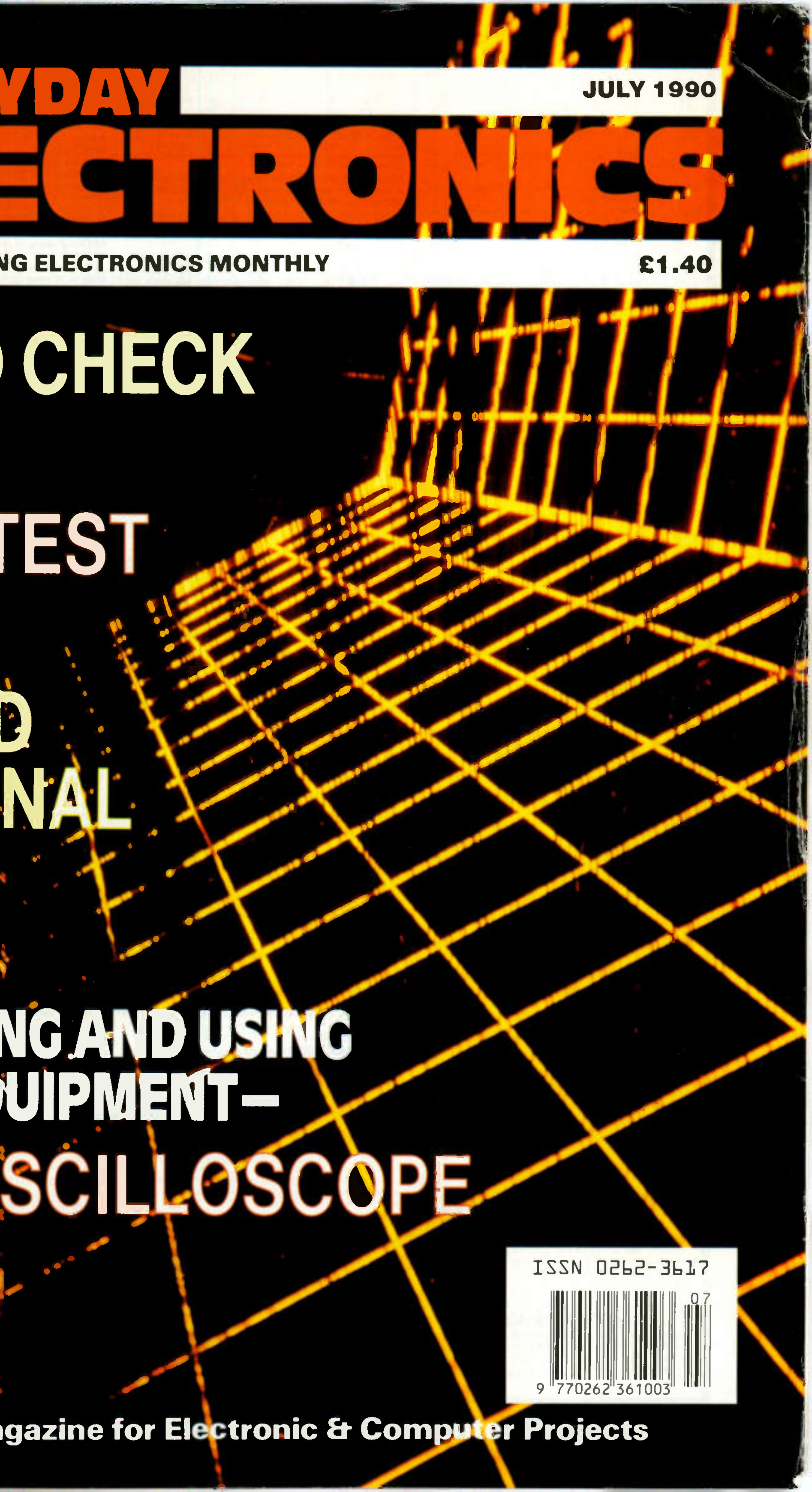
JULY 1990

# EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

£1.40



## VIDEO CHECK

## TOW-TEST

## GRAND NATIONAL GAME

## CHOOSING AND USING TEST EQUIPMENT– THE OSCILLOSCOPE

ISSN 0262-3617

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The Magazine for Electronic & Computer Projects

## ONE POUND PACKS

All packs are £1 each. Note the figure on the extreme left of the pack ref number and the next figure is the quantity of items in the pack, finally a short description.

| | | |
|---|---|---|
| BD2 | 5 | 13A spurs provide a fused outlet to a ring main where devices such as a clock must not be switched off. |
| BD9 | 2 | 6V 1A mains transformers upright mounting with fixing clamps. |
| BD11 | 1 | 6½in speaker cabinet ideal for extensions, takes our speaker. Ref BD137. |
| BD13 | 12 | 30 watt reed switches, it's surprising what you can make with these—burglar alarms, secret switches, relay, etc., etc. |
| BD22 | 2 | 25 watt loudspeaker two unit crossovers. |
| BD30 | 2 | Nicad constant current chargers adapt to charge almost any nicad battery. |
| BD32 | 2 | Humidity switches, as the air becomes damper the membrane stretches and operates a microswitch. |
| BD42 | 5 | 13A rocker switch three tags so on/off, or change over with centre off. |
| BD45 | 1 | 24hr time switch, ex-Electricity Board, automatically adjust for lengthening and shortening day. original cost £40 each. |
| BD49 | 5 | Neon valves, with series resistor, these make good night lights. |
| BD56 | 1 | Mini uniselector, one use is for an electric jigsaw puzzle, we give circuit diagram for this. One pulse into motor, moves switch through one pole. |
| BD67 | 1 | Suck or blow operated pressure switch, or it can be operated by any low pressure variation such as water level in water tanks. |
| BD103A | 1 | 6V 750mA power supply, nicely cased with mains input and 6V output leads. |
| BD120 | 2 | Stripper boards, each contains a 400V 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers, etc. |
| BD132 | 2 | Plastic boxes approx 3in cube with square hole through top so ideal for interrupted beam switch. |
| BD134 | 10 | Motors for model aeroplanes, spin to start so needs no switch. |
| BD139 | 6 | Microphone inserts—magnetic 400 ohm also act as speakers. |
| BD148 | 4 | Reed relay kits, you get 16 reed switches and 4 coil sets with notes on making c/o relays and other gadgets. |
| BD149 | 6 | Safety cover for 13A sockets—prevent those inquisitive little fingers getting nasty shocks. |
| BD180 | 6 | Neon indicators in panel mounting holders with lens. |
| BD193 | 6 | 5 amp 3 pin flush mounting sockets make a low cost disco panel. |
| BD199 | 1 | Mains solenoid, very powerful, has 1in pull or could push if modified. |
| BD201 | 8 | Keyboard switches—made for computers but have many other applications. |
| BD211 | 1 | Electric clock, mains operated, put this in a box and you need never be late. |
| BD221 | 5 | 12V alarms, make a noise about as loud as a car horn. Slightly soiled but OK. |
| BD252 | 1 | Panostat, controls output of boiling ring from simmer up boil. |
| BD259 | 50 | Leads with push-on ¼in tags—a must for hook-ups—mains connections etc. |
| BD263 | 2 | Oblong push switches for bell or chimes, these can mains up to 5 amps so could be foot switch if fitted into pattress. |
| BD268 | 1 | Mini 1 watt amp for record player. Will also change speed of record player motor. |
| BD305 | 1 | Tubular dynamic mic with optional table rest. |
| BD653 | 2 | Miniature driver transformers. Ref. LT44. 20k to 1k centre tapped. |
| BD548 | 2 | 3.5V relays each with 2 pairs changeover contacts. |
| BD667 | 2 | 4.7 μf non-polarised block capacitors, pcb mounting. |

**There are over 1,000 items in our Catalogue. If you want a complete copy please request this when ordering.**

**FLOPPY DISCS** 5¼" pack of 10 £5.00. Ref. 5P168. 3½" pack of 10 £10.00. Ref. 10P88.

**TOASTERS** 2 slice toasters — may need slight attention. Only £3.00 each. Ref 3P84.

**PERSONAL STEREOS** Again customer returns but complete and with stereo head phones. A bargain at only £3.00 each. Our ref 3P83.

**MICROWAVE CONTROL PANEL** Mains operated, with touch switches. This unit has a 4 digit display with a built in clock and 2 relay outputs — one for power and one for pulsed power level. Could be used for all sorts of timer control applications. Only £6.00. Our ref 6P18.

**EQUIPMENT WALL MOUNT** Multi adjustable metal bracket ideal for speakers, lights, etc. 2 for £5.00. Our ref 5P152.

**NEW MAINS MOTORS** 25 watt 3000 rpm made by Framco. Approx 6" x 3" x 4". Priced at only £4.00 each. Our ref 4P54.

**SHADED POLE MOTORS** Approx 3" square. Available in 24V and 240V AC. Both with threaded output shaft and 2 fixing bolts. Price is £2.00 each. 24V Ref 2P65, 240V Ref 2P66.

**SUB-MIN TOGGLE SWITCH** Body size 8mm x 4mm x 7mm SBDT with chrome dolly fixing nuts. 3 for £1. Order ref BD649.

**COPPER CLAD PANEL** for making PCB. Size approx 12in long x 8½in wide. Double-sided on fibreglass middle which is quite thick (about 1 16in) so this would support quite heavy components and could even form a chassis to hold a mains transformer, etc. Price £1 each. Our ref BD683.

## POWERFUL IONISER

Generates approx. 10 times more IONS than the ETI and similar circuits. Will refresh your home, office, workroom etc. Makes you feel better and work harder – a complete mains operated kit, case included. £18. Our ref 18P2.

**REAL POWER AMPLIFIER** for your car, it has 150 watts output. Frequency response 20hz to 20Khz and signal to noise ratio better than 60dB. Has built in short circuit protection and adjustable input level to suit your existing car stereo, so needs no pre-amp. Works into speakers ref. 30P7 described below. A real bargain at only £57.00. Order ref: 57P1.

**REAL POWER CAR SPEAKERS.** Stereo pair output 100W each. 4Ohm impedance and consisting of 6½" woofer, 2" mid range and 1" tweeter. Ideal to work with the amplifier described above. Price per pair £30.00. Order ref: 30P7.

**STEREO CAR SPEAKERS.** Not quite so powerful – 70w per channel. 3" woofer, 2" mid range and 1" tweeter. Again, in a super purpose built shelf mounting unit. Price per pair £30.00. Order ref: 28P1.

**VIDEO TAPES** These are three hour tapes of superior quality, made under licence from the famous JVC Company. Offered at only £3 each. Our ref 3P63. Or 5 for £11. Our ref 11P3. Or for the really big user 10 for £20. Our ref 20P20.

**ELECTRONIC SPACESHIP.** Sound and impact controlled, responds to claps and shouts and reverses when it hits anything. Kit with really detailed instructions. Ideal present for budding young electrician. A youngster should be able to assemble but you may have to help with the soldering of the components on the pcb. Complete kit £10. Our ref. 10P81

**COMPUTER KEYBOARDS** Brand new, uncased. £3.00 each. ref 3P89.

**12" HIGH RESOLUTION MONITOR** Amber screen, beautifully cased for free standing, needs only a 12v 1.5 amp supply. Technical data is on its way but we understand these are TTL input. Brand new in makers' cartons. Price: £22.00. Order ref: 22P2.

**SINCLAIR C5 WHEELS**

Including inner tubes and tyres. 13" and 16" diameter spoked poly carbonate wheels. Finished in black. Only £6.00 each.
13" Ref 6P10, 16" Ref 6P11

**COMPOSITE VIDEO KITS** These convert composite video into separate H sync, V sync and video. Price £8.00. Our ref 8P39.

**LINEAR POWER SUPPLY** Brand new +5v 3A, +/−12v 1A. Complete with circuit diagram. Short circuit protected. Our price £12.00 Ref 12 P21.

**3½in FLOPPY DRIVES** We still have two models in stock: Single sided, 80 track, by Chinon. This is in the manufacturers metal case with leads and IDC connectors. Price £40, reference 40P1. Also a double sided, 80 track, by NEC. This is uncased. Price £60.00, reference 60P2. Both are brand new.

**10 MEMORY PUSHBUTTON TELEPHONES** These are customer returns and "sold as seen". They are complete and may need slight attention. Price £6.00. Ref. 6P16 or 2 for £10.00. Ref. 10P77. BT approved.

**INDUCTIVE PROXIMITY SWITCHES** These will detect ferrous or nonferrous metals at approx. 10mm and are 10-36V operation. Ideal for alarms position sensors, etc. RS price is £64.00 each! Ours £12.00. Ref. 12P19.

**RETROFLECTIVE MODULATED INFRARED 5M BEAMS** IR transmitter and receiver housed in the same case. Ideal for beam alarms, counting, etc. RS price if £95.00 each! Ours £25.00. Ref. 25P15.

**ASTEC PSU.** Mains operated switch mode, so very compact. Outputs + 12v 2.5A, +5v 6A, ±5v .5A, ±12v .5A. Size: 7½in long x 4¾in wide x 2¼in high. Cased ready for use. Brand new. Normal price £30+, our price only £13.00. Order ref 13P2.

**VERY POWERFUL 12 VOLT MOTORS.** ⅓rd Horsepower. Made to drive the Sinclair C5 electric car but adaptable to power a go-kart, a mower, a rail car, model railway, etc. Brand new. Price £20. Our ref 20P22.

**ALSO AVAILABLE WITH GEARBOX** A 4:1 reduction giving 800rpm. Our ref 40P8. Price £40.

**PHILIPS LASER**

This is helium-neon and has a power rating of 2mW. Completely safe as long as you do not look directly into the beam when eye damage could result. Brand new, full spec. £35. Our ref. 35P1.
Mains operated power supply for this tube gives 8kv striking and 1.25kv at 5mA running. Complete kit with case £15.

**PANEL METERS** 270 deg movement. New. £3.00 each. Our ref 3P87

**SURFACE MOUNT KIT** Makes a super high gain snooping amplifier on a PCB less than an inch square! £7.00. Our ref 7P15.

**CB CONVERTERS** Converts a car radio into an AM CB receiver. £4.00. Our ref 4P48.

**GEIGER COUNTER KIT** Includes PCB, tube, loudspeaker, and all components to build a 9v battery operated geiger counter. Only £39. Our ref 39P1.

**12V TO 220V INVERTER KIT** This kit will convert 12v DC to 220v AC. It will supply up to 130 watts by using a larger transformer. As supplied it will handle about 15 watts. Price is £12. Our ref 12P17.

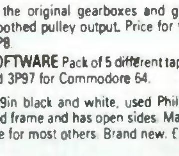
**SINCLAIR GEARBOXES** These are the original gearboxes and give about 50% reduction in speed and a toothed pulley output. Price for the gearbox AND motor is £40.00. Ref. 40P8.

**SPECTRUM AND COMMODORE SOFTWARE** Pack of 5 different tapes only £3.00. Ref. 3P96 for Spectrum and 3P97 for Commodore 64.

**HIGH RESOLUTION MONITOR** 9in black and white, used Philips tube M24/360W. Made up in a lacquered frame and has open sides. Made for use with OPD computer but suitable for most others. Brand new. £20. Our ref 20P26.

**12 VOLT BRUSHLESS FAN.** Japanese made. The popular square shape (4½in x 4½in x 1¾in). The electronically run fans not only consume very little current but also they do not cause interference as the brush type motors do. Ideal for cooling computers, etc., or for a caravan. **£8 each**. Our ref 8P26.

**MINI MONO AMP** on p.c.b. size 4" x 2" (app.)
Fitted Volume control. The amplifier has three transistors and we estimate the output to be 2W rms. More technical data will be included with the amp.
Brand new, perfect condition, offered at the very low price of £1.15 each, or 13 for £12.00.



# BULL ELECTRICAL

**Dept. EE 250 PORTLAND ROAD, HOVE, BRIGHTON, SUSSEX BN3 5QT.**

VISA

MAIL ORDER TERMS: Cash, PO or cheque with order. Monthly account orders accepted from schools and public companies. Please add £2.50 postage to orders. Minimum order £5. Phone (0273) 203500 Fax No. (0273) 23077.

## POPULAR ITEMS — MANY NEW THIS MONTH

**MAINS FANS** Snail type construction. Approx. 5" x 4" mounted on a metal plate for easy fixing. New. £5.00 each. Our ref 5P166.

**MICROWAVE TURNTABLE MOTOR** Complete with weight sensing electronics that would have varied the cooking time. Ideal for window displays, etc. Only £5.00. Our ref 5P165.

**JOYSTICKS** for BBC Atari, Dragon Commodore, etc. All £5.00 each. All brand new, state which required.

**TELEPHONE TYPE KEYPAD.** Really first class rear mounting unit. White lettering on black buttons. Has conductive rubber contacts with soft click operation. Circuit arranged in telephone type array. Requires 70mm by 55mm cutout and has a 10 IDC connector. Price £2.00. Ref. 2P251.

**SUB-MIN PUSH SWITCHES** Not much bigger than a plastic transistor but double pole PCB mounting. 3 for £1.00. Our ref BD688.

**AA CELLS** Probably the most popular of the rechargeable NICAD types. 4 for £4.00. Our ref. 4P44.

**20 WATT 4 OHM SPEAKER** With built in tweeter. Really well made unit which has the power and the quality for hifi 6½" dia. Price £5.00. Our ref. 5P155 or 10 for £40.00 ref. 40P7.

**MINI RADIO MODULE** Only 2in square with ferrite aerial and solid dia. tuner with own knob. It is superhet and operates from a PP3 battery and would drive a crystal headphone. Price £1.00. Our ref. BD716.

**BULGIN MAINS PLUG AND SOCKET** The old and faithful 3 pin with screw terminals. The plug is panel mounted and the socket is cable mounted. 2 pairs for £1.00 or 4 plugs or 4 sockets for £1.00. Our ref. BD715, BD715P, or BD715S.

**MICROPHONE** Low cost hand held dynamic microphone with on/off switch in handle. Lead terminates in 1 3.5mm and 1 2.5mm plug. Only £1.00. Ref. BD711.

**MOSFETS FOR POWER AMPLIFIERS AND HIGH CURRENT DEVICES** 140V 100 watt pair made by Hitachi. Ref 2SJ99 and its complement 2SK343. Only £4.00 a pair. Our ref. 4P51.

**TIME AND TEMPERATURE LCD MODULE** A 12 hour clock a Celsius and Fahrenheit thermometer a too hot alarm and a too cold alarm. Approx 50x20mm with 12.7mm digits. Requires 1AA battery and a few switches. Comes with full data and diagram. Price £9.00. Our ref. 9P5.

**REMOTE TEMPERATURE PROBE FOR ABOVE.** £3.00. Our ref. 3P60.

**PAPST** fan 80 x 80mm 230V. Our ref 9P7. Price £9.
**PAPST** fan 120 x 120mm 230V. Our ref 6P6. Price £6.

**600 WATT AIR OR LIQUID MAINS HEATER** Small coil heater made for heating air or liquids. Will not corrode, lasts for years. Coil size 3" x 2" mounted on a metal plate for easy fixing. 4" dia. Price £3.00. Ref. 3P78 or 4 for £10.00. Our ref. 10P76.

**EX-EQUIPMENT POWER SUPPLIES** Various makes and specs. Ideal bench supply. Only £8.00. Our ref. 8P36.

**ACORN DATA RECORDER** Made for the Electron or BBC computer but suitable for others. Includes mains adaptor, leads and book. £12.00. Ref. 12P15.

**PTFE COATED SILVER PLATED CABLE** 19 strands of .45mm copper will carry up to 30A and is virtually indestructible. Available in red or black. Regular price is over £120 per reel. Our price only £20.00 for 100m reel. Ref. 20P21 or 1 of each for £35.00. Ref 35P2. Makes absolutely superb speaker cable!

**NEW PIR SENSORS** Infra red movement sensors will switch up to 500W mains. UK made. 12 months manufacturers warranty. 15-20m range with a 0-10mm timer, adjustable wall bracket. Only £20.00. Ref. 20P24. Also available to switch 1000watts. Our ref: 25P16. Price £25.

**GEARBOX KITS** Ideal for models, etc. Contains 18 gears (2 of each size), 4 x 50mm axles and a powerful adjustable speed motor. 9-12V operation. All the gears, etc. are 2mm push fit. £3.00 for the complete kit. Ref. 3P93.

**MINI HIFI SPEAKERS** Made for televisions, etc. Two sizes available. 70mm x 57mm 3W 8 ohm, 2 for £3.00. Ref 3P99. 127mm x 57mm 5W 8 ohm, 2 for £3.00. Ref. 3P100.

**SPECTRUM SOUND BOX** Add sound to your Spectrum with this device. Just plug in. Complete with speaker, volume control and nicely boxed. A snip at only £4.00. Our ref. 4P53.

**BBC JOYSTICK INTERFACE** Converts a BBC joystick port to an Atari type port. Price £2.00. Our ref. 2P261.

**TELEPHONE EXTENSION LEAD** 5m phone extension lead with plug on one end, socket on the other. White. Price £3.00. Our ref. 3P70 or 10 leads for only £19.00! Ref. 19P2.

**LCD DISPLAY** 4½" digits supplied with connection data £3.00. Ref. 3P77 or 5 for £10. Ref. 10P78.

**CROSS OVER NETWORK** 8 Ohm 3 way for tweeter midrange and woofer nicely cased with connections marked. Only £2.00. Our ref. 2P255 or 10 for £15.00. Ref. 15P32.

**BASE STATION MICROPHONE** Top quality uni-directional electret condenser mic 600r impedence sensitivity 16-18KHz – 68db built in chime complete with mic stand bracket. £15.00. Ref. 15P28.

**MICROPHONE STAND** Very heavy chromed mic stand, magnetic base 4" high. £3.00 if ordered with above mic. Our ref. 3P80.

**SOLAR POWERED NICAD CHARGER** 4 Nicad AA battery charger. Charges 4 batteries in 8 hours. Price £6.00. Our ref. 6P3.

**SOLDERING IRON STAND** Price £3.00. Our ref. 3P66.

**INCAR GRAPHIC EQUALIZER/BOOSTER** Slimline 7 band with built in 30 watts per channel amplifier. 12V operation, twin 5 LED power indicators, 20-21KHz with front and rear fader plus headphone output! Brand new and guaranteed. Only £25.00. Ref. 25P14.

**SHARP PLOTTER PRINTER.** New 4 colour printer originally intended for Sharp computers but may be adaptable for other machines. Complete with pens, paper, etc. Price £16.00. Our ref. 16P3.

**CENTRONICS ADAPTER KIT** Converts the above plotter/printer to Centronics compatible. Price £4.00. Our ref. 4P57.

**CAR IONIZER KIT** Improve the air in your car, clears smoke and helps prevent fatigue. Case req. Price £12.00. Our ref. 12P8.

**NEW FM BUG KIT** New design with PCB embedded coil 9v operation. Priced at £5.00. Our ref. 5P158.

**NEW PANEL METERS 50UA** movement with three different scales that are brought into view with a lever. Price only £3.00. Ref. 3P81.

**STROBE LIGHTS** Fit a standard edison screw light fitting 240V 40/min. flash rate available in yellow, blue, green and red. Complete with socket. Price £10 each. Ref. 10p80 (state colour required).

**ELECTRONIC SPEED CONTROL KIT** Suitable for controlling our powerful 12v motors. Price £17.00. Ref. 17P3 (heatsink required).

**EXTENSION CABLE WITH A DIFFERENCE** It is flat on one side making it easy to fix and look tidy. 4 core, suitable for alarms, phones etc. Our price only £5.00 for 50m reel. Ref. 5P153.

**METAL PROJECT BOX** Ideal for battery charger, power supply etc. Sprayed grey size 8" x 4" x 4½". Louvred for ventilation. Price £3.00. Ref. 3P75.

VOL 19 No. 7 JULY 1990

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ABC

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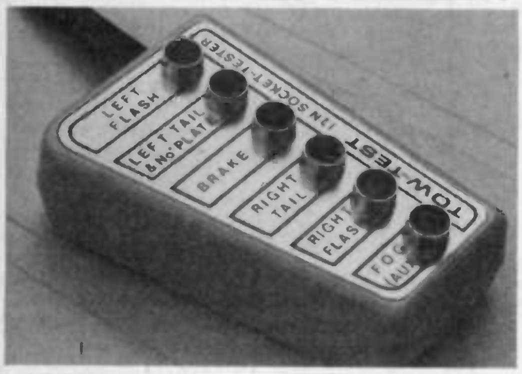
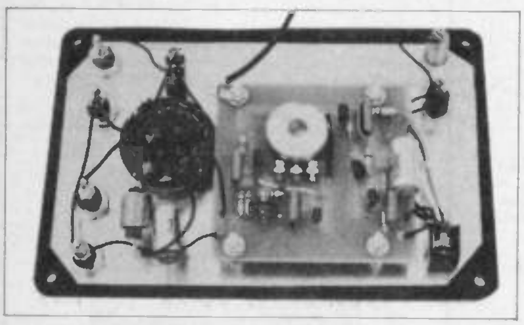
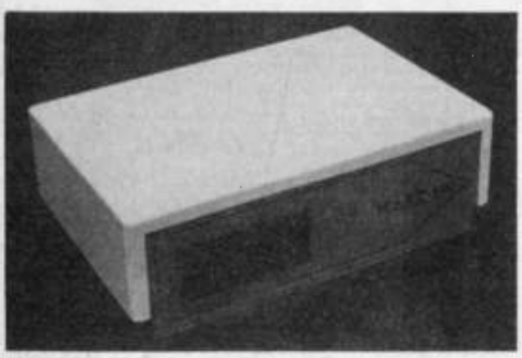
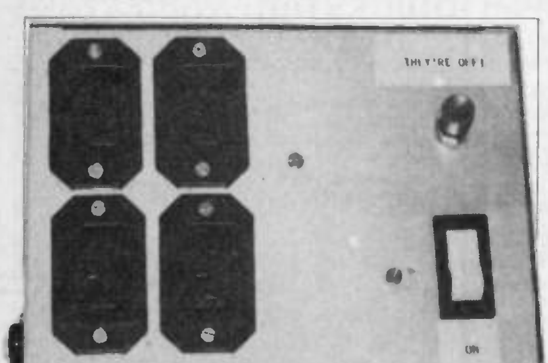
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .







## *Projects*



## *Series*



## *Features*





***Our August '90 Issue will be published on Friday, 6 July 1990. See page 427 for details.***



*Cover photograph by Reflections of Bournemouth*

# NEXT MONTH

## PRESSURE PAD ALARM

*Protect your valuables with this portable anti-theft system. This burglar alarm emits a loud tone when an intruder steps on a pressure pad placed under a window or other likely points of entry. The system is portable with self-contained batteries so could be found useful in many temporary or semi-permanent security applications such as for garden sheds or boats. It can operate a wide variety of 12V audible warning devices including high-powered sirens of up to 3A rating. The pad may be situated any reasonable distance from the main unit – if the interconnecting wire is cut or the plug pulled out, the alarm will sound.*

## SIMPLE METRONOME

*A "flash" and a "tick" for musicians. A linear control with excellent stability from a simple oscillator circuit. Variable from 40 to 200 beats per minute.*

## GAS RESERVE INDICATOR

*Make sure your camping gas supply does not let you down. The gas supply in a caravan is vital to maintain the refrigerator and cooking facilities. Failure is always inconvenient and can be disastrous where no back-up supply is available. Motor caravanners – due to shortage of space – often carry only one small (6lb) butane cylinder. This device will therefore be of particular interest to them. The indicator displays cylinder contents on a five-point scale – thermometer fashion – using a row of l.e.d's.*

## CHOOSING AND USING TEST EQUIPMENT

*POWER SUPPLIES • LOGIC PROBES • DIGITAL FREQUENCY METERS • R.F. GENERATORS • A.F. GENERATORS • SIGNAL TRACERS • MILLIVOLTMETERS • COMPONENT TESTERS*

**EVERYDAY ELECTRONICS**

AUGUST ISSUE ON SALE FRIDAY 6 JULY 1990

## TRANSISTORS

| | |
|---|---|
| AAY32 | 9p |
| AC107 | 40p |
| AC125 | 25p |
| AC126 | 25p |
| AC127 | 21p |
| AC128 | 21p |
| AC128K | 26p |
| AC141K | 30p |
| AC142K | 30p |
| AC176 | 22p |
| AC176K | 28p |
| AC187 | 21p |
| AC187K | 28p |
| AC188 | 21p |
| ACY18 | 48p |
| ACY19 | 48p |
| AD149 | 60p |
| AF124 | 50p |
| AF125 | 50p |
| AF126 | 50p |
| AF127 | 50p |
| AF139 | 30p |
| AF239 | 30p |
| AF379 | 45p |
| BA145 | 10p |
| BA148 | 10p |
| BA154 | 6p |
| BA157 | 12p |
| BB105B | 18p |
| BB205B | 24p |
| BC107 | 8p |
| BC108 | 8p |
| BC109 | 8p |
| BC109C | 10p |
| BC116 | 10p |
| BC118 | 11p |
| BC140 | 20p |
| BC141 | 20p |
| BC142 | 20p |
| BC143 | 20p |
| BC147 | 8p |
| BC148 | 8p |
| BC149 | 8p |
| BC157 | 8p |
| BC159 | 8p |
| BC160 | 30p |
| BC171 | 10p |
| BC172 | 10p |
| BC177 | 14p |
| BC178 | 14p |
| BC179 | 14p |
| BC182 | 7p |
| BC182L | 7p |
| BC183 | 7p |
| BC183L | 7p |
| BC184 | 7p |
| BC184L | 7p |
| BC212 | 7p |
| BC212L | 7p |
| BC213 | 7p |
| BC213L | 7p |
| BC214 | 7p |
| BC214L | 7p |
| BC237 | 7p |
| BC238 | 7p |
| BC239 | 7p |
| BC300 | 20p |
| BC301 | 20p |
| BC302 | 20p |
| BC303 | 20p |
| BC304 | 25p |
| BC308 | 10p |
| BC327 | 7p |
| BC328 | 7p |
| BC337 | 7p |
| BC338 | 7p |
| BC441 | 28p |
| BC446 | 8p |
| BC449 | 15p |
| BC461 | 28p |
| BC477 | 18p |
| BC478 | 18p |
| BC479 | 18p |
| BC489 | 20p |
| BC490 | 18p |
| BC516 | 22p |
| BC528 | 22p |
| BC537 | 25p |
| BC546 | 8p |
| BC547 | 8p |
| BC548 | 8p |
| BC549 | 8p |
| BC550 | 8p |
| BC556 | 8p |
| BC557 | 7p |
| BC558 | 8p |
| BC559 | 8p |
| BC560 | 8p |
| BC637 | 20p |
| BC638 | 20p |
| BC639 | 20p |
| BC640 | 20p |
| BCY32 | 200p |
| BCY33 | 200p |
| BCY34 | 200p |
| BCY70 | 16p |
| BCY71 | 16p |
| BCY72 | 16p |
| BD115 | 30p |
| BD124P | 50p |
| BD124 | 110p |
| BD131 | 25p |
| BD132 | 25p |
| BD133 | 50p |
| BD135 | 20p |
| BD136 | 20p |
| BD137 | 20p |
| BD138 | 20p |
| BD139 | 20p |
| BD140 | 20p |
| BD142 | 45p |
| BD150 | 30p |
| BD157 | 38p |
| BD158 | 38p |
| BD166 | 30p |
| BD175 | 30p |
| BD177 | 30p |
| BD179 | 32p |
| BD181 | 45p |
| BD182 | 60p |
| BD184 | 60p |
| BD187 | 30p |
| BD201 | 33p |
| BD202 | 38p |
| BD203 | 42p |
| BD204 | 42p |
| BD222 | 31p |
| BD225 | 31p |
| BD232 | 31p |
| BD233 | 32p |
| BD234 | 32p |
| BD235 | 28p |

| | |
|---|---|
| BD236 | 30p |
| BD237 | 21p |
| BD238 | 24p |
| BD239 | 30p |
| BD240 | 40p |
| BD241A | 40p |
| BD243A | 50p |
| BD244 | 50p |
| BD245 | 50p |
| BD246A | 50p |
| BD265 | 45p |
| BD267 | 45p |
| BD269 | 45p |
| BD278 | 50p |
| BD311 | 100p |
| BD312 | 100p |
| BD313 | 100p |
| BD314 | 100p |
| BD315 | 150p |
| BD316 | 150p |
| BD317 | 150p |
| BD318 | 150p |
| BD331 | 40p |
| BD332 | 40p |
| BD361 | 60p |
| BD362 | 60p |
| BD370 | 30p |
| BD371 | 30p |
| BD410 | 30p |
| BD433 | 28p |
| BD434 | 30p |
| BD435 | 31p |
| BD436 | 30p |
| BD437 | 28p |
| BD438 | 36p |
| BD439 | 40p |
| BD440 | 40p |
| BD441 | 40p |
| BD442 | 40p |
| BD520 | 60p |
| BD533 | 50p |
| BD534 | 38p |
| BD535 | 38p |
| BD536 | 38p |
| BD537 | 40p |
| BD538 | 40p |
| BD643 | 50p |
| BD645 | 50p |
| BD647 | 50p |
| BD649 | 50p |
| BD651 | 50p |
| BD675 | 40p |
| BD676 | 40p |
| BD677 | 38p |
| BD678 | 40p |
| BD680 | 40p |
| BD679 | 40p |
| BD681 | 45p |
| BD682 | 45p |
| BD705 | 50p |
| BD707 | 50p |
| BD709 | 50p |
| BD711 | 50p |
| BD736 | 50p |
| BD826 | 50p |
| BD828 | 50p |
| BD876 | 50p |
| BD897 | 50p |
| BD899 | 50p |
| BD901 | 50p |
| BD977 | 50p |
| BDX32 | 100p |
| BDX33 | 60p |
| BDX53 | 60p |
| BDX65 | 80p |
| BDW23 | 55p |
| BDW24 | 55p |
| BDW93 | 50p |
| BDW94 | 60p |
| BDY20 | 100p |
| BDY92 | 100p |
| BF137 | 35p |
| BF154 | 25p |
| BF167 | 30p |
| BF173 | 40p |
| BF178 | 30p |
| BF180 | 16p |
| BF181 | 18p |
| BF183 | 20p |
| BF185 | 20p |
| BF194 | 7p |
| BF195 | 7p |
| BF196 | 8p |
| BF197 | 10p |
| BF198 | 10p |
| BF199 | 8p |
| BF200 | 16p |
| BF225 | 30p |
| BF240 | 16p |
| BF245 | 25p |
| BF254 | 15p |
| BF255 | 20p |
| BF256 | 18p |
| BF257 | 18p |
| BF258 | 18p |
| BF259 | 18p |
| BF262 | 25p |
| BF263 | 28p |
| BF270 | 18p |
| BF273 | 15p |
| BF311 | 21p |
| BF324 | 25p |
| BF336 | 20p |
| BF337 | 20p |
| BF338 | 20p |
| BF355 | 28p |
| BF362 | 30p |
| BF367 | 13p |
| BF371 | 17p |
| BF392 | 18p |
| BF420 | 16p |
| BF421 | 18p |
| BF422 | 21p |
| BF423 | 25p |
| BF450 | 20p |
| BF455 | 14p |
| BF458 | 19p |
| BF459 | 19p |
| BF461 | 60p |
| BF462 | 52p |
| BF469 | 30p |
| BF470 | 28p |
| BF471 | 28p |
| BF472 | 28p |
| BF479 | 30p |
| BF493 | 18p |
| BF494 | 16p |
| BF495 | 16p |
| BF506 | 25p |
| BF595 | 16p |
| BF596 | 16p |
| BF615 | 30p |
| BF617 | 30p |
| BF757 | 40p |
| BF758 | 41p |

| | |
|---|---|
| BF759 | 40p |
| BF760 | 40p |
| BF763 | 40p |
| BF869 | 22p |
| BF870 | 22p |
| BF871 | 22p |
| BF872 | 23p |
| BF960 | 38p |
| BF961 | 35p |
| BF963 | 40p |
| BF964 | 38p |
| BF966 | 40p |
| BFR40 | 25p |
| BFR79 | 25p |
| BFR90 | 52p |
| BFR91 | 99p |
| BFT37 | 130p |
| BFT42 | 30p |
| BFT43 | 30p |
| BFT84 | 30p |
| BFW92 | 35p |
| BFX29 | 20p |
| BFX84 | 20p |
| BFX85 | 20p |
| BFX87 | 15p |
| BFX88 | 15p |
| BFX89 | 60p |
| BFY17 | 30p |
| BFY18 | 40p |
| BFY50 | 14p |
| BFY51 | 14p |
| BFY52 | 14p |
| BFY56 | 25p |
| BFY64 | 25p |
| BFY90 | 45p |
| BLY48 | 85p |
| BR100 | 14p |
| BR101 | 43p |
| BR103 | 37p |
| BR303 | 85p |
| BRY39 | 55p |
| BRY49 | 38p |
| BRY56 | 33p |
| BS574 | 33p |
| BSX20 | 15p |
| BSX26 | 18p |
| BSX29 | 19p |
| BT100A | 70p |
| BT106 | 180p |
| BT109 | 90p |
| BT116 | 80p |
| BT119 | 100p |
| BT138 | 60p |
| BT146 | 99p |
| BT151 | 58p |
| BTY79 | 140p |
| BU100A | 110p |
| BU104 | 100p |
| BU105 | 80p |
| BU108 | 100p |
| BU109 | 100p |
| BU110 | 110p |
| BU111 | 140p |
| BU124 | 60p |
| BU126 | 70p |
| BU180 | 150p |
| BU184 | 100p |
| BU204 | 75p |
| BU205 | 70p |
| BU206 | 100p |
| BU208 | 70p |
| BU208D | 80p |
| BU209 | 140p |
| BU225 | 190p |
| BU226 | 190p |
| BU312 | 120p |
| BU325 | 55p |
| BU326 | 75p |
| BU406 | 85p |
| BU406D | 95p |
| BU407 | 60p |
| BU407D | 95p |
| BU408 | 85p |
| BU408D | 95p |
| BU409 | 95p |
| BU426A | 75p |
| BU500 | 110p |
| BU508A | 85p |
| BU508D | 90p |
| BU536 | 150p |
| BU526 | 80p |
| BU546 | 140p |
| BU608 | 150p |
| BU626 | 150p |
| BU636 | 150p |
| BU801 | 95p |
| BU806 | 80p |
| BU807 | 75p |
| BU902 | 130p |
| BU903 | 130p |
| BU920 | 130p |
| BU921 | 130p |
| BU922 | 130p |
| BU930 | 130p |
| BUT11A | 90p |
| BUT56A | 250p |
| BUX80 | 180p |
| BUX82 | 180p |
| BUX84 | 50p |
| BUX85 | 50p |
| BUY69A | 200p |
| BUY71 | 300p |
| C106D | 28p |
| MEO411 | 38p |
| MEO414 | 125p |
| ME3001 | 12p |
| ME4103 | 12p |
| ME6001 | 12p |
| ME6002 | 15p |
| ME8001 | 15p |
| ME9021 | 12p |
| MJ802 | 350p |
| MJ900 | 200p |
| MJ1000 | 200p |
| MJ1001 | 200p |
| MJ10012 | 300p |
| MJ15001 | 325p |
| MJ15002 | 300p |
| MJ15003 | 325p |
| MJ15004 | 370p |
| MJ15022 | 400p |
| MJ2501 | 110p |
| MJ2955 | 55p |
| MJ3000 | 115p |
| MJ3001 | 115p |
| MJE29A | 30p |
| MJE30A | 30p |
| MJE340 | 25p |
| MJE350 | 80p |
| MJE520 | 30p |
| MJE2955K | 90p |
| MP8111 | 40p |
| MP8112 | 45p |
| MP8113 | 55p |

| | |
|---|---|
| MP8512 | 50p |
| MPS65781 | 20p |
| MPS9012 | 20p |
| MPS9013 | 20p |
| MPS9014 | 20p |
| MPS9015 | 20p |
| MPSA05 | 15p |
| MPSA06 | 15p |
| MPSA13 | 15p |
| MPSA20 | 15p |
| MPSA42 | 15p |
| MPSA43 | 15p |
| MPSA65 | 25p |
| MPSA66 | 25P |
| MPSA70 | 15p |
| MPSA92 | 20p |
| MPSA93 | 20p |
| MR510 | 35p |
| MR856 | 36p |
| OC28 | 250p |
| OC29 | 250p |
| OC35 | 250p |
| OC36 | 250p |
| OC45 | 50p |
| OC71 | 30p |
| OC72 | 50p |
| OC200 | 180p |
| OT121 | 120p |
| R2008B | 100p |
| R2010B | 100p |
| S2800D | 52p |
| S2800M | 72p |
| T2800D | 52p |
| T2800M | 72p |
| TIP29 | 15p |
| TIP29A | 22p |
| TIP29C | 25p |
| TIP30 | 25p |
| TIP30C | 30p |
| TIP31A | 24p |
| TIP31C | 30p |
| TIP32 | 24p |
| TIP32A | 24p |
| TIP32C | 28p |
| TIP33 | 50p |
| TIP33C | 60p |
| TIP34 | 50p |
| TIP34C | 60p |
| TIP35C | 65p |
| TIP36C | 65p |
| TIP41A | 22p |
| TIP41C | 25p |
| TIP42A | 22p |
| TIP42C | 25p |
| TIP47 | 40p |
| TIP48 | 40p |
| TIP49 | 45p |
| TIP50 | 60p |
| TIP51 | 120p |
| TIP52 | 120p |
| TIP53 | 120p |
| TIP54 | 140p |
| TIP105 | 65p |
| TIP106 | 65p |
| TIP107 | 65p |
| TIP110 | 47p |
| TIP111 | 50p |
| TIP112 | 40p |
| TIP115 | 45p |
| TIP116 | 50p |
| TIP117 | 50p |
| TIP120 | 43p |
| TIP121 | 46p |
| TIP122 | 47p |
| TIP125 | 47p |
| TIP126 | 56p |
| TIP127 | 56p |
| TIP130 | 30p |
| TIP131 | 30p |
| TIP132 | 30p |
| TIP141 | 90p |
| TIP142 | 90p |
| TIP145 | 65p |
| TIP146 | 90p |
| TIP147 | 100p |
| TIP150 | 90p |
| TIP151 | 90p |
| TIP2955 | 42p |
| TIP3054 | 45p |
| TIP3055 | 42p |
| TIS44 | 20p |
| TIS61 | 15p |
| TIS90 | 15p |
| TIS91 | 18p |
| VK1010 | 88p |
| VN10KM | 60p |
| VN66AF | 100p |
| VN88AF | 115p |
| ZTX107 | 11p |
| ZTX108 | 11p |
| ZTX109 | 12p |
| ZTX212 | 27p |
| ZTX300 | 13p |
| ZTX301 | 16p |
| ZTX302 | 16p |
| ZTX303 | 24p |
| ZTX304 | 17p |
| ZTX320 | 29p |
| ZTX500 | 13p |
| ZTX501 | 13p |
| ZTX502 | 18p |
| ZTX503 | 18p |
| ZTX504 | 25p |
| ZTX550 | 24p |
| 2N.696 | 26p |
| 2N.697 | 22p |
| 2N.698 | 40p |
| 2N.706 | 22p |
| 2N.708 | 22p |
| 2N.914 | 28p |
| 2N.930 | 18p |
| 2N.1131 | 28p |
| 2N.1132 | 28p |
| 2N.1613 | 24p |
| 2N.1711 | 24p |
| 2N.1893 | 30p |
| 2N.2102 | 50p |
| 2N.2218A | 20p |
| 2N.2219 | 24p |
| 2N.2221 | 24p |
| 2N.2222 | 23p |
| 2N.2369 | 15p |
| 2N.2484 | 20p |
| 2N.2646 | 40p |
| 2N.2904 | 20p |
| 2N.2905 | 20p |
| 2N.2906 | 18p |
| 2N.2907 | 18p |
| 2N.2926 | 8p |
| 2N.3019 | 28p |
| 2N.3053 | 18p |
| 2N.3054 | 40p |
| 2N.3055 | 38p |
| 2N.3055H | 50p |
| 2N.3440 | 58p |

| | |
|---|---|
| 2N.3442 | 85p |
| 2N 3583 | 90p |
| 2N.3585 | 120p |
| 2N.3702 | 9p |
| 2N 3703 | 9p |
| 2N 3704 | 9p |
| 2N 3705 | 9p |
| 2N 3706 | 9p |
| 2N 3707 | 9p |
| 2N 3708 | 9p |
| 2N 3710 | 12p |
| 2N 3711 | 12p |
| 2N 3771 | 85p |
| 2N 3772 | 90p |
| 2N 3773 | 110p |
| 2N 3799 | 18p |
| 2N 3819 | 29p |
| 2N 3866 | 68p |
| 2N 3903 | 11p |
| 2N 3904 | 11p |
| 2N 3905 | 11p |
| 2N 3906 | 11p |
| 2N 4031 | 25p |
| 2N 4036 | 25p |
| 2N 4037 | 25p |
| 2N 4062 | 12p |
| 2N 4064 | 100p |
| 2N 4401 | 12p |
| 2N 4403 | 12p |
| 2N 4443 | 76p |
| 2N 5061 | 20p |
| 2N 5088 | 20p |
| 2N 5163 | 45p |
| 2N 5192 | 50p |
| 2N 5241 | 500p |
| 2N 5245 | 45p |
| 2N 5294 | 30p |
| 2N 5296 | 30p |
| 2N 5320 | 90p |
| 2N 5321 | 60p |
| 2N 5366 | 25p |
| 2N 5401 | 12p |
| 2N 5448 | 12p |
| 2N 5496 | 80p |
| 2N 6107 | 40p |
| 2N 6109 | 40p |
| 2N 6254 | 110p |
| 2N 6292 | 40p |
| 2N 6384 | 120p |
| 2N 6385 | 120p |
| 2N 6403 | 160p |

### DIODES RECTIFIER DIODES

| | |
|---|---|
| BY100 | 40p |
| BY103 | 32p |
| BY126 | 6p |
| BY127 | 8p |
| BY133 | 8p |
| BY164 | 40p |
| BY179 | 35p |
| BY184 | 32p |
| BY196 | 20p |
| BY206 | 11p |
| BY207 | 11p |
| BY208 | 18p |
| BY210 | 22p |
| BY225 | 120p |
| BY226 | 18p |
| BY227 | 19p |
| BY228 | 32p |
| BY296 | 20p |
| BY298 | 26p |
| BY299 | 28p |
| BYX10 | 15p |
| BYX55/350 | 30p |
| BYX55/600 | 30p |
| BYX70/500 | 32p |
| BYX70/800 | 36p |
| OA91 | 8p |
| OA200 | 7p |
| OA202 | 7p |
| IN.914 | 2p |
| IN 4001 | 4p |
| IN.4002 | 4p |
| IN.4003 | 4p |
| IN 4004 | 4p |
| IN.4005 | 4p |
| IN.4006 | 4p |
| IN.4007 | 5p |
| IN.4148 | 2p |
| IN.5400 | 9p |
| IN.5401 | 10p |
| IN.5402 | 10p |
| IN.5403 | 11p |
| IN.5404 | 11p |
| IN.5405 | 12p |
| IN.5406 | 13p |
| IN.5407 | 13p |
| IN.5408 | 13p |
| SKE4F2/06 | 50p |
| SKE4F2/08 | 70p |
| SKE4F2/10 | 90p |

