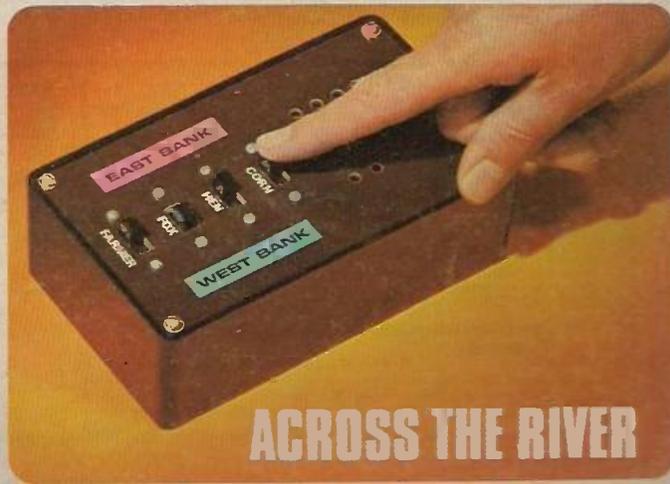


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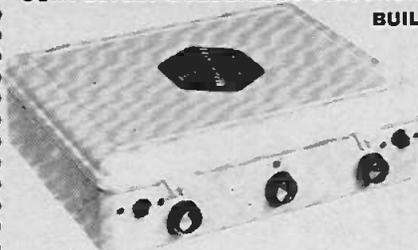
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Total Building Costs

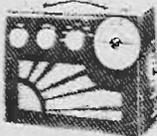
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P.P. & Ins. 44p.
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ROAMER TEN

with VHF including aircraft. 10 Transistors. Latest 4" 2 watt Ferrite Magnet Loudspeakers. 9 Tunable Wavebands. MW1, MW2, LW, SW1, SW2, SW3, Travler Band, VHF and Local Stations also Aircraft Band. Built in Ferrite Rod Aerial for MW/LW. Chrome plated 7 section Telescopic Aerial, can be angled and rotated for peak short wave and VHF listening. Push Pull output using 600 mw Transistors. Car Aerial and Tape Recording Sockets. 10 Transistors plus 3 Diodes. Ganged Tuning Condenser with VHF section. Separate coil for Aircraft Band. Volume on/off, Wave Change and tone Control. Attractive Case in black with silver blocking. Size 9" x 7" x 4". Easy to follow instructions and diagrams. Parts price list and plans 50p (FREE with parts). Total building costs **£8-50** P.P. & Ins. 52p (Overseas P & P £1-85) (+ 8% VAT 68p)



NEW EVERYDAY SERIES

Build this exciting New series of designs

E.V. 5 6 Transistors and 2 diodes. MW/LW. Powered by 4½ volt Battery. Ferrite rod aerial, tuning condenser, volume control, and now with 3" loudspeaker. Attractive case with red speaker grille. Size 9" x 5½" x 2½" approx.

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E.V. 6 Case and looks as above. 6 Transistors and 3 diodes. Powered by 9 volt battery. Ferrite rod aerial, 3" loudspeaker, etc., MW/LW coverage. Push Pull output. Parts price list and Plans 30p. Free with parts.

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E.V. 7 Case and looks as above. 7 Transistors and 3 diodes. Six wavebands, MW/LW, Travler Band, SW1, SW2, SW3, powered by 9 volt battery. Push Pull output. Telescopic aerial for short waves. 3" loudspeaker. Parts price list and easy build plans 35p. Free with parts.

Total Building Costs **£4-08** P.P. & Ins. 31p (Overseas P & P £1-85) (+ 8% VAT 32p)

ROAMER EIGHT Mk 1 NOW WITH VARIABLE TONE CONTROL

7 Tunable Wavebands: MW1, MW2, LW, SW1, SW2, SW3 and Travler Band. Built in Ferrite Rod Aerial for MW and LW. Chrome plated Telescopic aerial can be angled and rotated for peak short wave listening. Push pull output using 600mw transistors. Car aerial and Tape record sockets. Selectivity switch. 8 transistors plus 3 diodes. Latest 4" 2 watt Ferrite Magnet Loudspeakers: 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 x 7 x 4in. approx. Easy to follow instructions and diagrams. Parts price list and plans 50p (FREE with parts).

Total Building Costs **£6-98** P.P. & Ins. 47p (Overseas P & P £1-85) (+ 8% VAT 56p)



POCKET FIVE

Now with 3" loudspeaker. 3 Tunable wavebands. M.W./L.W. and Travler Band. 7 stages, 5 transistors and 2 diodes, supersensitive ferrite rod aerial, attractive Black and Gold Case. Size 6½" x 4½" x 3½" approx. Plans and parts price list 20p. (Free with parts).

Total Building Costs **£2-50** P.P. & Ins. 26p (Overseas P & P £1-25p) (+ 8% VAT 20p)



TRANSONA FIVE

now with 3" loudspeaker. Wavebands, transistors and speaker as Pocket Five. Larger Case with Red Speaker Grille and Tuning Dial. Plans and parts price list 20p (Free with parts).

Total Building Costs **£2-75** P.P. & Ins. 26p (Overseas P & P £1-25p) (+ 8% VAT 21p)

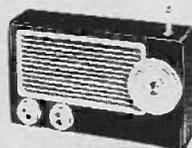


TRANS EIGHT

8 TRANSISTORS and 3 DIODES

6 Tunable Wavebands; MW, LW, SW1, SW2, SW3 and Travler Band. Sensitive ferrite rod aerial for M.W. and L.W. Telescopic aerial for Short Waves. 5in. 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 x 5½ x 2½in. approx. Push pull output. Battery economiser switch for extended battery life. Ampic power to drive a larger speaker. Parts price list and plans 35p (FREE with parts).

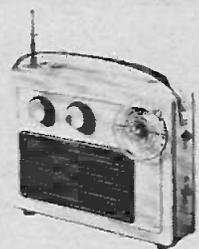
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NEW ROAMER NINE

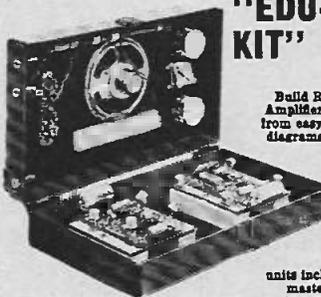
WITH V.H.F. INCLUDING AIRCRAFT



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 V.H.F. section, separate coil for aircraft, moving coil loudspeaker, volume ON/OFF and wavechange control. Attractive all white case with red grille and carrying strap. Size 9½" x 7" x 2½" approx. Parts Price list and Plans 40p (FREE with parts)

Total Building Costs **£6-95** P.P. & Ins. 44p. (Overseas P & P £1-85p) (+ 8% VAT 53p)

"EDU-KIT"



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

units including master unit to construct

Components include:

Tuning Condenser: 2 Volume Controls: 2 Slider Switches: Fine 3" Tone Moving Coil Speaker: Terminal Strip: Ferrite Rod Aerial: Battery Clips: 4 Tag Boards: 10 Transistors: 4 Diodes: Resistors: Capacitors: Three ½" 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 40p (FREE with parts).

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ROAMER SIX

Case and looks as Trans-Eight. 6 Tunable Wavebands: MW, LW, SW1, SW2, SW3, Travler band plus an Extra Medium waveband for aerial tuning of Luxembourg etc. Sensitive ferrite rod aerial and telescopic aerial for Short Waves. 2in. Speaker. 8 stages—6 transistors and 2 diodes. Attractive black case with red grille, dial and black knobs with polished metal inserts. Size 9 x 5½ x 2½in. approx. Plans and parts price list 35p (FREE with parts).

Total Building Costs **£3-98** P.P. & Ins. 31p (Overseas P & P £1-85) (+ 8% VAT 32p)

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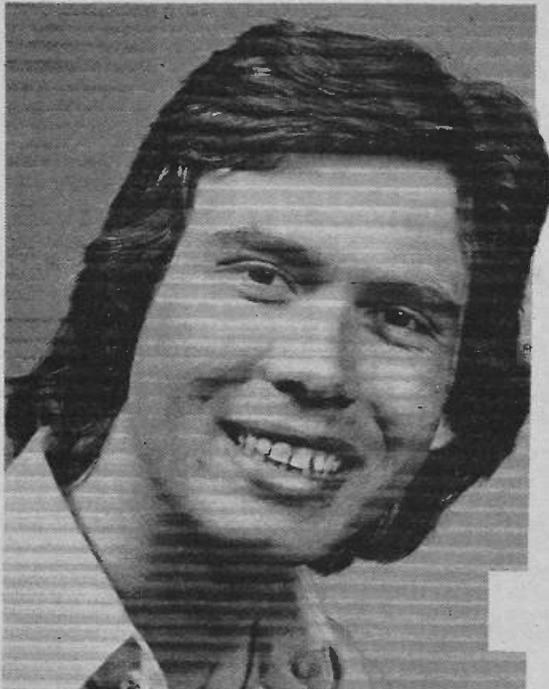
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What really counts however, is *the organisation behind the catalogue*, and in this connection I give full marks to Home Radio Components, because from my experience they really *care* about helping their customers. But don't merely take my word for it—find out for yourself. The best way to do that is to get a copy of their catalogue right away. Just send them a cheque or postal order for 98 pence (65p for the catalogue and 33p for postage, packing and insurance). By the way, they include 14 coupons in the catalogue, each worth 5 pence if used as directed, so you can get not only the cost of the catalogue back, but 5p towards the postage as well. If that's not philanthropy I don't know what is! It's just one of the ways Home Radio Components think of their customers. *Send for your catalogue today—you'll never regret it.*

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Size 69mm x 46mm x 35mm these meters require a 38mm hole for mounting.

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ME7 = 0 to 100 micro amp " "
ME8 = 0 to 500 micro amp " "
ME9 = 0 to 1mA " "
ME10 = 0 to 5mA " "
ME11 = 0 to 10mA " "
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£3.00



LOW VOLTAGE AMPLIFIER

5 transistor amplifier complete with volume control. Is suitable for 9V d.c. and a.c. supplies. Will give about 1W at 8 ohm output. With high IMP input this amplifier will work as a record player, baby alarm, etc., amplifier. £1.75



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3 KILOWATTS PSYCHEDELIC LIGHT CONTROL UNIT



Three Channels: Bass—Middle—Trebble. Each channel has its own sensitivity control. Just connect the input of this unit to the loudspeaker terminals of an amplifier, and connect three 250V up to 1000W lamps to the output terminals of the unit, and you produce a fascinating sound-light display. (All guaranteed.)

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2 1/2 x 5	84p	34p	18p
3 1/2 x 3 1/2	84p	84p	...
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1 7/8 x 2 1/2	1.06p	77p	60p
1 7/8 x 3 1/2	1.46p	1.16p	75p
1 7/8 x 5	1.85p	...	1.10p

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Finest quality British made Light weight Headphones. Incorporates ceramic piezo electric transducers.

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A Bargain at £1.25 each set

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Plug Stereo phones into this control box and you then incorporate a right and left hand volume control and a stereo/mono switch. Complete with stereo jack plug and 2 m cable. A Bargain at £1.

12-0-12 VOLT 500mA/240 VOLT PRIMARY TRANSFORMER

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Top value 1,000 opv pocket multi-meter. Ranges: 0/10/50/250/1000 volt AC and DC. DC current 0-1mA/100mA. Resistance: 0/150k ohms. Decibels: -10 to +22dB. Size 90 x 80 x 28mm. Complete with test leads.



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20,000 opv. Simple unit with audio/IF oscillator. Suitable for general receiver tuning. Ranges: 0.5/2.5/10/50/250/1000V DC. 2.5/10/15/250/500/1000V AC. 0.05/0.5/5/50/500mA DC. Resistance: x 10, x 100, x 1,000, x 10,000 (50k, 500k, 5k/1 centrascale). Battery operated. Size: 160 x 97 x 40mm. Supplied in carrying case complete with test leads.



OUR PRICE £7.70 P&P 30p

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30,000 opv. Overload protection. Ranges: 6/30/60/300/600/1200V DC. 12/60V DC. 12/60/1200V AC. 60uA/30mA 300mA. 2k/200k/2 Meg Ohm. -10 to 63dB.



OUR PRICE £7.50 P&P 30p

U4324 MULTIMETER

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



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20,000 opv. Ranges: 75mV/2.5/10/25/100/250/500/1000V DC. 2.5/10/25/100/250/500/1000V AC. Current: 50uA/175/25/100mA/0.5/2.5A DC. 0.5/2.5/10mA. 0.5/2.5/5A AC. Resistance: 0.3/30/300k ohms. Size: 705 x 110 x 84mm. Supplied complete with leads, crocodile clips and steel carrying case.



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extremely sturdy instrument for general electrical use. 5670V. 0/0.3/1.5/7.5/30/100/500/1000V DC. 900V DC & 75mV/0/0.3/1.5/7.5/30/60/150/300/600/900V AC. 0/300uA/1.5/6/15/150/60/600mA/1/1.5/6A DC. 0/1.5/6/15/60/150/600mA/1.5/6A AC. 0/200/3k/30k ohms. DC accuracy 1%. AC 15%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions.



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30,000 opv with overload protection. Mirror scale. 0/0.5/2.5/10/25/100/250/500/1000V DC. 0/2.5/10/25/100/250/500/1000V AC. 0/50/500/500mA DC. 500mA/2A DC. Current: 0/60k/6 meg/60 megohms. **OUR PRICE £13.95** Carr. paid Case for above £1.75



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43 ranges: 0-0.3/0.5/1.5/3/6/12/30/60/150/300/600/1200V DC. 0-30/150/300/600/1200V AC. Current: 0-30/60uA/1.5/3/15/30/150/300 mA/6/12A. Resistance 0-3/300k/3/30Mohms. Decibels: -10 to +17dB. Output: 0.3/1.5/3/10/30/60/120/300V. Accuracy: ± 3% DC, ± 4% AC. Sensitivity: 50,000 opv DC, 5,000 opv AC. 4 inch meter. Built in protection. Size: 67 x 102 x 153mm.



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46 ranges, mirror scale. 50kV/4 AC. 0.25/1/2.5/5/10/25/50/125/250/500/1000V AC. DC current 25/50uA/2.5/5/25/50/100mA/1A/5/10A. Resistance: 10k/100k/1 Meg/10 Meg ohms. -20 to +81.5dB.



OUR PRICE £12.50 P&P 20p

HIKOKI MODEL 700X

100,000 opv. Overload protection. Mirror scale. 0.3/0.6/1.2/1.5/3/6/12/30/60/120/300/600/1200V DC. 1.5/3/6/12/30/60/150/300/600/1200V AC. 15/30/150/300/600/1500/5000/6/12A DC. 2k/200k/2M/20M Ohms. -20 to +63dB.



OUR PRICE £14.95 P&P 30p

Model HT100B4 MULTIMETER

Overload protection, shock proof circuits. 9.5uA Meter with mirror scale. Sensitivity 100kV. Polarity change switch. Ranges: 0.5/2.5/1.5/50/250/500/1000V DC. 2.5/10/50/100/500/1000V AC. DC resistance: 0-20/200k/2/20 Meg. Ohms. DC current: 10/250uA/2.5/25/250 mA/10A. AC current: 0-10A. -20 to +62dB. Operates from 2 x 1.5V batteries. Size: 180 x 134 x 79mm.



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MODEL AS.1000 VOM

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



OUR PRICE £17.50 P&P 30p

MODEL C7202EN

20,000 opv. DC. 10,000 opv. AC. Mirror scale. 6/25/50/250/500/1000/2500V DC. 10/50/100/500/1000V AC. DC Resistance x10, x100 (30k centrascale) DC Current: 50uA/2.5mA/250mA. -20 to +48dB.



OUR PRICE £6.50 P&P 30p

KAMODEN HM720B FET VOM

Input impedance 10 Megohms. Ranges: 0/25/100/500/1000V DC. 0/2.5/10/50/250/1000V AC. 0/25uA/2.5/25/250 mA DC. 0/5k/50k/500k/5 M 500 Megohms.



OUR PRICE £21.00 P & P 40p

KAMODEN 360 MULTIMETER

High sensitivity. DC 100kOhm/V AC 10kOhm/V 5" mirror scale, overload protected. ed. Ranges: 0.5/2.5/10/50/250/1000V DC. 5/10/50/250/1000V AC. Current: 0.01mA/0.5/5/50/500mA/10A. Resistance: 0.1/1/10/100 ohms/10/100k ohms/10/100M Ohms. Decibels: -20 to +62dB. Battery operated. Size: 180 x 140 x 80mm. Supplied complete with test leads etc.



OUR PRICE £17.50 P & P 40p

TMK MODEL 117 FET ELECTRONIC VOLT METER

Battery operated. 11 Meg Input, 26 ranges. Large 4x" mirror scale. Size: 149x117x66mm. 0.3-12000V DC. 0.3-300V RMS AC. 6-300V DC. DC current 0.12-12mA. Resistance up to 2000M Ohms. Decibels: -20 to +45dB. Supplied complete with leads and instructions.



OUR PRICE £18.50 P&P 20p

TMK 100K LAB TESTER

100,000 opv. 6x" scale. Buzzer switch. Short circuit check. Sensitivity 100,000 opv DC. 5kV/4 AC. DC Voltage: 0.5/5/10/50/250/1000V AC. 3/10/50/250/500/1000V DC. Current: 10/100/2.5/10A. Resistance: 1k/10k/100k/10 Meg/100 Meg ohms. Decibels: -10 to +45dB. Plastic case with carrying handle. Size: 190 x 172 x 99mm.



OUR PRICE £19.95 P&P 20p

370WTR MULTIMETER

Features AC current ranges: 20,000 opv. 0/0.5/2.5/10/50/100/500/1000V DC. 0/2.5/10/50/250/500/1000V AC. 0/50uA/10/100 mA/1/10A DC. 0/100mA/10A AC. 0/5k/50k/150k/5 Meg/50 Meg. Decibels: -20 to +62dB.



OUR PRICE £19.95 P&P 30p

KAMODEN 72.200 MultiTester

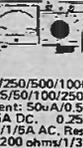
High sensitivity. 200,000 opv. Overload protected. Mirror scale. Ranges: 0.06/3/30/120/600/1200V DC. 0/3/12/60/300/1120V AC. 0/10uA/1mA/120mA/600mA/12A DC. 0/12A AC. -20 to +63dB. 0/2k/200k/2 Meg/200 Megohms.



OUR PRICE £22.50 P&P 30p

U4317 MULTIMETER

High sensitivity. Instrument for field and laboratory work. Knife edge pointer, 36mm mirror scale. Overload protection. Ranges: 100mV/0.5/2.5/10/25/50/100/250/500/1000/1000V DC. 0.5/2.5/10/25/50/100/250/500/1000V AC. Current: 50uA/0.5/1/5/10/50/250mA/1.5A DC. 0.25/0.5/1.5/10/50/250mA/1.5A AC. Resistance: 0.5/10/100/1000/200 ohms/1/3/30/300k ohms. Decibels: -5 to +10dB. Battery operated. Size: 210 x 115 x 50mm. Supplied in carrying case complete with test leads.



OUR PRICE £16.50 P&P 40p

MODEL C720BFM

30,000 opv DC. 15,000 opv AC. 6/3/15/60/300/600/1200V DC. DC/30/120/600/1200V V. AC. DC Resistance x1, x10, x100 (100k centrascale) DC Current: 30uA/3/30/600mA. -20 to +83dB.



OUR PRICE £8.95 P & P 30p

MODEL U4311 Sub-standard Multi-range Volt-Ammeter

Sensitivity 330 Ohms/Volt AC and DC. Accuracy 0.6% DC. 1% AC. Scale length: 165mm. 0/200/750uA/1.5/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5A DC. 0/7.5/15/30/75/150/300/750mA/1.5/3/7.5/15/30/75/150/300/750V AC. Automatic cut out device. Supplied complete with test leads, manual and test certificates.



OUR PRICE £52.00 P&P 50p

MODEL AF.105 VOM

50,000 opv. Mirror scale. Meter protection. 0/3/3/2/50/120/300/600/1200V DC. 0/6/30/120/300/600/1200V DC. 0/30uA/6/60/300mA/10A. Mirror 100k/1m/10m/100 Meg Ohms. -20 to 17dB.



OUR PRICE £12.50 P&P 30p

L83 TRANSISTOR TESTER

Tests ICD and E. PNP/NPN. Operates from 9V battery. Instructions supplied.



OUR PRICE £3.95 P&P 20p

L84 TRANSISTOR TESTER

Tests PNP or NPN transistors. LED indication. Operates on two 1.5V batteries. Complete with instructions etc.



OUR PRICE £4.50 P&P 20p

KAMODEN TT35 TRANSISTOR TESTER

High quality instrument to test reverse leak current and DC current. Amplification factor of PNP and NPN transistors, SiC P's etc. 4" square clear scale meter. Operates from internal batteries. Complete with instructions, leads carrying handles.



OUR PRICE £17.50 P & P 40p

U4341 Multimeter & Transistor Tester

27 ranges. 16,700 opv. Overload protected. Ranges: 0.3/3/15/30/60/300/3000V DC. 1.5/7.5/30/150/300/750V AC. Current: 0.06/0.5/6/60/600mA. DC. 0.3/3/30/300mA AC. Resistance: 0.06/0.6/6/60/250/2500 ohms/2 Mohms. Battery operated. Supplied complete with probes, leads and steel carrying case. Size: 115 x 215 x 90mm.



OUR PRICE £19.50 P&P 30p

S100TR MULTIMETER TRANSISTOR TESTER

100,000 opv. Mirror scale. Overload protection. 0/0.1/0.5/3/12/30/120/600V DC. 0/6/30/120/600V AC. 0/12/600uA/12/300mA/6/12A DC. 0/10k/1 Meg/100 Meg. -20 to +50dB. 0.01-0.2 MPFD. Transistor tester measures Alpha, Beta and ICO. Complete with instructions, batteries and leads.



