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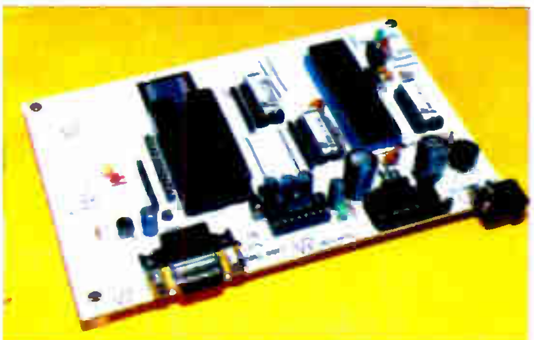

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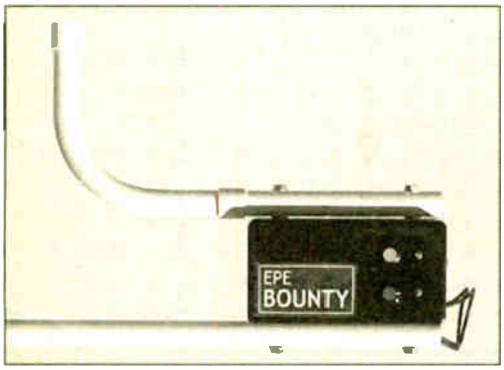

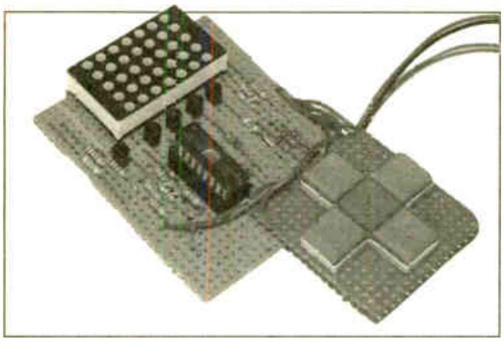

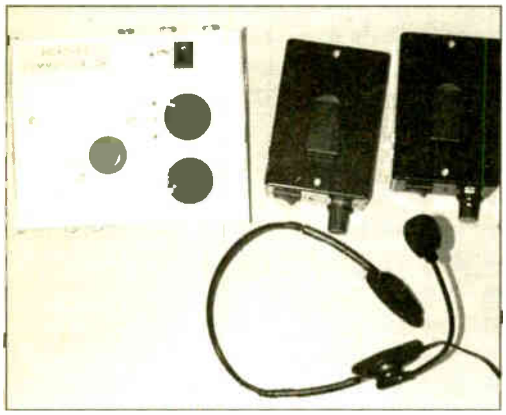

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PHILIPS HCS31 Ultra compact 9" colour video monitor with **standard composite 15.625 Khz video** input via SCART socket. Ideal for all monitoring / security applications. High quality, ex-equipment fully tested & guaranteed (possible minor screen burns). In attractive square black plastic case measuring W10" x H10" x 13½" D. 240 V AC mains powered. **Only £79.00** (D)

INDUSTRIAL COMPUTERS

Tiny shoebox sized industrial 40 Mhz 386 PC system measuring only (mm) 266 w X 88 h X 272 d. Ideal for dedicated control applications running DOS, Linux or even Windows ! Steel case contains 85 to 265 V AC 50 / 60 hz 70 Watt PSU, a 3 slot ISA passive backplane and a Rocky 318 (PC104) standard, single board computer with 8 MByte NON VOLATILE solid state 'Disk On Chip' RAMDISK. System comprises: Rocky 318 (PC104) SBC ISA card with 40MHz ALi 386SX CPU, 72 pin SIMM slot with 16 Mbyte SIMM, AMI BIOS, battery backed up real time clock, 2 x 9 pin D 16550 serial ports. EPP/ECP printer port, mini DIN keyboard connector, floppy port, IDE port for hard drives up to 528 MByte capacity, watchdog timer and PC/104 bus socket. The 8 MByte solid state 'disk on a chip' has its own BIOS, and can be fdisked, formatted & booted. Supplied BRAND NEW fully tested and guaranteed. For full data see featured item on website. Order as QG36

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Overall dimensions 66 mm wide x 117 deep x 43 high. Supplied BRAND NEW & fully guaranteed with user data, 100's of applications including Security, Home Video, Web TV, Web Cams etc, etc.

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NT4 WorkStation, complete with service pack 3 and licence - OEM packaged. ***ONLY £89.00*** (B)

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SOLID STATE LASERS

Visible red, 670nm laser diode assembly. Unit runs from 5 V DC at approx 50 mA. Orginally made for continuous use in industrial barcode scanners, the laser is mounted in a removable solid aluminium block, which functions as a heatsink and rigid optical mount. Dims of block are **50** w x **50** d x **15** h mm. Integral features include over temperature shutdown, current control, laser OK ouput, and gated TTL ON / OFF. Many uses for experimental optics, comms & lightshows etc. Supplied complete with data sheet.

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Unless marked NEW, items in this section are pre owned.

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FARNELL 0-60V DC @ 50 Amps, bench Power Supplies	£995
FARNELL AP3080 0-30V DC @ 80 Amps, bench Suppy	£1850
KINGSHILL CZ403/1 0-50V @ DC 200 Amps - NEW	£3950
1kW to 400 kW - 400 Hz 3 phase power sources - ex stock	£POA
IBM 8230 Type 1, Token ring base unit driver	£760
Wayne Kerr RA200 Audio frequency response analyser	£2500
INFODEC 1U, 24 port, RJ45 network patchpanels. #TH93	£49
3COM 16670 12 Port Ethernet hub - RJ45 connectors #LD97	£69
3COM 16671 24 Port Ethernet hub - RJ45 connectors	£89
3COM 16700 8 Port Ethernet hub - RJ45 connectors NEW	£39
IBM 53F5501 Token Ring ICS 20 port lobe modules	£POA
IBM MAU Token ring distribution panel 8228-23-5050N	£45
AIM 501 Low distortion Oscillator 9Hz to 330Khz, IEEE I/O	£550
ALLGON 8360.11805-1880 MHz hybrid power combiners	£250
Trend DSA 274 Data Analyser with G703(2M) 64 i/o	£POA
Marconi 6310 Programmable 2 to 22 GHz sweep generator	£4500
Marconi 2022C 10KHz-1GHz RF signal generator	£1550
HP1650B Logic Analyser	£3750
HP3781A Pattern generator & **HP3782A** Error Detector	£POA
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	£1800
HP6264 Rack mount variable 0-20V @ 20A metered PSU	£475
HP54121A DC to 22 GHz four channel test set	£POA
HP8130A opt 020 300 MHz pulse generator, GPIB etc	£7900
HP A1, A0 8 pen HPGL high speed drum plotters - from	£550
HP DRAFTMASTER 1 8 pen high speed plotter	£750
EG+G Brookdeal 95035C Precision lock in amp	£1800
Keithley 590 CV capacitor / voltage analyser	£POA
Racal ICR40 dual 40 channel voice recorder system	£3750
Fiskers 45KVA 3 ph On Line UPS – New batteries	£4500
Emerson AP130 2.5KVA industrial spec.UPS	£1499
Mann Tally MT645 High speed line printer	£2200
Intel SBC 486/133SE Multibus 486 system. 8Mb Ram	£945
HP6030A 0-200V DC @ 17 Amps bench power supply	£1950
Intel SBC 486/125C08 Enhanced Multibus (MSA) New	£1150
Nikon HFX-11 (Ephiphot) exposure control unit	£1450
PHILIPS PM5518 pro. TV signal generator	£1250
Motorola VME Bus Boards & Components List. SAE / CALL	£POA
Trio 0-18 vdc linear, metered 30 amp bench PSU. New	£550
Fujitsu M3041R 600 LPM high speed band printer	£1950
Fujitsu M3041D 600 LPM printer with network interface	£1250
Siemens K4400 64Kb to 140Mb demux analyser	£2950
Perkin Elmer 299B Infrared spectrophotometer	£500
Perkin Elmer 597 Infrared spectrophotometer	£3500
VG Electronics 1035 TELETEXT Decoding Margin Meter	£3250
LightBand 60 output high spec 2u rack mount Video VDA's	£495
Sekonic SD 150H 18 channel digital Hybrid chart recorder	£1995
B&K 2633 Microphone pre amp	£300
Taylor Hobson Tallysurf amplifier / recorder	£750
ADC SS200 Carbon dioxide gas detector / monitor	£1450
BBC AM20/3 PPM Meter (Ernest Turner) + drive electronics	£75
ANRITSU 9654A Optical DC-2.5G/b waveform monitor	£5650
ANRITSU ML93A optical power meter	£990
ANRITSU Fibre optic characteristic test set	£POA
R&S FTDZ Dual sound unit	£650
R&S SBUF-E1 Vision modulator	£775
WILTRON 6630B 12.4 / 20GHz RF sweep generator	£5750
TEK 2445 150 MHz 4 trace oscilloscope	£1250
TEK 2465 300 Mhz 300 MHz oscilloscope rack mount	£1955
TEK TDS380 400Mhz digital realtime + disk drive, FFT etc	£2900
TEK TDS524A 500Mhz digital realtime + colour display etc	£5100
HP3585A Opt 907 20Hz to 40 Mhz spectrum analyser	£3950
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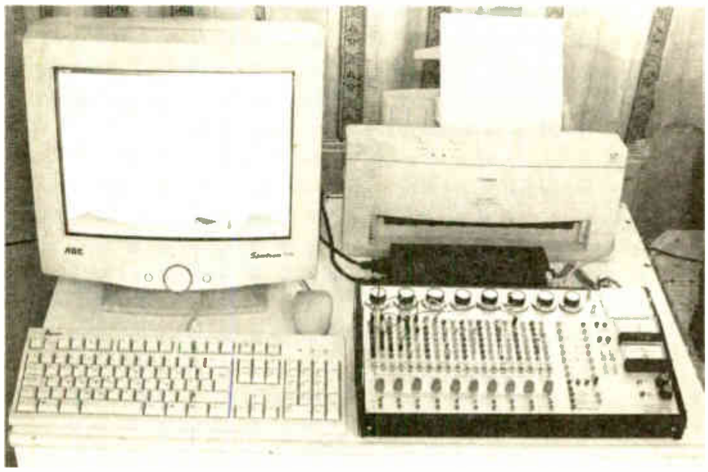
NEXT MONTH

EPE HYBRID COMPUTER

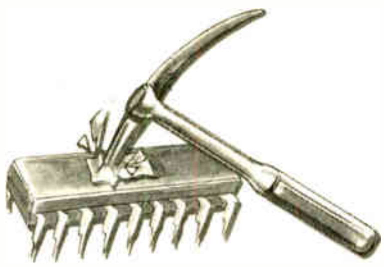


Analogue computers can solve many real world problems that are very difficult to resolve with a digital computer. The EPE Hybrid Computer combines the best of both worlds – an analogue computer to solve those real-world problems, plus a digital processor (MCU) to analyse and output the results to a PC.
The analogue system is programmed by connecting its modules using wires through a patch panel. The MCU has access to the analogue control circuits through the patch panel, and has the capability of converting analogue signals to digital.
Programming of the MCU, a Basic Micro ATOM, is carried out in BASIC and communication is via a serial link. The PC's Windows software is totally self-contained; it is written in Visual Basic but does not need VB to be resident on your PC, running as a standalone .EXE program.

PICAXE PROJECTS

For everyone who would like to use PICs without a major learning curve or expense, a three-part series of constructional articles based on PICAXE microcontrollers. Such controllers are a modified version of Microchip's PIC16F627, they have been modified by Revolution Education to allow them to accept program code written in a form of BASIC. Known as the PICAXE-18, these devices do not need special programming hardware and are simply programmed by means of a serial link to your PC.
There are nine simple and inexpensive designs presented in the series:

- *Egg Timer*
- *Dice Machine*
- *Four-Input Quiz Monitor*
- *Temperature Sensor*
- *Voltage Sensor*
- *VU Display*
- *Low Voltage Chaser Lights*
- *Mains Interface*
- *A selection of other Interface circuits*



The series will be of special interest to teachers responsible for technology education. It will also be of great interest to any readers who wish to learn to program PICs with their own simple designs, yet do not wish to learn PIC programming to the advanced level that more sophisticated designs require.

TUNING FORK AND METRONOME

"If music be the food of love, play on" – fine, but only if it's well tuned and on beat! This PIC-based design can help you ensure that your serenades at least start off with the correct notes – even if you do then play them in the wrong order.
The PIC accurately generates the seven basic tones of an octave, any of which can be selected via a switch, as can the octave. It can output the selected tone to headphones or a speaker, at a panel-controlled level. It also compares its own tone with the frequency of an acoustically or electrically input note, and indicates, via an l.e.d., how closely the two signals match. Lots of flashing and you're way off – no flashing and you're spot-on.
The metronome mode is selected in place of the tuning fork, and outputs a "click-track" which can be set for different time signatures and with an accented down beat.

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PROJECT KITS

Our electronic kits are supplied complete with all components, high quality PCBs (NOT cheap Tripad strip board!) and detailed assembly/operating instructions

● **2 x 25W CAR BOOSTER AMPLIFIER** Connects to the output of an existing car stereo cassette player, CD player or radio. Heatsinks provided. PCB 76x75mm. **1046KT. £24.95**

● **3-CHANNEL WIRELESS LIGHT MODULATOR** No electrical connection with amplifier. Light modulation achieved via a sensitive electret microphone. Separate sensitivity control per channel. Power handing 400W/channel. PCB 54x112mm. Mains powered. Box provided. **6014KT £24.95**

● **12 RUNNING LIGHT EFFECT** Exciting 12 LED light effect ideal for parties, discos, shop-windows & eye-catching signs. PCB design allows replacement of LEDs with 220V bulbs by inserting 3 TRIACs. Adjustable rotation speed & direction. PCB 54x112mm. **1026KT £15.95; BOX (for mains operation) 2026BX £9.00**

● **DISCO STROBE LIGHT** Probably the most exciting of all light effects. Very bright strobe tube. Adjustable strobe frequency: 1-60Hz. Mains powered. PCB: 60x68mm. Box provided. **6037KT £28.95**

● **ANIMAL SOUNDS** Cat, dog, chicken & cow. Ideal for kids farmyard toys & schools. **SG10M £5.95**

● **3 1/2 DIGIT LED PANEL METER** Use for basic voltage/current displays or customise to measure temperature, light, weight, movement, sound levels, etc. with appropriate sensors (not supplied). Various input circuit designs provided. **3061KT £13.95**

● **IR REMOTE TOGGLE SWITCH** Use any TV/VCR remote control unit to switch onboard 12V/1A relay on/off. **3058KT £10.95**

SPEED CONTROLLER for any common DC motor up to 100V/5A. Pulse width modulation gives maximum torque at all speeds. 5-15VDC. Box provided. **3067KT £12.95**

● **3 x 8 CHANNEL IR RELAY BOARD** Control eight 12V/1A relays by Infra Red (IR) remote control over a 20m range in sunlight. 6 relays turn on only, the other 2 toggle on/off. 3 operation ranges determined by jumpers. Transmitter case & all components provided. Receiver PCB 76x89mm. **3072KT £52.95**

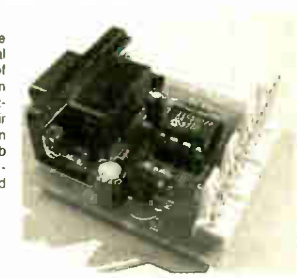
PRODUCT FEATURE

COMPUTER TEMPERATURE DATA LOGGER

PC serial port controlled 4-channel temperature meter (either deg C or F). Requires no external power. Allows continuous temperature data logging of up to four temperature sensors located 200m+ from motherboard/PC. Ideal use for old 386/486 computers. Users can tailor input data stream to suit their purpose (dump it to a spreadsheet or write your own BASIC programs using the INPUT command to grab the readings). PCB just 38mm x 38mm. Sensors connect via four 3-pin headers. 4 header cables supplied but only one DS18S20 sensor.

Kit software available free from our website.