### I.C. SOCKETS

| | |
|---|---|
| 8 PIN | 6p |
| 14 PIN | 8p |
| 16 PIN | 9p |
| 18 PIN | 12p |
| 20 PIN | 14p |
| 22 PIN | 16p |
| 24 PIN | 18p |
| 28 PIN | 20p |
| 40 PIN | 25p |

### ZENER

400 MV
BZY88 RANGE
2V7 TO 39V 6p
1.3W
BZX61 RANGE
2V7 TO 39V 12p

### VOLTAGE REGULATORS

| | |
|---|---|
| 7805 | 35p |
| 7806 | 35p |
| 7808 | 35p |
| 7812 | 35p |
| 7815 | 35p |
| 7818 | 35p |
| 7824 | 35p |
| 7905 | 35p |
| 7906 | 40p |
| 7908 | 40p |
| 7912 | 40p |
| 7915 | 40p |
| 7918 | 40p |
| 7924 | 40p |

| | |
|---|---|
| 78L05 | 28p |
| 78L08 | 28p |
| 78L12 | 28p |
| 78L15 | 28p |
| 78L18 | 28p |
| 78L24 | 28p |
| 79L05 | 40p |
| 79L08 | 40p |
| 79L12 | 40p |
| 79L15 | 40p |
| 7818KC | 100p |
| 7824KC | 100p |
| LM309K | 100p |
| LM317K | 220p |
| LM317T | 180p |
| LM323K | 420p |
| LM723 | 40p |
| 78HGKC | 570p |
| 78H05KC | 800p |
| 78H12KC | 700p |
| 78GU1C | 190p |
| 79GU1C | 215p |
| 79HGKC | 800p |

### L.E.D.'S

| | |
|---|---|
| LED 3MM RED | 5p |
| LED 3MM YELLOW | 10p |
| LED 3MM GREEN | 10p |
| LED 5MM RED | 5p |
| LED 5MM YELLOW | 10p |
| LED 5MM GREEN | 10p |

### RECTANGULAR L.E.D.'S

| | |
|---|---|
| RED | 10p |
| GREEN | 15p |
| YELLOW | 15p |

### LINEAR IC's

| | |
|---|---|
| LF-347 | 110p |
| LF-351 | 45p |
| LF-353 | 48p |
| LF-355 | 60p |
| LF-356 | 60p |
| LF-357 | 70p |
| LF-398 | 300p |
| LM-301 | 26p |
| LM-307 | 42p |
| LM-308CN | 70p |
| LM-311 | 35p |
| LM-318 | 120p |
| LM-319 | 165p |
| LM-324 | 35p |
| LM-334Z | 115p |
| LM-335Z | 120p |
| LM-337 | 250p |
| LM-339 | 37p |
| LM-348 | 55p |
| LM-358 | 45p |
| LM-377 | 220p |
| LM-380 | 100p |
| LM-381 | 150p |
| LM-382 | 130p |
| LM-384 | 130p |
| LM-386 | 85p |
| LM-387 | 100p |
| LM-392 | 100p |
| LM-393 | 55p |
| LM-709DIL | 30p |
| LM-710 | 45p |
| LM-711 | 85p |
| LM-723 | 40p |
| LM-733 | 60p |
| LM-741DIL | 18p |
| LM741MET | 45p |
| LM-747 | 58p |
| LM-748 | 35p |
| LM-1458 | 33p |
| LM-1889 | 400p |
| LM-3900 | 40p |
| LM-3909 | 80p |
| LM-3911 | 160p |
| LM-3914 | 250p |
| LM-3915 | 255p |
| LM-3916 | 290p |
| MB-3515 | 240p |
| MB-3614 | 180p |
| MB-3712 | 140p |
| MB-3713 | 130p |
| MB-3714 | 270p |
| MB-3715 | 250p |
| MB-3722 | 310p |
| MB-3730 | 200p |
| MB-3731 | 300p |
| MB-3756 | 230p |
| MB-3759 | 200p |
| MB-8719 | 360p |
| MC-1310P | 130p |
| MC-1455 | 45p |
| MC-1458 | 33p |
| MC-1469 | 290p |
| MC-1488 | 65p |
| MC-1489 | 65p |
| MC-1496 | 65p |

| | |
|---|---|
| MC-3302 | 70p |
| MC-3401 | 45p |
| MC-3403 | 60p |
| MC-3423 | 75p |
| NE-531 | 115p |
| NE-544 | 170p |
| NE-555 | 20p |
| NE-556 | 40p |
| NE-565 | 110p |
| NE-566 | 130p |
| NE-567 | 115p |
| NE-570 | 360p |
| NE-571 | 290p |
| NE-592 | 85p |
| NE-5532P | 140p |
| NE-5534P | 110p |

### 74 SERIES

| | |
|---|---|
| 7400 | 20p |
| 7401 | 16p |
| 7402 | 18p |
| 7403 | 20p |
| 7404 | 35p |
| 7405 | 10p |
| 7406 | 36p |
| 7407 | 36p |
| 7408 | 25p |
| 7409 | 20p |
| 7413 | 30p |
| 7414 | 45p |
| 7416 | 40p |
| 7417 | 32p |
| 7420 | 22p |
| 7421 | 25p |
| 7425 | 15p |
| 7430 | 25p |
| 7437 | 28p |
| 7438 | 32p |
| 7442 | 38p |
| 7447 | 60p |
| 7450 | 22p |
| 7451 | 10p |
| 7454 | 25p |
| 7470 | 30p |
| 7473 | 25p |
| 7474 | 35p |
| 7475 | 25p |
| 7481 | 90p |
| 7482 | 60p |
| 7485 | 28p |
| 7486 | 28p |
| 7489 | 75p |
| 7490 | 35p |
| 7492 | 45p |
| 7493 | 35p |
| 7495 | 48p |
| 7497 | 80p |
| 74107 | 30p |
| 74111 | 52p |
| 74116 | 85p |
| 74119 | 85p |
| 74122 | 40p |
| 74123 | 20p |
| 74125 | 40p |
| 74126 | 45p |
| 74132 | 42p |
| 74141 | 55p |
| 74145 | 70p |
| 74153 | 45p |
| 74155 | 45p |
| 74157 | 45p |
| 74160 | 50p |
| 74164 | 50p |
| 74167 | 35p |
| 74173 | 50p |
| 74174 | 60p |
| 74175 | 65p |
| 74176 | 45p |
| 74180 | 50p |
| 74182 | 45p |
| 74190 | 40p |
| 74196 | 40p |
| 74197 | 45p |
| 74393 | 70p |

### 74LS SERIES LOW POWER SCHOTTKY T.T.L.

| | |
|---|---|
| 74LS00 | 12p |
| 74LS01 | 12p |
| 74LS02 | 12p |
| 74LS03 | 12p |
| 74LS04 | 12p |
| 74LS05 | 12p |
| 74LS08 | 12p |
| 74LS09 | 14p |
| 74LS10 | 12p |
| 74LS11 | 12p |
| 74LS12 | 12p |
| 74LS13 | 20p |
| 74LS14 | 24p |
| 74LS15 | 14p |
| 74LS20 | 14p |
| 74LS21 | 14p |
| 74LS22 | 14p |
| 74LS24 | 35p |
| 74LS26 | 14p |
| 74LS27 | 14p |
| 74LS28 | 14p |

| | |
|---|---|
| 74LS30 | 14p |
| 74LS32 | 15p |
| 74LS33 | 15p |
| 74LS31 | 15p |
| 74LS38 | 15p |
| 74LS40 | 15p |
| 74LS42 | 25p |
| 74LS47 | 52p |
| 74LS48 | 48p |
| 74LS51 | 13p |
| 74LS54 | 13P |
| 74LS55 | 15p |
| 74LS73 | 24p |
| 74LS74 | 18p |
| 74LS75 | 24p |
| 74LS76 | 24p |
| 74LS78 | 24p |
| 74LS83 | 37p |
| 74LS85 | 37p |
| 74LS86 | 25p |
| 74LS90 | 26p |
| 74LS91 | 55p |
| 74LS92 | 32p |
| 74LS93 | 26p |
| 74LS95 | 41p |
| 74LS96 | 52p |
| 74LS107 | 28p |
| 74LS109 | 28p |
| 74LS112 | 28p |
| 74LS113 | 28P |
| 74LS114 | 28p |
| 74LS122 | 35p |
| 74LS123 | 35p |
| 74LS124 | 85p |
| 74LS125 | 30p |
| 74LS126 | 30p |
| 74LS132 | 30p |
| 74LS133 | 30p |
| 74LS136 | 30p |
| 74LS138 | 28p |
| 74LS139 | 28p |
| 74LS145 | 65p |
| 74LS147 | 90p |
| 74LS148 | 75p |
| 74LS151 | 27p |
| 74LS153 | 31p |
| 74LS154 | 78p |
| 74LS155 | 36p |
| 74LS156 | 36p |
| 74LS157 | 22p |
| 74LS158 | 27p |
| 74LS160 | 38p |
| 74LS161 | 38p |
| 74LS162 | 38p |
| 74LS163 | 36p |
| 74LS164 | 36p |
| 74LS165 | 50p |
| 74LS166 | 55p |
| 74LS168 | 60p |
| 74LS169 | 55p |
| 74LS170 | 68p |
| 74LS174 | 30p |
| 74LS175 | 32p |
| 74LS190 | 47p |
| 74LS191 | 43p |
| 74LS192 | 41p |
| 74LS193 | 41p |
| 74LS194 | 41p |
| 74LS193 | 44p |
| 74LS196 | 45p |
| 74LS197 | 42p |
| 74LS221 | 45p |
| 74LS240 | 45p |
| 74LS241 | 42p |
| 74LS242 | 43p |
| 74LS243 | 50p |
| 74LS244 | 40p |
| 74LS245 | 40p |
| 74LS247 | 40p |
| 74LS248 | 40p |
| 74LS249 | 70p |
| 74LS251 | 24p |
| 74LS253 | 36p |
| 74LS256 | 52p |
| 74LS257 | 32p |
| 74LS258 | 35p |
| 74LS259 | 50p |
| 74LS260 | 30p |
| 74LS266 | 22p |
| 74LS273 | 44p |
| 74LS279 | 33p |
| 74LS280 | 88p |
| 74LS283 | 51p |
| 74LS290 | 26p |
| 74LS293 | 26p |
| 74LS365 | 26p |
| 74LS366 | 31p |
| 74LS367 | 28p |
| 74LS368 | 30p |
| 74LS373 | 45p |
| 74LS374 | 45p |
| 74LS375 | 46p |
| 74LS390 | 42p |
| 74LS393 | 37p |
| 74LS399 | 68p |
| 74LS629 | 95p |
| 74LS641 | 88p |
| 74LS642 | 105p |
| 74LS644 | 105p |
| 74LS645 | 105p |
| 74LS670 | 62p |
| 74LS674 | 310p |
| 74LS687 | 250p |

### COMPUTER IC'S

| | |
|---|---|
| 2114 | 200p |
| 2532 | 330p |
| 2716 | 200p |
| 2732 | 280p |
| 2732A | 300p |
| 2764 | 240p |
| 27C64 | 550p |
| 27128 | 310p |
| 27256-25 | 400p |
| 41256-15 | 240p |
| 4116 | 75p |
| 4164-15 | 150p |
| 6116 | 150p |
| 6264-12 | 300p |
| 6502 | 300p |
| 6502A | 400p |
| 65C02 | 930p |
| 6503 | 570p |
| 6520 | 170p |
| 6522 | 330p |
| 6532 | 460p |
| 6545 | 880p |
| 6551 | 530p |
| 6800 | 210p |
| 6802 | 220p |
| 6803 | 800p |
| 6808 | 500p |
| 6809 | 600p |
| 6810 | 150p |
| 6818 | 380p |
| 6820 | 140p |
| 6821 | 140p |
| 6840 | 310p |
| 6845 | 620p |
| 6850 | 110p |
| 8080A | 400p |
| 8085A | 300p |
| 8086 | 500p |
| 8088 | 500p |
| 8155 | 360p |
| 8156 | 300p |
| 81LS95 | 120p |
| 81LS96 | 130p |
| 81LS97 | 130p |
| 81LS98 | 130p |
| 8224 | 240p |
| 8226 | 240p |
| 8243 | 250p |
| 8250 | 850p |
| 8251 | 270p |
| 8253 | 230p |
| 8255 | 200p |
| 8256 | 1200p |
| 8257 | 220p |
| 8259 | 280p |
| 8271 | 3400p |
| 8279 | 270p |
| 8284 | 440p |
| 8288 | 650p |
| 8748 | 1100p |
| 8755 | 1400p |
| AY3-1015 | 290p |
| SP0256AL2 | 500p |
| Z80ACPU | 150p |
| Z80BCPU | 400p |
| Z80ADMA | 500p |
| Z80AP10 | 220p |
| Z80BP10 | 340p |
| Z80ACTC | 200p |
| Z80BCTC | 320p |
| Z80AS10 | 460p |
| Z80AS10-1 | 580p |
| Z80AS10-2 | 580p |
| Z80ADART | 500p |

### SPECIAL OFFER DRAMS

| | |
|---|---|
| 4164-15 | 150p |
| 4164-12 | 175p |
| 41256-10 | 260p |
| 41256-12 | 240p |
| 41256-15 | 220p |
| 41464-12 | 360p |
| 41464-10 | 430p |
| 256KX4 | 1000p |
| 1MBRAM-8 | 1080p |
| 1MBRAM-10 | 1000p |

### SIPP

| | |
|---|---|
| 256KX9-10 | 3000p |
| 256KX9-8 | 3800p |
| 256KX9-7 | 5200p |
| 256KX9-6 | 6500p |

### SRAMS

| | |
|---|---|
| 6264LP15 | 250p |
| 6264LP12 | 280p |
| 6264LP10 | 300p |
| 32KX8-12 | 800p |
| 62256-12 | 800p |
| 27512 | 580p |

### SIMMS

| | |
|---|---|
| 1MX9-10 | 9500p |
| 1MX9-8 | 9800p |
| 1MX9-7 | 10500p |
| 2MX9-10 | 39000p |
| 4MX9-80 | 78000p |

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**Z8857** High quality Alphanumeric keyboard on aluminium frame 314 × 150mm. Contactless keys good for 20 million operations. Originally sold at over £100 each, they were used in a 'Printcom' portable terminal. Fully ASCII encoded output. Power supply + 5V and −12V @ 35mA. Supplied with comprehensive data. .......... **£14.95**

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### DISPLAYS

**Z4243** Display panel 152 × 112mm with NEC 8 digit display (Z1731); 8279-5, MC146818, 3 × uPA80C, & a couple of LS chips, crystal, etc. .......... **£2.90**

**Z1731** NEC Vacuum Fluorescent Display FIP8BII. 8 digit multiplexed output 10mm high. Heater voltage 2V, grid/anode voltage 24V. .......... **£2.00**

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**Z1637** LCD Display – Direct drive 3½ digit similar to RS 588-572. 12.7mm high digits. Op voltage 4-12 RMS @ 32Hz typ. Supplied with data. .......... **£2.00; 10+/ £1.75; 25+/£1.50; 100+/£1.00**

**Z1560** 7 seg display, 20mm high. Common anode. .......... **Only 70p! 25+/50p; 100+/42p**

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- Carrying case

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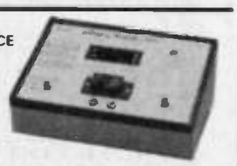
DC current 0-200μ-2m-200m-20Adc ±0.5%
Resist 0-200-2k-20k-200k-2M-20MΩ ±0.15%
Capacitance 0-20p-200n-20μF ±2.0%
Frequency 0-20k-200kHz ±2.0%
Transistor hFE 0-1000 NPN/PNP
Dims 176 × 90 × 36mm

### FREQUENCY COUNTER

**FC5250** 7 digit frequency counter for frequencies between 10Hz and 150MHz. Power on/off, ×1/×10 gate time and VHF/HF switches. Inputs via BNC sockets. Supplied complete with instruction manual and test lead. Requires an external 9Vdc nom 200mA power supply.
Price .......... **£65.00**

### DIGITAL CAPACITANCE METER



**CM3300** High accuracy AUTORANGING 3 digit capacitance meter. High resolution measurement in the range 0.1pF to 99900μF with 10 auto ranges. Range hold switch for batch testing capacitors. Range zero control. Inputs via spring terminals or test leads (supplied). Complete with leads and instruction manual.
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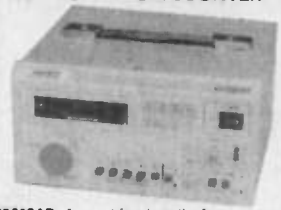
### AF GENERATOR/COUNTER



**AG2603AD** A combined audio frequency signal generator and frequency counter. A six character LED display allows direct reading of internally generated signal or signals from an external source. The frequency generator has a range of 10Hz to 1MHz with either square or sine waveforms and adjustable output level. The frequency counter has a range of 10Hz to 150MHz. Frequency range controlled by a 5-step selector and fine control. Adjustable ouput level with 0/20/40dB attenuator.

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Frequency range .......... 10Hz to 1MHz
Output Impedance .......... 600Ω unbalanced
Output control .......... 0-20-40dB and fine adjuster
Output control:
Sine .......... 8V rms max
square .......... 10V p-p max

**FREQUENCY COUNTER**
Frequency range .......... 10Hz to 150MHz
Input voltage .......... Less than 50mV
Max input voltage .......... 3V
Input impedance:
High frequency .......... 1MHz
VHF .......... 50Ω
Power .......... 240Vac 50Hz
Dims .......... 215 × 150 × 200mm
Price .......... **£175.00**

### RF GENERATOR/COUNTER

Similar in appearance to above with same frequency counter. Spec:
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RF Output .......... 100mV rms (up to 35MHz)
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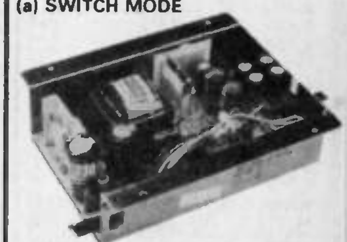
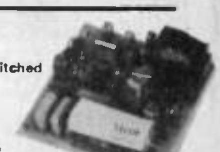


**ASTEC Model AA12531**
I/P: 115/230V ac 50/60Hz. O/P: V1 + 5V 5A; V2 + 12V 0.15A. Size: 160 × 104 × 45mm. Partially enclosed panel with fixing holes in steel case on 120 × 125mm centres. Inputs and Outputs are on colour coded leads; there is also an EEC socket on a flying lead. .......... **£6.95**

**Z660 Astec switched mode PSU Type AA7271.**



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**G712** As above, but mounted onto a rigid base plate complete with three 4mm terminals for power connections. A mounting bracket which clips into the base is also provided to accept a variety of components including switches and potentiometers, etc.
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KIT REF 835

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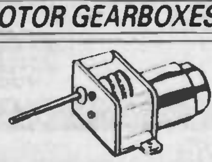

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| 596 | R.F. SIGNAL GENERATOR | £27.37 |
| 597 | FET VOLTMETER | £24.02 |
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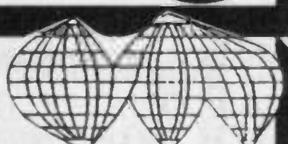
## INSULATION TESTER

EE APRIL 85

A reliable electronic tester which checks insulation resistance of wiring appliances etc., at 500 volts. The unit is battery powered simple and safe to operate. Leakage resistance of up to 100 Megohms can be read easily. One of our own designs and extremely popular.

KIT REF 444 **£21.89**



## 3 BAND SHORT WAVE RADIO

EE AUG 87

Covers 1.6–30 MHz in 3 bands using modern miniature coils. Audio output is via a built-in loudspeaker. Advanced design gives excellent stability, sensitivity and selectivity. Simple to build.

KIT REF 718 **£29.66**

## MINI STROBE

EE MAY '86

A hand held stroboscope which uses 6 "ultra bright" LEDs as the light source. Designed to demonstrate the principles of stroboscope examination, the unit is also suitable for measuring the speed of moving shafts etc. The flash rate control covers 170–20,000 RPM in two ranges.

KIT REF 529 **£15.50**

## EE EQUALISER

EE MAY '87

A mains powered Ioniser with an output of negative ions that give a refreshing feeling to the surrounding atmosphere. Negligible current consumption and all-insulated construction ensure that the unit is safe and economical in use. Easy to build on a simple PCB.

KIT REF 707 **£17.37**

## LIGHT RIDERS

EE OCT '86

Three projects under one title – all simulations of the Knight Rider lights from the TV series. The three are a lapel badge using six LEDs, a larger LED unit with 16 LEDs and a mains version capable of driving six main lamps totalling over 500 watts.

| | |
|---|---|
| KIT REF 559 CHASER LIGHT | £15.25 |
| KIT REF 560 DISCO LIGHTS | £21.93 |
| KIT REF 561 LAPEL BADGE | £11.40 |

## PET SCARER

EE MAY 89

Produces high power ultrasound pulses. L.E.D. flashes to indicate power output and level. Battery powered (9V–12V or via Mains Adaptor).

KIT REF 812
Mains Adaptor £1.98 **£14.49**

## DIGITAL FREQUENCY 200 MHz METER

EE NOV 86

An 8 digit meter reading from AF up to 200 MHz in two ranges. Large 0.5" Red LED display. Ideal for AF and RF measurements. Amateur and C.B. frequencies.

KIT REF 563 **£69.95**

## ACOUSTIC PROBE

EE NOV '87

A very popular project which picks up vibrations by means of a contact probe and passes them on to a pair of headphones or an amplifier. Sounds from engines, watches and speech travelling through walls can be amplified and heard clearly. Useful for mechanics, instrument engineers and nosey parkers!

KIT REF 740 **£19.58**

## MUSICAL DOORBELL

EE JAN '86

This project uses a special I.C. pre-programmed with 25 tunes and 3 chimes. A Magenta design, the circuit is battery powered and only draws current whilst producing sounds. Two rotary switches select the tune required. Provision is made for three bell pushes, each of which sounds a different tune, so that three points of entry can be identified.

KIT REF 497 **£20.95**

## EE TREASURE HUNTER

EE AUG '89

A sensitive pulse induction Metal Detector. Picks up coins and rings etc., up to 20cms deep. Low "ground effect". Can be used with search-head underwater. Easy to use and build, kit includes search-head, handle, case, PCB and all parts as shown.

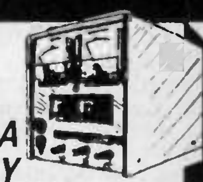
KIT REF 815 **£41.95**
Headphones **£1.99**

## DIGITAL CAPACITANCE METER

EE DEC 85

Simple and accurate (1%) measurement of capacitors from a few pF up to 1,000 $\mu$F. Clear 5-digit LED display indicates exact value. Three ranges – pF, nF, and $\mu$F. Just connect the capacitor, press the button and read the value.

KIT REF 493 **£46.46**



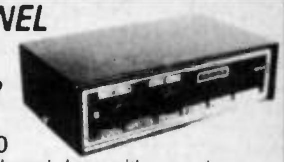
## MOSFET VARIABLE BENCH 25V 2.5A POWER SUPPLY

EE FEB 88

A superb design giving 0.25V and 0-2.5A. Twin panel meters indicate Voltage and Current. Voltage is variable from zero to 25V. A Toroidal transformer MOSFET power output device, and Quad op-amp IC design give excellent performance.

KIT REF 769 **£55.61**

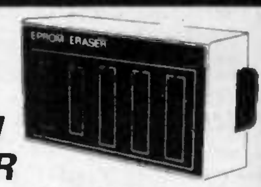
## 4 CHANNEL LIGHT CHASER



EE Jan '90

A 1000W per channel chaser with zero volt switching, hard drive, inductive load capability, mic sound sensor and sophisticated 'beat' detector. Chase steps to music or auto when quiet. Variable speed and mic. sens. LED mimic on front panel. Switchable for 3 or 4 channels. P552 output. Ideal for rope lights, pin spots, disco and display lighting.

KIT REF 833 **£31.45**



## EPROM ERASER

EE OCT '88

Safe low-cost unit capable of erasing up to four EPROM's simultaneously in less than twenty minutes. Operates from a 12V supply. Safety interlock. Convenient and simple to build and use.

KIT REF 790 **£27.90**

## STEPPING MOTOR INTERFACE

EE AUG '85

This interface enables 4 phase unipolar stepping motors to be driven from four output lines of any computer user port. The circuit is especially suitable for the ID35 motor and our MD200 which are commonly used in buggies and robot arms. Supplied complete with ribbon cable and connector for the BBC user port.

KIT REF 464 **£9.40**

# EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

**The Magazine for Electronic & Computer Projects**

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## UP TO DATE

Although we work on high tech. designs all the time and obviously electronics is our business we have been a little behind the times editorially. By this I mean that our typesetting has been done on rather old equipment. Recently we have come bang up to date with a fantastic new on screen page make-up system.

We now have a "sister" company *The Typesetting Bureau Ltd.*, which specialises in supplying a complete page make-up typesetting software package for just £185 plus VAT. The software provides WYSIWYG (what you see is what you get) page layout with over 200 type founts, variable in size from 1 to 1000 point, plus output on a 2000 dpi typesetter for £3 per foot (or less). But forget all the jargon – as you can see the quality of the final product is excellent.

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## OUT IN FRONT

I am pleased to be able to report that yet again EE is the UK's best selling monthly magazine for the electronics hobbyist. Our latest ABC figures show that we now outsell our nearest competitor by more than 5,000 copies each month. We hope and believe that this excellent trend is because you like what you read in EE and keep coming back for more. As I have said before, we always welcome constructive criticism of EE – so if there is anything you feel we can improve, or any project you would like to see published, just drop us a line – we will do our best to comply.

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# GRAND NATIONAL GAME

IVAN PATRICK GORE

## A grand day at the electronic races!

THIS GAME provides great fun at parties and could be useful as a fund-raiser at school open days and similar events. The original theme was *"a day at the races"* but the constructor's imagination could turn the basic circuits to many other ideas.

The display consists of pictures or models of four race horses with the odds against them winning clearly displayed. The true odds are 10:1, 5:1, 10:3 and 5:2 but the "bookmaker" will alter these to give an overall profit at the end of the session. For example, they could be marked 8:1, 4:1, 3:1 and 2:1 respectively. On pressing a switch momentarily, the "race" begins and lamps indicating each horse flash rapidly in turn. This continues for several seconds then stops suddenly with just one lamp illuminated – *that for the winning horse.*

Two versions of the circuit are described. The miniature one is battery-powered and uses 6V lamps. The alternative system, although using a battery to power the control circuit, operates mains bulbs. This would be more appropriate for village fetes and similar functions where a mains supply is available.

### CIRCUIT DESCRIPTION

The two-circuit diagrams for the Grand National Game are shown in Fig. 1. (miniature, battery version) and Fig. 2. (mains version). That part of the circuit up to diodes D2 and D11 is the same for both versions and centres on a CMOS dual integrated circuit timer, IC1, and a CMOS decade counter, IC2.

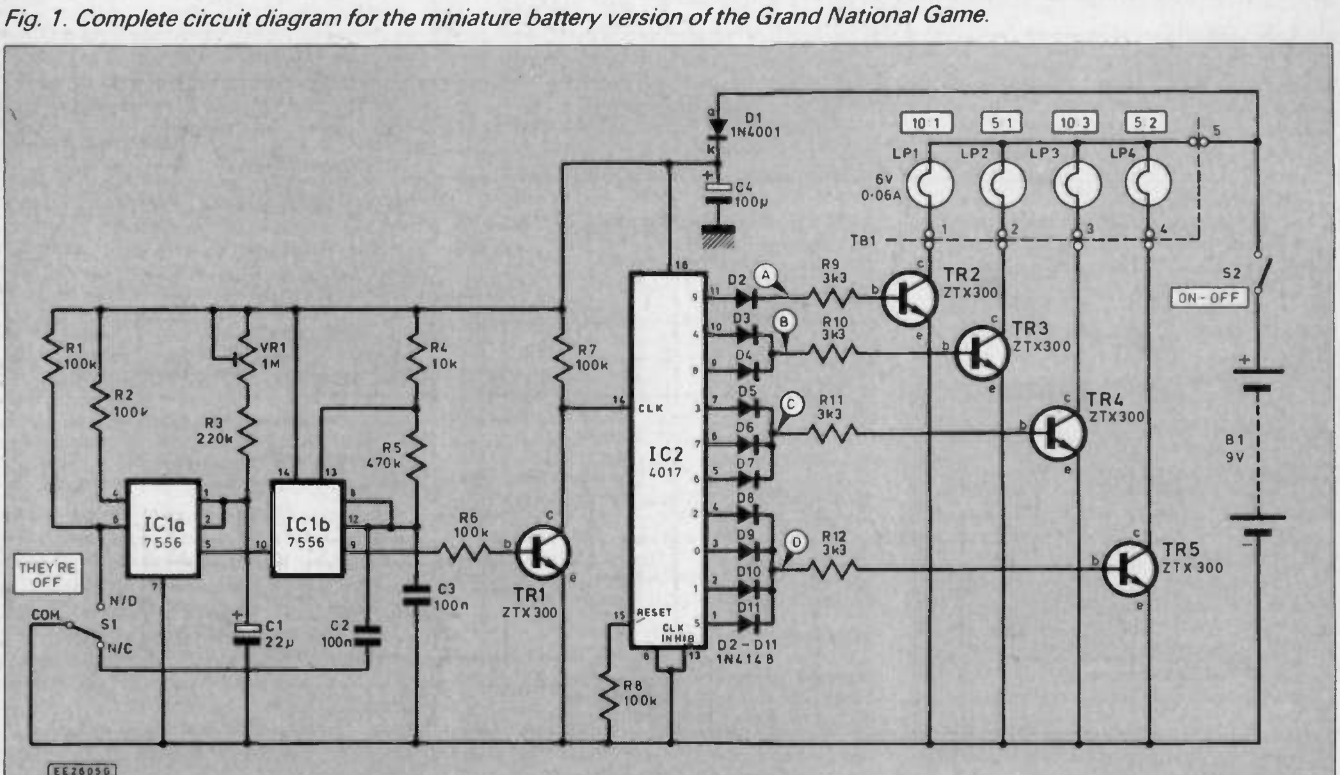
The first section, IC1a, of IC1 is configured as a monostable and with switch S2 (ON-OFF) switched on, a supply is established from battery, B1. The race is started by operating push-button switch S1 (THEY'RE OFF!).

Switch S1 has one pair of changeover contacts. The normally-open pair close and make IC1a trigger the input, pin 6, low momentarily. IC1a output, pin 5 then goes high (supply positive voltage) for a preset time then reverts to low.

The time during which the output remains high depends on the values of preset, VR1, fixed resistor, R3 and capacitor, C1. With the values specified this will lie between 5 and 20 seconds approximately depending on VR1 adjustment.

The output from IC1a pin 5 is connected to IC1b reset input, pin 10, and while high allows IC1b and associated components to operate as an astable multivibrator. This then delivers a stream of positive pulses from its output, pin 9, while the race is in progress. When pin 10 reverts to low, IC1b is disabled and the pulses stop. The frequency of the pulses is determined by resistors R4 and R5 in conjunction with capacitors C2 and C3.

*Fig. 1. Complete circuit diagram for the miniature battery version of the Grand National Game.*



When S1 is released, its normally-closed contacts connect capacitor C2 in parallel with C3 so increasing the capacitance appearing between IC1b pins 8 and 12 and the negative supply line. This reduces the flash repitition frequency.

With the specified component values, pulses will be produced at a rate of 20 per second (20Hz) approximately with S1 pressed and 10Hz when released. The purpose of this will be explained later.

Resistor R2 keeps IC1a reset input (pin 4) normally high. This enables the i.c. ready to receive a trigger pulse. Resistor R1 keeps IC1a trigger input (pin 6) high except while triggering – this prevents false operation due to possible stray pick-up.


## COUNTER

Pulses from IC1 pin 9 are applied to transistor TR1 base through resistor, R6, so the collector switches rapidly between high and low states. These are applied to IC2 clock input, pin 14, causing each one of the ten outputs 0 to 9 (pins 3, 2, 4, 7, 10, 1, 5, 6, 9 and 11 respectively) to go high in turn. IC2 then resets to begin a further cycle. This continues until IC1a inhibits IC1b, as previously described, whereupon the clock pulses stop and one output of IC2 will be left high.

There is clearly an equal chance of any particular output being on and this would not make the basis for a successful game. Diodes D2-D11 are therefore used to direct current from various combinations of outputs to the lamps indicating each horse.

Consider point *A*. This will be high only if pin 11 is high – a 10:1 chance. Point *B* will be high if either pin 9 or 10 is high – a 5:1 chance. Point *C* will be high if any of pins 5, 6 or 7 are high and with point *D*, a high state of any of pins 1, 2, 3 or 4 will make it high. These are 10:3 and 5:2 chances respectively. Of course, the horse which wins a particular race is a matter of chance but odds can be offered which will enable an overall profit to be made.

## MINIATURE VERSION

In the miniature circuit of the Grand National Game, Fig. 1, a high state at point *A*, *B*, *C* or *D* is applied to transistor TR2 to TR5 base as appropriate through current-limiting resistors, R9 to R12.

The collector current then operates the corresponding lamp, LP1 to LP4.

## MAINS VERSION

To operate mains lamps, a system of optical-coupling is used (see Fig. 2). This ensures that there is no electrical connection between the battery and high voltage sections of the circuit.

Four optically-coupled triacs, IC3 to IC6 are used for this. Within each of these components is an infra-red l.e.d. and a triac. These two sections are electrically isolated from one another but when the l.e.d. is on, the triac is optically triggered and mains current flows between the main terminals (pins 4 and 6).

Each point *A*, *B*, *C* and *D* is responsible for one l.e.d. and hence one triac. Only one l.e.d. current-limiting resistor, R13 is needed since only one l.e.d. is on at a time.

Since the internal triacs cannot supply sufficient current to operate mains lamps of a reasonable power direct, external triacs, CSR1 to CSR4 are used for this purpose. These are triggered when the internal triacs are on by gate current entering through current-limiting resistors R14 to R17 as appropriate.

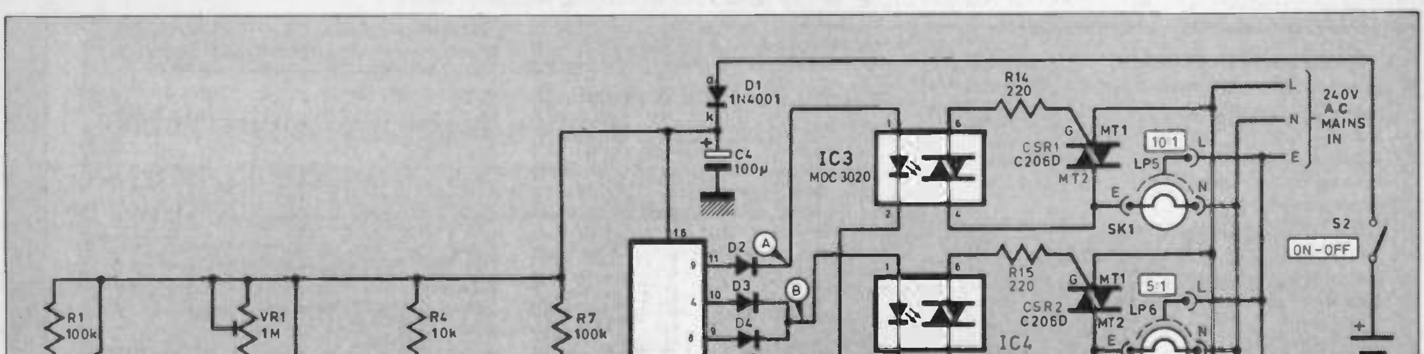
The external triacs handle sufficient current to operate 60W lamps without the use of heatsinks. In the prototype unit, coloured spotlights, LP5 to LP8, directed onto the horses were used.

## RANDOMIZATION

When push switch S1 (THEY'RE OFF!) is operated, IC1a is triggered in the manner already described via the normally-open contacts. At the instant these contacts close, timing of the monostable section begins.

With the release of S1, the normally-closed contacts connect capacitor C2 in parallel with C3 so the frequency of the multivibrator decreases. This introduces a measure of randomization since the time

*Fig. 2. Complete circuit diagram for the mains version of the Grand National Game.*



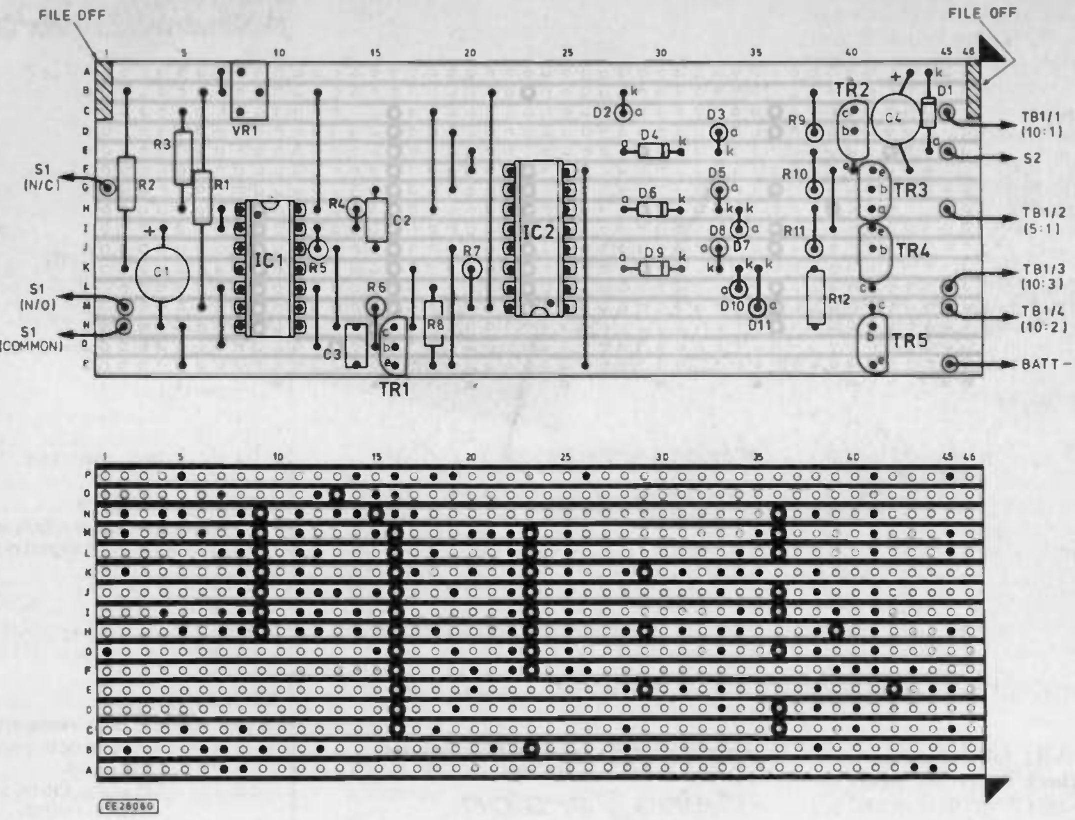



*Fig. 3. Stripboard component layout and details of breaks required in the underside copper tracks of the miniature battery version.*

during which the button is pressed varies slightly from one "race" to another. This is desirable to prevent any pattern developing – however unlikely – in the order of winning horses.

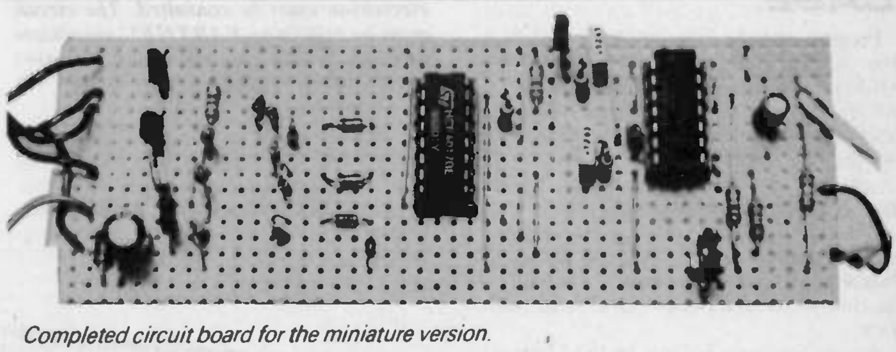
## CONSTRUCTION – Miniature Version

Construction of the Grand National miniature version is based on a circuit panel made from a piece of 0.1in. matrix stripboard, size 46 holes × 16 strips. The topside component layout and details of breaks in the underside copper tracks are shown in Fig. 3.

Begin by cutting the panel to size and checking that it slides into the grooves of the plastic box. Make all inter-strip links and track breaks as indicated. File off the top corners of the circuit board as indicated so that when this is in position the lid will close on the specified plastic box.

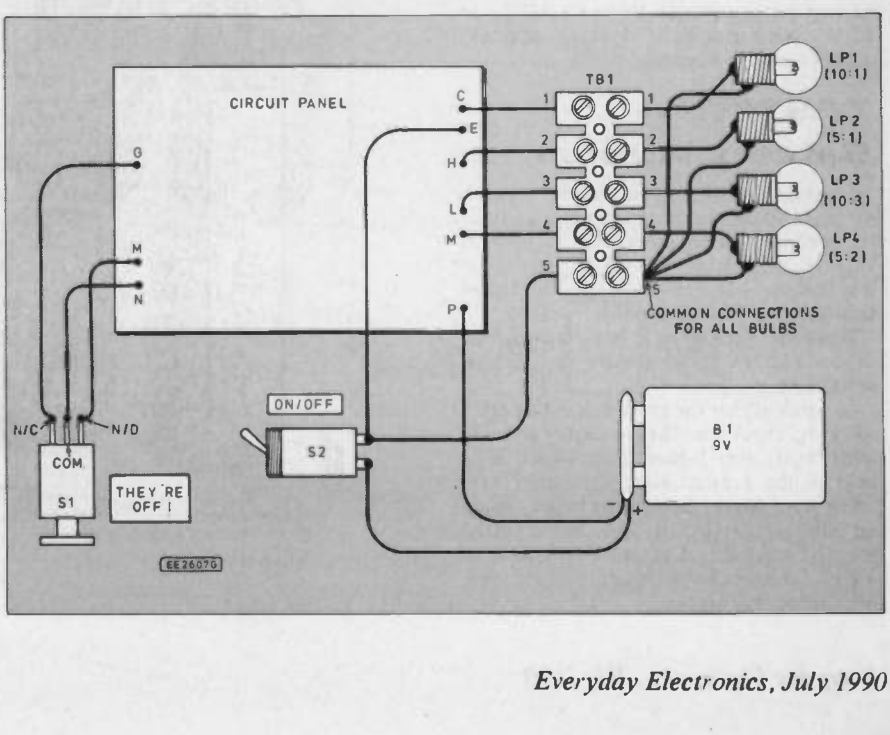
Solder the on-board components, including the i.c. holders, into position taking care over the polarities of all diodes and capacitors C1 and C4. Take care also over the orientation of transistors TR2 to TR5. Do not insert the i.c's themselves until the end of construction.

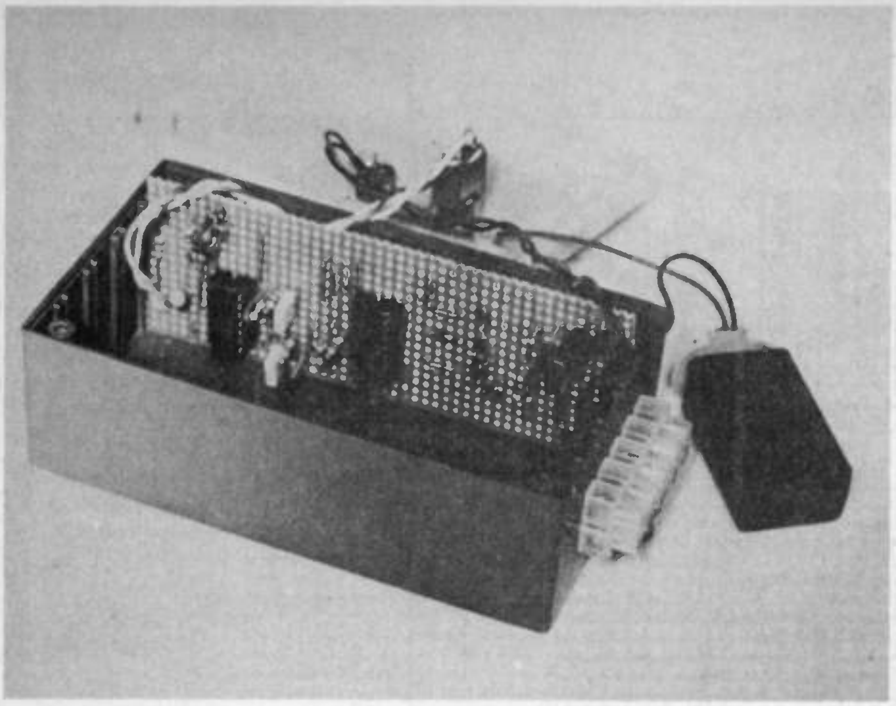
Once the on-board components, excluding the i.c.s, have been mounted in position, solder 12cm pieces of light-duty stranded connecting wire to strips *G*, *M* and *N* on the left-hand side of the circuit panel. Solder similar wires to strips *C*, *E*, *H*, *L* and *M* along the right-hand side. Solder the negative battery connector wire to strip *P*.



*Completed circuit board for the miniature version.*

*Fig. 4. Interwiring details for the miniature version.*





*The complete miniature version showing the lamp connecting block mounted on the outside of the case.*

Adjust preset VR1 fully clockwise and, after a careful check for errors, insert the i.c's. Since these are CMOS devices and can be damaged by the static charge which may exist on the body, take care to unpack and insert them without touching the pins. Note that IC2 is upside down compared with IC1.

## CASE

Prepare the box by making holes in the lid for push switch S1 (THEY'RE OFF!) and the toggle switch S2 (ON-OFF). Mount these components. Drill holes for, and mount, the 5-way terminal block TB1, on the side. Drill a 5mm hole below TB1 position to carry the wires passing through the box from the circuit panel.

Refer to Fig. 4 and complete all wiring. It will be found necessary to file off the fixing bushes in the lid of the case to enable this to close when the circuit panel is in position.

Attach the lamp holders to the "horses" and, using light-duty twin-stranded connecting wire, connect these to TB1/1 to TB1/5. Note that TB1/5 forms a common connection for *all* lamps.

## TESTING — Battery Version

Commence testing of the battery version by first sliding the circuit panel into position and connecting the battery. Switch on S2 – usually the circuit self-triggers when this is done – if not, press S1. The lamps should begin flashing rapidly.