OUR PRICE £19.95 P&P 25p

SWR METER MODEL SWR3

Handy SWR meter for transistor antenna alignment, with built-in field strength meter. Accuracy 5%. Impedance 52 Ohm indicator 100uA DC. Full scale 5 section collapsible antenna. Size 145 x 50 x 60mm.



OUR PRICE £4.25 P&P 30p

ALL PRICES EXCLUDE VAT

Also see following pages

C16 PULSE OSCILLOSCOPE

For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth: 10MHz. Sensitivity at 100kHz VRMS/mm: 0.1-25. HOR. AMP. Bandwidth: 500kHz. Sensitivity at 100kHz VRMS/mm: 0.3-25. Preset triggered sweep 1-3000usec. Free running 20-200 Hz in nine ranges. Calibrator pulse 220 x 360 x 430mm. 115-230V AC. **OUR PRICE £43.00** Carr. paid



RUSSIAN C116 Double Beam OSCILLOSCOPE

5 MHz pass band. Separate Y1 and Y2 amplifiers. Rectangular 5 x 4" CRT. Calibrated triggered sweep from 0.2usec. to 100msec/scan/cm. Free running time base. 50Hz-1MHz. Built-in time base Calibrator and amplitude Calibrator. Supplied complete with all accessories and instruction manual. **OUR PRICE £87.00** Carr. paid



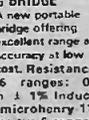
MODEL TE15 GRID DIP METER

Operates as Grid Dip Oscillator. Absorption Wave Meter and Oscillating Detector. Frequency range 400kHz-280MHz in six coils. 500uA meter. 9V battery operation. Size: 180 x 80 x 40mm. **OUR PRICE £19.95** P&P 30p



TRANSISTORISED L.C.R. A.C. BR/B' MEASURING BRIDGE

A new portable bridge offering excellent range and accuracy at low cost. Resistance: 6 ranges: 0.1 ohm-11.1 megohm ± 1% Inductance: 6 ranges: 1 microhenry 131 henries ± 2% Capacity: 6 ranges: 10pt-1110 mfd ± 2% Turns Ratio: 6 ranges: 1:1/1000-1:111000 ± 1% Bridge Voltage at 1.000cps. Operated from 9-volt battery. 100 microamp meter indication. Size 7 1/2" x 5" x 2" **OUR PRICE £25.00** P&P 30p



TE16A TRANSISTORISED SIGNAL GENERATOR

5 ranges, 400kHz to 30 MHz. An inexpensive instrument for the handy-man. Operates on 9V battery. Wide easy to read scale. 800kHz modulation. Size: 149 x 149 x 32mm. Complete with instructions and leads. **OUR PRICE £8.97** P&P 30p



TE-200 RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 kHz-500 MHz on 6 bands. Directly calibrated. Variable R.F. attenuator audio output. Xtal socket for calibration 220/240V a.c. Brand new with instructions. Size 140mm x 215mm x 170mm. **OUR PRICE £17.50** P&P 50p



TE22 SINE SQUARE WAVE AUDIO GENERATOR

Sine 20cps to 200kHz on 4 bands. Square 20 cps to 20 kHz. Output impedance 5000 Ohms. 200/250V AC operation. Supplied brand new guaranteed, with instruction manual and leads. **OUR PRICE £24.95** P&P 50p



ARF 300 AF/RF SIGNAL GENERATOR

All transistorised compact fully portable. AF sine wave 18Hz to 220 kHz. AF square wave 18Hz to 100k Hz. Output Square/Sine wave 10V P-P RF 100kHz to 200MHz. Output 1V maximum. 220/240V AC operation. Complete with instructions and leads. **OUR PRICE £37.50** P&P 50p



MODEL MG100 SINE SQUARE WAVE AUDIO GENERATOR

Wave 19- 100,000 Hz Square Wave. Output Sine or Square wave 10V P to P. Size 110 x 80 x 90mm. Operation 220/240V A.C. **OUR PRICE £19.95** P&P 50p

SPECIAL BARGAIN! FERGUSON 3406 HI-FI SPEAKERS

High quality 2 way speaker systems. 25 Watts. 4-8 ohms. 40Hz-18kHz. Size: 960 x 340 x 255mm. approx. Wood grain finish with black fronts. **OUR PRICE £22.50** PR. P&P £1



POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiring. Continuous rating. Simple hole fixing. 1/2" diameter shafts. Bulk quantities available. **25 WATT 10/25/50/100/500/1000/2500 ohms. £1.15 P&P 10p**
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100 WATT 1/5/10/25/50/250/500/2500 ohms. 300 Ohms £2.34 P&P 15p



EMI LOUSPEAKERS

Model 350 13 x 8" wide single tweeter/crossover. 20-20,000Hz. 15 watts RMS. Available 8 or 15 ohms. **OUR PRICE £7.50** each P&P 37p
Model 450 13 x 8" with twin tweeter/crossover. 55-13,000Hz. 8 watts RMS. Available 8 or 15 ohms. **OUR PRICE £3.62** each P&P 35p



SPECIAL PURCHASE LIMITED QUANTITY!

Bass Tweeter/DR/B Tannoy 12" 8" 8 ohms 30 watt. Heavy duty. Ideal for Hi-Fi P.A. Group. **OUR PRICE £12.50** P&P 60p



PS200 Regulated POWER SUPPLY UNIT

Solid state. Variable output 5-20V DC. up to 2 Amp. Independent meter to monitor voltage and current. Output 220/240V A.C. Size: 190 x 136 x 98mm. **OUR PRICE £19.95** P&P 50p



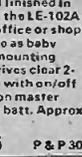
AUDIOTRONIC LE-102A INTERCOM

Beautifully made and finished in two tone ivory/buff. The LE-102A is useful in the home, office or shop and is suitable for use as baby alarm. Wall or desk mounting. 57mm speaker/mic gives clear 2-way communication with on/off and volume control on master unit. Operates on 9V batt. Approx. 601t lead. **OUR PRICE £3.95** P&P 30p



TRITON 4318 PORTABLE 8 TRACK CARTRIDGE PLAYER WITH MW/LW RADIO

Will play 8 track stereo cartridge monoaurally. Channel selector switch. Covers medium and long wave bands. Volume and tone controls. Earphone socket. Battery/ Mains operation. **OUR PRICE £11.95** P & P 50p



EA41 REVERBERATION AMPLIFIER

Self contained, transistorised, battery operated. Simply plug in microphone, gully etc. and output to your amplifier. Volume control and depth of reverberation control. Beautiful cabinet. 184 x 77 x 108mm. **OUR PRICE £7.50** P&P 30p



SPECIAL PURCHASES! RECORD DECK PACKAGE

by Famous Manufacturer GARRARD SP25 Mark 111 with 800 RPM cartridge in luxurious plinth with cover. **OUR PRICE £13.95** P & P 75p
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LH025 STEREO HEADPHONES

Light weight headphones with padded ear pieces. 4/16 ohms 20-20,000Hz. Complete with 6 1/2" lead and plug. **OUR PRICE £1.97** P&P 30p



DH025 STEREO HEADPHONES

Wonderful value and excellent performance. Combined adjustable head band. Impedance 8 ohms. 20-12,000Hz. Complete with lead and plug. **OUR PRICE £2.25** P&P 30p



TE1035 Stereo HEADPHONES

Low cost with excellent response. Foam rubber earcups. Adjustable headband. 8 ohms impedance. Frequency response 20Hz-18kHz. Complete with cable and stereo jack plug. **OUR PRICE £2.60** P&P 30p



SDHVV MONO/STEREO HEADPHONES

Volume control for each channel. 4/16 ohms impedance. Frequency response 20Hz-18kHz. Complete with 10ft. coiled lead and jack plug. **OUR PRICE £4.97** P&P 30p



BH001 HEADSET and Boom Microphone

Moving coil. Ideal for language teaching, communications etc. Headphone impedance 16 ohms. Microphone impedance 200 ohms. **OUR PRICE £5.95** P&P 30p



HANIMEX HRC 3075 CASSETTE TUNER

Covers Medium and FM wavebands. Slider volume and tone controls. Battery/ Mains operation. Will record direct from radio or through built in condenser microphone. Complete with batteries, earphone, and cassette. **OUR PRICE £24.30** P & P 50p



SPECIAL BARGAIN!! STEREO SOUND SPEAKERS

Matched pair of stereo bookshelf speakers. Deluxe teak veneered finish. Size: 368 x 228 x 190mm. 8 ohms. 8 watts RMS. 16 watts peak. Complete with Din lead. **OUR PRICE £12.95** PR. P&P 50p



FM TUNER CHASSIS

6 transistor high quality tuner. Size only 153 x 101 x 63mm. 3 IF stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9V battery. Covers 88-108MHz. Ready built, ready for use. Fantastic value for money. **OUR PRICE £8.95** P&P 20p
Stereo Multiplex Adaptor £5.95 extra



SPECIAL OFFER! SAVE OVER 50%

AMSTRAD 8000 2 Stereo amplifier 7 watts per channel rms. Inputs for tuner tape, phono. Headphone socket. List price £29.95. **OUR PRICE £12.95** P & P 60p

SPECIAL OFFER! CONVERT YOUR STEREO SYSTEM TO 4D SOUND FOR UNDER £16.

Exclusive offer of GOODWIN 4-CHANNEL CONVERTER and a pair of AD15 10 watt 8 ohm bookshelf speakers enables you to add 4D sound to your existing system. Complete with simple connection details. Normal retail value £25.50. **OUR PRICE £15.80** P & P £1.
GOODWIN CONVERTER available separately £3.95 P & P 50p.



Model A1018 FM TUNER

6 transistor high quality unit-3IF stages and double tuned discriminator. For use with most amplifiers. Covers 88-108MHz. Powered by 9V battery. **OUR PRICE £13.50** P&P 30p
Stereo multiplex adapter £5.95 extra.



ELECTRONIC CALCULATORS

We carry a tremendous range of both pocket and desk calculators from as little as £9. Owing to the demand it is not possible to include them in this advertisement, so send for our latest price list or call into any branch.



SINCLAIR SYSTEM 2000 STEREO AMPLIFIER AND TUNER

Amplifier output 8 watts per channel RMS. Distortion less than 0.06%. Silicon transistors. Two pick-up plus radio and tape inputs. Hi-Fi Diode detector circuit. Excellent Value. List £39.95. **OUR PRICE £27.50** P & P 60p.



2000 AMPLIFIER

Amplifier output 8 watts per channel RMS. Distortion less than 0.06%. Silicon transistors. Two pick-up plus radio and tape inputs. Hi-Fi Diode detector circuit. Excellent Value. List £39.95. **OUR PRICE £27.50** P & P 60p.



2000 FM TUNER

Excellent selectivity and sensitivity. Twin dual-varicap tuning. 4 pole ceramic filter. 19 transistor stereo demodulator giving 40 dB separation. Distortion 0.2% output. Fantastic Value. List £39.95. **OUR PRICE £27.50** P & P 60p.



SINCLAIR IC12 INTEGRATED CIRCUIT AMPLIFIER

Complete with printed circuit mounting board. **OUR PRICE £1.50** P & P 15p.



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IC20 Stereo Amp. kit. £7.95 P & P 15p
P220 Power Supply kit. £5.45 P & P 30p
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TE1021 Stereo Listening Station

For balancing and gain selection of loudspeakers with additional facility for stereo headphone switching. Two gain controls, speakers on-off slide switch, stereo headphone socket. **OUR PRICE £22.25** P&P 15p



AUDIOTRONIC LOW NOISE CASSETTES

TYPE	10	25
C60	£1.57	£3.00 £7.08
C90	£2.24	£4.25 £10.00
C120	£2.73	£5.17 £12.24

AUDIOTRONIC 8 TRACK CARTRIDGES

TYPE	Each	5	10
40M	£1.50	£4.20	£7.50
80M	£1.15	£5.40	£10.25

P&P Cassettes 3p, Cartridges 5p each OVER 10 of either POST FREE!

MPT MIXER-PREAMPLIFIER

5 Microphone inputs each with individual gain controls. Complete with simple connection details. Battery operated. Size: 235 x 127 x 76mm. Inputs: Mic, 3 x 3xV2 50k 2.5M Ohms. Phono. Mag. 4mV 50k; Phono Ceramic 100mV 1 Meg. Output 250mV 100k. **OUR PRICE £8.97** P&P 20p



AUDIOTRONIC AH401 Stereo Headphone Amplifier

All effect, transistor amplifier operates from magnetic ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9V battery. INPUTS: 5mV and 100mV. Output: 50mV per channel. **OUR PRICE £8.50** P&P 30p



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- HF310 FM tuner..... £16.32
- HF325 Fluxer FM tuner..... £26.33
- HF330 Decoder (HF310/325) £10.55
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- NT305 Voltage converter..... £8.64
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Amateur Electronics by Justy Kit - the professional book for the amateur - covers the subject from basic principals to advanced electronic techniques. Complete with circuit board for AE1 to AE10 listed below. **OUR PRICE £3.30** (No VAT) P&P 25p plus VAT.

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- AE6 Monostable multi-vibrator..... £1.11
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50mA	£3.65	10V DC	£3.65
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1mA	£4.10		
5mA	£4.10		
10mA	£4.10		
50mA	£4.10	10V DC	£4.10
100mA	£4.10	20V DC	£4.10
500mA	£4.10	50V DC	£4.10
1A DC	£4.10	300V DC	£4.10
5A DC	£4.10	15V AC	£4.20
10A DC	£4.10	30V AC	£4.20
5V DC	£4.10	VU Meter	£4.40



CLEAR PLASTIC MODEL MR 65P

Size: 86 x 78mm

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1mA	£3.70		
5.0-1000uA	£3.70		
1mA	£3.70		
5mA	£3.70		
10mA	£3.70	300V DC	£3.70
50mA	£3.70	15V AC	£3.80
100mA	£3.70	50V AC	£3.80
500mA	£3.70	300V AC	£3.80
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10mA	£3.60		
50mA	£3.60	300V DC	£3.60
100mA	£3.60	30V AC	£3.60
500mA	£3.60	50V AC	£3.60
1A DC	£3.60	1A AC	£3.60
2A DC	£3.60	300V AC	£3.60
5A DC	£3.60	500V AC	£3.60
10A DC	£3.60	VU Meter	£4.10
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C	1/2	4-7-10M	1-3	1-1	0-9 nett
C	3/4	4-7-10M	1-5	1-2	0-97 nett
C	1	4-7-10M	3-2	2-5	1-92 nett
MO	1/2	10-1M	4	3-3	2-3 nett
WW	1	0-22-3-9Ω	11	10	8
*WW	3	1-10K	9	8	6
*WW	7	1-10K	11	10	8

* Values under 12Ω, add 40%.

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2-2	—	—	—	—	11p	—	8p	9p
4-7	—	—	—	—	11p	—	8p	9p
10	—	—	—	—	—	—	8p	9p
22	—	—	—	—	—	—	8p	9p
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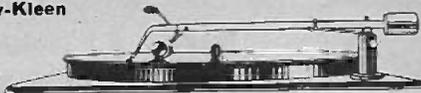
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AL10/AL20/AL30 AUDIO AMPLIFIER MODULES



The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S. The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

Parameter	Conditions	Performance
HARMONIC DISTORTION	Po = 3 WATTS f=1KHz	0.25%
LOAD IMPEDANCE	—	8-16 Ω
INPUT IMPEDANCE	f=1KHz	100 k Ω
FREQUENCY RESPONSE ±3dB	Po=2 WATTS	50Hz-25KHz
SENSITIVITY for RATED O/P	Vs=25V, RL=8 Ω f=1KHz	75mV, R.M.S.
DIMENSIONS	—	3" x 2 1/2" x 1"

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

Parameter	AL10	AL20	AL30
Maximum Supply Voltage	25	30	30
Power output for 2% T.H.D. (RL=8 Ω f=1 KHz)	3 watts RMS Min.	5 watts RMS Min.	10 watts RMS Min.

AUDIO AMPLIFIER MODULES

AL 10. 3 watts RMS	£2.19
AL 20. 5 watts RMS	£2.59
AL 30. 10 watts RMS	£3.01

POWER SUPPLIES

PS 12. (Use with AL10, AL20, AL30) 88p
SPM 80. (Use with AL60) £2.25
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PA 12. (Use with AL10 & AL20) £4.35
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TRANSFORMERS

T461 (Use with AL10) £1.88 P & P 15p
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BMT80 (Use with AL60) £2.15 P & P 25p

PA 12. PRE-AMPLIFIER SPECIFICATION

The PA 12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with *Ceramic cartridges while the auxiliary input will suit most †Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 152mm x 84mm x 35mm.

Frequency response—20Hz-50KHz (-3dB)
Bass control—±12dB at 60Hz
Treble control—±14dB at 14KHz
*Input 1. Impedance 1 Meg. ohm Sensitivity 300mV
†Input 2. Impedance 30 K ohms Sensitivity 4mV

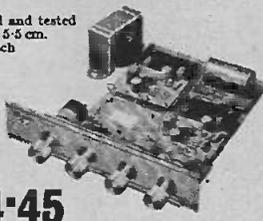
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The STEREO 20

The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm x 14 cm x 5.5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls, Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The 'Stereo 20' has been designed to fit into most turntable plinths without interfering with the mechanism or alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz-25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion: Bass control ±12dB at 60Hz typically 0.25% at 1 watt. Treble con. ±14dB at 14kHz.



£14.45

TC20 TEAK VENEERED CABINET

For Stereo 20 (front board undrilled) size 10 1/2" x 8 1/2" x 3", £3.95, plus 30p postage

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4-16 ohms impedance. Frequency response 20 to 20,000Hz Stereo/mono switch and volume controls £4.95

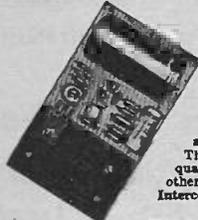
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Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.



STABILISED POWER MODULE SPM80



SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Main Transformer BMT80, the unit will provide outputs of up to 1.5 amps at 35 volts. Size: 63mm x 105mm x 30mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including:—Disc Systems, Public Address Intercom Units, etc. Handbook available 10p

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TRANSFORMER BMT80 £2.15 p. & p. 28p STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL60 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages. Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION

Frequency Response 20Hz-20KHz ±1dB better than 0.1%
Harmonic Distortion 3-25 mV into 50K Ω
Inputs: 1. Tape Head 75 mV into 50K Ω
2. Radio, Tuner 3 mV into 50K Ω
3. Magnetic P.U.
All input voltages are for an output of 250mV. Tape and P.U. inputs equalised to RIAA curve within ±1dB from 20Hz to 20KHz.
Bass Control ±15dB at 20Hz
Treble Control ±15dB at 20 KHz
Filters: Rumble (High Pass) 100Hz
Scratch (Low Pass) 8KHz
Signal/Noise Ratio better than -65dB
Input overload +26dB
Supply +35 volts at 20mA
Dimensions 292mm x 69mm x 35mm

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MK 60 AUDIO KIT

Comprising: 2 x AL60, 1 x SPM80, 1 x BMT80, 1 x PA 100, 1 front panel, 1 kit of parts to include on-off switch, neon indicator, stereo headphone sockets plus instruction booklets. Complete Price: £28.75 plus 30p postage

TEAK 60 AUDIO KIT

Comprising: Teak veneered cabinet size 16 1/2" x 11 1/2" x 3", other parts include aluminium chassis, heatsink and front panel bracket, plus back panel and appropriate sockets etc. Kit Price: £9.95 plus 30p postage

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NEW! Sinclair Scientific kit **£19.95** (INC. VAT)

Britain's most original calculator now in kit form

The Sinclair Scientific is an altogether remarkable calculator.

It offers logs, trig, and true scientific notation over a 200-decade range - features normally found only on calculators costing around £100 or more.

Yet even ready-built, the Sinclair Scientific costs a mere £32.35 (including VAT).

And as a kit it costs under £20!

Forget slide rules and four-figure tables!

With the functions available on the Scientific keyboard, you can handle directly

- sin and arcsin,
- cos and arccos,
- tan and arctan,
- automatic squaring and doubling,
- log₁₀, antilog₁₀, giving quick access to x^Y (including square and other roots),
- plus, of course, addition, subtraction, multiplication, division, and any calculations based on them.

In fact, virtually all complex scientific or mathematical calculations can be handled with ease.

So is the Scientific difficult to assemble?

No. Powerful though it is, the Sinclair Scientific is a model of tidy engineering.

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

Of course, we'll happily supply the Scientific or the Cambridge already built, if you prefer - they're still exceptional value. Use the order form.

Components for Scientific Kit (illustrated)

1. Coil
2. LSI chip
3. Interface chips
4. Case mouldings, with buttons, windows and light-up display in position
5. Printed circuit board
6. Keyboard panel
7. Electronic components pack (diodes, resistors, capacitors, etc)
8. Battery assembly and on/off switch
9. Soft carrying wallet
10. Comprehensive instructions for use

Assembly time is about 3 hours.



Features of the Sinclair Scientific



- 12 functions on simple keyboard
Basic logs and trig functions (and their inverses), all from a keyboard as simple as a normal arithmetic calculator's. 'Upper and lower case' operation means basic arithmetic keys each have two extra functions.

- Scientific notation
Display shows 5-digit mantissa, 2-digit exponent, both signable.

- 200-decade range
10⁻⁹⁹ to 10⁺⁹⁹.

- Reverse Polish logic
Post-fixed operators allow chain calculations of unlimited length - eliminate need for an = button.

- 25-hour battery life
4 AAA manganese alkaline batteries (e.g. MN2400) give 25 hours continuous use. Complete independence from external power.

- Genuinely pocketable
4 1/3" x 2" x 11/16".
Weight 4 oz. Attractively styled in grey, blue and white.

everyday electronics

PROJECTS...
THEORY.....

TRANSMITTING IN FREE SPACE

Just eighty years ago (as near as makes no difference) a young man barely in his twenties persevering with his experiments in an attic finally achieved the success he so earnestly sought. A key depressed at one end of the room caused a buzzer to sound at the opposite end of the room. There were no physical connections between the transmitting and receiving apparatus. Thus was wireless telegraphy born.