ORDERING: 3145KT **£23.95** (kit form); AS3145 **£29.95** (assembled); Additional DS18S20 sensors **£4.95** each



● **SOUND EFFECTS GENERATOR** Easy to build. Create an almost infinite variety of interesting/unusual sound effects from birds chirping to sirens. 9VDC. PCB 54x85mm. **1045KT £8.95**

● **ROBOT VOICE EFFECT** Make your voice sound similar to a robot or Darlek. Great fun for discos, school plays, theatre productions, radio stations & playing jokes on your friends when answering the phone! PCB 42x71mm. **1131KT £8.95**

● **AUDIO TO LIGHT MODULATOR** Controls intensity of one or more lights in response to an audio input. Safe, modern opto-coupler design. Mains voltage experience required. **3012KT £8.95**

● **MUSIC BOX** Activated by light. Plays 8 Christmas songs and 5 other tunes. **3104KT £7.95**

● **20 SECOND VOICE RECORDER** Uses non-volatile memory - no battery backup needed. Record/replay messages over & over. Playback as required to greet customers etc. Volume control & built-in mic. 6VDC. PCB 50x73mm. **3131KT £12.95**

● **TRAIN SOUNDS** 4 selectable sounds : whistle blowing, level crossing bell, 'clickety-clack' & 4 in sequence. **SG01M £6.95**

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● **LOCKS** - How they work and how to pick them. This fact filled report will teach you more about locks and the art of lock picking than many books we have seen at 4 times the price. Packed with information and illustrations. **R008 £3.50**

● **RADIO & TV JOKER PLANS** We show you how to build three different circuits for disrupting TV picture and sound plus FM radio! May upset your neighbours & the authorities!! DISCRETION REQUIRED. **R017 £3.50**

● **INFINITY TRANSMITTER PLANS** Complete plans for building the famous Infinity Transmitter. Once installed on the target phone, device acts like a room bug. Just call the target phone & activate the unit to hear all room sounds. Great for home/office security! **R019 £3.50**

● **THE ETHER BOX CALL INTERCEPTOR PLANS** Grabs telephone calls out of thin air! No need to wire-in a phone bug. Simply place this device near the phone lines to hear the conversations taking place! **R025 £3.00**

● **CASH CREATOR BUSINESS REPORTS** Need ideas for making some cash? Well this could be just what you need! You get 40 reports (approx. 800 pages) on floppy disk that give you information on setting up different businesses. You also get valuable reproduction and duplication rights so that you can sell the manuals as you like. **R030 £7.50**

● **PC CONTROLLED RELAY BOARD** Convert any 286 upward PC into a dedicated automatic controller to independently turn on/off up to eight lights, motors & other devices around the home, office, laboratory or factory. Each relay output is capable of switching 250VAC/4A. A suite of DOS and Windows control programs are provided together with all components (except box and PC cable). 12VDC. PCB 70x200mm. **3074KT £31.95**

● **2 CHANNEL UHF RELAY SWITCH** Contains the same transmitter/receiver pair as 30A15 below plus the components and PCB to control two 240VAC/10A relays (also supplied). Ultra bright LEDs used to indicate relay status. **3082KT £27.95**

● **TRANSMITTER RECEIVER PAIR** 2-button keyfob style 300-375MHz Tx with 30m range. Receiver encoder module with matched decoder IC. Components must be built into a circuit like kit 3082 above. **30A15 £14.95**

● **PIC 16C71 FOUR SERVO MOTOR DRIVER** Simultaneously control up to 4 servo motors. Software & all components (except servos/control pots) supplied. 5VDC. PCB 50x70mm. **3102KT £15.95**

● **UNIPOLAR STEPPER MOTOR DRIVER** for any 5/6/8 lead motor. Fast/slow & single step rates. Direction control & on/off switch. Wave, 2-phase & half-wave step modes. 4 LED indicators. PCB 50x65mm. **3109KT £14.95**

● **PC CONTROLLED STEPPER MOTOR DRIVER** Control two unipolar stepper motors (3A max. each) via PC printer port. Wave, 2-phase & half-wave step modes. Software accepts 4 digital inputs from external switches & will single step motors. PCB fits in D-shell case provided. **3113KT £17.95**

● **12-BIT PC DATA ACQUISITION/CONTROL UNIT** Similar to kit 3093 above but uses a 12 bit Analogue-to-Digital Converter (ADC) with internal analogue multiplexor. Reads 8 single ended channels or 4 differential inputs or a mixture of both. Analogue inputs read 0-4V. Four TTL/CMOS compatible digital input/outputs. ADC conversion time <10uS. Software (C, QB & Win), extended D shell case & all components (except sensors & cable) provided. **3118KT £52.95**

● **LIQUID LEVEL SENSOR/RAIN ALARM** Will indicate fluid levels or simply the presence of fluid. Relay output to control a pump to add/remove water when it reaches a certain level. **1080KT £5.95**

● **AM RADIO KIT 1** Tuned Radio Frequency front-end, single chip AM radio IC & 2 stages of audio amplification. All components inc. speaker provided. PCB 32x102mm. **3063KT £10.95**

● **DRILL SPEED CONTROLLER** Adjust the speed of your electric drill according to the job at hand. Suitable for 240V AC mains powered drills up to 700W power. PCB: 48mm x 65mm. Box provided. **6074KT £17.95**

● **3 INPUT MONO MIXER** Independent level control for each input and separate bass/treble controls. Input sensitivity: 240mV. 18V DC. PCB: 60mm x 185mm. **1052KT £16.95**

● **NEGATIVE/POSITIVE ION GENERATOR** Standard Cockcroft-Walton multiplier circuit. Mains voltage experience required. **3057KT £10.95**

● **LED DICE** Classic intro to electronics & circuit analysis. 7 LED's simulate dice roll, slow down & land on a number at random. 555 IC circuit. **3003KT £9.95**

● **STAIRWAY TO HEAVEN** Tests hand-eye co-ordination. Press switch when green segment of LED lights to climb the stairway - miss & start again! Good intro to several basic circuits. **3005KT £9.95**

● **ROULETTE LEO** 'Ball' spins round the wheel, slows down & drops into a slot. 10 LED's. Good intro to CMOS decade counters & Op-Amps. **3006KT £10.95**

● **12V XENON TUBE FLASHER TRANSFORMER** steps up a 12V supply to flash a 25mm Xenon tube. Adjustable flash rate. **3163KT £13.95**

● **LEO FLASHER 1** 5 ultra bright red LED's flash in 7 selectable patterns. **3037MKT £5.95**

● **LED FLASHER 2** Similar to above but flash in sequence or randomly. Ideal for model railways. **3052MKT £5.95**

● **INTRODUCTION TO PIC PROGRAMMING.** Learn programming from scratch. Programming hardware, a P16F84 chip and a two-part, practical, hands-on tutorial series are provided. **3081KT £21.95**

● **SERIAL PIC PROGRAMMER** for all 8/18/28/40 pin DIP serial programmed PICs. Shareware software supplied limited to programming 256 bytes (registration costs £14.95). **3096KT £10.95**

● **ATMEL 89Cx051 PROGRAMMER** Simple-to-use yet powerful programmer for the Atmel 89C1051, 89C2051 & 89C4051 uC's. Programmer does NOT require special software other than a terminal emulator program (built into Windows). Can be used with ANY computer/operating system. **3121KT £24.95**

● **3V/1.5V TO 9V BATTERY CONVERTER** Replace expensive 9V batteries with economic 1.5V batteries. IC based circuit steps up 1 or 2 'AA' batteries to give 9V/18mA. **3035KT £5.95**

● **STABILISED POWER SUPPLY 3-30V/2.5A** Ideal for hobbyist & professional laboratory. Very reliable & versatile design at an extremely reasonable price. Short circuit protection. Variable DC voltages (3-30V). Rated output 2.5 Amps. Large heatsink supplied. You just supply a 24VAC/3A transformer. PCB 55x112mm. Mains operation. **1007KT £16.95.**

● **STABILISED POWER SUPPLY 2-30V/5A** As kit 1007 above but rated at 5Amp. Requires a 24VAC/5A transformer. **1096KT £27.95.**

● **MOTORBIKE ALARM** Uses a reliable vibration sensor (adjustable sensitivity) to detect movement of the bike to trigger the alarm & switch the output relay to which a siren, bikes horn, indicators or other warning device can be attached. Auto-reset. 6-12VDC. PCB 57x64mm. **1011KT £11.95** Box **2011BX £7.00**

● **CAR ALARM SYSTEM** Protect your car from theft. Features vibration sensor, courtesy/boot light voltage drop sensor and bonnet/boot earth switch sensor. Entry/exit delays, auto-reset and adjustable alarm duration. 6-12V DC. PCB: 47mm x 55mm. **1019KT £11.95** Box **2019BX £8.00**

● **PIEZO SCREAMER** 110dB of ear piercing noise. Fits in box with 2 x 35mm piezo elements built into their own resonant cavity. Use as an alarm siren or just for fun! 6-9VDC. **3015KT £10.95**

● **COMBINATION LOCK** Versatile electronic lock comprising main circuit & separate keypad for remote opening of lock. Relay supplied. **3029KT £10.95**

● **ULTRASONIC MOVEMENT DETECTOR** Crystal locked detector frequency for stability & reliability. PCB 75x40mm houses all components. 4-7m range. Adjustable sensitivity. Output will drive external relay/circuits. 9VDC. **3049KT £13.95**

● **PIR DETECTOR MODULE** 3-lead assembled unit just 25x35mm as used in commercial burglar alarm systems. **3076KT £8.95**

● **INFRARED SECURITY BEAM** When the invisible IR beam is broken a relay is tripped that can be used to sound a bell or alarm. 25 metre range. Mains rated relays provided. 12VDC operation. **3130KT £12.95**

● **SQUARE WAVE OSCILLATOR** Generates square waves at 6 preset frequencies in factors of 10 from 1Hz-100KHz. Visual output indicator. 5-18VDC. Box provided. **3111KT £8.95**

● **PC DRIVEN POCKET SAMPLER/DATA LOGGER** Analogue voltage sampler records voltages up to 2V or 20V over periods from milli-seconds to months. Can also be used as a simple digital scope to examine audio & other signals up to about 5KHz. Software & D-shell case provided. **3112KT £18.95**

● **20 MHz FUNCTION GENERATOR** Square, triangular and sine waveform up to 20MHz over 3 ranges using 'coarse' and 'fine' frequency adjustment controls. Adjustable output from 0-2V p-p. A TTL output is also provided for connection to a frequency meter. Uses MAX038 IC. Plastic case with printed front/rear panels & all components provided. 7-12VAC. **3101KT £69.95**

SURVEILLANCE

High performance surveillance bugs. Room transmitters supplied with sensitive electret microphone & battery holder/clip. All transmitters can be received on an ordinary VHF/FM radio between 88-108MHz. Available in Kit Form (KT) or Assembled & Tested (AS).

ROOM SURVEILLANCE

● ***MTX*** **- MINIATURE 3V TRANSMITTER** Easy to build & guaranteed to transmit 300m @ 3V. Long battery life. 3-5V operation. Only 45x18mm. **B 3007KT £6.95 AS3007 £11.95**

MRTX **- MINIATURE 9V TRANSMITTER** Our best selling bug! Super sensitive, high power - 500m range @ 9V (over 1km with 18V supply and better aerial). 45x19mm. **3018KT £7.95 AS3018 £12.95**

HPTX **- HIGH POWER TRANSMITTER** High performance, 2 stage transmitter gives greater stability & higher quality reception. 1000m range 6-12V DC operation. Size 70x15mm. **3032KT £9.95 AS3032 £18.95**

● ***MMTX*** **- MICRO-MINIATURE 9V TRANSMITTER** The ultimate bug for its size, performance and price. Just 15x25mm. 500m range @ 9V. Good stability. 6-18V operation. **3051KT £8.95 AS3051 £14.95**

● ***VTX*** **- VOICE ACTIVATED TRANSMITTER** Operates only when sounds detected. Low standby current. Variable trigger sensitivity. 500m range. Peaking circuit supplied for maximum RF output. On/off switch. 6V operation. Only 63x38mm. **3028KT £12.95 AS3028 £24.95**

HARD-WIRED BUG/TWO STATION INTERCOM Each station has its own amplifier, speaker and mic. Can be set up as either a hard-wired bug or two-station intercom. 10m x 2-core cable supplied. 9V operation. **3021KT £15.95 (kit form only)**

● ***TRVS*** **- TAPE RECORDER VOX SWITCH** Used to automatically operate a tape recorder (not supplied) via its REMOTE socket when sounds are detected. All conversations recorded. Adjustable sensitivity & turn-off delay. 115x19mm. **3013KT £9.95 AS3013 £21.95**

TELEPHONE SURVEILLANCE

● ***MTTX*** **- MINIATURE TELEPHONE TRANSMITTER** Attaches anywhere to phone line. Transmits only when phone is used! Tune-in your radio and hear both parties. 300m range. Uses line as aerial & power source. 20x45mm. **3016KT £8.95 AS3016 £14.95**

● ***TRI*** **- TELEPHONE RECORDING INTERFACE** Automatically record all conversations. Connects between phone line & tape recorder (not supplied). Operates recorders with 1.5-12V battery systems. Powered from line. 50x33mm. **3033KT £9.95 AS3033 £18.95**

● ***TPA*** **- TELEPHONE PICK-UP AMPLIFIER/WIRELESS PHONE BUG** Place pick-up coil on the phone line or near phone earpiece and hear both sides of the conversation. **3055KT £11.95 AS3055 £20.95**

HIGH POWER TRANSMITTERS

● **1 WATT FM TRANSMITTER** Easy to construct. Delivers a crisp, clear signal. Two-stage circuit. Kit includes microphone and requires a simple open dipole aerial. 8-30VDC. PCB 42x45mm. **1009KT £12.95**

● **4 WATT FM TRANSMITTER** Comprises three RF stages and an audio preamplifier stage. Piezoelectric microphone supplied or you can use a separate preamplifier circuit. Antenna can be an open dipole or Ground Plane. Ideal project for those who wish to get started in the fascinating world of FM broadcasting and want a good basic circuit to experiment with. 12-18VDC. PCB 44x146mm. **1028KT £22.95 AS1028 £34.95**

● **15 WATT FM TRANSMITTER (PRE-ASSEMBLED & TESTED)** Four transistor based stages with Philips BLY 88 in final stage. 15 Watts RF power on the air. 88-108MHz. Accepts open dipole, Ground Plane, 5/8, J, or YAGI antennas. 12-18VDC. PCB 70x220mm. SWS meter needed for alignment. **1021KT £99.95**

● **SIMILAR TO ABOVE BUT 25W Output. 1031KT £109.95**

BARGAIN BUY!!

30-In-ONE Electronic Projects Lab

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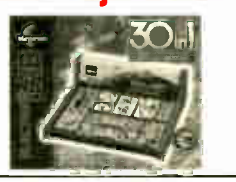

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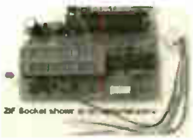
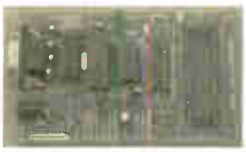
Enhanced 'PICALL' ISP PIC Programmer



Kit will program virtually ALL 8 to 40 pin* serial and parallel programmed PIC micro-controllers. Connects to PC parallel port. Supplied with fully functional pre-registered PICALL DOS and WINDOWS AVR software packages, all components and high quality DSPTH board. Also programs certain ATMEL AVR, SCENIX SX and EEPOM 24C devices. New devices can be added to the software as they are released. Blank chip auto detect feature for super-fast bulk programming. Hardware now supports ISP programming.
*A 40 pin wide ZIF socket is required to program 0·3in. devices (Order Code AZIF40 @ £15.00).

3144KT	Enhanced 'PICALL' ISP PIC Programmer	£59.95
AS3144	Assembled Enhanced 'PICALL' ISP PIC Programmer	£64.95
AS3144ZIF	Assembled Enhanced 'PICALL' ISP PIC Programmer c/w ZIF socket	£79.95

ATMEL AVR Programmer



Powerful programmer for Atmel AT90Sxxxx (AVR) micro controller family. All fuse and lock bits are programmable. Connects to serial port. Can be used with ANY computer and operating system. Two LEDs to indicate programming status. Supports 20-pin DIP AT90S1200 & AT90S2313 and 40-pin DIP AT90S4414 & AT90S8515 devices. NO special software required – uses any terminal emulator program (built into Windows). The programmer is supported by BASCOM-AVR Basic Compiler software (see website for details).