When the timing cycle has elapsed, one of the lamps should remain on. Repeat several times.

To confirm that the randomization part is working, check that the frequency of flashing is noticeably higher while switch S1 is held in the pressed state compared with when it is released. Secure the battery using an adhesive fixing pad. The timing period may be adjusted as require by means of VR1 – anti-clockwise rotation of the sliding contact increases it.

## CONSTRUCTION — Mains Version

***Safety note:***
***Construction of the mains circuit should only be undertaken by readers who are sure of their ability to make a safe job. Where any uncertainty exists, a qualified electrician must be consulted. The circuit must be built in an EARTHED aluminium box and on no account may a non-earthed mains supply be used.***

Construction of the mains version is based on two circuit panels each made from 0.1in. matrix stripboard. The component layout and details of the underside breaks in the copper tracks is shown in Fig. 5 and Fig. 6.

## COMPONENTS

### MINIATURE VERSION

**Resistors**

| | |
|---|---|
| R1, R2, R6, R7, R8 | 100k (5 off) |
| R3 | 220k |
| R4 | 10k |
| R5 | 470k |
| R9-R12 | 3k3 (4 off) |

All 0.25w 5% carbon.

See SHOP TALK Page 468

**Potentiometer**

| | |
|---|---|
| VR1 | 1M sub-min preset, vert. |

**Capacitors**

| | |
|---|---|
| C1 | 22μ axial elec. 10V |
| C2, C3 | 100n ceramic (2 off) |
| C4 | 100μ elec. 16V |

**Semiconductors**

| | |
|---|---|
| D1 | 1N4001 1A 50V rec. |
| D2 to D11 | 1N4148 signal diode (10 off) |
| TR1-TR5 | ZTX300 *npn* silicon (5 off) |
| IC1 | ICM 7556 dual CMOS timer |
| IC2 | 4017B CMOS decade counter |

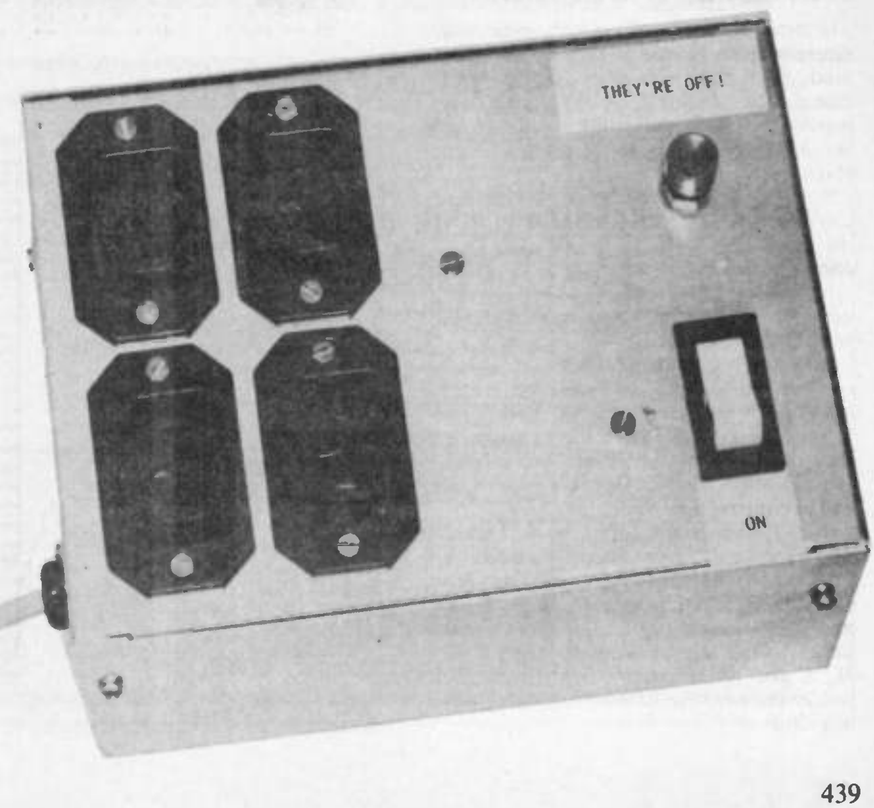
**Miscellaneous**

| | |
|---|---|
| S1 | Push-to-make switch, with single-pole changeover contacts |
| S2 | SPST miniature toggle or rocker switch |
| LP1-LP4 | 6V 0.06A m.e.s. lamp and bulbholder (4 off) |

Stripboard 0.1in. matrix, size 16 strips × 46 holes; case, size 125mm × 70mm × 49mm (external); 5-way 3A screw terminal block; 14-pin d.i.l. socket; 16-pin d.i.l. socket; PP3 battery and connector (see text); materials for "horses"; connecting wire; solder etc.

*Approx cost guidance only* **£12**

The main panel, on which most of the components are mounted, uses a piece of stripboard size 36 holes × 16 strips. The



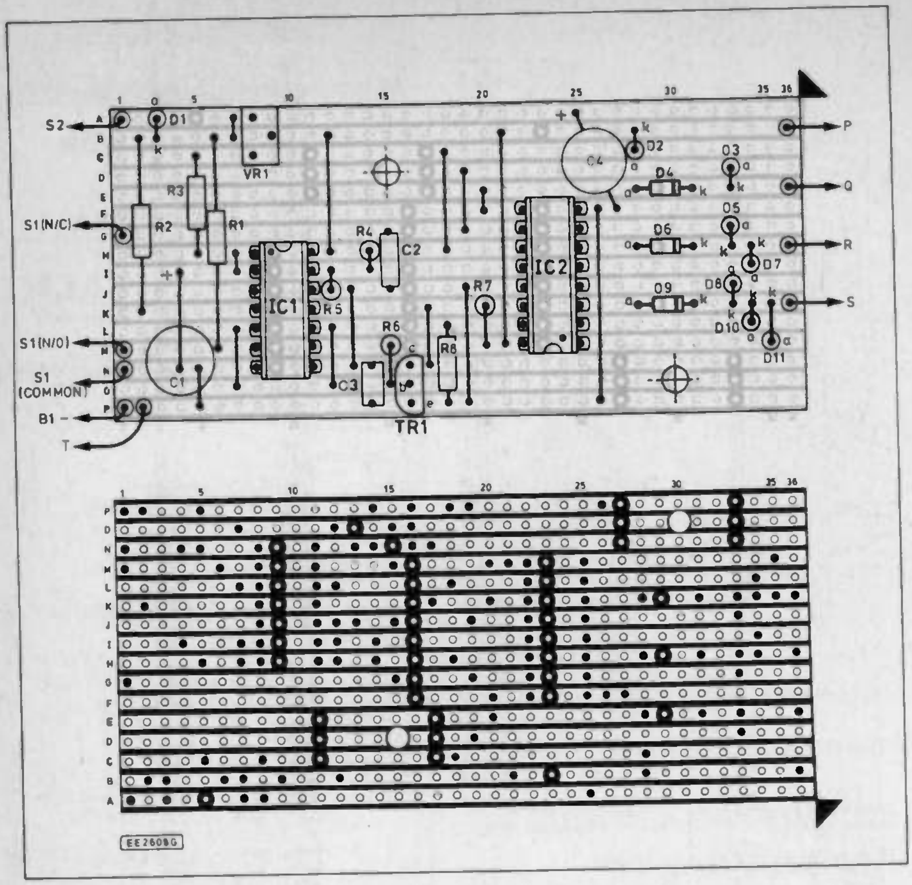
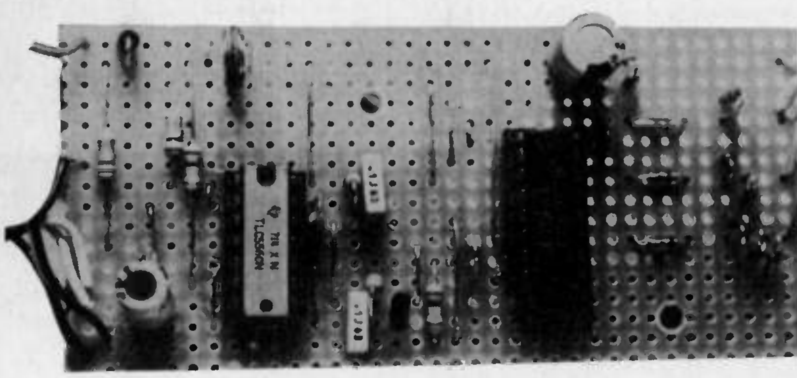



*Fig. 5. Mains version main stripboard component layout and details of breaks required in the underside copper tracks.*



*Completed mains version circuit board.*

## COMPONENTS

### MAINS VERSION

**Resistors**

| | | |
|---|---|---|
| R1, R2, R6, R7, R8 | 100k (5 off) | |
| R3 | 220k | |
| R4 | 10k | |
| R5 | 470k | |
| R13 | 470 | |
| R14-R17 | 220 1W (4 off) | |

All 0.25W 5% carbon except where stated.

See SHOP TALK Page 468

**Potentiometer**

VR1 1M sub-min preset, vert.

**Capacitors**

| | |
|---|---|
| C1 | 22µ axial elec. 10V |
| C2, C3 | 100n ceramic (2 off) |
| C4 | 100µ elec. 16V |

**Semiconductors**

| | |
|---|---|
| D1 | 1N4001 1A 50V rec. |
| D2 to D11 | 1N4148 signal diode (10 off) |
| TR1 | ZTX300 *npn* silicon |
| IC1 | ICM 7556 dual CMOS timer |
| IC2 | 4017B CMOS decade counter |
| IC3-IC6 | MOC3020 optically-isolated triacs (4 off) |
| CSR1-CSR4 | C206D 3A triac (4 off) |

**Miscellaneous**

| | |
|---|---|
| S1 | Push-to-make switch, with single-pole changeover contacts |
| S2 | SPST miniature toggle or rocker switch |
| LP5-LP8 | 60W coloured spotlight and lamp holder (4 off) |

Stripboard 0.1in. matrix, size 16 strips × 36 holes (main panel) and 28 strips × 21 holes (triac panel); aluminium case, size 152mm × 114mm × 76mm (AB31 box); 8-pin d.i.l. socket (4 off – see text); 14-pin d.i.l. socket; 16 pin d.i.l. socket; PP3 battery and connector (see text); Euro-type 3-pin chassis socket and plug (4 off); materials for "horses"; plastic feet (4 off); connecting wire; solder tags; solder etc.

*Approx cost guidance only* **£29** *plus lamps*

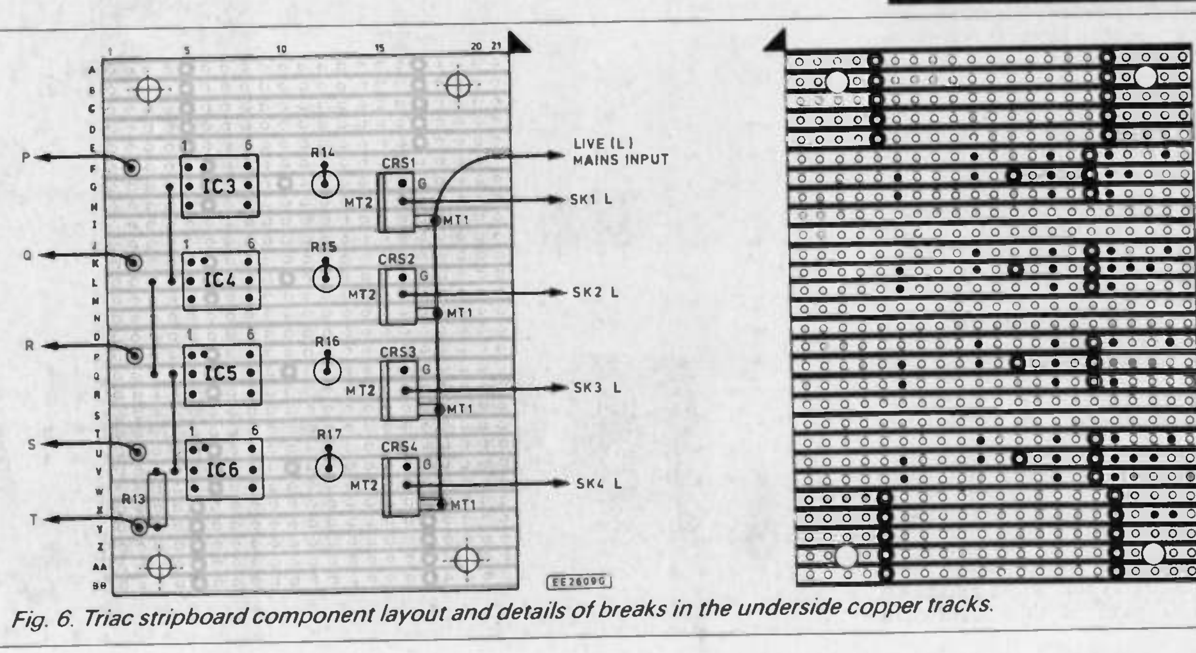



*Fig. 6. Triac stripboard component layout and details of breaks in the underside copper tracks.*

other panel, size 21 holes × 29 strips, is used for the optically-coupled triacs (IC3-IC6) and main triacs (CSR1-CSR4).

Cut the main circuit board to size and drill the two mounting holes. Follow with the track breaks and inter-strip links as indicated.

Mount and solder in position all on-board components as shown in Fig. 5. Pay particular attention to polarity sensitive components, such as the semiconductors and electrolytic capacitors.

Solder 10cm pieces of light-duty stranded connecting wire to strips *A, G, M, N* and *P* on the left-hand side. Solder 20cm pieces of similar wire to strips *B, E, H* and *K* on the right-hand side. Using different colours will help in avoiding errors.

Solder the negative battery connector wire to strip *P* on the left-hand side. Insert the i.c's without touching the pins and adjust VR1 sliding contact fully clockwise.

## TRIAC PANEL

For safety reasons, great care must be taken when constructing the triac panel and all work must be carefully checked. In particular, all track breaks must be complete. Referring to Fig. 6, cut the stripboard to size, drill the four mounting holes, and make all inter-strip links and track breaks as indicated.

Solder the on-board components into position. The opto-triacs IC3 to IC6 are 6-pin devices and since matching sockets are not freely available, it may be necessary to cut/file 8-pin ones to size. Check the orientation of CSR1 to CSR4, noting that the left hand connection (MT1) on each is bent upwards away from the circuit panel and not soldered to copper strips as the other two triac connections (G and MT2) are.

Solder 10cm pieces of light-duty mains-type wire direct (that is, not through the copper strips) to the MT2 tags on the underside. Use similar wire to inter-connect the left-hand (MT1) triac connections.

Connect the wires from the right-hand side of the main circuit panel to strips *F, K, P* and *U* as indicated. Connect the wire from strip *P* on the main panel to strip *Y* on the triac panel. Finally, insert IC3 to IC6 into their respective sockets.

## CASE

Note that everything is mounted in the lower section of the case with nothing on the lid. Prepare the box by making holes for S1 (THEY'RE OFF!), S2 (ON-OFF) also for the four mains output sockets (SK1-SK4). Mount these components (see photograph). Make holes for circuit panel mounting and drill one for the strain relief bush on the mains lead to be fitted later.

Refer to Fig. 6 and complete all interwiring. Note that all wiring shown in bold print must be made with mains-type wire of 3A rating minimum.

Make the mains input lead using 3-core mains wire – fit this with a mains plug carrying a 3A fuse. Secure it with the strain relief bush to prevent it from being pulled free in service and make the internal connections.

Note the solder tag at one of SK1 fixings which is used to EARTH the case. Secure the battery using an aluminium bracket to prevent it from moving in service.

Mount the circuit panels using short stand-off insulators and, as an additional precaution, a piece of thick cardboard

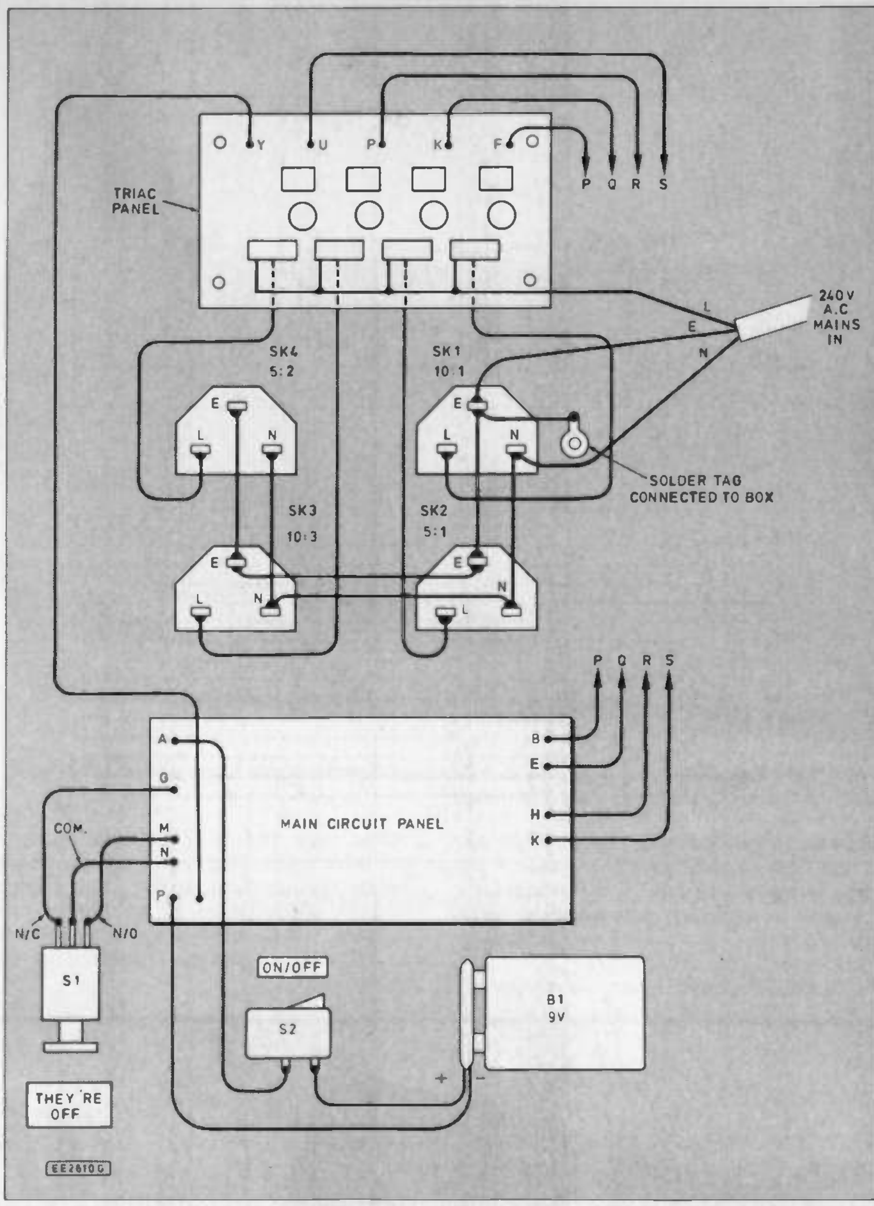
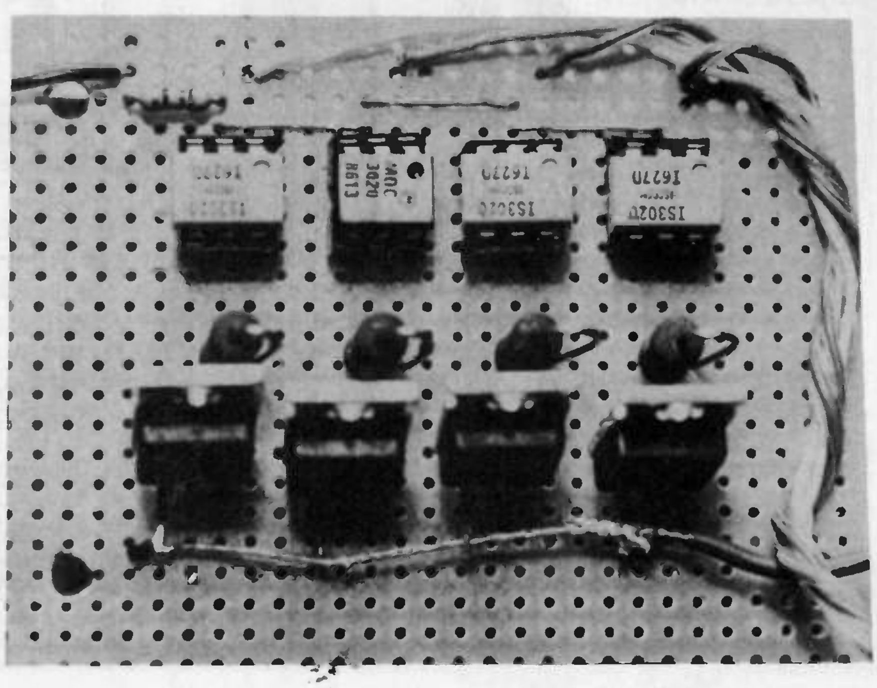
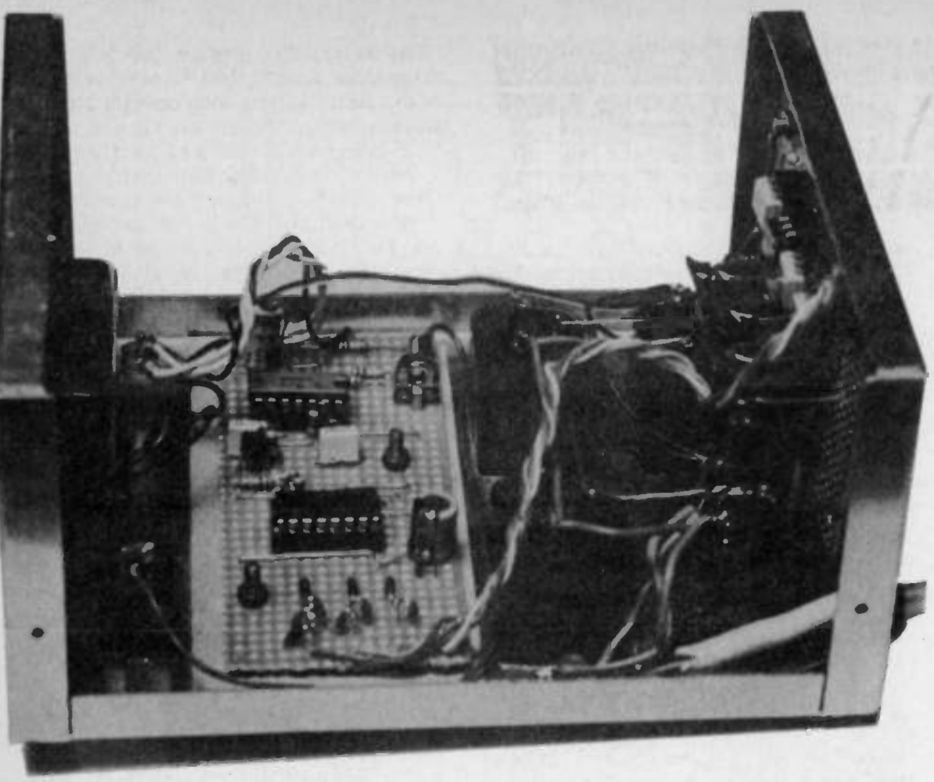



*Fig. 7. Interwiring to the two mains version circuit boards. Use 3A wire for connecting up all mains sockets (SK1-SK4).*

*The completed opto/triac circuit board.*





*The completed mains version of the Grand National Game with the metal shroud removed to reveal positioning of components and wiring.*

underneath each. Make certain that no connections on the copper strip side – or anywhere else – can touch the metalwork. Ensure a clearance of 3mm minimum here. Make a special check on the wires leading from the MT2 tag of each triac.

Connect the lampholders to pieces of mains wire and fit Euro-style plugs to the other ends. Plug them into SK1-SK4. Secure the lid, checking for trapped wires and short-circuits as it is brought into position. Fit four self-adhesive plastic feet to the case to prevent scratching of the table top.

## TESTING

***Note that whenever the unit is plugged into the mains, the lid must remain on.*** This is because there are exposed live connections inside. Note also that although normal on-off switching is achieved using S2, the mains remains connected. At the end of a period of use, therefore, the unit MUST always be unplugged from the mains.

Insert the lamps. To prevent overheating of the triacs, these must NOT exceed 60W rating on 240V mains. Plug in the unit and switch on S2. Press S1 (THEY'RE OFF!). The lamps should flash rapidly and after a while only one should be left on.

To increase the operating time, adjust VR1 anticlockwise as required. Check the randomization part in the same way as with the battery circuit. Make up the horses and direct the spotlights on to them. Make signs to indicate the odds.

The mains circuit gives excellent service from an internal PP3 battery because the quiescent current requirement is only 10mA approximately compared with 60mA for the miniature version. For very long periods of use, a PP6 battery could be used since there is sufficient space inside the case of the mains version to accommodate this.

The miniature version gives reasonable service from a PP3 battery but this should be of the alkaline – or better still lithium – type. For long periods of use, an external battery should be used and here it is suggested that two type 126 4.5V batteries be connected in series.

It only remains to label the switches, place your bets and have fun at the Grand National! □

# FOR YOUR ENTERTAINMENT

BY BARRY FOX

## Not British

Earlier this year I heard, purely by chance, that the British Museum was demonstrating high definition television (HDTV). There was advance publicity for the "extraordinarily clear fine grained pictures" and "a wholly new experience" with an explanation that although the system was "originally developed with general broadcasting in mind, it is now clear that it has great potential in many fields such as industry and public exhibition".

The European electronics industry is currently spending literally hundreds of millions of pounds on developing the *Eureka* HD-MAC system to rival Japan's *Hi Vision* (the British Government has chipped in £5 million) so I initially assumed that the British Museum would be demonstrating the Eureka system. But no. The BM has wandered innocently into the minefield of HDTV politics by signing a deal with Japanese broadcasting station NHK on Japanese Hi Vision.

At a demonstration in the British Museum, NHK engineers proudly showed Hi Vision HDTV pictures on a 32 in. Sony monitor and 50 in. Panasonic rear projector. Why is the BM endorsing the very technology which European researchers are trying so hard to rival?

The answer is simple. When the BM last appealed for money, it was NHK which made an offer they could not possibly refuse. NHK is giving the British Museum £200,000 in return for the rights to make six programmes and publish a series of books about the museum's historic treasures.

Needless to say NHK and the consortium of ten Japanese manufacturers making Hi Vision equipment are making the most of the liaison and demonstrating the system to as many pillars of the British establishment as the BM can muster.

When push comes to shove, Europe only has Eureka's prototypes and promises to offer; Japan has a working system ready to use. The BBC has already adopted a similar pragmatic approach by using Hi Vision for the *Ginger Tree* series.

## Drawing the Line

In the face of such enterprise, it seems churlish to say it, but NHK's demonstration of Hi Vision at the BM was one of the worst I have ever seen. Whereas pictures live from an HDTV camera were superb, the pictures off tape were blemished by nasty coarse horizontal lines.

Like everyone who sees HDTV for the first time, the historians watching the demonstration were bowled over. But once the picture defects were pointed out to them they saw them only too clearly. Faced with this unpalatable truth, the NHK engineers owned up and explained.

The pictures were being sourced from a half inch professional broadcast cassette recorder, modified to record 1125 line Hi Vision signals. Whereas the luminance bandwidth of an HDTV camera spreads over 30MHz, the tape VCR can only cope with 22MHz. And the two colour difference signals only have 'half bandwidth (11MHz).

What's more these colour signals are interlaced, like a conventional TV picture. This is what causes the relatively coarse horizontal lines across the picture which NHK seemed to expect no-one would notice.

## All That Jazz

Britain is now getting its first "incremental" local radio stations, the new local radio stations licensed by the IBA. The IBA's "flag ship" incremental is *Jazz F.M.* in London. What makes these stations special is the extraordinarily high level of technical automation. Being "green field" sites they equip them with all the latest high tech.

Jazz F.M. wants to be the first "paper free" radio station; the enabling technology is called Media Touch. Virtually everything in the studio can be controlled by touch sensitive screens, even from outside the studio.

A presenter miles away on an outside broadcast with a portable screen can use it to control CD players and DAT recorders in the studio by digital signals sent down a telephone line by modem. It isn't necessary even to have record sleeves and notes in the studio; these are electronically scanned and displayed on the touch sensitive screen. Computer software, called *Selector*, juggles the running order of records to suit the music mix which market research has shown listeners to prefer.

These stations, (along with other independent radio stations) are now distributing news programmes and commercials by satellite link, in one case piggyback on top of consumer programmes on the *Astra* satellite, in other cases in digital code for unattended recording by DAT decks.

The technology used by Jazz F.M. and other new incrementals, was developed in the US to let one man operate a radio station. So far there are no plans to use it that way in the UK. And so far Jazz F.M. looks like being a runaway success.

So far the human touch will remain. But if other stations round the country run into financial problems, it doesn't take a genius to predict where the first cuts will be made – the people will go and one man, a guard dog and the technology will run the show.

The use of a computer to map out a running order of music tracks, timed to fit the programme length, is seen by some disc jockeys as a bogey.

But, as one ex-BBC man put it to me, "There is not really much difference between using a computer music scheduling system, to display a list of what tracks to play, than using a play list written by the producer. In one case you do what the computer says, in the other case you do what the producer says or get fired".

## Moody Blues

"Off the record" DJ's talk frankly of their distrust of touch screen systems. They like the hard hands-on feel of the faders on their control desk; they don't like soft-touching a cursor on a TV screen, and then hoping that the electronics does what it should.

What DJ's worry about most, is the problem of how to "recover" if something goes wrong. In a traditional studio they can juggle jingle cartridges and flick faders, while apologising for having spilled the coffee on a record. But as anyone who has faced an LCD screen that blinks an error message well knows, there is a feeling of hopelessness when a digital system throws a moody.

Significantly, Martin Charman, Chief Engineer at Jazz F.M. tells of his conversation with the firm which had been contracted to fit an automated system before he was hired. "What happens if the computer crashes?" he asked. "It won't" he was told. "Yes, I know it won't" he countered "but what if it does?"

At his insistence the automation at *Jazz F.M.* can all be over-ridden by hand if "the impossible" happens, and the electronics go wrong.

## *Crystal Gazing*

No-one talks about crystal sets these days*.

In the twenties, many families used crystal sets, because they were cheap to make and cost nothing to run. With no active circuitry, they needed no power supply other than the aerial signal.

The idea dates back to 1906. A crystal of quartz (silicon dioxide), carborundum (silicon carbide) or galena (lead sulphide) works just like a modern transistor. It carries current in one direction only. When put into a circuit carrying radio signals down from an aerial to earth, the crystal rectifies or "detects" the sound which has modulated the radio signal.

The rectifying junction is between two crystals or, more often, between one crystal and a thin copper wire, known as a *cat's whisker*. A tuning circuit selects one radio frequency and rejects others. The detected signal is fed direct to a pair or earphones, without amplification. It's a *passive* system.

The snag of course is that the volume level is limited. Early loudspeaker radios relied on batteries and rechargeable lead-acid cells to deliver the D.C. voltages needed for the amplifier valves. Mains power came later, but many homes still did not have electricity. Cable radio stations pushed enough power down the line to drive a loudspeaker. Later these stations converted to TV distribution.

Today, passive systems are forgotten. But headphone listening is back in favour. Perhaps the time is right for the modern equivalent of a crystal set, with passive transistor detection and personal stereo headphones.

Radio stations put out plenty of power. The receiver would be cheap and cost nothing to operate, so it could be ideal for third world education. Batteries are like gold dust in some countries; the locals collect dead cells discarded by tourists. Of course a passive radio of this kind only works with A.M. transmissions but in practice most wide area coverage is on the A.M. band anyway.

* Barry, did you not read the Amateur Radio Supplement *(May '90)? – Ed.*


# VIDEO CHECK

T. R. de VAUX-BALBIRNIE

## A go/no-go light-level indicator for camcorder users

THE author recently bought a video camcorder and very satisfactory it is too. Later, it became clear that certain accessories were needed. This is probably the manufacturer's way of getting more money out of an unsuspecting public!

Advertisements indicate that the equipment will work in amazingly low light levels – perhaps down to seven lux. It will – but what the blurb fails to say is that it does not work particularly well under these conditions. In low light, colour degradation and "noise" spoil the picture. Using extra light improves the results dramatically.

A video light could be the answer but these are expensive. Simply moving the subject or shifting the angle of view can greatly improve matters. Switching on some ordinary lights can also help – although a mixture of daylight and artificial light brings its own problems.

Note that the small black-and-white viewfinder picture gives no serious indication of picture quality. Also, any "low light" warning tends to be optimistic showing an adequate rather than a reasonable working level.

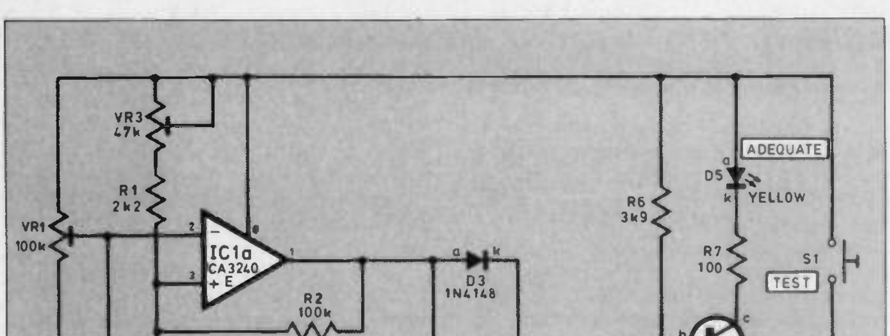
### THE PROJECT

This device, uses three l.e.d.s – arranged traffic light fashion – to indicate whether the light is "poor", "adequate" or "good". The small constructional cost makes it a worthwhile project to build and one which, as far as the author knows, is not available commercially.

The battery should last for a long time since power is used only when a push-button switch is operated. The current requirement is only 20mA approximately. Readers wishing to use the circuit for other purposes should note that it is not calibrated in terms of light intensity. It would, therefore, make only a very rough and ready photographic exposure meter.

The Video Check is designed as an "incident light" indicator. This means that it is pointed towards the camera position from the subject. The button is pressed and the result noted. If the flashing red l.e.d. comes on, the light is inadequate. The yellow one shows that the light, although satisfactory, will lead to some loss of picture quality. The green l.e.d. shows that the light is sufficient for good quality recording.

*Fig. 1. Complete circuit diagram for the Video Alert.*




### CIRCUIT DESCRIPTION

The complete circuit of the *Video Check* is shown in Fig. 1 and centres around dual operation amplifier, IC1. This integrated circuit package contains two identical CMOS input operational amplifiers, IC1a and IC1b. These are used as voltage comparators. Thus, when the non-inverting (+) input voltage exceeds the inverting (−) one, the corresponding output will he high (supply positive voltage). In other cases it will be low.

Light is detected by light dependent resistor, LDR1, which has a response similar to that of the human eye or video camera. The resistance of this component rises as the light level fails. LDR1 forms the lower arm of a potential divider with fixed resistor R1 and preset VR3 forming the upper one. Thus, as the light intensity falls, an increased voltage is developed across LDR1 and this is applied to both IC1a non-inverting input (pin 3) and IC1b inverting input (pin 6).

IC1a inverting input (pin 2) receives a fixed voltage dependent on the adjustment of preset VR1 connected as a potentiometer across the supply. Similarly, IC1b non-inverting input (pin 5) receives a voltage dependent on the adjustment of preset VR2. VR2 is arranged in a slightly different way to VR1 and the reason for this will be explained later.

### VOLTAGE LEVELS

To state typical values, suppose 3V is developed across LDR1 in dim light and 1V in adequate light. A voltage of less than 1V will then be produced in good light. VR1 will be adjusted at the end of construction to provide marginally more than 3V and VR2 marginally less than 1V at IC1a inverting input and IC1b non-inverting input respectively.

Under light which is too dim for video purposes and with S1 (TEST) pressed, IC1a will be on (pin 1 high) since the non-inverting input voltage exceeds the inverting one. The red (POOR) l.e.d. D2, will then operate with current flowing from pin 1 through limiting resistor, R4.

Under light which is adequate, IC1a will be off since now the non-inverting voltage falls below the inverting one. IC1b will also be off because its inverting input exceeds the non-inverting one. The yellow (ADEQUATE) l.e.d., D5, will now operate in the manner to be described later.

Under good lighting conditions, IC1b will switch on with pin 7 high because the inverting input voltage now falls below the non-inverting one. The green (GOOD) l.e.d., D1, will operate through current limiting resistor, R4. It is acceptable for l.e.d.s D1 and D2 to share R4 as a common current limiting resistor since both are never on at the same time.

## ADEQUATE LIGHT

The yellow (ADEQUATE) l.e.d., D5, operates in the following way. With both IC1a and IC1b off (that is, in conditions of adequate light) no base current flows into transistor TR1 which therefore remains off, with its collector high. Transistor TR2 is thus turned on with base current flowing through R6. This, in turn, lights D5 in the collector circuit with R7 limiting the operating current to the correct working value.

In conditions of either poor or bright light, current will flow through diode D3 or D4, as appropriate. Base current will then flow into transistor TR1 via resistor R5 so

## COMPONENTS

See SHOP TALK Page 468

**Resistors**
R1 2k2
R2 100k
R3 1M
R4 150 (220 if 9V battery is used)
R5, R6 3k9 (2 off)
R7 100 (180 if 9V battery is used)
All 0.25W 5% carbon.

**Potentiometers**
VR1, VR2 100k horizontal presets (2 off)
VR3 47k vertical preset

**Semiconductors**
IC1 CA3240E f.e.t. input bipolar output dual op.amp
TR1, TR2 BC108 *npn* silicon (2 off)
D1 5mm green l.e.d.
D2 5mm red l.e.d. (standard or flashing type)
D3, D4 1N4148 (2 off)
D5 5mm yellow l.e.d.
LDR1 ORP12 light-dependent resistor

**Miscellaneous**
S1 sub-miniature push-to-make switch
B1 4SR441 6V silver oxide battery 12.6mm diameter 25.2mm high or PP3 battery and connector (see text).

Stripboard; 0.1inch matrix, size 11 strips by 28 holes; plastic case size 94 x 61 x 27mm overall (Verobox type 401); 8-pin i.c. socket; l.e.d. clips (3 off); stranded wire; solder; adhesive fixing pads etc.

*Approx cost guidance only* **£9**

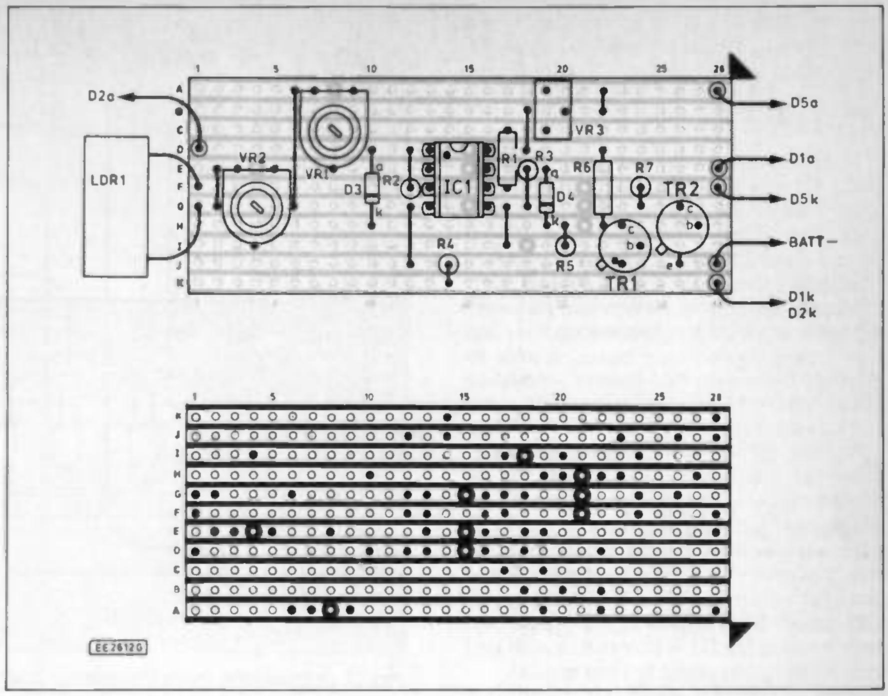



*Fig. 2. Circuit board component layout and details for breaks required in the underside copper tracks.*

turning it on. The collector then goes low turning off TR2 and hence D5.

Resistors R2 and R3 provide a small amount of positive feedback to IC1a and IC1b non-inverting inputs respectively. This provides for sharp switching of the op-amp in conditions of gradual changes in light level.

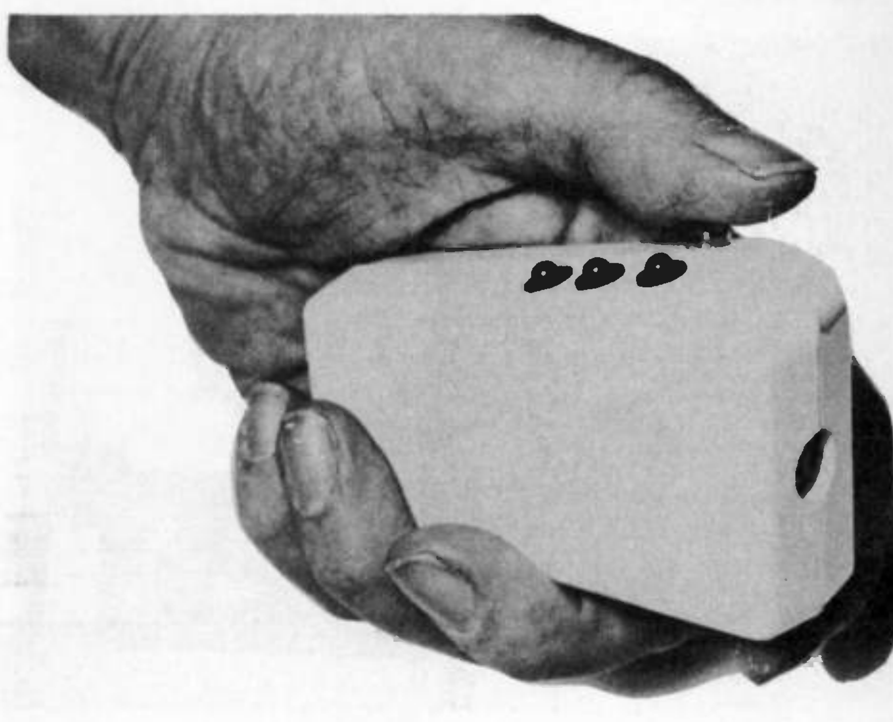
Note that VR2 upper track connection is connected to VR1 sliding contact. This is because the voltage at IC1b non-inverting input will always need to be less than that at IC1a inverting one and this arrangement ensures that this is so.

## CONSTRUCTION

Construction of the *Video Check* is based on a circuit panel made from a piece of 0.1inch matrix stripboard size 11 strips by 28 holes. Fig. 2 shows top and underside details. Begin by making all track breaks and inter-strip links as indicated. Note that the track interconnecting IC1 pins 3 and 6 must be left intact. Follow with the soldered on-board components noting that diodes D3 and D4 must be connected the correct way round as shown.

Do not insert IC1 into its socket until the end of construction as it requires special handling precautions. Note the manner in which LDR1 is mounted. Sleeve its connections to within 2mm of their ends. Solder into position then bend the leads carefully so that the device takes up the position shown in the photograph. Take care to avoid bending the wires too near to the LDR body since they are easily broken off.

Solder 8cm pieces of light-duty stranded connecting wire to strip *D* on the left-hand side and to strips *A*, *E*, *F*, *J* and *K* on the right-hand side of the circuit panel. Make a



careful check of the completed panel then adjust VR1, VR2 and VR3 to approximately mid-track position.

## CASE

The smart hand-held box specified in the parts list was used to house the prototype unit. This device is going to be used with expensive video equipment and should have a good appearance. However, to save money any small plastic box could be used.

Because space is at a premium, the small 6V silver oxide battery specified in the parts list is used. With larger boxes, it may be possible to house a PP3 battery – resistors R4 and R7 will then need to have the alternative values specified.

Prepare the case by marking out carefully and drilling holes for S1 and for the three l.e.d.s (see photograph). The best appearance is obtained by using proper l.e.d. clips but a reasonable job can be made by making holes which are a tight push fit and securing the l.e.d.s with a little adhesive on the inside. Note that a flashing red l.e.d. may be used for D2 – however, a standard non-flashing one could be used instead.

Hold the circuit panel temporarily in position (see photograph) and check the position of the LDR. Drill a hole 10mm in diameter in the side of the case corresponding to this position. This is best done by clamping the two halves of the case together using the plastic jaws of a small vice. A small pilot hole should then be drilled and the diameter increased progressively to the full size. It should then be smoothed carefully.

## INTERWIRING

Secure the circuit panel using two or three adhesive fixing pads. This method is quite satisfactory and avoids ugly bolt heads on the outside of the case. Refer to Fig. 3 and complete all wiring observing the polarity of the l.e.ds. Solder the connecting wires leading from the circuit panel direct to the l.e.d.s using minimum heat from the soldering iron. Bend the soldered connections apart to prevent short circuits. Adjust the LDR position if necessary so that it lies directly behind the hole in the case.