That initial success of young Guglielmo Marconi set in train great and staggering developments in communications without the use of intervening wires. Today, life as we know it would not be possible without the great variety of services we have become dependent upon (knowingly or unknowingly) and which are borne along on electromagnetic waves.

Yet, somewhat ironically, the technique that gives freedom from wires is not freely available for all and sundry to use for themselves as they wish. (Could young Guglielmo ever have imagined the restrictions that would be imposed upon future generations of amateur experimenters by his own brilliant success!)

It is a fact, though apparently not always properly understood, that any form of transmission in the radio frequency spectrum is subject to regulations based on the Wireless and Telegraphy Act. It is illegal to make transmissions (regardless of power) without a proper licence from the Home Office (Radio Regulatory

Division). There are various kinds of transmitting licences. These are granted for specific purposes and permit operation only within particular frequency bands allocated exclusively for such purposes.

This in a few words makes clear the legal position in the UK, frustrating though it may be to budding experimenters. It should explain also why we do not (despite frequent requests) publish designs for radio transmitters, other than those intended for few exceptional applications where licences to operate will be granted with the minimum of formality to ordinary members of the general public. Model control and metal sensing devices are two obvious examples.

All is not lost, however. Sound or pressure waves operating above normal human hearing range can be employed in a rather similar fashion to electromagnetic waves for remote control, signalling, and certain other purposes over short distances through air.

Ultrasonic waves cannot provide a complete alternative to radio waves of course. But for certain limited purposes they offer an ideal solution to the problem of how to dispense with undesirable interconnecting wires. Furthermore, this technique has the great advantage that it can be used without let or hindrance from officialdom—as yet!

Fred Bennett

Our January Issue will be published on Wednesday, December 18

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DECEMBER 1974

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ULTRASONIC

A simple ultrasonic transmitter and receiver employing integrated circuits for ease of construction and reliability.

THIS article describes how a simple ultrasonic transmitter and receiver can be constructed for a host of applications such as remote control, intruder alarm, signalling system, leak testing, garage door opening, object counter etc.

When a 40kHz ultrasonic beam from the transmitter falls on the receiver, a relay in the latter closes and can be used to carry out any desired operation. The maximum operating range in the open air is about 12 metres (40 feet).

Integrated circuits are employed in the design so that the number of components required is greatly reduced. Unlike many other ultrasonic circuit designs, the relay specified for this receiver is not a delicate reed relay, but one which has two pairs of large change over contacts. Each pair of contacts can switch up to 10A at 250V a.c.

TRANSDUCERS

The transducers used in the circuits to be described contain piezoelectric "bimorph" plates which resonate at the ultrasonic frequency concerned. These plates are a few square millimeters in area and are sealed in the transducer.

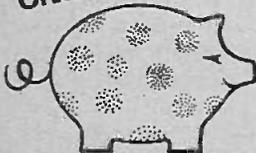
FOR GUIDANCE ONLY

ESTIMATED COST* OF COMPONENTS including V.A.T.

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In the transmitter a square-wave voltage of the ultrasonic frequency is applied to the transducer. The latter produces ultrasonic pressure waves which are just like sound waves except that their frequency is much too high for them to be detected by the human ear. Ultrasonic waves are much more directional than ordinary sound waves.

A similar transducer in the receiver converts the incoming waves into a 40kHz electrical signal.

The voltage across the terminals of the receiver transducer varies greatly with its distance from the transmitter, but is normally in the range of some tens of microvolts up to hundreds of millivolts. This signal must therefore be amplified considerably before it can be used to operate a relay.

The transducers will operate only at or near to their resonant frequency. If the transmitter circuit feeds signals to the transmitter transducer at any other frequency, the ultrasonic output will be very small.

The transducer in the transmitter behaves like a miniature loudspeaker which will operate at only one frequency, whilst the one in the receiver acts like a microphone which is sensitive only to signals near to its resonant frequency.

A relatively new type of miniature transducer, the 96D-40, was selected for use in the prototype equipment. It is available as the "T" and "R" versions which are designed for use in the transmitter and in the receiver respectively.

Although it is possible to interchange these units, optimum results can be expected only if a "T" type unit is used in the transmitter and an "R" type unit in the receiver.

Both types have an identical appearance. They have a metal grille at the front of the unit through which the ultrasonic waves pass. There are two connecting pins at the back, one of which is connected to the metal case of the device.

THE RECEIVER

The low level signal from the transducer in the receiver must be amplified at 40 kilohertz to bring the level up to a few volts. The gain

work for you — (No licence required!)

REMOTE CONTROL

PART 1 RECEIVER

By J.B. DANCE

required is around 80db if the transmitter is well away from the receiver.

The two transducers are themselves frequency selective and it is not necessary to include circuits to control the bandwidth of the system.

The amplification at 40 kilohertz can be carried out using discrete transistors, but it was felt that the use of an integrated circuit would be desirable to reduce the circuit complexity. A type TAA 930B i.c. was selected.

This device contains four cascaded wide-band differential amplifier stages and is intended for use in the sound section of television receivers at a 5.5 megahertz intermediate frequency.

Each amplifier stage is coupled to the succeeding one by an internal emitter-follower buffer stage in an arrangement which allows a high gain to be obtained with good stability.

RECEIVER CIRCUIT

The complete circuit of the receiver unit is shown in Fig. 1. All of the decoupling capacitors

are 10 microfarads in value so that the impedance of these capacitors is less than 0.5 ohm at 40 kilohertz.

The output from the "R" type transducer is applied to the input of the TAA 930B pins 4 and 6.

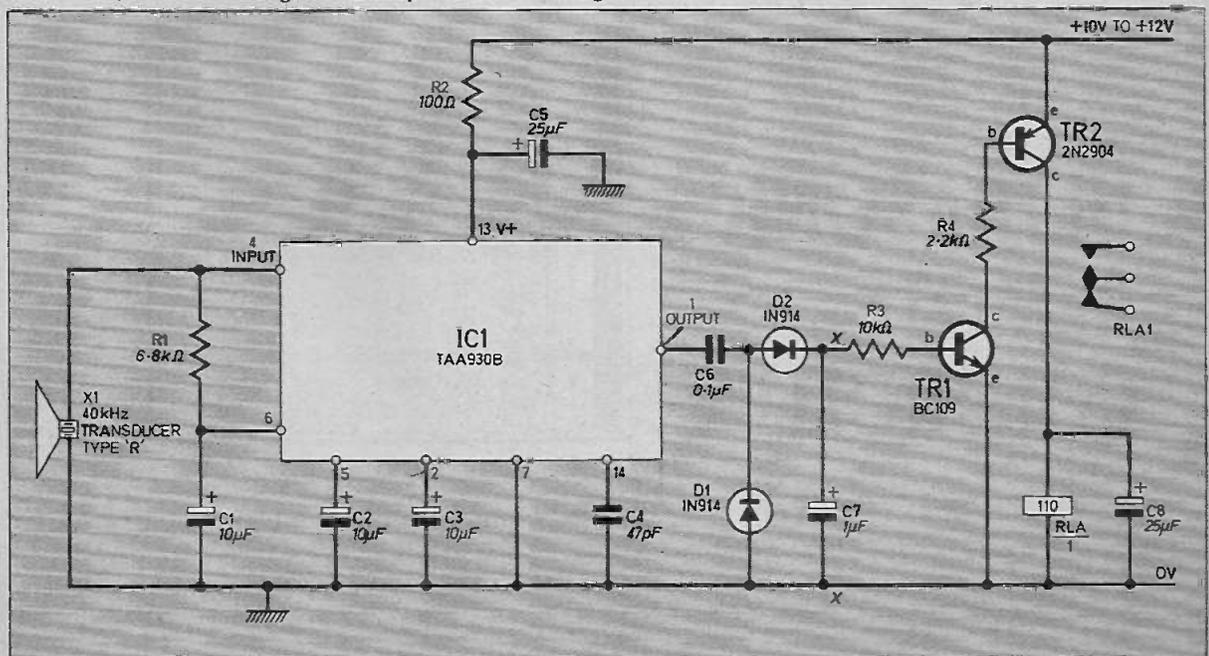
In order that the metal case of the transducer can be earthed, the connection to pin 6 is made via C1.

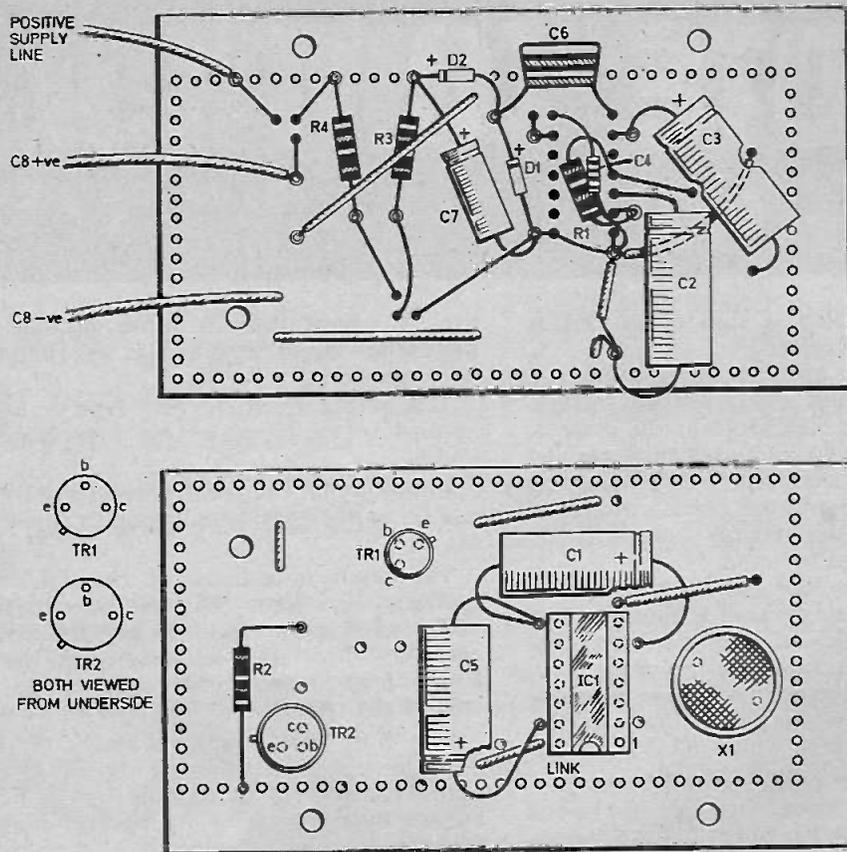
The input impedance of the TAA 930B is typically 15 kilohm, but the resistor R1 must be included in the circuit to bias the input stage correctly. The input capacitance of the device, 8 picofarads, is negligible when compared with that of the transducer.

The differential amplifier stages of the TAA 930B incorporates a limiter circuit so that the output at pin 10 of the device is twice the emitter-base voltage of a forward biased silicon transistor.

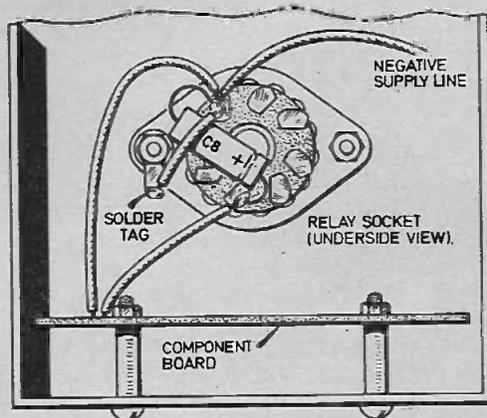
In practice this means that a square wave output of just over 1 volt at 40 kilohertz is

Fig. 1. Complete circuit diagram of the ultrasonic receiver.





ULTRASONIC REMOTE CONTROLLER



obtainable at pin 10 no matter what the input level from the transducer provided that the latter exceeds the minimum threshold of 50 microvolts at pin 4.

Initially it had been intended to use the output from pin 10. However, this signal is internally coupled to further circuits inside the integrated circuit which were designed for use as an f.m. detector. It was found that a 40 kilohertz signal of about 8 volts could be obtained from pin 1 of the device and this proved very satisfactory for the operation of the succeeding circuits shown in Fig. 1.

A 47 picofarad capacitor, C4, is connected from the output of pin 14 to ground, since this was found to improve r.f. stability.

The voltage at pin 14 is fed through an internal emitter-follower to pin 1 where a low impedance output (100 to 150 ohm) is available. The capacitor C6 blocks the steady voltage at the output.

DIODE PUMP

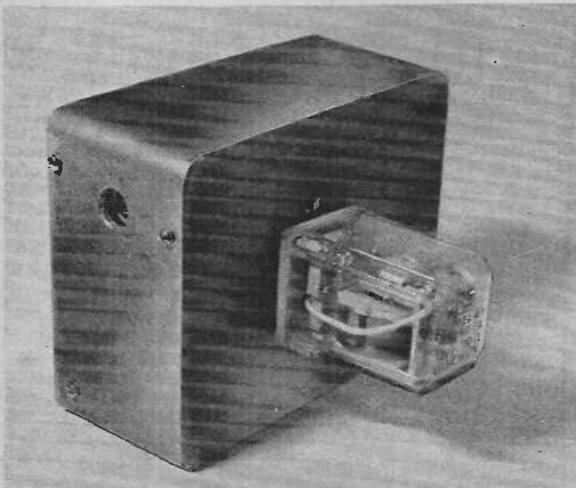
The two diodes D1 and D2 form a diode pump circuit. Each cycle of the 40 kilohertz voltage at pin 1 causes a certain amount of charge to be "pumped" into C7.

A high impedance voltmeter connected across C7 will give a reading up to about 8V as the transmitter transducer is pointed at the receiver transducer. The voltmeter may consist of a 50 μ A meter in series with a 200 kilohm resistor.

RELAY DRIVE CIRCUIT

When the voltage across C7 exceeds about 0.5 volt, a current is driven into the base of the high gain transistor TR1 and causes it to conduct. A current of about 5 milliamps can then flow from the base of TR2 into the collector of TR1.

Photograph of the completed unit.



Components....

Resistors

- R1 6.8k Ω
- R2 100 Ω
- R3 10k Ω
- R4 2.2k Ω
- All $\pm 10\%$ $\frac{1}{4}$ W carbon

Capacitors

- C1 10 μ F elect. 15V
- C2 10 μ F elect. 15V
- C3 10 μ F elect. 15V
- C4 47pF polystyrene 15V
- C5 25 μ F elect. 15V
- C6 0.1 μ F polyester 63V
- C7 1 μ F elect. 15V
- C8 25 μ F elect. 25V

Semiconductors

- TR1 BC109 silicon *n*p*n*
- TR2 2N2904, 2N2905 or 2N1132 silicon *p*n*p*
- D1, D2 IN914 (2 off)
- IC1 TAA930B integrated circuit and holder
- X1 96D-40(R) ultrasonic transducer [96D-40(T) required for the transmitter] (Hall Electronics)

Miscellaneous

- RLA1 12V relay (coil resistance 100 Ω or greater) with at least 1 set of changeover contacts rated as required (R.S. plug-in type 1A used in prototype); socket to suit relay if required; 0.1 inch matrix component board 90 x 50mm; connecting wire; on-off switch if required; battery and connectors (see text); case approx. 120 x 100 x 55mm; 6BA fixings.

The *p*n*p* transistor TR2 therefore becomes saturated and almost the whole of the supply voltage appears across the output relay.

The capacitor C8 absorbs the transient voltage generated when the current ceases to flow through the relay. It also increases the time constant of the circuit and helps to prevent the relay from "chattering" rapidly when the input signal is barely adequate to switch on the relay.

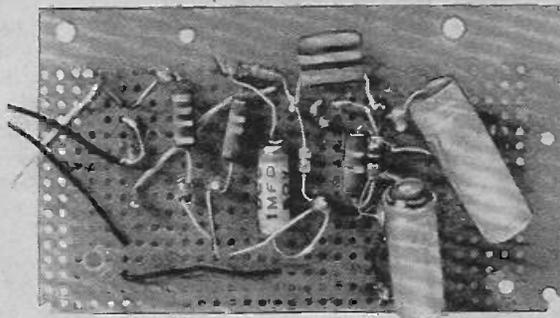
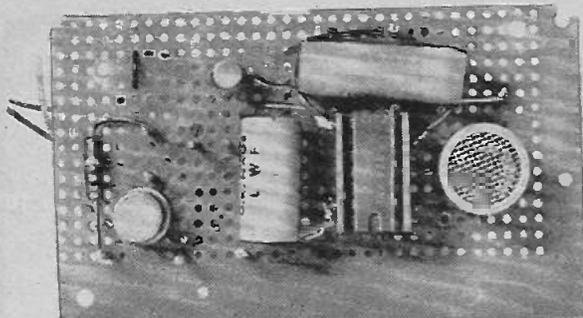
POWER SUPPLY

The absolute maximum permissible power supply voltage to the TAA 930B is 15 volts, but 12 volts should be regarded as the upper limit for the circuit of Fig. 1. The current required by the device is about 15 milliamps from a 12 volts supply or about 11 milliamps from a 9 volt supply.

When the relay is switched on, an additional current of about 100 milliamps will be required.

In some applications a smaller relay may be used. This will reduce the current taken by the receiver when the relay is energised and this can be important if the power supply is a battery.

SEE
**SHOP
TALK**



Two photographs showing the construction of the prototype circuit board.

RECEIVER CONSTRUCTION

The prototype receiver was housed in an Eddystone die-cast box size 120 x 95 x 55mm. The circuit is built on a piece of 0.1in matrix board size 85 x 50mm. Both sides of the board are used for mounting the components and the layout of each side is shown in Fig. 2. Cut the board to size and drill the fixing holes.

Begin construction by inserting the Veropins and integrated circuit holder and then one by one, position and solder the other components on the board, leaving the transistors and diodes till last. A heatshunt should be used on the latter when soldering. The pin of the transducer connected to its metal case should be earthed.

The die-cast box should now be prepared to accept the relay socket and the latter fitted in place.

Now offer up the board to one of the shorter sides of the case and a 12mm diameter hole drilled in line with the transducer and the fixing holes drilled to secure the board in this position.

Mount the component board using 6BA fixings and spacers to ensure that the transducer does not touch the die-cast box, otherwise vibrations from the relay may be picked up, and then wire the board to the relay socket (Fig. 3).

In some applications the receiver will be switched on for long periods. It is then most convenient to employ a mains power supply in the box rather than a battery; a suitable supply can be obtained from the *Battery Eliminator*, *E.E. Nov. '74*.

Next month: the transmitter, testing and applications.

Ruminations By Sensor

Down on the Farm

Electronics is slowly finding a place in agriculture. The electronically operated fencer is now used extensively throughout the industry and has earned the respect of the farmer and his stock. Cattle are not slow to discover when a fencer is not working and invariably do so before the farmer does. They then seem to take a particular pleasure in dragging the wire around the field and pulling all the insulator posts out of the ground, this, of course, in addition to breaking out of the grazing area where the electric fence was intended to keep them.

The result of their uncontrollable wanderings is, at best, a

great nuisance; hence the farmer's insistence on reliability.

Perhaps surprisingly, electronic equipment can be more robust than the equipment it replaces—the simple transistor operated grain moisture meter comes to mind in this category. It's predecessor was more a laboratory instrument than a general farm tool, consequently, it was not used as often or as widely as was desirable. Kept in a box at the back of the wardrobe in the farmer's bedroom, it could well be overlooked during the hustle and bustle of harvest time.

X Marks the Spud

The electronic potato harvester is currently the most exciting development in farm machines. It enables one man—the tractor driver—to carry out the harvesting. On the earlier potato harvesters, a squad of workers rode on the machine and sorted stones and clods of earth from the potatoes as they were raised from the ground; the new machine is fitted

with an electronic sorting unit in which X-ray beams distinguish potatoes from stones and earth clods and actuate sorting fingers to separate the crop from the rubbish.

Every effort has been made to simplify the electronic equipment, and simple replacement parts are available that can be fitted easily by the tractor driver.

The savings in time and labour are considerable and the electronic unit is claimed to be reliable in operation. Other vegetables and bulbs can be harvested with the aid of special fittings.

The manufacturers point out that the electronic sorting devices works at faster-than-human speeds, is more accurate and does not need a tea-break. However the tractor driver still needs his tea-break—but electronics may have the answer to this, too, a tractor guided by a magnetic tape can be made to follow a predetermined course around the field and will continue to run until it breaks down or runs out of fuel!

the WORLD of the I.C.

springs to mind.

These microcircuits also have much more down-to-earth applications—domestic uses in circuitry for colour TV sets and ultra-miniature radios, and commercial uses as in ever more complex computers and pocket calculators.

Simple to use and even simpler to replace, integrated circuits are producing an electronics revolution comparable with the impact of the transistor itself.

FROM THE TRANSISTOR

To begin with, let's look at a conventional low power silicon transistor. If it's of the usual cylindrical can type, it will occupy a small volume, typically rather less than a cubic centimetre.

However, the active part of the device, the silicon chip, is very much smaller than this (perhaps one thousandth of the volume of the can). Even then, the actual transistor is considerably smaller than the chip. In other words, the vast bulk of the physical transistor is either unused or used only for the protection and support of its tiny semiconductor. Not much more volume would be needed if more transistors were included in the package. In fact, if we could find some way of electrically isolating the transistors, we could even produce many of them on the same chip.

This can be achieved but one would think that the only components permitted in such an assembly would be those normally produced from semiconductors, i.e. transistors and diodes.

However due to the unusual properties of semiconductors, particularly those of the *pn* junction, other components such as resistors and capacitors can be formed. In fact, almost all the components to be found in a normal electronic circuit can be manufactured simultaneously on the same silicon chip, even, in theory at least, an entire circuit.

We have arrived at the i.c.

TO THE I.C.

The technology of the i.c. although complete in itself, has much in common with that of the transistor. Both usually begin life, for example, as a very pure crystal of silicon which is doped to give *p* or *n* type silicon.