3122KT	ATMEL AVR Programmer	£24.95
AS3122	Assembled 3122	£34.95

Atmel 89Cx051 and 89xxx programmers also available.

PC Data Acquisition & Control Unit

With this kit you can use a PC parallel port as a real world interface. Unit can be connected to a mixture of analogue and digital inputs from pressure, temperature, movement, sound, light intensity, weight sensors, etc. (not supplied) to sensing switch and relay states. It can then process the input data and use the information to control up to 11 physical devices such as motors, sirens, other relays, servo motors & two-stepper motors.

FEATURES:
- 8 Digital Outputs: Open collector 500mA, 33V max.
- 16 Digital Inputs: 20V max. Protection 1K in series, 5·1V Zener to ground.
- 11 Analogue Inputs: 0-5V, 10 bit (5mV/step.)
- 1 Analogue Output: 0-2·5V or 0-10V. 8 bit (20mV/step.)

All components provided including a plastic case (140mm x 110mm x 35mm) with pre-punched and silk screened front/rear panels to give a professional and attractive finish (see photo) with screen printed front & rear panels supplied. Software utilities & programming examples supplied.

3093KT	PC Data Acquisition & Control Unit	£99.95
AS3093	Assembled 3093	£124.95

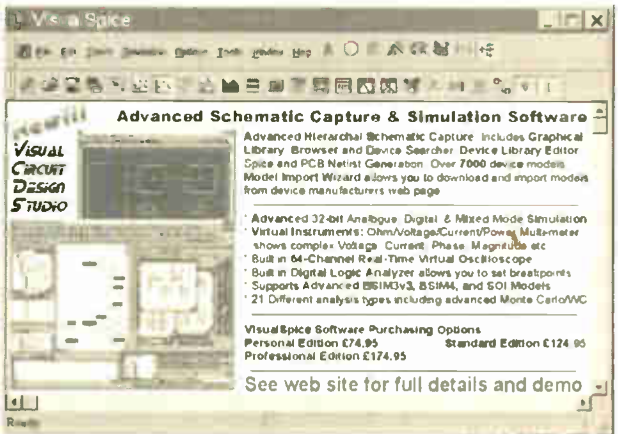
See opposite page for ordering information on these kits

ABC Mini 'Hotchip' Board

Currently learning about microcontrollers? Need to do something more than flash a LED or sound a buzzer? The ABC Mini 'Hotchip' Board is based on Atmel's AVR 8535 RISC technology and will interest both the beginner and expert alike. Beginners will find that they can write and test a simple program, using the BASIC programming language, within an hour or two of connecting it up. Experts will like the power and flexibility of the ATMEL microcontroller, as well as the ease with which the little Hot Chip board can be "designed-in" to a project. The ABC Mini Board 'Starter Pack' includes just about everything you need to get up and experimenting right away. On the hardware side, there's a pre-assembled micro controller PC board with both parallel and serial cables for connection to your PC. Windows software included on CD-ROM features an Assembler, BASIC compiler and in-system programmer. The pre-assembled boards only are also available separately.

ABCMINISP	ABC MINI Starter Pack	£64.95
ABCMINIB	ABC MINI Board Only	£39.95

Advanced 32-bit Schematic Capture and Simulation Visual Design Studio



Serial Port Isolated I/O Controller

Kit provides eight relay outputs capable of switching 4 amps at mains voltages and four optically isolated digital inputs. Can be used in a variety of control and sensing applications including load switching, external switch input sensing, contact closure and external voltage sensing. Programmed via a computer serial port, it is compatible with ANY computer & operating system. After programming, PC can be disconnected. Serial cable can be up to 35m long, allowing 'remote' control. User can easily write batch file programs to control the kit using simple text commands. NO special software required – uses any terminal emulator program (built into Windows). All components provided including a plastic case with pre-punched and silk screened front/rear panels to give a professional and attractive finish (see photo).

3108KT	Serial Port Isolated I/O Controller Kit	£54.95
AS3108	Assembled Serial Port Isolated I/O Controller	£64.95

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We often receive phone calls from potential readers asking where they can get a copy of *EPE*, both from UK customers and those abroad. Basically *EPE* should be available from any newsagent almost anywhere in the world, but generally speaking you will need to order a copy in advance, either to be delivered to your home by the newspaper boy/girl or shop saved for you.

In the UK most large newsagents will also have copies on their shelves but if they do not, please don't be put off by the checkout person telling you it has not arrived, is late at the printers or is no longer published. Unfortunately, it appears that a few staff members in stores will give a "fob off" reply rather than sort out the problem, presumably because they don't have the time to help individual customers buying low-priced items.

EPE is distributed in the UK by COMAG, who deliver to every UK wholesaler, and therefore copies are available to any UK newsagent/supermarket/garage/convenience store etc. *EPE* has not missed an issue or been late publishing in the last 20 years and we don't intend to start now!

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Of course, even 1,000 different magazines take up a large display area and most stores cannot hope to carry so many different titles. For instance, our sister magazine *Radio Bygones* (see the Supplement in this issue) cannot get into the retail supply chain and is only available on subscription, so it is not even counted as one of the 3,000 magazines.

SOLUTION

If you cannot get hold of a regular copy of *EPE*, then there are a couple of solutions; the cheapest is to download issues from our *EPE Online* web site, which has now been operating for four years. Go to **www.epemag.com**, pay by credit card ($9.99 US for 12 issues – around £7) and download the magazine within a few minutes.

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Mike Kenward

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Constructional Project

EPE BOUNTY TREASURE HUNTER

THOMAS SCARBOROUGH

An inexpensive, easy-to-build, induction balance design that will find a 25mm (1 inch) diameter coin at up to 240mm (9½in.) depth

METAL detecting is a popular pastime. The author himself, with his son, located a wreck with an old *EE* design – uncovering, among other things, small items of gold and pinfire ammunition.

There are two significant barriers, however, to owning and operating one's own metal detector. The first is cost. A good metal detector may easily cost a hundred pounds plus, and this may not represent an offhand investment, particularly for young people.

The second is complexity. A typical metal detector may comprise fifty or a hundred components even without the hardware, and this would represent a serious challenge to many constructors, not to mention the time involved.

Alternatively, one can settle for a simpler and cheaper design. However, while such designs may initially provide good fun, they typically have poor depth of penetration, a predilection for rusty iron, and poor stability.

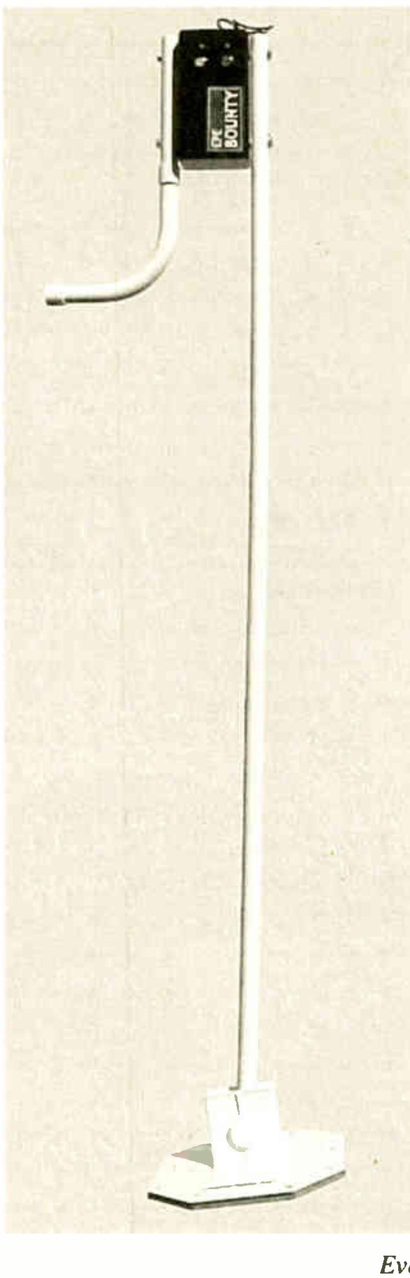
The author's aim with this design was to create a minimalist induction balance (I.B.) metal detector, while also achieving good performance. This method of metal detection has a good depth of penetration, and distinguishes well between ferrous and non-ferrous metals.

It is also capable to a large extent of rejecting iron, and also tin foil. This is a boon for anyone who is searching in the first instance for coins or noble metals.

GOING DIGITAL

The reason for the simplicity of the design is that it largely dispenses with analogue circuitry, and uses a digital transmitter and digital peak detector instead. The full block diagram for the *EPE* Bounty Treasure Hunter is shown in Fig.1.

As the search coils pass over metal, only digital signals of a certain amplitude break through. Since these are in the audio range, they are immediately transferred to a piezo sounder (WD1) or headphones. (This has the added bonus, in some countries, of eliminating the need for an operating licence.)



GOOD DETECTION

The resulting circuit, as simple as it is, bears comparison with some of the best. For example, the *EE Buccaneer* (*not now available*) was described at the time as "outperforming almost any other design of its type" – the *EPE Bounty*, by comparison, exceeds its performance by around 40 per cent.

The following is the Bounty's response to a 25mm (one inch) diameter brass coin at varying distances, with good tuning:

160mm	A "singing" tone
200mm	A clear tone
240mm	A barely discernible signal

The *EPE* Bounty will detect a pin at 35mm, and large non-ferrous objects at half a metre's distance and more. Note, however, that these measurements apply *in air*, and not *in the ground*, where depth of penetration will depend largely on the mineralisation present.

Contrasted with this, it is far more reluctant to pick up tin-foil. A tin-foil disc of the same size as the brass coin is detected at only half the distance in air. This rejection of tin-foil is due in part to the metal detector's low frequency, which avoids what is called "skin effect". Besides this, if the two coils are positioned as described, ferrous metals are to a very large extent rejected – to such an extent, in fact, that a 25mm diameter brass coin looks the same to the detector as a lump of iron weighing *twenty times* as much.

Bounty's power consumption is conveniently low – it draws around 10mA, which means that it may potentially be powered off a small PP3 9V battery. As it is, it is powered off eight AA batteries in

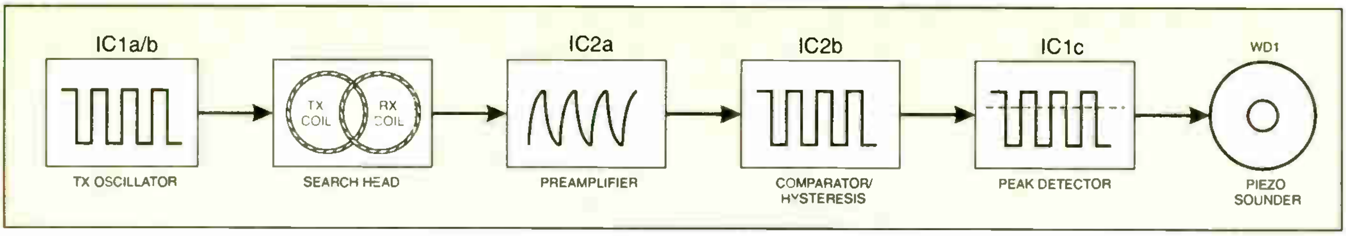


Fig.1. Block diagram of the EPE Bounty Treasure Hunter.

series (12V), which should provide about 100 hours of continuous use when using cheap batteries.

CIRCUIT DESCRIPTION

The complete circuit diagram for the *EPE* Bounty Treasure Hunter is shown in Fig.2. The search head of a typical I.B. metal detector comprises two coils – a transmitter coil (Tx), and receiver coil (Rx). In this case, the Tx coil is driven by a square wave oscillator, which sets up an alternating magnetic field in the coil.

The receiver coil is positioned in such a way that it partly overlaps the transmitter coil – see Fig.3. By adjusting the amount of overlap, a point can be found where the voltages in the Rx coil "null", or cancel out, so that little or no electrical output is produced. A metal object which enters the field then causes an imbalance, resulting in a signal being generated.

The transmitter oscillator, built around IC1a, is a simple clock generator, based on a single gate of a 40106 hex Schmitt inverter i.c. While such oscillators tend to be unstable in operation, this is unimportant for our purposes here – we merely need to set up the alternating magnetic field in the coil Tx.

So that IC1a is not unduly loaded, IC1b is used as a buffer. IC1a oscillates at an audio frequency determined by resistor R1 and capacitor C1, while resistor R2 limits the peak current passing through the transmitter coil to 12mA.

ON THE LEVEL

The front end of the receiver section is a simple yet sensitive preamplifier, based on IC2a, which boosts the signal from the coil Rx. Its gain (about 165) is set to a level where signal amplitude shows good variation at the presence of metal. It also provides sufficient gain for the following stages.

Wired as a comparator or rather, a level detector, IC2b detects the peaks of the amplified receiver waveform. These peaks, however, are sharp and small, like the proverbial tip of the iceberg, and this could severely stunt the sensitivity of the circuit. It is at this point that a simple yet vital enhancement is introduced. Resistor R9 is added to provide hysteresis, through positive feedback, thereby returning the signal to a square wave, and effectively tripling the sensitivity of the detector.

The output of IC2b at pin 7 is fed, via capacitor C5, to peak detector IC1c. Since IC1c is a Schmitt inverter, only pulses of a certain amplitude break through to output pin 6. With correct adjustment of the Tune and Fine Tune controls, VR2 and VR3, there is a point at which the signal just breaks through in the form of a random crackling sound. No further amplification is required, and since capacitor C6 blocks d.c., virtually any kind of earpiece, sounder, or loudspeaker may be used to make the signal heard.

SEARCH COILS

The winding of the two search coils is relatively easy, and is not critical – a little give and take is permissible. Both the coils are identical. The full coil winding and construction details are shown in Fig.3.

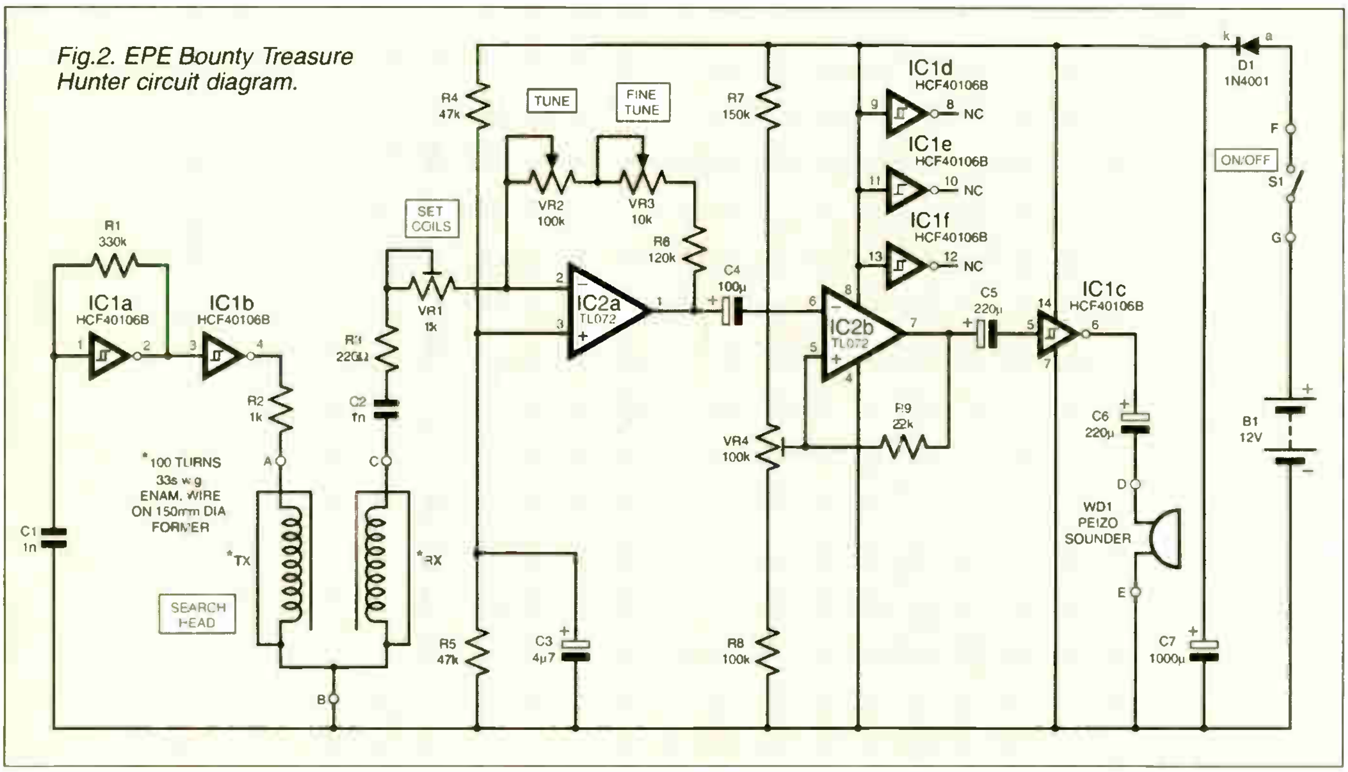
Use 33s.w.g. (about 0·26mm) enamelled copper wire, winding 100 turns on a 150mm dia. former (see Fig.3). You may create the former with a sheet of stiff cardboard with twelve pins stuck through it at a suitable angle (the heads facing slightly outwards). The coil should be wound clockwise around the pins, then temporarily held together with stubs of insulating tape passed underneath and pressed together over the top. The coil may be jumble-wound.

