 35V	22μF 16V	12p
0.22μF 35V	4.7μF 35V	33μF 10V	
0.47μF 35V	6.8μF 25V	47μF 6.3V	
1.0μF 35V	10μF 25V	100μF 3V	

## VEROBOARD

2 1/2 x 3 1/2	0.1	0.15
2 1/2 x 5	22p	16p
3 1/2 x 5	24p	24p
3 1/2 x 3 1/2	24p	24p
2 1/2 x 5	27p	27p
1 7/8 x 2 1/2	75p	57p
1 7/8 x 3 1/2	100p	78p
1 7/8 x 5 (plain)	—	82p
1 7/8 x 3 1/2 (plain)	—	60p
1 7/8 x 2 1/2 (plain)	—	42p
2 1/2 x 5 (plain)	—	12p
2 1/2 x 3 1/2 (plain)	—	11p
Pin insertion tool	52p	52p
Spot face cutter	42p	42p
Pkt. 50 pins	20p	20p

## JACK PLUGS AND SOCKETS

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

## D.I.N. PLUGS AND SOCKETS

2 pin, 3 pin, 5 pin 180°, 5 pin 240°, 6 pin  
Plug 12p. Socket 8p.  
4 way screened cable, 15p/metre.  
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2500μF 50V	58p	3200μF 16V	50p	5000μF 50V	£1.10

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0.022μF 12p	0.1μF 13p	0.47μF 22p

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Detector GDI, £2. Kit of parts for detectors including GDI and P.C. board but excluding case. Mains operated detector £5.20. 12 or 24V battery operated audible alarm £7.30. As above for PP9 battery, £6.40.

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7400	18	16	14	13	7450	18	16	14	13	74121	43	40	38	36
7401	18	16	14	13	7451	18	16	14	13	74141	100	95	90	85
7402	18	16	14	13	7453	18	16	14	13	74145	140	140	135	130
7403	18	16	14	13	7454	18	16	14	13	74150	330	280	250	220
7404	20	18	16	14	7460	18	16	14	13	74151	110	100	95	89
7405	20	18	16	14	7470	30	28	25	24	74153	120	110	105	95
7406	30	45	40	35	7472	40	38	36	30	74154	200	180	170	160
7407	50	40	44	34	7473	40	38	36	30	74155	150	120	100	86
7408	36	30	27	23	7474	40	38	36	30	74156	130	120	100	96
7409	36	30	27	23	7475	55	52	50	49	74180	155	136	112	105
7410	18	16	14	13	7476	40	36	32	30	74190	195	190	185	180
7411	23	21	20	18	7480	100	95	90	85	74191	195	190	185	180
7412	36	30	27	23	7481	125	115	110	105	74192	200	190	180	164
7413	36	30	27	23	7482	100	96	90	85	74193	200	180	170	150
7414	34	28	26	22	7483	100	97	95	92	74196	200	190	180	170
7415	45	43	39	34	7484	120	115	110	105	74197	200	195	180	170
7416	18	16	14	13	7485	250	245	240	230					
7417	36	30	27	23	7486	45	42	37	33					
7418	36	30	27	23	7487	75	67	60	52					
7419	20	18	16	14	7490	100	92	85	79	709	14 pin DIL			32p
7420	20	18	16	14	7491A	100	92	85	79	741	8 pin DIL			34p
7421	40	36	32	28	7492	75	70	65	60	741	14 pin DIL			28p
7422	20	18	16	14	7493	75	68	60	52	741	14 pin DIL			28p
7423	80	75	70	65	7494	95	90	85	80	723	14 pin DIL			95p
7424	80	75	70	65	7495	105	100	95	90	747	14 pin DIL			85p
7425	125	120	115	115	7496	100	95	90	85	748	8 pin DIL			35p
7426	175	165	150	120	74100	250	240	235	230		DIL socket,	14 pin and 16 pin		16p

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

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

All Electro Spares supplied components are new, branded products of reputable manufacturers, and carry full makers' guarantee.

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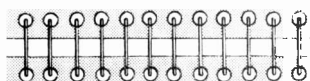
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1N21	5p	AFZ12	1-50	BYZ10	0-45	OAZ209	0-40	Z8170	0-10
1N23	0-35	ASV26	0-25	BYZ11	0-40	OAZ210	0-40	Z8271	0-18
1N85	0-85	ASV27	0-30	BYZ12	0-40	OAZ211	0-40	Z8271	0-25
1N233	0-50	ASV28	0-25	BYZ13	0-55	OAZ222	0-45	ZT231	0-25
1N236	0-50	ASV29	0-30	BYZ15	1-25	OAZ223	0-45	ZT233	0-25
1N645	0-25	ASV36	0-25	BYZ16	0-80	OAZ224	0-45	ZTX107	0-12
1N725A	0-20	ASV50	0-20	BYZ88C3V3	0-10	OAZ241	0-22	ZTX108	0-10
1N914	0-05	ASV51	0-40	BYZ88C3V3	0-10	OAZ242	0-22	ZTX300	0-14
1N4007	0-12	ASV53	0-20	BYZ88C3V3	0-10	OAZ244	0-25	ZTX304	0-24
18113	0-15	ASV55	0-20	BYZ88C3V3	0-10	OAZ246	0-25	ZTX500	0-15
18131	0-13	ASV62	0-25	C111	0-55	OAZ290	0-38	ZTX503	0-18
18292	0-23	ASV66	0-33	CR81/05	0-30	OC16	0-85	ZTX531	0-25
2G371	0-40	ASZ21	1-00	CR81/40	0-45	OC16T	0-38	<b>INTEGRATED CIRCUITS</b>	
2G381	0-25	ASZ23	0-75	CS48	2-50	OC19	0-50		
2G414	0-30	AU101	1-50	CS10B	3-13	OC20	1-25	7400	0-20
2G417	0-25	ALY10	0-98	DD009	0-15	OC22	1-00	7401	0-20
2N404	0-22	BU007	0-12	DD003	0-15	OC23	1-25	7402	0-20
2N897	0-15	BU008	0-12	DD006	0-15	OC24	1-10	7403	0-20
2N898	0-30	BU009	0-12	DD007	0-40	OC25	0-40	7404	0-20
2N706	0-10	BU113	0-18	DD008	0-38	OC26	0-35	7405	0-20
2N706A	0-12	BU115	0-20	GD3	0-33	OC28	0-65	7406	0-20
2N708	0-15	BU116	0-20	GD4	0-10	OC29	0-65	7407	0-20
2N709	0-40	BU116A	0-23	GD5	0-33	OC30	0-40	7408	0-25
2N1091	0-55	BU118	0-15	GD8	0-25	OC35	0-55	7409	0-33
2N1131	0-25	BU121	0-20	GD12	0-10	OC38	0-65	7410	0-20
2N1132	0-25	BU122	0-20	GET102	0-40	OC41	0-35	7411	0-23
2N1302	0-13	BU125	0-68	GET103	0-40	OC42	0-40	7412	0-28
2N1303	0-18	BU126	0-65	GET113	0-35	OC43	0-70	7413	0-28
2N1304	0-22	BU140	0-55	GET114	0-30	OC44	0-18	7416	0-20
2N1305	0-22	BU147	0-12	GET115	0-75	OC44M	0-17	7417	0-20
2N1306	0-28	BU148	0-10	GET116	0-85	OC45	0-18	7420	0-20
2N1307	0-28	BU149	0-12	GET120	0-50	OC45M	0-18	7422	0-28
2N1308	0-28	BU157	0-14	GET872	0-30	OC46	0-27	7423	0-28
2N2147	0-75	BU158	0-12	GET875	0-40	OC57	0-60	7425	0-37
2N148	0-60	BU160	0-63	GET880	0-55	OC58	0-60	7427	0-37
2N2160	0-61	BU169	0-14	GET891	0-25	OC59	0-60	7428	0-48
2N2218	0-23	BU31	0-45	GET882	0-35	OC66	0-50	7430	0-20
2N2219	0-25	BU32	0-85	GET885	0-35	OC70	0-18	7432	0-87
2N3489A	0-15	BU33	0-38	GET886	0-48	OC71	0-18	7433	0-48
2N2444	1-99	BU34	0-45	GET894	0-08	OC72	0-25	7437	0-48
2N2613	0-28	BU38	0-55	GET941	0-30	OC73	0-60	7438	0-48
2N2646	0-50	BU39	1-00	GD3M	0-50	OC74	0-30	7440	0-48
2N2904	0-20	BU40	0-80	GD4M	0-38	OC75	0-30	7441AN	0-85
2N2904A	0-25	BU42	0-30	GD5M	0-25	OC76	0-30	7442	0-85
2N2906	0-20	BU70	0-15	GD7M	0-50	OC77	0-25	7450	0-20
2N2907	0-23	BU71	0-20	MG1005	0-50	OC78	0-25	7451	0-20
2N2924	0-28	BUZ10	0-60	H8100A	0-20	OC79	0-30	7453	0-20
2N2925	0-15	BUZ11	0-65	MAT100	0-20	OC81	0-28	7454	0-20
2N2926	0-10	BD121	1-00	MAT101	0-25	OC81D	0-28	7460	0-20
2N3054	0-45	BD123	1-00	MAT120	0-20	OC81M	0-20	7470	0-38
2N3055	0-45	BD124	0-40	MAT121	0-25	OC81DM	0-18	7472	0-38
2N3702	0-10	BDY11	1-45	MJE520	0-65	OC82	0-28	7473	0-44
2N3703	0-12	BF115	0-20	MJE2855	1-10	OC82D	0-25	7474	0-48
2N3708	0-11	BF117	0-50	MKT3055	0-75	OC82D	0-25	7475	0-59
2N3707	0-13	BF167	0-23	NKT128	0-45	OC83	0-25	7476	0-80
2N3709	0-10	BF173	0-25	NKT129	0-30	OC84	0-25	7480	0-80
2N3710	0-11	BF181	0-33	NKT211	0-25	OC114	0-38	7482	0-87
2N3711	0-11	BF184	0-22	NKT213	0-25	OC122	1-00	7483	1-20
2N3819	0-35	BF185	0-22	NKT214	0-24	OC123	1-10	7484	1-00
2N5027	0-58	BF184	0-13	NKT216	0-40	OC139	0-40	7486	0-50
2N5088	0-35	BF185	0-13	NKT217	0-45	OC149	0-65	7489	0-76
28301	0-59	BF196	0-15	NKT218	1-13	OC141	0-60	7490	1-10
28304	1-15	BF197	0-15	NKT219	0-33	OC169	0-20	7492	0-75
28501	0-37	BF861	0-25	NKT222	0-30	OC170	0-25	7493	0-76
28703	1-00	BF898	0-25	NKT224	0-25	OC171	0-80	7494	0-85
AA129	0-20	BFX12	0-20	NKT231	0-24	OC200	0-55	7495	0-85
AAZ12	0-75	BFX13	0-25	NKT271	0-25	OC201	0-80	7496	1-00
AAZ13	0-10	BFX29	0-28	NKT272	0-20	OC202	0-70	7497	4-82
AC107	0-35	BFX30	0-28	NKT273	0-20	OC203	0-55	7498	4-86
AC126	0-25	BFX35	0-88	NKT274	0-20	OC204	0-65	7499	0-51
AC127	0-25	BFX63	0-50	NKT275	0-25	OC205	1-00	7499	0-57
AC128	0-20	BFX84	0-25	NKT277	0-20	OC206	1-10	7499	0-86
AC187	0-20	BFX85	0-25	NKT278	0-25	OC207	1-00	7499	1-00
AC188	0-20	BFX86	0-25	NKT301	0-85	OC460	0-60	7499	1-00
AC177	0-35	BFX87	0-25	NKT304	0-75	OC470	0-30	7499	1-00
AC194	0-27	BFX88	0-22	NKT403	0-70	OCP71	1-00	7499	1-00
AC199	0-27	BFY10	1-00	NKT404	0-80	ORP12	0-55	7499	1-00
AC200	0-22	BFY11	1-25	NKT408	0-30	ORP60	0-45	7499	1-00
AC21	0-22	BFY17	0-25	NKT713	0-30	ORP61	0-48	7499	1-00
AC22	0-16	BFY18	0-45	NKT773	0-25	S197	0-30	7499	1-00
AC27	0-25	BFY19	0-55	NKT777	0-38	SAC40	0-25	7499	1-00
AC28	0-25	BFY24	0-45	OT8B	0-38	SFT308	0-38	7499	1-00
AC339	0-65	BFY44	1-00	OA6	0-12	ST722	0-38	7499	1-00
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AC41	0-22	BFY51	0-20	OA70	0-10	SX68	0-20	7499	1-00
AC44	0-32	BFY52	0-20	OA71	0-10	SX631	0-45	7499	1-00
AD140	0-50	BFY53	0-17	OA73	0-15	SX632	0-45	7499	1-00
AD149	0-50	BFY64	0-45	OA74	0-15	SX640	0-75	7499	1-00
AD181	0-31	BFY90	0-75	OA79	0-10	SX641	0-75	7499	1-00
AD162	0-39	BSX27	0-50	OA81	0-10	SX642	0-60	7499	1-00
AF106	0-30	BSX60	0-93	OA85	0-15	SX645	0-85	7499	1-00
AF114	0-25	BSX76	0-18	OA86	0-15	SX645	0-85	7499	1-00
AF115	0-25	BSX28	0-18	OA90	0-07	V15/30P	0-75	7499	1-00
AF116	0-25	BSY77	0-18	OA91	0-07	V30/20P	0-75	7499	1-00
AF117	0-20	BSY51	0-50	OA95	0-07	V60/20P	0-50	7499	1-00
AF118	0-50	BSY95A	0-12	OA200	0-08	V60/20P	0-75	7499	1-00
AF119	0-20	BSY95	0-12	OA202	0-10	XA101	0-10	7499	1-00
AF124	0-30	BT102/500R	0-75	OA210	0-25	XA102	0-15	7499	1-00
AF125	0-30	BTY42	0-92	OA211	0-30	XA151	0-18	7499	1-00
AF126	0-30	BTY79/100R	0-75	OA2200	0-50	XA152	0-15	7499	1-00
AF127	0-30	BTY79/400R	0-75	OA2201	0-45	XA161	0-25	7499	1-00
AF139	0-38	BTY79/400R	1-10	OA2202	0-45	XA162	0-25	7499	1-00
AF178	0-55	BY100	0-16	OA2203	0-45	XB101	0-43	7499	1-00
AF179	0-55	BY126	0-15	OA2204	0-45	XB102	0-30	7499	1-00
AF180	0-55	BY127	0-15	OA2205	0-45	XB103	0-35	7499	1-00
AF181	0-50	BY182	0-85	OA2206	0-45	XB113	0-30	7499	1-00
AF186	0-40	BY182	0-85	OA2207	0-45	XB121	0-43	7499	1-00
AFY19	1-13	BY213	0-25	OA2208	0-40	ZR24	0-68	7499	1-00
AFZ11	1-16	BY213	0-25	OA2208	0-40	ZR24	0-68	7499	1-00