The actual manufacturing processes of both devices are similar too. They rely on the phenomenon of *diffusion*—the name given to the entrance and subsequent spread of one substance into another. In this case, special impurity atoms are allowed to diffuse into the silicon wherever *p* and *n* type regions are wanted. Devices of both types which are conventional (i.e. are not field-effect) are made by the same process. It is the silicon planar epitaxial process.

By S. McCLELLAND

THE integrated circuit, or i.c., as it is generally known, is possibly the ultimate concept in electronics. It certainly stretches one's imagination even to think of an entire electronic circuit on a tiny silicon chip—a chip perhaps no larger than the central dot of the marker used at the end of this article!

However, the increasing importance of i.c.s in electronics is not only because of their minute size but also because they offer us increased reliability over conventional circuits.

Often they alone can perform as specified over long periods of time in extreme and variable conditions, and provide the vital link from man or machine to civilisation. In this context, the Apollo moon-programme immediately

MAKING AN I.C.

In the silicon planar process, i.c. chips, like transistors, are mass produced in thin slices, which is why they are such inexpensive pieces of a highly complex technology.

They begin life as a circular slice of *p* type silicon upon which a very thin layer of *n* type silicon is specially grown. This layer is called the epitaxial layer and it will be the one to receive the impurity diffusions. We now have a composite slice about 25cm² in area and only about 0.3mm thick but it will yield many hundred i.c. chips. Let us follow the manufacture of a single *npn* transistor of one of these chips in the slice.

FORMING TRANSISTORS

The slice has a layer of silicon oxide formed on it initially by heat treatment. In the area selected for the base of the transistor the oxide layer is etched away, exposing the slice beneath (Fig. 1).

This etching is defined and controlled by a method rather like "photographic stencilling" using a photographic mask and light sensitive chemicals. The process is similar to making a printed circuit board or contact print in photography. The slice is now placed in an atmosphere of *p* type impurity which diffuses into the epitaxial layer via its etched areas. The un-etched oxide acts as a barrier to diffusion elsewhere.

After the formation of this *p* type (base) region, the slice is re-coated with oxide and the etching process is repeated with a smaller area of oxide. This time *n* type impurity is allowed to diffuse into central part of the base region to form the emitter region.

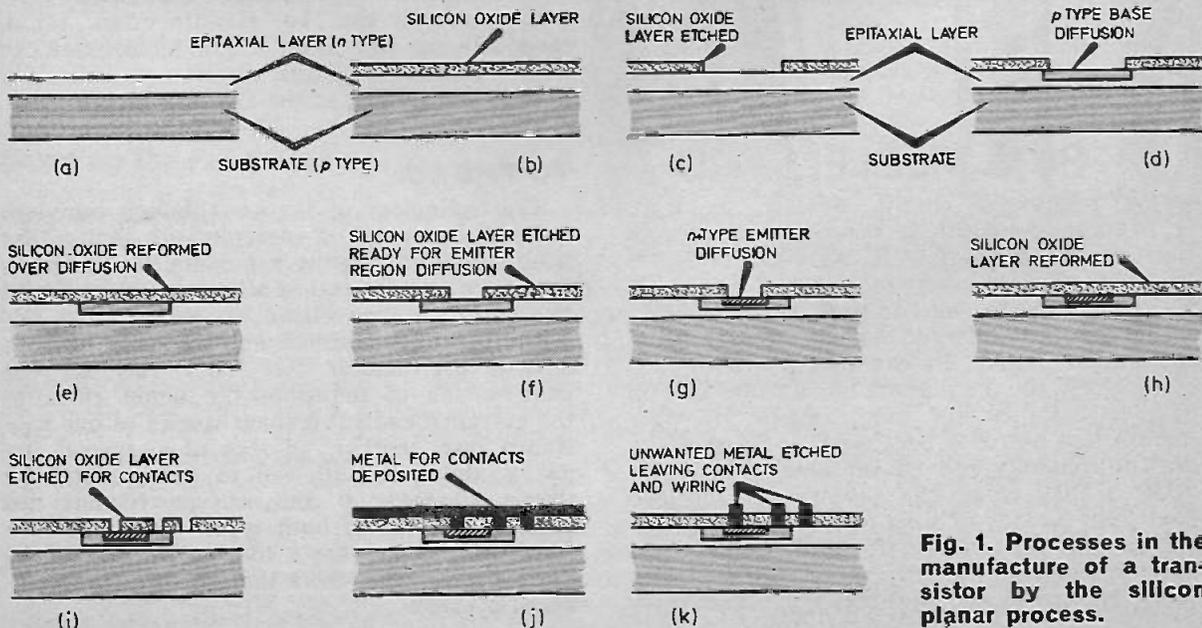
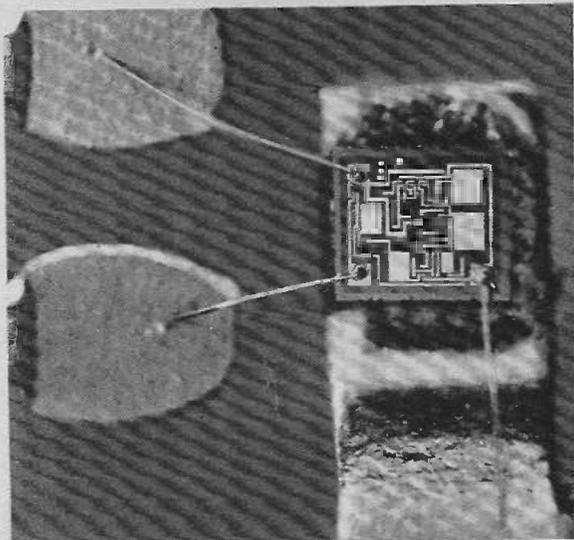


Fig. 1. Processes in the manufacture of a transistor by the silicon planar process.



The Ferranti ZN414 integrated circuit—much magnified.

The slice is once more oxidised and then etched to prepare for the deposition of aluminium which will act as the component interconnections on the surface of the slice. A final etching removes the unwanted metal. Thus it can be seen that in cross section the familiar *npn* transistor structure is built up. All the regions reach the surface of the slice, the epitaxial layer itself acting as the collector of the transistor.

N+ REGIONS

The description of the silicon planar epitaxial process as applied to i.c.s above is considerably

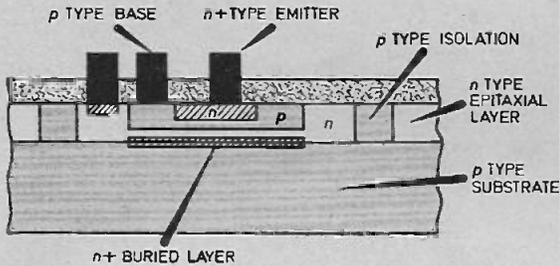


Fig. 2. Schematic drawing of an actual i.c. transistor.

simplified. In practice the first diffusion is not the base diffusion but a diffusion of n type material into the p type substrate before the epitaxial layer has been grown, forming an $n+$ region (Fig. 2).

This diffusion takes place under the collector region of the transistor and will of course be covered over by the epitaxial layer. It is therefore called the "buried layer" and its function is to combat the collector resistance problems which arise from having the collector in such a configuration.

Two other $n+$ regions will be seen. One is the actual emitter diffusion, the other a diffusion which takes place simultaneously at the position of the collector contact to reduce contact resistance.

OTHER COMPONENTS

If a diode is required in the circuit, a transistor is made as above, and then one of its pn junctions is simply short-circuited to leave a diode junction.

Capacitors, provided they are of small value, can be formed from diodes by employing the capacitive properties of the pn junction. Resistors, too, are easily formed. They are merely p type diffusions in the epitaxial layer of varying length and thickness.

ISOLATION

All the components above—transistors, diodes, capacitors and resistors will be formed in the same epitaxial layer of the same i.c. chip. They will therefore be electrically interconnected through this layer as well as by the wiring on top of the slice. Clearly, these short-circuits are unacceptable in i.c. chips but the amazing versatility of the pn junction comes to our rescue once again.

A p type "ring" is formed by diffusion around the position of each component by diffusion. The diffusion takes place early in the manufacturing process—between the buried $n+$ diffusion and the base diffusion—and penetrates the epitaxial layer so deeply that it reaches the p type layer underneath it. Thus a "shell" of p type material surrounds each component.



Holding a 120 component decade counter chip.

When this is connected to a negative potential, a reverse biased pn junction is formed between it and the epitaxial layer and the short circuits are eliminated.

ENCAPSULATION

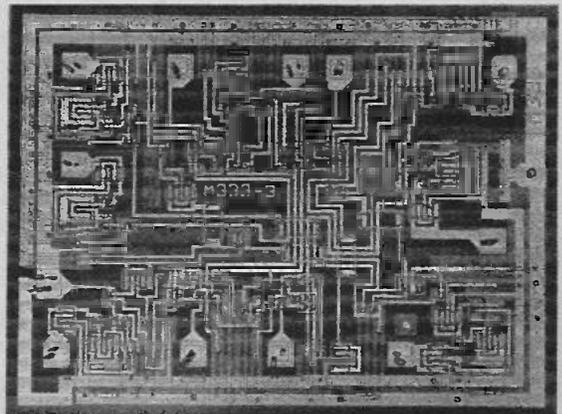
Each i.c. on the slice is tested before the slice is broken up into individual, identical chips each of which is bonded to a supporting "header" in preparation for packaging. The package will protect the tiny delicate i.c. chip and enable it to be easily connected to circuits in the outside world.

There are several types of i.c. packages available, the more usual ones being the TO-configurations (like conventional transistor housings) and the dual-in-line (d.i.l.) configurations which are rectangular blocks of plastic. The metal "flatpack" system is also available.

MOS DEVICES

Until now only bipolar i.c.s have been discussed, but there also exists a i.c. technology

An enlarged view of an i.c. chip.



parallel to, and employing, field effect transistors (f.e.t.s). These are the metal-oxide-silicon (MOS) devices. There are three contacts: source, gate and drain in f.e.t.s, roughly corresponding to the emitter, base and collector respectively in bipolar devices.

Here, however, the resemblance ends. Because of the different principles on which MOS devices operate, they can be made considerably smaller than bipolar devices of similar function. This arises partly because no isolating channels between components are needed. The fact that the device doesn't need an epitaxial layer either makes some stages of the manufacturing processes easier but the device has certain special problems associated with it, particularly concerned with the gate.

The design of the MOS makes is particularly suitable for digital applications, and it is very useful where size is at a premium. For example, the Sinclair Executive pocket calculator uses an MOS chip containing 7,000 transistors. (This calculator now costs less than £30).

CDI TECHNOLOGY

Although MOS devices are more suitable for some applications than bipolar devices, they are less suitable for other applications. Thus, until recently, no general technology has existed. However, several paths have been explored and the collector diffusion isolation (CDI) process, largely developed by Ferranti Ltd., appears to be an extremely promising one.

Already, using this technology which combines the advantages of the two previously mentioned technologies, Ferranti have introduced a t.r.f. i.c. tuner, the ZN414. This chip needs only a few external components to turn it into a radio receiver—yet the actual chip is only about 0.5mm² in area!

SPECIFICATION

In each stage of the manufacture of an i.c., precision work is required for the device to perform as specified. For example, the epitaxial layer in bipolar i.c.s must be carefully grown although it is only of the order of a hundredth of a millimetre thick, while exacting manufacturing techniques, indeed, are needed to form a silicon oxide layer about one ten thousandth of a millimetre thick for MOS device gates!

Even before the manufacture proper of an i.c., the amount of impurities in the silicon crystal to be processed must be known with little error. In an i.c., as in every other semiconductor device the semiconductor properties of the silicon depends on the extent to which it is "doped" with *p* and *n* impurities.

TEMPERATURE

The semiconductor properties also depend upon the temperature at which the device is



The Sinclair Executive pocket calculator.

operated and this is another critical factor which must enter its design.

For military purposes an i.c. has often to be designed to withstand an incredible temperature range—one of 180 degrees C is typical. This is equivalent to requiring the i.c. to operate below arctic temperatures and then, not long afterwards, at temperatures well above the boiling point of water! Commercial applications don't usually call on i.c.'s to be so rugged. They employ less tolerant devices with temperature characteristics more like conventional transistors.

LINEAR AND DIGITAL

All electronic devices—whether integrated or discrete—fall into two classes, those which are linear and those which are digital in operation. Linear devices have no particular electrical states of operation but instead function over a continuous range. Amplifiers, for example, are in this class—they must provide a faithful reproduction of a continuously changing input signal.

Digital devices, on the other hand, are designed to handle only particular levels of signal—usually only two levels in fact. Thus, at any time digital devices will be in only one of two states. Bistables are a good example of this type of device. Both linear and digital devices are found in i.c. form, but because the latter is the more important type, only it and the principles underlying it will be discussed.



An engineer works on a visual display unit which employs MOS memory chips.

BINARY OPERATION

The two states in digital electronics are usually taken to be an "on" or "high" state and an "off" or "low" state. In practice the high level will be of the order of a few volts (positive, with *npn* devices) and the low level about 0 volts.

So that we can perform calculations with digital systems we assign numerical values to the two states—the high state is "1", the low state "0". Using only these two numbers we can build up a counting system—called the **binary system** to distinguish it from our normal or denary counting methods using ten as a base.

LOGIC

If we can predict the output of a digital circuit i.e. whether the output will be "0" or "1" for a given input or combination of inputs at "0" or "1", we say the circuit is operating **logically** i.e. we are using the principles of logic to get our results. Conversely, if we want to produce a certain output from a certain input or combination of inputs we can again use logic principles to tell us what basic circuit (called a **logic element** or **function**) or arrangement of basic circuits we need to achieve this.

If you have been wondering what i.c.s have to do with this, this is where they come in. There are only a few logic elements but large numbers of them are often needed to make a digital system. They can be regarded as the building blocks of digital devices, so each element must be as cheap as possible to manufacture and use.

Integrated circuits offer us, by the mass production methods of their manufacture real economy, and also reliability and a great complexity in a very small space. Thus they are ideally suited to the requirements of large digital systems.

DTL AND TTL

In most industrial fields, there is more than one solution to a given problem. It is no less true in microelectronics where there are several different ranges of i.c.s with the same logic function. The differences have arisen from the manufacturers' attempts to improve speed or power dissipation, say of a logic element, and it is really a matter of the customer deciding for himself what particular electrical characteristics are important in his digital systems and then deciding accordingly.

Thus we have in bipolar digital i.c.s, logic elements the active components of which are diodes and transistors using diode-transistor logic (DTL) and also logic elements the active components of which are only transistors using transistor-transistor logic (TTL). Some other abbreviations for alternative systems the reader may find are RTL (resistor-transistor logic) and ECL (emitter-coupled logic). TTL is now used extensively and the others are seldom found.

USING I.C.S

Although i.c.s are internally far more complicated than transistors the constructor should find them considerably easier to work with than discrete components.

The same basic rules still apply to i.c.s as to discretes, and they include:

- (1) Using soldering irons specifically adapted to such miniature work and soldering as quickly as possible. In fact, soldering problems can be largely eliminated if you use an i.c. holder.
- (2) Checking that i.c. leads are correctly connected up and that no shorts are present at i.c. package connections.
- (3) Checking power supplies especially in digital systems.

THE FUTURE—L.S.I. AND T.S.I.

In the future more and more electronic circuits will become integrated. In the predictable future there seems to be an era of **total system integration** (t.s.i.) where entire, almost ready to use, circuit systems are manufactured on a single chip.

We have seen the beginnings of this already with large scale integration (l.s.i.) techniques where much of the system is already integrated and needs relatively few discrete interface components to make it work. So, for as long as consumer demand continues, we can look forward to further exciting and spectacular developments in the world of the integrated circuit. □

ACKNOWLEDGEMENTS

The author wishes to thank the following firms for their help: Ferranti Ltd., Mullard Ltd., Sinclair Radionics Ltd., Texas Instruments Ltd.

BEGIN HERE

PART ONE BASIC COMPONENTS

By DONALD MAYNARD



FOR a newcomer to electronics, the prospect of building anything from a circuit diagram can be daunting. In this short series of articles it is intended to help newcomers by giving them practical information about components and also about methods of construction.

In this first part we take a look at resistors, capacitors, inductors, transformers and potentiometers. The second part is concerned with semi-conductors and we will go on to see how to test the various components and how to assemble them together to make up a circuit.

RESISTORS

A resistor is a component which dissipates power, usually in the form of heat. Its use is summed up in the relationship called Ohm's law:

$$V = I \times R$$

where V is the voltage across the resistor in volts, I is the current through the resistor in amps and R is the value of the resistor in ohms. The symbols for a resistor are shown in Fig. 1.1. Either we can use the resistor to change the voltage at a point in the circuit, or we can use it to alter the current at a given point.

The resistor's value can be determined from the coloured bands around it. There are three bands which give us this information (Fig. 1.2). The bands are coloured and each band corresponds to a number as shown in Table 1.1.

If the bands are brown, red and orange for example, then the value is $12 \times 1,000$ or 12,000 ohms; 1,000 ohms is usually called a kilohm or $k\Omega$ while 1,000,000 is called a megohm or $M\Omega$. The last band indicates the tolerance, or variation, in the actual resistor value. Gold indicates a plus or minus 5 per cent ($\pm 5\%$) tolerance while silver shows that it is plus or minus 10 per cent ($\pm 10\%$). If no band is present the tolerance is ± 20 per cent. Some older types of

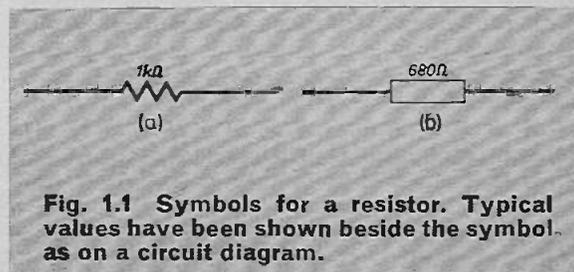


Fig. 1.1 Symbols for a resistor. Typical values have been shown beside the symbol as on a circuit diagram.

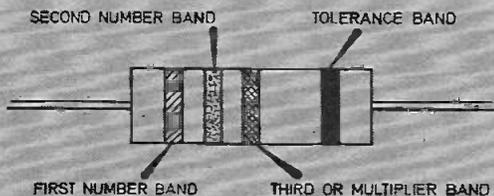


Fig. 1.2 The resistor and significance of the coloured bands

TABLE 1.1 Resistance Colour Code

Colour	Number	Multiplier
Black	0	× 1
Brown	1	× 10
Red	2	× 100
Orange	3	× 1,000 (kΩ)
Yellow	4	× 10,000
Green	5	× 100,000
Blue	6	× 1,000,000 (MΩ)
Violet	7	× 10,000,000
Grey	8	× 100,000,000
White	9	× 1,000,000,000

Tolerance—no band ±20%, silver band ± 10%, gold band ± 5%, red band ±2%, brown band ±1%. Gold and silver are sometimes used as multipliers, they represent ×0.1 and ×0.01 respectively.

resistor have the colours in the form of a general body colour (1st. number), one end another colour (2nd. number) and a spot or band in the middle (multiplier).

In general, the larger the resistor, the more power it can handle. The rating in watts can vary from $\frac{1}{8}$ W up to several watts. This power is simply the voltage (V) multiplied by the current (I) through it. Using Ohm's law we can say that the power (P) dissipated by a resistor is $P = V \times I = I^2 R = \frac{V^2}{R}$ where R is the resistor's value.

There is no electrical disadvantage in using a resistor that is physically larger than required, only the disadvantage of increased mechanical size and possibly cost.

CAPACITORS

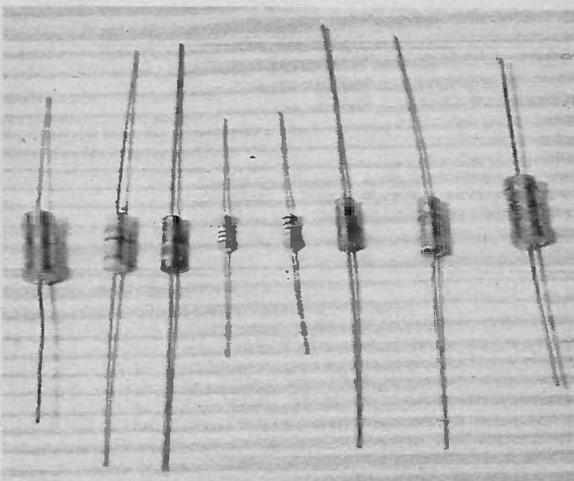
The old name for a capacitor was condenser, but the new name is more in keeping with its function. It has the capacity for storing energy. The simplest way of thinking about a capacitor is that it will pass an alternating current (a.c.) through it but not a direct current (d.c.).