Once this has been done, the pins are removed, and a second coil is wound in exactly the same way. In each case, mark the beginning and end wires. Label one coil Tx (transmitter), the other Rx (receiver). Each coil is then tightly bound by winding insulating tape around its entire circumference.

FARADAY SHIELD

Next, each coil needs a Faraday shield. This minimises "ground and capacitive

Fig.2. EPE Bounty Treasure Hunter circuit diagram.



effects (electrostatic coupling)" in the search head. The shield is made with some long, 20mm wide strips of aluminium or tin-foil.

Scrape the enamel off the base of the Tx coil's "end" and Rx coil's "beginning" wires. Now solder a 100mm length of stiff, bared wire to each scraped area, and twist this around the coil, over the insulating tape. This provides an electrical contact for the Faraday shield.

Beginning at the base of this wire, the foil is wound around the circumference of the coil, so that no insulating tape is still visible underneath it – but the foil *does not complete* a full 360 degrees. Leave a small gap – say 10mm – so that the foil does not meet after having done most of the round. Do this with both coils. Each coil is now again tightly bound with insulating tape around its entire circumference.

Attach each of the coils to quality single-core screened audio cable (microphone cable), with the Faraday shields being soldered to the screen. *Do not use* stereo or twin-core audio cable, as this may cause interference between the coils.

Gently bend the completed coils until each one is reasonably flat and circular, with the wires facing away from you. Both coils' beginning wires should be to the left of their end wires. The Faraday shield connections should be side by side.

Now bend the coils further (see Fig.3), until they form lopsided ovals – like capital Ds. The backs of these Ds overlap each other slightly on the search head – this is the critical part of the operation, which we shall complete after having constructed the circuit.

Last of all, wind long, 20mm wide strips of absorbent cloth around each coil (thin dishwashing cloth would suit), using a little all-purpose glue to keep them in place. Later, when resin is poured over the coils, the cloth meshes the coils into the resin.

CONSTRUCTION

EPE Bounty's printed circuit board (p.c.b.) measures just 76mm × 46mm. The topside component layout, off-board interwiring and full-size underside copper foil master pattern details are shown in Fig.4. This board is available from the *EPE PCB Service*, code 370.

Component values and types are not critical, although high grade components will improve performance. The author's preferred choice for IC1 was the SGS-Thomson HCF40106BEY, although any 40106 i.c. should work adequately.

Begin construction by soldering the 8 solder pins, the 14-pin and 8-pin d.i.l. sockets and resistors in position. Finish up with diode D1 (note the cathode (k) is marked by a band and points away from the edge of the p.c.b.), and the capacitors. Once soldering is complete, carefully check the p.c.b. for any solder bridges and wiring errors.

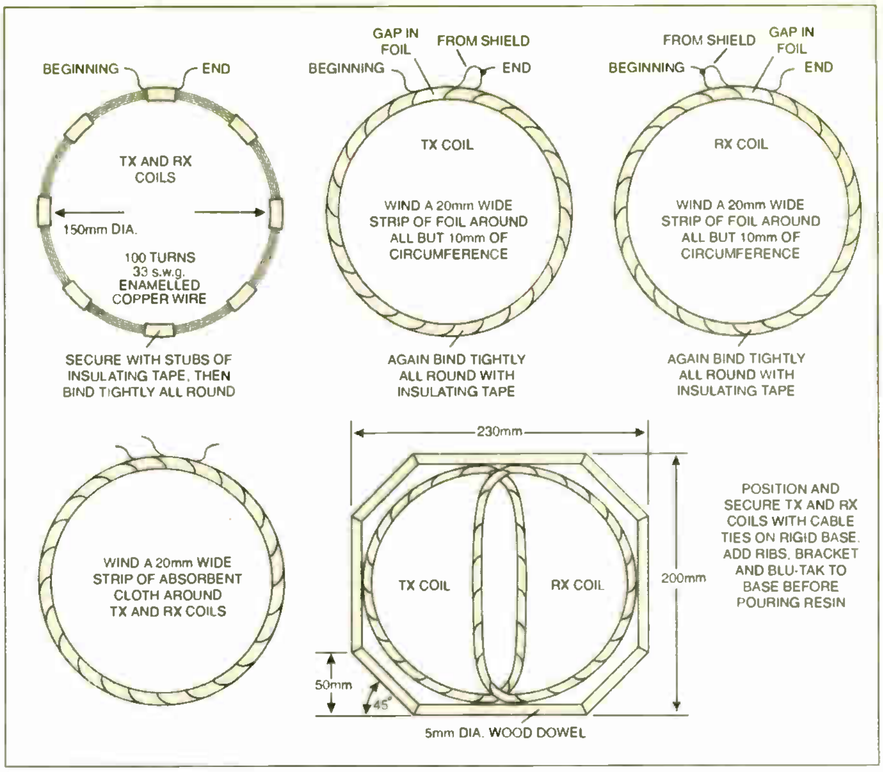
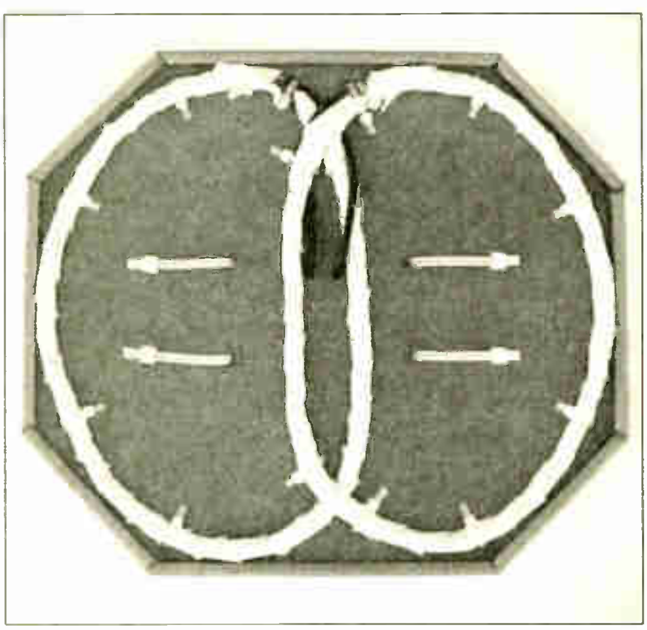


Fig.3. Search head construction for the EPE *Bounty.*

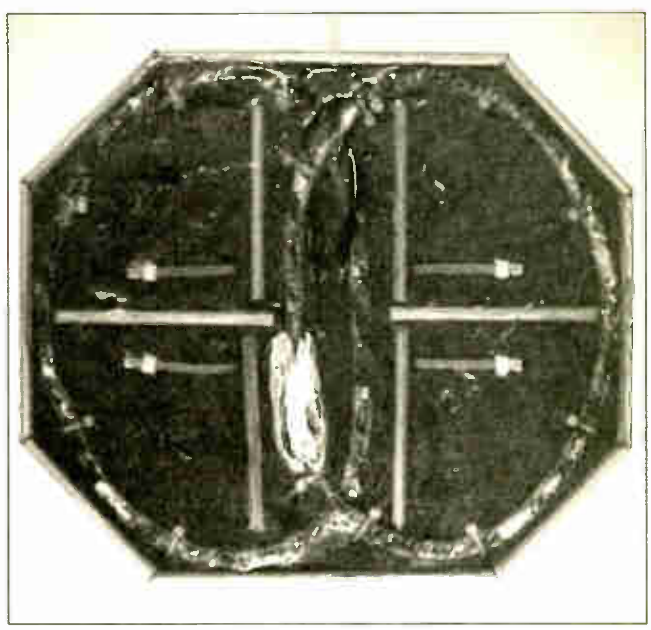
CASING-UP

Prepare the case for the audio cable, switch S1, potentiometers VR2 and VR3, and piezo sounder WD1. Drill four holes for the steel nuts and bolts, which will hold the two lengths (one long, one short) of p.v.c. conduit (see Fig.5).

Mount VR2 and VR3 where quick and easy adjustment is possible. Wire up piezo sounder WD1, tuning controls VR2 and VR3, switch S1, and the battery clip to the p.c.b. Keep all wires short. Choose potentiometers with metal cans (bodies) and



The search coils positioned with cable ties prior to potting.



The potted coils with a small section left for final adjustment.

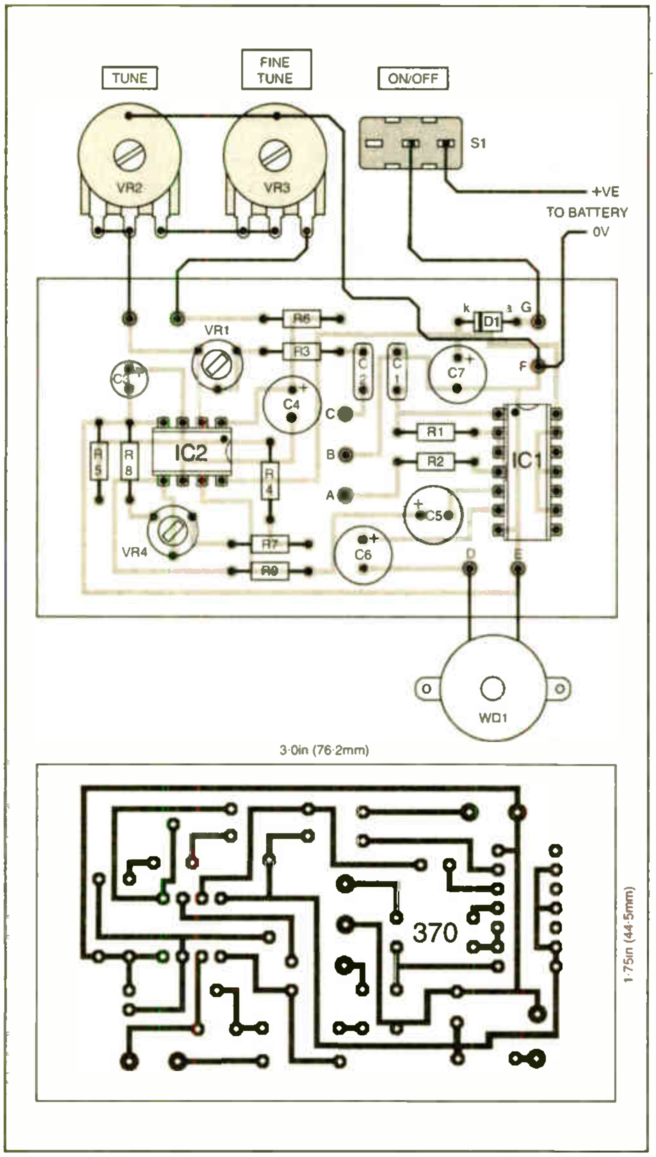
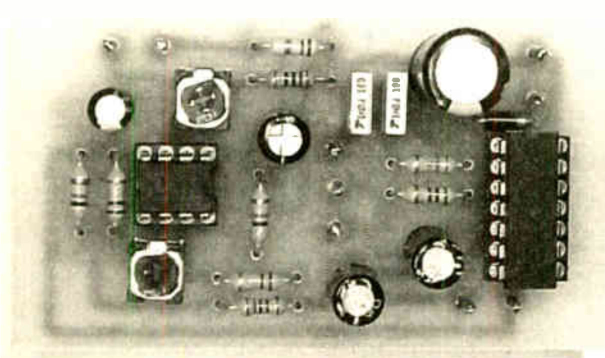


Fig.4. P.C.B. layout and wiring and full size master foil pattern.

plastic shafts for VR2 and VR3, and connect the cans to 0V on the p.c.b. (perhaps via the potentiometers' washers) – this is important for circuit stability.

A slider switch, S1, prevents accidental switching as the unit is transported. If you wish, add a socket for headphones in parallel with, or in place of, the piezo sounder WD1. Make sure that the battery is secure, and will not move about in the case.

In the case of extremely noisy environments, an l.e.d. may be used besides the piezo sounder. This is wired from IC1c pin 6, via a 1k series resistor, to 0V.



The finished prototype p.c.b. D1 has been moved in the final version.

COMPONENTS

Resistors

R1	330k
R2	1k
R3	220Ω
R4, R5	47k (2 off)
R6	120k
R7	150k
R8	100k
R9	22k

All carbon film 0·25W 5%

See SHOP TALK page

Potentiometers

VR1	1k cermet preset
VR2	100k carbon track (metal can, plastic shaft)
VR3	10k carbon track (metal can, plastic shaft)
VR4	100k cermet preset

Capacitors

C1, C2	1n metallised polyester film (2 off)
C3	4μ7 16V radial electrolytic
C4	100μ 16V radial electrolytic
C5, C6	220μ 16V radial electrolytic (2 off)
C7	1000μ 16V electrolytic

Semiconductors

IC1	HCF40106BEY hex Schmitt inverter (see text)
IC2	TL072 dual j.f.e.t. op.amp

Miscellaneous

WD1	piezo sounder
S1	on-off slider switch
SK1	3·5mm mono jack socket (optional – see text)
B1	12V battery (8 x AA)

Battery holder (8 x AA); PP3 battery clip (for battery holder); 100m 33s.w.g. (approx. 0·26mm) enamelled copper wire; printed circuit board, available from the *EPE PCB Service*, order code 370; ABS case with external dimensions 150 x 80 x 50mm; 14-pin d.i.l. socket; 8-pin d.i.l. socket; link wire; solder pins; solder, etc. 3m quality single-core screened audio cable; 2m 20mm wide strips of aluminium-foil; 100mm stripped single-core wire (2 off); control knobs (2 off); quality insulating tape; all-purpose glue

Hardware

White masonite 230mm x 200mm (search head baseplate); 1m x 5mm dia. wooden dowel (baseplate surround to contain resin); 1·5m 20mm outer diameter p.v.c. conduit (shaft and upper handle); 90° angle bend to suit 20mm p.v.c. conduit (hand-grip); square rainwater downpipe socket (swivel bracket on search head); plastic w.c. seat hinge nut and bolt set (swivel bracket); 500ml polyester resin and hardener/catalyst; 2·5mm nylon cable-ties (12 off); 4mm nylon cable-ties (4 off); 5mm x 30mm nuts and bolts (4 off); 5mm washers (16 off); 200g Blu-tack/Pres-stik; epoxy glue.