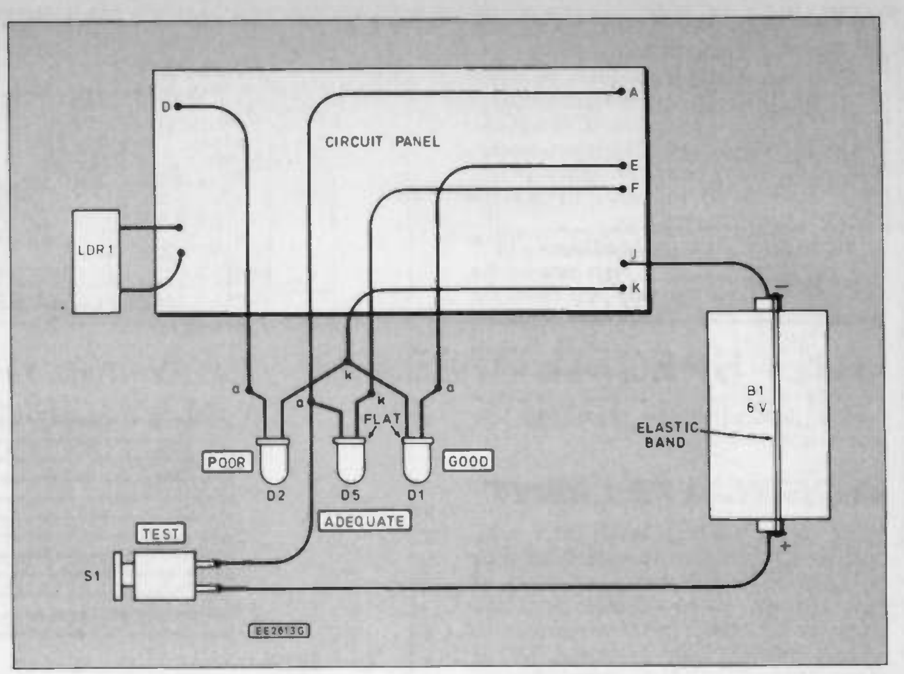


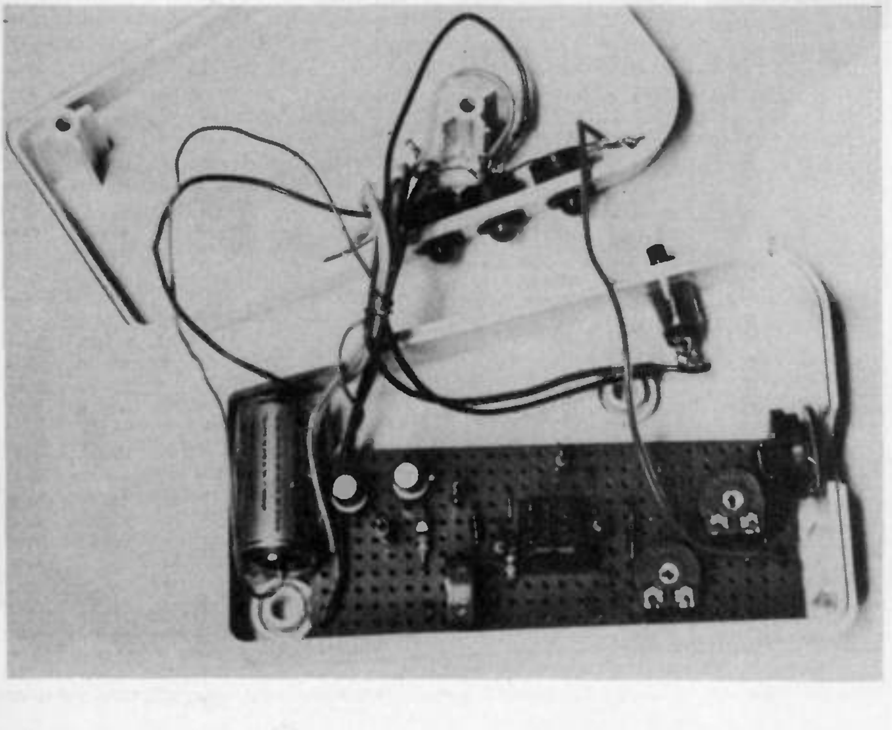

*Fig. 3. Interwiring from the circuit board to off-board components.*

## FINAL CONSTRUCTION

Remove IC1 from its special packing and, without touching the pins, insert it into its socket with the correct orientation. It is necessary to take this precaution since IC1 is a CMOS device which could be damaged by any static charge existing on the body.

The silver oxide battery may be connected by removing the end 3mm of insulation from the wires, bending them double and tinning them with solder. A small elastic band may then be used to hold them in position. Do not attempt to solder the wires direct to the battery and do not allow the wires to touch the metal case of the battery or a short-circuit could be caused.

If a PP3 battery is being used then a standard PP3 battery clip will make the connections. Secure the battery to the base of the case using an adhesive fixing pad. Leave the lid off since access is required to adjust the presets.



## SETTING-UP

Using normal room lighting, perform a basic check by shading the LDR with the hand and pressing S1. The display should go from yellow or green to red. If it remains yellow or green, rotate VR1 sliding contact clockwise and re-check. If it is red all the time, adjust VR1 anti-clockwise a little.

Now allow bright light to shine on the LDR and adjust VR2 so that the display is green – clockwise rotation increases the light level at which it comes on. With intermediate levels of light, the yellow l.e.d. should be on. If adjustment to VR1 or VR2 cannot achieve the desired effect, adjust VR3 a little – clockwise rotation (as viewed from VR1) will raise the light level at which all l.e.d.s operate.

Accurate adjustment of the presets is now required so that the *Video Check* operates at the correct light levels. This can only be done with the camcorder set up and the results viewed critically.

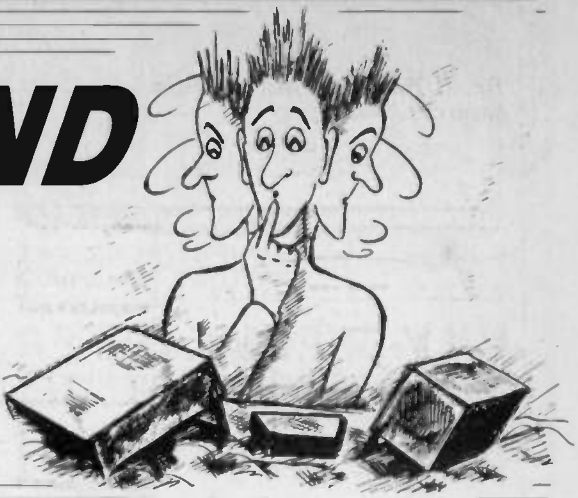
Attach a detailed object such as an Ordnance Survey map on the wall and set up the camcorder on a tripod at least 2m away to view it. Arrange a bright light source to shine evenly on the map. By moving the light back and forth and carefully viewing the recordings made on a colour T.V., find the least light which will provide a satisfactory picture, reasonably free from noise (a grainy appearance).

Point the *Video Check* towards the camera from the map position making sure that you do not shade any light which would otherwise reach it. Press S1 and adjust VR1 until the red l.e.d. is just off. Now re-adjust the lamp so that the best quality picture is just obtained. Adjust VR2 until the green l.e.d. is just on. At intermediate light levels, the yellow l.e.d. should be on. Secure the two halves of the case together taking care to avoid trapped wires and short circuits. The l.e.d.s and switch could be labelled but in the interest of giving a clean appearance, this was not considered necessary in the prototype unit.

In theory, the type of light used affects the results. The *Video Check* was tested in daylight, artificial (tungsten) and fluorescent light. Good indications were obtained in all cases. □

Special Feature

# CHOOSING AND USING TEST EQUIPMENT



**Robert Penfold**

## THE OSCILLOSCOPE

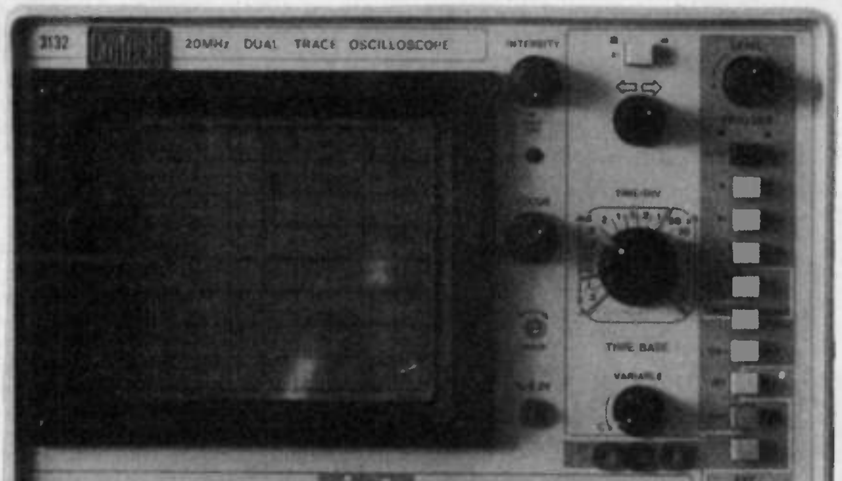
*A short series of self-contained articles looking at the various items of test gear available. How useful are they? How to use them! What to look for.*

FOR shear versatility the oscilloscope has no real competition. It can be used to undertake most of the testing that can be done using a multimeter, plus a great deal besides. It's not that an oscilloscope can reach the parts of circuits that other equipment cannot reach, but having reached it an oscilloscope will almost invariably be able to tell you exactly what is happening. More simple test equipment such as a multimeter will often give ambiguous results.

If a test point measures up at half the supply voltage, it is actually static at this level, or is there a squarewave signal which is giving an average voltage equal to half the supply potential? A multimeter cannot distinguish between static levels and fast pulse signals, but an oscilloscope is unlikely to let you mistake one for the other.

Although an oscilloscope tends to be regarded as a device for viewing waveforms, it is actually a true measuring instrument. It can tell you the maximum and minimum voltages in a waveform, the duration of one cycle, or with a simple calculation, the frequency of the signal.

The accuracy of readings will not equal that of sophisticated digital instruments, since you are having to take the readings from what is basically just a simple analogue scale, but the degree of precision is adequate for most purposes.




*A typical 20MHz dual trace oscilloscope. The Crotech 3132.*

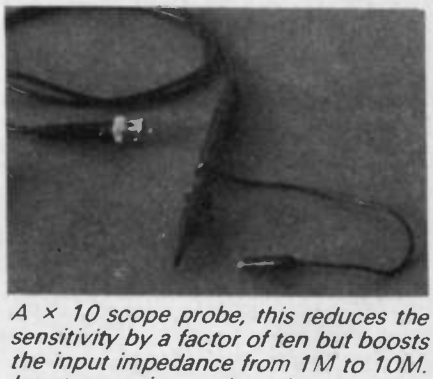
### SCOPE BASICS

The basis of an oscilloscope is the cathode ray tube. This has a heated cathode at the rear which generates an electron beam, and in this respect it is similar to a conventional valve. The electrons are focused into a very narrow beam by sets of electrodes carrying suitable charges, and then travel on until they reach the phosphor screen at the front of the device. Where the electrons strike the screen light is produced, and the narrowly focused electron beam results in a small spot of light being generated (usually no more than about 1 millimetre in diameter).

In order for the c.r.t. to function in an oscilloscope it is essential to have some means of directing the beam to any desired part of the screen. This can be achieved by electro-magnets or by electro-static forces. It is this second method that seems to be preferred for oscilloscope c.r.t.s.

Two plates on either side of the beam and just ahead of the screen enable the spot to be moved from side to side, while plates above and below the beam provide vertical control. These are the "X" and "Y" plates respectively.

A voltage difference across a pair of plates causes a shift in the spot, and the amount of shift is proportional to the voltage difference. The direction of the shift can be changed by changing the polarity of the voltage.



*A × 10 scope probe, this reduces the sensitivity by a factor of ten but boosts the input impedance from 1M to 10M. Input capacitance is reduced, aiding good results at high frequencies.*

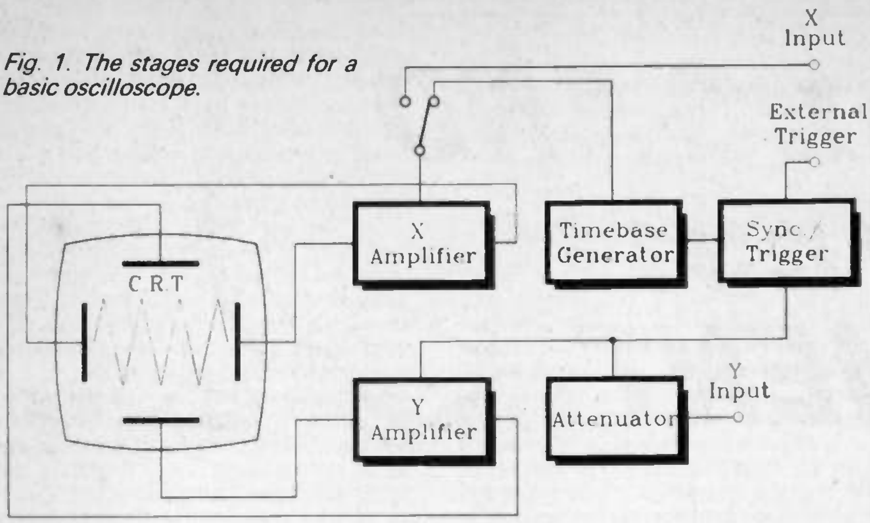



*Fig. 1. The stages required for a basic oscilloscope.*

## X AND Y AMPLIFIERS

In its most basic form an oscilloscope consists of the stages shown in Fig. 1. An obvious first requirement is for separate amplifiers to drive the X and Y plates. There is little difficulty in producing amplifiers having the required differential outputs, but there is a complication in that quite high voltages are needed.

At least a few hundred volts peak to peak is needed to drive the plates properly, and until relatively recently many oscilloscopes still used valves or a mixture of valves and semiconductors. Probably all new oscilloscopes now have semiconductor circuits. The amplifiers which drive the plates are, appropriately, called the X and Y amplifiers.

An oscilloscope is sometimes used with two external signals – one coupled to each amplifier. This produces shapes on the screen known as "lissajous figures". However, this is not the normal way of using an oscilloscope, and usually the X signal is provided by an internal circuit.

This is called the "timebase generator" or "sweep generator". It generates a sawtooth waveform that sweeps the spot across the screen from one side to the other (left to right) at a steady rate, and then rapidly moves it back to the left hand side of the screen again. The electron beam is blanked during the "flyback" period so that it does not leave a slight trace on the screen as it is moved back to the starting point.

## INPUT

The input signal is applied to the Y amplifier, and it has the effect of moving the spot up and down as the timebase sweeps the spot across the screen. The spot therefore traces out the waveform of the input signal, with X axis representing time and the Y axis representing amplitude. At low sweep rates the spot will be clearly visible as such, and the waveform may not be clearly displayed.

Some oscilloscopes have a long persistence phosphor or a special form of c.r.t., so that the phosphor glows for some time after the spot has moved on. This elongates the spot into a line which clearly shows the input waveform.

Much testing is at sweep rates of more than about 25 hertz, and even with a short or medium persistence c.r.t. the spot will appear to be a line. This is due to the inability of the human eye to perceive very fast movement properly.

## FREE-RUNNING SINGLE SWEEP

The timebase can operate in the free-running or triggered modes. In the free-running mode the operator sets the sweep frequency, and the timebase runs continuously at this frequency. This is perhaps not strictly accurate, since this mode normally operates in conjunction with a synchronisation circuit. This synchronises the timebase with the input signal so that a stable display is obtained.

Without this synchronisation successive sweeps will start at a different point on the waveform (Fig. 2). This gives a waveform that appears to move across the screen, or if the timebase is well out of synchronisation the screen will probably just be a complete blur of lines.

This form of timebase is perfectly all right for repetitive waveforms, but it has a weakness in that the X axis cannot be accurately calibrated. In order to give a stable display, the synchronisation circuit will probably pull the sweep frequency well away from the one you have set. The exact sweep frequency will probably be unknown.

Another problem is that the synchronisation circuit is unlikely to have a very wide pull-in range. Quite small changes in the input frequency can result in the controls having to be adjusted in order to give a stable trace again. Where accurate X scaling is not needed, and the input signal is a repetitive waveform of reasonably constant frequency, this form of timebase is perfectly satisfactory.

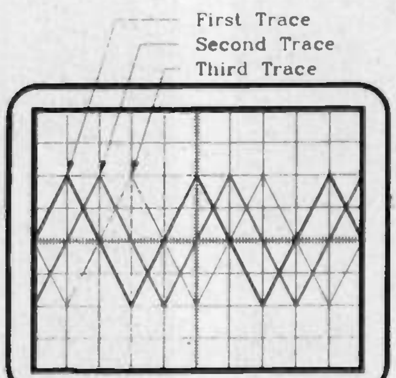



*Fig. 2. With a lack of synchronisation each new sweep produces a trace that is offset from its predecessor. This gives a scrambled display.*

The more popular form of sweep these days is the "triggered", or "single sweep" type as it is also known. The single sweep name is not necessarily a particularly apt one, since this type of timebase will be continuously triggered by a repetitive waveform. However, it is different to a true free-running type in one important respect.

A free-running timebase synchronises with the input signal at some multiple of the timebase frequency. A certain number of half cycles are therefore displayed on the screen, and changing the input frequency will leave the same number of half cycles displayed.

With the triggered timebase the sweep commences at the same point in the waveform each time a sweep occurs. The sweep rate controls the number of half cycles that are displayed, and the number displayed may not be an integer. If the set sweep duration happens to equal (say) 5.386 half cycles, then that is the number that will be displayed.

If the input frequency should change, then so will the number of half cycles displayed. The X (time) scaling is unaffected by the input frequency, and this type of timebase enables accurate time measurements to be made.

## NON-REPETITIVE WAVEFORMS

Apart from being what is often a better form of free-running timebase, a triggered sweep facility is useful for monitoring intermittent or non-repetitive waveforms. Highly irregular or totally random waveforms are difficult to display with most oscilloscopes.

In order to obtain a stable and continuous trace the electron beam must be moved over exactly the same path time and time again. With irregular waveforms this is not possible, since they will not provide the same input signal over and over again.

The triggered sweep offers a means around this by permitting "single shot" operation. Usually the sweep can be triggered by the input signal, or by a signal connected to the trigger input.

Using the internal triggering, setting the trigger sensitivity quite low will give intermittent triggering, so that you get a series of separate glimpses of the signal, rather than a continuous jumble of lines. There is not usually any provision for manual triggering, but this is not too difficult to rig up via the external trigger socket.

You need to be aware that the single shot sweep mode has its limitations on an ordinary workshop oscilloscope. At low sweep speeds the spot is visible as such, with a relatively faint line trailing a short distance behind it. At higher sweep speeds you see a proper line trace, but only momentarily.

At very short sweep speeds the trace can be quite dim, even with the brightness at maximum. As mentioned previously, there are long persistence c.r.t.s that provide a storage effect so that fast traces can be maintained for some length of time.

These days there are also digital storage oscilloscopes which can store a waveform and output it repeatedly at a high rate. In practice you are unlikely to use an oscilloscope offering any of these facilities, as they are simply not offered on the cheaper instruments. You therefore have to do the best you can with the available view.

## DOUBLE VISION

It can often be useful to display two waveforms simultaneously so that their relative timing can be assessed. Ideally this is done using a dual beam oscilloscope. This is one which has a special c.r.t. with two electron beams. These are both controlled by the same X signal, but the vertical deflection of the beam is controlled via separate Y plates and amplifiers. This gives two separate waveform displays on the screen which can be set one above the other, or superimposed one upon the other.

Double beam oscilloscopes now seem to be something of a rarity, and as far as I can gather, there are no new low cost instruments of this type available. There are plenty of low cost dual trace instruments available though. These have an ordinary single beam c.r.t., but have a so-called "beam splitter" ahead of the Y amplifier. This can operate in either the "alternate" or the "chopped" mode.

In the alternate mode the two traces are produced on alternate sweeps, which gives a good quality display, but leaves the possibility of the relative timing of the two traces not being shown with absolute integrity. The chopped mode is better in this respect, and it operates by rapidly switching the beam from one trace to the other. This leaves little chance of the two waveforms being displayed with any relative X offset, but the display quality is often noticeably inferior to the alternate mode.

The traces are effectively formed by a series of dots, although this is not usually apparent. At certain input frequencies the display can become rather rough though, with bits of the traces missing. Ideally both alternate and chopped modes should be available so that you can choose the most appropriate one for each application.

## SPECIFICATIONS

The main specification of an oscilloscope is its bandwidth. This tends to confuse beginners, as it tends to be assumed that the bandwidth figure is the highest input frequency that can be displayed properly. Actually, in order to be sure of obtaining an accurate waveform display the bandwidth must be several times higher than the input frequency. The reason for this is that a complex repetitive waveform consists of the fundamental frequency, plus harmonics (multiples) of that frequency. A squarewave for example, contains odd order harmonics (i.e. three times, five times, seven times the fundamental frequency, etc.).

If the bandwidth of the oscilloscope is only just adequate to accommodate the fundamental frequency, any harmonics will be greatly attenuated. A waveform containing just one frequency is a sinewave, and sinewave-like waveform is what will be displayed if the instrument's bandwidth is inadequate, regardless of the actual input waveform. Most current low cost instruments offer a bandwidth of about 10MHz to 20MHz, and this is adequate for most purposes.

## SENSITIVITY

The other main figure in the specification is the sensitivity, which is normally given as so many millivolts per division. The screen of an oscilloscope has a graticule, which is a piece of transparent plastic marked with (usually) 10 millimetre squares, plus marks at 1 or 2 millimetre intervals along the main X and Y axis.

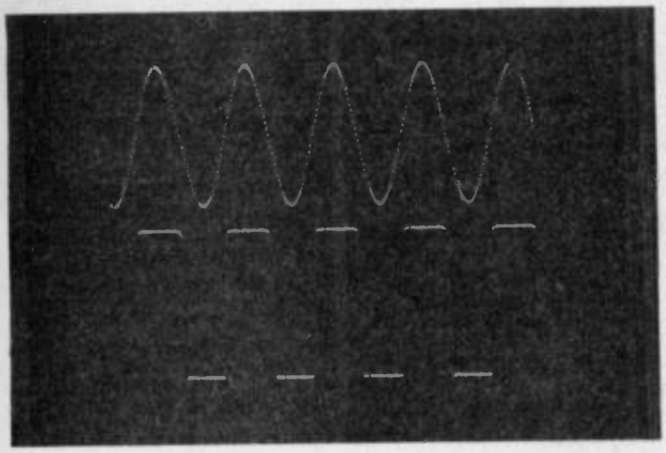
The "division" quoted in many specification sheets is the main 10 millimetre divisions, not the smaller ones. The higher the sensitivity the better, but for most purposes 10 millivolts per division will suffice, and most of the current low cost instruments comfortably exceed this figure.

Another important figure is the size of the screen. A large screen is preferable, but likely to be expensive. One about 100 by 80 millimetres or more should be perfectly adequate. The sweep speed should be variable over wide limits from; about 0.25 seconds per division to around 0.5 microseconds per division.

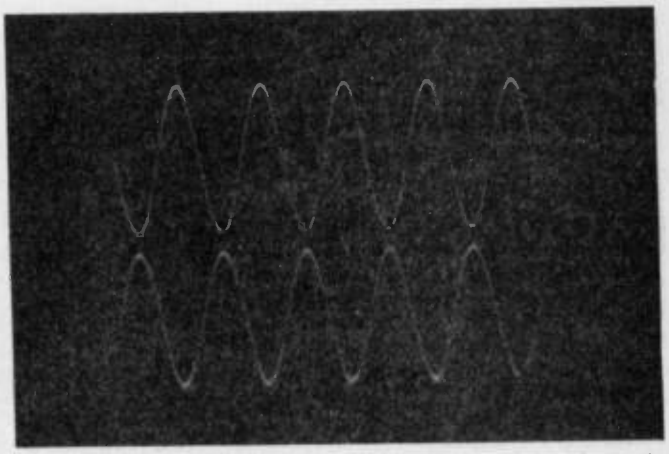
## CHOOSING

As funds will presumably be limited, the choice is likely to be governed more by price than by selecting an instrument which has the features you desire. Funds permitting, I would certainly recommend buying a dual trace instrument (or one of the triple trace types that are now available).

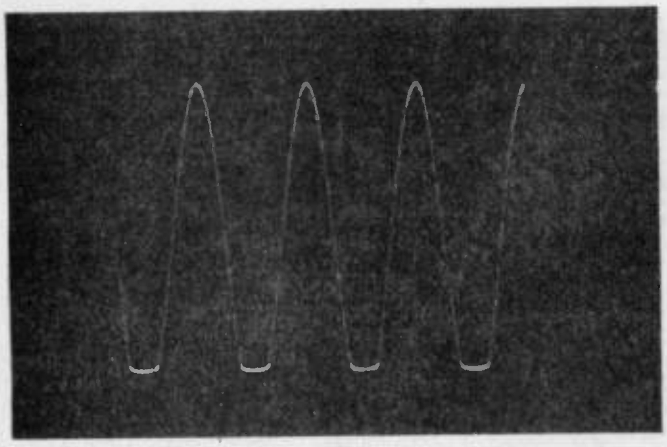
It is unlikely that any modern oscilloscope will provide anything other than good results. You can be reasonably sure that the instrument will live up to expecta-



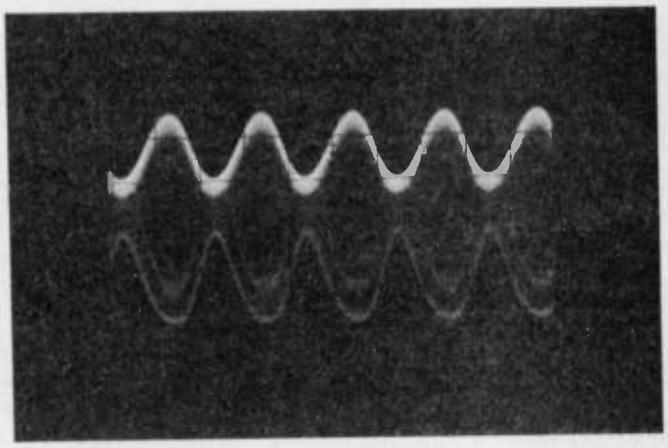
*The "chopped" dual trace mode can give some undesirable effects as shown here.*



*Here the input (top) and output waveforms are in anti-phase. The blurring of the bottom trace is caused by noise.*



*Faulty biasing is causing negative half cycles to be clipped.*



*A high frequency signal modulated by an audio one. In audio equipment this indicates high frequency instability.*

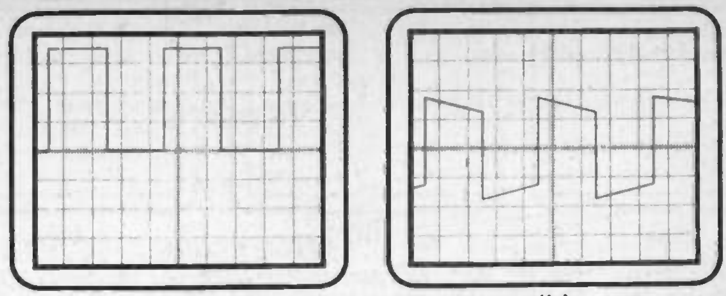
tions, and that it will provide many years of service.

The same is not true if you buy an old secondhand oscilloscope. Some quite cheap units with very high specifications can be obtained, but there are potential problems with these oscilloscopes. They are often extremely large and heavy, using valve rather than semiconductor circuits. They are designed to be used on special heavy duty trolleys or benches, and could well cause the collapse of the average kitchen table!

The main problem is that professional servicing might not be available, and would be prohibitively expensive anyway. It could be difficult (and potentially dangerous) to do any d.i.y. repairs. It is not difficult to find people who have experienced problems with old oscilloscopes, but satisfied users would seem to be a bit thin on the ground. A modern secondhand instrument might be a good buy, but an old unit is not something that could be recommended.

## CONTROLS

Many of the controls on an oscilloscope are self explanatory. There is a brightness control, plus a focus control which is adjusted to give the sharpest possible trace. Multi-way switches provide a range of preset sensitivities and sweep speeds. There may also be continuously variable sensitivity and sweep rate controls. However, using these means that the graticule calibration is rendered invalid. X and Y position controls enable you to adjust the position of the trace, and with a dual trace instrument there will be separate Y position and sensitivity controls for each trace.



(a) (b)

*Fig. 3.(a) A squarewave displayed using d.c. coupling and (b) the distortion that can occur on low frequency signals when using a.c. coupling.*

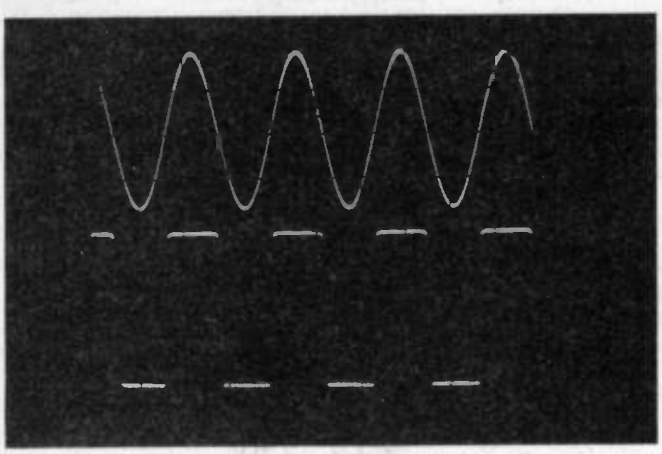
Virtually all oscilloscopes offer a choice of a.c. or d.c. coupling. D.C. coupling is better in that it enables you to measure the true voltages present in a varying d.c. signal. Most signals in a circuit are varying d.c. types and not true a.c. voltages (i.e. they are always positive and have no negative content). With a.c. coupling the peak to peak voltage can be measured, but no indication of the actual signal voltages will be provided.

D.C. coupling is also better in that it gives a more accurate representation of waveforms that have a significant low frequency content. A low frequency squarewave displayed using d.c. coupling will be shown properly, as in Fig. 3(a). Using the a.c. setting it would look more like Fig. 3(b). This waveform distortion is due to the inevitable low frequency roll-off introduced by the d.c. blocking capacitor. The a.c. bandwidth of an oscilloscope is extended as far as reasonably possible, but this effect can never be eliminated.

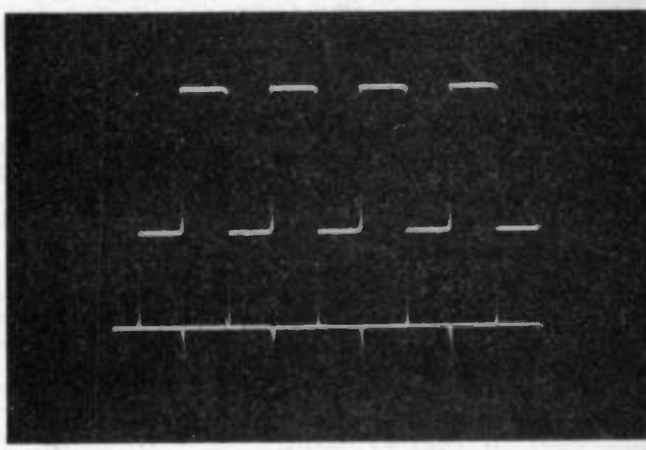
A.C. coupling is best when you wish to view a low amplitude waveform that has a high d.c. content. Taking an extreme example, you might wish to measure the noise level on the output of a power supply. There could be a 30 volt d.c. level with a noise level of only a couple of millivolts peak to peak. Using d.c. coupling and high sensitivity there is little chance of the Y shift control being able to bring the trace onto the screen!

## TRIGGER CONTROLS

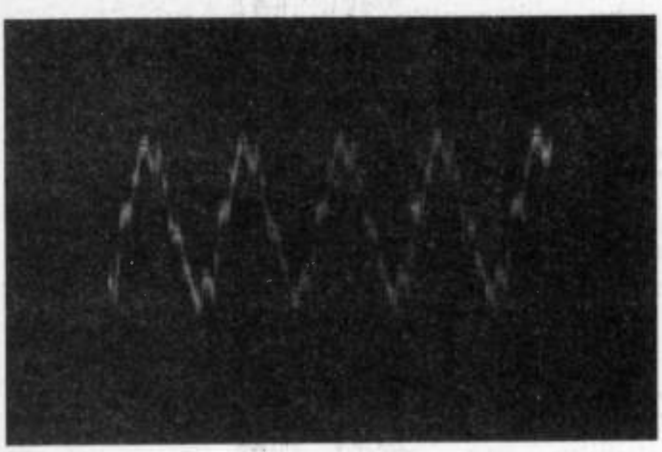
An important but sometimes rather confusing control is the trigger level one. This is occasionally in the form of a sensitivity



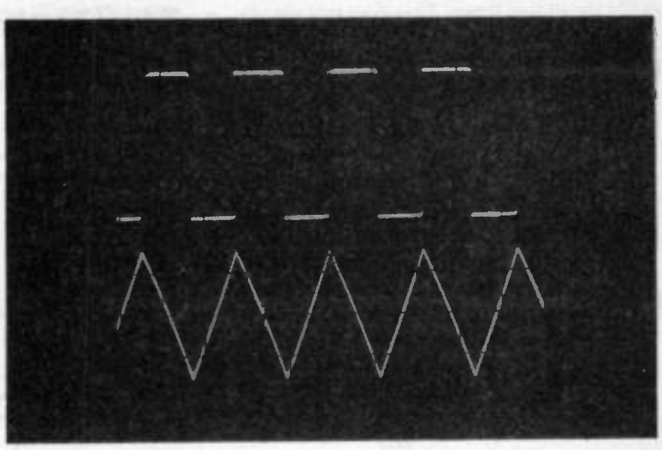
*Getting the input level too high results in the sinewave signal (top) being clipped to produce a squarewave signal.*



*Only very high frequencies in the squarewave (top) are being coupled to the test point giving the bottom waveform.*



*Noise output from a power amplifier. This is predominantly 50Hz mains "hum".*



*The effect of inadequate bandwidth, low pass filtering has reduced the squarewave to a triangular signal.*

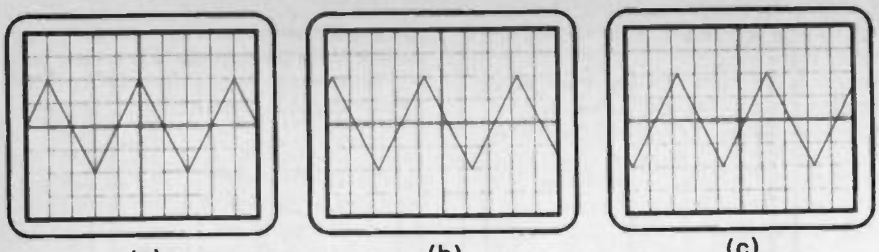



*Fig. 4. Displays obtained with; (a) zero trigger level, (b) moderate positive trigger level, and (c) moderate negative trigger level.*

control plus a positive/negative switch, but is more commonly a centre zero control which offers positive or negative triggering depending on which way it is adjusted. This controls the voltage at which triggering occurs and a new sweep commences.

In terms of the on-screen display, a setting near zero will give a display along the lines of Fig. 4(a). Setting quite high positive and negative settings gives a display of the types shown in Figs. 4(b) and 4(c). In other words, you are setting the point in the waveform at which the display commences.

Modern oscilloscopes seem to be equipped with large numbers of switches. If we consider some typical functions for these, a normal/auto triggering switch enables the sweep to be set so that in the event of an inadequate input level to the trigger circuit, the timebase triggers itself. In the normal mode with no triggering the result is a blank screen.

The trigger circuit often has highpass and lowpass filters that can be switched in if required. These are used where noise, or the nature of the waveform, results in an unstable trace. Switching in one or both of these will often effect a great improvement if trace instability is giving problems.

With a dual trace instrument there is usually a switch that enables you to select channel 1 or channel 2 as the source for the synchronisation signal. If an external synchronisation socket is fitted, there will be a switch to enable internal/external synchronisation to be selected.

Yet another trigger option is provided by the +/− switch. Normally triggering occurs on the rising edge of the signal (Fig. 5(a)), but with the " − " mode selected triggering occurs on the falling edge (Fig. 5(b)).

## MAGNIFICATION

A sweep magnification switch is usually included, offering a magnification of typically about five times. This does not simply speed up the timebase by a factor of five so that the initial part of the waveform can be viewed in more detail. By using the X shift control it is possible to move along the waveform to examine any desired part of it in detail.

The effect is very much as if the trace is made five times wider than the screen width, with the screen providing a moveable window to permit the desired part of the waveform to be examined (as in Fig. 6).

## A.C./D.C.

The a.c./d.c. switch will probably also include a "ground" setting. This disconnects the oscilloscope's Y input from the input signal and connects it to earth (ground) instead. This facility is used when the input has been fed with a strong d.c. signal that has effectively resulted in the trace being shifted a few metres off the screen.

If the signal is removed and you wait long enough, the trace will eventually come back onto the screen. Briefly switching to the "ground" setting provides a quicker means of restoring normality. Note that this feature is only needed when using a.c. coupling.

## OTHER FEATURES

Other features that might be available include the ability to switch between single and double trace operation, with perhaps the option of selecting alternate or chopped mode in the dual trace mode. An interesting facility provided by some instruments is one which enables the voltage difference between two input signals to be displayed. This is useful for showing slight differences between signals that might be overlooked if the two waveforms are simply displayed one above the other, or with one superimposed on the other.

Some oscilloscopes have a switch that enables one channel to be inverted. This makes two signals easier to compare if they are in anti-phase, effectively making them in-phase.

## TESTING

Much of the testing that can be undertaken using an oscilloscope is more relevant to circuit design and development than to servicing. There are also some clever "tricks" that are quite interesting, but largely of academic importance. Here we will concentrate on using an oscilloscope for fault finding on projects.

For checking linear circuits an oscilloscope can be used as a sort of signal tracer. It is much better than a signal tracer in that it enables the signal levels to be accurately measured, and will clearly show the nature of any waveform distortion.

With an input signal applied to the unit under test, the oscilloscope can be used to measure the signal's amplitude at various points in the circuit. If you start at the input and work forwards, you will eventually find a test point where there is no signal, an inadequate signal level, or distortion of the waveform. The fault should be in the immediate vicinity of this test point.

If there is waveform distortion it may give a clue as to the fault. Normally a sinewave is used for this type of testing, but a squarewave can sometimes give more informative results. If only brief spikes are obtained at the test point, this would suggest that only high frequency signals are being coupled through the unit, probably due to stray coupling. A faulty inter-stage coupling capacitor is then the likely culprit.

If the signal level is within the range that the stage should be able to handle, but one set of half cycles are being clipped (or removed altogether), this would seem to indicate a fault in the biasing circuit, or possibly in the amplifying device itself (transistor, op.amp., or whatever). Make sure that the amplitude of the input signal is appropriate. In particular, setting the input level too high will cause severe clipping at some points in the circuit, making some of the test results of relatively little value.

Remember that it can be worthwhile testing for signals where they should not be, rather than testing for a lack of activity in the signal path. This basically means testing to see if there is a significant signal level across the decoupling capacitors. If a significant signal level is found, then the decoupling capacitor in question is almost certainly faulty, or has one leadout not connected properly.

Many projects contain one or more oscillators, and an oscilloscope is ideal for checking that these are producing a

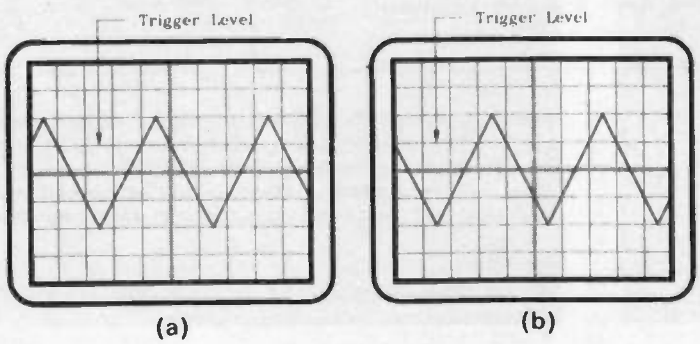



*Fig. 5.(a) Type of display obtained using the normal positive edge triggering. (b) Shows the equivalent trace using negative edge triggering.*

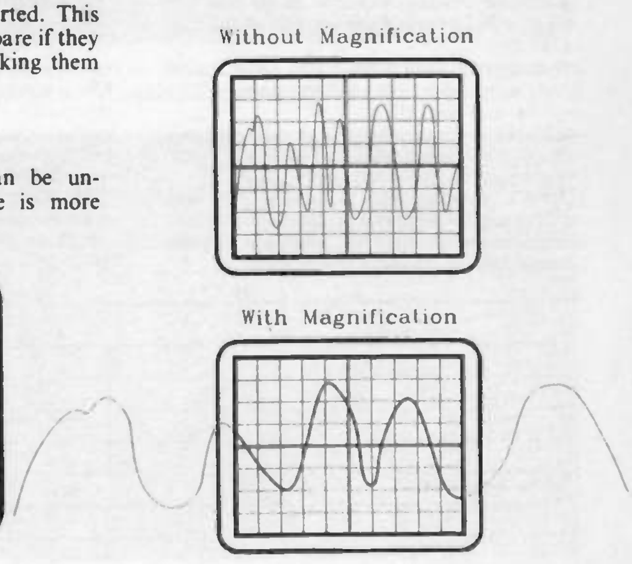



*Fig. 6. The "multiply" facility effectively stretches the waveform.*

suitable output frequency and waveform. In order to measure frequency it is necessary to use the X scale of the graticule to measure the duration of one cycle. Dividing one by the duration of one cycle gives the frequency of the signal. Measurements made in seconds, milliseconds, and microseconds respectively give answers in hertz, kilohertz, and megahertz.

## DIGITAL TESTING

An oscilloscope is well suited to much digital testing. Many circuits have clock oscillators driving one or more frequency dividers, and there is obviously no difficulty in checking that the clock is producing an appropriate output, with suitably reduced frequencies from any divider stages.

With d.c. coupling selected it is quite straightforward to measure the maximum and minimum signal voltages to confirm that they are within the valid range for the logic family concerned. It is also possible to check static levels to see if they are at legal voltages.

Whereas a multimeter might indicate that a test point is at an invalid voltage when it is in fact pulsing and an average voltage reading is being produced, with an oscilloscope you can clearly distinguish between static and pulsing signals.

Some logic signals, particularly those in microprocessor circuits, are non-repetitive even over a fairly long time scale, there is then no chance of clearly viewing the waveform on a continuous basis. Single sweeps can give example glimpses of the waveform, but really you can do little more than check that a pulsing signal at suitable levels is present. This is often all you will need to know.

While much linear testing only needs a single trace oscilloscope, a dual trace instrument is needed for a lot of digital testing. Often you need to know the state of one or more lines while a certain point in the circuit is pulsed to a certain state.

A typical example would be when testing a parallel printer port, where the strobe line goes low when a fresh byte of data is output. An obvious means of testing the port is to repeatedly output a certain byte, and to use the leading edge of the strobe pulse to trigger the sweep generator. With one channel used to monitor the strobe line, the other input can be connected in turn to each of the data and handshake lines. You can then check that these are set to the correct levels at the right time.

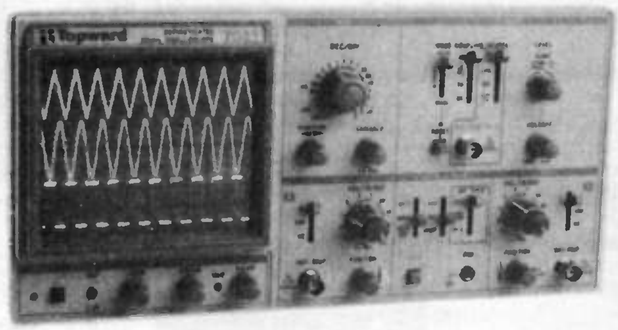
With a single trace scope you can do much the same sort of thing, but obviously the strobe pulse cannot be viewed on the screen at the same time as the other signal. It must be viewed first and its duration noted, after which the other waveforms are viewed. With this method it is a little harder to interpret results, but with a little effort you should find out what you want to know.

For this system to work it is essential to have an oscilloscope with an external trigger input. Otherwise it is not possible to trigger the sweep from the strobe pulse while viewing a different signal.

## VALUE

It is not possible to give a complete course on oscilloscopes in an article of this size, but this should at least give you a good idea of what an oscilloscope does, and how the electronics enthusiast can put one to good use.

An oscilloscope is an expensive piece of equipment, but if you undertake a lot of project building it is likely to be worth every penny. If you start designing your own circuits, an oscilloscope is virtually essential. □



*The topward triple tr ace scope.*

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Constructional Project

# MARC

## MAINS APPLIANCE REMOTE CONTROL SYSTEM

**CHRIS WALKER**

### Part Two: Mains Encoder

*Allows up to 15 different household mains appliances, placed anywhere in the house, to be controlled from the safety of your armchair. Can be linked to the home computer.*

LAST MONTH we dealt with the handheld Infra-Red Transmitter for the MARC mains appliance remote control system. This month we move on to the Encoder circuit and construction.

The Encoder Unit is the most complicated part of the MARC system. Its job is to receive instructions from the IR Remote Controller or optional external microcomputer and encode these onto the 240 volt mains so that they can be picked up by the various decoder units placed through the house. The block diagram illustrated in Fig. 1.5, last month, outlined the operation of the Encoder Unit.

### ENCODER CIRCUIT

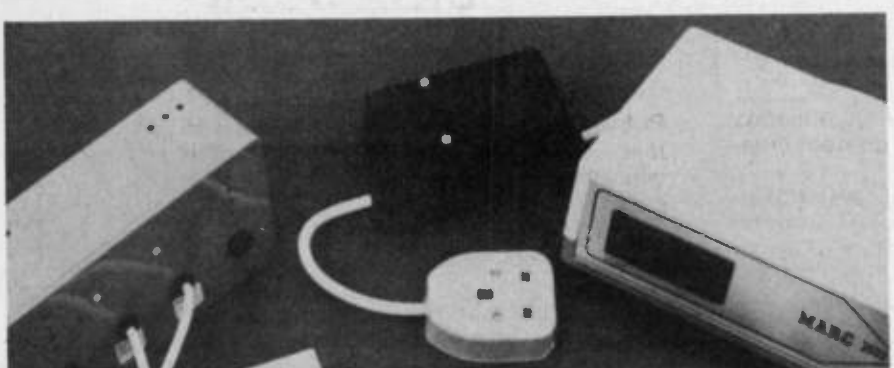
The MARC Encoder was designed in a systems-based manner, making extensive use of integrated circuit technology. Therefore, its circuit diagram bears some resemblance to the systematic (block) diagram of Fig. 1.5 (last month) but some points require extra clarification.

The complete Encoder circuit is built on two printed boards, the circuit diagram for Board A is shown in Fig. 2.1 and that for Board B in Fig. 2.2. Refer to Fig. 2.1 first.

The infra-red receiving diode D1 is reverse biased by resistor R1. Signals from the junction of these two components are coupled to the two-stage high gain amplifier containing transistors TR1 and TR2. Capacitors C1 and C2 also provide simple high-pass filtering to block 50Hz received signals.

Transistor TR3 is wired in the "switch" configuration and low-going signals from the collector of TR2 will produce positive 15V pulses at the collector of TR3 which are coupled, via capacitor C4, to the PPM input (pin 3) of the two demodulators IC1 and IC2.

*The complete MARC control system showing, from left to right, temperature mains interface, decoder, encoder, infra-red transmitter and temperature display.*




Capacitor C5 together with resistor R8 and variable preset potentiometer VR1 set the frequency of the oscillator within IC1. C6, R9 and VR2 behave similarly for IC2. In order to receive the PPM code correctly from the SL490 transmitter i.c. this oscillator frequency should be adjusted to be forty times the transmitter clock frequency.

The four least significant bits of the received binary code are outputted on pins 5 to 8 of IC1 if the code is between 00000 and 01111 or pins 5 to 8 of IC2 if between 10000 and 11111. Each decoder i.c. waits to receive two consecutive and identical codes before responding. By using this method, receiving errors are greatly reduced. R10 to R17 act as pull-down resistors for the open drain outputs, in the absence of transmitted data these outputs will, therefore, remain low.

The two multiplex chips IC3 and IC4 will take data from the "A" inputs (pins 2, 5, 11 and 14) if the select control (pin 1) is low or from the "B" inputs (pins 3, 6, 10 and 13) when a high logic level is present on pin 1. Data for the "B" inputs and the select pin comes from the computer port on Board B. The multiplexer output is available on pins 4, 7, 9 and 12 of IC3 and IC4.