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# INDUSTRY NOTEBOOK

*By NEXUS*

## CMOS CATCHES ON

Last year European manufacturers bought £1 million worth of CMOS devices. This year the figure will be £3 million and 1974 will see European sales topping £7 million. If these figures are correct, and top Motorola marketing men believe they are, then the faith of the pioneers led by RCA will be fully justified.

Watch out for Motorola grabbing a big share of the CMOS market. Their UK marketing manager is talking of "dedication" to the technique and is backing his words with a costly promotional campaign centred on a big applications seminar... to be staged in London in early October. The seminar will also be going on tour to other European capitals.

Motorola latched on to the CMOS bandwagon by second-sourcing established RCA devices. But the pattern is now changing. Of 48 device types brought to the market last year by Motorola, 23 types were second-sourced RCA but 25 were Motorola originals. This year's developments bring the score up to 30 types second-sourcing RCA plus 50 Motorola originals.

While Motorola's newest European plant was in construction at East Kilbride there was indecision on its final function. But now the CMOS market is firming up I can reveal that East Kilbride is to be the major European centre for CMOS production.

At present, wafer diffusion is based on Phoenix, Arizona, assembly and packaging in plants in Mexico, Korea and Malaysia and with European testing in Scotland.

But East Kilbride is scheduled to start diffusion of 3-inch wafers in October and will thus have complete capability to serve Europe and will be totally committed to this task.

Manufacturers of CMOS see a world market worth more than £80 million annually in two years time. CMOS, they say, will bite savagely into the present TTL and DTL dominated markets at frequencies up to 25MHz. But more important is the opening up of completely new markets for which other forms of logic are not suitable. Cited are watches and clocks, car electronics, domestic appliances, and even toys.

## DRIVE-IN

The car market is not only opening up for electronic component manufacturers. The automatic test equipment (ATE) brigade are also moving in.

Historically, ATE found its feet in testing complex avionic systems and has slowly found its way down to more mundane tasks such as checking out PCB boards and other assemblies in manufacturing plants where it is used to speed up production and cut costs because automatic diagnosis of faults dispenses with skilled labour.

Car manufacturers are being invited to attend Automatic Testino '73 Exhibition and Conference in Brighton in November where the programme includes papers on automated engine test beds. More than 30 ATE equipment manufacturers will be showing their skills in hardware and novel applications in the exhibition halls. But potential users of ATE still need a lot of education on the subject. I note from the provisional list of papers to be presented that D. B. Gemmell of Membrain Ltd. has submitted one with the intriguing title "Some Fancies and Fantasies in ATE Architecture" that could be amusing as well as instructional.

## TECHNICIAN TRAINING

A discussion document on technician training has been produced by a working party of the Institution of Electrical and Electronics Technician Engineers under the chairmanship of Robert Winton of Mullard Ltd. Entitled "The Future Development of Further Education Courses for Technician Engineers and Technicians" it proposes a modular course structure which will bring students forward to the educational standards stipulated by the Engineers' Registration Board.

An "open house" meeting will take place at 2.30 p.m., October 16, at the IEE H.Q., Savoy Place, for those interested in discussing the document with the working party. The document can be obtained free on request from the IEETE, 2 Savoy Hill, London, WC2R 0BS.

## CUT-PRICE COMPUTERS

While world meat prices soar, the cost of computing comes tumbling down. Computer Automation is now offering the latest Naked Mini/LSI for less than £500 in quantities of 200 or more. This is a computer-on-a-card, a single PCB of 15 x 17 x 1in dimensions weighing only 4lbs and designed for OEM use.

If you want the same thing boxed as a stand-alone unit with control console, data input keyboard and power supply the cost is £995 for one-off but still, say Computer Automation, less than half the listed price of the PDP-11-05 or Nova 1210 of comparable specification. Secret of the new low price is a central processor that uses only seven MOS LSI chips custom-built for the company.

## AUTUMN BOOM

After the August holiday season expect plenty of product and business announcements in September. FR Electronics is concluding marketing deals with more overseas companies. Dymar Electronics will be launching a complete new range of land mobile communications equipment in London on September 12 which could well be countered by a surprise announcement from market leader Pye. But Dymar, one of the liveliest companies in mobile radio, has a fine reputation and should continue to prosper in this highly competitive but fast-expanding field.

Expect, too, some new products from Racal Group whose 5th biennial Racalex exhibition and conference opens on September 25

## RAIDING PARTY

While British TV manufacturers are worried about the invasion of Japanese sets in the UK market, a group of British components and equipment manufacturers will be probing the Japanese market at the great Japan Electronics Show in Osaka in October.

Fifteen companies are taking the long trip East with the backing of the Department of Trade and Industry and the Electronic Engineering Association. Trade prospects in Japan, say the DTI, are good for companies that have the right products.

# Readout —

## A SELECTION FROM OUR POSTBAG

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

### PLUGGING THE LEAK

Sir—With regard to your present series of articles "P.E. Sound Synthesiser". First, may I point out, that my comments are in no way intended to "have a go" at Mr Shaw's circuits, which show considerable technical ability and have no doubt required considerable effort on his behalf.

I have found, however, during evaluation of the Ramp Generator circuit a possible snag and therefore supply my findings as other readers may find my conclusions useful.

In Mr Shaw's circuit, an OC140 transistor is employed to switch the direction of integration. It would appear that the two main factors governing the choice of transistor type are: low leakage—since the transistor is in a high current amplifying loop—and high base/emitter reverse bias capability—since the emitter is fixed at  $-3.5V$  during main ramp, with the base held at approximately  $-14V$  by the comparator output.

On testing my constructed generator, it was found that upon switching on the integrator output ramped positive to its positive

saturation level, although zero volts was applied to the input and the 10 megohm shunt in circuit. Adjustment of the offset null pot proved useless.

The problem, it was found, was due to leakage in TR1, being sufficient to drive the integrator, which once started, naturally continued to ramp until hitting the rail; the leakage being too large to be offset by the null control.

I believe Mr Shaw's choice of transistor was due to the OC140's base/emitter reverse bias capability, which is in the order of  $20V$ ; however, the leakage current of the device, being of germanium junction construction, can be as high as 3 microamps, more than adequate to cause IC1 to integrate. Further, since the direction of integration produced is positive, the comparator cannot switch and a steady state is produced with IC1 output "stuck" at the positive rail.

My suggested solution to the problem, should it arise, is as follows:

The OC140 may be replaced by a silicon transistor such as a BC109; this will reduce the maximum possible leakage current to nA. However, since the BC109 cannot withstand the high reverse bias, the

base/emitter junction will Zener. This will not affect the circuit operation, but if it is considered "not nice" to Zener the junction, a small signal diode—such as an 1N914—can be inserted in series with the base to protect the transistor.

Finally, since a silicon transistor has a higher "on" resistance than a germanium device the 82 ohm resistor should be reduced in value until the ramp starts at zero volts. Without modification of this value the ramp will be approximately 200mV negative of earth.

Alan A. Thomas,  
Engineering Dept.,  
Dolby Laboratories Inc.

I am indebted to Mr Thomas who, with his lucid explanation of an apparent fault in the Ramp Generator, has highlighted an omission in the setting-up procedure for which I humbly apologise.

In order to avoid the problems associated with current leakage through TR1 it is necessary to temporarily disconnect R6 from the summing junction of IC1 during the balancing of the offset. With the setting-up procedure as outlined in the original text IC1 can be prevented from going into positive saturation by adjustment of VR1 to counteract the leakage through TR1 but this is a rather unsatisfactory method since it is not possible to be absolutely sure of the input conditions at IC1 and thus there is little point in nulling the offset.

Mr Thomas's suggestion of replacing the OC140 with a diode protected BC109 is particularly valid since it has been learned that, although the OC140 is still available from a number of sources, it is now considered to be an obsolete device.

G. D. Shaw

### BACK NUMBERS WANTED

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

#### November 1972

Mr. J. M. Cathrine, 53 Boosbeck Road, Skelton-in-Cleveland, Saltburn-by-the-Sea, Yorkshire, TS12 2DQ.

#### May 1971

Mr. D. J. Broad, 34 Rowan Crescent, Dartford, Kent, DA1 2QX.

#### January to October 1968

Mr. N. Lee, Cheadle Hulme School, Cheadle Hulme, Cheshire, SK8 6EF.

#### July to October 1972

Mr. S. J. Saw, 19 Malvern Road, Southsea, Hants., PO5 2LZ.

#### September 1971, February 1972, May 1972

Mr. S. E. Berry, Old Rectory, Tunworth, Basingstoke, Hants.

#### April to August 1971

Mr. R. J. Patterson, Laburnum Cottage, Poplar Road, Hargham Road, Attleborough, Norfolk.

#### September and October 1972

Mr. J. Williams, 31 Peel Crescent, Westfield, Lancaster, Lancs.

#### December 1972

Mr. J. I. Lewis, 89 The Grove, Isleworth Middlesex, TW7 4JD.

#### June 1971

Mr. A. J. Holmes, 4 Castle Avenue, Datchet, Bucks.

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Mr. J. Y. T. Lee, 20 Wong Chuk Hand Road, 2nd Floor, Aberdeen, Hong Kong.