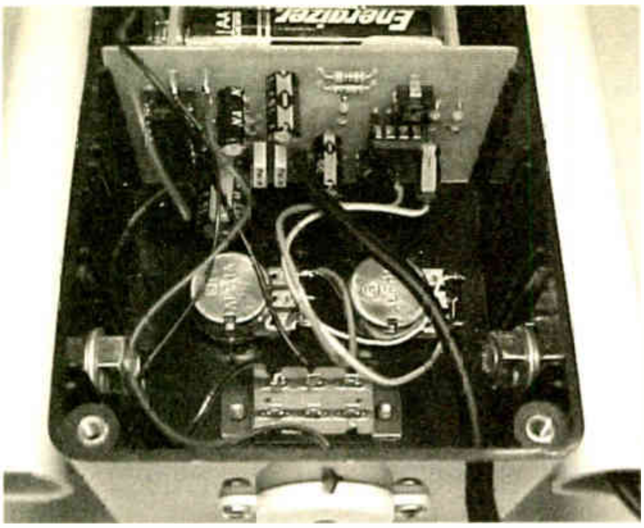
Approx. Cost Guidance Only **£20** *excluding headset & batts*

HARDWARE

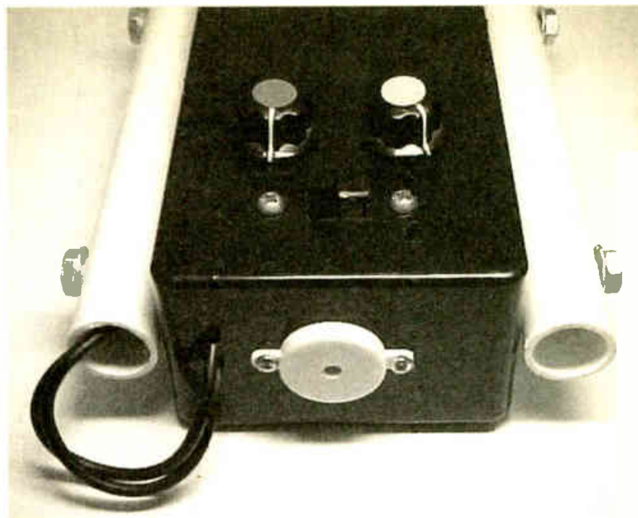
Suggested hardware construction using p.v.c. piping and joints is shown in Fig.5. The author again chose a minimalist approach. Attach the base of the detector's shaft (the longest piece of p.v.c. conduit) to the search head by means of a swivel-joint. Use 4mm nylon cable-ties to secure the brackets to the search head. The author made the brackets from a square rainwater downpipe socket sawn in two. The large plastic nut and bolt of the swivel-joint were taken from a w.c. seat hinge set. *Do not use any metal fittings or fastenings on the search head.*

Before bolting the shaft to the control box, feed the audio cable through it – then bolt it to the side of the control box. Bolt the shorter length of p.v.c. conduit to the other side of the control box, and push the 90 degree angle bend onto its bottom end.

Attach the audio cables from the search coils to the p.c.b. as shown (see Fig.3), with the screen of both audio cables again going to 0V. Finally, insert IC1 and IC2 in the d.i.l. sockets. IC1 is static sensitive – discharge your body to earth before handling.



Mounting of the p.c.b., controls and sounder in the case.



Case mounted between the conduit handle and search head shaft.

SETTING THE COILS

The one downside to any I.B. metal detector design is its need for two coils, which must be very carefully and rigidly positioned in relation to one another. The present design does make some room for error, though not much. Nonetheless, the method of setting the two search coils is simple enough, if one works patiently and carefully. A completed p.c.b. is required before we can "pot" the coils.

The coils should be potted with clear polyester resin on a hard, non-metallic base (do not buy polyester resin *filler*). Any base will do, on condition that it is *rigid*. The author used a piece of white masonite (see Fig.3), and glued a border of 5mm wood dowelling around the perimeter to hold the resin. The potted coil was left "raw" beneath the masonite, protected by the resin.

Begin by placing the coils directly on top of one another, ensuring that they are correctly orientated (their Faraday shield connections being side by side – see the Search Coils cross-head earlier). Adjust VR2, VR3, and VR4 to their mid-points. Adjust VR1 to 780 ohms. Attach a 12V battery pack, and switch on. The circuit should be "singing" – that is, beeping loudly and continuously.

Now slowly move the coils apart. When they are somewhere past the halfway mark, the piezo sounder will fall silent. This is where the voltages in the receiver (Rx) coil "null". Note that there may be a few peaks and troughs in the volume as you move the coils apart – you need to find a place of virtually complete silence.

Continue to move the coils apart. At a precise point, in a very narrow "slice" between silence and singing, the piezo sounder will crackle – or it might hum and then crackle.

Now edge the coils closer together again, ever so slightly, adjusting preset VR4 as you go, so as to maintain a loud singing in the piezo sounder (not just a hum), until the coils cannot be edged any closer while still maintaining the loud singing. It is at this precise point – not a fraction of a millimetre this way or that – that the coils need to be set.

The main purpose of preset VR4 is to find the precise point at which there is a crisp transition from silence to singing. With the correct setting, any intermediate hum should be eliminated. (While the hum does not affect performance, it may be a distraction).

MAKE YOUR MARK

Take a marker pen, and mark a series of holes in the baseplate around both sides of the coils. These holes are used to pass 2·5mm cable-ties through, to hold the coils tightly to the baseplate. Use five or six cable-ties for each coil, to ensure that they are firmly and flatly secured before pouring the resin.

Also, use cable-ties to secure the audio cables as well. Further, glue some lightweight wooden ribs across the bottom of the search head (to the baseplate), across the centre of the coils. Their purpose is to

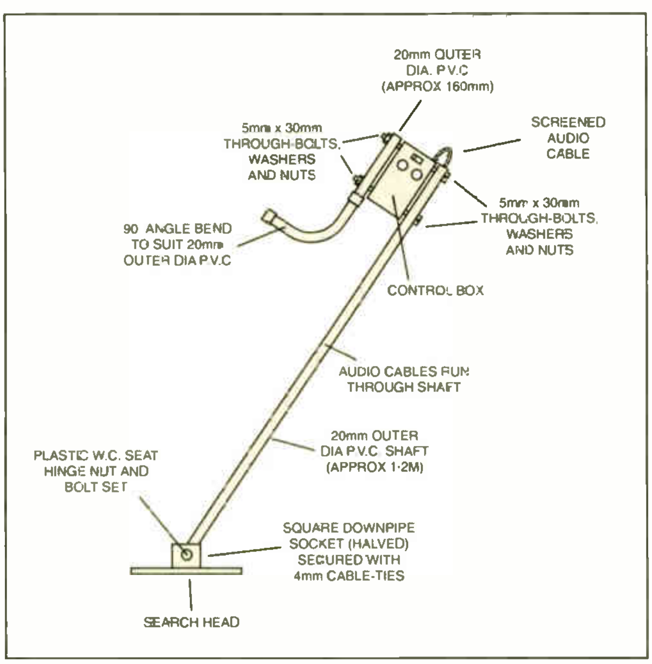
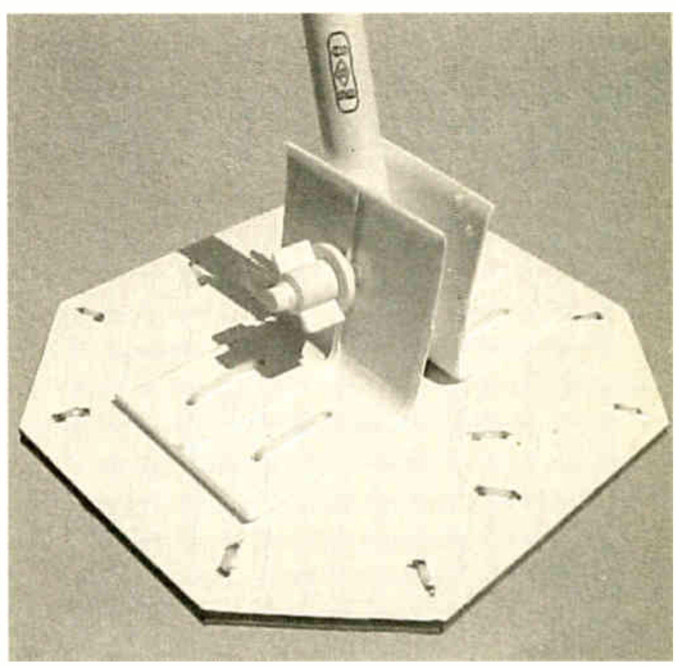


Fig.5. General construction of the hardware items.



The finished search head.

limit shrinkage in the resin, since this could seriously unbalance the circuit.

Use some Blu-tack (or Pres-stik) to tightly seal the holes underneath the baseplate before pouring the resin – polyester resin is very "runny", and sticks faster than many glues. Make sure the baseplate's dowel surround is "resin-tight". Carefully bend the coils at the centre of the baseplate until you reach the exact balance at which there is neither silence nor singing from the piezo sounder, but a crackle.

Finished control box mounted to the handle and search head shaft.

Also – *this is important* – cover a small section (about 40mm) of one of the coils, at its centre, with Blu-tack (Pres-stik), giving the Blu-tack vertical walls. This will be removed after the resin has set, and allows for final bending of this small section of coil.

Now you are ready to mix and pour the resin. Use about 80 per cent of the recommended amount of catalyst, so that there is not too much heat and shrinkage in the resin. Pour the resin over the cloth which surrounds the coils, so as to soak it, and keep on pouring until the entire baseplate is well covered with resin.

The circuit may no longer function correctly at this point until the resin has hardened, so make no more adjustments, but switch off. Wait at least 24 hours until removing the Blu-tack from the small section of coil, which will leave the section exposed.

Set tuning controls VR2 and VR3 to their mid-points, and bend the exposed section of coil (likely inwards) until a crackle is heard, between silence and singing. Now pour resin over this patch also, to fill it.

Finally, preset VR1 serves as an emergency measure to alter the gain at the inverting input of preamplifier IC2a, without destabilising the rest of the carefully balanced circuit around IC2a/IC2b. Use VR1 in case the setting of the coils did not go well, and the bending of the small section of coil proves fruitless.

IN USE

Keep the search head away from all metal, and away from computer equipment, which may cause serious interference with the circuit – and switch on. Adjust VR2 until the *EPE* Bounty is at a point where a crackle is heard, between silence and singing – use VR3 for fine-tuning. Carefully experiment with board-mounted preset VR4 in case a low-level hum has been interjected between the silence and singing.

For best results, keep front panel controls VR2 and VR3 tuned for a fast crackle. While a slow crackle is more pleasing to the ear, this will reduce sensitivity. Move a coin over the search head, and piezo sounder WD1 should "sing".

In actual use, the adjustment of the *EPE* Bounty Treasure Hunter will be affected by the mineralisation of the ground you are searching, as well as temperature and voltage variations. While the design has good stability, some readjustments to tuning controls VR2 and VR3 are inevitable.

An investment in a metal case for the electronics, while costing a few pounds more, would maximise stability, but this is not essential. A higher value for resistor R6 will give the detector a sharper edge (that is, a sharper transition between silence and singing), while a lower value will provide a gentler transition.

For best results, the search head is moved slowly to and fro over the ground, just skimming its surface.

May you be rewarded with much bounty! □

News . . . A roundup of the latest Everyday News from the world of electronics

VIRTUAL KEYBOARDS

Will anyone ever produce a virtual keyboard? asks Barry Fox

BRITISH company UbiNetics has patented – but already lost interest in – a device which could have finally solved the age-old problem of squeezing a large keyboard into a small computer device. Ubinetics' patent application GB 2 370 395 tells how to create a virtual keyboard by projecting its image onto any flat surface, such as a table top or book.

A PDA, pocket computer or cellphone has a solid state laser which rapidly projects (with flickerfree scans at 25Hz or higher) the image of a conventional computer keyboard. The size and focus of the zero-mass image is adjusted to suit the available surface area, and the language and keyboard layout are chosen from a menu to suit the owner's nationality and wishes. A sensor in the device picks up light reflected from the image, through a half-silvered mirror. When the user fingers a virtual key it interrupts the light and the device registers a key click and displays the key character on its screen. So the virtual keyboard allows normal typing.

The patent was filed in December 2000, naming Alun Morris as inventor, but the UbiNetics spokeswoman surprisingly confirms that "UbiNetics is no longer involved in the consumer side as it used to be and is concentrating purely on developing GPRS/3G technologies."

But surely, a large zero-mass keyboard that folds into zero space is just what will be needed to make 3G and GPRS phones and PDAs usable?

"The company no longer produces the projection keyboard you were inquiring about," says Ms Lewis cryptically.

Sleight of Hand Cashing

This is actually not the first time a company has tried to use a projected image for user control. NCR of Dayton, Ohio has previously suggested a projection system that saves drivers the effort of getting out of their cars or leaving the window open for too long when using a drive-in bank. Currently the driver needs to push a cash card into the machine, and then enter a PIN and instruction codes.

A few years ago NCR proposed (GB 2 350 457) a projector which is slung high on the forecourt to beam an image of the ATM keyboard down onto the windscreen. The driver points at the key numbers and these movements are tracked by an optical or infra-red sensor mounted alongside the camera. The sensed numbers are projected onto the windscreen with an OK button to point at. The driver then only has to open the window or door quickly to grab the dispensed cash. The same system could be used to order goods or food, said NCR. But there is no sign yet of a drive-in service which works this way.

TRIP RECORDER

THE LATEST Global Positioning System (GPS) and Automated Vehicle Location (AVL) technologies have been incorporated into a Trip Recorder manufactured by Directions Ltd.

The recorder is supplied with four different versions of mapping software. Using its GPS module, it saves its position at regular intervals. The position reports, which include time, data, speed, latitude and longitude, give you a comprehensive schedule of your vehicle's movements. It has a large storage capacity, for 210,000 positions, and if set to record at one minute intervals it can save 145 days of drive time information.

Designated the G-5010, the recorder is compatible with any PC running Windows, contains a 12-channel GPS receiver and accessory kit, comprising external antenna, a.c. power supply, cigarette lighter adaptor, and control centre software. It can also be linked with a GSM modem for remote tracking and data retrieval. Two versions of the InfoMap 7.0 mapping software are available, Street Router and the Professional.

The Trip Recorder G-5010 weighs only 120g, measures 11·3cm x 5·2cm x 3·3cm, and the recommended retail prices for the various models start at £199.99, including VAT.

For more information, contact Directions Ltd., Dept. EPE, PO Box 296, Sevenoaks, Kent TN3 1WY. Tel: 01732 741123. Fax: 01732 743345. Email: sales@directions.ltd.uk. Web: www.directions.ltd.uk.

CAN ELECTRONICS CURE OBESITY?

By Barry Fox

AN ITALIAN inventor and US medical company think that implanting an electric shocker in a fat person's stomach can curb wayward appetites. Clinical trials suggest it may work and be a lot nicer than having your intestines sewn up, stapled together or cut down.

Italian doctor Valerio Cigaina first tried it on humans in 1995 and Transneuronix of New Jersey has now bought his patents and implanted electrical anti-obesity devices in 300 patients. The device recently won CE safety approval in Europe but has not yet got a green light from the US Federal Drug Administration.

The implant works like a heart pacemaker but is buried in the stomach wall. From there it sends out low power electric shock waves which slow the natural peristalsis of the alimentary tract and make the esophageal and pyloric sphincters contract. So food takes much longer to pass through and the patient feels full and sated.

Transneuronix spokesman Stephen Adler says he wants to "stay away from details on how the system works" but the international patent filings (WO 02/43467) claim best results with an implant in muscle near the nerve centres of the lesser curvature of the stomach, releasing 12 pulses a per minute, each lasting two seconds and being made from a train of much shorter pulses. At 5V and 10mA the patient feels no shock. The pacemaker can work all the time or be switched on when the patient feels the urge to eat.

Eighteen hospitals in the US, Europe and Australia have been fitting devices; it takes an hour under general anaesthesia. Dr Cigaina has now published the results of his first tests, begun in 1995 (Obesity Surgery, 12, 6S-11S; **www.obesity-surgery.com**) All patients lost weight. "We have had no deaths or major complications" says Stephen Adler.

GOODBYE RCS

RADIO Component Specialists, who you might also know as Baker Loudspeakers Ltd., tell us that after 50 years (founded in 1952) they have decided to cease trading at the end of October.