The other important point is that if a d.c. voltage, say from a battery, is applied across a capacitor, ideally that voltage will remain there until either a component such as a resistor connected across it, or you happen to touch both ends simultaneously, when the capacitor will

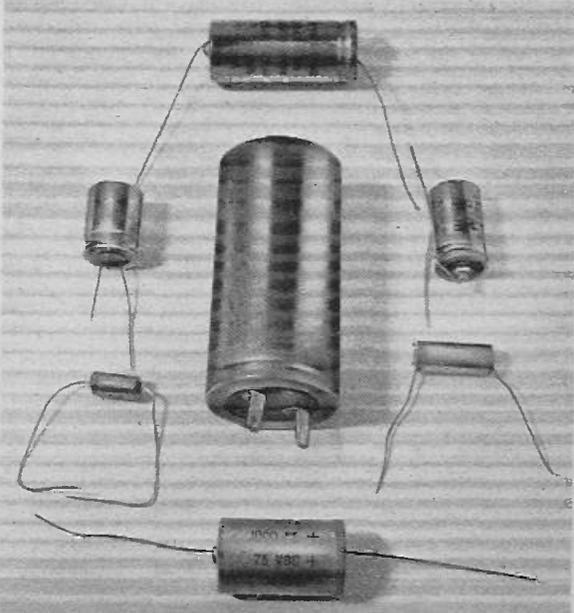


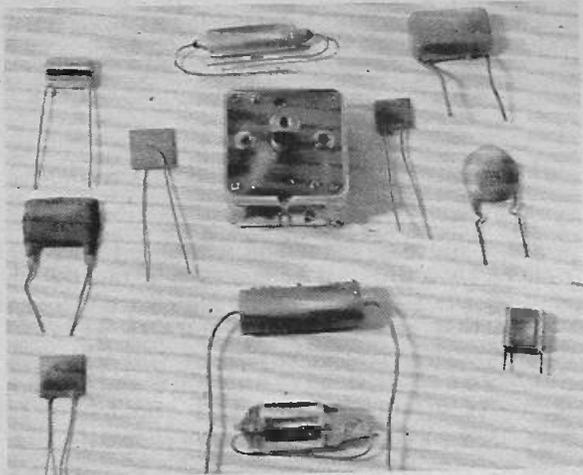
Fig. 1.3 Symbols for capacitors (a) fixed (b) variable (c) electrolytic

lose its voltage by passing a current through you! In case this makes you decide to give up without going any further, I had better hasten to add that at most of the voltages we meet these days—9, 12, 18, or similar—no sensation will be felt at all. Beware, though, if the voltage should be a hundred or more it could be very dangerous. Various symbols are shown in Fig. 1.3.



A selection of resistors (above) and some electrolytic capacitors (below).





A selection of capacitors—a variable type is shown in the centre.

CONSTRUCTION

Basically, a capacitor consists of two plates separated by an insulating material called the dielectric. The dielectric may be air, paper, ceramic, polystyrene or any other suitable material. For larger values of capacitance an electrolyte is used for the dielectric and this has the property of greatly increasing the energy storage capability of the capacitor. A steady potential is usually necessary for these, and so on circuit diagrams the positive side of the capacitor is shown as an open block (Fig. 1.3.c).

Variable capacitors (Fig. 1.3.b) have rotating vanes separated by an air gap. The amount of overlap of the vanes, and therefore the capacitance, is then variable.

Capacitance is measured in Farads, although a one Farad capacitor would be very large indeed. Practically, capacitors are marked either in microfarads (μF) or in picofarads (pF). There are a million picofarads in one microfarad, and a million microfarads in one Farad. Occasionally one meets nanofarads (nF) and one nanofarad is a thousand picofarads.

Some small capacitors are colour coded in a similar fashion to resistors (Fig. 1.4). The values can be worked out in pF from Table 1.1. The bottom two bands indicate the tolerance and working voltage.

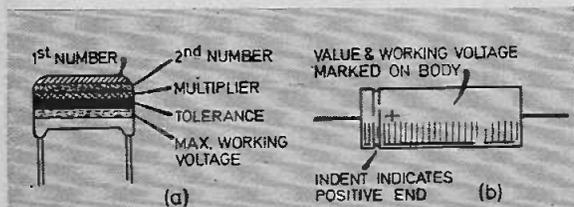


Fig. 1.4 (a) Colour coding of a "banded" capacitor (b) an electrolytic capacitor.

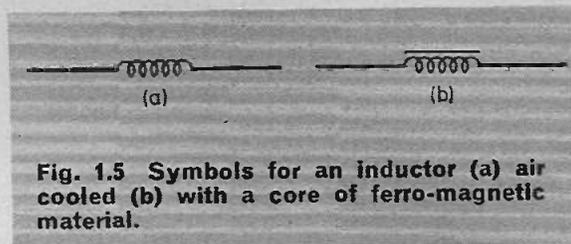


Fig. 1.5 Symbols for an inductor (a) air cooled (b) with a core of ferro-magnetic material.

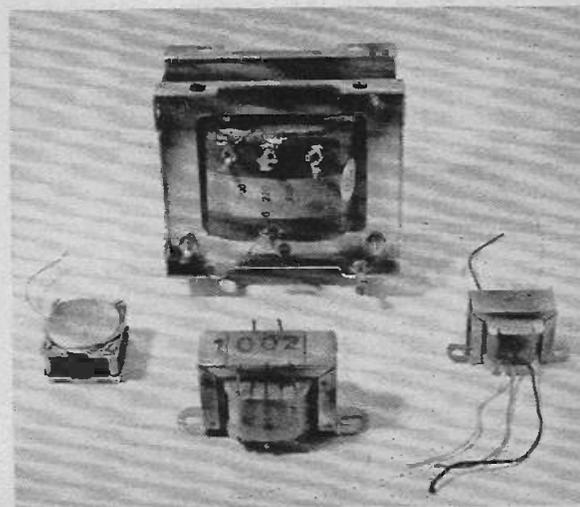
It is important that the working voltage of the capacitor is not exceeded and that, in the case of the electrolytic capacitor, the polarity is correct. (Note the indented positive end shown in Fig. 1.4.b).

INDUCTORS

Inductors may be considered to be the inverse of capacitors in that they tend to pass a direct current but not an alternating one. They are coils of wire usually wound around a former. To obtain higher values of inductance, some form of ferrous material may be used in the core and round the outside of the coil.

An important feature of the inductor is that if a voltage source is removed from across it, a "back e.m.f." is set up in the coil which will try and maintain the original current. Symbols for the inductor are shown in Fig. 1.5. The unit of inductance is the Henry, although we usually use millihenrys or microhenrys (mH and μH respectively). There are a thousand microhenrys to one millihenry and a thousand millihenrys in one Henry.

Inductors are perhaps the most difficult component to identify once they have left the manufacturer's box. Often they are wound by the constructor himself on either home-made or commercial formers. When they are used to stop



A selection of transformers—a pot core type inductor is shown on the left.

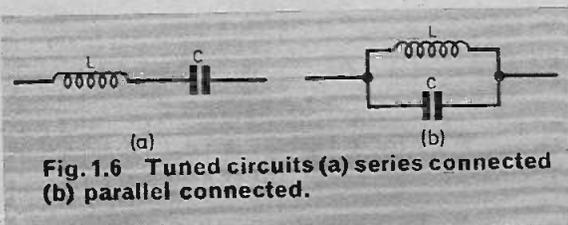


Fig. 1.6 Tuned circuits (a) series connected (b) parallel connected.

a.c. signals from appearing in other parts of the circuit they are usually called radio frequency chokes (r.f.c.). Inductors may also be used with capacitors to form tuned circuits.

TUNED CIRCUITS

A tuned circuit (Fig. 1.6), consisting of an inductor L and a capacitor C , will, ideally, either pass one frequency and stop all others, or else will stop one frequency and pass the others. A measure of the selectivity of a circuit is its Q (for quality) factor.

At the resonant frequency (f_0 , measured in hertz or cycles per second) the series circuit (Fig. 1.6.a) has a low loss but the parallel circuit (Fig. 1.6.b) has a high loss. When we talk about loss in this context we mean the ratio of voltage across, to current in, the circuit. This is also termed its impedance (Z). The impedance of specific components sometimes has another name, e.g. resistance (R) for resistors and reactance (X) for inductors and capacitors.

TRANSFORMERS

Transformers are used to modify alternating voltages or currents, and also to isolate one part of a circuit from another. Two transformers are shown in Fig. 1.7. We can denote everything on the primary, or input, side by the suffix "1", the secondary, or output side, having the suffix "2"; T_1 and T_2 are the number of turns on the primary and secondary respectively. Then:

$$\frac{V_2}{V_1} = \frac{T_2}{T_1} \quad \frac{I_2}{I_1} = \frac{T_1}{T_2}$$

and

$$\frac{Z_2}{Z_1} = \frac{V_2 \times I_2}{V_1 \times I_1} = \left(\frac{T_2}{T_1}\right)^2$$

In a transformer for converting mains voltage (240 volts) to a low voltage, say 6 volts, the



A selection of preset and standard potentiometers.

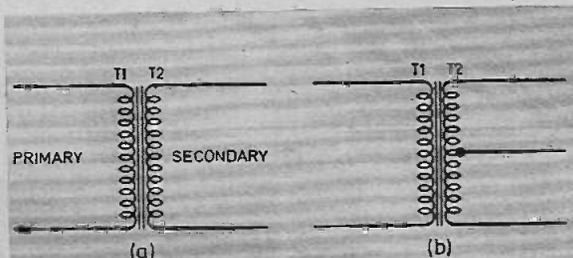


Fig. 1.7 Symbols for transformers—both are with laminated cores (a) with two winding (b) with a tapped secondary winding.

primary winding will have many turns of relatively fine wire while the secondary will have far fewer turns but of thicker wire to take a heavier current.

If the transformer is tapped (Fig. 1.7.b), a voltage will appear across each winding proportional to the number of turns in each section. The overall voltage across the secondary will still be in accordance with the relationship shown above. For any transformer its size will depend on the secondary current required. The larger the current the larger the transformer.

Some transformers (those used in the intermediate frequency [i.f.] sections of radios for example) are purchased with capacitors connected across the windings. This has the effect of tuning the transformer in much the same way as when we connected the inductor and capacitor together. This causes the transformer to be selective in the band of frequencies that can pass from input to output.

POTENTIOMETERS

The potentiometers that we meet are used as variable resistors or as potential dividers. Shown schematically in Fig. 1.8, they are made either of a high resistance wire wound round a former, or else they utilise a track made from a carbon compound. The slider (B or E) moves along the carbon track or coiled wire changing the relative resistance between A to B and B to C (or D to E and E to F). If B is connected to A , then we have a variable resistor from effectively zero up to the maximum value of resistance i.e. A to C .

Values are again in ohms but in addition we may have a linear, logarithmic or antilogarithmic variation in resistance as the spindle is turned. If unspecified, a linear type would normally be used. Logarithmic types are used for volume controls as the human ear responds to change in volume in a logarithmic, rather than linear way.

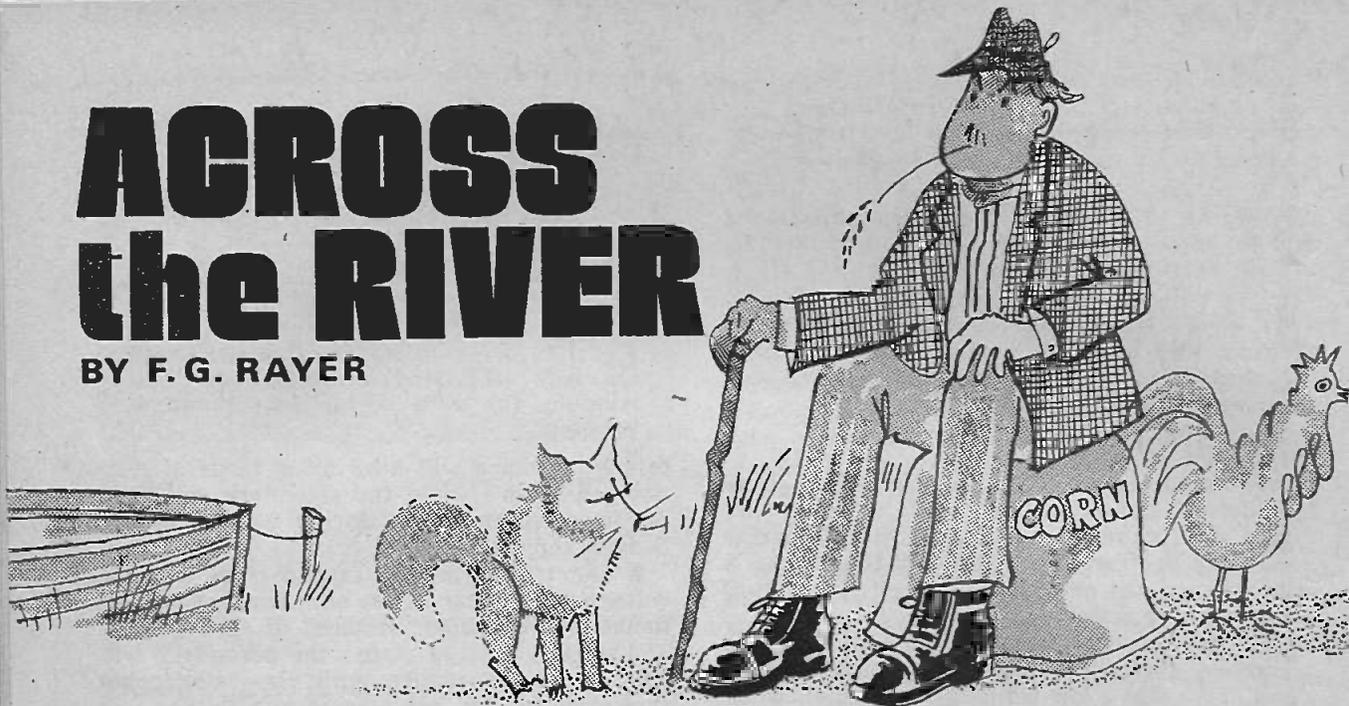


Fig. 1.8 Symbols for a potentiometer.

Next month: semiconductor devices.

ACROSS the RIVER

BY F. G. RAYER



An interesting electronic puzzle for all the family.

This solo game is played electronically, and is derived from an old puzzle. Once the solution is seen, it is extremely easy, but until this moment it can be very puzzling. The whole unit is self contained, and can be handed to any one who wishes to try their skill.

A story leads up to the presentation of the puzzle, and the attempt at a solution is then made by moving switches, which are wired to produce a warning sound when an error is made.

STORY

Once upon a time a farmer was carrying a fox, a hen, and a sack of corn. When he reached the east bank of a shallow river he found that he could only carry any one item at a time in the small boat. His problem is to get the items to the west bank of the river safely.

If he carries the corn over first, thus leaving the hen with the fox on the east bank, the fox will attack the hen. If he carries the fox over first time, leaving the hen with the corn, the hen will eat the corn. On the other hand, if he carries the hen over to the west bank first, leaving the fox and corn together on the east bank, this is so far in order, and he can leave the hen safely on the west bank, and return to fetch the fox or corn. But now, if he carries the fox over, and leaves it with the hen on the west bank, the fox will attack the hen while he returns for the corn. Should he take the corn over at this stage, the hen on the west bank will eat it while he returns for the fox.

So what does the farmer do to transport his items, one at a time, with safety?

The problem may appear impossible, but a solution does in fact exist. It will be observed from the story that hen and corn, or fox and hen, may safely be on one bank together when the farmer is present, as he would of course prevent the danger to hen or corn, which may arise when he is not present.

CIRCUIT

The complete circuit diagram is shown in Fig. 1; TR1, TR2 and the associated components form an oscillator, and values were chosen in an attempt to produce a sound which might be looked upon as that made by a startled hen.

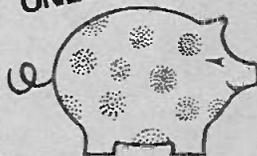
However, almost any two audio *pnp* transistors are likely to work satisfactorily in a multi-vibrator of this type, and none of the component values are critical. They may, in fact, be modified to change the sound produced, as may the battery voltage.

The switch network completes the circuit only when a mistaken move is made (e.g., fox left alone with hen) and this sounds the warning speaker.

In Fig. 1, all the switches are at the east bank

FOR
GUIDANCE
ONLY

ESTIMATED COST*
OF COMPONENTS
including V.A.T.



£2.20

excluding case

*Based on prices prevailing at
time of going to press

position. The problem is thus to move them all to the other position without completing the circuit. A maximum of two switches are allowed to be moved at one time, one being the farmer.

As example, if the farmer should take the fox across, the battery negative circuit is completed via A of S2, B of S3, C of S4 and D of S1, sounding the warning. (That is, hen is eating corn which is an unsatisfactory attempt).

SWITCHES AND LOUDSPEAKER

In the prototype the four switches were mounted on the removable lid of a plastic case of dimensions 160×90×50mm. A metal case is also suitable provided precautions are taken to ensure there is no shorting of the battery or other components against the case walls.

Four standard-size slide switches were chosen as these are inexpensive, robust, and more easily operated than miniature types.

Begin construction by making the slots and fixing holes in the front panel (lid) to accommodate the slide switches and then drill a matrix of holes to suit the loudspeaker. Glue (or screw) the latter in position and then secure the four switches. Now wire up in accordance with Fig. 2.

OSCILLATOR BOARD

The oscillator components were wired on a short length of standard tagboard, as shown in Fig. 2, a screw afterwards fixing this to the base of the case. The transistors should be soldered in last of all and a heatshunt used on their leads to prevent thermal damage.

As mentioned previously, C1 and C2 need not be the same values, nor need the two transistors be the same type number. Reducing the values of R2 and R3 will raise the pitch, and increasing the values of C1 and C2 will lower it.

Solder two flying leads to the tag board and connect these to the loudspeaker and solder the

Components....

Resistors

R1 5.6k Ω
 R2 100k Ω
 R3 1M Ω
 All $\frac{1}{4}$ W carbon $\pm 10\%$

SEE
**SHOP
 TALK**

Capacitors

C1 0.047 μ F
 C2 0.047 μ F

Transistors

TR1 AC128 germanium *npn* or similar
 TR2 AC128 germanium *npn* or similar

Miscellaneous

S1, 2, 3, 4 d.p.d.t. standard slide switch 4 off)
 LS1 80 ohm loudspeaker (65mm dia.)
 B1 9 volt PP4
 Battery clips for PP4; plastic or metal case, 160 x 90 x 50mm; standard tagboard 3-way.

lead between board and S1. Finally solder the two battery leads in position and secure the board to the base of the case, and connect the battery. The battery can be held in position by means of a Terry-clip or a home-made aluminium bracket.

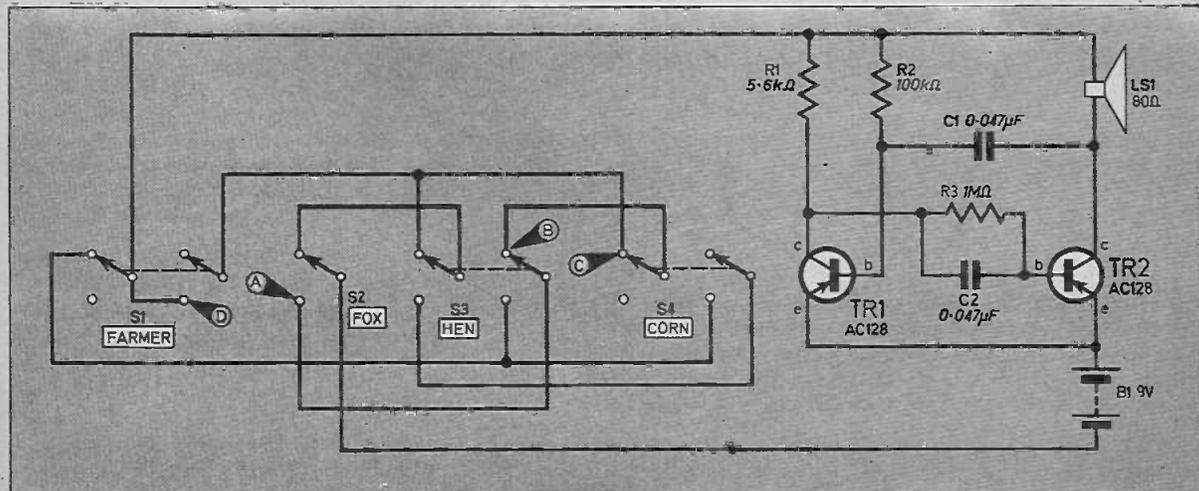
LABELS AND USE

Labels should be marked CORN, HEN, FOX and FARMER and placed near the appropriate switches.

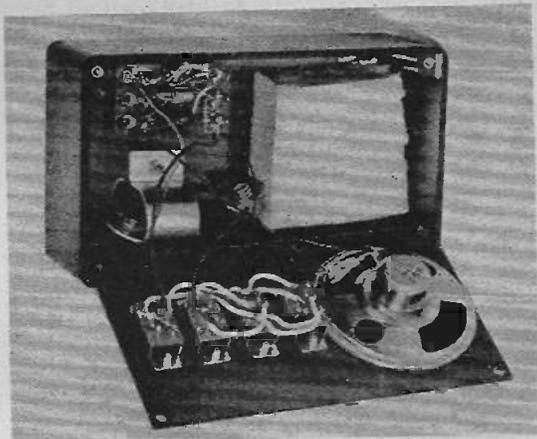
Some embellishment would be possible for children, such as a panel drawn and painted with a river, with pictures for the corn, hen, etc., as in our heading design.

Though the "old story" was preferred, it would

Fig. 1. The complete circuit diagram for the Across the River puzzle.



ACROSS the RIVER



Photograph of the completed prototype.