### LATCH

When "receiver number" data appears on the output pins of IC3, the output of OR-gate IC8a goes high and triggers monostable IC7b which produces a negative-going 10ms pulse at pin 9. The rising edge at the *end* of this pulse is used to load the received data into latch IC5. A similar arrangement is provided for the "function code" data bits from multiplexer IC4.

The latch loading pulses, "*X*" and "*Y*", are also used to *reset* a ten second timer formed by IC9a. The output of this timer, "*Z*", will go high ten seconds after the last pulse is received at its input and this causes both latches IC5 and IC6 to reset.

The latches will hold data for a maximum of ten seconds or until new data is loaded by the OR-gate/monostable arrangement. Connections *J* to *Q* are decoded on Board B to provide the front panel display explained earlier.

The M145026 serial encoder, IC10 belongs to a group of three i.c.'s which form a very powerful remote control/data transfer facility. The M145027 receiver is utilised in the decoder units.

A low level on the "Transmit Enable" input (pin 14, IC10) initiates a sequence whereby the nine input data bits (pins 1 to

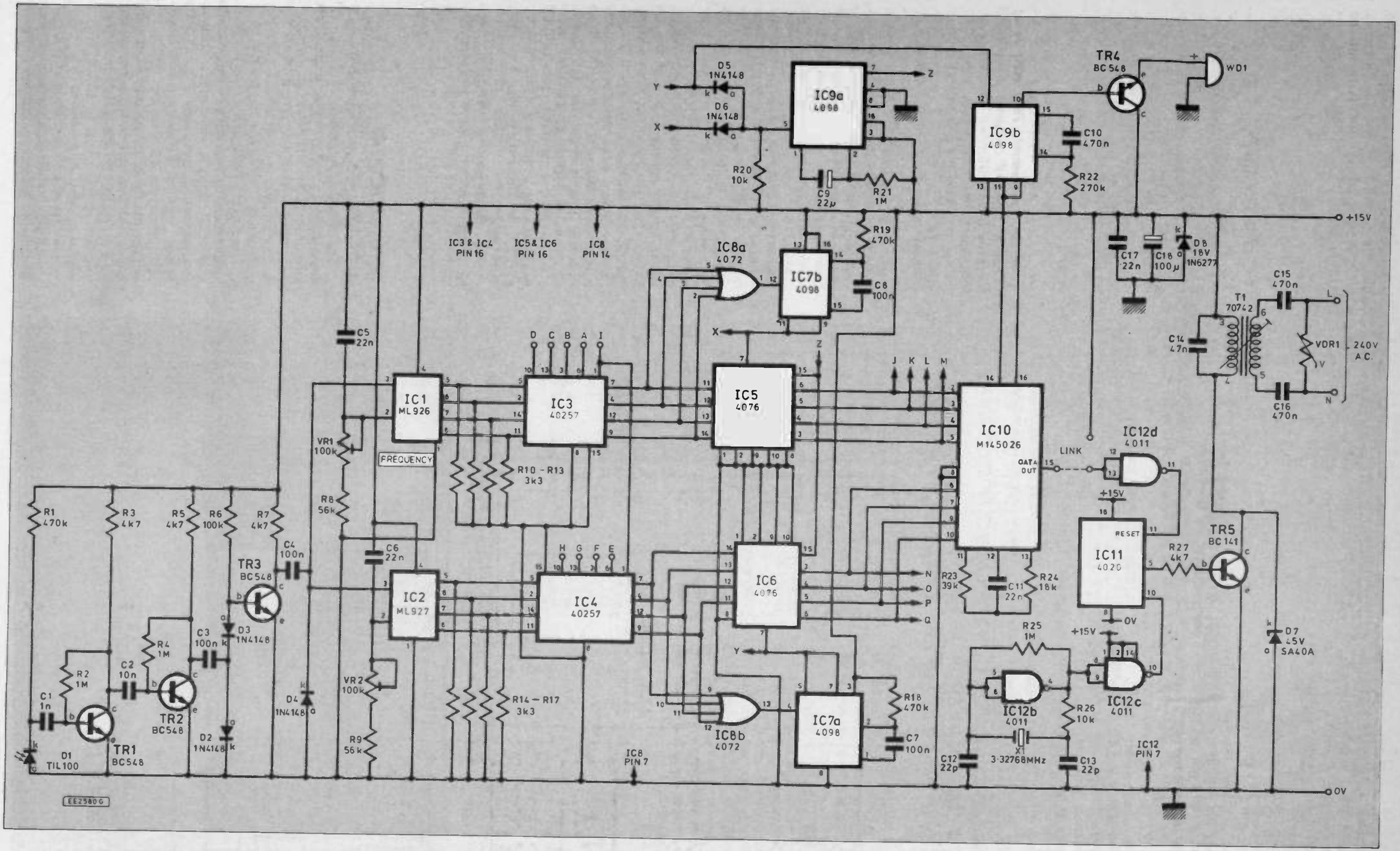



*Fig. 2.1. Circuit diagram for the MARC Encoder Board A. Letters A to Q label connections to Board B.*

7, 9 and 10) are transmitted from pin 15 by pulse width modulation (PWM); two short pulses for a "0" and two long ones for a "1". Two complete words are sent for the purposes of error reduction and the Decoder Modules i.c.'s will only respond when two consecutive and identical words are received.

Notice that pin 1 of IC10 is tied to 0V because nine data bits are not required in this application. Ambitious constructors wishing to utilise this pin can increase the number of addressable receiver units from 15 to 31.

Resistors R23 and R24 and capacitor C11 set the transmitter clock frequency. The manufacturers of these encoder/decoder chips state that no provision for clock frequency adjustment is necessary so long as 5 per cent tolerance timing components are used.

The 100ms long "Transmit Enable" pulse is generated by monostable IC9b which, in turn, is triggered by the "Y" function code present pulse from IC7a. Therefore, it should be apparent that, in order to send a complete appliance command, one should first press a "receiver number" button on the handheld IR Transmitter Controller.

This causes data to be loaded into IC5. Then, within ten seconds, a function command is selected which loads data into IC6 and also initiates the encoded transmit sequence

The pin 10 output from monostable IC9b drives buzzer WD1 via emitter-follower TR4. The short audible tone produced confirms transmission.

The NAND gate IC12b is wired as an inverter and together with quartz crystal X1 and its associated components forms a stable oscillator running at 3.32768MHz. This frequency is divided by 32 and reduced to 104kHz by ripple counter IC11.

The output from IC11 is available at pin 5 and a crude (but effective) form of keyed carrier modulation is achieved by feeding the inverted serial data from IC10 into the RESET pin of divider IC11. A temporary link between +15V and IC12d is used to generate a permanent carrier for setting-up purposes.

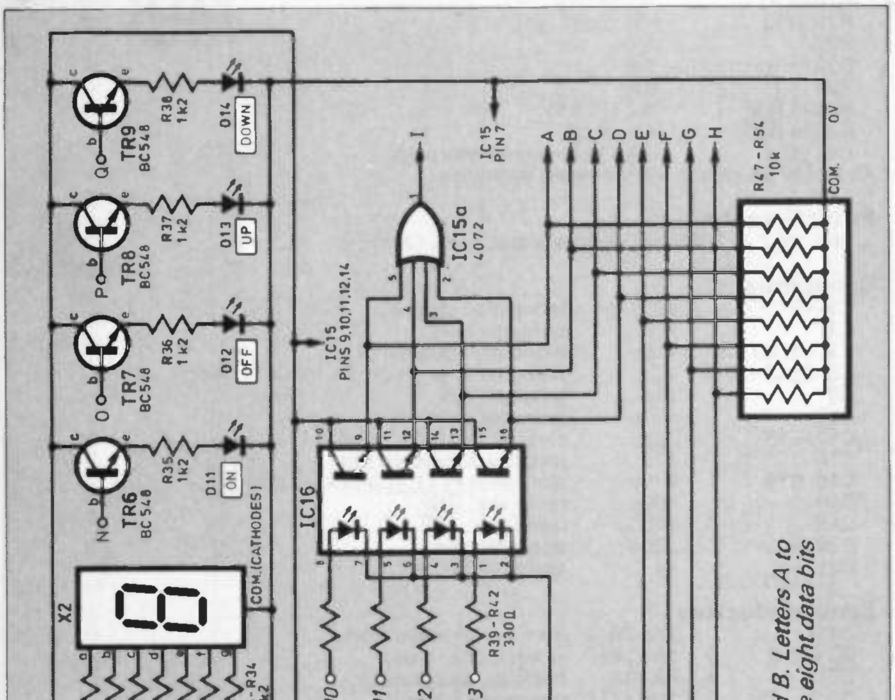


Fig. 2.2. Circuit diagram for the MARC Encoder – Board B. Letters A to Q label connections to Board A. Points D0 to D7 are the eight data bits from the external computer (optional).

## TUNED CIRCUIT

Transistor TR5 drives current into the tuned circuit formed by capacitor C14 and one half of matching transformer T1. This tuned circuit resonates at the carrier frequency and couples energy into the secondary winding of T1 and through capacitors C15 and C16 onto the mains wiring. These two capacitors all but block the low frequency 50Hz current from flowing through T1 secondary whilst presenting a low impedance to the 100kHz carrier.

***Do not use any old capacitor for this job since they are connected directly between live and neutral. They must be of "Class X" standard, cheaper ones could fail disastrously.*** Transformer T1 acts as an impedance matching device between the driver transistor and the low impedance mains line.

Unfortunately, as well as transferring data *onto* the mains, these interface components will also allow spikes, glitches and other high-voltage "nasties", frequently present on the house wiring, to pass into the electronics of the Encoder Unit. Such spikes could easily damage the delicate electronic components if they are not removed.

Varactor VDR1 normally presents a high impedance to the 240V r.m.s. mains but should a spike appear which has an amplitude significantly greater than the peak value of the mains voltage its impedance drops and the spike energy is dissipated as heat. Should really vicious spikes break through this first line of defence they are (hopefully) removed by the transient suppressors D7 and D8.

These devices act in a similar manner to a Zener diode although with a much faster switching time (within one picosecond, $10^{-12}$s). D8 clamps the positive supply and prevents it rising above about 18V, D7 works in a similar manner for the collector of TR5, the clamping voltage here being about 45V.

*Don't be tempted to omit these protection components or you will have had your "chips"!*

## ENCODER CIRCUIT-BOARD B

The circuit diagram of Fig. 2.2 should present no problems to most readers. The voltage regulator (IC13) and its associated smoothing and stabilising capacitors C19 to C21 produce the +15V rail from mains transformer T2. Notice that the 0V rail is connected to mains Earth.

The b.c.d. to 7-segment display decoder chip IC14 displays the current "receiver number" present on lines J to M from Board A on a common cathode seven-segment display X2. Resistors R28 to R34 are current limiters. The four front panel l.e.d.'s D11 to D14 indicate the selected function code ON, OFF, UP or DOWN and they are driven by transistors TR6 to TR9 wired as emitter followers.

Two quad opto-isolators IC16 and IC17 provide complete electrical isolation from the computer input connections *DO* to*D7*.

The eight bits A to H go to the multiplexer i.c.'s on Board A, the s.i.l. resistor pack (R47-R54) provides the eight pull-down resistors. OR-gate IC15a detects the presence of data on the four least significant computer bits and a high level from the output of this gate causes the multiplexer to switch its source from the IR receiver to the computer port.

## CONSTRUCTION – ENCODER

This project is not intended for the *absolute* beginner, so any constructor attempting to build the MARC system should not encounter any particular problems when assembling the encoder boards.

It is probably best to fully asssemble both boards but do not make any interconnections between them at this stage. Figs. 2.3 and 2.4 detail the component layout and copper foil patterns for printed circuit boards A and B. These are available through the *EE PCB Service*, codes EE694 and EE695.

The use of i.c. sockets is strongly recommended. Do not insert the i.c.'s themselves until ready to test the boards, all the devices are CMOS and should be handled accordingly.

***Board A*** requires some discussion. There are 19 wire links to insert, do these first before you forget. The use of terminal pins for all flying lead connections will eliminate the need to access the underside of the board later on. Transistor TR5 should be fitted with a clip-on heatsink (TO5 can); under normal conditions it won't need it but when generating the permanent carrier for alignment it tends to get a bit warm.

It is vital that the matching transformer T1 is orientated properly. Use a multimeter to check for continuity according to the pinout sketch in Fig. 2.3.

When soldered in place there should be ***NO*** continuity between the pins connected to capacitor C14 and those connected to capacitors C15 and C16. On all these transformers that I have purchased the identification number has been printed on the side shown, but I would still check to be sure.

At this stage you can decide whether you wish to include both the IR Receiver and the Computer Port as a data source. If only one is built then the components relating to the other can be omitted. Also, the multiplex chips can be left out but you will need to insert permanent wire links in their place to carry data between the appropriate pins.

***Board B*** should present no problems either. Resistors R47 to R54 are contained in a 9-pin s.i.l. package consisting of eight "commoned" 10k resistors, the common end should be marked with a dot or something similar; again, the use of a multimeter will dispel any doubts.

The voltage regulator IC13 gets warm in use and should be fitted with a small heat-sink, a scrap of aluminium will suffice. The use of terminal pins is recommended on this p.c.b. too.

## SAFETY FIRST

The unit is connected to the mains via a thin 3-core cable. If the conductors in this cable are soldered to terminal pins in the printed circuit board it is very important to insulate these with sleeving to prevent accidental contact. Don't forget the Earth connection to the 0V rail.

Two wires from the printed circuit board supply 240V to transformer T2 primary and the solder tags on this component must also be insulated. Stick some insulating tape over the live part of the board's copper tracks around the vicinity of the transient suppressor VDR1 and transformer T1.

***This project involves direct connection to the mains and, in spite of the blocking capacitors, the area around transformer T1 must be considered LIVE when the unit is connected to the mains. Also, although it provides impedance matching, T1 is NOT intended to provide guaranteed electrical isolation in the event of a failure. Therefore, take great care on the whole encoder circuit boards when carrying out live tests.***

The mains transformer T2 has two secondary windings, 0-15V and 0-15V. These are wired in series to give a single 15V-0-15V winding with 0V at the centre join.

## COMPONENTS

### Encoder Unit

See SHOP TALK Page 468

**Resistors**

| | |
|---|---|
| R1, R18, R19 | 470k (3 off) |
| R2, R4, R21, R25 | 1M (4 off) |
| R3, R5, R7, R27 | 4k7 (4 off) |
| R6 | 100k |
| R8, R9 | 56k (2 off) |
| R10 to R17 | 3k3 (8 off) |
| R20, R26 | 10k (2off) |
| R22 | 270k |
| R23 | 39k |
| R24 | 18k |
| R28 to R38 | 1k2 (11 off) |
| R39 to R46 | 330 (8 off) |
| R47-R54 | 10k s.i.l. 8-way resistor pack. |

All 0.25W 5% carbon, unless stated otherwise.

**Potentiometer**

VR1, VR2 100k min. skelton preset, horiz. (2 off)

**Capacitors**

| | | |
|---|---|---|
| C1 | 1n | monolithic ceramic |
| C2 | 10n | polyester layer |
| C3, C4, C7, C8 | 100n | monolithic ceramic (4 off) |
| C5, C6, C11, C17 | 22n | polyester layer (+/− 5% for C11) (4 off) |
| C9 | 22µ | tantalum 25V |
| C10 | 470n | polyester layer |
| C12, C13 | 22p | ceramic (2 off) |
| C14 | 47n | metallised polyester film |
| C15, C16 | 470n | metallised PETP *(Class X)* (2 off) |
| C18 | 100µ | radial elec. 25V |
| C19 | 1000µ | radial elec. 35V |
| C20 | 220n | polyester layer |
| C21 | 1µ | tantalum 35V |

**Semiconductors**

| | | |
|---|---|---|
| D1 | TIL100 | infra-red sensitive diode |
| D2 to D6 | 1N4148 | signal diode (5 off) |
| D7 | SA40A | transient suppressor |
| D8 | 1N6277 | transient suppressor |
| D9, D10 | 1N4001 | rec. diode (2 off) |
| D11 to D14 | l.e.d's | (various shapes) (4 off) |
| TR1 to TR4 | BC548 | *npn* silicon (4 off) |
| TR5 | BC141 | *npn* silicon |
| TR6 to TR9 | BC548 | *npn* silicon (4 off) |
| IC1 | ML926 | remote control decoder |
| IC2 | ML927 | remote control decoder |
| IC3, IC4 | 40257BE | CMOS multiplexer (2 off) |
| IC5, IC6 | 4076BE | CMOS latch (2 off) |
| IC7, IC9 | 4098BE | CMOS dual monostable (2 off) |
| IC8, IC15 | 4072BE | CMOS dual 4-input OR (2 off) |
| IC10 | M145026 | Remote control encoder |
| IC11 | 4020BE | CMOS ripple counter |
| IC12 | 4011BE | CMOS Quad 2-inut NAND |
| IC13 | 7815 | +15V 1A voltage regulator |
| IC14 | 4511BE | CMOS b.c.d. to 7-seg decoder |
| IC16, IC17 | Quad Opto-isolator (2 off) | |
| X2 | Common cathode 7-segment l.e.d. display | |

**Miscellaneous**

| | |
|---|---|
| T1 | 707VXA0242YUK transformer (Cirkit) |
| T2 | Mains Transformer, 0-15V 0-15V 330mA secondaries |
| X1 | 3.32768MHz Quartz crystal |
| VDR1 | Mains transient suppressor |
| WD1 | 12V electronic buzzer |

Two single-sided printed circuit boards available from *EE PCB Service*, codes EE694, EE695; dil sockets, 8-pin (2 off), 14-pin (3 off), 16-pin (11 off); TO5 clip-on heatsink; terminal pins; plastic case; plain matrix board; display bezel; red filter; 3-core cable; short length of screened cable; multi-coloured ribbon cable; connecting wire; solder etc.

*Approx cost. Guidance only* **£50**

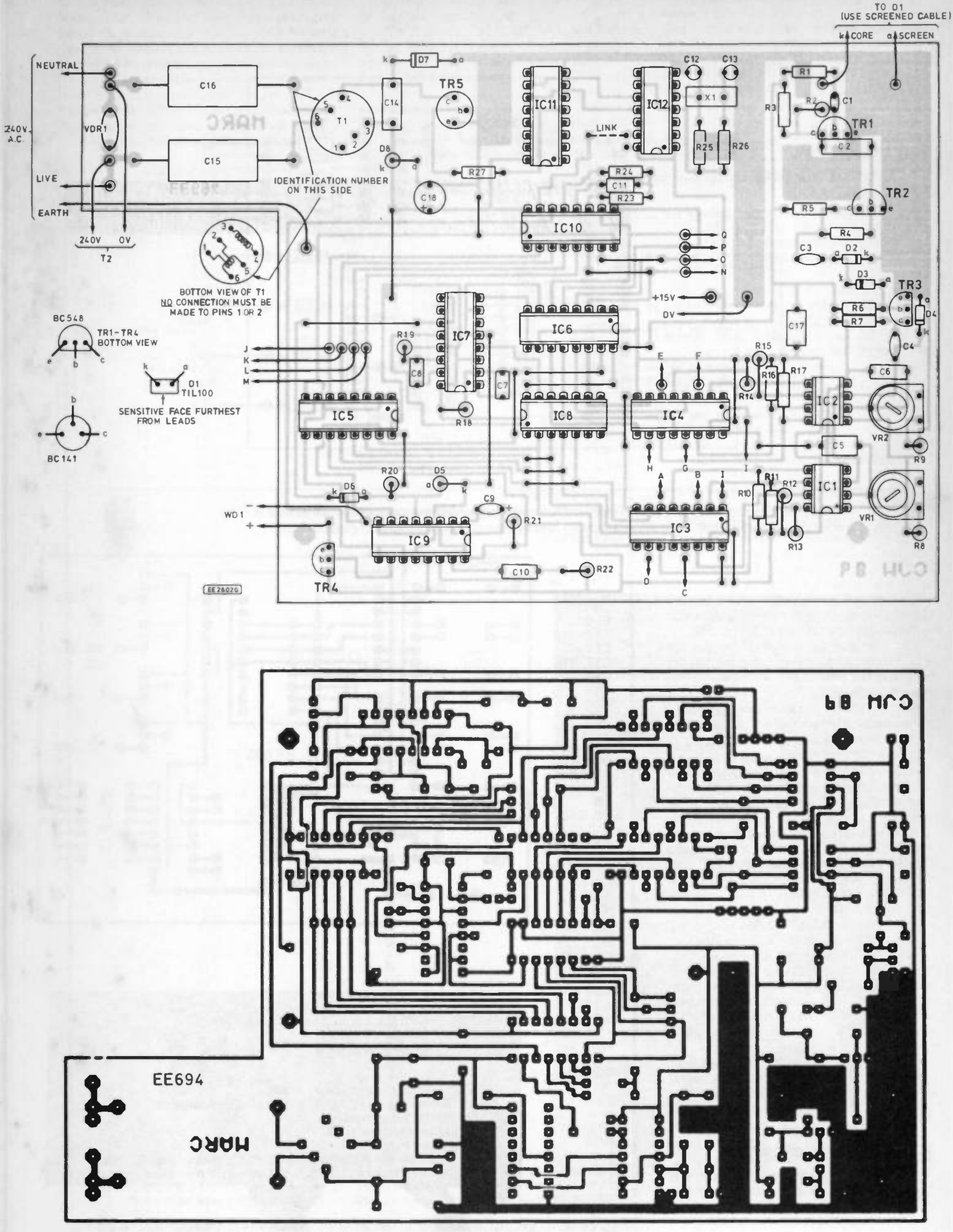



*Fig. 2.3 Component layout and full size printed circuit board copper foil master pattern for Board A. The four inset diagrams to the left of the component layout give the connection details for the impedance matching transformer T1, the transistors and the infra-red sensitive diode D1. Diode D1 should be connected to the board using a screened lead.*

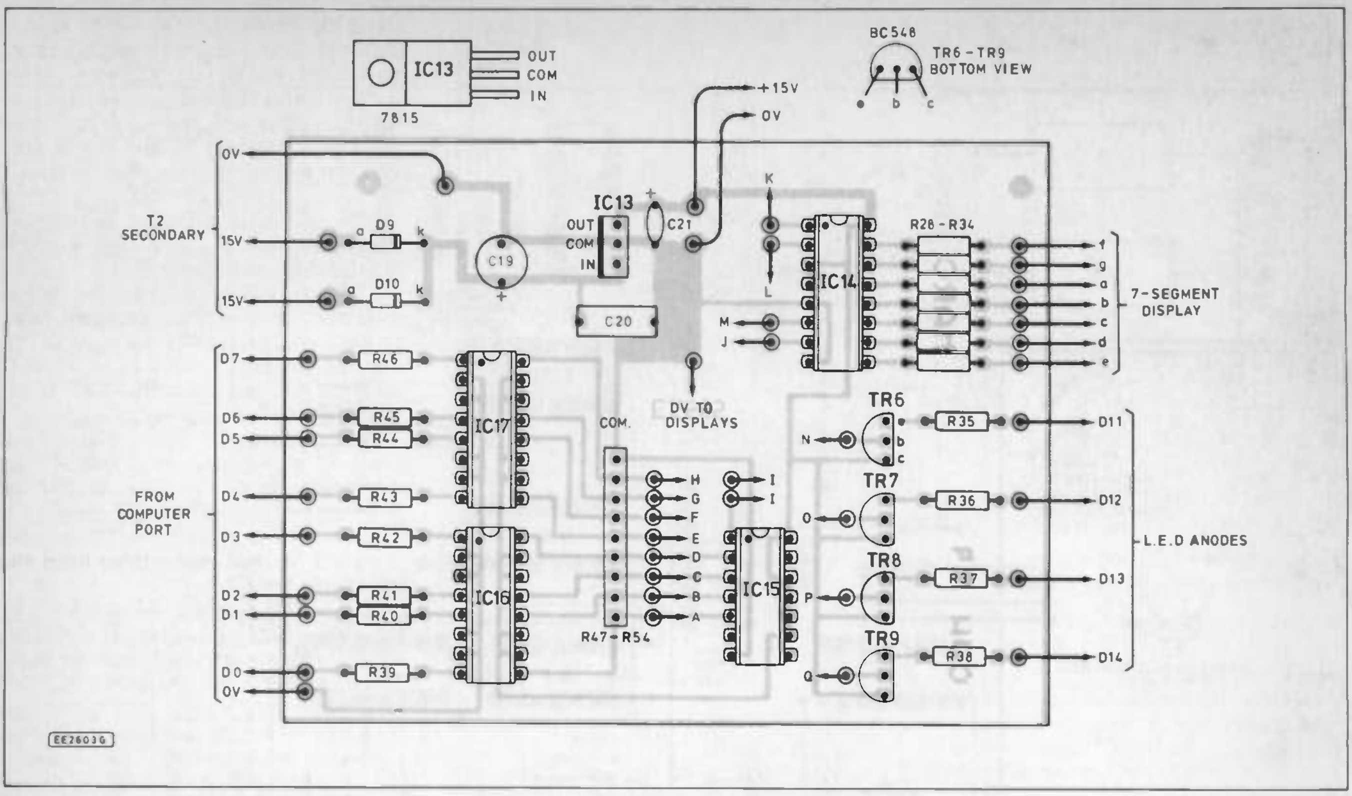
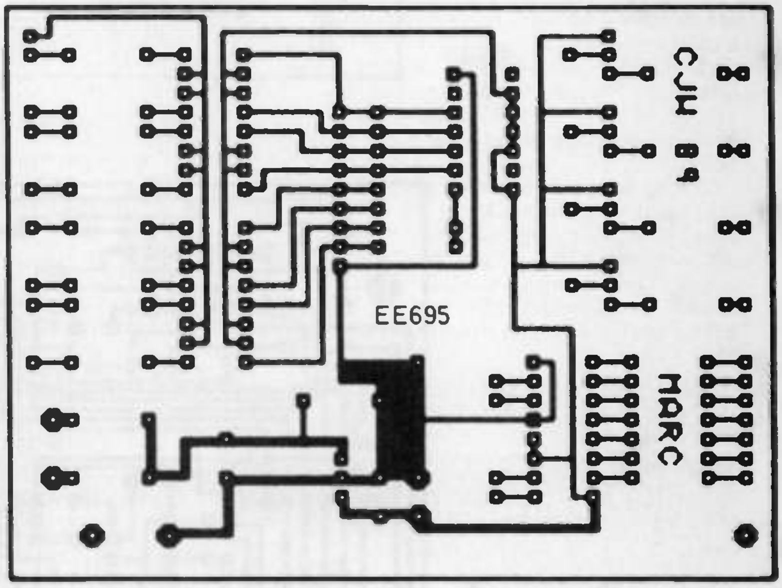
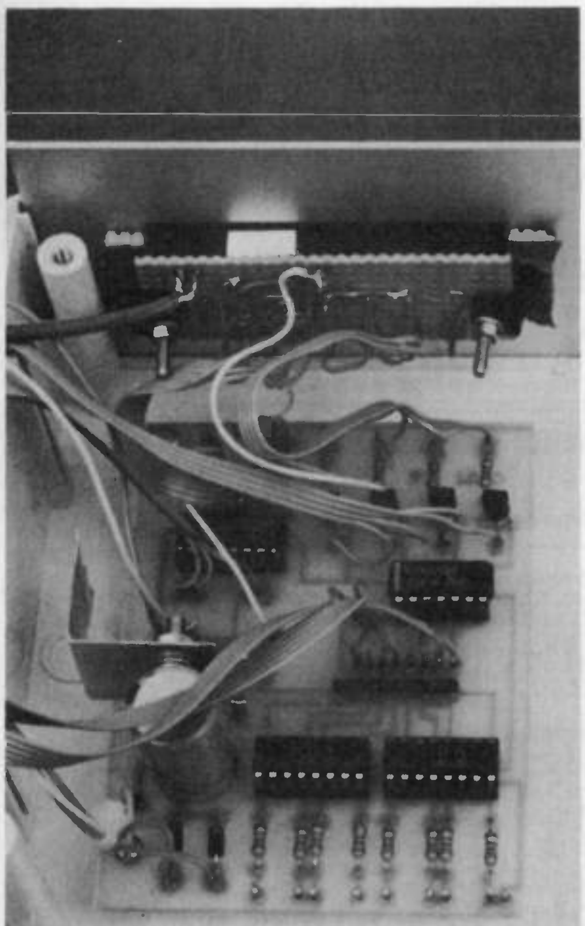
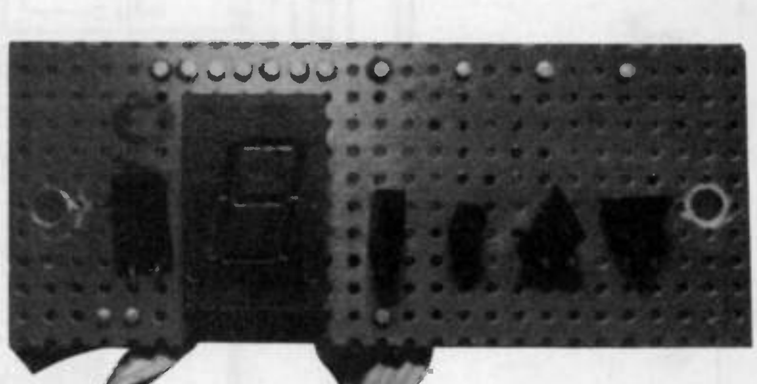



*Fig. 2.4. Printed circuit board component layout and full size copper foil master pattern for Board B. The display components are mounted on a separate plain matrix board, see photograph bottom right.*



*Completed Board B wired to the rear of the display board. A small aluminium heatsink is bolted to the voltage regulator IC13.*



*Front view of the function display board showing the infra-red receiver diode, seven-segment display and the different shaped l.e.d.s.*


*The completed Decoder unit (next month), Encoder and the handheld Infra-red Transmitter (last month).*

Link these terminals to Board B, apply a.c. power (CARE) and check for 15V between the power supply pins near IC13. If all is OK, switch off and complete all flying lead connections between the two boards then insert all integrated circuits (*be careful, not all devices face in the same direction*).

## DISPLAY

In the prototype unit the display l.e.d.'s are mounted on a small piece of *plain* 0.1in matrix board and flying leads link this to the terminals on Board B. The cathodes (k) of all l.e.d.'s including the common connection of the 7-segment display can be brought back to the 0V terminal pin on this board.

During design it was not thought practical to make another p.c.b. for the display board since the pinouts of different makes of 7-segment displays vary greatly. The infra-red receiver diode D1 is also placed on this matrix board and a screened lead links it to Board A. The screen connects to 0V.

## CASE

Encasing the whole circuit is a simple task. The prototype is housed in a Verobox type 202-21035 with Board A and transformer T2 fastened in the bottom half and Board B in the lid.

To present a professional finish the display board is mounted behind a display bezel which includes a red filter for improved viewing contrast. Because of this it is not possible to use different coloured l.e.d.'s for the different function codes. Instead, I made use of the various l.e.d. shapes available as can be seen in the photographs.

## ALIGNMENT

Commence the alignment procedure by making sure that the temporary link on Board A is connected between IC10 and IC12 pin 13. Connect an ammeter in series with the positive power supply lead from Board B to Board A and apply mains power.

The displayed current drain should be about 20mA, switch off if significantly above this before the blue smoke starts to curl up! The 7-segment display should show a zero and no l.e.d.'s lit.

Now comes the time to test your infra-red transmitter and receiver circuits. Press a "receiver number" button on the transmitter (have you remembered to connect the battery and insert the i.c.? I forgot the latter, I must admit!). Adjust preset VR1 until the 7-segment display follows the selection on the transmitter.

Similarly, adjust VR2 until the function code buttons cause the appropriate l.e.d.'s to light and buzzer WD1 to sound (note that the ON l.e.d. always lights when UP and DOWN are selected). The display should clear after a ten second wait.

Disconnect power and move the temporary link between IC12 pin 13 and +15V. ***Do not try to solder this link with power applied to the board*** because an earthed soldering iron bit will cause short circuits if touched on anything other than the 0V line.

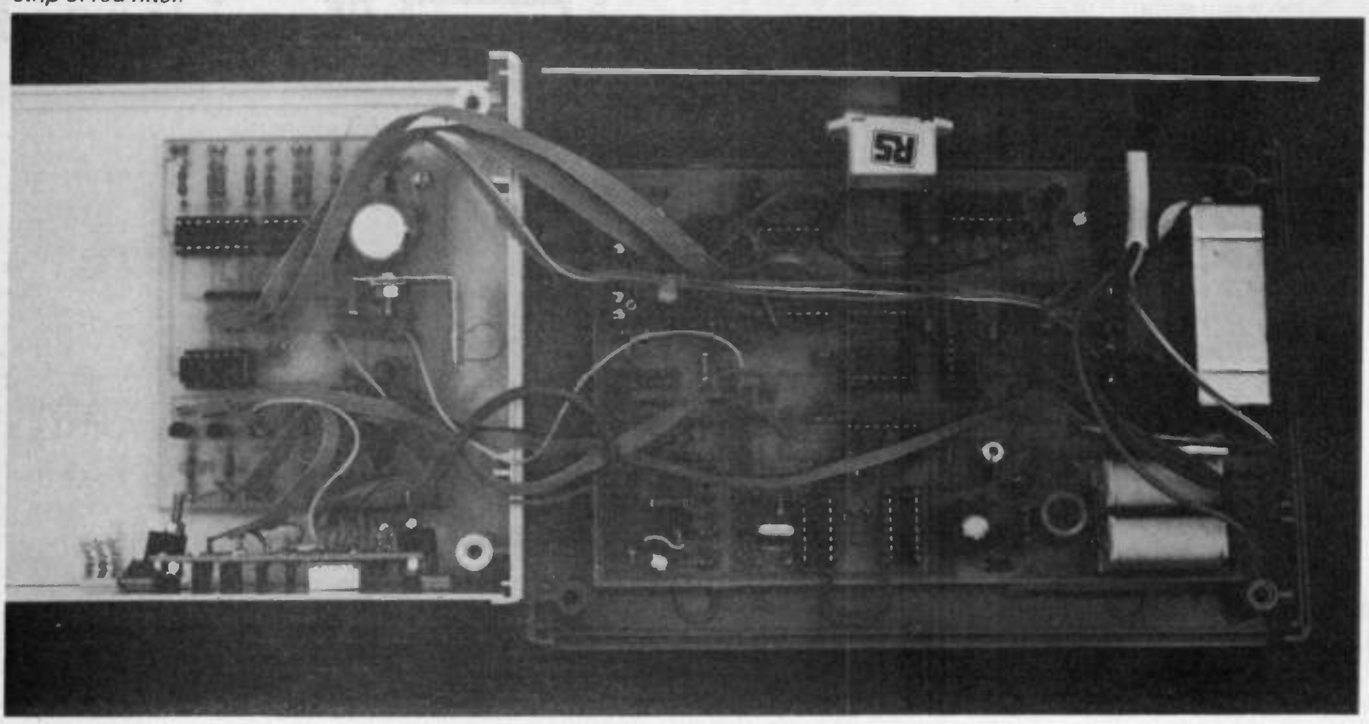
Re-apply power via the ammeter and bring the tuned circuit into resonance by adjusting the tuning slug in transformer T1 for *minimum* current drain (about 100mA when the carrier is running). Use a plastic trim-tool for this adjustment. A better method is to look at the carrier signal at TR5 collector using an oscilloscope and tune for maximum amplitude (somewhere in the region of 30V peak-to-peak). Replace the link between IC10 and IC12.

This completes assembly and testing of the MARC Encoder. Situate the unit away from TV's and other "electrically noisy" appliances as the front-end of the IR receiver is very sensitive and easily swamped. Alternatively you could screen TR1 and associated components using thin aluminium sheet connected to 0V.

## COMPUTER INTERFACING

Many users may be quite happy to do away with computer control of the MARC system and only make use of the infra-red remote control link. Indeed, as was

*The completed Encoder unit opened up to show board A mounted in the bottom of the case and board B positioned in the lid. The display board is mounted on one of the aluminium panels. A cutout must be made in this panel to take a display bezel and a strip of red filter.*



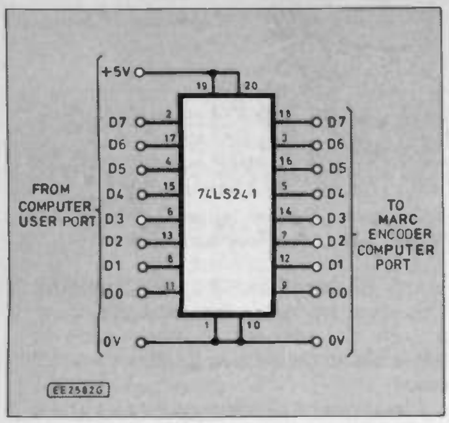



*Fig. 2.5. Circuit diagram for buffering the computer user port to increase its current sourcing capacity.*

mentioned earlier, the SL490 transmitter i.c. has the ability to send all the necessary codes to the encoder if extra switches are used on the handheld transmitter unit. Some constructors may like to take the trouble to purchase a data sheet for this i.c. and experiment along these lines.

Microcomputers are so commonly owned these days that it seemed an obvious addition to include a computer data input port during the design stage of this project. Also, since many micros have a "user-port" already fitted (or have provision for adding one) the MARC systems offers an ideal way to increase the power of "real-world interfacing" without the birds-nest of wires spewing from the computer and running around the house to all the appliances.

Resistors R39 to R46 are chosen to give an opto-isolator diode current of about 10mA for a 5V high logic level. Your computer user-port must be capable of supplying 10mA per line, some output chips are not, e.g. the 6522 VIA on the BBC user-port or the Z80 PIO.

In these cases it will be necessary to buffer each line to increase the current sourcing capability and the use of an octal buffer/driver chip such as the 74LS241 will reduce the need for extra circuit building to a minimum. Fig. 2.5 shows how this i.c. can be used in such an application. It is important to note that the 5V power supply *MUST* come from the micro, any attempt to derive it from the MARC encoder supply defeats the aim of using an opto-isolator.

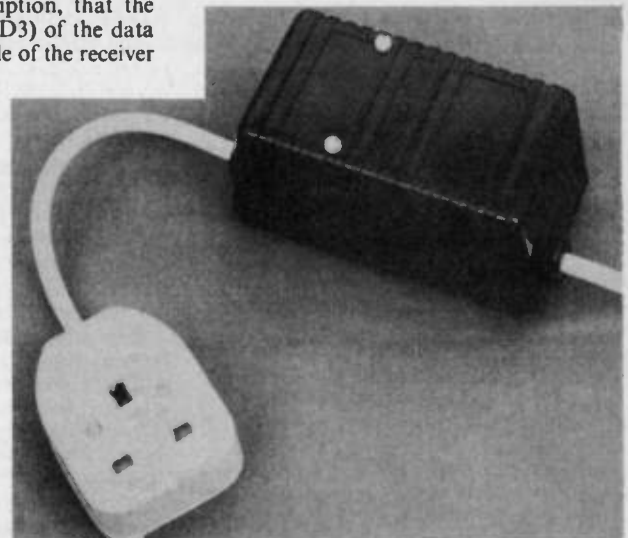
You should remember, from the preceeding technical description, that the lower order four bits (D0-D3) of the data byte contain the binary code of the receiver to be accessed. Bits D4-D7 hold the "function code" for this receiver. All that is required to send this data byte along the mains is to place it on the MARC computer input lines for a time period *exceeding 10ms* (this is the length of the pulse which loads data into the encoder latches).

For example, say you wish to send "function code" 1 (ON) to receiver number three. The hexidecimal form of the data byte would thus be 13, which corresponds to binary 00010011. Sending function 9 (DOWN) to receiver 12 (C, in hex) would mean outputting a byte of value 9C from the user port, 10011100.

Although function codes 1, 2, 5 and 9 are used by the MARC decoders to be described in future articles, there is nothing to stop designers using all 15 possible codes for their own purposes if desired.

The requirement for a 10ms "data-present" time will require some thought when writing software. It may be necessary to introduce a short delay loop to achieve this. Do not forget to clear the user-port lines to zero after sending the code, otherwise the continuous presence of data on the computer port will cause the multiplexer chips to ignore signals from the IR receiver circuit.

**Next Month: Decoder ON/OFF Switch.**



# Robot Roundup

NIGEL CLARK

## ROBOT WAYS

For anyone who has ever wondered what top and middle managers get up to when they go away on management training courses Stevenage Adventure Workpacks may have the answer. The company has been asked to look at the possibility of creating a robot game which can be used on such get-away-from-it-all jaunts.

The thought of high technology entering the world of management assessment appealed to George Walker and his colleagues at Adventure Workpacks and they have come up with an idea which he thinks many people may find interesting.

"I was approached by a large company which was looking for something different but interesting to do on its courses in the evenings," said Walker. "It was such a delightful suggestion and the thought of managing directors chasing around playing with robots made me chuckle so I set to and came up with this."

## GREAT EGG RACE

What Walker came up with was a sort of Great Egg Race combined with model car racing.

Two teams begin with a set of components and the instructions telling how they should be put together to create a pick and place robot on wheels (see photo). When they have completed the construction of the robot, members of each team split into pairs and race each other to pick up an object, carry it through a course and place it in a container.

Possible adaptations on this basic theme include making the mobile robot negotiate an obstacle course and replacing the control board, which is basically a set of switches wired to the robot and set on a lump of wood which can be hung around the driver's neck, with a remote control system.

This brief explanation makes it appear quite simple but as Walker pointed out there are plenty of opportunities for getting things wrong in the construction and even if that is successfully achieved directing the robot needs a special skill of its own.

## STEERING COMMITTEE

The steering is based on the tank principle with the movement of the wheels on one side relative to the movement on the other side governing the direction in which the robot travels.

One concession to the environment in which the game is likely to take place has been the rear wheels which are 10 inch diameter to allow the robot to travel across the deep pile carpets that are expected to be found in the premises in which the courses are likely to be held.

For companies wishing to know about the abilities of its management, accessors could be on hand to judge how the staff work together in teams, who has leadership potential and in the event of everything not running smoothly see who is best able to overcome the difficulties.

Walker said that the cost would be about £1,500 and expected the main market to be companies who were looking for something different in their training systems. As well as selling the game he is also considering hiring it out as part of a promotional or conference package.

## REASSESSMENT

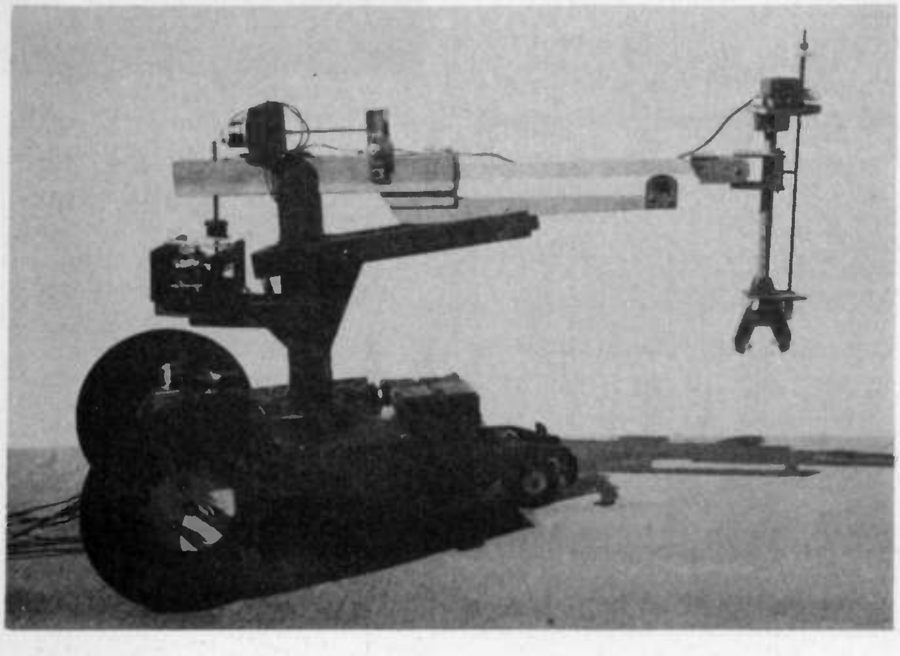
He has also been reassessing his kit range again. Under the banner of Starting Points he has introduced a series of packs intended to act as introductions to a range of electronic and mechanical concepts.

The results of completing one of the packs is that it looks similar to his original Heath Robinson-like Robotech models. This time however, the intention is to provide an inexpensive introduction to the subjects rather than build a beautiful model.

The robotics kit contains motors, gears and switches for a pick and place robot as well as comprehensive building plans, instructions and ideas on how to work it. The structural components can be made from any junk material but there are plans for wooden components, some of the more complex of which are included in the kit.

To give the models computer control from a BBC B he has included a circuit diagram for an interface. There is also a circuit diagram for a switching board.

All this comes for £98 plus VAT. Anyone already having the necessary hardware can get the plans by themselves as well as the other documentation for £49.



## NEW DRIVE

Hasfield Systems is continuing its moves to make the best use it can of the Armdroid, the manufacture of which it took up in 1988. Having brought out an improved version, named the Armdroid HS 1B, John Allright and his colleagues are now trying to increase its specification further by developing a new drive board.

The main basis of the improvement is coming from a decision to make the stepper motors bi-polar. This will have the advantage over the present machine of making the arm faster, up to three times faster has been claimed.

It is also claimed the lifting capacity is increased by up to four times. That would increase the capacity of the five-axis arm from 250gms to 1kg working at a maximum speed of three metres per second.

Another major change is that the standard gripper would be two-fingered instead of the present three finger standard. As before grip sensing is optional. Hardware development has been completed and the company is now working on the software which it expects to finish in the near future.

Their idea in upgrading the Armdroid is to give it a complementary role to the company's bigger Gamma arm, which is produced as part of a system for use in laboratories. While the full Gamma system can cost about £10,000, the improved Armdroid could be priced at about £1,500 which would allow laboratories to purchase one to give them an idea of how they could make use of a robot before perhaps investing in the full system.

Allright said that the company thought that the development work on the improvement had lead to a useful by-product. It is a control board which can control up to eight bi-polar motors.

The board would sell for about £300. Allright said it would allow people to power their machines cheaply.

Constructional Project

# TOW-TEST

PETER RAWNSLEY

*Anyone can check out the tow socket wiring with this simple unit.*

ANYONE who tows a caravan or trailer will come up against this problem sooner or later.

You're all hitched up and ready to roll when a voice from the back says, "Better check the lights are working." The owner of the voice is duly despatched to the rear of the outfit:

**"SYSTEMS CHECK!"**

"RIGHT FLASHER?" - "O.K."
"LEFT FLASHER?" - "O.K."
"BRAKELIGHTS?" - "NO! TAILIGHTS"
"TAILIGHTS?" - "NO! LEFT BRAKELIGHT"

"OH! BO!!*RDS!"