Many long-term hobbyists will know the name and much regret its passing. Over the years their adverts featuring PA equipment, amplifiers, lighting, speakers, discos, components and accessories, have regularly appeared in the hobbyist electronics magazines, including us in our various guises of *PE, EE, HE, ETI* and *EPE*, as well as others such as *Practical Wireless, Wireless World* and *Practical Television*. Their address at 337 Whitehouse Road, Croydon, Surrey probably features in the address books of many of you.

We send our best wishes to the Director of RCS, Frank Jackson, and wish him a long and happy retirement.

MOBILISING TRAFFIC

By Barry Fox

NEC's UK Research Centre has come up with a clever way to track traffic flow, without the expense of erecting cameras. Details have escaped because the company has recently filed a patent application NEC (GB 2 369 709). The scheme could let a new company compete economically with the current Trafficmaster system.

The idea is to use cellphones as a telltale of traffic movement. In the future advanced phones will have GPS chips built in, but even current GPS-less phones can be tracked by the cellphone network with a fair degree of accuracy, because they are continually moving from one radio cell to another and this is automatically registered by the network. Except in deep rural areas, cells are only a few miles wide and in urban areas there may be several per mile.

So if the network tracks the speed at which a cellphone moves from cell to cell, it gives a good indication of the cellphone's movements. Tracking a large number of phones increases accuracy. To overcome disadvantages of previously proposed systems and avoid the clutter of misinformation which will come from inevitably tracking phones carried by walkers, cyclists or train passengers, NEC weights the information gathered so that phones used to call up for traffic information will have most effect on the average speed deduced from cell handovers in any area.

This can create a virtuous circle. If cellphone users know they are contributing to the accuracy of a service, they will be more inclined to access the service for information – especially if whatever subscription they pay to receive the traffic flow information is reduced in return for agreeing to let their phones be used as a source of information for the service.

DONATE YOUR OLD PC!

TOUGH new legislation will come into force in the UK by 2005 banning the "scrapping" of old computers. Computer Aid International, the world's largest non-profit supplier of computers to developing countries, is calling on corporates and the public sector to donate their end-of-life PCs to schools and community groups for worthwhile projects overseas.

The charity is seeking Pentium PCs and aims to source 50,000 of them for shipment to developing countries, in which 99 per cent of children leave school without ever touching a computer in the classroom. For the price of just one new PC, the charity can supply 20 refurbished machines.

For further information about Computer Aid International, visit **www.computeraid.org,** email info@computeraid.org, or call 020 7281 0091.

YEDA 2002

Josh Arkell and Adam Wolley of Radley College with their Drive Alert.

THE 2002 Young Electronic Designer Awards (YEDA) were presented on 9 July at the Science Museum in London during a special celebration dinner in their honour attended by 200 guests, including HRH The Duke of York, parents, teachers, local dignitaries and members of the business community.

The Awards, now in their seventeenth year, recognise the achievements of students who have used modern technology to devise solutions to everyday problems and which they have identified. Projects include safety and security devices for the home and for travel, PC and internet devices, devices to help the physically handicapped and to enhance enjoyment and performance in sport.

This year the Duke of York's Award for the most imaginative concept went to Susie Short, aged 17, from Sevenoaks School, Sevenoaks, Kent. She designed a Programmable Sailing Race Countdown Timer. She shares £1000 with her school, receives a crystal trophy to retain for one year, a hand-painted certificate signed by His Royal Highness, and a "Think Pad" computer, courtesy of IBM UK Ltd.

Susie Short of Sevenoaks School with her Programmable Sailing Race Countdown Timer.

We were interested to learn that a prize winner from last year, Martin Rosinski (17), whose achievements we publicised last September, also featured in this year's awards list. Martin is from the Ponteland Community High School, Ponteland, Newcastle upon Tyne. He won the John Eggleston Prize for outstanding or sustained achievement in YEDA with his Lance – a Global Data Acquisition System.

As in many YEDA ceremonies over the years, Radley College, Abingdon, Oxon featured again. We have a particular interest in this college as one of contributors, Max Horsey, is a teacher there. This year his pupils Josh Arkell (14) and Adam Wolley (14), designed a Drive Alert which won them the Best Under 15 Project Award, receiving £500 and a trophy. We are pleased to say that we expect to publish this design in the future.

Max Horsey's latest series of projects, which teachers will find of interest on behalf of their pupils, starts next month. They are based on the PICAXE microcontroller and allow many simple functions to be programmed easily and at minimal expense.

For a full list of the YEDA finalists, the many organisations who sponsor YEDA, and how your school or college can participate next year, contact The YEDA Trust, PO Box 2118, Pulborough, West Sussex RH20 1XQ. Tel: 01798 839548. Fax: 01798 839546. Email: yeda@cix.co.uk. Web: www.yeda.org.uk. Note that the address and tel/fax details have changed since last year.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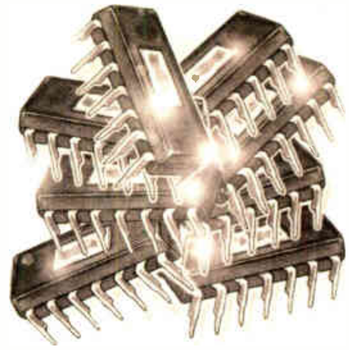
Constructional Project

DIGITAL I.C. TESTER



JOE FARR

Let a PIC and a PC check the health of your digital logic chips.

DURING project construction, many hobbyists must have wondered if the reason their masterpiece wasn't working was due to a faulty i.c., or if the i.c. they've just removed from an old board actually works. The project described here provides a simple way to quickly test the operation of most TTL and CMOS digital i.c.s.

HOW IT WORKS

To explain how the Digital I.C. Tester works, let's examine the humble 7400 TTL NAND gate device as an example. The datasheet says the package contains four logic gates, each one having two inputs and one output, which behave according to the truth table in Table 1.

Table 1. Truth table for a 2-input NAND gate

Input 1	Input 2	Output
L	L	H
L	H	H
H	L	H
H	H	L

To test the satisfactory functioning of each of the four gates in the i.c. package, each of the four input logic configurations in Table 1 must be applied to each gate and the resulting logic output levels recorded and compared against the expected results.

A profile for an i.c. to be tested is first generated from the device's datasheet. Within the profile, an instruction sequence is specified that applies defined logic levels to the specified input pins, and records the results generated on the output pins.

The actual results received are compared against those that are expected, and from this it is possible to ascertain if the i.c. is functioning correctly.

It should be noted that some i.c.s require a great many individual logic operations to test them completely. For example, the 7430 8-input NAND gate requires 256 separate input logic level permutations to be tested.

CIRCUIT DESCRIPTION

The complete circuit diagram for the Digital I.C. Tester is shown in Fig.1. When power is supplied to the board, it first passes through bridge rectifier REC1. If the input supply input is a.c., REC1 converts it to d.c. If the input is already d.c. it ensures that the polarity is correct for IC1, which then regulates the voltage down to approximately 5V. Capacitors C1 to C4 plus C11 provide smoothing.

A PIC16F877-20 microcontroller, designated as IC3, is used as the core of the circuit and is run at its maximum speed of 20MHz, as defined by crystal X1. Since this design uses RS232 protocol to interface to a serial port on a PC, a voltage level converter is employed to convert the PIC's 5V logic levels to the ±12V levels required by the RS232 standard (*many PCs do not actually require this higher voltage for serial comms input and will accept +5V/0V inputs. Ed*).

This is accomplished by IC2, a MAX232 line driver. Capacitors C5 to C8 are used by IC2's internal circuitry to convert the supplied voltage from 5V to ±12V. Connection to the PC is via a 9-pin female D-type connector, SK2.

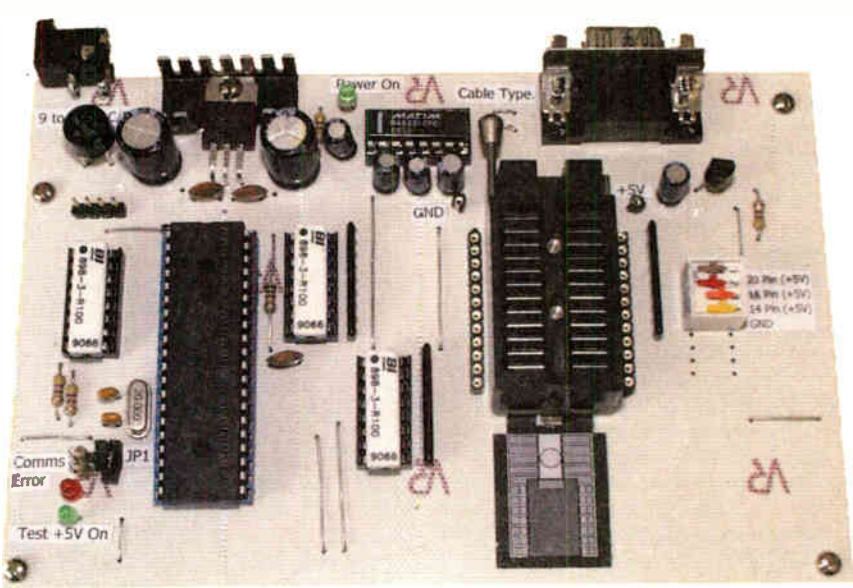
To test the functionality of a digital logic i.c., a known set of logic levels must be presented on each pin and the resulting responses received back from the i.c. then analysed.

I/O PINS

The PIC16F877 has a total of 33 I/O (input/output) pins. Of these, 24 are used to connect the PIC to the i.c. under test. Each of the 24 I/O pins is connected to a pin on the i.c. test socket (SK3) via a 100Ω resistor, within resistor modules RM1 to RM3. These resistors act as current limiters to protect the PIC and the device under test. The danger is that an output of the test i.c. could become connected to a PIC I/O pin also designated as an output.

Each pin on the i.c. test socket is biassed to the +5V test power rail via a 4k7Ω resistor (within resistor modules RM4 to RM6). This is to force unused pins on the test socket to a known logic level, and also enables open collector TTL i.c.s that have their outputs either floating or pulled to ground to be tested.

During the test cycle, the PIC sends a low logic level to the base of transistor



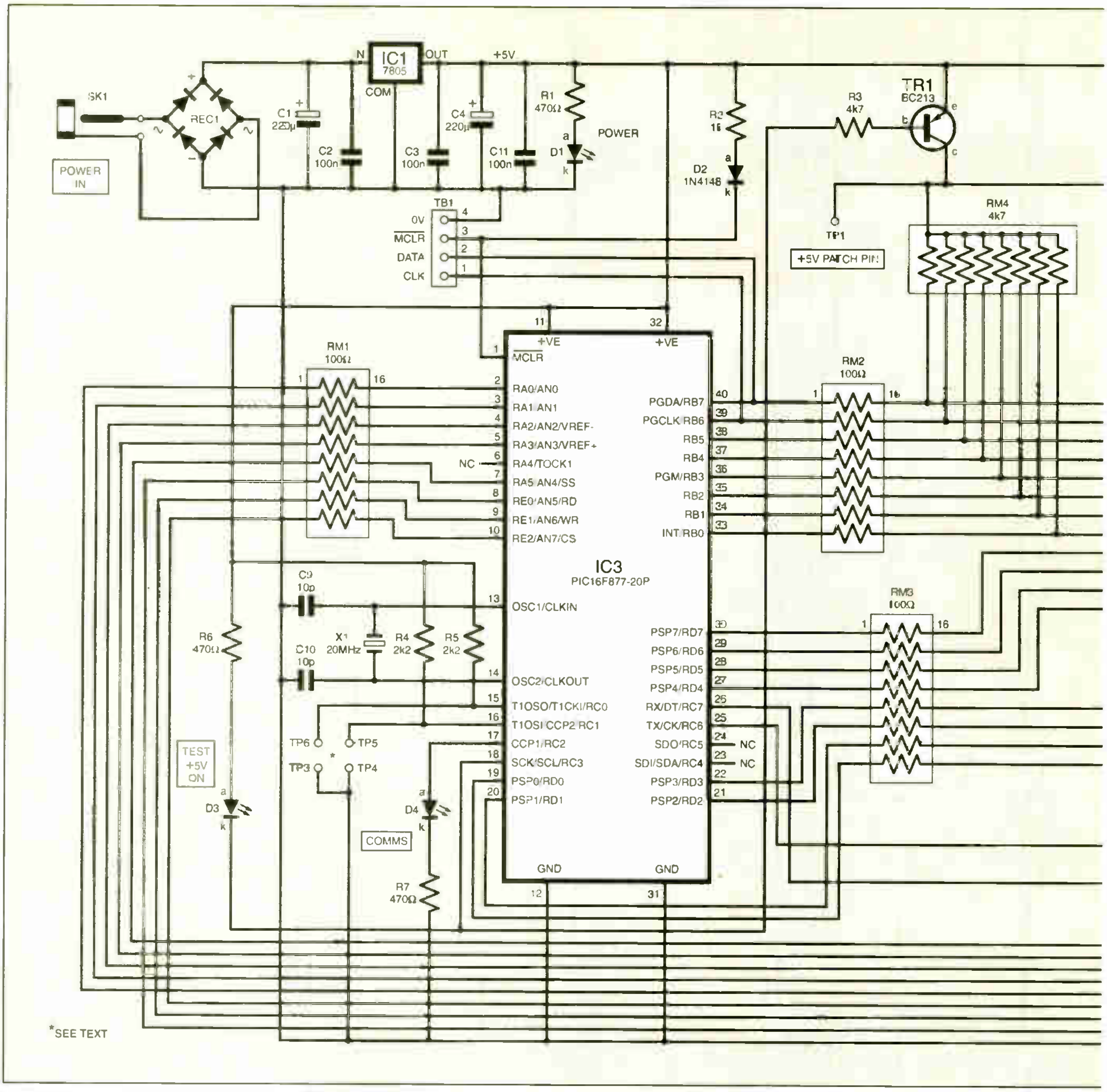


Fig. 1. Complete circuit diagram for the Digital I.C. Tester.

TR1 via resistor R3, which in turn applies power to the i.c. under test, via either the power patch pin (TP1) or via the dual-in-line (d.i.l.) switch module S1.

Transistor TR1 also supplies +5V to the common pins of the pull-up resistors within modules RM4 to RM6. As soon as testing is complete, TR1 is switched off automatically, disconnecting power from the test i.c. Capacitor C12 provides smoothing of the switched +5V rail from TR1.

With power applied to the board and TR1 off (non-test mode), the PIC's RB6 and RB7 pins are available to allow an external programmer access to the PIC.

POWER SUPPLY

It is expected that when in service the project will be powered from a sealed plug-in mains power supply adaptor. Either an a.c. or d.c. power supply unit can be used and the connections to the printed circuit board (p.c.b.) are not polarity sensitive.

A power supply unit capable of supplying around 100mA and between 9V to 12V should be ideal. If the input voltage exceeds this, then it might be necessary to fit a larger heatsink to IC1. The prototype draws approximately 30mA when in standby, rising when testing. The exact current drawn will depend on the i.c. being tested.