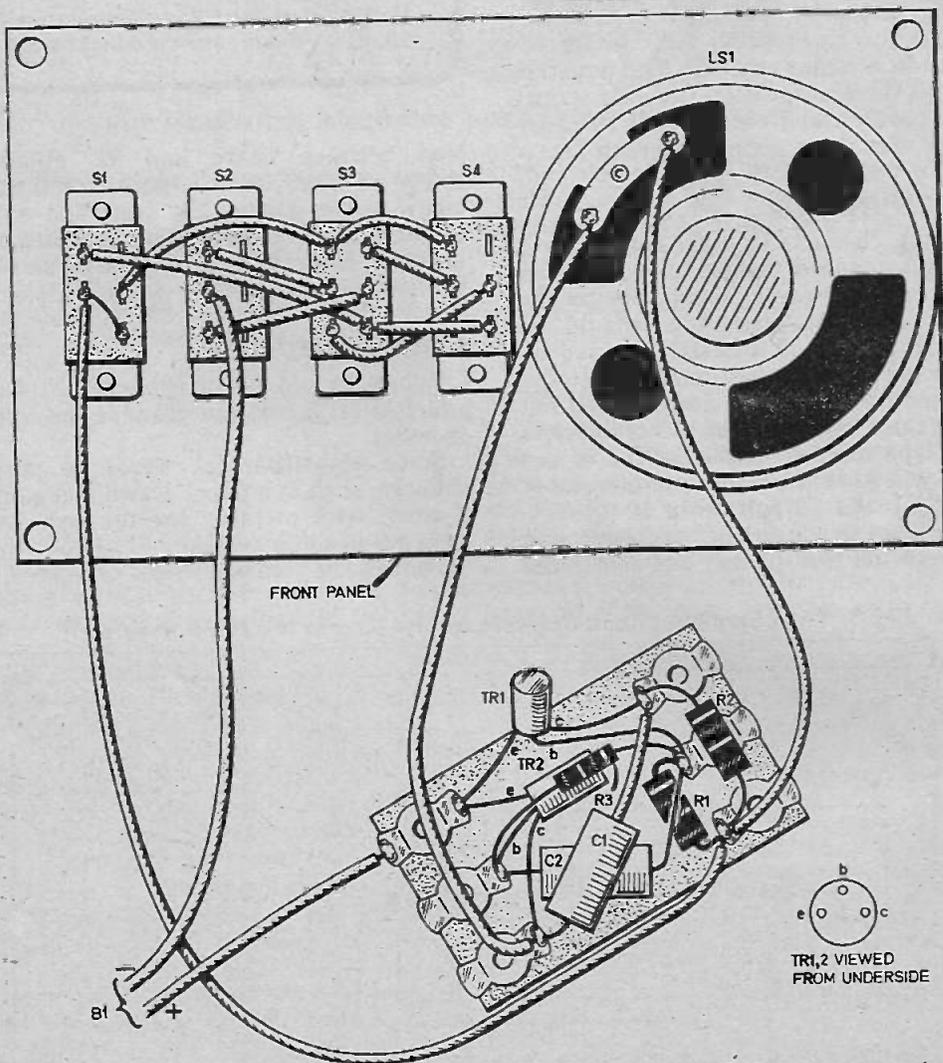
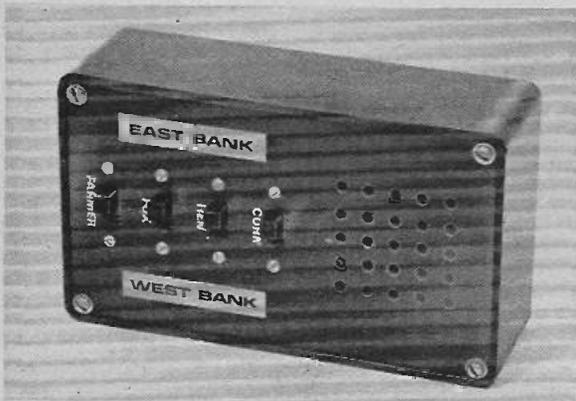


Fig. 2. The layout of the components on the tag board and complete wiring up details.



be possible to modify or up-date this. For example, the Corn, Hen, Fox and Farmer may become a Bomb, Violent Anarchist, Pacifist and Policeman respectively.

If the Violent Anarchist is left alone with the Bomb, he will explode it, while if Pacifist and

Violent Anarchist are left alone, the Violent Anarchist will attack the Pacifist. Though it is, of course, in order to leave the Bomb with the Pacifist, unattended by the Policeman.

Check that wiring is correct by following the moves already given. No warning is produced with all switches at the East Bank or all at the West Bank, or with Fox and Corn unattended either side, or with any combination where the Farmer is present.

SOLUTION

As with many things, this is easy when the secret is known. All start at the East Bank.

- (1) Farmer carries Hen over, leaving Fox and Corn at East Bank.
- (2) Farmer returns to East Bank.
- (3) Farmer carries Fox to West Bank.
- (4) Farmer returns to East Bank taking Hen with him.
- (5) Farmer carries Corn to West Bank.
- (6) Farmer returns to East Bank.
- (7) Farmer carries Hen to West Bank. □



...Counter Intelligence

BY PAUL YOUNG

A retailer discusses component supply matters.

AT THE end of September (when the birds migrate south in search of millionaire husbands) the British winter will soon be on us, between then and Christmas many thousands will join the ranks of the electronic hobbyist. This is hardly surprising when you weigh up the advantages.

All you need is the corner of a kitchen table, a few simple tools, some bits and pieces and an indulgent wife or mother. Then for a few hours a day you are a would be Faraday, Fleming, or Davey. Even if initially, your knowledge is nil, there are such excellent magazines as EVERYDAY ELECTRONICS to guide you along the right lines.

We retailers naturally have a vested interest in keeping it that way. We know that inevitably we must lose a few novices by the sheer frustration of being unable to obtain the right parts easily and quickly.

BEGINNERS

It is with the beginners and

particularly the last few in mind, that I direct this article. With any hobby, a certain amount of patience is required and electronics is no exception, so let me assume that you're raring to go and just need a few vital components to get started. How do you set about it. A few of you may be fortunate enough to have some good shops locally but the majority will have to rely on mail order firms which brings me to my first point, which is this. No one firm will be able to supply 100 per cent of your wants and it is as well to accept that from the very beginning.

So your first task is to read through the more popular electronic magazines and purchase as many varied component catalogues as you can afford. I assure you this is a good investment and even if your outlay is a pound or two, spread over a year or so its fairly small, and many firms return their catalogue price when you make purchases. If you find all your wants in any one of them, try that firm out first, but be resigned to dealing with three or four.

Now to deal with the actual ordering. If the firm concerned enclose an order form—use it. It is quicker for them to deal with their own order forms than scraps of paper. If not, I suggest you buy a duplicate order book not smaller than 200 x 120mm from W. H. Smiths or Rymans. These have about 100 duplicate pages and carbon paper. Put your address at the top in block letters and then put down your requirements, with the quantity you require first.

If the firm has catalogue numbers use them, if not make sure your descriptions are adequate, i.e., if you order a pot, say if its log. or lin. do not forget to write down colours if applicable. Now carefully check prices and totals and if you pay by cheque do make sure (a) you sign it, (b) the date is correct, (c) that the words and figures agree.

DELAY

Don't be worried if a week or ten days goes by before the arrival of your goods, that excellent organisation the Post Office is very undermanned at present. One way of avoiding frustration is to plan ahead i.e., while you are constructing one project select your next project and order the bits for that.

Physics is FUN!

By Derrick DAINES



OPPOSITE CHARGES

I am told that I have left one or two things unexplained.

- (1) Why do the tufts of the electroscope not fly apart until the charged plastic sheet is lifted off the table?
- (2) Why does the hair of the head lift when a charged sheet is brought near it, but not actually touching?
- (3) Why do all these static experiments work best in a dry atmosphere?

The first two questions are really the same question couched in different terms. But let's do experiments to see it.

Charge a plastic sheet by rubbing it with wool; prove it with the electroscope. Now lay the sheet down again—the tufts of the electroscope collapse. Remove the electroscope and pass the hand over the sheet, stroking it gently. Replace the electroscope and lift the sheet. The electroscope remains collapsed.

Stroking with the hand
conducts away the charge

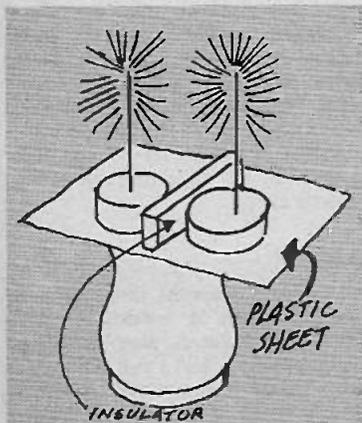


Fig. 1. On removing a charged plastic sheet the tufts remain extended.

Make a second tufted electroscope (it won't take long). Now put the discharged plastic sheet on a tall insulator, such as a vase or china mug, and on it put the two tufted electroscopes, just touching.

Charge another sheet of plastic film and bring it up close to one of the tufts. Both tufts will fly out, just what we would expect! Take the charged sheet away—both tufts collapse. Fine—nothing odd about that. Now try this.

Bring the charged sheet near to one of the tufts again—both fly apart. Now holding the sheet steady, slide between the metal boxes of the electroscopes an insulator, such as a piece of glass or plywood about 50mm wide. Leave it there and remove the charged sheet. The tufts stay up, Fig. 1.

What on earth has happened? Let us assume for the sake of argument that the charged sheet had a negative charge on it. The tufts nearest to it become positively charged.

As long as the two metal boxes were touching, the second tuft also had a positive charge, but when we insert the insulator the second tuft assumed a negative charge. Removing the charged sheet thus left the two tufts of opposite polarity attracting each other and hence unable to collapse.

You can prove that they are opposite polarity by bringing the charged sheet close to each tuft in turn and observing their different behaviour; one repelled by the sheet, one attracted by it, Fig. 2.

We can say then that when a charge is brought close to an insulator a charge of opposite polarity is induced on its surface. This is of vital consequence to electronics, since capacitors depend entirely upon this effect.

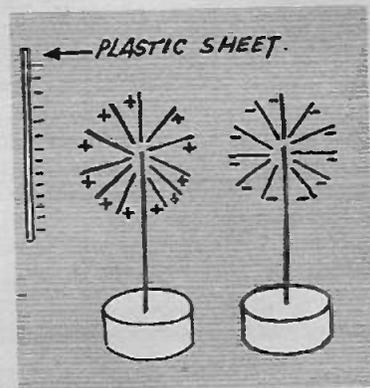


Fig. 2. Bringing a charged plastic sheet up to the two electroscopes shows that the tufts are oppositely charged.

When the charged sheet is lying on the table, an equal and opposite charge is therefore present on the surface of the table! We will return to this point another time, Fig. 3.

As for the third question, dry atmosphere, you can see that if the table and sheet have equal and opposite charges, there is a tendency for the negative electrons to migrate across the gap, thus cancelling out. This tendency is increased in a damp atmosphere. This, too, we will return to another time.

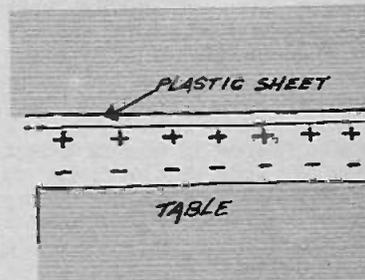
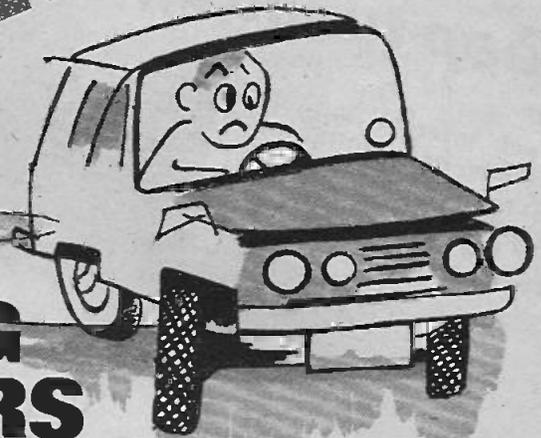


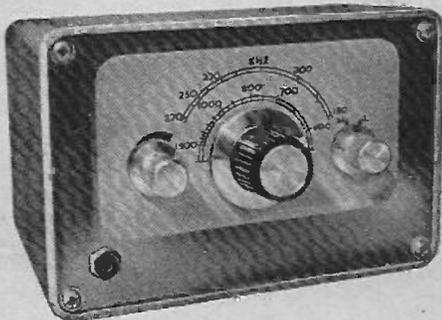
Fig. 3. A charged plastic sheet lying on a table top causes the table to acquire an equal and opposite charge.

NEXT MONTH...



ICE WARNING FOR CARS

Don't get caught out by ice this winter! Build this simple device to give you an audible and/or visual warning when the temperature outside the car falls to freezing point.



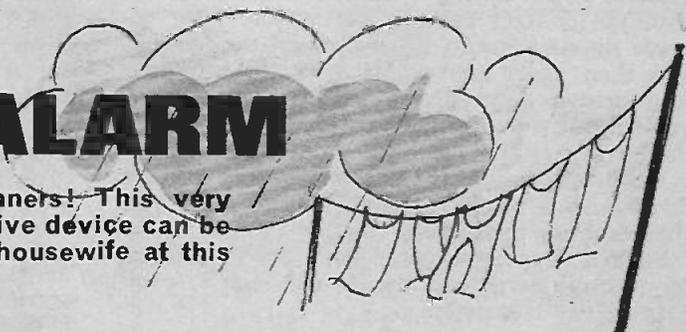
2 Band SUPERHET TUNER...

A m.w. and l.w. tuner that can be used with almost any amplifier. Employing ready-made i.f. transformers this tuner is easy to build but provides good sensitivity and selectivity.



RAIN ALARM

Just right for beginners! This very simple and inexpensive device can be a great help to the housewife at this time of the year.

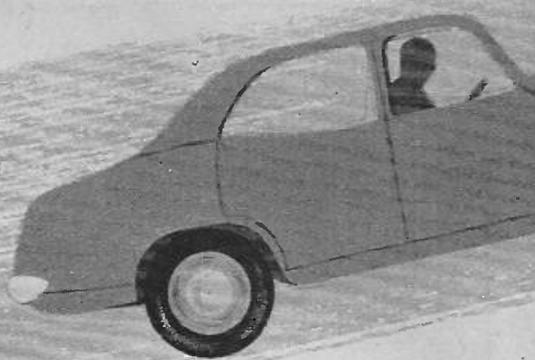


everyday electronics

JANUARY
ISSUE ON
SALE 18
DECEMBER

keep tuned up with...

Great interest in this system has warranted this revised article which embodies details for BOTH 6V and 12V systems.



TRANSISTOR ASSISTED IGNITION

6V VERSION

Eliminates electrical wear of contact breaker points

THE Transistor Assisted Ignition system described in the April issue of EVERYDAY ELECTRONICS can be adapted for use with 6 volt systems without any great difficulty. However, it is first necessary to check the current taken by the coil to ensure that it is not excessive. The current is checked by inserting a current meter capable of measuring 5 amp or more in series with the contact breaker connection. Next remove the distributor cap, switch on the ignition and then short the points with an insulated screwdriver. Any current reading less than 4 amps is satisfactory and you may proceed with the project.

Beware, also, that the unit is designed for cars fitted with a negative earth system only, you should verify this before starting the project.

Such a simple design is not easy to achieve for positive earth cars due to the lack of comparable pnp transistors.

PRINCIPLE

Each revolution of a four cylinder engine requires the points to produce two sparks to fire the engine. The points start to deteriorate after a few hundred miles as a result of producing all these sparks and by the time the car is serviced, at say 6,000 miles, the points may be in a very poor condition. This deterioration affects the timing, reduces the power available at the plugs and can give a noticeable drop in performance.

The simple ignition system described main-

tains performance between services; in fact the points will experience no electrical wear at all. However, the points should be replaced after 24,000 miles to reduce the risk of failure through spring fatigue.

Fitting the unit to a vehicle which already has worn points can produce an immediate improvement. However, this unit should not be confused with the more complicated "capacity discharge-ignition systems" which are designed to improve performance.

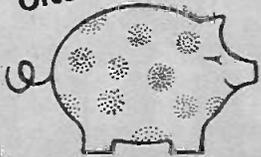
Warning. Although simple, this project should not be attempted as a first project. A high standard of soldering is necessary for the unit to work under the adverse conditions found in a car engine compartment.

THE CIRCUIT

A switch is incorporated into the unit so the normal car circuit can be easily restored in the event of failure, or suspected failure. This feature, together with the circuit design requires

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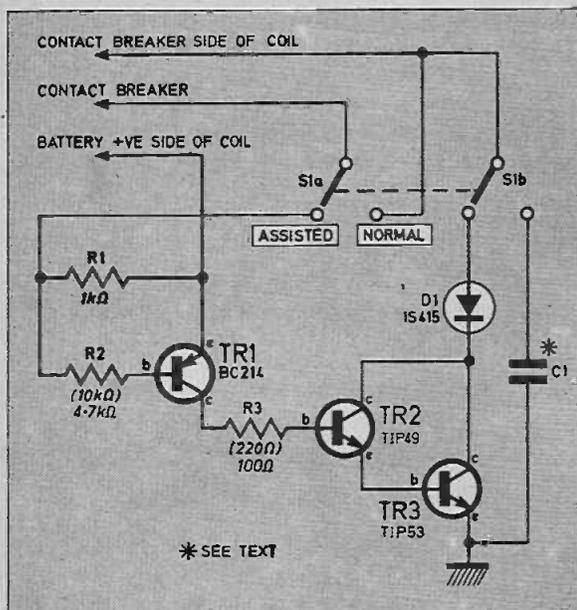


Fig. 1. The complete circuit diagram of the Transistor Assisted Ignition. Values in brackets are for the 12V version.

that the capacitor (sometimes referred to as a condenser) be removed from the distributor and fitted into the unit (see "testing" and "installation" later).

The complete circuit diagram is shown in Fig. 1. The points are connected via switch S1a (in the position shown) and resistor R2 to transistor TR1. When the points are open, TR1 is cut off by R1, fed from the positive battery connection. Each time the points close the base of TR1 is connected to earth through R2 switching it into its conduction state. The current passing through the points is about 7mA (13mA for 12V system), instead of the 3 amp or so normally required.

The current flowing through the collector of TR1 and R3 in turn switches on TR2, which in turn switches on TR3 thereby connecting the coil to earth every time the points close. Thus TR3 takes the place of the points and passes the 3 amps or so required by the coil. Diode D1 is necessary to protect TR2 and TR3 from high voltage spikes generated when the points open.

If S1 is switched to the "normal" position the points are connected directly to the coil. In this position the capacitor is connected across the points in the conventional manner, except that the capacitor is housed in the diecast case instead of the distributor.

CONSTRUCTION

The prototype unit was housed in a diecast aluminium case measuring 115x90x50mm. All the components are mounted on the lid of the case as shown in Fig. 2. The exact positioning of the components is not critical and can be estimated from the full-size photograph of Fig.

2. Begin construction by drilling all the components' fixing holes in the lid.

The wire attached to the capacitor is taken to an insulated terminal and screwed into position. Make the insulated terminal by bolting a 4BA nylon screw and nut through the lid and then screwing a 25mm 4BA tapped metal spacer onto the nylon screw thread projecting above the nylon nut.

The diode and power transistors must be mounted very carefully on their mica washers; insulating bushes must be used for fixing TR2 and TR3; check after fitting that they are properly insulated from metal lid. If in doubt use two mica washers on the transistors, or mica washers from larger power transistors.

All wiring must be mechanically fixed to each solder point and soldered to a high standard. Under the adverse operating conditions which this unit has to work poor soldering will very quickly give rise to failure.

The capacitor C1 must be removed from the distributor and mounted without modification to its leads, the capacitor can then easily be returned to the distributor if required. All distributor capacitors are bolted to earth with a metal clip. The lid must be drilled to suit the particular capacitor fitted to the car.

TESTING

No car owner will willingly fit an untested unit to his car, nor allow the capacitor to be removed from the distributor. Fortunately the unit can easily be tested without removing the capacitor.

First remove the centre lead from the distributor and fix it with adhesive tape so that the

Components

Resistors

- R1 1k Ω
- R2 4.7k Ω (10k Ω , 12V)
- R3 100 Ω (220 Ω , 12V)
- All $\frac{1}{4}$ watt $\pm 5\%$ metal oxide

Semiconductors

- TR1 BC214 silicon *npn*
- TR2 TIP49, TIP50, or TIP53 silicon *npn*
- TR3 TIP53 silicon *npn*
- D1 1S415 or similar 4 amp 450V stud cathode type

Miscellaneous

- S1 double-pole double-throw 250V 3A with insulated toggle. Diecast aluminium box, 115 x 90 x 50mm; 5 way tag strip; mica washers and bushes to suit TR2 and TR3; insulating washer/bush to suit D1; 25mm long 4BA tapped metal spacer; 4BA nylon nut and bolt; 6BA nuts, bolts and washers (6 off each); 6BA 6mm long spacers (2 off); rubber grommet; solder tags, 2BA (2 off) 4BA (1 off).

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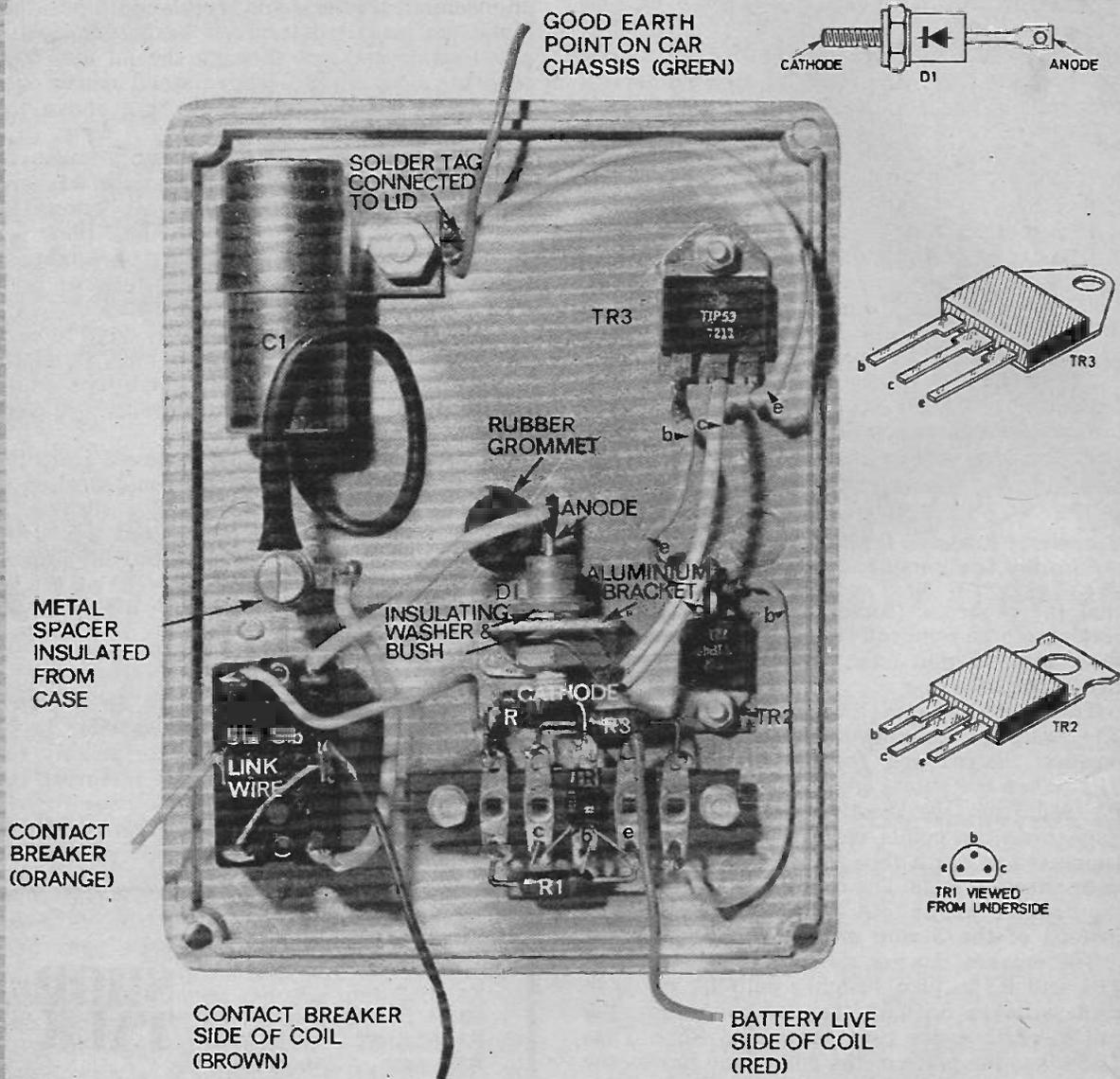


Fig. 2 (above). Position and wiring up details of the components on the lid of the diecast box. Wires leave the case through the grommet.