Where do you start to locate such faults? In the above scenario, with the car probably loaded to the gunnels with the kids and luggage, all raring to go on that long awaited holiday, car ferry to meet at 6 p.m., the pressure is on. E.E. has the answer: –

## SOCKET-TESTER

This device is basically a piece of test equipment used to test the correct function of the towing socket fitted to cars, vans etc, and will be of use to all caravan/trailer owners. The sockets fitted to cars are prone to malfunction due to ingress of dirt and broken wires. But the main problem owners face when they find their lighting systems faulty is determining whether it is the car or caravan/trailer electrics at fault.

All cars equipped for towing are fitted with a black 7PIN(12N) socket wired to the European standard as shown in Fig. 1.

The *Tow-Test 12N Socket-Tester* is wired to this standard and is effectively a miniature trailer-board, consisting of six l.e.d.s mounted in a small handheld case, connected to a length of seven core trailer cable with a 7PIN(12N) trailer plug connected at the other end.

## CIRCUIT

The circuit diagram for the tester is shown in Fig. 2. The six l.e.d.s D1 to D6 represent the lighting circuits, each has its own current limiting resistor R1 to R6 all are the same value which has been chosen to provide optimum brightness for the two l.e.d. colours used whilst easing construction.

Diode D7 provides reverse polarity protection for the l.e.d.s should this be caused by faulty wiring under test. The circuit is then connected via seven core trailer cable to the appropriate pin number of the 7PIN(12N) plug as shown in the diagram and Fig. 1.

## COMPONENTS

**Resistors**
R1 to R6 470 0.6W (6 off)

See SHOP TALK Page 468

**Semiconductors**

| | |
|---|---|
| D1 | 5mm yellow l.e.d. |
| D2 | 5mm red l.e.d. |
| D3 | 5mm red l.e.d. |
| D4 | 5mm red l.e.d. |
| D5 | 5mm yellow l.e.d. |
| D6 | 5mm yellow l.e.d. |
| D7 | 1N4002 diode |

**Miscellaneous**
5mm l.e.d. panel mounting chrome bezel (6 off); 7-way tag strip (cut from 13-way); 3/8in grommet; 5/16in p-clip; type 401 handheld Verobox; 7PIN(12N) trailer plug; seven core trailer cable (see text); fascia panel (copied or cutout from page); 4BA x 1/2in csk screw (3 off); 4BA shakeproof washer (3 off); 4BA nut (3 off); 4in 22 s.w.g. tinned copper wire; solder.

Approx cost. Guidance only **£8**

Fig. 1. Wiring of the 12N plug.

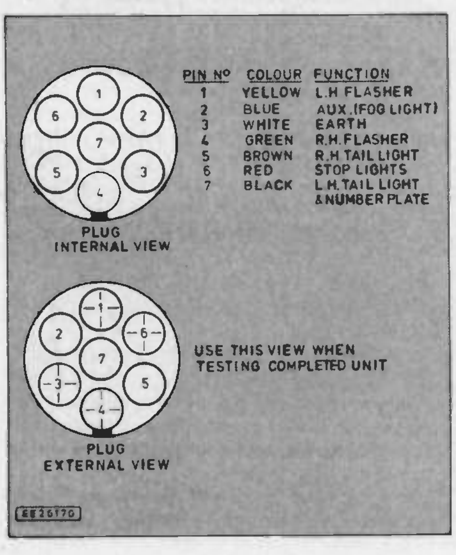
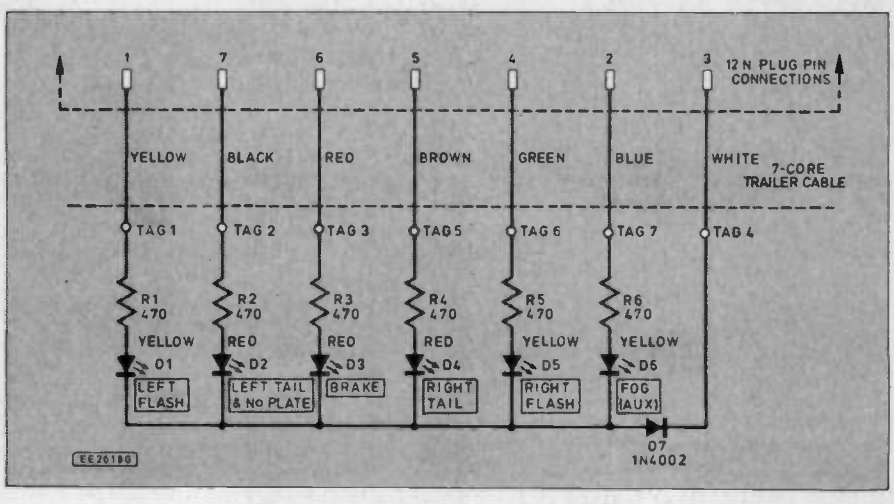



Fig. 2. Circuit diagram of the Tow Test.



## CONSTRUCTION

The case used for this project is a small handheld Verobox type 401. The l.e.d.s are panel mounted in chrome bezels with the rest of the components mounted via a seven-way tag strip.

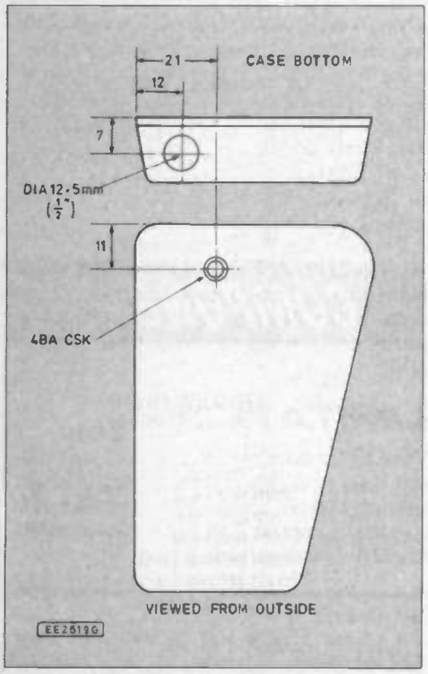
Commence construction by marking out then drilling the case as shown in Figs. 3 and 4. The positioning of the l.e.d. bezels can be simplified by using the fascia panel Fig. 5. (use an actual size copy of Fig. 5) as a template, marking through to the plastic with the fascia in position on the case front.

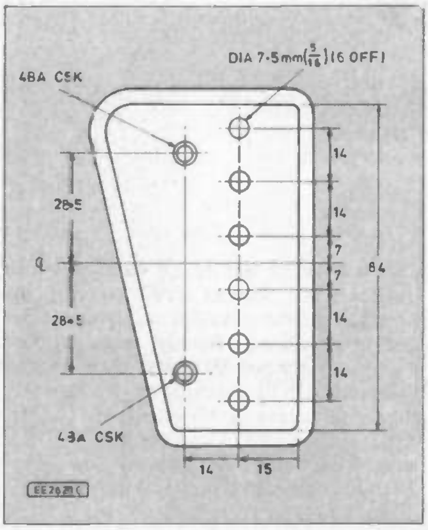
With all holes drilled begin assembly, mounting the seven-way tag strip first using the 4BA countersunk screws. Position the fascia and stick in place. The l.e.d. bezel mounting holes in the fascia will require enlarging to the size of those previously drilled in the plastic case beneath, before the bezels can be mounted.

The rest of the components are mounted and wired as shown in Fig. 6. observing that the correct polarity of the l.e.d.s and D7 is achieved. The 7PIN(12N) plug is wired via a length of seven-core cable long enough to reach from the socket on your car to the drivers seat and wired according to Fig. 1.

## TESTING

Once completed the tester is nearly ready to use but resist the urge to plug it straight into you car. **Faulty test equipment is of no**



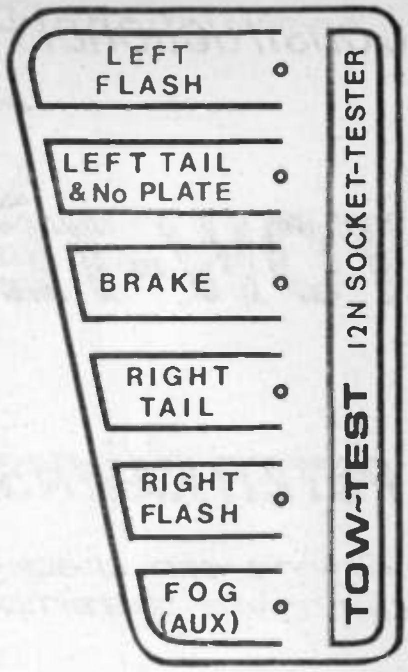
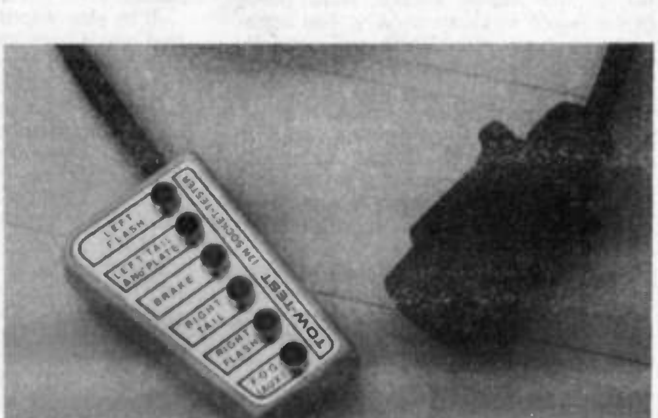




*Fig. 5. Actual size facial panel.*

*Fig. 3. (far left) Case drilling details.*

*Fig. 4. (left) Drilling of the case top – outside view.*



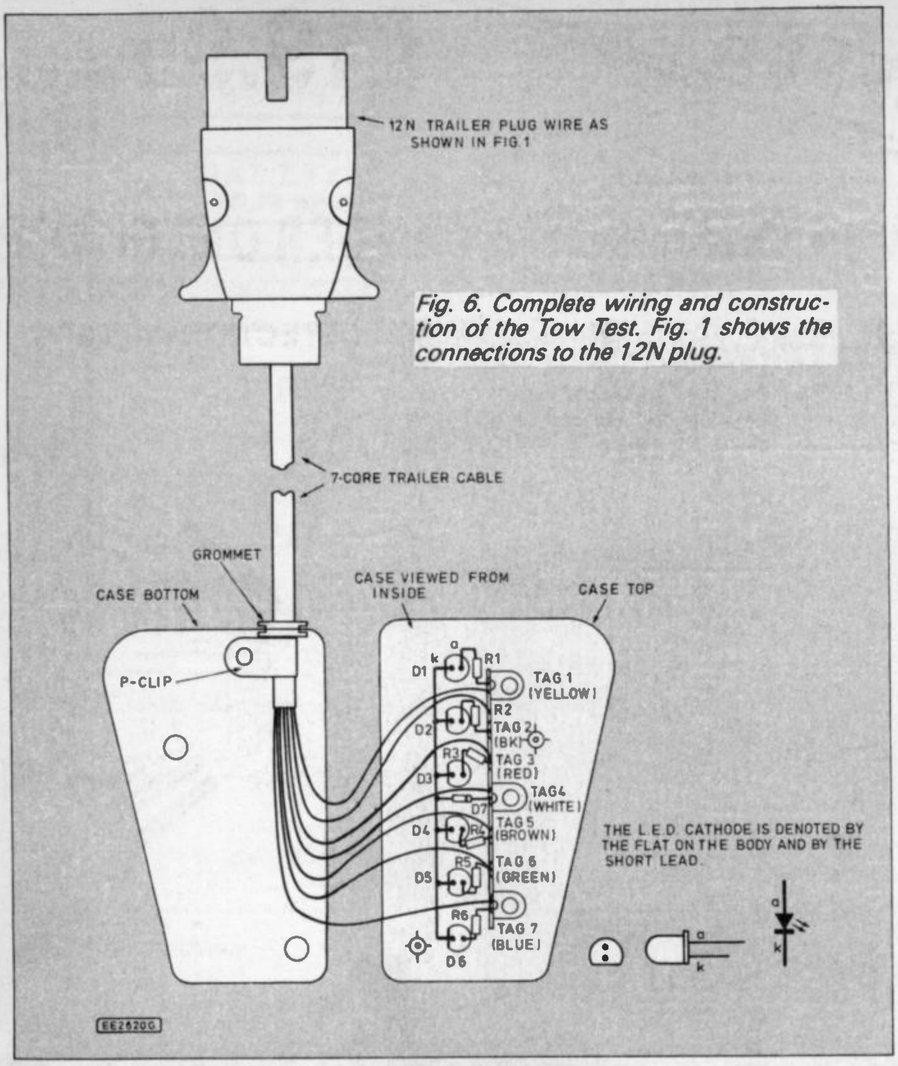



*Fig. 6. Complete wiring and construction of the Tow Test. Fig. 1 shows the connections to the 12N plug.*

**use whatsoever!** Carry out the following tests first using a 12V d.c. power supply or batteries. If a car battery is used include a 100mA fuse in the +ve supply lead to protect against accidental short circuits.

1. Connect – ve supply lead to pin 3 of the 7PIN(12N) plug.
2. Connect +ve supply lead in turn to the remaining six pins, observing the pin number and noting the resulting indication.

If all is well the pin numbers and resulting indications should correspond to each other as in Fig. 1. If not then recheck all the wiring and the polarities of the l.e.d.s and D7.

## IN USE

Assuming all is well you can now proceed to single-handedly test the socket on your car/van. Plug the tester in and then, sitting in the drivers seat, operate the cars lighting system and observe the results on the tester.

If abnormal results are obtained then a fault exists on the car wiring and not the trailer/caravan. Check the socket wiring for loose or shorted connections or poor earthing and the pins for signs of corrosion and remedy any problems found.

It is unlikely that the socket will be wired incorrectly if it has functioned correctly up to this point. But it is a possibility on a new untried installation so check it is wired as in Fig. 1.

## LIMITATIONS

The tester does not impose the same current loading on the connector as the actual lighting system would and therefore certain heavy current/bad earth related faults might not be detectable. Happy towing!

# SHOP TALK

## with David Barrington

### Grand National Game

The components required for the miniature version of the *Grand National Game* are mostly standard "off the shelf" items and should not cause any purchasing problems. The rating of the m.e.s. lamps may vary very slightly from supplier to supplier, but should work quite happily in this circuit.

However, a couple of items called for in the Mains version may prove troublesome to locate locally. The opto-isolators type MOC3020 are currently listed by **Cricklewood, Omni** and **Greenweld**.

The 3-pin Euro-style chassis sockets and plugs are sometimes listed in catalogues under the "Bulgin" name and are now fairly common. Although these are rather expensive items, because of the mains safety aspect we strongly recommend these types be used.

A complete kit of parts including lamps and case for the miniature version (£8.95) and a complete kit, including case, mains lamps and holders, for the mains version (£27.95) are available from **Greenweld Electronic Components, Dept EE, 27D Park Road, Southampton, Hants SO1 3TB. Add £2 per order for post and packing.**

### Mains Appliance Remote Control

The *Encoder Unit*, this month's project in the *MARC* system, is the most complicated section and due to its connection to the mains supply only new first class components should be used.

The capacitors C15 and C16 are special types designed to withstand continuous mains voltage, other types must ***NOT*** be used as replacements. These capacitors were purchased from **Maplin**, code JR36P (IS Cap 0.47μ).

It is also important to use the specified mains transient suppressor. This was also obtained from Maplin, code HW13P (Mains Trans Supp). Both the transient suppressor and mains capacitors should be stocked by other advertisers.

The SA40A suppressor diode D7 (code QY71N), the ML926 and ML927 decoder i.c.s (codes QR57M, QR58N) and the M145026 encoder (code UJ49D) i.c. also came from Maplin. The other suppressor diode (D8) 1N6277 is an RS component and is available through **Electromail** (☎ *0536 204555*), stock code 283-277.

The "impedance matching" transformer T1 was obtained from **Cirkit** and is listed under their "inductor" section. When ordering quote code 35-70742.

The two Encoder printed circuit boards are obtainable through the *EE PCB Service*, codes EE694 and EE695 (see page 492 for details of prices).

### Video Check

We do not expect any component buying problems to be encountered when building the *Video Check* project. Most component suppliers will be able to offer a suitable flashing l.e.d. at a reasonable price.

The light dependent resistor ORP12 or an equivalent should be stocked by most of our advertisers. It is not imperative that the specified handheld case be used, any small plastic case will do the job as long as there is sufficient room for the board, ORP12 and the push switch.

### The Tester

The only component likely to cause concern when purchasing components for *The Tester* is the 2N4289 transistor. This a.f. low noise transistor (99p + VAT) appears to be only listed by **Cricklewood Electronics** (☎ ***081 425 0161***).

It is quite possible that the more common 2N3702 transistor may work in this circuit. This device has not been tried but select for high gain if it is used.

The small printed circuit board is available from the *EE PCB Service*, code EE969 (see page 492).

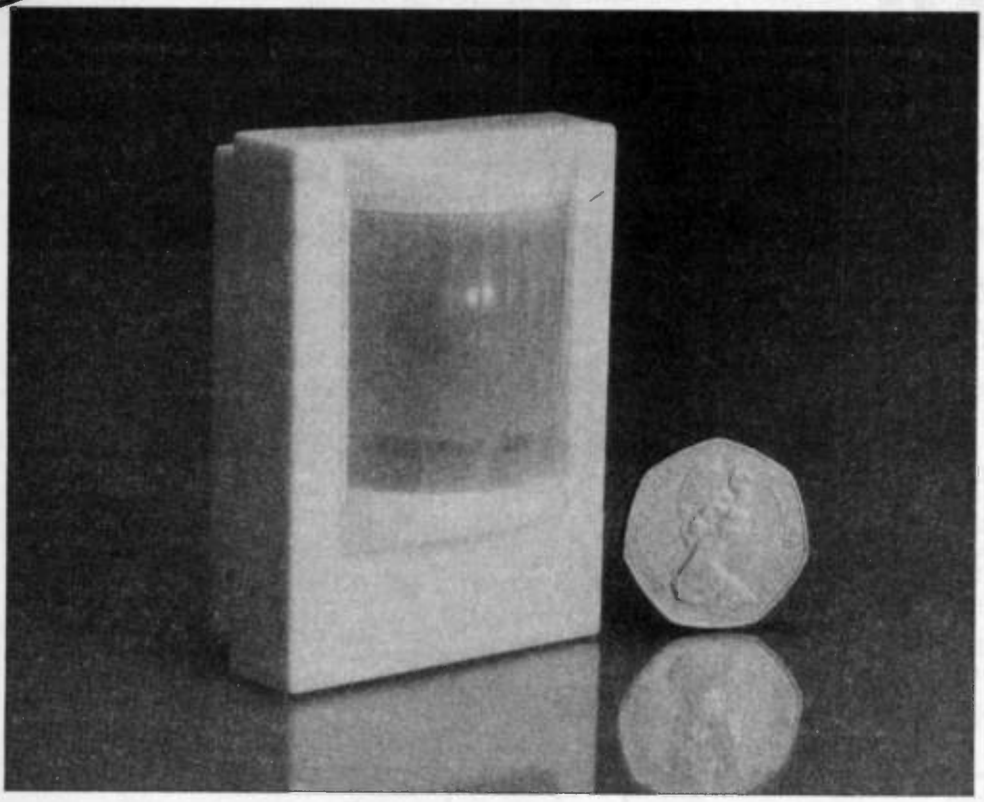
### Tow-Test

The 7-pin 12N plug and 7-core trailer cable called for in the *Tow-Test* should be available from most large caravan accessories and motor spares shops. The handheld control case, type 401, used in the prototype was purchased from **Maplin**, code LL14Q (Verobox 401).

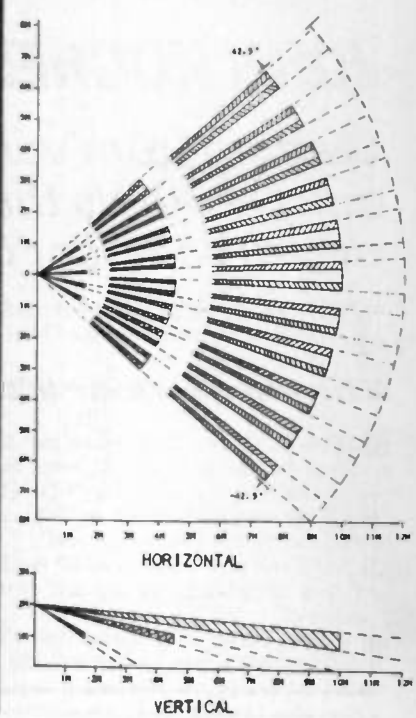
EE SPECIAL OFFER

# £19.95 inc VAT & P&P

# PASSIVE INFRA-RED INTRUDER DETECTOR



## DETECTION PATTERN




THE RP33 Riscomp passive infra-red intrusion detector is designed for use in both residential and commercial security systems. It operates by detecting the body heat of an intruder moving across the detection field. The detector employs a dual element pyroelectric sensor which is designed to overcome the effect of changes in ambient temperatures, thus ensuring a stable and reliable performance, while the considerable filtering employed in the advanced circuitry ensures that the sensor is unaffected by RF interference and electrical transients.

Installation is easily carried out on a flat surface or in a corner location without the need for additional brackets, whilst the angled rear of the case permits the unit to be mounted in an off-set position as may be required in some locations to achieve optimum coverage. Vertical adjustment of the detection pattern over a 10° range is provided, whilst the dual range facility allows the installer to optimise coverage for the intended location.

The RP33 is suitable for use with the Riscomp control units type CA 1382 and CA 1250, or any equivalent high quality control unit.

### SPECIFICATION

| | |
|---|---|
| Operating voltage: | 9-15V d.c. |
| Current consumption: | 14mA at 12V. |
| Relay output: | Normally closed contacts rated at 0.5A with 22 ohm resistor in series. |
| Anti-tamper switch: | Normally closed rated at 1A. |
| Detection range: | Switchable between 7 and 12 metres. |
| Detection zones: | 24 in 3 planes. |
| Maximum operating angle: | 85° |
| Mounting height: | 2-3 metres. |
| Walk test: | Red l.e.d. (with disable switch) |
| Dimensions: | 80mm × 60mm × 40mm. |
| Sensor type: | Dual element ambient cancelling. |

**POST TO: EE Intruder Detector offer, Riscomp Ltd., 51 Poppy Rd., Princes Risborough, Bucks HP17 9DB**

**INTRUDER DETECTOR OFFER**

**Please suply:**

| Quantity | Product | Price |
|---|---|---|
| | RP33 Intruder Detector | £ |

**Prices include VAT and delivery** — Overseas Airmail Postage £

Total £

Please make cheques payable to Riscomp Ltd.

Access/Visa No.............................................................

Card Ex. Date.............................................................

Signature.............................................................

I enclose cheque No.............................................................

Name.............................................................

Address.............................................................

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Normally sent within two days, but please allow up to 28 days for delivery

**OFFER CLOSES FRIDAY AUGUST 3, 1990**

**Readers outside of Europe please add £3 for airmail postage**

# Special Series

# MICRO IN CONTROL

**JOHN HUGHES**

## Part Eight

*Starting from very basic principles this series quickly builds through logic to simple microprocessor control.*

THIS month we look at the three-floor lift logic and then meet the "Micro".

### The three-floor lift:

**T** Now let's take a deep breath and start working out the logic for an extra floor. We've already got a plan (Fig. 8.1). How far can we adapt the circuit we've already worked out for the two-floor model?

**S** *We'll still need a timer/and all the door and limit circuits/and the top and bottom floor logic?*

**T** Seems reasonable, though our "bistable" approach may be less suitable for more than two floors. This time it might be a good idea to use a bistable (memory) for each floor. (Fig. 8.2). When does output A need to be 1?

**S** *If P2 is called/or P1/only if the lift is below it/Oh, it CAN be above it, now/it's the same for B/only DOWN, A is for Up . . .*

**T** Right, so we'll need extra TERMS in out Boolean equations, and they will OR with the others (remember the steps we discussed last time). A is 1 (for UP) if . . . ?

**S** *P2 is called (C2 is made 1) AND S2 is 1.*

**S** *(others) and T is 1, don't forget/and NOT B/let's leave out T, can we?*

**T** So we can write as before, to start with: $A = (C2 + A).S2.\overline{B}.T$ leaving out T for now: $A = (C2 + A).S2.\overline{B}$

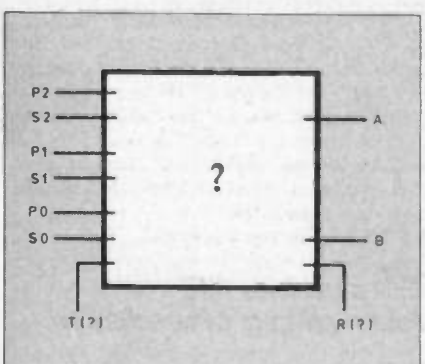



*Fig. 8.1. Making a start on a three-floor version. T and R omitted initially. Note: Same outputs but, of course, more input signals.*

**S** *We don't need "OR A" with the bistable.*

**T** Right, omit it. Also, A is 1 when P1 is called, if the lift is at floor 0.

**S** *This gives* $A = C1.\overline{S0}$. *with B, I suppose, again, so* $A = C1.\overline{S0}.\overline{B}$

**T** If we combine the two alternatives (with OR), we have $A = C2.S2.\overline{B} + C1.\overline{S0}.\overline{B}$

**S** *And* $B = C0.S0.\overline{A} + C1.\overline{S2}.\overline{A}$ *We'll need a 7420 and more inverters (7404)/and the 7432. Can we try it out?*

**T** Certainly. The more snags you foresee, however, the less rebuilding needed. It'll test your dexterity.

**S** *And my eyesight! But don't we need an "S1" somewhere to make the lift stop at floor 1?*

**T** Good thinking. In the second term,

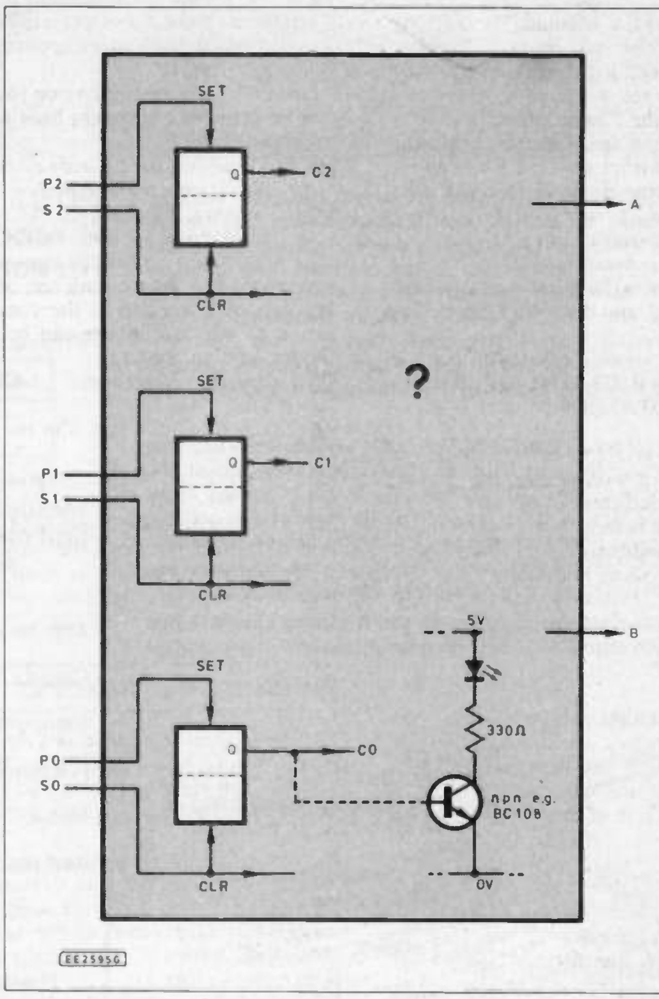



*Fig. 8.2. Adding "memory" bistables (Set-Reset) for each call button. Indicator l.e.d.s could be driven from each bistable via a transistor, as suggested, but are not part of the control logic.*

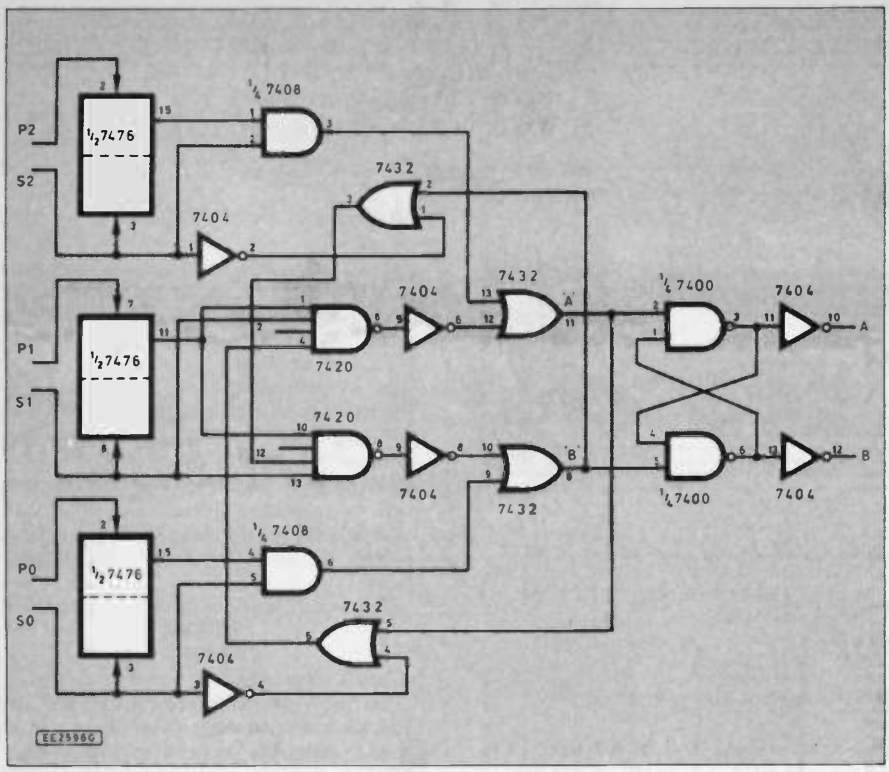



*Fig. 8.3. "Three-floor" logic. Note unused (timer?) inputs of the 7420, left "floating" for now.*

thus: $A = \bar{B}.(C2.S2 + C1.S1.\bar{S0})$ Notice the slight rewriting, too. It may help.

**S** *Won't the lift stop as soon as it leaves S0 or S2?*

**T** Well done again. It could. We need the "OR" signals after all, in term 2. Let's think through the logic again. You may like, when you set it up, to meet a very useful device, the "logic probe". If you don't have one, a spare output indicator will help. Try to trace the logic levels either back from the output end or forward from the inputs, and see where there may be something we've overlooked.

**S** *Or a wrong connection!*

**T** We'd better write what we hope will cover everything, and draw a diagram (Fig. 8.3).

**S** *I won't look till I've had a go myself!* $A = \bar{B}.(C2.S2 + C1.S1.(\bar{S0} + A))$
$B = \bar{A}(C0.S0 + C1.S1.(\bar{S2} + B))$

**T** Remember, you can test the logic on your breadboard without the lift, if you have to, using indicators and switches or push-buttons as before. But be careful not to send signals indicating, for instance, that the lift is in two places at the same time!

**S** *Short leads to dab on to the 0V line can simulate the sensors and call buttons. I had to do that, because I couldn't finish my model in time. The logic seems to work fine, though.*

**T** Don't forget that there are alternative circuit arrangements which can work just as well. If some of you have finished testing, and want a new challenge, you could think about the sort of control system that might operate, say, a model railway.

**S** *It would be best to start with a small loop or circle, I expect? Then add sidings and branch lines later. I might have a go at my lad's train set later on.*

**S** *(others) Ask him first!/He means his own set.*

**T** Anyway, you'd need sensors and motor drivers rather like the present ones. Perhaps more of them.

**S** *And reversing circuits/and speed controls/and signals/and a way of identifying them if you have more than one train. . . .*

**T** So there's plenty to get your teeth into. it could become a major project. No doubt you'll think of many more applications for these logic systems.

However, we need to move on to see what can be done with a system built around a microprocessor.

**S** *Presumably a model train could also be controlled by a microprocessor?*

**T** Indeed, yes. We could equally well use a train to illustrate the two systems, direct logic control and control by a programmed (micro) system. As we shall see, one of the beauties of the micro is the comparative ease with which a change can be made in the action of the system

**S** *Changing "software" instead of "hardware", I bet.*

**T** That's it. That's why the micro is so flexible.

**S** *Are there any advantages to straight logic circuits?*

**T** The main ones are: Low cost for simple systems, and the fact that they can be much faster in their response than a programmed system, though some of these can be much faster than others, as we'll see.

## Meet the Micro

**T** We've seen how logic circuits can be made to control a system such as a lift, and how, by means of gates and flip-flops anything seems possible, well, almost anything.

**S** *But it can get complicated. I found the lift much more complex than I'd expected*

**S** *(another) Yes, but it IS complex. We assume that it just moves up (or down), but there's a lot more to it, and all sorts of conditions had to be met.*

**T** Would you agree that one of the tiresome jobs is to alter a circuit so as to modify or improve its performance?

**S** *Or to get it to work at all!*

**T** Quite. Any change means rewiring, sometimes quite a lot of it.

Well, one of the beauties of using a micro is that much of this re-wiring can be done away with, as we shall see.

**S** *How does a microprocessor work?*

**T** Perhaps we can look briefly, then, at some of the basic units which form the microprocessor. We've already become familiar with most types of logic gates, and with bistables. I'd like to point out one or two important features, some of which will be apparent from what we've already been doing.

## How many bits?

**T** You'll know that digital systems are nowadays sometimes called "information systems", and a thought about what we mean by "information" won't come amiss.

**S** *Isn't it just messages, names and numbers?*

**T** That's not a bad way to describe it. We know, too, that we'll be dealing with binary numbers, using 0 and 1 as our only digits.

**S** *And using electrical on and off signals from them/the 0V and 5V levels/our "logic levels"/voltages.*

**T** Good. Now just think of a single binary digit, a "bit". As you say, it can have either of just two elementary items of information, like "yes" or "no"?

**S** *And the question must be decided beforehand. Like: "Can I come round tonight? Leave the bedroom light ON" for "Yes, the coast is clear" or OFF for "No, better keep away!"*

**S** *(others) he knows/the voice of experience/etc.*

**T** A good example, anyway. How might a third message be conveyed?

**S** *We'd need another light, downstairs, say. Then we could send three messages/four messages, in fact.*

**T** Yes, Two "bits" can represent four different numbers, can't they. We've seen them written out:

| | |
|---|---|
| 0 | 0 |
| 0 | 1 |
| 1 | 0 |
| 1 | 1 |

representing 0, 1, 2, 3 respectively, in binary notation.

**S** *We've counted up to fifteen (sixteen numbers, including zero) with FOUR BITS, in the binary counter chip.*

**S** *(another) and used gates to convert it to denary.*

**T** Yes, so you can appreciate the need to use several bits (at least four) in, for example, a calculator unit.

**S** *We've even written them in hex code!*

**T** OK. So now, let's think of four bistables linked, not necessarily as a counter, but just as a "register" of four bits. The right-hand bit will be the "units" bit, the next on its left the "twos", next the "fours" and finally the "eights" bit, often referred to as the "most significant bit" (MSB). The right-hand one is the. . . .?

**S** *LSB/"least significant bit"*

## Exercise 12
## Handling the data

**T** We saw a four-bit counter in action, remember? The kind we used was an "asynchronous" counter, also called a "ripple-through" counter, because each stage triggers the next one in turn.

We should be aware that sometimes a "synchronous" counter is preferable.

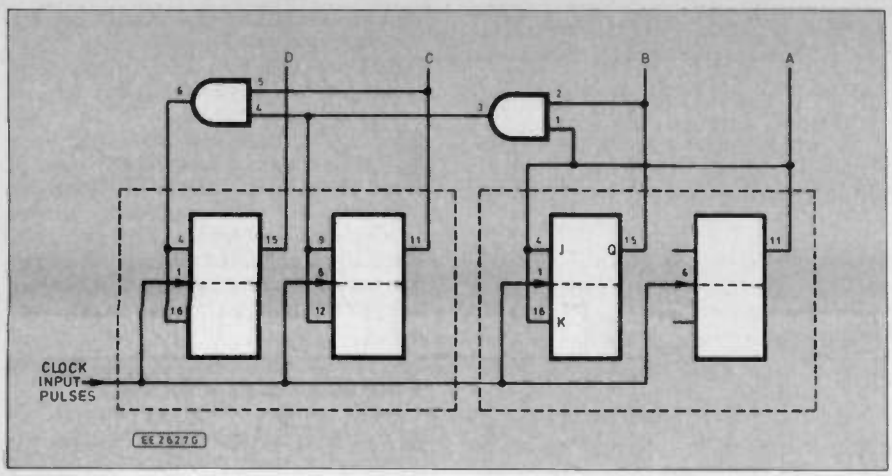



*Fig. 8.4. Synchronous 4-bit counter using two 7476 and ½ 7408. A, B, C and D linked to indicators.*

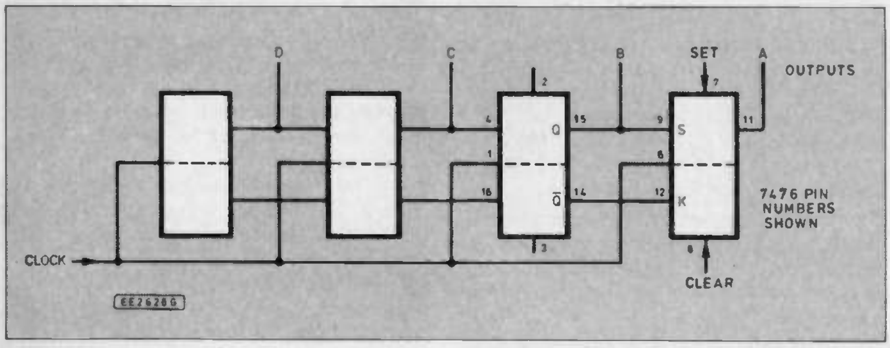



*Fig. 8.5. Shift register. It could be reversed by crossing the links between Q, $\bar{Q}$ and J, K. Note how a single SET signal can be shifted along on each clock pulse. It could be extended, or looped back into a "ring".*

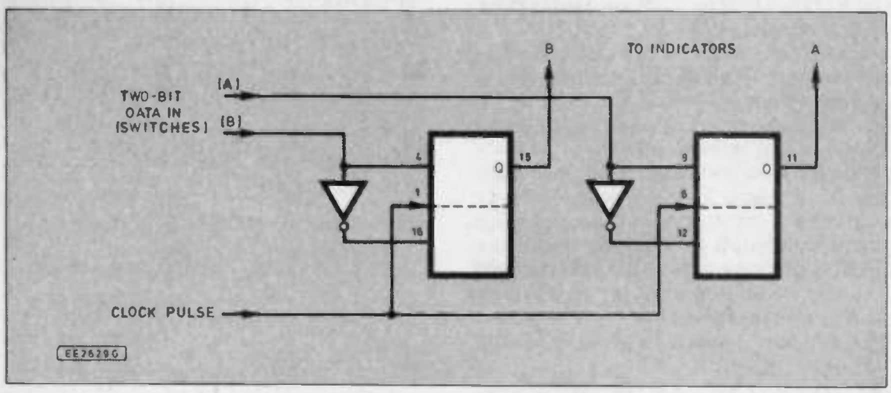



*Fig. 8.6. Data latch using 7476. Note inverters (7404) linking J and K inputs. Clock pulse causes values on DATA lines to be stored on QA and QB. (The 7475 chip is a "ready made" 4-bit latch).*

That's one in which each bistable is triggered by a common clock pulse, so they change (those whose turn it is) all at the same moment. For those of you who'd like to build a synchronous counter using 7476 chips, here's a circuit: (Fig. 8.4)

**S** *It uses gates to do the dividing by two.*

**T** Another useful circuit is a "shift register", in which a bit can be, as the name implies, "shifted" along the register from one end to the other (Fig. 8.5).

**S** *What's the point?*

**S** *(others) it multiplies by two/or divides/or by four/or eight*

**T** Exactly. And it has useful control applications, too.

Another register I'd like you to look at is called a "latch". It's important for its ability to catch and store binary numbers (data) (Fig. 8.6).

**S** *As a memory store?*

**T** Indeed. As you know, memory circuits abound in microprocessor applications. Let's now look at what sort of circuits (we needn't draw them in detail) a microprocessor might contain. Some of them may be in adjacent chips, but a typical microprocessor will have:

- an ARITHMETIC and LOGIC unit (ALU), which can add or subtract binary numbers, and perform the AND, OR and NOT functions, with others, such as shifting up or down
- A number of storage REGISTERS, for temporary holding of working data, and COUNTERS, to keep track of events.
- Additional control GATES and BISTABLES, to direct incoming signals to the right areas, and to send out the appropriate data when needed.

We'll be more specific when we decide which type to use for our initial exercises.

**S** *How can a micro add and subtract/multiply/divide?*

**T** We'll spend a few minutes assuring ourselves that it can be done, if you like, by building and testing a binary adder (let's have no cracks about snakes!)

## Exercise 13 "one and one makes...?"

**T** This is really another exercise in logic design. First we must consider what inputs we have, and what outputs they must produce, so let's do some addition "sums". There are only a few possibilities, in binary, right?

**S** *Four?/six?/eight?*

**T** Any advance....

**S** *We only need to add two numbers, then two more, and so on/but what if there's "one to carry"?*

**T** Well done. It seems reasonable to consider two numbers, but also a "carry" from one column to the next (if it helps some of you, try some ordinary "denary" sums first)

Think of a couple of multi-digit numbers:

XXXXX
XXXXX

Any X can, of course, be a 0 or a 1.

As usual, we start adding at the right-hand column, so what possibilities will we need to deal with?

**S** *Two noughts, two ones, or one of each/there are four cases, but two of them will give the same result.*

**T** You've got it. Let's write them down:

| Case 1 | Case 2 | Cae 3 (and 4) |
|---|---|---|
| 0 | 1 | 0 1 |
| 0 | 1 | 1 0 |
| 0 | 2 | 1 1 |

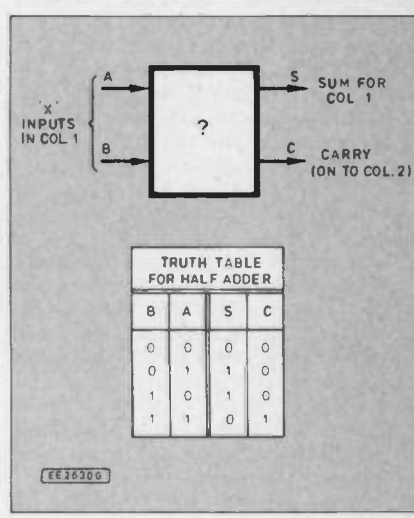
Hello, what have I done in Case 2?

**S** *You can't write 2 in binary/you have to put down 0, with 1 to CARRY.*

**T** There it is, we need TWO outputs, a SUM and a CARRY, so our "box" will look like this (Fig. 8.7). And we can write a Truth Table for it, and consider what gates we could use to build this "half adder" circuit. Try to work it out yourself before looking at my suggestion (Fig. 8.8).

**S** *Why a "half adder"?*

**T** Because we'll find we need an extra input to make a "Full Adder" when we deal with our second (and later) columns. Anyone explain why?




TRUTH TABLE FOR HALF ADDER

| B | A | S | C |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 |

*Fig. 8.7. Half-adder inputs and outputs. Note how C requires just an AND gate, S an "exclusive-OR" arrangement.*

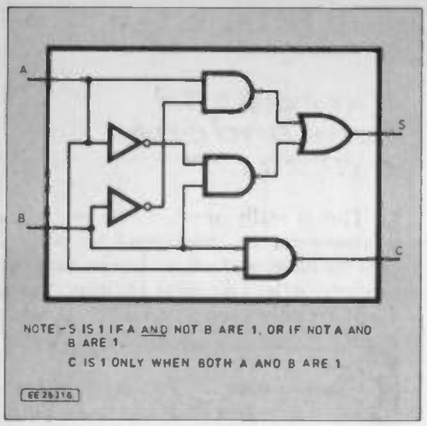



*Fig. 8.8. Possible half-adder circuit.*

**S** *(after thought) To deal with the "carry" signal.*

**T** Spot on. When we add the next two digits, we'll also have to add in the carry from the first (right hand) column, and this will happen for every column except the first.

**S** *So we need one half adder and a number of full adders in an adding circuit.*

**T** Yes. Can you design a full adder now? It'll have three inputs and two outputs (Fig. 8.9).

**S** *(eventually) How about this (Fig. 8.10)?/and its Truth Table, too.*

**T** Good. I see some of you have used different gates to achieve the same result. Fine. Now we'd better move on.

**S** *What about subtraction/multiplication, etc.?*

**T** Well, they can all be built around adder circuits, with counters and some more logic thrown in. For example, the process of multiplication is really repeated addition, so a register could be used to hold one number, then the other number added to itself once, (and the register counts down ONE), then again, and again, until the register is zero, at which stage the addition will have been done enough times to give the result of multiplying the two original numbers together. It sounds tedious, but the logic circuits can do it extremely quickly, as we've seen.

**S** *We'd need comparator circuits, too, to check when the counter reaches zero.*

**T** Quite, and they can also compare any two numbers. If you want to, you can (in your own time) build up comparators and other useful circuits using gates, but, of course...?

**S** *(chorus) There are chips to do it for us.*

**T** Indeed there are. Perhaps you'd be better occupied in getting to know some of them by testing them in your breadboard, and trying to assemble your own "computer" circuits.

We really must press on with a look at the micro, which is really an assembly of these fascinating circuits in itself. However, I shall just mention subtraction, which one of you wondered about.

**S** *We could design a "subtractor" like we did for the adder circuits.*

**T** You could, but it may be possible to use the adders themselves, by making use of a mathematical "trick."

The trick is, firstly, to "complement" (invert) each digit in the number to be SUBTRACTED, then ADD it to the original number. Add an extra 1 (in the "units" column), and ignore any final carry which may "spill over" from the left-hand column.

An example will help. Let's subtract five from eleven, say, in binary, of course:

11 becomes 1011
5 becomes 0101

**S** *The 11 would be B in hex, wouldn't it?*

**T** it would, as a matter of fact, but we'll stick to our binary for now. Now to do our sum. The 11 stays as it is, and we invert each digit of the 5:

```
                1011
                1010
Adding, we get 10101
```

Now, we add another 1, to get 10110, and knock out the initial 1, giving 0110, which is denary 6. OK?

So, by using some extra inverters, our ADDER circuit can also be made to SUBTRACT. In fact, you could build a complete computer now from the various gates and flip-flop circuits you've already tried out. But a microprocessor does it all, anyway.

**S** *It's good to understand a little of what's inside it, however. There must be many gates etc.*

**T** Tens, even hundreds, of thousands. The story goes that it came about as a result of a request from a Japanese manufacturer to an American i.c. supplier for a series of chips for a range of calculators.