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Mr. A. G. Morgan, 123 Queen Road, Eastwood, Nottingham, NG16 3NG.

#### July 1971

Mr. E. S. Eaves, Winthorpe, Holmfield Avenue, Blackpool, Cleveleys, Lancs., FY5 2QT.

#### August 1972

Mr. S. A. Hook, 21 Peak Veiw Road, Chesterfield, Derbyshire, S40 4NW.

#### June 1969 to March 1970

Mr. D. Quarterman, 49 Badesley Road, Olton, Solihull.

#### April 1973

Mr. D. Weightman, 21 Glenroy Street, Roath, Cardiff.

#### July 1972 to March 1973

Mr D. Couser, Winnipeg, Manitoba, Canada.

#### March 1973

Mr H. Brede, 24 Branet Road, Scunthorpe, Lincs.

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

#### August 1972 and February 1973

Mr Hans Gram, Civilingenior Tarphagevej 253-6800 Varde, Scandinavia.

#### October 1972

Mr G. Hibbert, 12 Moray Street, Richmond, NSW, Australia.

#### October and November 1972

Mr R. Thomas, 8440 18th Ave. S.W. Seattle, Washington, 98106, USA.

#### November and December 1968

Mr P. Ghose, Wireless inspector, 310-8, Hill Colony, P.O.—Bihar, India.

#### February to April 1973

Mr R. Shaul, 23 Southlea Avenue, Southbourne, Bournemouth.

#### February 1972

Mr C. Kelly, 59 Glentown Road, Whitehall, Dublin 9.

#### September 1968, April, June and September 1970

Mr D. Hill, The Jacarandas, Bois Lane, Chesham Bois, Bucks.

#### January and February 1973

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151	200	8 0	12.1 x 9.3 x 10.2	5.31	52
152	250	13 12	12.1 x 11.8 x 10.2	7.01	67
153	350	15 0	14.0 x 10.8 x 11.8	9.40	82
154	500	19 8	14.0 x 13.4 x 11.8	13.55	*
155	750	29 0	17.2 x 14.0 x 14.0	19.26	*
156	1000	38 0	17.2 x 16.6 x 14.0	24.97	*
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4	150	3 4	8.9 x 7.7 x 7.7	0-115-200-220-240	2.42	36
66	300	6 4	9.9 x 9.6 x 8.6	"	4.70	52
67	500	12 8	12.1 x 11.2 x 10.2	"	6.98	67
84	1000	19 8	14.0 x 13.4 x 14.3	"	12.69	82
93	1500	30 4	14.0 x 15.9 x 14.3	"	18.39	*
95	2000	32 0	17.2 x 16.6 x 14.0	"	24.00	*
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213	1.0	0.5	1 4	6.1 x 5.8 x 4.8 0-12V at 0.5A x 2	1.22	22
71	2	1	12 7	7.0 x 6.4 x 6.1 0-12V at 1A x 2	1.60	22
18	4	2	12 8	8.9 x 7.7 x 7.0 0-12V at 2A x 2	2.24	36
70	6	3	18 8	8.9 x 8.0 x 7.7 0-12V at 3A x 2	2.70	42
108	8	4	5 8	9.9 x 8.9 x 8.6 0-12V at 4A x 2	3.00	52
72	10	5	6 4	9.9 x 9.6 x 8.6 0-12V at 5A x 2	3.55	52
17	16	8	12 12	12.1 x 9.9 x 10.2 0-12V at 8A x 2	5.48	52
115	20	10	11 8	14.0 x 9.6 x 11.8 0-12V at 10A x 2	6.98	67
187	30	15	8	14.0 x 12.1 x 11.8 0-12V at 15A x 2	12.90	82
226	60	30	32 0	17.2 x 15.3 x 14.0 0-12V at 30A x 2	23.72	*

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79	1.0	2 4	7.0 x 6.7 x 6.1	"	1.62	36
3	2.0	3 4	8.9 x 7.7 x 7.7	"	2.43	36
20	3.0	4 8	9.9 x 8.3 x 8.6	"	2.99	42
21	4.0	6 4	9.9 x 9.6 x 8.6	"	3.55	52
51	5.0	6 12	12.1 x 8.6 x 10.2	"	4.42	52
117	6.0	8 0	12.1 x 9.3 x 10.2	"	5.28	52
88	8.0	12 0	12.1 x 11.8 x 10.2	"	6.82	67
89	10.0	13 12	14.0 x 10.2 x 11.8	"	8.36	67

Ref. No.	Amps.	Weight lb oz	Size cm.	Secondary Taps	P & P £	P & P p
102	0.5	1 12	7.0 x 6.4 x 6.1	0-19-25-33-40-50V	1.60	30
103	1.0	2 12	8.3 x 7.4 x 7.0	"	2.34	36
104	2.0	5 8	7.9 x 8.9 x 8.6	"	3.25	42
105	3.0	6 12	9.9 x 10.2 x 8.6	"	4.41	52
106	4.0	10 0	12.1 x 10.5 x 10.2	"	5.84	52
107	6.0	12 0	14.0 x 10.2 x 11.8	"	8.63	67
118	8.0	18 0	14.0 x 12.7 x 11.8	"	11.27	97
119	10.0	25 0	17.2 x 12.7 x 14.0	"	14.13	*

Ref. No.	Amps.	Weight lb oz	Size cm.	Secondary Taps	P & P £	P & P p
124	0.5	1 4	7.0 x 6.7 x 6.1	0-24-30-40-48-60V	1.62	36
126	1.0	3 4	8.9 x 7.7 x 7.7	"	2.26	36
127	2.0	6 4	9.9 x 9.6 x 8.6	"	3.55	42
125	3.0	8 12	12.1 x 9.9 x 10.2	"	5.41	52
123	4.0	13 12	12.1 x 11.8 x 10.2	"	6.98	67
120	6.0	15 8	14.0 x 12.1 x 11.8	"	10.12	82
122	10.0	25 0	17.2 x 12.7 x 14.0	"	16.75	*

**EQUIPMENT TRANSFORMER**  
Ref. 238 PRI 0240 Screen Sec. 3-0 3V. RMS at 200mA. Size cm. 2.8 x 2.6 x 2.0. Weight 2oz. £1.18. P & P 10p.

Ref. No.	Amps.	Weight lb oz	Size cm.	P & P £	P & P p
45	1.5	1 8	7.0 x 6.1 x 6.1	1.61	30
5	4.0	3 4	8.9 x 7.7 x 7.7	2.45	42
86	6.0	6 4	9.9 x 9.6 x 8.6	3.70	52
146	6.0	6 12	9.9 x 10.2 x 8.6	4.22	52
50	12.5	12 0	14.0 x 10.2 x 11.8	6.29	67

All ratings are continuous. Standard construction: open with folder tags and vacuum impregnation.  
\*Carriage via B.R.S.  
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BC107/108/109 12p each. 2N3055 60p each. AD161/162 60p pair + mica and bushes. 1 + mica and bushes.

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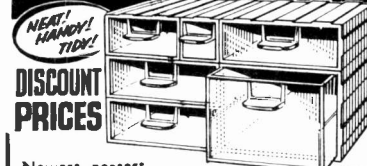
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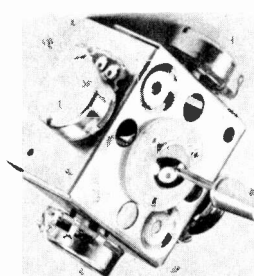
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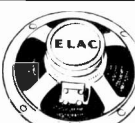
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32/450V	35p	8+8/450V	22p	350+50/325V	55p
25/25V	10p	8+16/450V	25p		
50/50V	10p	16+16/450V	40p	32+32+32/350V	55p
100/25V	10p	32+32/350V	40p	100+50+50/350V	55p

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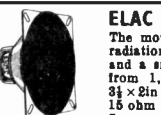
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25W	35W	50W
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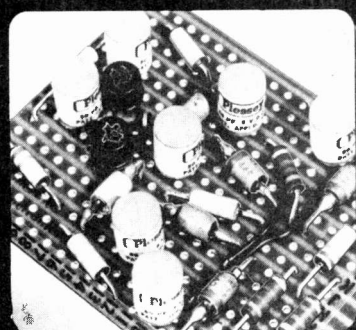
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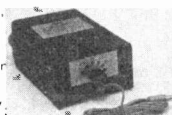


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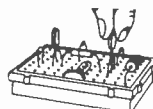
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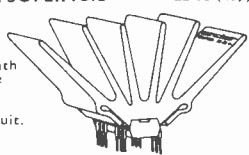
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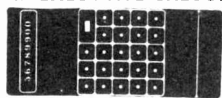
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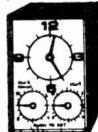
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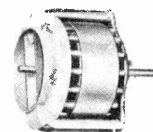
## DESK TELEPHONES

Ex G.P.O. Black standard model with dialing dial but no internal bell. Supplied with connection diagram £1 each. Ditto, with bell but without dialing dial £1.25. Model as illustrated with bell and dial £1.50 each plus 50p post for single then 65p per pair.



## PAPST MOTORS

Est. 1/40th h.p. Made for 110-120 volt working, but two of these work ideally together off our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible. £1.65 each. Postage one 23p, two 33p, 23V model £3.30.



## 10 AMP DIMMER CONTROL

For the control of lighting on stage or in a studio or for control of portable equipment in workshops, etc. This has two 13 amp socket outlets each is controlled by a 5 amp solid state regulator. The overall length is 17in, width 3 1/2in and depth 1 1/2in. In the end is fitted a master On/Off switch indicator, lamp and fuse. Price £3.25.

## STANDARD WAFER SWITCHES

Standard size 1 1/2in wafer—silver-plated 5 amp contact, standard 1/2in spindle 2in long—with locking washer and nut.

No. of Poles	2way	3way	4way	5way	6way	8way	9way	10way	12way
1 pole	44p	44p	44p	44p	44p	44p	44p	44p	44p
2 poles	44p	44p	44p	44p	44p	44p	44p	44p	44p
3 poles	44p	44p	44p	44p	44p	44p	44p	44p	44p
4 poles	44p	44p	44p	44p	44p	44p	44p	44p	44p
5 poles	44p	44p	44p	44p	44p	44p	44p	44p	44p
6 poles	44p	44p	44p	44p	44p	44p	44p	44p	44p
7 poles	44p	44p	44p	44p	44p	44p	44p	44p	44p
8 poles	44p	44p	44p	44p	44p	44p	44p	44p	44p
9 poles	44p	44p	44p	44p	44p	44p	44p	44p	44p
10 poles	44p	44p	44p	44p	44p	44p	44p	44p	44p
11 poles	44p	44p	44p	44p	44p	44p	44p	44p	44p
12 poles	44p	44p	44p	44p	44p	44p	44p	44p	44p

## THE TWENTYLITE

Fluorescent lighting units with polyester choke and finished white enamel 2ft. model, ideal kitchen, bedroom, hallway, porch, lift, etc., with tube. Assembled ready to install. Price £2.20 + 40p P. & P.

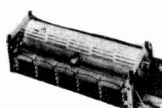


## MULLARD UNILEX

This D.I.Y. Stereo Amplifier is still available complete at £7.00 for the four Mullard Modules, or Modules can be bought separately as follows:—  
4 watt amplifier module (2 required) Mullard Ref. No. E.P.9000—£1.60.  
Pre amp module Mullard Ref. No. E.P.9001—£1.98 each.  
Power Module—Mullard Ref. No. E.P.9002—£2.53 each.  
In addition and made to Mullard specification we offer:—  
Standard Control Unit with escutcheon and knobs—£3.30.  
Knobs—Set of 4—50p.  
Special offer the complete Unilex with control panel at Pre VAT price £10.00 post paid.

## TANGENTIAL HEATER UNIT

This heater unit is the very latest type, most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. We have a few only. Comprises motor, impeller, 2kW element and 1kW element allowing switching 1, 2 and 3kW and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only needs control switch £3.85. 3kW Model as above except 2kW £2.75. Don't miss this. Control Switch 35p. P. & P. 40p.