TEST SOCKET

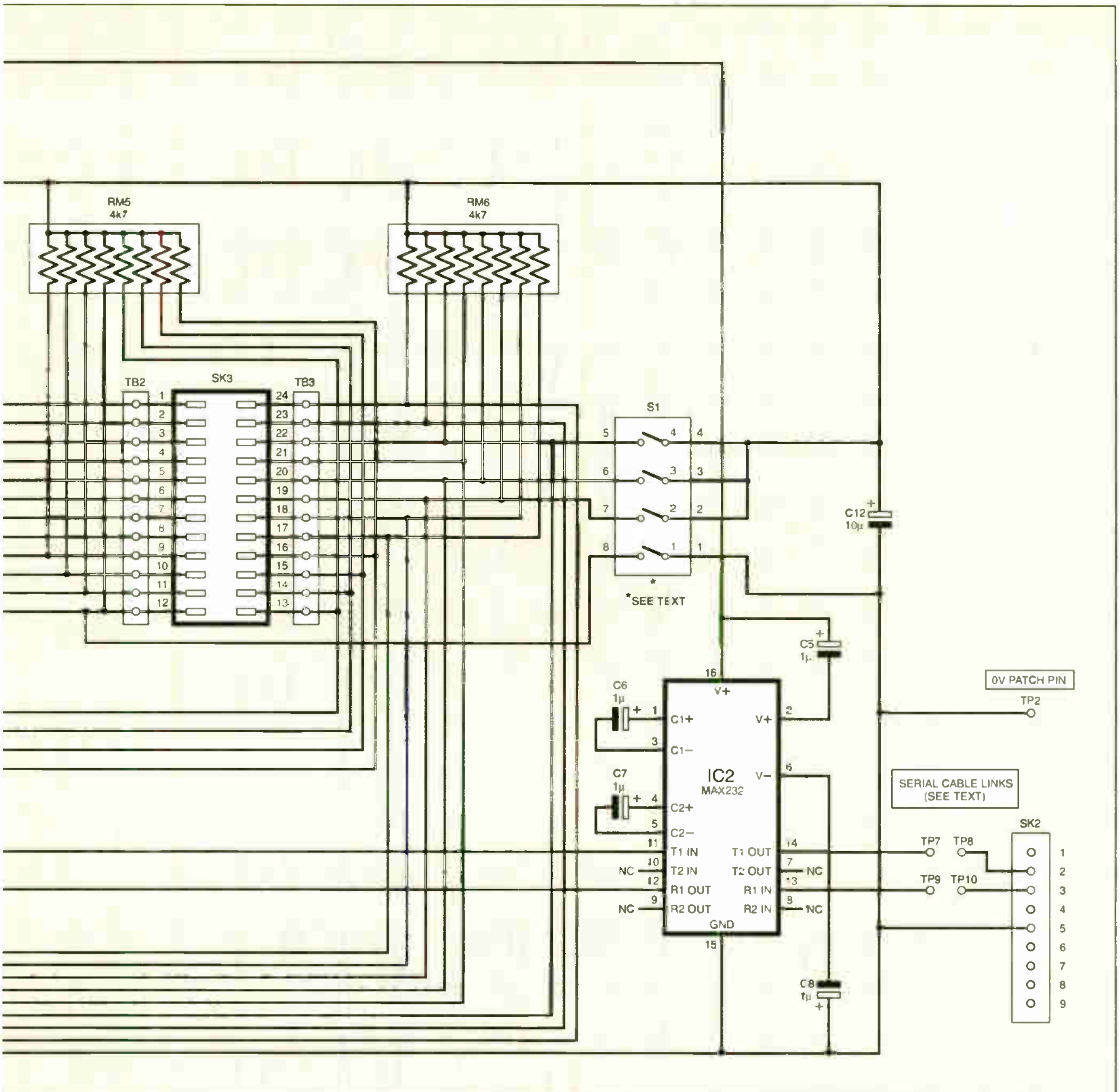
There are several possible choices for the method that will be used to connect i.c.s to the tester via socket SK3. The preferred method is a ZIF (Zero Insertion Force) socket. They are available in different sizes and formats but one should be chosen that accepts i.c.s of up to 24 pins and different package widths (a "universal" type).

The ZIF socket can be mounted directly on the board, or a 24-pin turned socket can be fitted first and then the ZIF pushed firmly into that. This allows the ZIF to be easily removed and used elsewhere if required. If a turned pin socket is not available, two rows of turned pin socket strips can be used instead.

Provision has been made on the p.c.b. to accommodate two pairs of turned pin socket strips, one pair of 10 pins (within the SK3 area), and one pair of 12 pins (TB2 and TB3) which may be used if it is decided not to use a ZIF socket. This allows narrow i.c. packages of up to 20 pins or the wider packages of up to 24 pins to be tested. Though not as convenient as a ZIF, this does make a cheaper option.

D.I.L. SWITCH OPTIONS

Power can be applied to the i.c. under test either via the jumper patch pins (TP1 and TP2), or predefined power configurations can be selected from the 4-way d.i.l. switch bank, S1. This switch allows a GND (0V) connection to be made to pin 12 of the test socket and a +5V connection to be made to pins 19, 20 and 22, as



COMPONENTS

Resistors

R1, R6, R7	470Ω (3 off)	
R2	1k	
R3	4k7	
R4, R5	2k2 (2 off)	
RM1 to RM3	100Ω 8 x individual resistors d.i.l. module (3 off)	
RM4 to RM6	4k7 8 x commoned resistors s.i.l. module (3 off)	

All 0·25W 5% carbon film or better except RM1 to RM6.

See **SHOP TALK** page

Capacitors

C1, C4	220µ radial elect. 25V (2 off)
C2, C3, C11	100n ceramic disc, 5mm pitch (3 off)
C5 to C8	1µ radial elect. 50V (4 off)
C9, C10	10p ceramic disc, 5mm pitch (2 off)
C12	10µ radial elect. 16V

Semiconductors

REC1	bridge rectifier 50V 1A
D1, D3	green l.e.d., 3mm (2 off)
D2	1N4148 signal diode
D4	red l.e.d., 3mm
TR1	BC213 *pnp* transistor (or similar)
IC1	7805 +5V 1A voltage regulator
IC2	MAX232 RS232 line driver
IC3	PIC16F877-20P microcontroller, preprogrammed (see text)

Miscellaneous

X1	20MHz crystal
S1	4-way s.p.s.t. d.i.l. switch, p.c.b. mounting (see text)
SK1	power connector (see text)
SK2	9-way D-type sub-min. connector, female, p.c.b. mounting
SK3	24-pin universal ZIF socket (see text)
TB1	4-way terminal pin strip
TB2, TB3	turned pin socket strip (2 x 12-way) (see text)

Printed circuit board, available from the *EPE PCB Service*, code 371; p.c.b. supports (4 off); 40-pin d.i.l. socket; 16-pin d.i.l. socket (4 off); heatsink 21°C/W for IC1 and mounting hardware; solid insulated wire for jumper links; solder, etc.

Approx. Cost Guidance Only **£25** *excl. connectors*

DIGITAL I.C. TESTER CIRCUIT BOARD

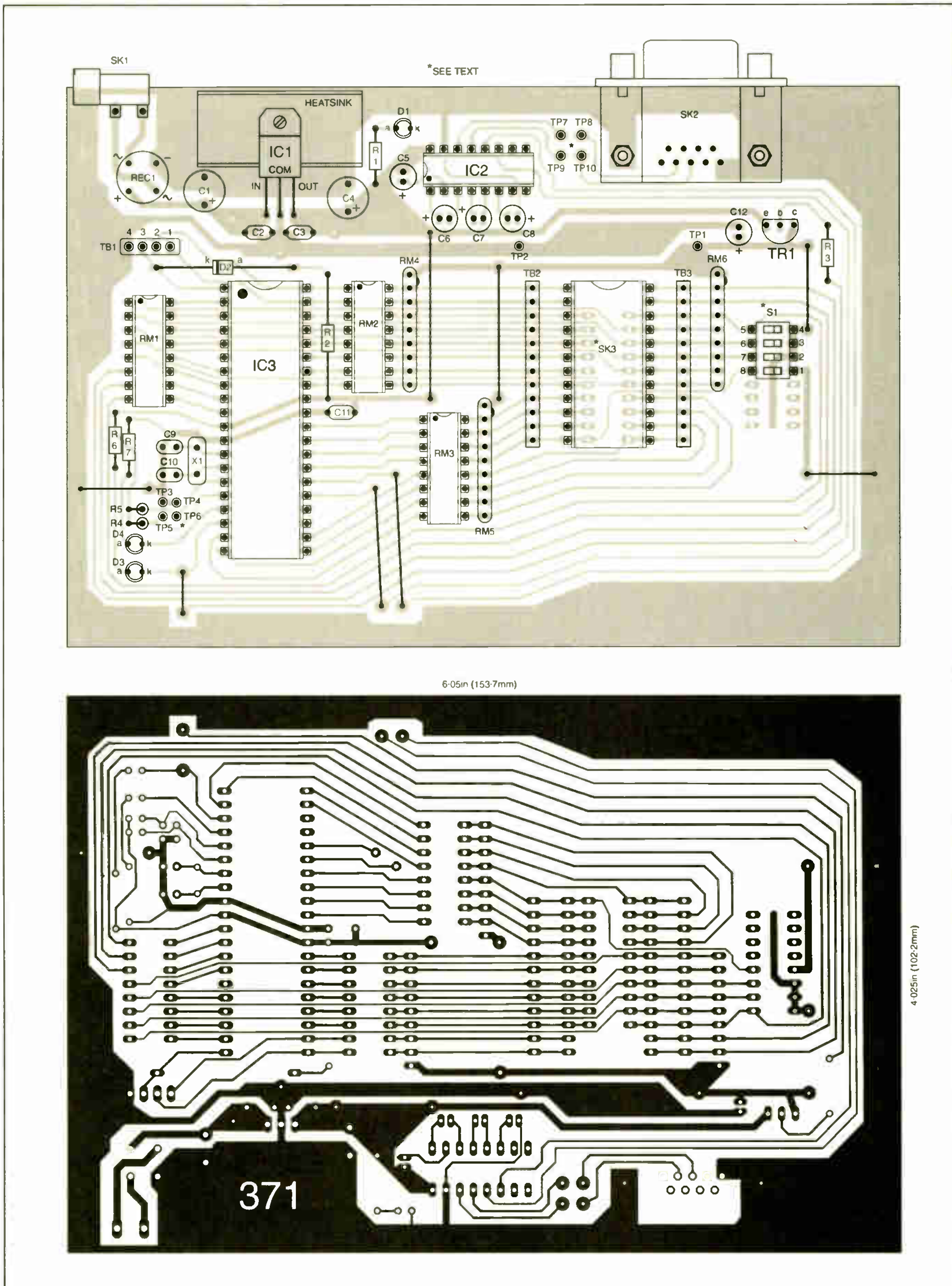


Fig.2. Printed circuit board component layout and full size copper foil master track pattern.

required. These combinations cater for the majority of 14, 16 and 20-pin packages.

Provision has been made on the p.c.b. to accommodate an 8-way d.i.l. switch bank for S1 if required instead of the 4-way (using the unused holes seen below S1 on the p.c.b. in Fig.2). The additional four ways can be hard-wired to any combinations wanted. The p.c.b. tracks located below the switch should make the setting up of these combinations easy.

CONSTRUCTION

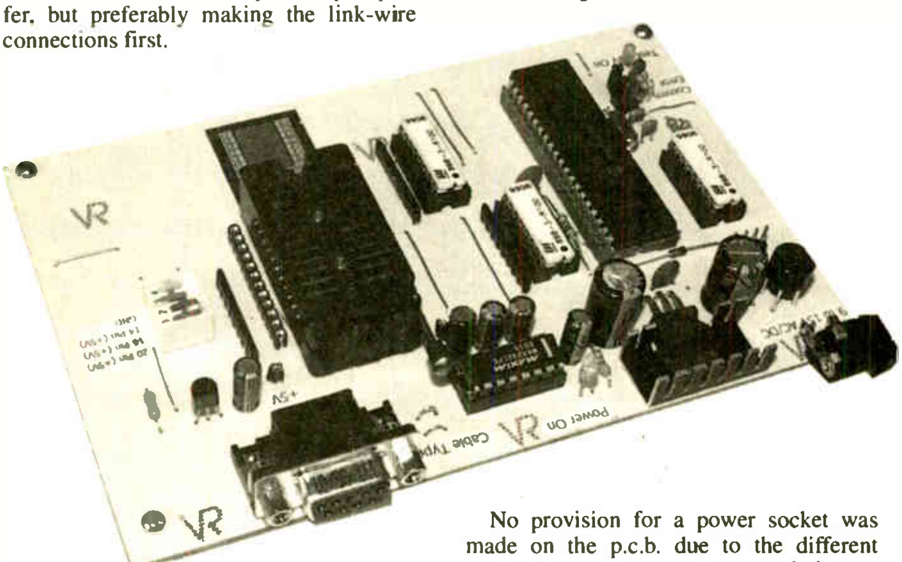
The Digital I.C. Tester is constructed on a single-sided p.c.b. whose component layout and tracking details are shown in Fig.2. This board is available from the *EPE PCB Service*, code 371.

It is recommended that good quality i.c. sockets are used for IC2, IC3 and the three 100Ω resistor modules, RM1 to RM3. Assemble the board in any order you prefer, but preferably making the link-wire connections first.

Be careful to observe the correct polarity of the semiconductors, electrolytic capacitors and l.e.d.s. It is also worthwhile orientating the i.c. sockets as shown, even though they are not actually "polarity conscious" in the normal sense. Doing so helps to ensure that the i.c.s. themselves are inserted the correct way round.

Do not insert IC2 and IC3, or connect the tester to the PC, until preliminary checks have been completed.

If the board is to be used as is (i.e. without a case), attaching small stick-on rubber feet to each corner is a wise precaution. If the intention is to house it in a suitable case, a 24-pin wire-wrap type socket can be used for SK3 as this will provide adequate clearance between the components on the p.c.b. and the case lid. The ZIF socket can then be plugged into the wire-wrap socket. A similar arrangement can be used for mounting d.i.l. switch S1.



The two link wires located to the left of SK2, the 9-pin RS232 connector (between TP7/TP8 and TP9/TP10), help determine which type of serial cable will be used, see Fig.3. If a straight-through serial cable is to be used, pin 2 to pin 2, pin 3 to pin 3, then these links should be parallel to each other as shown in Fig.3b.

If a cross-over serial cable is being used (pin 2 to pin 3 and pin 3 to pin 2 – as in Fig.3a) then the links should be crossed as in Fig.3c. Place a small piece of sleeving over one of the link wires so that they do not short together.

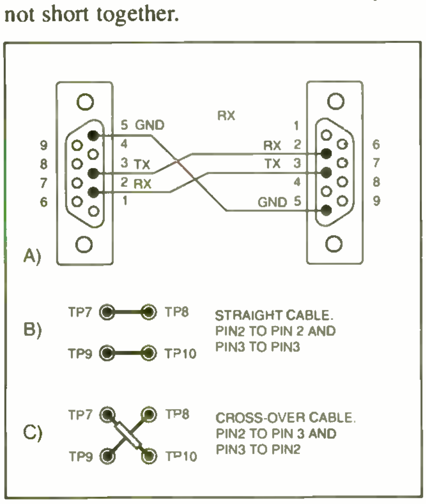


Fig.3. Links to be made in respect of serial lead type, see text.

No provision for a power socket was made on the p.c.b. due to the different types of power connectors currently in use. Instead, two terminal pins can be fitted and then an appropriate power socket for the chosen power supply soldered directly to these, as in the prototype.

Note that there are three holes located around IC1 that are not used. These points enable power to be tapped off for use with other circuits if desired.

There are four terminal pins (TP3 to TP6) located to the left of IC3. Ignore pins TP3 and TP5. The TP4/TP6 pair control the RS232 interface rate. With the default PIC firmware and 20MHz crystal, connecting TP4 to TP6 selects an interface speed of 57·6K baud. Without this link, 19·2K baud is used. A plug-in jumper link was used on the prototype.

FIRST TESTS

Once construction is completed, recheck that all components have been oriented correctly and look for any solder splashes or bridges that might have occurred during assembly. Using a multimeter set to ohms, check the resistance across capacitor C4 to ensure that there is no short circuit. A brief reading may be obtained whilst C3 and C4 charge.

If all is OK, continue testing, otherwise do not attempt to apply power until the problem has been removed as IC1, the bridge rectifier or the power supply unit could be damaged.

Making sure that the board is not resting on anything conductive, connect a suitable power supply. Switch on the power and l.e.d. D1 should illuminate. Switching the multimeter to d.c. volts, measure the voltage on pins 11 (+VE) and 31 (GND) of the socket for IC3. A reading of approximately 5V, within a few percent, should be seen.

If the 5V rail is not present or l.e.d. D1 does not illuminate, carefully check around IC1 and IC3 for short circuits or dry joints, and check the polarity of the D1.

Switch off the power supply and disconnect it from the mains supply when making any changes to the board.

ASSEMBLY COMPLETION

Once everything seems to be in order, insert IC2 and IC3, being careful of correct orientation and not to let any of the i.c. pins bend under whilst being inserted. The PIC, IC3, can either be a preprogrammed version (see later) or if a suitable in-circuit programmer is available (*Toolkit Mk3/TK3* for instance), it can be programmed on board via the TB1 connector.