It was realised that a single chip might be possible which could fulfil all the required functions if it were designed to respond to extra control signals. Hence the microprocessor, at first with a four-bit capacity, later with eight. This was over twenty years ago, so the micro is about as old as some of you.

**S** *Can we plug a micro into our breadboard?*

**T** You could, and there are specially wide-gapped boards just for such very large scale integrated circuits (VLSI).

However, you would need many other chips to enable you to do anything useful with most micros, but it's just what a circuit designer has to do, as you may imagine. In the early days, firms who advertised micros in journals like this one soon found that they had to print a sort of "health warning" advising customers not to purchase a micro unless they knew how to drive it!

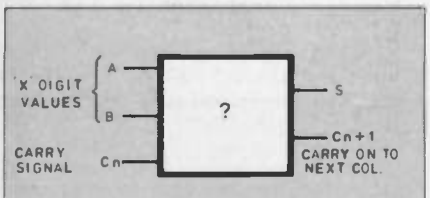
Fortunately there are available a number of "development systems" which can be used to investigate the behaviour of a microprocessor together with a suitable family of "support" chips (some of which, as we shall see, are almost as complex as the micro itself).

**S** *Can we build such a system?*

**T** The answer, again, is that you COULD, but it would be tedious, and might only appeal to a very dedicated enthusiast. Some are made by the chip makers themselves, others by specialist suppliers for education and training. We shall look at some typical systems.

**S** *Is a home computer such a system?*

**T** In some ways, yes, but it may not have adequate means of linking it to our sen-




TRUTH TABLE

| Cn | B | A | S | Cn+1 | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | |
| 0 | 0 | 1 | 1 | 0 | * |
| 0 | 1 | 0 | 1 | 0 | * |
| 0 | 1 | 1 | 0 | 1 | † |
| 1 | 0 | 0 | 1 | 0 | * |
| 1 | 0 | 1 | 0 | 1 | † |
| 1 | 1 | 0 | 0 | 1 | † |
| 1 | 1 | 1 | 1 | 1 | × † |

THESE ROWS GIVE S = 1
THESE GIVE Cn+1 = 1

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*Fig. 8.9. Extra (carry) inputs included, from previous column.*

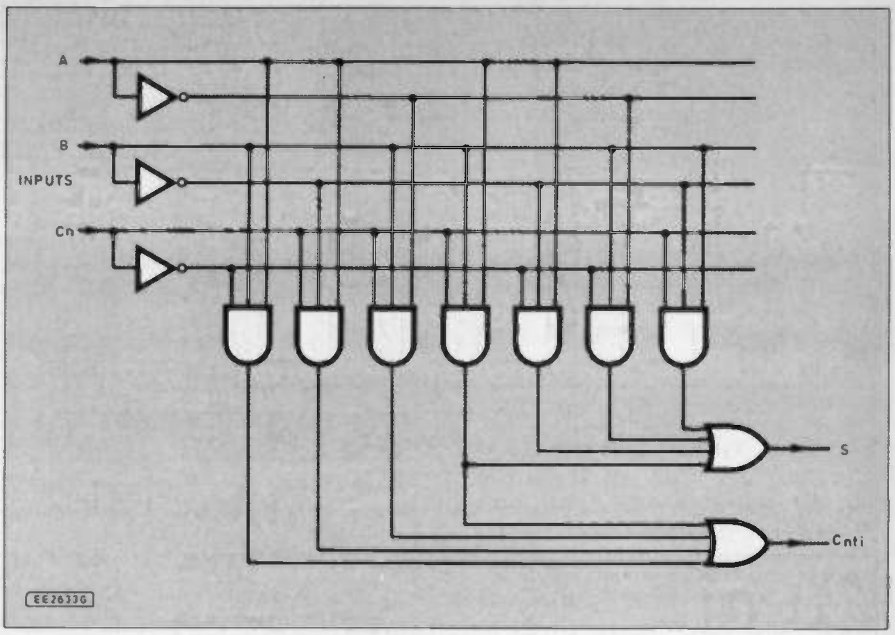



*Fig. 8.10. Possible circuit for full adder (refer to Truth Table in Fig. 8.9) The S=1 rows give these AND terms (with OR relating each term): $\bar{C}_n.\bar{B}.A + \bar{C}_n.B.\bar{A} + C_n.\bar{B}.\bar{A} + C_n.B.A$. The $C_{n+1} = 1$ rows give: $\bar{C}_n.B.A + C_n.\bar{B}.A + C_n.B.\bar{A} + C_n.B.A$.*

sors and drivers, but we'll include some exercises using such a computer later on. Now we should consider briefly some typical microprocessors we might meet.

For our control purposes, we don't need a very large number of bits, and the popular and inexpensive eight-bit micros are fine. In fact, there are, in industrial use, specialised four-bit and even "one-bit" chips available. Designing a new microprocessor is, as you may imagine, a major and expensive development. Nevertheless, several have been launched, and a number have survived for many years.

Probably the most familiar and widely-used eight-bit chip is the Z80, derived from an earlier winner, the 8080. Another well-tried design is the 6800 micro, followed by the popular 6500 series, which we shall study more closely, because it had many features which make it particularly suitable for our purposes.

Some of you may have met, too, a few other types such as the 1802, or SC/MP (called "scamp" by some!). Each has its own attraction, but, unfortunately, the details of the individual designs make it impossible to do more than mention general similarities, and we must settle on one unit for a detailed understanding, if we are to make reasonably quick progress.

**S** *I've heard of all those/I have a Z80 in my home computer/I have a 6502, I think.*

**T** Good. Both these chips are extremely and deservedly popular, and hence are available at very reasonable cost.

**S** *Will we have to programme them?*

**T** Yes. Every microprocessor has to be programmed. It is designed to carry out small, simple instructions very quickly and in strict sequence, as you probably know. That's why we need memory circuits to store the necessary data and instructions.

**S** *We'll still need our sensors and output circuits, won't we, to connect to the "real" world.*

**T** Sure we will, so keep the motor and light cell units handy, and the "debounced" pulse and clock generators.

**S** *Will our five-volt signals be OK?*

**T** Yes, the micro circuits are all designed to accept these "TTL-compatible" signal levels. We need to take extra care, however, not to allow excessive voltages to reach our microprocessor system simply because the chips, though very good value indeed, are somewhat more costly than the small i.c.s we've used up to now!

**S** *Can we make the micro control our model lift?*

**T** I hope so, for that's the idea. It will enable us to make a convenient comparison between direct logic control and microprocessor control, since the same sensors ought to be suitable in both cases.

Let's now prepare the ground for looking in detail at our microprocessor system. We've talked a great deal about the need for memory storage circuits, so a practical exercise in the behaviour of a memory store may be welcome.

**S** *Isn't it just the latch we looked at earlier?*

**T** On the whole, yes, but we can go on to consider how to identify a particular part of a memory store, among other things. We'll start with a suitable chip, the 7475 4-bit latch which, as you say, we looked at earlier. Remember, it will only change state to correspond to an input signal if the ENABLE input is at logic 0. Note too that there are two separate enable lines, one for each pair of bistables.

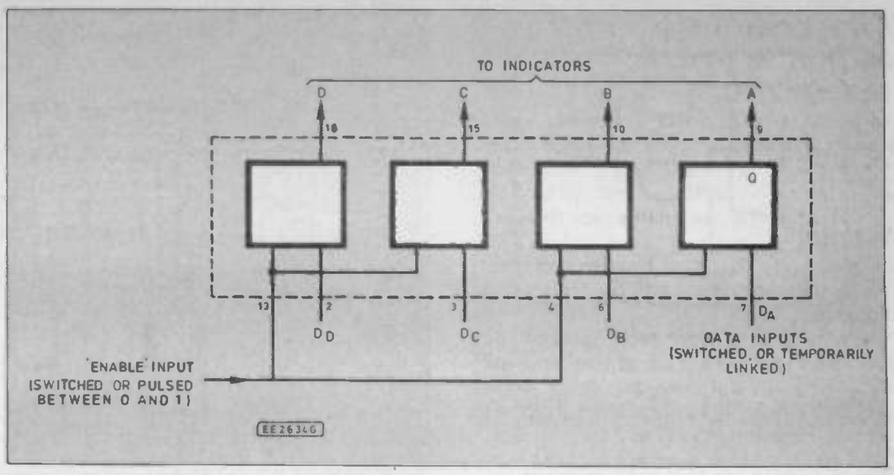



*Fig. 8.11 Testing a data latch (7475). Set inputs $D_A$, $D_B$ etc., to any 4-bit pattern, then note how a pulse to logic 0 on "enable" line will "store" the pattern on the bistable outputs.*

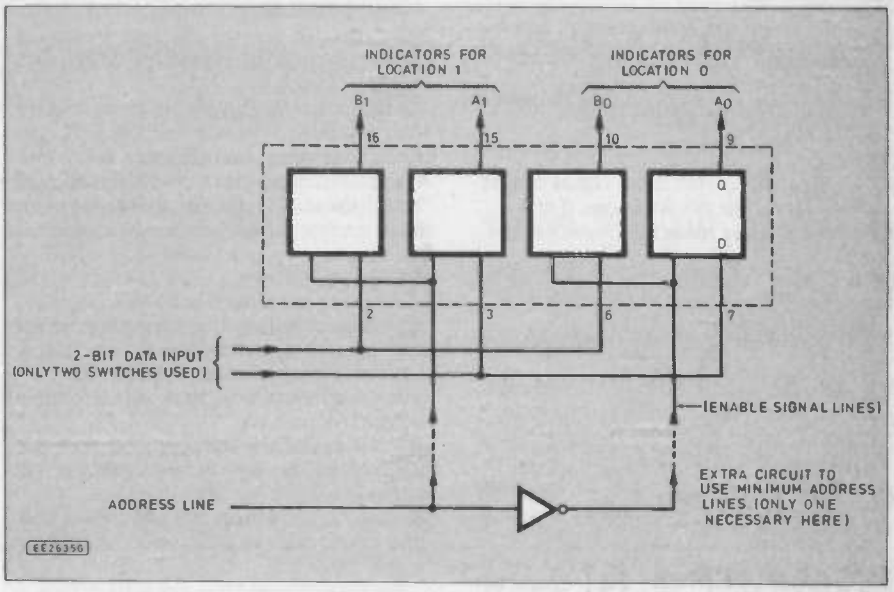



*Fig. 8.12. Selecting a particular location using address signal (only two locations here!)*

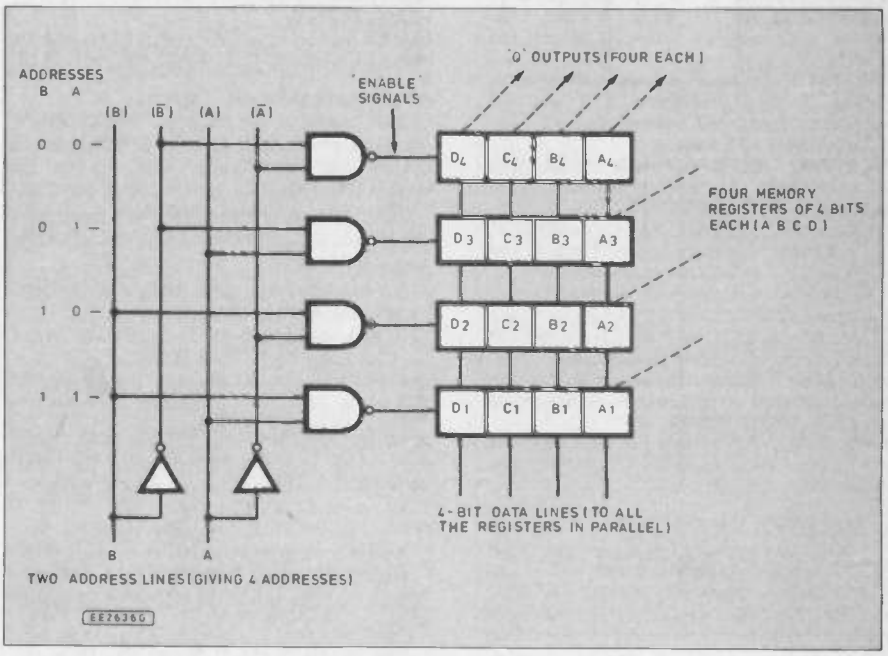



*Fig. 8.13. Selecting any one of four addresses (locations).*

## *Exercise 14 What's your address.*

Set up the 7475 in your breadboard with an output indicator linked to each Q output (Fig. 8.11) and a switched input to each D (data) pin. You'll also need to be able to switch or plug the enable pins to either logic 0 or logic 1.

Check again that each bistable will store (on Q) the value on its data pin ONLY if it is enabled.

Now we'll re-arrange the "memory" to give just TWO units, each of two bits, and allow ourselves only two data lines (up to now we've used four). This means that we use two-bit numbers only as data.

**S** *Sounds like something in a Western film!*

**T** You know what I mean. The point is that we must now "tell" the chip whether we wish to store a particular data value in the left or right half location. We can choose.

**S** *We need a gate or two/and an extra signal.*

**T** Just so. Let's see if we can draw a possible circuit (Fig. 8.12). You'd better try it to confirm that we can now store our two bits of DATA in either of two LOCATIONS. Right?

**S** *Or left!*

**T** Clever. ... Now the extra signal can be used to "label" the two locations, 0 or 1.

**S** *Is this what we mean by a memory "Address?*

**T** It is. Our "addresses" here are 0 or 1. That's all. So, make sure. The ADDRESS is a number which identifies a particular LOCATION in the memory store. This location can hold DATA, which is also a number. OK

**S** *So every location in a memory address will have two numbers associated with it/its ADDRESS, and the DATA it may hold?*

**T** Couldn't have put it better. Some of you may wish to go through this exercise again and see how to change the data in either or both of the addresses. Make sure before you leave it.

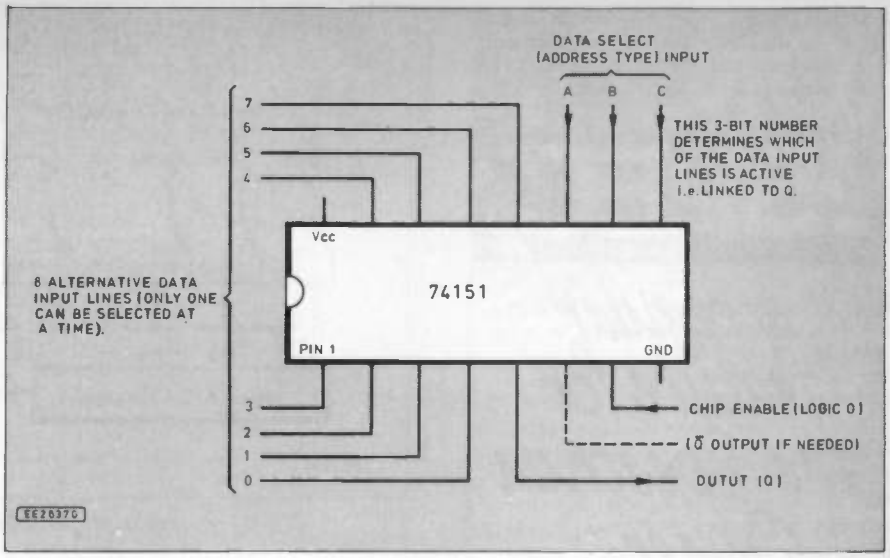



*Fig. 8.14. A useful chip for sensing any one of eight inputs e.g. if A and C are at logic 0 and B at logic 1, then Q will follow input (010) i.e. line 2.*

Notice that the SAME data is sent to both locations, but the "address" signal selects which (if either) accepts it into store. A similar arrangement could be used to "read" the data value from one only of a number of locations.

**S** *A real computer memory store would be much bigger and have more addresses?*

**T** Sure. In the system we shall use, each location will be eight bits wide (to match the micro), and there will be many thousands of them available. But each will have its own address, and will of course contain its own data.

**S** *How could we distinguish several addresses. Wouldn't we need more address signal lines*

**T** Indeed we would, as we'll see. You could use gates to select the various addresses. If you wish, you could experiment with selector circuits such as these (Fig. 8.13). Of course, yet again there are selector chips available, and they can have uses in control systems, too (Fig. 8.14). Try to find time to familiarise yourselves with some of them on the breadboard, using either indicators or even motors and sensors.

There are so many TTL and other logic chips that we can't possibly mention them all! But they can be fun as well as useful. For example, a long shift register driven by a medium-speed clock, can, with suitable drivers, produce flashing or moving light displays, and musicians could use binary dividers to lower the pitch of a note by one or more octaves.

Our next task, though, will be to study the 6502 microprocessor in action.

# MARKET PLACE

**FOR SALE** ex. equip. tordidal transformer 12-0-12V. 120VA. 5A bridge and 22,000µF electrolytic all for £20 p&p inclusive. Paul Brown, 48 Lanndale Lawns, Springfield, Dublin 24, Eire.

**FOR SALE** Spectrum service manual Issue 2-Issue 6. New condition £14 includes postage. R. Garas, 147 Seaforth Avenue, New Malden, Surrey KT3 6JW.

**EVERYDAY ELECTRONICS** 1982-1988. Sell yearly lots only £15 each lot, includes postage. Derbyshire (0332) 862378.

**STEREO CASSETTE** Ferguson 3280K. Dolby system VU meters. Good cond. low sound hence £10. Tel: 081-647 2633.

**FOR SALE** Cinerex 8mm dual sound projectors. New boxed £65 or exchange for Commodore 64 Vic-20. David Wood, 17 Boydon Close, Ettingshall, Wolverhampton WV2 2NE.

**WANTED** old broken computers for college student. Will pay up to £20 including postage. Tel Shaun (0525) 319571.

**OSCILLOSCOPE** for sale. Lerkakit type with all manuals etc. would suit beginner. Any reasonable offer. Tel: (0373) 826454 evenings.

**HANDHELD** 22Mc/s AM BC RX. Will accept mini 160 mtrs. receiver of Vibroplex automatic keyer or similar. No callers please. Gebbs, 10 Woodcote Place, Norwood, London DE27.

**HAS ANYONE** managed to get a Greenweld Aderhoff Dictaphone to work? If so please contact me. Keith Twamley, 25 Davena Drive, Weoley Castle, Birmingham B29 5UL. Tel: 021-426 4471.

**WANTED** for Spectrum S1A-1 interface adaptor board, TIF1 transceiver interface CB convertors. Tel Richard (Abingdon) (0235) 529005.

**CAN ANYONE SUPPLY** tie-clip mic's 1.5 metre cable. Will buy several if right price. Tel: (0884) 257040.

**FLUKE** digital meter £50. Avo 8 £110. Clamp meter £16. HV probe £16. Tel: 081-554 2913 6-8 p.m.

**COMMUNICATIONS RECEIVER** B40D 0.64-30MHz. AM/CW/SSB 240V. £60. 70cms beams 21 ELE £20. 12 ELE X Crossed £16. Tel: (0562) 743253.

**BARGAIN** TRS 80 Level II comp, monitor, interface, manuals also Dragon 32 with I/O interface with manuals £80 o.n.o. W. Daley, 071-582 7839.

**CROTECH** 3132 dual trace 20MHz 'scope with X10 probe and leads. Hardly used £220 o.n.o. Tel: (040377) 545.

**SOLDER** 2½kg reel 18 s.w.g. 60/40 Ersin Multicore £25. Tel: (0908) 502425.

**WANTED**: solar panels, any condition, for my garden light project. Please ring Bob on Woking (0483) 755463 evenings.

**WANTED** Power supply (2 pin variety) and cassette recorder for VIC20. Must be fairly cheap! Matthew Aldridge, 2A West End Road, Silsoe, Beds. MK45 4DU. Tel: (0525) 60743.

**WANTED** BM81LS95N, DM81LS96N, two F2102LIPC RAM chips, 4116 DRAM chip. P. A. Murphy, 72 Southview Road, Carlton, Notts NG4 3QL. Tel: (0602) 873793.

**BBC MODEL B** with or without extras wanted by student. Will pay £130 max. No rubbish please. Colin O'Regan, 66 Meadow Grove, Black Rock, Ireland.

**BEGINNER** to electronics requires components for nothing or a small price. Will pay for p&p. 109 Shenley Road, Bletchley, Milton Keynes MK3 7AS.

**SWAP YAESU** FDRX400 SW RX or Advance OS1000A DB scope, or Yamaha DSR100 for Amstrad 8512. Lancs (0744) 27067.

**PENFRIEND** University student looking for penfriends in the field of electronics, computer and communication. Reza Haseli, P.O. Box 336/71645, Shiraz 71645, I.R. Iran.

**ADVANCE** OS1000 twin trace Oscilloscope complete with probes, manual, very good condition. Bargain at £175.00. A. S. Davy, Springclover, Crestlands Corner, Alresford, Essex CO7 8AF.

**SUMA VOX75** voice activated transmitter – advertised in EE has been assembled and is working well £15. John Gold, 35 Cavendish Place, Jesmond, Newcastle-upon-Tyne NE2 2NE.

**WANTED**, Leak valve preamp, power amp and pick-up. Garrard 301. Wharfdale corner speaker and cabinet (0745) 825036.

**CIRCUIT** please for 2nd parallel hand held r/control computer keyboard hard wired (have neck disability) DDS 081-550 7708

**WANTED** i.c. TDA1050 to complete a project. Price to L. Myers, 70A Lawford Road, London N1 5BL.

**FOR SALE**. EE Nov. 71 to Dec. 82. PW May 66 to Dec. 84. HE Nov. 78 to Dec. 82. Haywards Heath 416603.

**WANTED** Bearcat 220 switch pad for freq. control. Tel: (0642) 678869.

**WANTED** information on Mazda valves: EGC83/12AX7, ECL86/6GW8 and EM87/6HU6. Please write: N. A. Barnes, 30 Water Royd Crescent, Mirfield, West Yorkshire WF14 9SY.


*a regular feature for the Spectrum Owner...*

**by Mike Tooley BA**

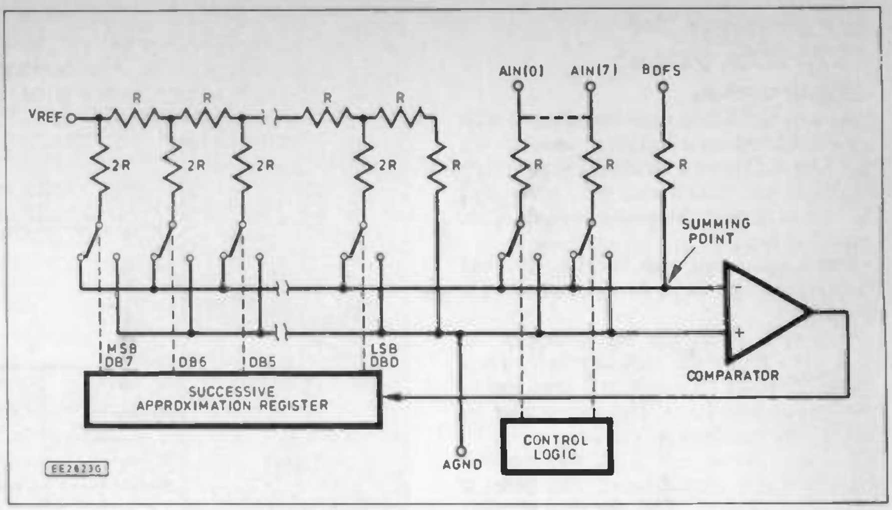



*Fig. 3. Simplified internal circuit for the DAC.*

IN LAST month's instalment of *"On Spec"* we introduced the Spectrum Music Group and took a first look at MGT's SAM Coupé "Communications Interface". This month (in an effort to tempt readers to return to their soldering irons!) we present the first in a series of interface projects for the SAM Coupé. This project takes the form of an 8-Channel Analogue to Digital Converter (ADC).

## SAM ADC

Regular readers may recall that I described the construction of an eight channel ADC for the Spectrum in *Everyday Electronics* for December 1986. This interface was based on a 7581 ADC chip and used just three other devices to provide a total of eight analogue input channels.

Judging from the correspondence received, this simple interface attracted a good deal of interest from readers, many of whom reported excellent results when using it. With this in mind, I recently set about re-designing the unit for use with the SAM Coupé.

## THE 7581

The 7581 (employed in our original 8-Channel Analogue interface) provides a simple solution to the need for a multichannel analogue input capability. The chip is microprocessor compatible and incorporates its own internal 8x8 dual port memory buffers which are used to store the results of conversions on each channel until they are ready to be read by the microprocessor.

The simplified internal arrangement of the 7581 is shown in Fig. 1. The device contains a single 8-bit DAC and the eight analogue inputs are multiplexed before application to the internal ADC arrangement which employs successive approximation techniques. The 7581 is housed in a 28-pin DIL package, the pin connections for which are shown in Fig. 2.

The 7581 DAC is based on a conventional R-2R ladder network, as shown in Fig. 3. In sophisticated circuits, comparator offset may be trimmed out by means of the bipolar offset input ($B_{OFS}$).

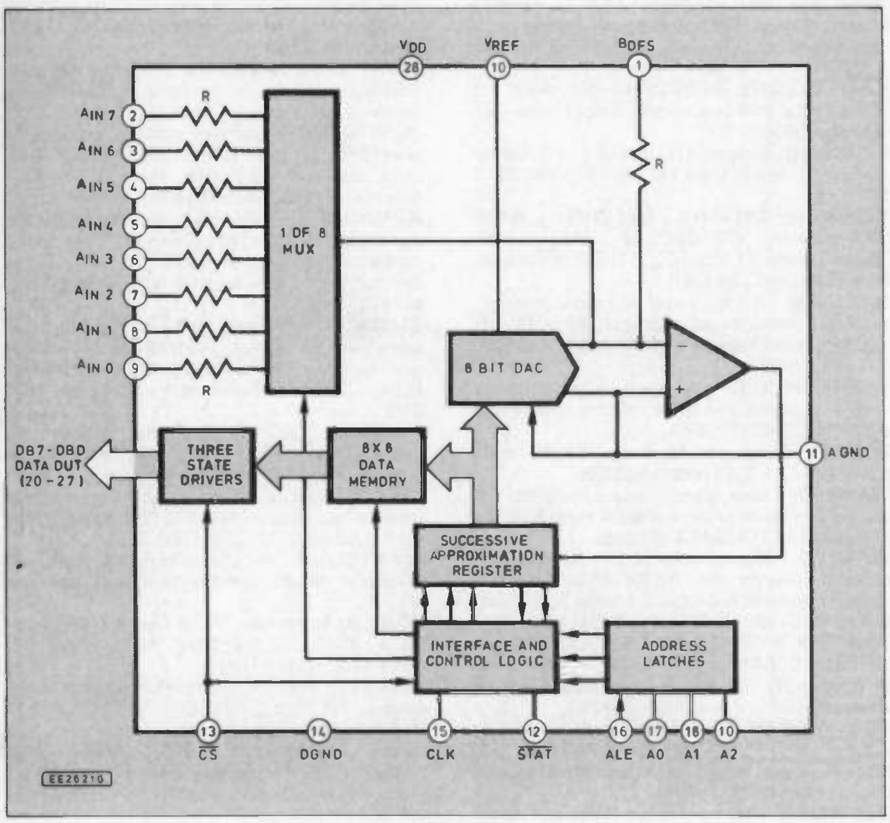
Conversion of a single channel takes 80 clock periods with a complete scan through all eight channels taking 640 clock cycles. With the 1MHz clock used in this latest interface circuit, conversion time for one channel amounts to 8μs whilst a complete scan of all eight channels requires 0.64ms.

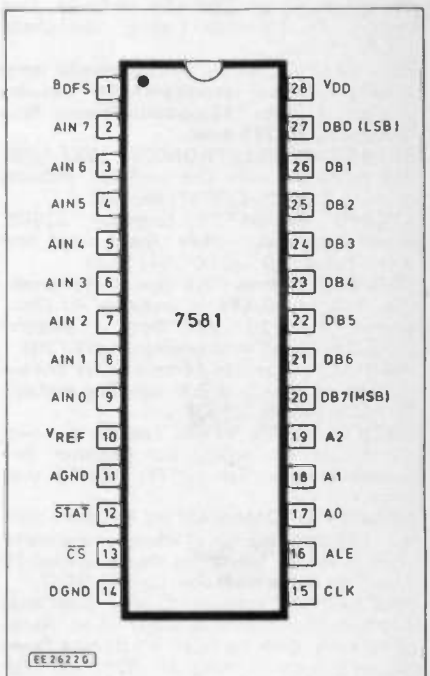
When channel conversion is complete, the successive approximation register's contents are transferred into the appropriate internal dual port RAM location. The contents of this RAM can later be examined by placing the appropriate binary address pattern on the address latch select lines (A0, A1, and A2) whilst, at the same time, taking the $\overline{CS}$ line low.

To ensure that memory updates only occur when the host microcomputer is not addressing the converter's memory, automatic interleaved direct memory access (DMA) is provided by on-chip logic.

*Fig. 1. Internal arrangement for the 7581.*

*Fig. 2. Pin connections for the 7581.*



## 8-CHANNEL ANALOGUE-TO-DIGITAL CONVERTER

The complete circuit of a 7581-based SAM Coupé 8-Channel ADC is shown in Fig. 4. Address decoding for the $\overline{CS}$ line is provided by IC2 and IC3. This arrangement ensures that the output of the 7581 is only placed on the data bus when address lines A3 to A6 are all high with A7 and both $\overline{RD}$ and $\overline{IORQ}$ simultaneously low.

The remaining three address lines (A0 to A2) are taken to the 7581's address latch select inputs (where they are used to select individual analogue channels). This address assignment of the ADC is shown in Table. 1.

A simple Schmitt oscillator, with buffered output, is formed by IC2f and IC2e. This configuration provides a square wave clock input to the 7581 at a frequency of approximately 1MHz (the precise frequency of this signal is unimportant).

The negative reference voltage required by the 7581 is provided by IC4 (a 555 timer) and associated components which form an astable oscillator. This arrangement produces a square wave output at approximately 7.25kHz which is fed to a voltage doubler arrangement provided by diodes D2 and D3.

The negative rectified output is filtered and then applied to a potential divider arrangement in order to produce a clean voltage reference of 2.55V at pin-10 of IC1. Note that 2.55V is chosen as the reference voltage (rather than the more usual 10V which was employed within our earlier Spectrum interface) in order to make the circuit operate in discrete steps of 10mV. This helps keep the software straightforward!

### CONSTRUCTION

The eight channel ADC is assembled on a piece of stripboard measuring approximately 90mm x 90mm. The precise dimensions of the board are unimportant provided that it has a minimum of 32 copper tracks.

The DIN 41612 indirect edge connector (a plug type with rows *a* and *c*) should be

**Table. 1: Address assignment for the SAM Coupé 8-Channel ADC**

| Channel No. | Address (binary) | (decimal) | (hex.) |
|---|---|---|---|
| 1 | 01111000 | 120 | 78 |
| 2 | 01111001 | 121 | 79 |
| 3 | 01111010 | 122 | 7A |
| 4 | 01111011 | 123 | 7B |
| 5 | 01111100 | 124 | 7C |
| 6 | 01111101 | 125 | 7D |
| 7 | 01111110 | 126 | 7E |
| 8 | 01111111 | 127 | 7F |

## COMPONENTS

**Resistors**

| | |
|---|---|
| R1 | 220 |
| R2, R12 | 470 (2 off) |
| R3-R10, R13 | 1k (9 off) |
| R11, R14 | 10k (2 off) |

All 0.25W 5% carbon

See SHOP TALK Page 468

**Capacitors**

| | |
|---|---|
| C1, C8 | 47μ p.c.b. elec. 16V (2 off) |
| C2 | 100n polyester |
| C3 | 1n5 polystyrene |
| C4 to C6 | 10μ p.c.b. elec 16V (3 off) |
| C7 | 10n polyester |

**Semiconductors**

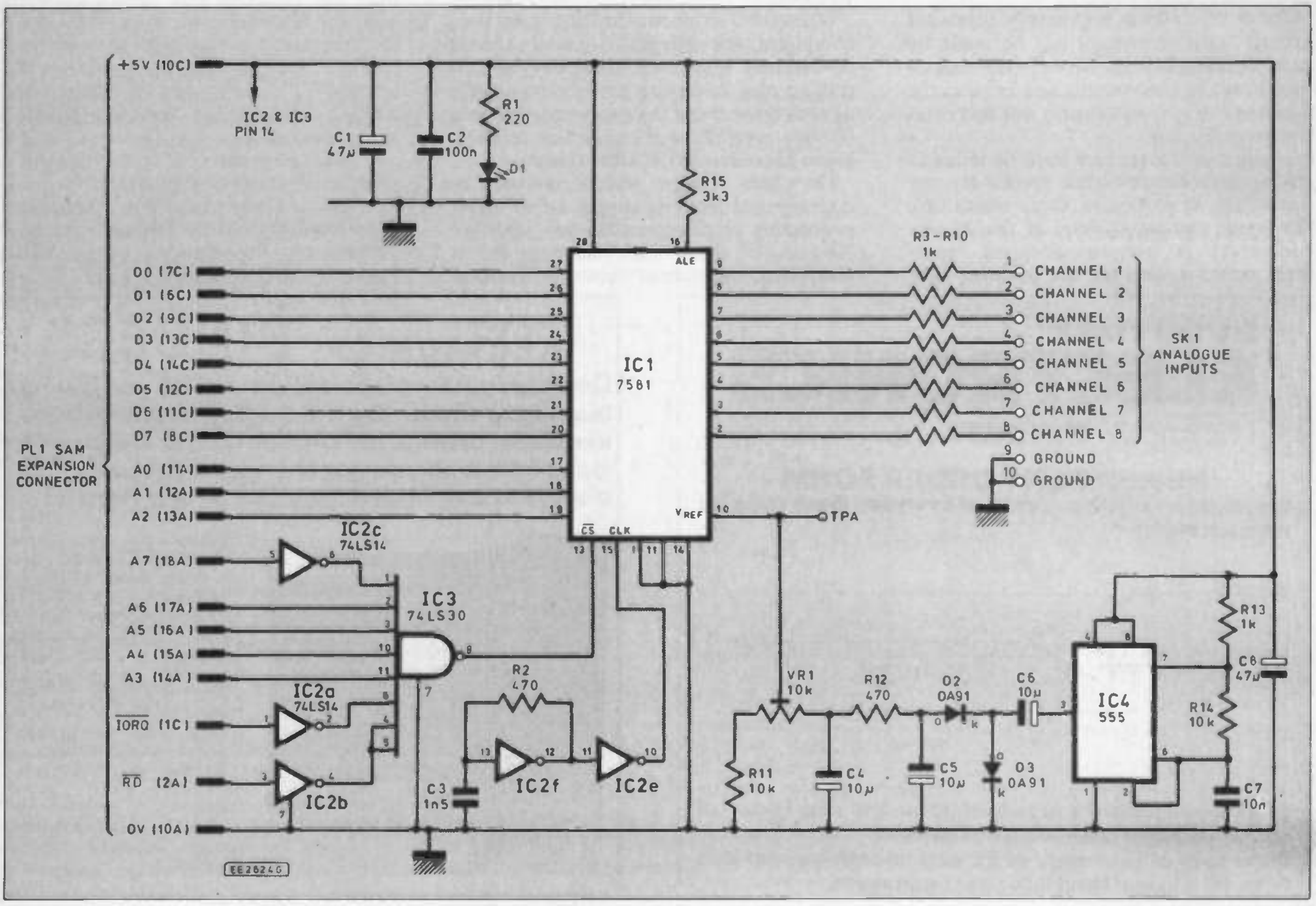
| | |
|---|---|
| D1 | red l.e.d. |
| D2, D3 | OA91 germanium signal diode (2 off) |
| IC1 | 7581 8-bit 8-channel ADC |
| IC2 | 74LS14 Schmitt Hex inverter |
| IC3 | 74LS30 8-input NAND gate |
| IC4 | 555 timer |

**Miscellaneous**

Low-profile d.i.l. sockets, 8-pin, 14-pin, 28-pin; 10-way 0.1in pitch p.c.b. mounting input socket; stripboard, 0.1in matrix (with 32-tracks) measuring approx. 90mm x 90mm; 64-way indirect edge plug DIN 41612 (with rows *a* and *c* (e.g. RS stock code 468-119)

*Approx cost guidance only* **£20**

*Fig. 4. Complete circuit of the SAM Coupé 8-channel ADC.*



## Table. 2: Individual pin assignments for the SAM Coupé expansion connector

| Pin | Signal | Pin | Signal | Pin | Signal | Pin | Signal |
|---|---|---|---|---|---|---|---|
| 1A | $\overline{\text{DBDIR}}$ | 1C | $\overline{\text{IORQ}}$ | 17A | A6 | 17C | A14 |
| 2A | $\overline{\text{RD}}$ | 2C | $\overline{\text{MREQ}}$ | 18A | A7 | 18C | A13 |
| 3A | $\overline{\text{WR}}$ | 3C | $\overline{\text{HALT}}$ | 19A | A8 | 19C | A12 |
| 4A | $\overline{\text{BUSAK}}$ | 4C | $\overline{\text{NM1}}$ | 20A | A9 | 20C | A11 |
| 5A | $\overline{\text{WAIT}}$ | 5C | INT | 21A | A10 | 21C | DISC 2 |
| 6A | $\overline{\text{BUSREQ}}$ | 6C | D1 | 22A | $\overline{\text{MSEINT}}$ | 22C | $\overline{\text{ROMCS}}$ |
| 7A | $\overline{\text{RESET}}$ | 7C | D0 | 23A | $\overline{\text{XMEM}}$ | 23C | EARMIC |
| 8A | $\overline{\text{CMI}}$ | 8C | D7 | 24A | 8MHz | 24C | $\overline{\text{DISC 1}}$ |
| 9A | REFRESH | 9C | D2 | 25A | RED 1 | 25C | $\overline{\text{PRINT}}$ |
| 10A | 0V | 10C | +5V | 26A | GREEN 1 | 26C | BLUE 1 |
| 11A | A0 | 11C | D6 | 27A | $\overline{\text{CSYNC}}$ | 27C | ROMCSR |
| 12A | A1 | 12C | D5 | 28A | SPEN | 28C | AUDIO RIGHT O/P |
| 13A | A2 | 13C | D3 | 29A | BLUE 0 | 29C | AUDIO LEFT O/P |
| 14A | A3 | 14C | D4 | 30A | RED 0 | 30C | COMP. VIDEO |
| 15A | A4 | 15C | CPU CLK | 31A | BRIGHT | 31C | GREEN 0 |
| 16A | A5 | 16C | A15 | 32A | +5V | 32C | 0V |

Note that Row *A* is at the bottom and Row *C* is at the top. Pin 1 is at the left and pin 32 is at the right (see Fig. 6).

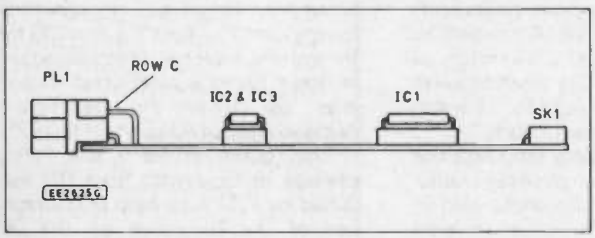



*Fig. 5. Mounting the 64-way indirect edge plug.*

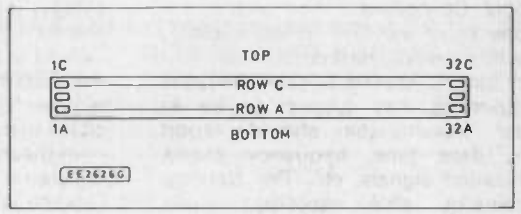



*Fig. 6. Pin numbering for the SAM Coupé expansion connector.*

fitted to the extreme edge of the board. The board will fit flush to the base of the connector as shown in Fig. 5. The pin numbering for the Coupé's expansion bus is shown in Fig. 6 whilst the individual pin assignments are given in Table. 2.

Component layout is generally uncritical though some economies can be made by carefully planning the layout in advance of mounting the components and i.c. sockets. Readers are advised to carry out this exercise on paper first!

In any event, great care must be taken to ensure that all unwanted tracks are cut (including, in particular, those which link the upper and lower sides of the 28-way connector). A purpose designed "spot-face" cutter is ideal for this purpose, or if such a tool is not obtainable, a small sharp drill bit may be used. Links on the underside of the board should make use of appropriate lengths of miniature insulated wire (of the type normally used for wire wrapping).

When the stripboard wiring has been completed, the intergrated circuits should be inserted into their respective sockets (taking care to ensure correct orientation of each device) and the entire board should be very carefully checked before attempting to connect it to the SAM Coupé.

The Sam Coupé should ***always*** be disconnected from its supply ***before*** either connecting or disconnecting ***any*** interface module. If all is well, when power is re-applied, the normal copyright message should appear. If not, disconnect the power, remove the interface and check again!

**Next Month:** We shall describe the procedure for adjusting and testing the ADC and will describe some basic applications for the interface (together with software routines). For good measure, we shall also attempt to dispell some of the mystery which surrounds the Spectrum BASIC's logical operators.

In the meantime, if you have any problems, queries or suggestions for inclusion in *On Spec*, please don't hesitate to drop me a line: Mike Tooley, Faculty of Technology, Brooklands College, Heath Road, Weybridge, Surrey, KT13 8TT.



# ...REPORTING AMATEUR RADIO...

**TONY SMITH G4FAI**

## INTRUDER WATCH

While various frequency bands are designated for amateur use on an "exclusive" basis they often suffer from interference caused by transmissions from non-amateurs. Some of these illegal transmissions are deliberate, some are unintentional.

The International Amateur Radio Union Monitoring System, formerly known as "Intruder Watch". Deals with this problem under the leadership of an International IARUMS co-ordinator who has access to the International Frequency Registration Board (IFRB) through the IARU Council. Each IARU Region has a Regional Co-ordinator and within the Regions most national radio societies have a National Co-ordinator.

The idea is that individual amateurs hearing what they suspect to be an intruder transmission should report details, date, time, frequency, mode, identification signals, etc. The National Co-ordinator, after assessing these reports, passes on details to his national licensing authority with a request for action. At the same time he reports to his Regional Co-ordinator who passes on appropriate details to the Co-ordinators of the other two Regions enabling the situation to be acted on world-wide if necessary.

## DIVERSE REPORTS

In the UK the RSGB Monitoring System receives little publicity but in other countries individual amateurs are constantly urged to send in reports. In *Amateur Radio*, journal of the Wireless Institute of Australia, for instance, details are published monthly of intruders as diverse as taxi cab radio systems in Hong Kong, CBers from Asia and Indonesia, the Voice of America, the Chinese Diplomatic Service, Thai fishing boats, Russian broadcasts and Vietnamese News Agency bulletins from around the world.

On one occasion it was reported with some glee that a Russian intruder in the 40m band had been compelled to move frequency because of interference from another Russian station which was jamming an illegal station from another country! It was a limited celebration however as the frequency moved to was also within the amateur band!

Even when identified it is not an easy task to stop the offending transmissions. Some stations operate with official blessing and complaints or pressure via official channels have no effect.

Nevertheless, the Australians reported some notable successes when they celebrated the 20th anniversary of their Intruder Watch two years ago. These included the removal of Australian Defence Forces stations using obsolete transmitters causing harmonic radiation; the removal of French Polynesian R/T services in the 40m band; the removal of Chinese RTTY stations; and the removal of licensed amateurs working maritime mobile and passing traffic on behalf of commercial interests.

Every victory is hard won, requiring hours, weeks or months of persistent monitoring and reporting, with the solution often plagued by diplomatic and political considerations. It is hard to realise sometimes that amateur radio is "just a hobby"!

## ESPERANTO AND THE AMATEUR

At the first Congress of the International Amateur Radio Union, in 1925, Esperanto was recommended as a standard auxiliary language for radio telephony, for translations from periodicals and for use at Congresses. According to "World at their Fingertips" (the History of the RSGB), however, the Scandinavian representatives "held out for English claiming it to be the easiest to learn."

In theory an international language like Esperanto is ideal for amateur radio. Despite what the Scandinavians said in 1925, it is claimed to be easier to learn than any other language, having straighforward grammar and construction with no irregular features. Today, English is the assumed common language of amateur radio, but contacts with foreign stations demonstrate that in many cases what knowledge of the language they have does little to advance the claim that amateur radio breaks down barriers and generates international friendship.

I am involved in publishing a small international magazine concerned with Morse telegraphy. I receive many letters and articles from foreign subscribers who have what would normally be termed a "good command" of English but I often have to put a lot of work into "Anglicising" their contributions to make for good reading and comprehension. To my mind, despite the ever-increasing amount of English being taught worldwide, the need to use someone else's language is the greatest barrier to clear understanding between individuals.

With this background I was interested to learn recently about the activities of the Internacia Ligo de Esperantistaj Radio Amatoroj, the International League of Esperantist Radio Amateurs, or ILERA.

## NO INTERPRETERS!

Last year the International Esperanto Congress was held in the UK, at Brighton. 2,400 delegates attended from 54 countries – without the need for a single interpreter!

ILERA set up a special event station, GB0UKE, operated by one French, one American, and three British Esperantists. The station had 183 contacts during which the operators took the opportunity to explain to non-Esperantists the value of their international language, and had 35 contacts overseas in Esperanto, including one with the President of ILERA, in Central Siberia, and one with ILERA's Secretary, in Hungary.

The objectives of ILERA are to encourage the use of amateur radio by existing Esperantists; to encourage radio amateurs to learn and use Esperanto; to organise nets and contests to keep members in touch with each other. Also, to establish a special event station at each Esperanto congress; to standardise Esperanto vocabulary of amateur radio matters; and to publish a quarterly news bulletin.

Esperanto was established in 1887 to make it easier for people of different countries to communicate with each other. It is not intended to replace any national language but to provide a simple secondary language to overcome language barriers. It seems an ideal medium for an international fraternal activity like amateur radio and a great opportunity was lost when the fledgling IARU decided against adopting it in 1925.

The following are a few "standard" phrases in Esperanto from the list published by ILERA to help encourage more use of the language on the amateur bands. In pronunciation there is only one sound to each letter, and emphasis is always given to the next-to-last syllable of a word.

CQ CQ CQ. Anyone in the Esperanto net? *Iu ajn, iu ajn, iu ajn. Generala alvoko en la esperanta reto?*

My shack is a small room at the top of the house. *Mia kabano estas malgranda cambro en la supro de la domo.*

Thanks for the contact. *Dankon pro la kontakto.*

I will QSL via the bureau. *Mi sendos konfirmkarton per la buro.*

If you want to hear Esperanto being spoken, listen to the French ILERA net on 7.066MHz at 0830 GMT, weekdays, or the international net on 14.266MHz around 1230 GMT on Sundays and Mondays. For more information about ILERA, contact *Barry Foreman G0EXS, 10 Wilmington Close, Brighton BN1 8JE.*

For those interested in learning Esperanto there is a free introductory postal course available from *The Esperanto Centre, 140 Holland Park Avenue, London W11 4UF.* ***Tel: 071-727 7821.***

## NOVICE LICENCE IN 1991

The DTI published a final draft of the proposed novice licence on 19th April. Work is in hand to set up arrangements for the training and examination of potential licensees and it is hoped the first licence will be issued in early 1991.