## THIS MONTH'S SNIP

Room Thermostat made by the famous Smiths Company. 15 amp at 250V. Elegant white and beige case, size 4 1/2in long by 1 1/2 square approx. Adjustment is by slider (lockable), adjusts through range 30°-90°F. Special Snip price £1.65.

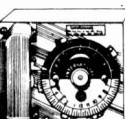
## CENTRIFUGAL FAN

Mains operated, turbo blower type. Pressed steel housing contains motor and impeller. Motor is 1 1/10th h.p. giving considerable air flows but virtually no noise. Approx. dimensions 10 1/2in wide x 12in dia. outlet into trunking 10 1/2 x 4 1/2in. £8.55 plus £1 post and insurance.



## TAPE PLAYBACK UNITS

Mains operated. Made by Reditone the famous "music in background people". These are complete units ready to work and we understand that they are in good going order. We have not tested them but would exchange any that do not work properly. These have a superior motor driven fly wheel to control the tape through the capstan and also an even equally useful valve amplifier with EL84 output. In a steel case with carrying handle. Two models offered, good as new £6.50 and somewhat used at £3.50. 75p carriage up to 200 miles then 50p per 100 miles extra.



## 24-HOUR TIME SWITCH

Made by Smiths, these are A.C. mains operated, NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. Two completely adjustable time periods per 24 hours. 5A changeover contacts will switch circuit on or off during these periods. £2.75 post and ins. 25p. Additional time contacts 55p pair.

## MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied.  
Model 1153 500mW power output 72p.  
Model 1172 750mW power output 94p.  
Model EP9000 4 watt power output £1.60.  
EP9001 twin channel or stereo pre amp. £1.99.  
10% discount if 10 or more ordered.



TERMS: 10% discount if ten of an item ordered, send postage where quoted—other items, post free if order for these items is £6.00, otherwise add 20p.

## NEW ITEMS THIS MONTH

### MINIATURE SEALED RELAY

American made. Our Ref.: REL A1. Measures only 1/2in wide x 1/2in thick and 1 1/2in high and it's a double change over, we don't know the contact rating but estimate this at 3/5 amps. The coil resistance is 600 ohms and 9-12 volt will close it. Ideal for models and miniaturised equipment. It's a plug in relay but we supply complete with base. Price £28p including base.

### SUB-MINIATURE MICROSWITCH

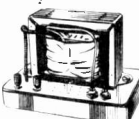
Made by Burgess, their ref. V476 our ref. MS A1. These measure only 1/2in x 1/2in x 1 1/2in thick—have change over contacts and tag connection. Price 16p each or 10 for £1.44.

### 3 CORE MAINS FLEX

Metric size 30mm which is approx. equivalent to the old 14/36 rating. Suitable therefore for mow or similar portable tools. Cores are colour coded to the new European standard. Brown—live; Blue—neutral; Yellow/Green—earth. Grey P.V.C. covered overall. 100m coils £25. 50m coils £3 and 25m coils £1.75. Post 40p on 100m. 25p for 50m coils and 20p for 25m coils.

### PANIC SWITCHES

Tough enough to be foot switches and elegant enough to be panel switches. Bakelite construction with white push rod. Price 40p less quantity discounts. Switch is rated 250V-2 amp.



### 12 VOLT 1 AMP POWER PACK

This comprises double-wound 230/240V mains transformer with full wave rectifier and 2000 mF smoothing. Price £2.20, plus 20p post and packing.

### 6 MAINS TRANSFORMERS

Our Ref.: MTM1 27 volt at 8 amp. Upright mounting fully shrouded—flying leads—fully tapped primary. Price £3.30.  
Our Ref.: MTM2 12v at 1 amp. Upright mounting with fixing lugs, tag connection. 240v primary—12v 1 amp secondary. Price 82p.  
Our Ref.: MTM3 6-3v 2 amp upright mounting with fixing lugs, tag connections. 240v primary 6-3v 2 amp secondary. Price 77p.  
Our Ref.: MTM4 18v-1 amp with thermal cut-out, upright mounting with fixing lugs—tag connections. Primary 240v—secondary 18v at 1 amp. Price 88p.  
Mains Isolation MTM5 350 watts earth shielded—flex leads—upright mounting lugs for fixing. Price £4.40 each.

### 6 VOLT RELAYS

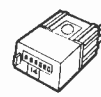
Our ref.: REL M1. Removable clear plastic enclosed two screw fixing. Have a 6 volt D.C. operated coil but two change-over contacts, each rated to make and break 240V A.C. at 15 amps. Price 66p each.

### P.O. TYPE 3000 RELAY

Our ref.: REL M2—100 ohms coil and 2 pair normally open heavy duty contacts. Price 75p each.

### 6 DIGIT COUNT

Resettable. 440 ohm coil up to 25 impulses per second. Ex-equipment but guaranteed perfect. £2.20 each.



### COMBINATION SWITCH

This comprises of 12 miniature change-over micro switches. Joined in banks of 3 and mounted on frame with four digital numbered thumb wheels and a removable lever for locking the thumb wheel—the thumb wheel operates 3 banks. Over 4,000 combinations are possible but by re-wiring the switch connections underneath then thousands more variations are possible. If you are making equipment which you don't want switched on accidentally or without authority then this is a switch to consider—this can also be used as a coding switch for many other operations. Very neat and compact and measuring approx. 4in x 1 1/2in x 1 1/2in deep. Priced at £3.03.

### PUSH BUTTON SWITCH

Type 14 D.M.G. A very fine switch made by Honeywell. The switch is intended for mounting on panel through oblong hole. No screws required for fixing its sprung clips secure it quite firmly. The operating button is approx. 1in dia. round and disheal for ease of operation. Has 2 sets of 10 amp change-over contacts. Spring loaded, returns to normal when pressure is released. Ideal for instrument or quality gear. Price 50p each. 10 for £4.50. 100 for £40.

### PHOTO-MULTIPLIER TUBE

American R.A. type No. 4555. These tubes have a gain of a million or more. Regular Price—over £15. We have a limited quantity and offer these at £4.50.

## J. BULL (ELECTRICAL) LTD.

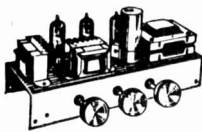
(Dept. P.E.), 7 Park Street, Croydon CRO 1YD  
Callers to 102/3 Tamworth Road, Croydon

## SUPERSOUND 13 HI-FI MONO AMPLIFIER



A superb solid state audio amplifier. Brand new silicon transistors plus 2 power output transistors in push-pull. Full wave rectification. Output approx. 13 watts r.m.s. into 8 ohms. Frequency response 12Hz-30KHz  $\pm$  3dB. Fully integrated pre-amplifier stage with separate Volume, Bass boost and Treble cut controls. Suitable for 8-15 ohm speakers. Input for ceramic or crystal cartridge. Sensitivity approx. 400V for full output. Supplied ready built and tested, with knobs, esutech panel, input and output plugs. Overall size 3in high x 6in wide x 7in deep. AC 220/250V. **PRICE £11.60. P. & P. 25p.**

## DE LUXE STEREO AMPLIFIER



A.C. mains 200-240V. Using heavy duty fully isolated mains transformer with full wave rectification giving adequate smoothing with negligible hum. Valve line up: 2 x ECL86 Triode Pentodes, 1 x EZ80 as rectifier. Two dual potentiometers are provided for bass and treble control, giving bass and treble boost and cut. A dual volume control is used. Balance of the left and right hand channels can be adjusted by means of a separate 'Balance' control fitted at the rear of the chassis. Input sensitivity is approximately 300mV for full peak output of 4 watts per channel (8 watts mono), into 3 ohm speakers. Full negative feedback in a carefully calculated circuit, allows high volume levels to be used with negligible distortion. Supplied complete with knobs, chassis size 11in x 6in x 4in. Overall height including valves 3in. Ready built and tested to a high standard. **PRICE £9.90 P. & P. 43p.**

## PRECISION ENGINEERED PLINTHS

Beautifully constructed in heavy gauge "Colorcoat" plastic coated steel. Resonance free. Designed to take Garrard 1025, 2000, 2025TC, 2500, 3000, 3500, 3100, RP25 II and III, SL65B, AT60 etc. or B.R.K. C109, C129, A21, etc. Black leatherette finish. Size 12in x 14in x 3in high (approx. 7in high, including rigid smoked acrylic cover). **NOW ONLY £4.95 P. & P. 35p.**

## SPECIAL OFFER!

### HI-FI LOUDSPEAKER SYSTEMS

Beautifully made teak finish enclosure with most attractive Tegan-Vynal front. Size 16in high x 10in wide x 6in deep. Fitted with E.M.I. Ceramic Magnet 13in x 8in bass unit, two H.F. tweeter units and crossover. Maximum power handling 10 watts. Available 3 or 8 or 15 ohms impedance.

**OUR PRICE £9.25 Carr. 70p.**

Cabinet Available Separately £4.95 Carr. 65p. Also available in 8 ohms with EMI 13 in x 8in bass speaker with parasitic tweeter £7.15 Carr. 70p.

### HARVERSON'S SUPER MONO AMPLIFIER

A superb quality gram amplifier with 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. 3.5 watts. Volume and tone controls. Chassis size only 7in. wide x 3in. deep x 6in. high overall. A.C. mains 200/240V. Supplied absolutely Brand New completely wired and tested with good quality output transformer. **£3.30 P. & P. BARGAIN PRICE 55p.**



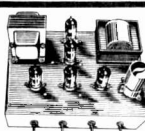
## SPECIAL OFFER!

### LIMITED NUMBER OF BRAND NEW ELAC 10in TWIN CONE LOUDSPEAKERS

With large ceramic magnet and plasticised cone surround. 8 ohm impedance. **£2.70. P. & P. 25p.**

### 10/14 WATT HI-FI AMPLIFIER KIT

A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for music and speech records and announcements to follow each other. Fully shrouded section wound output transformer to match 3 to 15  $\Omega$  speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up 2 EL84s, ECC83, EP86 and EZ80 rectifier. Simple instruction booklet. **£3.45 P. & P. 55p.** Also available ready built and tested **£12.10 P. & P. 60p.**



## HARVERSONIC SUPER SOUND 10 + 10 STEREO AMPLIFIER KIT



**NEW FURTHER IMPROVED MODEL WITH HIGHER OUTPUT AND INCORPORATING HIGH QUALITY READY DRILLED FIBRE GLASS PRINTED CIRCUIT BOARD MARKED FOR EVEN EASIER 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. Very simple to modify to suit magnetic cartridge—instructions included. Output stage for any speakers from 3 to 15 ohms. Compact design, all parts supplied including drilled metal work, high quality ready drilled fibreglass printed circuit board, smart brushed anodised aluminium front panel with matching knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief specification: Power output: 14 watts r.m.s. per channel into 5 ohms. Frequency response  $\pm$  3dB 12-30,000Hz Sensitivity: better than 80mV into 1M $\Omega$ . Full power bandwidth:  $\pm$  3dB 12-15,000Hz. Bass boost approx. to  $\pm$  12dB. Treble cut approx. to  $\pm$  16dB. Negative feedback 18dB over main amp. Power requirements 35V at 1.0 amp. Overall Size 12in w. x 8in d. x 2in h. Fully detailed 7 page construction manual and parts list with kit or send 18p plus large S.A.E.