TRANSISTOR ASSISTED IGNITION



Photograph of the completed unit.

metal end is about 6mm from some earthed point on the car. This will enable you to see when a spark is generated.

Secondly disconnect from the ignition coil, the wire leading to the contact breaker. This connection may be labelled CB on some coils. Twist the brown lead from the ignition unit onto this connection. The red lead is twisted onto the other side of the coil without removing the existing wiring. Thirdly, connect the green wire to an earth point such as under the mounting clip of the coil. The system is now ready to test.

Switch the unit to "assisted" and switch on the car ignition, then dab the orange wire on and off an earthed point. Each time the orange wire breaks contact from earth it should make a spark leap from the centre lead of the coil to its nearest earth point 6mm away.

The "normal" switch position may be tested the same way, but don't touch the bare end of the orange wire. Use an insulated screwdriver to push the wire firmly against the earth point for this test. When this test is complete turn the ignition off and reconnect the two leads so that the car is ready for use again.

INSTALLATION

The unit is installed in a cool part of the engine compartment not forgetting to mount it

on some form of rubber shock absorbers. It is very important to remove the capacitor (condenser) from the distributor and refit it into the unit immediately prior to installation.

Due to the inherent voltage drop of about 1.2 volts across D1 and TR3 the system may not be able to provide a good enough spark for cold starting or for starting with a low battery voltage. This voltage drop will be no more than that experienced with a normal system operating with worn points. (The points should be cleaned, or a new set installed, and adjusted before installation.)

To overcome the starting difficulty simply switch to the normal position during very bad weather or when the battery voltage is low. Because the points will have been saved from electrical wear by the ignition system they will be able to provide a much better spark than would be the case had the normal system been in continual use—thus in an indirect way the system can help with cold weather starting. It is not advisable to switch over to the assisted position with the engine running.

There is no doubt that with this system changing the points and retiming can be carried out at very much greater intervals than would otherwise be the case, thus saving the cost of the unit in a relatively short period. □

EVERYDAY ELECTRONICS "MULTIMETER" COMPETITION

Winners

First: (Chinaglia Dino multimeter) Mr. Frederick J. Pavey, Petersfield, Hants

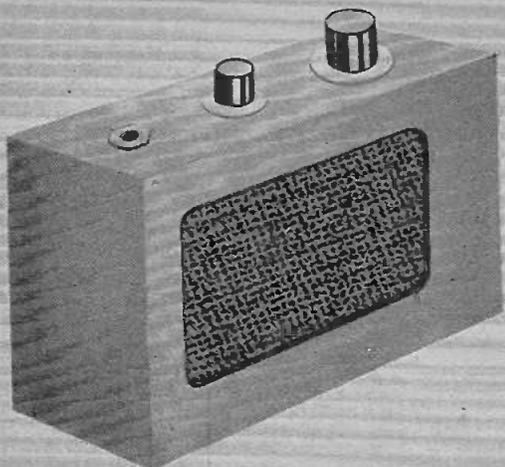
Second: (Chinaglia Minor multimeter) Mr. David E. Young, Ashford, Kent

Third: (Chinaglia Minor multimeter) Mr. K. Reed, Bracknell, Berks.

Runners-up: (each wins a Chinaglia Cito pocket multimeter) Mr. W. Barry, East Boldon, Co. Durham; Mr. I. Brownlee, Stranraer; Mr. M. Coles, Clynder, Dunbartonshire; Mr. I. Juliff, Livingston, West Lothian; Mr. P. Kimmance, Horton, Bristol; Mr. J. Malham, Selby, Yorks; Mr. C. Mannix, Liverpool; Mr. J. Noonan, Stoke Poges, Bucks; Mr. N. Patrick, Orpington, Kent; Mr. R. Thomson, Salford, Lancs.



Left: Mr. Frederick J. Pavey (right) being presented with the Dino multimeter (1st prize) by the editor, Mr. F. E. Bennett (left) in the presence of sponsor Mr. Alberto Coniglio (Managing Director, Chinaglia U.K.). Right: runner-up, Mr. David E. Young receives his Minor multimeter.



M.W. REFLEX RECEIVER

By R.A. PENFOLD

THIS article describes a five transistor m.w. receiver, which for simplicity uses a t.r.f. circuit. It is not of the pocket portable type, and measures approximately 200×150×90mm., which allows a well spaced layout to be used, and this greatly simplifies construction.

The internal 150×100mm loudspeaker can be driven by a maximum output power of around 250mW r.m.s. A home made plywood case with an aluminium front panel is used.

The set does not have a performance equal to that of a more complicated superhetrodyne circuit, but stations, Radio 1, 3, and 4, plus a few continental stations can be received at full volume on the prototype receiver. A class B output stage is used, and this gives a reasonable battery life (type PP3) at normal listening levels.

REFLEX CIRCUIT

The circuit diagram of the receiver is shown in Fig. 1. This consists of a reflex stage, TR1, followed by a conventional four transistor a.f. amplifier using a complementary output stage.

A reflex amplifier is one which gives amplification at r.f., and when the r.f. signal has been detected, then amplifies the resultant audio signal.

Thus a single transistor provides two stages of gain and Fig. 2 shows the effective circuitry around TR1 during r.f. amplification and detection (Fig. 2a), and during a.f. amplification (Fig. 2b).

Referring to Figs. 1 and 2, L1 is the tuned winding on the ferrite aerial, and C2 is the tuning capacitor. The high impedance signals across L1 are matched into the low input impedance of TR1 by L2. Capacitor C4 provides d.c. blocking.

Resistor R1 is the biasing resistor for TR1, and L3 is its collector load. Components R2 and C3 form an r.f. decoupling network, and prevent the r.f. signal from entering other parts of the circuit via the supply lines.

Coils L3 and L4 form a wideband transformer, and unlike L1 and L2 which only operate over a narrow range of frequencies at one time, these operate satisfactorily over the entire m.w. band.

The signal across L3 is therefore induced into L4, and from here fed via C5 to an ordinary diode detector, D1. Capacitor C4 smoothes the positive r.f. half cycles remaining after detection, leaving an insignificant d.c. bias, and the required audio signal.

In Fig. 2 there are two capacitors marked "C4", but if reference is made to Fig. 1 it will be seen that this is in fact one component, and that it is used twice. It will also be seen that the audio signal across C4 is coupled into the base circuit of TR1 via L2.

At audio frequencies L3 has a negligible reactance, and appears as a virtual short circuit, and can be ignored. Resistor R1 still operates as the biasing resistor, and R2 now becomes the collector load for TR1.

The reactance of C6 is too high at audio frequencies to have any noticeable effect on the circuit, and can also be ignored. This leaves the simple a.f. amplifier circuit of Fig. 2b. The amplified audio signal appears across R2; and is coupled via C7 to the volume control, VR1.

REGENERATION

The two main disadvantages of this type of circuit are that the r.f. amplification is fairly low, there being only one stage of this, and the selectivity (the ability of the receiver to reject signals in close proximity to the desired one) is poor as there is only one tuned circuit. Both these can be improved by adding regeneration, and this is the purpose of C3.

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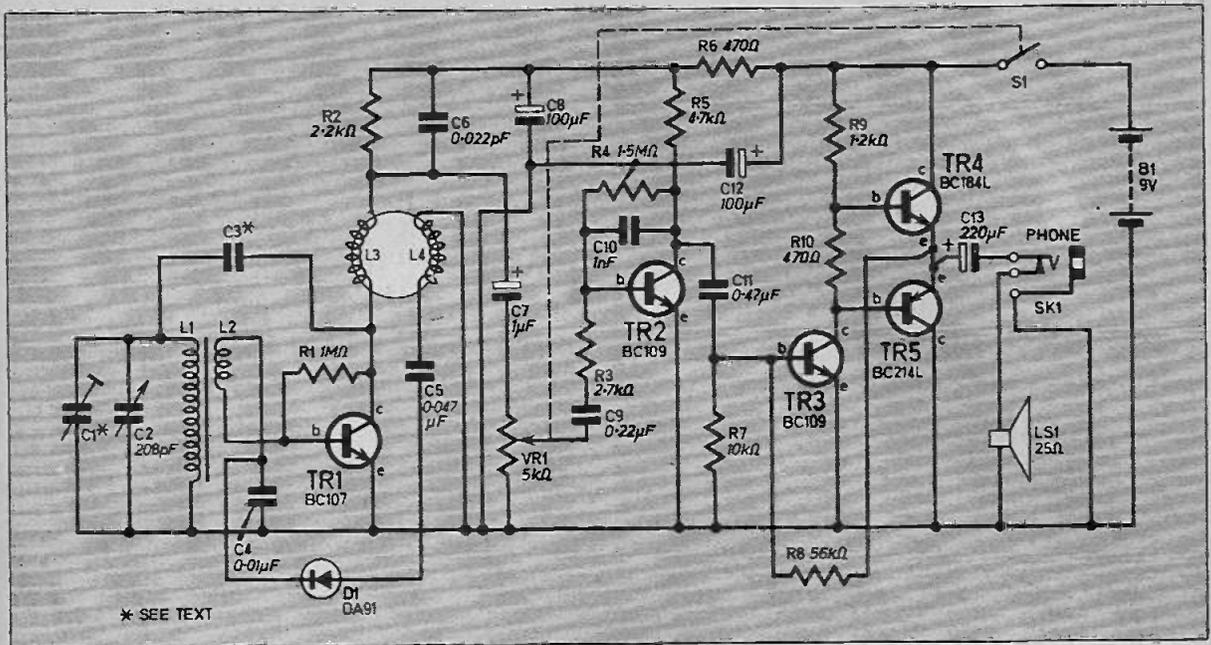


Fig. 1. The complete circuit diagram of the receiver.

This merely couples some of the amplified r.f. at TR1 collector back to the tuned circuit, where it is sent back through the circuit for amplification for a second time. This differs from reflexing in that the signal has not been detected, and is still at r.f.

There is a limit to the amount of regeneration that can be applied, and if this is exceeded, TR1 will oscillate, and the receiver will be unable to resolve signals properly. Capacitor C3 has an extremely low value, and merely consists of two pieces of wire in close proximity to one another.

AUDIO AMPLIFIER

The amplifier is quite conventional, and has a high gain common emitter input stage, TR2, a common emitter driver stage, TR3, and a complementary emitter follower output stage, TR4 and TR5.

A break contact on the earphone socket disconnects one of the speaker leads when the earphone plug is inserted. Any type of earphone can be used, although ideally a magnetic phone of about 60 to 250 ohms impedance should be used.

WIDEBAND TRANSFORMER

There is no ready made component suitable for use as the wideband transformer, and this is home made using an FX1593 ferrite ring, and two lengths of 38 s.w.g. enamelled copper wire. Details of this are shown in Fig. 3.

There is no need to keep the two windings particularly neat, but an attempt should be made to keep the turns of each coil running in the same general direction along the core.

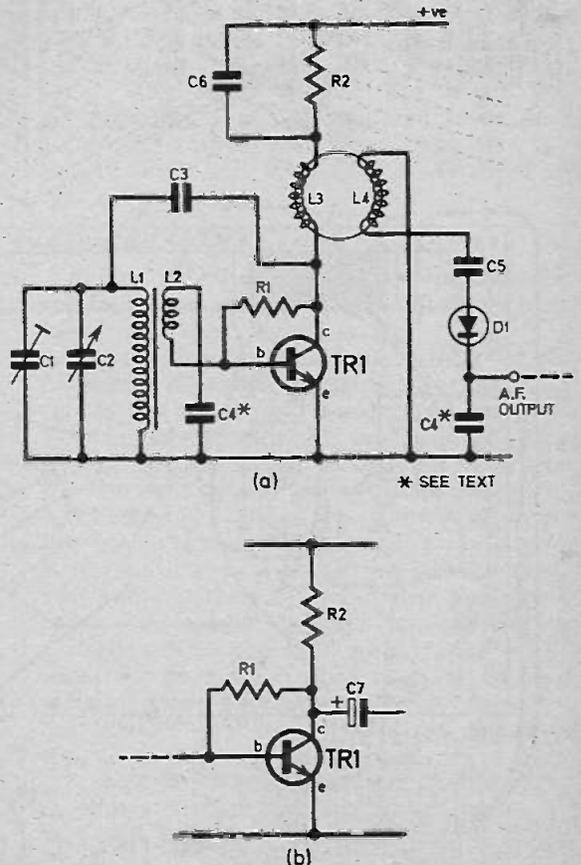


Fig. 2. The same circuit being used to amplify r.f. and then detected r.f. (a.f. signals).

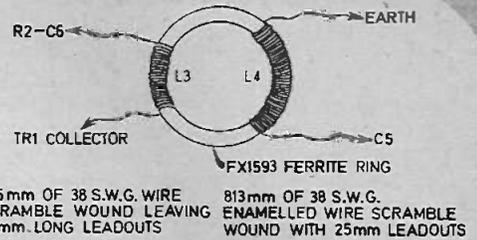
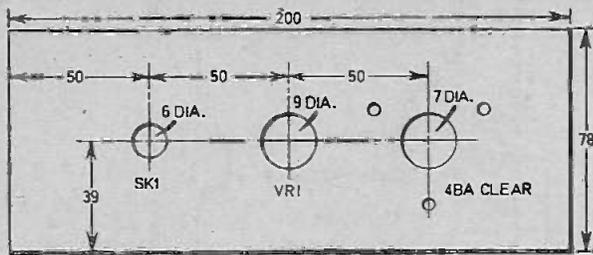


Fig. 3. Winding details of the wideband transformer.

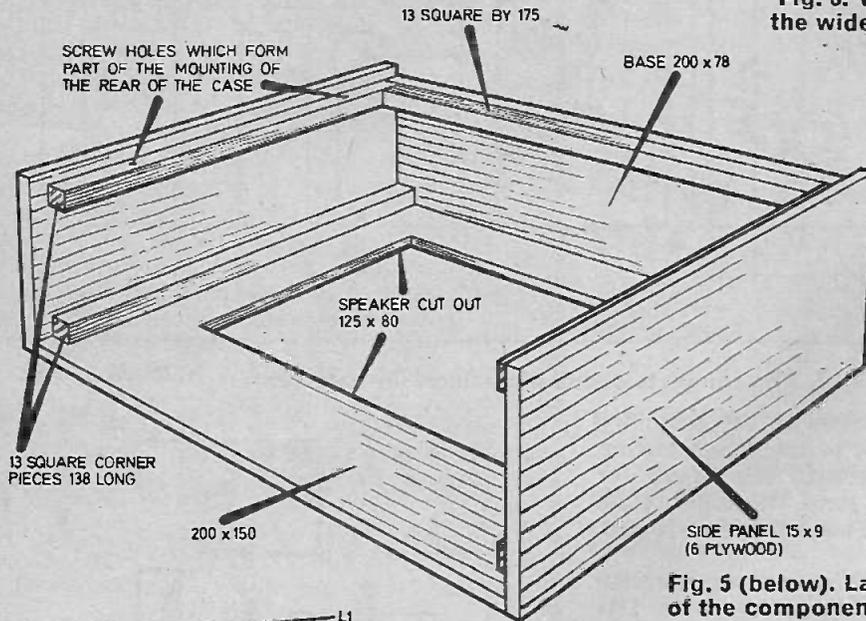
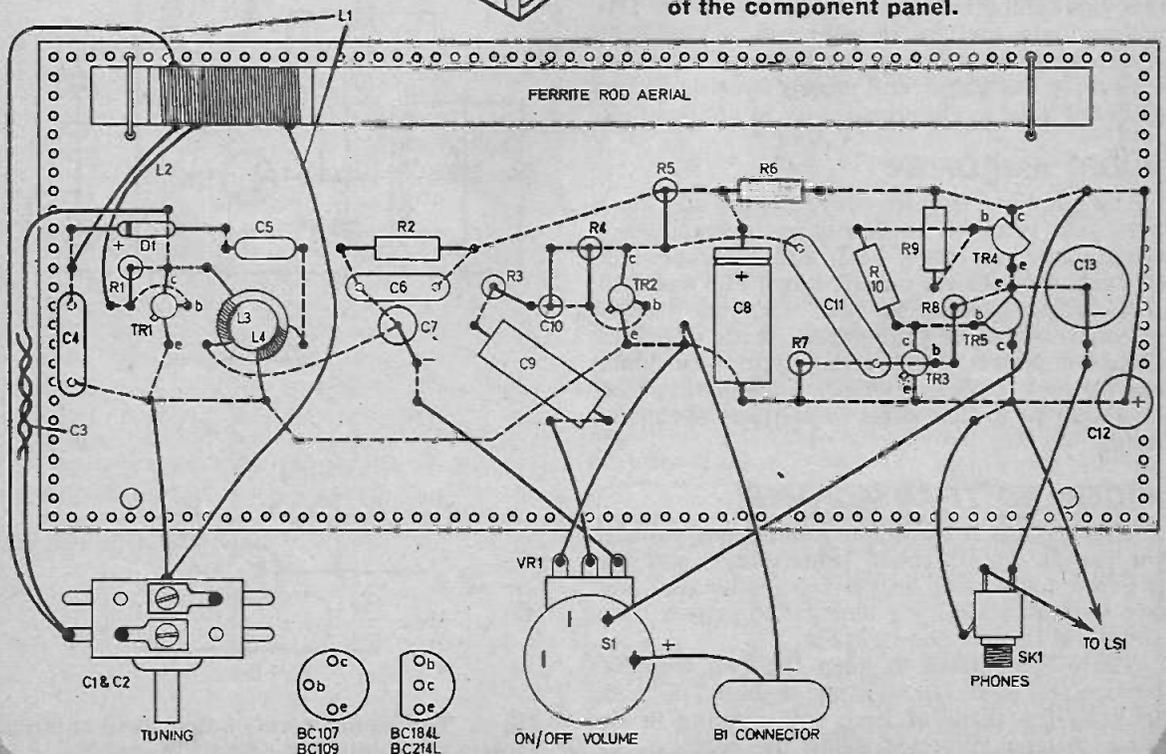


Fig. 4. Details of the prototype case and front panel.

Fig. 5 (below). Layout and wiring details of the component panel.



Components....

Resistors

R1	1M Ω	R6	470 Ω
R2	2.2k Ω	R7	10k Ω
R3	2.7k Ω	R8	56k Ω
R4	1.5M Ω	R9	1.2k Ω
R5	4.7k Ω	R10	470 Ω

All $\frac{1}{4}$ W $\pm 10\%$ carbon

Capacitors

C1	Trimmer section of C2
C2	208pF (front part of 208-176 Jackson 00, with trimmers)
C3	See text
C4	0.01 μ F
C5	0.047 μ F
C6	0.022 μ F
C7	1 μ F elect. 16V
C8	100 μ F elect. 10V
C9	0.22 μ F Mullard C280
C10	1nF polystyrene
C11	0.47 μ F Mullard C280
C12	100 μ F elect. 10V
C13	220 μ F elect. 10V

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Semiconductors

D1	OA91
TR1	BC107 silicon <i>npn</i>
TR2, 3	BC109 silicon <i>npn</i> (2 off)
TR4	BC184L silicon <i>npn</i>
TR5	BC214L silicon <i>pnp</i>

Miscellaneous

VR1	5k Ω log. pot with switch (S1)
L1/L2	Denco MW/5FR ferrite aerial
L3/4	FX1593 ferrite ring and 38 s.w.g. enamelled copper wire
LS1	25 ohm loudspeaker (150 x 100mm size used in prototype)
B1	9V PP3 battery and clips
SK1	3.5mm jack socket with switch and ear-phone with plug to suit, control knobs (2 off), 0.1 inch matrix component board 150 x 65mm, materials or ready made plastic case, connecting wire, 6BA fixings.

THE CASE

The case is home made from 6mm plywood and 12mm square timber, Fig. 4 shows constructional details of this, and also details of the aluminium front panel. The various wooden parts of the case can be either pinned or glued together (or both).

It is advisable to make the speaker cut-out before assembly. It can be made using a fret saw. A piece of speaker fret is glued behind this, and then the speaker glued to the fret.

The front panel is glued to the four corner pieces. The back of the case is made from 6mm ply, and is drilled so that four wood screws can pass through this, and into the four corner pieces, so holding the back in place. The case is finished by being covered with a self adhesive plastics material (Contact, Fablon, etc).