Applicants will be required to complete a practical training course run by the RSGB. There will be no minimum age for licensees and it is envisaged that the licence fee will be waived for those under 21.

Fees will be reviewed annually but it is intended to keep them as low as possible. I will provide more information on this important new entry route into amateur radio as soon as it becomes available.

# THE TESTER

GEORGE HYLTON

*A handy bench aid with many uses Connect it to a circuit and it makes the circuit oscillate.*

THE TESTER performs only one trick, but it does it well. Connect it to a circuit and it makes that circuit oscillate. Simple, but very useful. It can help you to measure inductance, capacitance and $Q$. It can provide r.f. or a.f. test signals. It can act as a selective amplifier. After many years I still find new uses for it.

Reduce to essentials The Tester is a box containing a variable resistance $R_v$ (Fig. 1) and equipped with input ($X$) terminals and output terminals. In use, the component or network under test is connected to $X$ and $R_v$ adjusted until the circuit just oscillates. The effective resistance of the circuit can then be read off the scale of $R_v$.

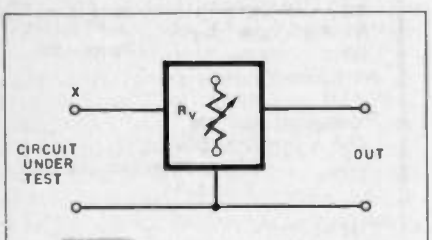



*Fig. 1. Basic arrangement.*

If, for example, you connect an unmarked resistor to $X$ and adjust for the threshold of oscillation (indicated by listening with an earphone, for example), the scale tells you what its resistance is. Not very impressive? An ohmmeter does the job more easily? True, but if instead of a resistor a parallel-tuned LC circuit is connected to $X$ the same adjustment of $R_v$ tells you its effective resistance at its resonant frequency. You can't find that out with an ohmmeter.

## CALIBRATION

Even uncalibrated The Tester can do some useful work, but it becomes more versatile if $R_v$ is given a scale marked with resistance values. These are the resistances which when connected to $X$ just allow the circuit to oscillate at that setting of $R_V$.

Calibration is child's play. After an initial "set infinity" adjustment (described later) you connect an ordinary 10k resistor to $X$ (Fig. 2), set for the threshold of oscillation (with resistors this is at audio frequency and can be detected with a high impedance earphone at the output) and mark the scale of $R_v$ "10k". Now repeat with 1k and 100k and you have the three major calibration points. You can get some intermediate points by using other resistor values.

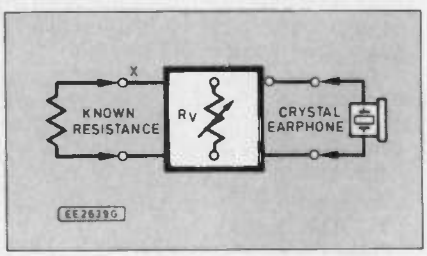



*Fig. 2. Calibration method.*

Since $R_v$ is a log. law potentiometer its scale is nonlinear and may be quite cramped in places, so there's not much point in aiming at fine graduations. The minimal useful calibration is 300, 1k, 3k, 10k, 30k, 100k, 300k. If you have only E12 values you can use 330, 3k3, etc. This gives a scale which is unconventional but quite usable. (If you like, you can make 300 ohms by connecting 330 and 3k3 in parallel, and 3k by paralleling 3k3 and 33k, and so on.)

The lower limit of measurable resistance depends on the gains of the transistors used and on the supply voltage. With a voltage at the low end of the usable range (6V to 20V) some units go down to 100 ohms, some only to 150 ohms or 200 ohms. The upper end goes to infinity, but as with ohmmeters is very cramped and not very readable above about 300k.

Ordinary five percent tolerance carbon film resistors are quite accurate enough for the calibration. If you ever want to make precise measurements, use the resistance-box substitution method described later.

## INPUT ARRANGEMENTS

The handiness of the circuit is enhanced by providing some extra facilities at the input (Fig. 3). Two pairs of input terminals are connected to a changeover switch (S1) which selects the operative pair. This enables one circuit or component to be compared with another and is useful for matching and calibration work.

In its essential form The Tester works properly only with circuits at $X$ which are resistances or which behave like resistances at some frequency. If a purely reactive element such as a capacitance or inductance is connected to $X$, oscillation is still obtainable, but the significance of the critical $R_v$ is no longer clear. It usually helps, in such cases, to turn the reactance into a tuned circuit by connecting a coil or capacitor across it. This is done by S2.

A capacitance at $X$ can now be resonated with internal inductance standard $L_s$, or an inductance at $X$ with internal capacitance $C_s$. Only one $C_s$ and $L_s$ are shown in Fig. 3, but of course you can usefully provide a selection. At least one position of S2 must be left free so that tests which do not require an internal shunt can still be made.

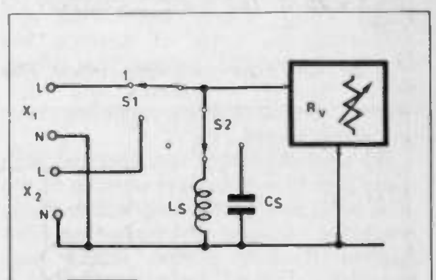
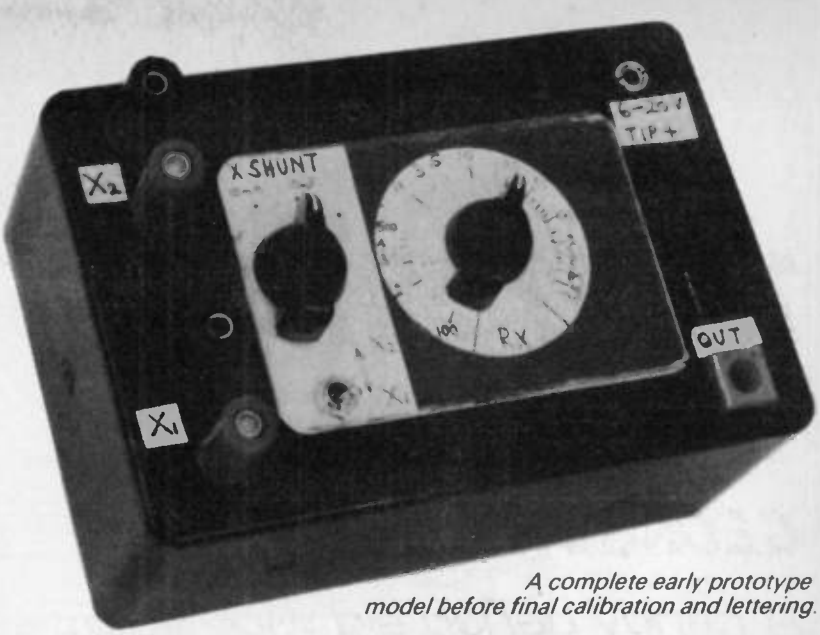



*Fig. 3. Input arrangements. S1 enables one unknown (X) to be compared with another. S2 places inductances or capacitances across the input to assist measurement.*

## HIGH FREQUENCIES

As noted earlier, the oscillation is at a.f. when $X$ is a resistor. An earphone can then be used to detect the onset of oscillation. But when $X$ is an $LC$ circuit with a resonant frequency above audio an earpiece is not usable. You need a high-frequency voltmeter, a good oscilloscope or, failing these, a radio receiver.

When searching for an r.f. output with a receiver an insulated wire from the live output terminal, wrapped a few turns round the whip aerial will inject plenty of signal. A direct connection may deliver too much and damage the receivers input transistor. Searching can be eased by initially turning $R_v$ to zero resistance. This is the condition for maximum oscillation and the result, with most LC circuits, is to provoke squegging (oscillation which turns itself on and off at an audio frequency).




*A complete early prototype model before final calibration and lettering.*

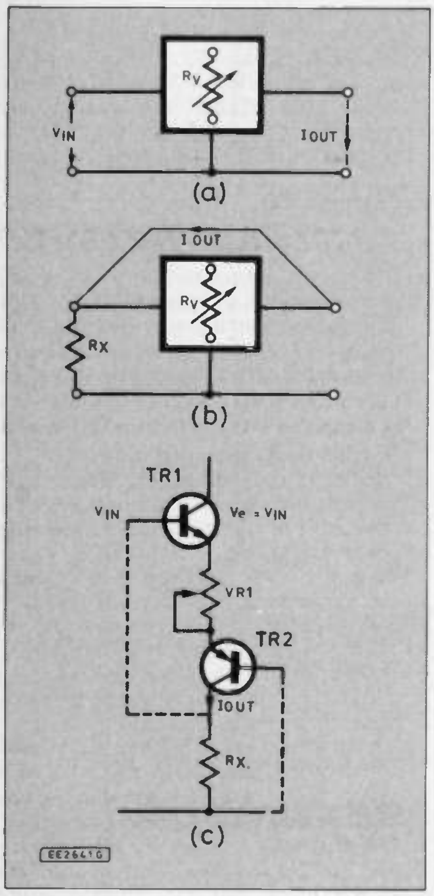



*Fig. 4(a) Essential scheme, (b) feedback added, (c) basic oscillation circuit.*

The resulting deeply-modulated signal, rich in sidebands, is easy to find. Once found you reset $R_v$ to give a pure signal, detectable by the "mush" it produces in the receiver. Whistles are also produced as The Tester interacts with other signals.

## HOW IT WORKS

In Fig. 4a, an input voltage is applied to a "black box" which contains (among other things) a variable resistance $R_v$. The effect of the other things is to make the black box give out a current. The size of this current is $V_{in}/R_v$.

In Fig. 4(b), an unknown resistance $R_x$ is connected to the input. To create an input voltage ($V_{in}$), the output current ($I_{out}$) is fed back through $R_x$. For $V_{in}$ and $I_{out}$ to exist the circuit must oscillate. Calculation shows that oscillation just starts when $R_v$ is marginally less than $R_x$.

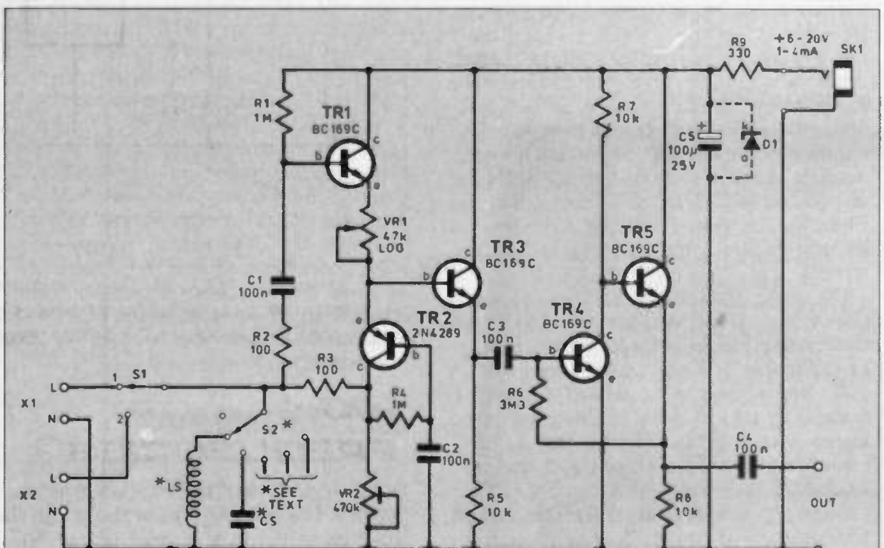
The essentials of the circuit in the black box are shown at Fig. 4(c), with bias and d.c. blocking components omitted for clarity. Here TR1 is an emitter follower with a voltage gain of 1. Thus the signal voltage at the emitter ($V_e$) is the same as $V_{in}$. This drives a current $I_e$ through $R_v$. (Thus $I_e = V_{in}/R_v$).

This current is the input current to TR2, a common-base amplifier with a current gain of 1. Thus $I_{out} = I_e$, and $I_{out}.R_x = V_m$. The condition for oscillation is $R_v = R_x$, or rather this is the borderline beyond which any reduction in $R_v$, however small, gives oscillation.

In practice, the gains for TR1 and TR2 are slightly less than 1, but this is allowed for in the calibration.

In the complete circuit (Fig. 5) the oscillator part is followed by a buffer amplifier which delivers an output signal at low impedance. The Tester will oscillate at frequencies up to about 30MHz, but its accuracy falls off with rising frequency.

*Fig. 5. The Tester complete circuit. The last three transistors form a buffer amplifier.*




## COMPONENTS

**Resistors**
R1 1M
R2, R3 100 (2 off)
R4 1M
R5 10k
R6 3M3
R7, R8 10k (2 off)
R9 330
All 0.25W 5% carbon

See SHOP TALK Page 468

**Potentiometers**
VR1 47k or 50k log.
VR2 470k or 500k min. skeleton preset, lin.

**Capacitors**
C1 to C4 100n polyester (C280) (4 off)
C5 100µ elect. 25V

**Semiconductors**
TR1, TR3, TR4, TR5 BC169C *npn* (4 off)
TR2 2N4289 *pnp*
D1 Zener diode, see text

**Switches**
S1 s.p. changeover
S2 s.p. wafer switch with three or more ways (see text)

**Miscellaneous**
Metal case (see text); printed circuit board available from *EE PCB Service*, code EE696; six terminals for input and output connections; jack socket for power input; knobs for S2, VR1; solder tags, solder etc.

*Approx cost guidance only* **£14**

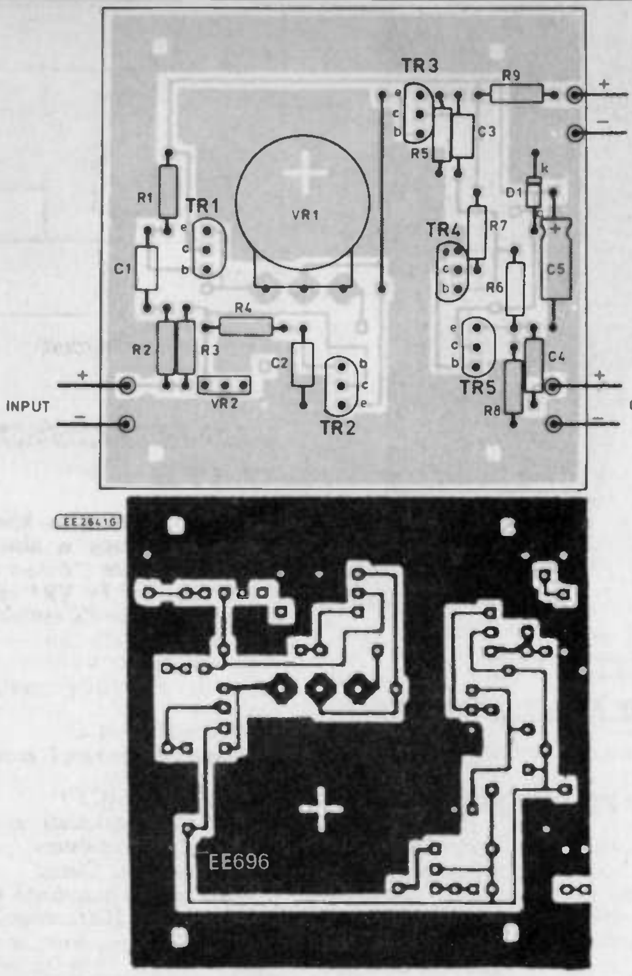



*Fig. 6. Printed circuit design and component layout.*

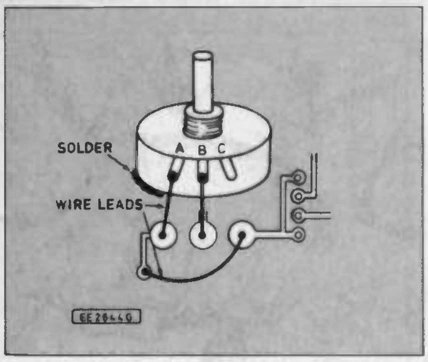



*Fig. 7. Mounting the potentiometer so as to carry the p.c.b.*

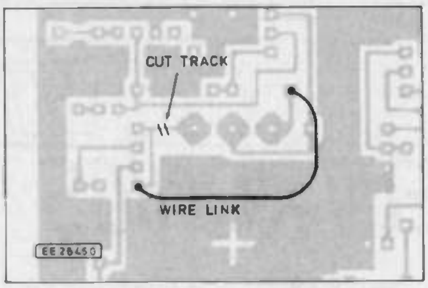
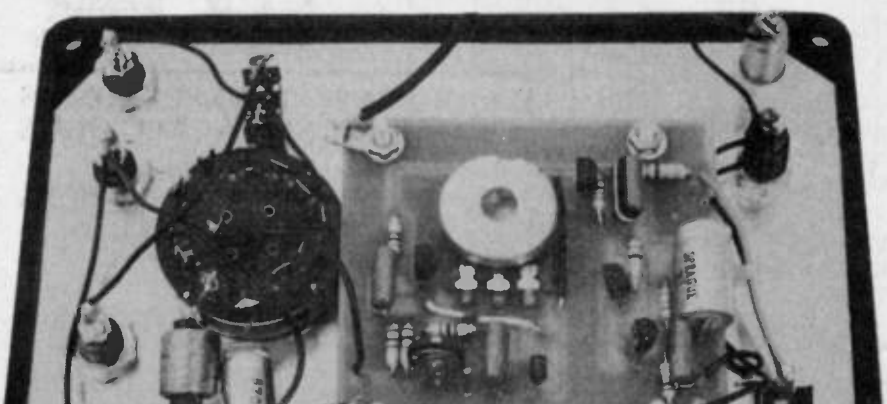



*Fig. 8. Track modifications for conventional potentiometer mounting (viewed from track-side).*

*All the components, including the p.c.b. are mounted on the lid of the case. The lead from the solder tag goes to the "screening" connection lead.*



## CONSTRUCTION

A printed circuit helps to ensure repeatable results and one has been designed. The component layout and full size copper foil master pattern is shown in Fig. 6. This board is available from the *EE PCB Service*, code EE 696.

Two points should be noted. First, the layout is for transistors with a "central collector" leadout arrangement. While in principle any small high-gain general purpose silicon transistors may be used the leads of some types will have to be bent to suit the layout. It helps if TR1 and TR2 have roughly the same current gain ($H_{FE}$) but close matching is not necessary.

Secondly, the layout envisages that the log. law pot VR1 is mounted on the "wrong" side of the p.c.b.; i.e. on the copper side. The clamping nut then presses the metal case to the copper to earth it. Another unconventional but useful arrangement (Fig. 7) is to solder the pot's case to the copper and run leads to the pads as shown. The potentiometer then carries the p.c.b. on its back and no other mounting arrangements are needed.

If you don't like this (or you must use a p.c.b. mounting pot with no bush), the pot can be placed on the component side of the board in the conventional way. However, the copper pattern then selects the wrong pair of tags (B and C instead of A and B) and this gives a "fierce" change of resistance as the spindle is rotated.

To avoid this you can either bend the tags clear of the copper and run leads from A and B to the p.c.b., or solder the tags to the board and make a minor change (Fig. 8) to the layout. You could also avoid the problem by using a reverse log. pot, if you can find one.

There are some spare pads to allow the use of different styles of miniature preset (VR2) and for the addition of a Zener diode across the smoothing capacitor C5.

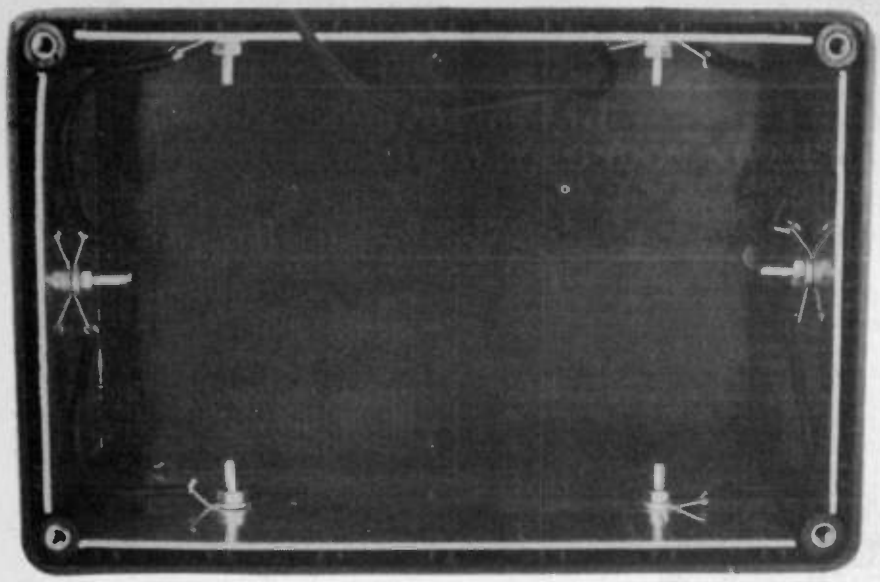
## SETTING UP

After assembly, connect a d.c. supply in the range 6V to 20V (the current drain is modest and a battery may be used) and monitor the output with a crystal (or high impedance magnetic) earphone. With no shunt across the input and VR2 max, a ticking, buzz or whistle will be heard at most positions of VR1.

Set VR1 fully clockwise (maximum resistance). Mark its scale with this end point of travel. Adjust preset VR2 until the oscillation just stops. Mark the point on the scale of VR1 where it restarts as "infinity". You can now calibrate VR1 as described earlier, using five percent (or better) resistors, or a resistance box if you have access to one. (The wirewound resistors in some old boxes are significantly inductive, especially the lower values. To prevent this from upsetting accuracy, put a capacitance of about 10n across the box, but remove it when using more than 1k.) Note that VR1 works "backwards"; clockwise rotation eventually prevents oscillation.

## SCREENING

It is advisable to use a metal cabinet to minimise hand effects and hum pickup. If this is not possible and a plastic cabinet has to be used, line it with metal foil or sheet, connected to battery negative. A suggested method can be seen in the photograph on the next page.



Screening panels mounted inside the plastic case and solder tags used to interlink them together and form the "Earth" connection.

## PRECISION MEASUREMENTS

If a precise reading of the critical resistance is needed, connect the circuit under test to one pair of *X* terminals and an accurate resistance box to the other. Set VR1 critical with the "unknown" circuit selected by S1. Leave VR1 at this setting and use S1 to substitute the resistance box. Find a resistance which just gives oscillation. This is now the resistance (or effective resistance) of the "unknown".

## SELECTIVE AMPLIFICATION

Connect an *LC* circuit tuned to the wanted frequency (Fig. 9) across the input (*X*). Feed a signal to it via a high resistance or small capacitance. Bringing VR1 near the critical setting provides selectivity.

Note that the LC circuit can in principle be sited inside an existent piece of equipment. With LC circuits of low *C* this may be impracticable because the input capacitance of The Tester (about 40p) can cause serious detuning.

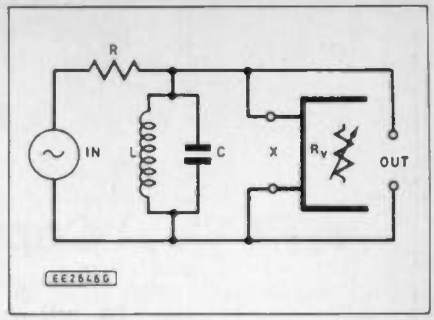



*Fig. 9. Selective circuit.*

## TUNED CIRCUIT DATA

If either *L* or *C* is known and the resonant frequency is also known, the effective resistance ("dynamic resistance", rd) as measured by VR1 can be used to obtain the Q of the LC circuit.

$Q = R_v1/(6.28.f.L)$

or $Q = R_v1/(6.28.f.C)$

If L and f are known, C is calculable:

$C = 25287/(L.f^2)$

If C and f are known, L is calculable:

$L = 25287/(C.f^2)$

In the above calculations the following sets of units are consistent:

Henries, Hertz, Ohms;
microhenries, megahertz, Ohms;
microfarads, Hertz, megohms;
picofarads, megahertz, megohms.

Once tried The Tester becomes an invaluable workshop aid. □

# ...RTTY...Computer Communications...RTTY...

IN THE two previous "*BEEB Micro*" articles we have considered the subjects of Morse and RTTY tone decoding. This month we will conclude out look at this subject with some software to complete the RTTY decoding set up.

The story so far has a filter type tone decoder to decode the f.s.k. (frequency shift keying) signal into conventional serial types, an opto-isolator and level shifter circuit to couple this to a UART, with the latter then decoding the received five bit serial codes into corresponding five bit bytes of parallel data. I suspect that the term byte, which is generally taken to mean 8 bits of data, is incorrect when we are dealing with 5-bit chunks of data. A "nibble", which is four bits of data, would seem more appropriate in a way, but in the absence of a really concise term for these five bit codes I will continue to refer to them as bytes.

## Clocking In

The basic way in which the UART is used was described in the previous *BEEB Micro* article. As UARTs have been covered in some detail in two or three *BEEB Micro* articles over the past few years I will not elaborate on their method of working on this occasion.

The suggested method of interfacing has the clock signal generated by the computer's timer/counters and output on line PB7 of the user port. This has the advantage of giving accurate and repeatable results without the need for any extra hardware, or any test equipment to aid accurate clock frequency adjustment.

If you wish to use this equipment with a computer other than the BBC micro, and no similar facility is available, then a simple *R-C* oscillator based on the indispensable 555 timer device will do the job quite well. However, you will need to have access to a frequency counter in order to permit the output frequency to be set with good accuracy, or a lot of trial and error will be called for.

The clock frequency must be at sixteen times the required baud rate, which gives the following frequencies for the popular baud rates:

| BAUD RATE | UART CLOCK FREQ. |
|---|---|
| 45.45 | 727.2Hz |
| 50 | 800Hz |
| 75 | 1200Hz |
| 150 | 2500Hz |
| 300 | 4800Hz |

As these frequencies are all reasonably low, they can be obtained with quite good accuracy from the timer/counters. With just five bits per byte an error of even a few percent in the clock frequency would probably not produce malfunctions, and the timer/counters can certainly produce much better accuracy than this.

It is actually only timer 1 that is utilized in this case, and the length of one output cycle is equal to 2 × (N + 2) microseconds, where "N" is the value in timer 1. In the current context, what we need to know is that the timer value required for a given output frequency. This can be calculated by first dividing 1000000 by the required output frequency (in hertz), then halving this figure and deducting two.

This leaves a slight complication in that the timer/counter is a sixteen bit type, but it must be loaded using two 8-bit bytes. These are the high byte (the eight most significant bits) and the low byte (the eight least significant bits). The total counter value is equal to 256 times the number loaded into the high byte, plus the number loaded into the low byte.

It is not too difficult to calculate the two numbers required for a given total value, especially if you make use of the MOD and DIV functions of BBC BASIC. However, everything has already been worked out for you, and is summarised in the table below.

| BAUD RATE | TIMER VALUE | HIGH BYTE | LOW BYTE |
|---|---|---|---|
| 45.45 | 687 | 2 | 175 |
| 50 | 623 | 2 | 111 |
| 75 | 415 | 1 | 159 |
| 150 | 206 | 0 | 206 |
| 300 | 1665 | 0 | 102 |

The counter/timers are part of a 6522 VIA, and they are at addresses &FE65 (high byte) and &FE64 (low byte). At least, this is where the latch registers for this timer/counter are situated, and it is these that are used when setting the frequency of a squarewave output on PB7.

The operating mode of timer 2 is controlled by bits six and seven of the Auxiliary control register which is at address &FE6B. In order to set the mode where a squarewave output is produced on PB7 these bits must both be set high, which is achieved by writing a value of 192 (decimal) to address &FE6B.

## Handshake Monitoring

Monitoring the handshake output of the UART is achieved using PB5, and this line going high indicates that a fresh byte of data is ready and waiting to be processed. This bit is easily masked using the logic AND function, giving a reading of 0 when it is low, or 32 when it is high.

Alternatively, line CB1 can be used as a high-to-low handshake input. However, using PB6 is probably a more simple and direct method.

The handshake output used to clear the data received flag of the UART can be either PB6 or CB2. CB2 cannot be used to automatically provide a negative output pulse each time the user port is read, as its automatic mode only works on write operations.

However, using a dummy write operation to the user port represents an easy way of producing the reset pulse, and is the one I recommend. CB2's mode is controlled by bits five to seven of the peripheral control register at address &FE6C. To set the automatic output mode a value of 160 (decimal) must be written to this register.

Finally, the data direction register for port B must be set up for the right combination of input and output lines. With the suggested method of interfacing, PB0 to PB5 are all inputs, PB6 is unused and should therefore be left as an input, and PB7 is used as an output to provide the clock signal. This gives a value of 128 to be written to the data direction register at address &FE62.

However, setting timer 1 to the mode where it provides a squarewave output on PB7 also seems to set PB7 as an output line. Consequently it is not essential to set up the data direction register in this case.

## Software

The accompanying program, Listing. 1, enables the BBC micro plus the circuits featured in the past two *BEEB Micro* articles to function as a simple RTTY receiving terminal. This program is written on the assumption that the data will be read from the UART on PB0 to PB4.

The handshake output will be monitored by PB5, the clock signal is provided by PB7, and CB2 is used to reset the UART's handshake output. A different method of interfacing would almost certainly require minor modifications to the program.

Lines 30 to 70 set up the 6522 VIA correctly, and the values written to the timers at lines 60 to 70 are for a baud rate of 45.45. You can substitute values from the table provided previously if operation at a different baud rate is required.

The rest of the program is largely concerned with reading in bytes of data, and converting them from Baudot codes into corresponding ASCII characters which are then printed on the screen. I have not tried it in practice, but presumably using the standard Control-B method or the appropriate operating system command would result in everything being echoed to the printer as well if desired.

The program has to deal with the slight complication of the shift characters, and moving between the two Baudot character sets. You may sometimes find that the wrong character set is being produced.

This can easily occur if you tune in to a station in the middle of a message, or if interference causes corruption of the received data. You can shift manually between character sets simply by pressing the "S" key. If you wish to clear the screen and start afresh, press the "C" key.

## In Use

The program and the hardware lack any "frills", but when used with a Yaesu FRG-8800 receiver I obtained quite good results. The main problem when using a computer with a communications receiver is usually one of electrical noise produced by the computer and monitor being picked up by the receiver. This can provide very

**Listing. 1: RTTY Program**

```
10REM RTTY PROGRAM
20REM 23/4/1990
30?&FE60=192
40?&FE6C=160
50?&FE6B=192
60?&FE64=111
70?&FE65=2
80
90DIM LOOKUP$(32,2)
100PROCLOAD_DATA
110COL=1
120REPEAT
130PROCKBD
140ROW=FNGET_CODE(0)
150PRINT LOOKUP$(ROW,COL);
160UNTIL FALSE
170END
180DATA E,3
190DATA 10,10
200DATA A,-
210DATA 32,32
220DATA S,07
230DATA I,8
240DATA U,7
250DATA 13,13
260DATA D,$
270DATA R,4
280DATA J,'
290DATA N,44
300DATA F,%
310DATA C,:
320DATA K,(
330DATA T,5
340DATA Z,34
350DATA L,)
360DATA W,2
370DATA H,32
380DATA Y,6
390DATA P,0
400DATA Q,1
410DATA O,9
420DATA B,?
430DATA G,&
440DATA 00,00
450DATA M,46
460DATA X,/
470DATA V,59
480DATA 00,00
490
500DEF PROCLOAD_DATA
510FOR ROWS=1 TO 31
520FOR COLS=1 TO 2
530READ LOOKUP$(ROWS,COLS)
540L=LEN(LOOKUP$(ROWS,COLS))
550IF L>1 THEN LOOKUP$(ROWS,COLS)=FNCHAR(ROWS,COLS)
560NEXT COLS
570NEXT ROWS
580ENDPROC
590
600DEF FNCHAR(ROW,COL)
610V=VAL(LOOKUP$(ROW,COL))
620CHAR$=CHR$(V)
630=CHAR$
640
650DEF PROCKBD
660K$=INKEY$(0)
670IF K$="s" OR K$="S" THEN COL=COL EOR 3
680IF K$="c" OR K$="C" THEN CLS
690ENDPROC
700
710DEF FNGET_CODE(D)
720REPEAT
730V%=?&FE60
740UNTIL (V% AND 32)<>0
750?&FE60=0
760V%=V% AND 31
770IF V%=27 THEN COL=2:GOTO 720
780IF V%=31 THEN COL=1:GOTO 720
790=V%
```

strong signals in some cases, blotting out all but the strongest of transmissions.

Using the opto-isolator between the receiver and the computer should help, by eliminating any direct connection between the two parts of the system. However, the problem is mainly one of signals being radiated by the computer equipment and picked up by the aerial.

Using a short indoor aerial generally gives very severe noise problems. A longer outdoor type gives stronger reception of RTTY stations, and seems to reduce noise picked up from computer equipment.

The short wave bands contain countless RTTY signals, but most of these are of no great interest to the amateur radio enthusiast. In fact receiving some of these stations could break copyright or other laws.

The amateur bands are the only major source of legitimate RTTY stations, and the twenty metre band around 14.090MHz is generally quite productive when this band is open. The 80 metre band just below 3.6MHz is also worth investigating, but these days seems to be a less prolific source of RTTY signals than the 20 metre band.

Remember that the input signal to the UART must be of the correct polarity if it is to be decoded properly. If a strong signal is obtained, but the reproduced characters are gibberish, try switching to the inverted signal.

Alternatively, change from u.s.b. to l.s.b. (or vice versa, as appropriate), which also has the effect of changing the polarity of the output signal. If inverting the signal does not have the desired effect, then the problem is probably one of a baud rate or shift frequency mismatch.

The subject of computer aided communications is a complex one. Morse and RTTY reception and decoding are just two aspects of an interesting branch of amateur electronics. A more in-depth coverage of the subject goes beyond the scope of *BEEB Micro* articles, but the circuits and software provided in the last three articles should at least provide a good introduction to computer communications.

# DOWN TO EARTH

## BY GEORGE HYLTON

### INTERFERENCE FILTERS

When is a capacitor more than a capacitor? When it has four leadouts instead of two!

An interference filter is intended to prevent electrical noise energy from reaching circuits where it isn't wanted. A common case is found in a motor vehicle, where noise from the ignition system must be prevented from reaching a radio receiver in the car.

The first step is to place the aerial outside the car body where interference is low, and connect it via a screened cable to the screened receiver. This by itself is not enough. Interference can still get into the receiver via the battery connection.

### CAPACITORS

The conventional solution is to suppress the interference where it arises. This is done partly by placing resistance in the high-tension circuit so that noise from the spark plugs is attenuated, and partly by connecting capacitors at strategic points to short the high-frequency interference currents to "earth" (i.e. the metal chassis or body).

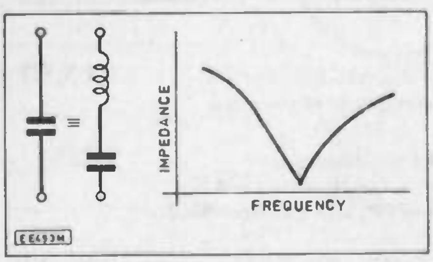



*Fig. 1. At high frequencies a capacitor is an LC circuit.*

In this case simple two-terminal capacitors may be enough. However, a practical capacitor of this kind always has inductance, if only in the connection leads.

The capacitor is in effect a capacitance in series with an inductance (Fig. 1). Its impedance varies with frequency as shown. There is a minimum when the inductive and capacitive reactances are equal and cancel one another out. The effectiveness of the capacitor at short-circuiting interference current is greater at this frequency and deteriorates at lower or higher frequencies.

### TRANSMISSION-LINE FILTERS

Fortunately, for some applications, such as suppressing mains-borne interference, the materials used to make a capacitor can be arranged in a different way to form a more effective filter.

If a capacitor of the sandwich type (metal foil-dielectric-metal foil) is unrolled (Fig. 2a) and connections made at each end of the foil the capacitor becomes a transmission line. This is electrically equivalent to (Fig. 2b), which is a low-pass *LC* filter.

Interference entering at *a, b* is attenuated by the line on its way to *c, d*. The attenuation increases with frequency. In practice, of course, the filter capacitor is rolled up again for convenience.

Sometimes one foil is connected internally to a metal case. The filter is then a three-terminal one, with input *a* output *c* and common (the case *b, d*) connections.

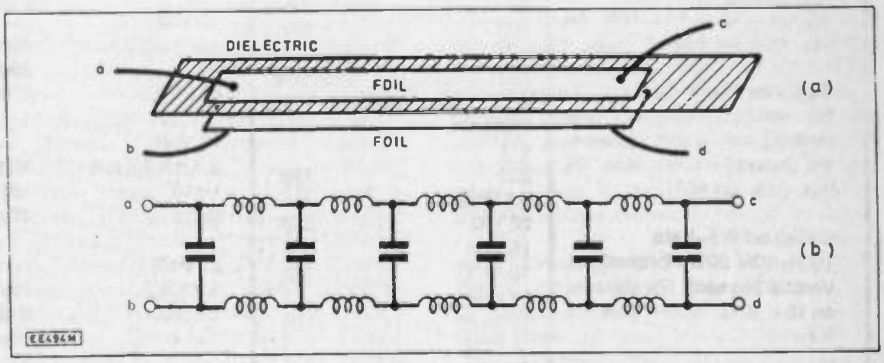



*Fig. 2. A four-terminal capacitor acts as a low-pass filter. (a) Unrolled capacitor. (b) Equivalent circuit.*

### TRIPLE FILTER

The domestic mains (in Britain and many other countries) is carried round the house by a three-wire system: live (*L*), neutral (*N*) and earth (*E*). Interference filters often embody three capacitances (Fig. 3).

Here C1 comes across the mains (live, L and neutral, N), while C2 and C3 shunt the L and N wires to earth, E. The N lead is remotely earthed at the power station or some nearer point, but can still carry interference locally.

It would seem logical to make C1, C2 and C3 equal. However, there is a snag. if the earth connection of a piece of equipment becomes accidentally disconnected, then nominally earthed exposed metal parts are in fact connected to L and N by C2 and C3, and ***LETHAL*** shocks might be given to anyone touching the metal.

In theory, the risk could be reduced by making C3 much greater than C2. These two capacitors form a voltage divider in which the E-N section (C3) receives only part of the mains voltage. The greater C3 is with respect to C2 the less voltage appears at E if the earth connection is missing.

However, anybody who is careless enough to leave off the earth at the mains plug may well also reverse L and N. C3 would then deliver a lethal current.

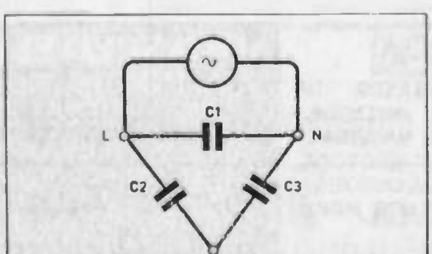



*Fig. 3. Triple mains filter capacitors.*

To be on the safe side, C2 and C3 are in practice made equal, so that whatever way L and N are connected only half the voltage can appear at E. They are also made small, to limit current.

Typical values are 100nF (0.1μF) for C1 and 2700pF (2.7n, 0.0027μF) for C2 and C3. All these capacitors ***MUST*** be rated to carry at least the full a.c. mains voltage (240V in Britain) continuously.

### LC FILTERS

Where very large amounts of attenuation are required inductances may be incorporated in filters (Fig. 4). The inductors L1, L2 may be wound on the same iron or ferrite core. This reduces the risk of core saturation (which would lower the effective inductance).

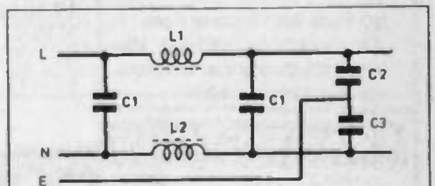



*Fig. 4. LC Filter.*

The use of inductance increases the size and cost of the filter but can produce high attenuation at the lower radio frequencies where capacitance-only filters may not be good enough.

### FEED-THROUGH FILTERS

Conventional filters tend to be rather bulky. Where space is limited it is sometimes possible to utilise a type of filter capacitor which doubles as a connecting link between the inside of a metal cabinet and the outside world. (See Fig. 5).

When the interference is all at high frequencies a relatively small amount of capacitance may be enough. The resulting feed-through filter can then be very compact. Indeed, nowadays these filters are often built into the sockets used for conveying power or low frequency signals into or out of a cabinet or module.

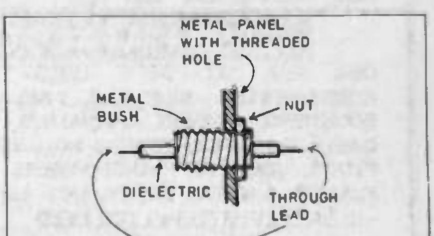



*Fig. 5. Feed-through capacitor filter.*

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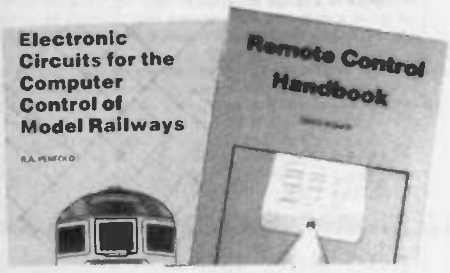


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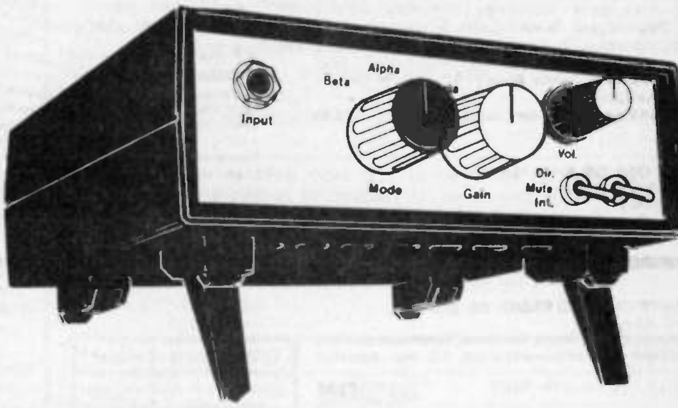


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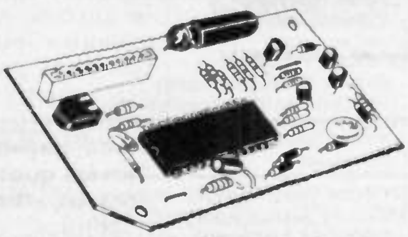

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*Boards for some older projects – not listed here – can often be obtained from Magenta Electronics, 135 Hunter St., Burton-on-Trent, Staffs DE14 2ST. Tel: 0283 65435 or Lake Electronics, 7 Middleton Close, Nuthall, Nottingham NG16 1BX. Tel: 0602 382509.*

**NOTE: While 90% of our boards are now held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail. Please check price and availability in the latest issue before ordering. We can only supply boards listed in the latest issue. Boards can only be supplied on a payment with order basis.**

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| AMATEUR BAND | RECEIVER TUNING RANGE | TUNING PACK |
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| 80m 3.500–3.800MHz | 3.490–3.810MHz | 1 |
| 40m 7.000–7.100MHz | 6.690–7.150MHz | 2 |
| 10.100–10.150MHz | 10.000–10.500MHz | 2 |
| 20m 14.000–14.350MHz | 13.990–14.400MHz | 3 |
| 18.068–18.168MHz | 18.000–18.500MHz | 3 |
| 15m 21.000–21.450MHz | 20.990–21.500MHz | 3 |
| 24.890–24.990MHz | 24.540–25.000MHz | 4 |
| 10m 28.000–29.700MHz | A, 27.975–28.525MHz | 4 |
| | B, 28.475–29.025MHz | 4 |
| | C, 28.975–29.525MHz | 4 |
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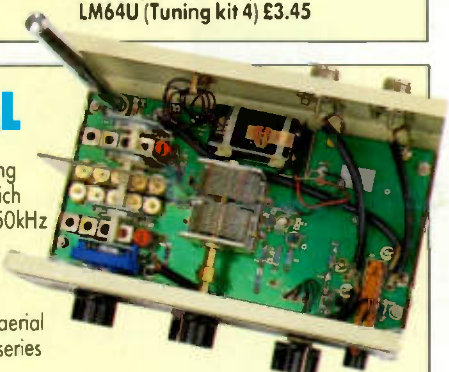

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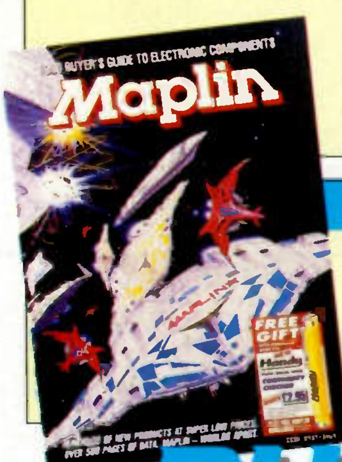
Optional items:
**FA99H (Active Aerial f/panel) £3.95**
**XY45Y (Case 222) £6.45**

Photo shows Kit with some optional extras, see Maplin Catalogue for further details.



## THE MAPLIN CATALOGUE

Further details and specifications on all the items shown on this page are to be found in the Maplin Catalogue. Over 580 pages of electronics ideas from Projects and Modules, Tools, Components, Books, Connectors, Batteries and Power Supplies to Test Gear, Audio, Video and Computers and much, much more.
Available from branches of WHSMITH, Only £2.25, or by post £2.75 inc p&p (CA07H).

# DXer's AUDIO PROCESSOR

★ **No modifications to receiver**
★ **High filter attenuation rate** ★ **Easy construction**

The processor features a low-pass filter giving a 36dB per octave attenuation under 150Hz and an expander which severely attenuates noise during pauses in the received speech. The unit is especially suited for SSB & FM CB reception and simply fits between the receiver's audio output and the headphones, thus no modification is necessary to the receiver. The single PCB makes construction very simple.

**LK05F (DXer's Processor Kit) £11.95**
Optional items: **HB26D (Knob (3 off required)) 68p each**
**XY45Y (Case 222) £6.45 FM03D (9V PP6 Battery) £1.98**

# SW/MW AERIAL TUNING KIT

Given that the aerial impedance of most communications receivers is 50, unless the impedance of the aerial matches this exactly all of the RF energy will not be efficiently transferred from the aerial to the receiver. The greater the mismatch, then the weaker the signal will appear, and under adverse conditions it could vanish completely into background noise. This aerial tuning unit comprises two variable tuning capacitors and a tapped inductor in a passive 'T' configuration. This arrangement covers approximately 600kHz to 30MHz, and matches the aerial load impedance to the input impedance of the receiver. The ATU can also be used for transmitter aerial matching in the same frequency range, including the 27MHz citizen band, up to a power rating of 10 Watts. A printed stick-on front panel is available as an optional extra for the aerial tuner unit.

**LM06G (Aerial Tuner Kit) £36.95**
Optional items: **FD11M (Aerial Tuner f/panel) £3.95**
**XY45Y (Case 222) £6.45 FW38R (Pkt Stick-on Feet) 24p**

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