**AMPLIFIER KIT £11.55 P. & P. 18p**

**POWER PACK KIT £3.30 P. & P. 33p**

**CABINET £3.30 P. & P. 33p**

(Post Free if all units purchased at same time)

Full after sales service

Also available ready built and tested **£23.10. Post Free.**

### QUALITY RECORD PLAYER AMPLIFIER MK. II

A top quality record player amplifier employing heavy duty double wound mains transformer, ECC83, EL84, and rectifier. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. wide x 3in. deep x 6in. high. Ready built and tested. **PRICE £4.40 P. & P. 40p.** ALSO AVAILABLE mounted on board with output transformer and speaker. **PRICE £5.95 P. & P. 50p.**

Open 9-5.30 Mon. to Fri. 9-5 Sat. Early closing Wed. 1 p.m. A few minutes from South Wimbledon Tube Station. **PRICES NOW INCLUDE VAT**

## HARVERSON SURPLUS CO. LTD.

(Dept. P.E.) 170 HIGH ST., MERTON, LONDON, S.W.19 Tel. 01-540 3985

**SEND STAMPED ADDRESSED ENVELOPE WITH ALL ENQUIRIES**

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## NORTH AMERICAN SEMICONDUCTOR COMPANY LIMITED

### TRANSISTORS

2N696	0.150	2N2219A	0.270	2N3108	0.540	2N3638	0.120	2N4135	1.500	2N5132	0.080
2N697	0.180	2N2221	0.180	2N3109	0.540	2N3639A	0.130	2N4140	0.270	2N5133	0.080
2N699	0.340	2N2222A	0.230	2N3110	0.540	2N3639	0.200	2N4141	0.290	2N5134	0.090
2N706	0.100	2N2222B	0.180	2N3117	0.850	2N3640	0.200	2N4142	0.310	2N5135	0.090
2N708	0.145	2N2222A	0.245	2N3120	0.540	2N3641	0.150	2N4143	0.320	2N5137	0.100
2N718	0.230	2N2243	0.930	2N3121	0.500	2N3642	0.150	2N4208	1.870	2N5138	0.090
2N722	0.680	2N2243A	0.930	2N3133	0.280	2N3643	0.150	2N4209	2.000	2N5139	0.090
2N744	0.180	2N2270	0.380	2N3134	0.280	2N3644	0.160	2N4227	0.300	2N5140	0.170
2N753	0.180	2N2297	0.400	2N3135	0.280	2N3645	0.160	2N4228	0.370	2N5141	0.185
2N760	0.270	2N2303	1.330	2N3136	0.280	2N3646	0.130	2N4248	0.100	2N5142	0.105
2N760A	0.270	2N2368	0.150	2N3209	0.605	2N3665	0.800	2N4249	0.130	2N5143	0.105
2N834	0.255	2N2369	0.155	2N3248	1.880	2N3666	0.950	2N4250	0.150	2N5144	0.105
2N814	0.200	2N2369A	0.170	2N3249	0.220	2N3691	0.150	2N4257	0.175	2N5145	0.105
2N915	0.300	2N2483	0.210	2N3250	0.300	2N3692	0.150	2N4258	0.230	2N5146	0.105
2N916	0.300	2N2484	0.245	2N3250A	0.440	2N3693	0.150	2N4258A	0.245	2N5147	0.105
2N917	0.330	2N2509	0.100	2N3251	0.580	2N3694	0.150	2N4258B	0.275	2N5148	0.105
2N918	0.330	2N2510	0.710	2N3251A	0.820	2N3724	0.100	2N4274	0.135	2N5149	0.105
2N929	0.185	2N2511	1.330	2N3252	0.680	2N3724A	1.100	2N4275	0.135	2N5150	0.105
2N929A	0.740	2N2586	1.080	2N3253	0.740	2N3725	0.425	2N4313	0.250	2N5151	0.105
2N930	0.180	2N2604	0.340	2N3299	0.340	2N3725A	1.080	2N4354	0.210	2N5152	0.105
2N930A	0.680	2N2605	0.800	2N3300	0.405	2N3734	1.170	2N4355	0.240	2N5153	0.105
2N956	0.320	2N2657	3.070	2N3301	0.285	2N3735	2.700	2N4356	0.240	2N5154	0.105
2N980	2.210	2N2658	4.500	2N3302	0.420	2N3903	0.165	2N4400	0.180	2N5155	0.105
2N995	1.080	2N2890	3.600	2N3304	0.700	2N3904	0.180	2N4401	0.240	2N5156	0.105
2N1131	0.235	2N2891	3.500	2N3439	0.800	2N3905	0.175	2N4402	0.180	2N5157	0.105
2N1132	0.235	2N2904	0.320	2N3440	0.800	2N3906	0.180	2N4403	0.240	2N5158	0.105
2N1133	0.235	2N2904A	0.685	2N3444	0.830	2N3945	0.500	2N4406	0.110	2N5159	0.105
2N1613	0.180	2N2904	0.255	2N3502	0.700	2N3946	1.200	2N4917	0.160	2N5160	0.105
2N1711	0.220	2N2904A	0.225	2N3503	1.150	2N3947	1.700	2N4943	0.300	2N5161	0.105
2N1893	0.270	2N2904	0.270	2N3504	1.150	2N3948	1.700	2N4944	0.300	2N5162	0.105
2N1990	0.280	2N2905A	0.300	2N3505	0.700	2N3963	0.160	2N4965	0.170	2N5163	0.105
2N2017	0.870	2N2906	0.230	2N3545	4.500	2N3964	0.455	2N4966	0.170	2N5164	0.105
2N2102	0.375	2N2906A	0.245	2N3546	1.320	2N3965	0.760	2N4967	0.170	2N5165	0.105
2N2192	0.405	2N2907	0.220	2N3547	1.500	2N4030	0.465	2N4968	0.170	2N5166	0.105
2N2192A	0.405	2N2907A	0.245	2N3548	1.170	2N4031	0.510	2N4969	0.170	2N5167	0.105
2N2193	0.470	2N3011	0.180	2N3549	2.100	2N4032	0.330	2N4970	0.190	2N5168	0.105
2N2193A	0.570	2N3012	0.500	2N3550	2.500	2N4033	0.670	2N4971	0.340	2N5169	0.105
2N2194	0.480	2N3013	0.500	2N3551	2.500	2N4034	0.670	2N4972	0.340	2N5170	0.105
2N2194A	0.530	2N3019	0.500	2N3552	2.500	2N4035	0.670	2N4973	0.340	2N5171	0.105
2N2195	0.420	2N3020	0.500	2N3553	2.500	2N4036	0.670	2N4974	0.340	2N5172	0.105
2N2195A	0.470	2N3053	0.450	2N3556	0.130	2N4037	0.670	2N4975	0.340	2N5173	0.105
2N2217	0.275	2N3054	0.450	2N3557	0.130	2N4038	0.670	2N4976	0.340	2N5174	0.105
2N2218	0.215	2N3072	0.580	2N3558	0.170	2N4039	0.670	2N4977	0.340	2N5175	0.105
2N2218A	0.245	2N3073	0.550	2N3559	0.150	2N4040	0.670	2N4978	0.340	2N5176	0.105
2N2219	0.240	2N3107	0.450	2N3576	1.220	2N4134	1.500	2N4979	0.340	2N5177	0.105

### THYRISTORS

Type No	Price	IT (RMS) DROM	V
NAS106F	0.250	4A	50
NAS106A	0.310	4A	100
NAS106B	0.360	4A	200
NAS106C	0.580	4A	400
NAS206F	0.283	6A	50
NAS206A	0.348	6A	100
NAS206B	0.405	6A	200
NAS206C	0.653	6A	400
NAS306F	0.313	8A	50
NAS306A	0.389	8A	100
NAS306B	0.450	8A	200
NAS306C	0.725	8A	400
NAS406F	0.350	10A	50
NAS406A	0.434	10A	100
NAS406B	0.504	10A	200
NAS406C	0.812	10A	400
NAS506F	0.438	16A	50
NAS506A	0.543	16A	100
NAS506B	0.630	16A	200
NAS506C	1.015	16A	400

### EPOXY 4 AMP AND 6 AMP BRIDGE RECTIFIERS

Type No	IF	V/RM	Price
N7001	4A	50PIV	0.320
N7012	4A	100PIV	0.360
N7013	4A	200PIV	0.430
N7014	4A	400PIV	0.580
N7015	4A	600PIV	0.755
N7021	6A	50PIV	0.360
N7022	6A	100PIV	0.430
N7023	6A	200PIV	0.540
N7024	6A	400PIV	0.755
N7025	6A	600PIV	0.910

### 2 AMP ENCAPSULATED PLASTIC BRIDGE RECTIFIERS

Type No	IF	V/RM	Price
N6001	2A	50PIV	0.350
N6002	2A	100PIV	0.380
N6003	2A	200PIV	0.460
N6004	2A	400PIV	0.630
N6005	2A	600PIV	0.800

### PLASTIC RECTIFIER

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

ADD 10% to order for VAT. p. & p. 15p per order.

Available from **THE RADIO SHOP**

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Tel Bristol 421196. Open Mon-Sat. 9.00 a.m.-5.30 p.m.

## VARIABLE VOLTAGE TRANSFORMERS

INPUT 230/240V a.c. 50/60 OUTPUT  
VARIABLE 0-260V

All Types  
from 1 to 50 amp from stock.

**SHROUDED TYPE**  
1A £7. Post 50p 10A £22.50  
2A £8.05. Post 15A £25  
60p 20A £49  
5A £11.75. Post 37.5A £82  
75p 50A £98

CARRIAGE AND PACKING  
EXTRA unless shown  
(Panel Mounting)  
1 amp £7. Post 50p. 2½ amp £8.05. Post 60p.

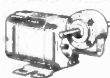


2.5 amp  
OPEN TYPE

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All primaries 220-240V	Type No.	Sec. Taps	Price Post
1 30, 32, 34, 36V at 5A			£4.70 + 45p
2 30, 40, 50V at 5A			£6.90 + 60p
3 10, 17, 18V at 10A			£5.00 + 50p
4 6, 12V at 20A			£6.50 + 60p
5 17, 18, 20V at 20A			£7.30 + 60p
6 6, 12, 20V at 20A			£6.90 + 60p
7 24A at 10A			£5.30 + 50p
8 4, 6, 24, 32V at 12A			£7.20 + 60p
9 6 and 12V at 10A			£3.80 + 40p

**PARVALUX Type: SD1.**  
5/86896/OJ  
230/250V A.C. 50 r.p.m. 7 lb/in.  
Continuously rated. Less base.  
£6. Post 30p incl. base.



**PARVALUX TYPE SD19 230/250 VOLT A.C.**  
**REVERSIBLE GEARED MOTORS**

30 r.p.m. 40 lb. ins.  
Position of drive spindle  
adjustable to 3 different  
angles. Ex-equip-  
ment. Tested and in  
first-class running order.  
A really powerful motor  
offered at a fraction of  
makers' price. £6.30. Post 70p.



**PARVALUX TYPE SD2. 200/250 VOLT**  
**A.C./D.C. HIGH SPEED MOTOR**

Speed 9,000 r.p.m. approx. or 3,200  
r.p.m. if used with built-in governor,  
or variable speed over a wide range  
if used in conjunction with our  
Dimmer Switch, illustrated below.  
PRICE £1.75. Post 35p.



**600 WATT DIMMER SWITCH**  
Easily fitted. Fully guaranteed by  
makers. Will control up to 600W of all  
lights except fluorescent at mains  
voltage. Complete with simple in-  
structions. £2.75. Post 25p.



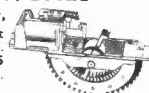
**240V A.C. SOLENOID FLUID VALVE**

Will handle liquids or gases up to  
7 p.s.i. Forged brass body, stainless  
steel core and spring. 1/2 in b.s.p.  
inlet/outlet. Precision made, British  
mfg. PRICE: £1.75. Post 25p.  
Special quotation for quantity.  
(New in makers' carton)



## UNISELECTOR SWITCHES

**NEW 4 Bank 25 Way.**  
24V d.c. operation. £6.90. Post 30p.  
6 Bank 25 Way, 24V d.c.  
£7.90. Post 30p. 8 Bank 25  
Way, 24V d.c. operation.  
£9.50. Post 40p.



## GENERAL ELECTRIC POWER-GLAS TRIACS

10 amp. Glass passivated plastic triac. Latest device  
from U.S.A. Long term reliability. Type SC146D  
10 amp, 400 PIV. £1. Post 5p. Type SC146E 10 amp,  
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tion sheet.) Suitable DCA 18p.

## VOLTAGE CHANGING TRANSFORMER

M.f.g. to highest W.D. spec. Auto wound, and  
tapped 0-130-160-200-250 at least 2kVA. Can also  
be used as 230-240V input, 115V out for U.S.A.  
equipment, or reverse to obtain 240V from 115V.  
The ideal transformer for making up solid state  
constant voltage unit, by use of taps the following  
voltages may be obtained 30-40-50-70-90V at  
10 amps. Weight 40lb, length, 260mm, height  
190mm, width 230mm. In original maker's wooden  
case, £8. Carr. £1.