A mounting bracket is required for the com-

ponent panel, and this is made from 18 s.w.g. aluminium. This fits behind the front panel, and is held in place by C2, VR1, and SK1 when these are mounted on the front panel. For the time being these are mounted on the bracket. The component panel is mounted on the bracket by two 6mm long 6BA bolts.

COMPONENT PANEL

A diagram showing the component side of the component panel, and all external connections is given in Fig. 5. The ferrite rod is tied to the board by two tethers made from thin p.v.c. sleeving. The coil former is slid along the rod to one end, as shown in the diagram. The coil assembly L3/L4 can be secured to the panel in the same way as the ferrite rod.

The other components can then be mounted, and their leadouts bent over at right angles on the reverse side of the panel. These are then soldered together, as shown in the diagram, the underside wiring is shown dotted. Where leads pass close to each other, and there is a danger of a short circuit, one of the leads should be insulated with p.v.c. sleeving.

At any points where interconnecting leads are too short to reach one another, extension leads made from thin tinned copper wire (about 22 s.w.g.) are used to join them.

Connections to SK1, VR1, etc. can then be made. The leads to LS1 are about 300 to 450mm long. The two insulated leads forming C3 are each about 8 to 12mm long, and preferably of single core wire. C1 is ready wired across C2.

ADJUSTMENTS

Before mounting the component assembly in the case, the unit should be checked for mistakes, and then turned on.

Initially, the two wires comprising C3 should be kept well apart. Rotating the spindle of C1 should enable several stations to be received. The two wires forming C3 should now be brought together. If this causes an increase in sensitivity, the two lead outs of L2 should be swapped.

It should be checked that the frequency coverage is correct. If this is found to be incorrect, adjusting C1 should enable this to be amended. The unit can then be mounted in the case. The battery is wedged between two corner pieces.

Capacitor C3 can then be adjusted. The two wires are brought as close together as possible without either quality seriously breaking up, or the circuit oscillating (which is heard as a whistle as the receiver is tuned over a station).

It may be possible to twist the wires together as shown in the diagram, but in many cases they will only be able to be brought to within 25mm or so of each other. They can in this circumstance, be taped to the side of the case to ensure that they are not accidentally moved once correctly adjusted. □

New products and component buying for constructional projects

SHOP TALK

By Mike Kenward

WHEN is a toy not a toy? That is a question one could ask about the Fischertechnik range of construction kits. We recently received an invitation to the launch of their range in this country (the product is of German origin) and wondered quite why they thought an "electronic" magazine would be interested. It turned out that they produce electro-mechanical and electronic kits that can be used to control and drive the models made from the basic kits. The electronics are supplied in module form with sensors—light sensitive, heat sensitive etc.—supplied as plug-in parts. A modular relay is also provided to drive the model motors or lights.

The basic construction set (suitable for age 6 upwards) costs £12.05 and to this can be added a motor kit £6.95 and an elec-

tronics kit £14.55, however, the range and versatility are vast.

The kits are made of moulded nylon (non-toxic) are guaranteed against breakage—the electronic parts are also said to be protected against damage from wrong connection. They should be available from your local toy shop by the time you read this.

Ultrasonic Remote Controller

The receiver for the *Ultrasonic Remote Controller* requires one or two parts that are not generally available—the TAA 930B integrated circuit and the ultrasonic transducer.

Phoenix Electronics Ltd, can supply the i.c.—they do advertise in our pages—the i.c. costs £1.23 including VAT.

The transducer costs £3.75 and it would be a good idea to get the "R" and "T" versions in one go (receiver and transmitter) since the "T" will be required for the construction detailed next month. Total cost for the two including p. and p. and VAT is £7.00. They come from Hall Electronics, 48 Avondale Rd., Leyton, E17.

Other components in the receiver should not be difficult to get—almost any metal case could be used to house the unit.

M.W. Reflex Receiver

Once again just a couple of unusual components are required for the *M.W. Reflex Receiver*. The ferrite ring is available from Henry's Radio and the ferrite aerial from Denco for 66p plus VAT, plus postage—a total of

85p. Denco are at 355/9 Old Road, Clacton-on-Sea, Essex, CO15 3RH.

The case for the receiver can be home made or the complete unit could be housed in one of the plastic cases that are generally available.

The River

None of the components specified for *The River* should be difficult to get hold of. The 75 or 80 ohm speaker may need looking for, but most of the larger supplies should be able to provide it for you.

The tagboard used to mount the components is becoming rather outdated but does provide a simple and satisfactory base for this unit.

Ignition System

As regular readers of this page will know after the publication of the original *Transistor Assisted Ignition* system A. Marshall ran out of the TIP49 transistors and have still not been able to replenish their stocks. This means that two TIP53 transistors have to be used instead—at an increase in cost.

Once Marshalls receive some more 49's they will resume supply at the lower price (£2.85); until then, the cost of the semiconductors (diode and all transistors) from them is £3.80 including postage and packing and VAT. Since it is very difficult to say quite when supplies from the manufacturers will resume we suggest readers send the larger amount—those who send off in a few months time may get a refund!

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H38	30	Short lead Transistors, NPN Silicon Planar types	50p
H36	6	Integrated Circuits, 4 Gates BMC 962, 2 Flip Flops BMC 945	50p
H41	2	Sil Power transistors comp pair BD131/132	50p
H63	4	2N3055 type NPN Sil. power transistors. Below spec. devices	50p
H64	4	3B19 N Channel FETs 2N3819 in plastic case	50p



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B84	100	Silicon Diodes DO-7 glass equiv. to OA200, OA202	50p
B88	100	Sil. Diodes sub. min. IN914 and IN918 types	50p
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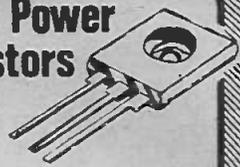
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The Extra-ordinary Experiments of Professor Ernest Eversure

by Anthony John Bassett



Professor Ernest Eversure, or the Prof. as his friends call him, has been experimenting in electronics for more years than anyone can remember and we thought that you might like to hear of, and perhaps repeat, some of his extraordinary experiments. Anthony J. Bassett will be recounting some of the experiments every month so why not follow the Prof's work and learn along with young Bob, his friend.

AS THE ROBOT drew even nearer to him, the startled Professor saw that the unusual movements caused by Bob's oscillator seemed to be making the robot perform a strange dance. Despite this, the robot seemed to be keeping to its original instructions. It seemed to dance towards the Prof. in time with Bob's tune. It gently placed the ohm-meter on the work bench, then danced off and disappeared amongst the equipment at the other end of the room.

The Prof. interrupted Bob's musical attempts, which were now taking the form of a series of gently rising and falling notes, rather like the electronic music sometimes heard from the soundtrack of a science-fiction fantasy film, and pointed out to him that the ohm-meter had now arrived.

What the robot had brought was actually a multimeter but Bob picked it up and switched it to a resistance range. He soon found, by applying the test probes of the meter to various pencils, that each one did in fact have a different resistance (as deduced from his experiments described

in the last issue) and that by sliding the probes to different distances apart along the pencil line on his piece of Paxolin, different resistance readings appeared on the meter scale.

Meanwhile, the Prof. had prepared a few more experimental resistors similar to the ones described earlier. He had painted graphite paste around the solder tags, but had not yet put a carbon conducting track across from one tag to the other.

"Now," said the Prof., "We can use these to produce a number of different values of carbon resistor."

"Can I do some?" asked Bob. The Prof. gave some of the partly made resistors to Bob and together they began to make a variety of resistors.

Bob painted resistors with wide tracks between the tags, medium tracks, and narrow tracks down to about 1mm. Some of the tracks were made up of several layers of mixture and some consisted of only one thin layer. The Prof. had meanwhile made up another mixture of graphite and quick-drying varnish using more graphite so

that the mixture was a thick paste which could be spread like butter. He spread a thick layer of this from one tag to the other about 3mm wide by 3mm deep on some resistors. Bob painted a thin zig-zag line from one tag to another.

After a break for lunch the pair returned to the now dry resistors and Bob began using the multimeter to measure the resistance values of the various resistors they had made.

The resistors covered a really wide range of values. The lowest value was the one with the thickest, deepest track and this measured 12 ohms. The highest value was the one with the thin zig-zag track and this measured about four megohms. Between these were resistors of a variety of values and Bob knew immediately that it should be possible to make any value of resistor from a few ohms up to a few megohms, quite easily.

"Suppose I wanted to make a 15 ohm resistor, Prof?" asked Bob. "Could I alter the 12 ohm resistor sufficiently?"

"Yes," said the Prof. "Just use a craft knife to scrape off some of the mixture and the value will rise."

Bob connected the meter to the 12 ohm resistor and checked the resistance reading. He left the meter leads connected while carefully scraping away thin layers of

graphite mixture. As the mixture was removed, the meter reading gradually changed... 12 ohms... 13 ohms... 14 ohms... 15 ohms... 15.5 ohms... "Whoops! I've taken too much off!" said Bob, looking wryly at the meter reading. The Prof. picked up a very soft lead pencil and carefully rubbed the surface of the resistor, using very light pressure. Gradually, the meter reading crept back down to 15 ohms.

"Now, let's try some high value resistors. We should be able to trim the values of all these resistors to our preferred values," the Prof. stated. He changed the range on the multimeter and connected it to the four megohm resistor. Bob saw that the meter needle moved to the same reading as previously. Using a typist's ink eraser, the Prof. very carefully rubbed the fine carbon track, using very light pressure. The meter reading altered slowly as he did so, until a reading of five megohms was obtained.

"Prof.," said Bob, "The carbon line on that four megohm resistor is very thin and while you were altering it to five megohms suppose you rubbed a little too hard and broke the line?"

"If I broke the line," replied the Prof., "It would break the electrical connection so that no current would flow through the resistor. The meter would then read open-circuit. Let me demonstrate." The Prof. rubbed the line with the eraser and as he did so, the meter needle moved even higher until at one point the carbon track was severed and the meter swung to read open-circuit.

"Now," said the Prof. "We can repair the break in the carbon track quite easily by rubbing it with a hard pencil, or by using more graphite mixture." He selected a 8H pencil and rubbed it carefully across the track at the point of the break. The meter needle began to move and gradually crept back to five megohms.

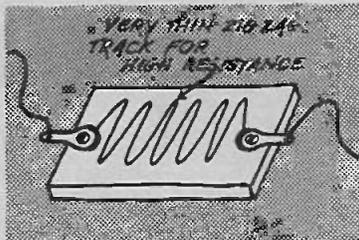
"If we wanted a lower value resistor, say one megohm, just by continuing to rub with the pencil, the value will become lower." The Prof. demonstrated by continuing to rub with the pencil. The meter reading went back to four then lower, three, two, one megohm. "To go much lower, we would have to use a much softer pencil," observed the Prof. He used the eraser to bring the resistor up

once again to five megohms.

"It all looks so simple, Prof.," remarked Bob. "But I'm sure I would not find it so easy to alter such fine lines to the accuracy you have just demonstrated!"

"The higher the value of the resistor you are making and the finer the carbon track which you must produce, the more difficult this becomes," agreed the Prof. "But if you start off by making resistors of a few kilohms, rather than a few megohms, it is much easier to do."

"I see. So if I practice first with some of these other resistors

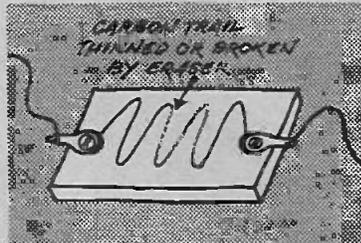


One of the Prof's experimental resistors. This one uses a zig-zag track to obtain high resistance

with the wider tracks, I could tackle more difficult ones later."

"Now that we can make resistors of almost any value," said Bob, "we should be able to connect a few of them together to make a simple note selector for my musical note generator. Something similar to a keyboard!"

"Yes," agreed the Prof. I will show you how to build a note selector, using a number of resis-



The value of the resistor can be raised by rubbing away the track

tors which we can make and connect together on a single piece of printed circuit board or Paxolin. It will enable you to use the oscillator to produce melodies or to produce musical notes which can be tape-recorded to make some electronic sound effects!"

At this moment an amazing sound effect became apparent in the laboratory. An electronic tone rising and falling like a siren.

"Oh, no!" wailed Bob. "I know that sound. It is the alarm signal for your latest experiment. It's out of control and could be dangerous. We cannot go near it and if we don't stop it soon it could synchronise the brain wave patterns of everyone nearby. What can we do, Prof.? "Think of something quickly!"

To Bob's amazement, the Prof. seemed impervious to the blaring alarm signal and completely unaware of the obvious danger. Could it be that the experiment had already begun to affect his brain wave patterns?

Continued next month!

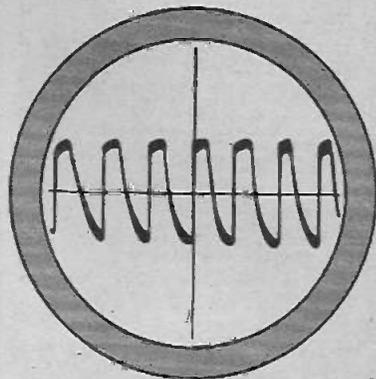
Oh, no! wailed Bob. I know that sound. It is the alarm signal for your latest experiment."



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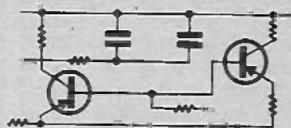
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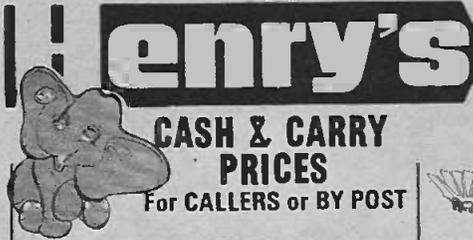
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DOWN TO EARTH

By GEORGE HYLTON

"My transistor radio hums when placed close to an electric clock on the bedside table, but only when it's tuned into a station. What is happening?"

Well, here's a deceptively simple question! Hum—mains hum, that is—can get into circuits in at least three ways: leakage through imperfect insulation; capacitive coupling; magnetic coupling. I'm going to stick my neck out and declare in a firm, confident tone that the present case is clearly one of magnetic coupling.

MODULATION HUM

The really clinching clue, as I see it, is the observation that the hum appears only along with a programme. This makes it almost certain that we have a case of what's usually called "modulation hum." Modulation is usually thought of as something that happens at radio transmitters rather than at receivers. It's the term used to describe how the audio programme-signal is impressed on the radio frequency carrier wave which the transmitter broadcasts.

In an amplitude-modulated (a.m.) transmission the strength (amplitude) of the carrier wave is made to vary in sympathy with the programme. In an f.m. transmission it's the frequency of the carrier wave that varies. Either way, some form of modulation circuit is involved. Receivers, oddly enough, also contain bits of circuitry which are quite capable of functioning as modulators, even though that's not their purpose, e.g., frequency changers, amplifiers, and detectors.

If you apply to any of these two signals simultaneously, one a high frequency, the other a low frequency, and at the right relative strengths, then the strength of the high frequency will be made to vary in sympathy with the low one, just as in an a.m. transmission.

In our reader's case, the h.f. signal is the carrier frequency

of the incoming station. The low frequency is the 50Hz mains, picked up from the electric clock.

Why am I so confident that it's a case of magnetic pickup? Well, both clocks and transistor radios are usually in well-insulated plastic cases, which more or less rules out leakage. It would be hard to get the clock and radio close enough together to cause an appreciable amount of capacitive pickup. But transistor a.m. radios have a beautifully efficient gadget inside them for picking up magnetic signals, in the shape of a ferrite rod aerial.

AERIAL

It's true that the aerial isn't designed to work at 50Hz, but it does. Not as well as at r.f., of course, but well enough to pick up a good strong signal from the magnetic field of the clock motor. The input circuitry of the average transistor portable is on the lines of Fig. 1. The first transistor is a frequency changer, to which the incoming transmissions are applied via the coupling winding of the ferrite rod aerial (L2) and the local oscillation via the winding of the oscillator coil in the emitter circuit.

The 50Hz signal that does the

damage is the one induced in L2. A much bigger one is induced in L1 but the impedance of the aerial tuning capacitor C1 is so enormous at 50Hz that practically no current circulates. A 50Hz signal in L2 on the other hand can get straight to the base of TR1.

This 50Hz signal, if strong enough, produces a 50Hz variation in the collector current. Since the gain of a transistor in this sort of circuit is a function of its collector current, any other signals present (including the incoming station) are subject to a gain which varies at 50Hz. The transistor is acting as a modulator.

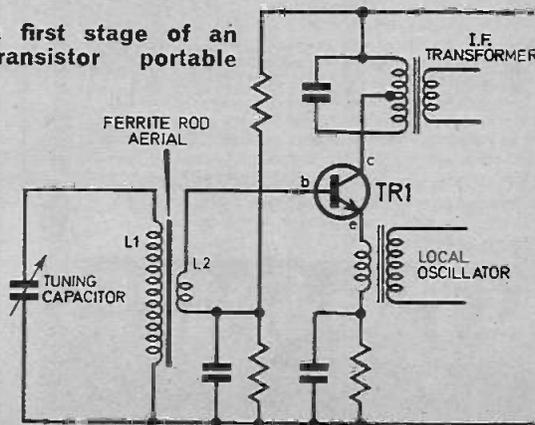
The h.f. signals which go into the i.f. amplifier are now all modulated not only with the audio programme but with 50Hz. When applied to the detector after i.f. amplification the 50Hz comes out along with the programme. Hence the hum.

Moreover, it's not just the incoming r.f. carriers that get modulated at 50Hz but the modulation sidebands as well, so the 50Hz and the programme get quite inextricably entangled, and every audio tone which emerges from the loudspeaker has a 50Hz wobble on it.

OTHER RECEIVERS

It makes no difference if the first stage of the receiver is a radio-frequency amplifier instead of a frequency-changer. The possibility of hum modulation is still there. So t.r.f. receivers can pick up hum, too. It's less likely in f.m. receivers, but still possible, because the oscillator coil may pick up hum, which pushes the frequency around at 50Hz and so produces a genuine 50Hz frequency modulation on all incoming signals!

Fig. 1. The first stage of an average transistor portable radio.



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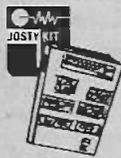
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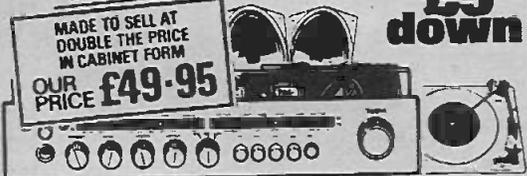
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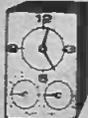
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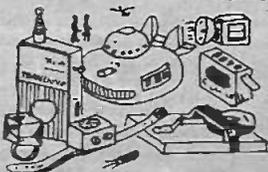
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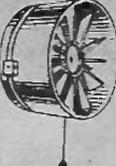
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FOR 7

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 Pair of 15 ohm speakers made by E.M.L. are also available if required, £3.30 the pair. No extra postage if ordered with the above, otherwise add 25p.



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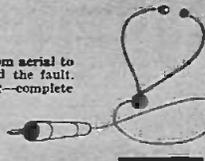
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PORTABLE CABINET OFFER

A nicely made portable cabinet, soft padded black finish intended for portable stereo system. Dimensions as sketch. With motor board cut out for Garrard SP 25. This was obviously a very costly cabinet originally made for a deluxe record player. Offered at £1.95 plus £1 carriage free if bought with the Garrard or BBR record decks.



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For digital instruments, counters, timers, clocks, etc. Hi-vac XN.3. Price 39p each. 10 for £3.



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8TC sealed relays, Bakera type ref. 6945. These are metal encased plug in with two pairs changeover contacts. Approx. size 1 1/2" high x 1 1/2" x 1 1/2". We understand these are vacuum sealed. Two types available 6v (45 ohms coil) price £1.50; 24v (700 ohms coil) price £1.75. Sealed relay, Agrin, type 6945, sealed metal STC case plug in but for 12v operation (170 ohms coil) and with 2 pairs normal open contacts. £1.25.

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Unit made by the American GEC company. 8 transistor, all-wired ready to work. Complete with tuner condenser, needs only scale and pointer. Times AM range 540 to 1620 KHz. FM range 88 to 108 MHz. Switches for on-off and AFC. Output for MXP or direct. Special snip price £5 plus 30p post. Three or more post free.

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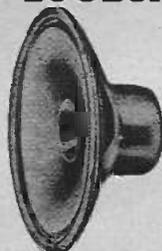
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3	7d	8d	9d	10d	11d	12d	13d	14d	15d	16d
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11	15d	16d	17d	18d	19d	20d	21d	22d	23d	24d
12	16d	17d	18d	19d	20d	21d	22d	23d	24d	25d
13	17d	18d	19d	20d	21d	22d	23d	24d	25d	26d
14	18d	19d	20d	21d	22d	23d	24d	25d	26d	27d
15	19d	20d	21d	22d	23d	24d	25d	26d	27d	28d
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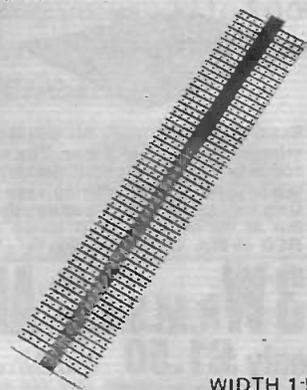
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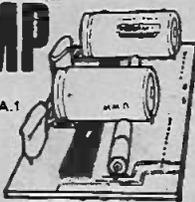
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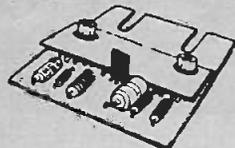
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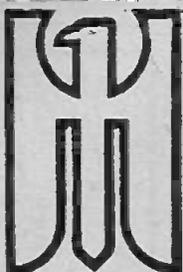
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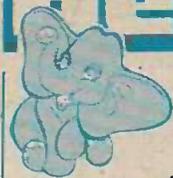
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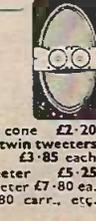
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