## 4 BANK 3c/o PUSH BUTTON ASSEMBLY

Black rectangular buttons.  
5 units (min. order) 85p.  
Post 15p.



## FOOT SWITCH

Suitable for Motors, Drills,  
etc. etc. 5 amp. 250 volt.  
Price 75p. Post 15p.



## STROBE STROBE STROBE

Build a Strobe Unit, using the latest type Xenon  
white light flash tube. Solid state timing and  
triggering circuit. 230/250V a.c. operation.

**EXPERIMENTERS' ECONOMY KIT**  
Speed adjustable 1 to 30 flash per sec. All  
electronic components including Xenon Tube  
and instructions £6.30. Post 30p.

**NEW INDUSTRIAL KIT**  
Ideally suitable for schools, laboratories, etc.  
Speed adjustable 1-80 f.p.s.  
Approx. 1 output of Hy-Light. Price £10.50.  
Post 50p.

**HY-LIGHT STROBE MK III**  
For use in large rooms, halls and utilises a silica  
tube, printed circuit. Speed adjustable 0-20 f.p.s.  
Light output greater than many (so called 4  
joule) strobes. £12. Post 50p.

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Approx. four times the light output of our well  
proven Hy-Light strobe.

- Variable speed from 1-3 flash per sec.
- Reactor control circuit producing an intense  
white light. ONLY £20. Post 75p.

**ROBUST, FULLY VENTILATED METAL CASE.** For Hy-Light Kit including reflector £4.75.

Post 25p.  
Super Hy-Light Kit including reflector £7. Post  
60p.

**7-inch POLISHED REFLECTOR**  
Ideally suited for above Strobe kits. Price 55p.  
Post 15p.

## 1 R.P.M. MOTOR

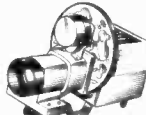
120/240 volt a.c. 1 r.p.m. synchronous motor.  
2 watt. A/clock. Spindle 10mm long. 3mm dia.  
Motor only 20mm deep. Fixing centres 44mm.  
Price £1.10. Post 5p.

## RAINBOW STROBE FOUR LIGHT CONTROL MODULE

Will operate four of our Hy-Light or Super  
Hy-Light Strobes in either 1, 2, 3, 4 sequence;  
2 + 2; or all together. Thoroughly tested  
and reliable. Complete with full con-  
nection instructions. Price: £18. Post 50p.  
Send S.A.E. for details.

## COLOUR WHEEL PROJECTOR

Complete with oil-  
filled colour wheel.  
100 watt lamp. 200/  
240V A.C. Features  
extremely efficient op-  
tical system. £18.50.  
Post 50p.  
6 INCH COLOUR WHEEL  
As used for Disco  
lighting effects, etc. Price £5. Post 30p.



## BIG BLACK LIGHT

400Watt. Mercury vapour  
ultra violet lamp.  
Powerful source of u.v.  
Innumerable industrial appli-  
cations also ideal for stage,  
display, discos, etc. P.F. ballast  
is essential with these bulbs.  
Price of matched ballast and  
bulb £16. Post £1.  
Spare bulb £7. Post 40p.



## BLACK LIGHT FLUORESCENT U.V. TUBES

4ft 40 watt. Price £5.50. Post 30p. 2ft 20 watt,  
£4.25. Post 25p. (For use in stan. bi-pin  
fittings.)  
MINI. 12in 8 watt, £1.60. Post 15p. 9in 6  
watt, £1.30. Post 15p. Complete ballast  
unit and holders for 9in and 12in tube.  
£1.70. Post 25p. (9in and 12in measures  
approx.)



## ELECTRONIC ORGAN KIT

Easy to build. Solid State. Two full octaves  
(less sharps and flats). Fitted hardwood case.  
Powered by two penlite 1.5V batteries. Com-  
plete set of parts including speaker, etc.,  
together with full instructions and 10 tunes.  
Price £3.25. Post 35p.

All prices are subject to

**10% VAT. (10p in the £)**

To all orders add 10% VAT to total  
value of goods including carriage/  
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## Superior Quality Precision Made NEW POWER RHEOSTATS



New ceramic construction, vitreous  
enamel embedded winding, heavy  
duty brush assembly, continuously  
rated.

25 WATT 10/25/50/100/250/300/500/1k/2.5k  
ohm 95p. Post 10p.  
50 WATT 1/5/10/25/50/100/250/500/1k/1.5k/  
2.5k/5k ohm £1.35. Post 10p.  
100 WATT 1/5/10/25/50/100/250/500/1k/1.5k/2.5k/  
3.5k/5k ohm £1.95. Post 15p.  
BLACK Silver, Skirted knob calibrated in Nos.  
1-9. 1½ in. dia. brass bush. Ideal for above Rheostats.  
20p each.

## RELAYS SIEMENS, PLESSEY, Etc. MINIATURE RELAYS

Col. (1)	1	2	3	4
Coil ohms	52	4-6	6M	60p*
Working	150	6-12	4 c/o	80p*
d.c. volts	185	8-12	6M	60p*
Col. 3	280	8-16	2 c/o	60p*
Contracts	410	10-18	4 c/o	70p*
Col. (4)	600	9-18	2 c/o	60p*
Price	700	16-24	4M 2B	60p*
HD=	700	16-24	6M	80p*
Heavy duty	700	6-12	1 c/o HD	50p*
	1,250	20-30	6 c/o	80p*
	2,500	24-36	4 c/o	60p*
*Incl. Base	2,500	36-45	6M	60p*
All prices	2,400	30-48	4 c/o	50p*
incl. P. & P.	9,000	40-70	2 c/o	50p*
	15k	85-110	6M	50p*

## 9 VOLT D.C. RELAY

3 c/o 5 amp contacts. 70 ohm coil. 75p. Post 5p.

## 12 VOLT D.C. RELAY

3 c/o 5 amp contacts. 120 ohm coil. 75p. Post 5p.

## 230 VOLT A.C. 'DIAMOND H' RELAYS (Unused)

Three sets c/o contacts rated at 5 amps.  
Price: 55p. Post 5p. (100 lots) £40.  
24 volt A.C. 3 c/o 55p. Post 5p.



## MINIATURE LATCHING RELAY

Manufactured by Clare-Elliott Ltd. Type F. 2 c/o per-  
manent latching in either direction. Coil 1150 ohm,  
15-30 Volt D.C. Size 1½ high, 1½ wide, 1½ thick. Com-  
plete with 3in. leads. New 65p. Post 5p.

## BLOWER UNIT

200-240 Volt A.C. Precision  
German built. Dynamically  
balanced, quiet, continuously  
rated, reversible motor. Con-  
sumption 60mA. Size 120 mm.  
dia. x 60 mm. deep. Price £3.  
Post 30p.



## 230V FAN ASSEMBLY

Continuously rated, special  
sealed bearing, removable  
aluminum blades. Price 80p.  
Post 20p.



## "HONEYWELL" PUSH BUTTON, PANEL MOUNTING MICRO SWITCH ASSEMBLY

Each bank comprises a c/o rated at  
10 amps 240V. A.C. Black knob 1 in.  
Firing hole ½ in. ONE bank 30p;  
TWO bank 40p; THREE bank  
50p. Quote for quantity.



## VERY SPECIAL OFFER

Micro Switch, 5 amp c/o con-  
tacts. M.f.g. by Honeywell.  
NEW. Twenty for £1.50. Post  
10p (min. 20).



## "HONEYWELL" LEVER OPERATED MICROSWITCH

15 amps 250 volt A.C. c/con-  
tacts. In maker's carton.  
PRICE: 10 for £1.90. Post 15p.



## INSULATION TESTERS

Test to I.E.E. Spec. Rugged metal  
construction, suitable for bench or  
field work, constant speed clutch.  
Size L: 8in, W: 4in, H: 6in, weight 6lb.  
1,000V, 1,000 megohms, £34. Post  
60p. 500V, 500 megohms, £28. Post  
60p.



## BALANCE/LEVEL METERS

100-0-100 Micro Amp. Size 1½ in + 1½ in +  
7in. Price only 70p. Post 5p.



**AMMETERS NEW!** 2½in. Flush  
round. Available in D.C. Amps 1, 5, 10,  
15, 20 or A.C. Amps 5, 10, 15, 20, both  
types \*£1.85. Post 15p. 0-300V A.C.  
£2. Post 15p.



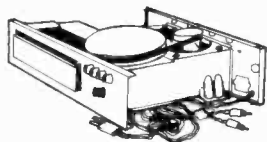
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# BI-PRE-PAK

## AUDIO BARGAINS



### 8 TRACK ONLY £11

incl. P. & P. and VAT

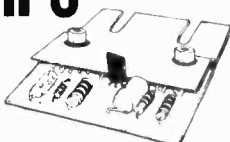
The latest **B.S.R. 8 Track** cartridge **Replay Deck**.  
**Ready to install in your Hi-Fi Stereo System.**

This unit comes complete with Hi Gain Stereo Pre-Amplifier, 4-Programme Indicator Lamps, Track Selector Switch, all leads and plugs, etc. for 230 volt A.C. mains operation.

## 5W & 10W AMPS

**5W ONLY £1.98**  
**10W ONLY £2.49**

incl. P. & P. and VAT



#### Specification:—

	5 Watt	10 Watt
Nominal Volts	12-14V	25-30V
Into 3 Ohms	5W	10W
Into 8 Ohms	2W	10W
Into 15 Ohms	1W	5W
Typical Distortion	0.5%	0.5%
Freq. response at 3dB	10Hz to 30KHZ	10Hz to 30KHZ
Sensitivity (Typically)	20mV	20mV
Full power consumption (30 Ohms)	650mA	580mA
Size	2 1/2 in x 1 1/2 in	2 1/2 in x 1 1/2 in

The **5W matchbox sized amplifier** will run satisfactorily from a 12V car battery. Can also be used for portable voice reinforcement such as public functions where mains supply is not accessible. A small mains unit kit is available.

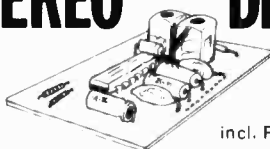
Two amplifiers are ideal for Stereo. Complete connection details and treble, bass, volume and balance control circuit diagrams are supplied with each unit.

Discounts are available for quantity orders.

**Cheapest in the U.K. Built and tested**

## STEREO DECODER

### £4.95



incl. P. & P. and VAT

A ready built unit, ready for connection to the I.F. stages of your existing FM Radio or Tuner. A tell-tale light can be connected to show the presence of a Stereo transmission and correct operation.

The Unit is in the form of a small printed circuit, and no further alignment is necessary, as all preset adjustments have already been carried out at the factory.

It is recommended that a L.E.D. is used as the indicating light and a suitable device is available from us at 36p. Supplied with all necessary instructions.

I enclose £..... for ..... 8 Tracks/..... 5W  
Amps./..... 10W Amps./..... Decoders (Please  
insert quantities and delete those not applicable.)

Name .....

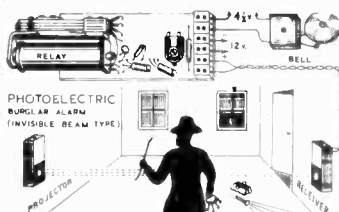
Address .....

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Co. Regn. No. 820919

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Westcliff-on-Sea, Essex SS0 9DF  
Tel.: Southend (0702) 46344

## PHOTOELECTRIC KIT

**CONTENTS:** P.C. Chassis Board, Chemicals, Etching Manual, Infra-Red Photo-transistor, Latching Relay, 2 Transistors, Diode, Resistors, Gain Control, Terminal Block, Elegant Case, Screws, etc. In fact everything you need to build a Steady-Light Photo-Switch/Counter/Burglar Alarm, etc. (Project No. 1) which can be modified for modulated-light operation with a few additional components.



### PHOTOELECTRIC KIT

**£2-85**

Postage and Pack. 16p (U.K.)

Commonwealth

**SURFACE MAIL 25p**

**AIR MAIL £1-40**

Australia, New Zealand,

S. Africa, Canada and U.S.A.

Also Essential Data Circuits

and Plans for Building

10 Advanced Designs

### INVISIBLE BEAM OPTICAL KIT

Everything needed (except plywood) for building: 1 Invisible-Beam Projector and 1 Photo-cell Receiver (as illustrated). Suitable for all Photoelectric Burglar Alarms, Counters, Door Openers, etc.

**CONTENTS:** 2 lenses, 2 mirrors, 2 45-degree wooden blocks, Infra-red filter, projector lamp holder, screws, nails, brackets, building plans, etc. Price **£1-45**. Postage and Pack. 10p (U.K.). Commonwealth: Surface Mail 20p, Air Mail 50p

### LONG RANGE INVISIBLE BEAM OPTICAL KIT

**CONTENTS:** As above. Twice the range of standard kit. Larger Lenses, Filter, etc. Price **£2-10**. Postage 15p (U.K.). Commonwealth: Surface 20p, Air Mail £1-15

### BIOFEEDBACK AMPLIFIER KIT

Tunable, General-Purpose, Interference-Rejecting Differential Amplifier for experimental investigation of signals produced by the brain, heart and muscles. When used with an oscilloscope, or aural indicator, it enables you to monitor your brainwaves, learn to relax, meditate, etc.

**CONTENTS:** All Capacitors, Resistors, Pots, Semiconductors, I.C.s, Electrodes, Leads, Chassis, Case, Batteries, Plans and Instructions. Price **£4-75** postage and pack. 25p (U.K.). Commonwealth: Surface 30p, Air Mail £1.

### ALPHA-BETHA-THETA BRAINWAVE MONITOR KIT

Aural Brainwave Indicator for use with a Biofeedback Amplifier. Converts subsonic brain frequencies into audible signals for easy recognition.

**CONTENTS:** Resistors, Pots, Capacitors, Transistors, Diodes, Leads, Chassis, Case, Earphone, Battery, Plans and Instructions. Price **£3-25**, postage and pack. 15p (U.K.). Commonwealth: Surface 25p, Air Mail 75p.

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BLOCK CAPS please

## 909

# Sinclair Project 60

## New performance standards ...new safety margins

Such are the results of using a PZ8 Mk 3 to drive two Z.50 Mk 2 power amplifiers. Developed from the original Z 50, the Mk 2 has improved thermal stability, better regulated D.C. limiting to ensure more symmetrical output voltage swing with still less distortion at lower outputs and automatic transient overload protection. The PZ.8 Mk.3 is the most advanced power supply unit ever to be made at a reasonable price. It cannot be damaged by direct shorting, nor will it fail through overloading, because of an ingenious re-entrant current limiting principle used usually only in expensive laboratory equipment. Because output voltage is variable, the PZ8 Mk 3 makes a worthwhile alternative where PZ.5 and PZ.6 are recommended for Project 60 applications, particularly since this most powerful of all Sinclair supply units can be operated from a smaller mains transformer. Together, the Z 50 Mk 2 and PZ8 Mk 3 provide new standards of performance and reliability and these modules are compatible with earlier types in the Project 60 range.

### Z.50 Mk.2 SPECIFICATIONS

Input impedance 100 K $\Omega$   
Input (for 30W into 8 $\Omega$ ) 400mV  
Signal to noise ratio, referred to full o/p at 30v HT 80dB or better  
Distortion 0.02% up to 20W at 8 $\Omega$   
See published curve  
Frequency response 10Hz to more than 200 KHz  $\pm$  1dB  
Max. supply voltage 45v (4 $\Omega$  to 8 $\Omega$  speakers) (50v 15 $\Omega$  speakers only)

Min. supply voltage 9v  
Load impedance – minimum: 4 $\Omega$  at 45v HT  
Load impedance – maximum: safe on open circuit

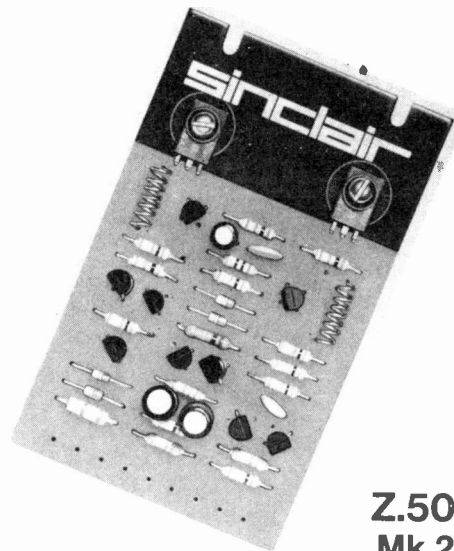
£5.48 + V.A.T.  
54p

### PZ.8 Mk.3 SPECIFICATIONS

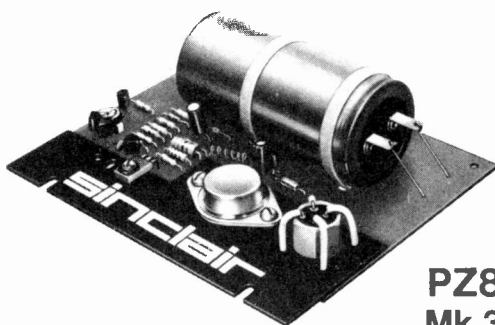
Nominal working output 45V.  
Adjustable between 20 & 50V

£7.98 + V.A.T.  
79p

Mains Transformer £5.98 + V.A.T. 59p



**Z.50  
Mk 2**



**PZ8  
Mk 3**

### Other power supplies

In addition to the remarkable Sinclair PZ 8 Mk.III as described, there are two other power units available, which should be chosen according to their types in order to buy to best advantage. All are for operation from A.C. mains 240V.

PZ.5 30 volt, un stabilised  
£4.98 + V.A.T. 49p

PZ.6 35 volt, stabilised (Not suitable for Super IC 12).  
£7.98 + V.A.T. 79p

### Guarantee

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

Each Project 60 module is tested before leaving our factory and guaranteed to work perfectly. Should any defect arise in normal use, we will service it at once and without any charge to you. A small charge may be made in those cases where damage arises through mis-use. No charge is made for postage by surface mail. Air Mail charged at cost.

## Typical Project 60 applications

System	The Units to use	together with	Units cost
Simple battery record player	<b>Z.50</b>	Crystal P.U., 12V battery volume control, etc.	<b>£5.48</b> + V.A.T. 54p
Mains powered record player	<b>Z.50, PZ.5</b>	Crystal or ceramic P.U. volume control, etc.	<b>£10.46</b> + V.A.T. £1.04
12W. RMS continuous sine wave stereo amp. for average needs	<b>2 x Z.50, Stereo 60; PZ.5</b>	Crystal, ceramic or mag. P.U., F.M. Tuner, etc.	<b>£25.92</b> + V.A.T. £2.59
25W. RMS continuous sine wave stereo amp. using low efficiency (high performance) speakers	<b>2 x Z.50, Stereo 60; PZ.6</b>	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	<b>£28.92</b> + V.A.T. £2.89
80W. (3 ohms) RMS continuous sine wave de luxe stereo amplifier. (60W. RMS into 8 ohms)	<b>2 x Z.50 Mk.2, Stereo 60; PZ.8 Mk.3 transformer</b>	As above	<b>£34.90</b> + V.A.T. £3.49
Indoor P.A.	<b>Z.50 Mk.2, PZ.8 Mk.3 transformer</b>	Mic., guitar, speakers, etc., controls	<b>£19.44</b> + V.A.T. £1.94

A.F.U. (£5.98 + V.A.T. 59p) may be added as required.

# sinclair

SINCLAIR RADIONICS LTD., LONDON RD., ST. IVES, HUNTINGDONSHIRE PE17 4HJ Telephone: St. Ives (0480) 64311 Telex: 32250 Reg. No. 699483 England



# the world's most advanced high fidelity modules

## Q.16 high fidelity loudspeaker

The Q.16 employs original and by now well proven acoustic principles in which a special driver assembly is meticulously matched to a uniquely designed cabinet. In performance it comfortably stands comparison with very much more expensive loudspeakers. A solid teak surround is used with a special all-over cellular black foam front chosen both for its appearance and ability to pass all audio frequencies without masking.

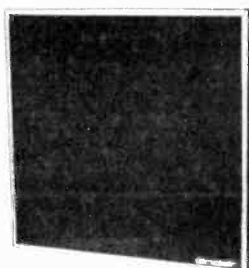
### Specifications

**Construction:** A sealed seamless sound or pressure chamber is used with internal baffle, and special high flux driver

**Loading:** Up to 14 watts RMS into 8 ohms

**Frequency response:** From 60 to 16,000 Hz

**Size and styling:** 248 mm square x 120 mm deep (9 7/8" x 4 3/4") with neat pedestal base



£7.70 + V.A.T.  
77p



## Stereo 60 pre-amp/control unit

Designed specifically for Project 60 systems, the Stereo 60 is equally suitable with any high quality power amplifier. Silicon epitaxial planar transistors used throughout ensure high signal-to-noise ratio and excellent tracking between channels. Input selection is by press buttons, with accurate equalisation on all input channels. The unit is easy to mount.

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

Built, tested and guaranteed

£9.98 + V.A.T.  
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## AFU filter unit

For use between Stereo 60 and two Z.30's or Z.50's in stereo formation. Cut off frequencies are continuously variable, with 12dB/octave cut in the rejection band. Two stages of filtering—rumble (high pass) and scratch (low pass). Amplitude and phase distortion are negligible. Supply voltage needed—15–35V. H.F. cut-off (–3dB) 28KHz to 5KHz; L.F. (–3dB) 25Hz to 100Hz. For Project 60 or any good stereo system.

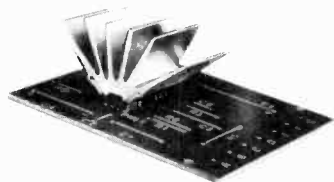
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## Super IC.12 Integrated circuit high fidelity amplifier



Having introduced Integrated Circuits to hi-fi constructors with the IC.10, which was the first time an IC had ever been made available for such purposes, we followed it with an even more efficient version, the Super IC.12. This needs very few external resistors and capacitors to make an exceedingly efficient high fidelity amplifier for pick-up, F.M. radio or small P.A. set up etc. The free 40 page manual supplied details many other applications which this remarkable IC make possible. The Super IC.12 is the equivalent of a 22 transistor circuit

contained within a 16 lead DIL package, and the finned heat sink is sufficient for all likely requirements. The Super IC.12 is also compatible with those Project 60 modules which would be used with the Z.50 and Z.30 amplifiers. Complete with free manual and printed circuit board.

### SPECIFICATIONS

**Output power:** 6 watts RMS continuous (12 watts peak) into 6–8  $\Omega$ . **Frequency Response:** 5Hz to 100KHz  $\pm 1$ dB. **Total Harmonic Distortion:** Less than 1% (Typical 0.1%) at all output powers and frequencies in the audio band (28V). **Load Impedance:** 3 to 15 ohms. **Input Impedance:** 250 Kohms nominal. **Power Gain:** 90dB (1,000,000,000 times) after feedback. **Supply Voltage:** 6 to 28V. **Quiescent current:** 8mA at 28V. **Size:** 22 x 45 x 28mm including pins and heat sink.

Manual available separately 15p post free

With FREE printed circuit board and 40 page manual.

£2.98 + V.A.T. 29p  
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## Project 605



## the simple way to build a Project 60 system without soldering

For the many audio enthusiasts anxious to build to high standards without too many involvements, there could be nothing better or simpler than Project 605. It offers the advantages of Project 60 and is absolutely complete down to the last piece of wire cut to length. Whilst not as powerful as assemblies using Z.50 power amplifiers, we know from experience that there are many for whom the specifications of Project 605 are ideal, particularly in relation to the environment in which it is required to be used. In Project 605 you have everything necessary to build a versatile Project 60 thirty watt high fidelity amplifier system suitable for all domestic requirements. The convenient pack includes two Z.30 power amplifiers, a Stereo 60 pre-amp control unit and the special Masterlink unit to and from which all input and output connections are made. For power a PZ.5 is provided. Building is particularly easy since all necessary leads are supplied colour coded, cut to length and terminated by contact clips which connect firmly to the modules. There is absolutely no soldering to be done. Complete with comprehensive, easy to follow instructions manual.

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170W r.m.s. sq. wave 300W instantaneous peak into 8 ohm (60W into 16 ohm). £14.28, carr. 45p.

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Four control pre-amp, Vol., Bass, Treble, Middle controls. Designed to drive most amplifiers using F.E.T. first stage. £3.96, carr. 25p.

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A fantastic bargain. If you purchase all three modules £25, carr. 75p. Send S.A.E. for further details on this or our ready built amplifiers.

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2G309	0-25	2N3418	0-15	40364	0-61	BC137	0-15	BF115	0-25	BSV39	0-25
2G345B	0-25	2N3419	0-15	40365	0-61	BC138	0-15	BF117	0-43	BSV39	0-25
2G371	0-15	2N3420	0-15	40366	0-61	BC139	0-15	BF119	0-43	BSV39	0-25
2G374	0-15	2N3421	0-15	40367	0-61	BC140	0-15	BF121	0-25	BSV34	0-20
2N174	1-40	2N3422	0-10	40406	0-44	BC141	0-39	BF123	0-27	BSV36	0-15
2N404	0-43	2N3423	0-10	40407	0-33	BC142	0-24	BF125	0-25	BSV65	0-70
2N456	0-75	2N3424	0-14	40408	0-50	BC143	0-21	BF152	0-20	BSV78	0-40
2N456A	0-75	2N3425	0-10	40409	0-52	BC144	0-24	BF153	0-20	BSV79	0-40
2N457A	0-80	2N3426	0-09	40410	0-58	BC145	0-21	BF154	0-16	BSV9A	0-09
2N491	3-25	2N3427	0-07	40411	2-25	BC147	0-12	BF158	0-28	CU11	0-09
2N696	1-18	2N3428	0-09	40412	3-55	BC148	0-12	BF159	0-27	D40N3	0-55
2N697	1-21	2N3429	0-10	40467A	0-69	BC149	0-12	BF160	0-23	GET111	0-45
2N698	0-25	2N3430	0-12	40468A	0-44	BC150	0-18	BF161	0-42	GET114	0-20
2N699	0-52	2N3431	0-09	40600	0-69	BC154	0-18	BF163	0-20	GET115	0-30
2N706	0-18	2N3432	0-06	40601	0-67	BC157	0-14	BF166	0-35	GET119	0-65
2N706A	0-18	2N3433	1-95	40602	0-46	BC158	0-18	BF167	0-21	GET130	0-20
2N708	0-13	2N3434	2-29	40603	0-58	BC159	0-14	BF173	0-24	GET136	0-20
2N709	0-38	2N3435	1-23	40604	0-56	BC160	0-11	BF177	0-29	GET180	0-20
2N711	0-80	2N3436	3-96	40636	1-10	BC167B	0-11	BF178	0-35	GET183	0-20
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2N748	0-48	2N3463	0-32	AC146	0-22	BC200	0-25	BF238	0-22	ME4022	0-18
2N749	0-48	2N3464	0-32	AC147	0-22	BC201	0-25	BF239	0-22	ME4023	0-18
2N750	0-48	2N3465	0-32	AC148	0-22	BC202	0-25	BF240	0-22	ME4024	0-18
2N751	0-48	2N3466	0-32	AC149	0-22	BC203	0-25	BF241	0-22	ME4025	0-18
2N752	0-48	2N3467	0-32	AC150	0-22	BC204	0-25	BF242	0-22	ME4026	0-18
2N753	0-48	2N3468	0-32	AC151	0-22	BC205	0-25	BF243	0-22	ME4027	0-18
2N754	0-48	2N3469	0-32	AC152	0-22	BC206	0-25	BF244	0-22	ME4028	0-18
2N755	0-48	2N3470	0-32	AC153	0-22	BC207	0-25	BF245	0-22	ME4029	0-18
2N756	0-48	2N3471	0-32	AC154	0-22	BC208	0-25	BF246	0-22	ME4030	0-18
2N757	0-48	2N3472	0-32	AC155	0-22	BC209	0-25	BF247	0-22	ME4031	0-18
2N758	0-48	2N3473	0-32	AC156	0-22	BC210	0-25	BF248	0-22	ME4032	0-18
2N759	0-48	2N3474	0-32	AC157	0-22	BC211	0-25	BF249	0-22	ME4033	0-18
2N760	0-48	2N3475	0-32	AC158	0-22	BC212	0-25	BF250	0-22	ME4034	0-18
2N761	0-48	2N3476	0-32	AC159	0-22	BC213	0-25	BF251	0-22	ME4035	0-18
2N762	0-48	2N3477	0-32	AC160	0-22	BC214	0-25	BF252	0-22	ME4036	0-18
2N763	0-48	2N3478	0-32	AC161	0-22	BC215	0-25	BF253	0-22	ME4037	0-18
2N764	0-48	2N3479	0-32	AC162	0-22	BC216	0-25	BF254	0-22	ME4038	0-18
2N765	0-48	2N3480	0-32	AC163	0-22	BC217	0-25	BF255	0-22	ME4039	0-18
2N766	0-48	2N3481	0-32	AC164	0-22	BC218	0-25	BF256	0-22	ME4040	0-18
2N767	0-48	2N3482	0-32	AC165	0-22	BC219	0-25	BF257	0-22	ME4041	0-18
2N768	0-48	2N3483	0-32	AC166	0-22	BC220	0-25	BF258	0-22	ME4042	0-18
2N769	0-48	2N3484	0-32	AC167	0-22	BC221	0-25	BF259	0-22	ME4043	0-18
2N770	0-48	2N3485	0-32	AC168	0-22	BC222	0-25	BF260	0-22	ME4044	0-18
2N771	0-48	2N3486	0-32	AC169	0-22	BC223	0-25	BF261	0-22	ME4045	0-18
2N772	0-48	2N3487	0-32	AC170	0-22	BC224	0-25	BF262	0-22	ME4046	0-18
2N773	0-48	2N3488	0-32	AC171	0-22	BC225	0-25	BF263	0-22	ME4047	0-18
2N774	0-48	2N3489	0-32	AC172	0-22	BC226	0-25	BF264	0-22	ME4048	0-18
2N775	0-48	2N3490	0-32	AC173	0-22	BC227	0-25	BF265	0-22	ME4049	0-18
2N776	0-48	2N3491	0-32	AC174	0-22	BC228	0-25	BF266	0-22	ME4050	0-18
2N777	0-48	2N3492	0-32	AC175	0-22	BC229	0-25	BF267	0-22	ME4051	0-18
2N778	0-48	2N3493	0-32	AC176	0-22	BC230	0-25	BF268	0-22	ME4052	0-18
2N779	0-48	2N3494	0-32	AC177	0-22	BC231	0-25	BF269	0-22	ME4053	0-18
2N780	0-48	2N3495	0-32	AC178	0-22	BC232	0-25	BF270	0-22	ME4054	0-18
2N781	0-48	2N3496	0-32	AC179	0-22	BC233	0-25	BF271	0-22	ME4055	0-18
2N782	0-48	2N3497	0-32	AC180	0-22	BC234	0-25	BF272	0-22	ME4056	0-18
2N783	0-48	2N3498	0-32	AC181	0-22	BC235	0-25	BF273	0-22	ME4057	0-18
2N784	0-48	2N3499	0-32	AC182	0-22	BC236	0-25	BF274	0-22	ME4058	0-18
2N785	0-48	2N3500	0-32	AC183	0-22	BC237	0-25	BF275	0-22	ME4059	0-18
2N786	0-48	2N3501	0-32	AC184	0-22	BC238	0-25	BF276	0-22	ME4060	0-18
2N787	0-48	2N3502	0-32	AC185	0-22	BC239	0-25	BF277	0-22	ME4061	0-18
2N788	0-48	2N3503	0-32	AC186	0-22	BC240	0-25	BF278	0-22	ME4062	0-18
2N789	0-48	2N3504	0-32	AC187	0-22	BC241	0-25	BF279	0-22	ME4063	0-18
2N790	0-48	2N3505	0-32	AC188	0-22	BC242	0-25	BF280	0-22	ME4064	0-18
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2N794	0-48	2N3509	0-32	AC192	0-22	BC246	0-25	BF284	0-22	ME4068	0-18
2N795	0-48	2N3510	0-32	AC193	0-22	BC247	0-25	BF285	0-22	ME4069	0-18
2N796	0-48	2N3511	0-32	AC194	0-22	BC248	0-25	BF286	0-22	ME4070	0-18
2N797	0-48	2N3512	0-32	AC195	0-22	BC249	0-25	BF287	0-22	ME4071	0-18
2N798	0-48	2N3513	0-32	AC196	0-22	BC250	0-25	BF288	0-22	ME4072	0-18
2N799	0-48	2N3514	0-32	AC197	0-22	BC251	0-25	BF289	0-22	ME4073	0-18
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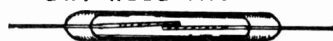
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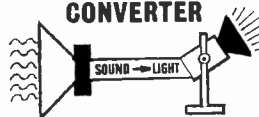
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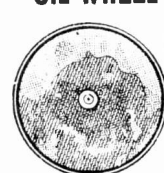
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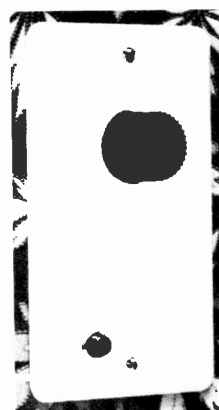
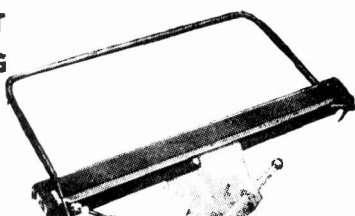
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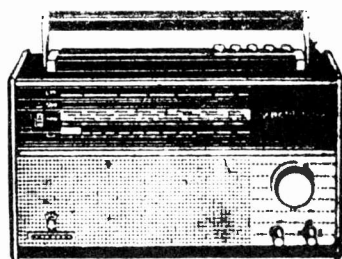
Wharfedale Unit 3	£8-25
Wharfedale Unit 4	£14-50
Wharfedale Unit 5	£21-00
Richard Allan Twinkit	£7-33
Richard Allan Triple 8	£10-76
Richard Allan Triple Assem	£19-36
Richard Allan Super Triple	£19-36
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Fane Mode One	£9-00

Kefkit 2	£24-75
Kefkit 3	£35-50
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Trio KA2002	£41-00
Hitachi TRQ232S stereo cassette	£48-50
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ITT/KB Studio 73 stereo cassette	£44-00
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Prices include VAT.

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(carr. and ins. £1)

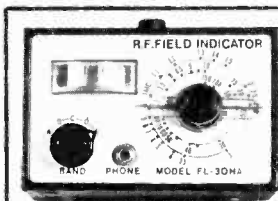
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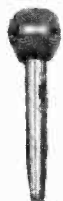
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P	9	3	13	£4-34
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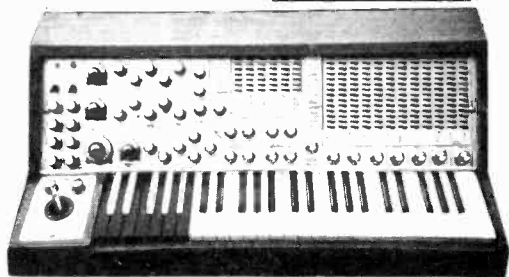
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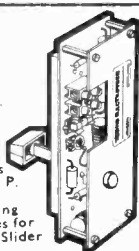
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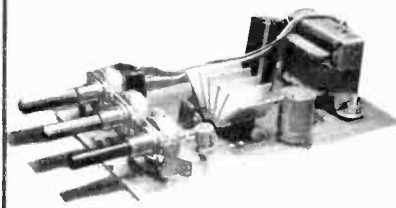
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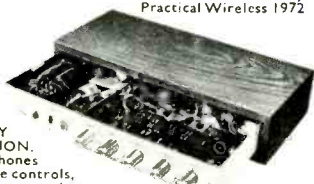
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