Referring to Fig.1, resistor R2 and diode D2 permit the correct use of the PIC's $\overline{MCLR}$ pin 1 both during and after programming.

The completed unit needs to be connected to a suitable serial port on the PC. The cable should have a 9-pin male connector on one end for the unit and a suitable connector for the PC's serial port on the other. Fig.3a shows a cable schematic for a computer having a 9-pin serial port connector. For this cable, the cable selector links on the p.c.b. should be straight, as in Fig.3b (see earlier).

INSTALLING PC SOFTWARE

The PC software has been written in Visual Basic 6 (VB6) and should run on any recent Microsoft operating system including Windows 95, 98, ME, NT 4.0, 2000 and XP.

The installation set consists of four files: **Setup.exe**, which is the installation program, **Setup.lst**, which provides setup control parameters to the **Setup.exe**, plus **ICTest1.cab** and **ICTest2.cab** which contain the actual Digital I.C. Tester program, VB6 runtime files and i.c. model definition (type number) files.

Create a temporary new folder having any name of your choice, e.g. **C:\ICTester**, and copy the files into it. Then run the **Setup.exe** either by entering **C:\ICTester\Setup.exe** in the Windows run dialogue window or by double-clicking on **Setup.exe** in the File Explorer.

Once the setup has begun, most users should be able to accept the default settings offered. During the installation process, you may be asked to restart your computer if you have not previously installed the Visual Basic 6 runtime components or they are out of date. Reboot the computer and restart the setup process as required.

The temporary directory **C:\ICTester** can be deleted if no longer required once the setup is complete. If running the installation from the *EPE* CD-ROM, insert the disk into the disk drive and run the **Setup.exe** program located on it, as described above, then follow the prompts.

Once complete, the Setup program will create a new program group called **Digital I.C. Tester**. You can find it be clicking the

Start icon on the lower left hand side of the main Windows screen, and then selecting programs. You should see it listed there.

TESTING THE INTERFACE

Connect the serial cable and power supply unit and switch on. The l.e.d. D1 should illuminate. Also, to confirm that the PIC is running and executing its firmware, l.e.d. D4 should also illuminate.

Start the PC program running and you will be presented with the main working area, similar to Photo 1.

Photo 1. Main working area toolbar on PC screen.

By default, the PIC firmware and the PC software are set to communicate at 19·2K baud (TP4/TP6 link excluded – see earlier).

The PC software must be configured to use the COM port that you have connected the serial cable to. By default, the software uses COM:1. If you are not using COM:1, you can change this setting by selecting the Tools menu and then Configuration, which produces a display such as in Photo 2. A short-cut is to click the spanner icon on the toolbar.

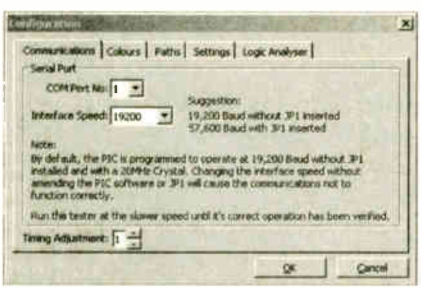


Photo 2. Serial communications configuration screen.

From here, you can change settings that control communication, default display colours, directories or folder locations and some other *ad-hoc* settings. Change the COM port to the required setting and click OK. All configuration changes are stored for later use.

Next you need to test the actual communication link between the PC and the Digital I.C. Tester. Again, select Tools from the top and this time select Confirm Communication Interface at the bottom of the menu.

A screen will be displayed detailing some checks you should first make. When you are ready, click the Start button. You will see some text scroll up in the panel on the right hand side of the window and perhaps l.e.d. D4 flickering on the tester.

The panel on the window will turn green if the communications link is satisfactory. If it turns red this indicates that the computer cannot establish a communications link with the tester. Perform the checks as detailed and try again. Most often the communications failure is due to the wrong COM port being selected or an incorrect cable being used.

If all is well, you can now proceed to test an i.c., but note that if l.e.d. D4 illuminates constantly during the testing process, this indicates a possible communications problem. In which case check the serial cable and the PC software speed settings in the configuration window.

TESTING AN I.C.

The software is supplied with profiles for a selection of common TTL and CMOS devices. For the following testing example we shall use a TTL 74LS00, a quad 2-input NAND gate. To properly follow this discussion now, it is best to have the PC software running.

Drop the i.c. to be tested into the test socket, making sure that the bottom right hand pin of the i.c. is located in the bottom right hand pin of the socket.

Different i.c.s can have their power rail pins located in different positions. Typically, the bottom left hand pin is GND and the top right hand pin is +VE but this is by no means always the case. The rows of turned pin sockets alongside the test socket can be used to route power to the correct pins, but more on this in a moment.

Next, you need to tell the PC software which i.c. type is going to be tested. To do this, you need to load a profile file that relates to the specified type. This file contains details about the number of pins on the i.c., which pins are inputs and outputs, have no internal connection and which are its power pins.

The profile also contains detailed instructions on how to test the i.c. From the program's main menu select File and then Load IC Profile. After a few moments, a list of the available profiles should be displayed in the right hand panel (see Photo 3).

If the panel is empty then you will need to tell the software where the "Datasheets" folder is located. The default is **c:\Program Files\ICTester\DataSheets**. The left hand panel allows you to browse your computer's drives and folders until you locate the "Datasheets" folder.

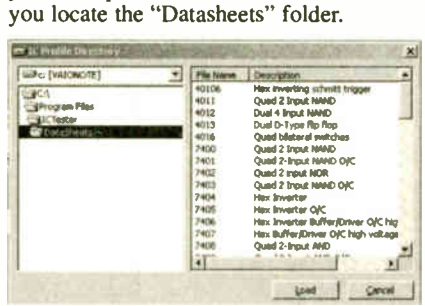


Photo 3. Selection screen for i.c. types.

Scroll down the list of available profiles and select "7400". You can double-click to load or click once and then click the Load button. The Profile Directory window should now disappear and you will see just the main application window. On the status bar at the bottom, though, you should now see some additional information, such as that in Photo 4.

Photo 4. Status bar.

TESTING OPTIONS

To start the testing process, select IC Test from the top menu and then select Test Specified IC. A window similar to that in Photo 5 will be displayed.

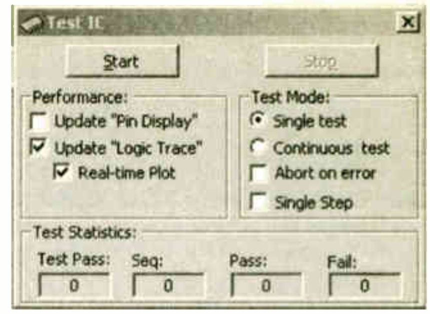


Photo 5. The "testing" screen.

There are four main areas to this window. The Start and Stop buttons are used to begin and terminate the testing process accordingly. The Performance panel is used to get additional information displayed during the testing process.

If Update Pin Display has a check mark displayed, a representation of the i.c. being tested will be displayed on the screen. As the logic levels change on the actual device being tested, they will be reflected on this display (this is useful when the Single Step option is also selected).

The function Update Logic Trace will record a trace similar to a storage oscilloscope that can be studied after the testing process has been completed. Enabling the Real-time Plot option will keep the trace updated as the testing progresses instead of just displaying the results at the end of the test.

These options, if selected, will impact on the performance of slower PCs. To get the best possible speed, do not enable these options. However, for now, enable all three so you can see exactly what happens.

The Test Mode panel controls how the testing is performed. Normally, Single Test would be selected. If you suspect that a device has an intermittent problem, though, you can set the software to do a Continuous Test. The test-cycle will then be repeated up to 999 times.

Abort On Error will terminate the testing cycle if any error is detected in the i.c.

Single Step is useful if, for example, you want to probe around the i.c. under test

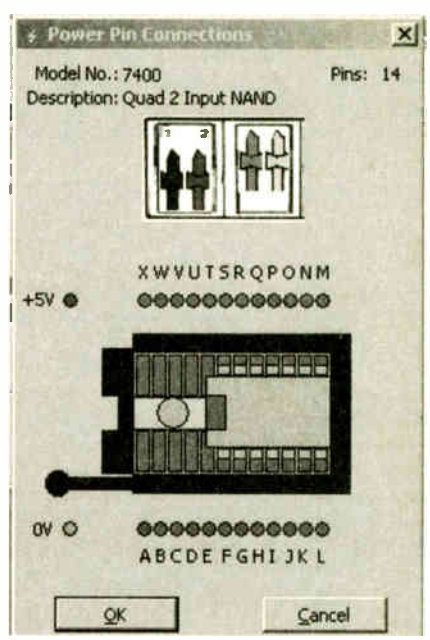


Photo 6. Pin connections dialogue screen.

with an oscilloscope or logic probe. Every time a pattern is sent to the test i.c., the PC software will display a message box asking you to press the <CR> (<ENTER>) key before it moves onto the next step.

The Test Statistics panel shows how many test cycles have been made (0 to 999), the current sequence or pattern number being executed as specified in the device profile file, and how many test-cycles the device has passed or failed.

TEST PROCEDURE

When ready, click the Start button. Because this is the first time you have tested an i.c. with this power pin configuration, a dialogue box is displayed (see Photo 6). The picture shows how to correctly apply power to the i.c. under test. Also, it shows you how the i.c. should be inserted in the socket.

Notice that in this case, no power patch wires are required as this i.c. package is supported by the on-board d.i.l. switches. So, set d.i.l. switches S1/3 and S1/4 to the ON position, as indicated.

Press OK to start the test. All being well, after a couple of seconds you should have a display similar to that in Photo 7.

Select Window from the top menu and then Tile Vertically to get the software to arrange everything neatly for you on the screen.

In the case of the i.c. represented in Photo 7, it actually failed during the testing process. The right hand panel shows that the problem occurred with pattern sequences 0007 and 0008. Sequence 0007 shows what the Digital IC Tester sent to the i.c. Sequence 0008 shows what the device profile says should be the response from the i.c. The next line shows what the response from the i.c. actually is. An "X" means Don't Care about the logic level.

Whilst this is helpful, it is not too clear exactly what the problem is. The trace on the left hand side of the screen shows the logic levels present on each pin of the i.c. during the test. The trace is updated after each Read operation is performed.

The display has four yellow traces which are the outputs of each of the four NAND gates. Since they should all behave the same, it's quite clear that there is a problem with the gate whose output is on pin 11. In some cases, though, the actual problem might not be clear, especially if the i.c. only contains one or two gate arrays. If you select Diff on the Pin Logic Trace, the trace display will change and look similar to that in Photo 8.

The dotted line indicates what the profile is expecting back as a response from the i.c. under test. As can be seen with pin

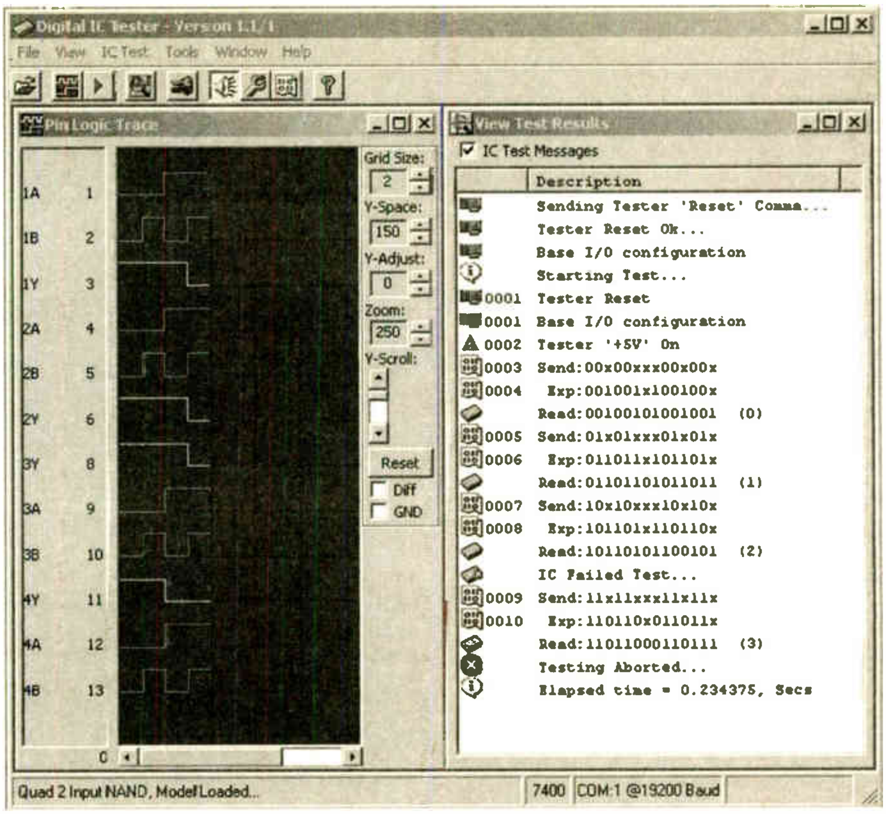


Photo 7. Typical screen display during testing, on this occasion showing that the i.c. is faulty (see text).

11, the logic level dropped from high to low before it was expected. Another option available is GND, located directly under the Diff option. Enabling GND forces a dotted line showing where the low logic level for each pin would be on the display. This makes a useful trace separator when the screen starts looking crowded.

CREATING PROFILES

Since the number of i.c. devices on the market is constantly changing, the tester would soon become obsolete if the user did not have the ability to add new profiles as required. To create a new profile, select Create IC Profile on the main Tools menu, see Photo 9.

You will need to enter the i.c.'s type number and a brief description about the device. Next select how many pins the device has, and specify which pins are designated as inputs, outputs, power or have no internal connection. You do this by

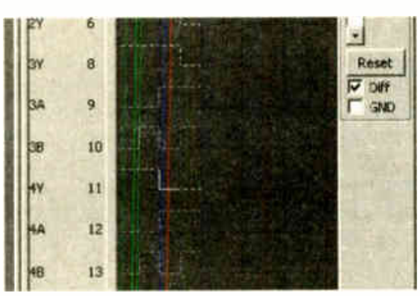


Photo 8. Test screen in "difference" highlighting mode.

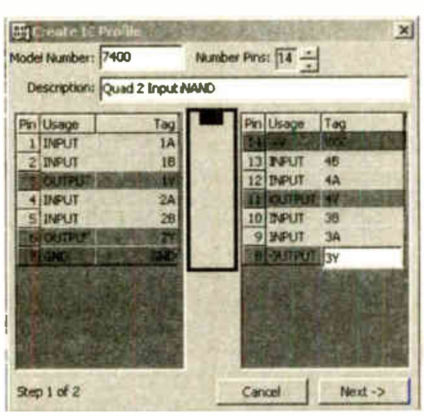


Photo 9. Creating an i.c. pin function profile.

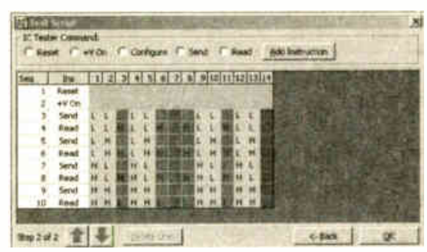


Photo 10. Creating an i.c. test procedure profile.

repeatedly clicking on each pin in the usage column. Additionally, you can create short tags (descriptions) for each pin, which are displayed along with the pin numbers on the Logic Trace screen. When ready, click the Next button.

TEST EXAMPLE

You must now tell the Tester what logic levels to send to the i.c. and what the expected results will be (see Photo 10).

To test a 7400 quad 2-input NAND gate, for example, 10 instructions are required:

Sequence 1 – Reset. This sends a Reset command to the PIC and should always be included unless there is a specific reason not to. You can include as many Reset commands as required and at any location within the script.

Sequence 2 – +VE On. This switches on the +5V supply to the i.c. under test. It also applies +5V via transistor TR1 to the three commons of the pull-up s.i.l. resistor modules, RM4 to RM6.

Sequence 3 – Send. Here, we are sending low logic levels to pins 1, 2, 4, 5, 9, 10, 12 and 13. These pins were defined on the previous screen as inputs. You can only send logic levels to pins defined as inputs.

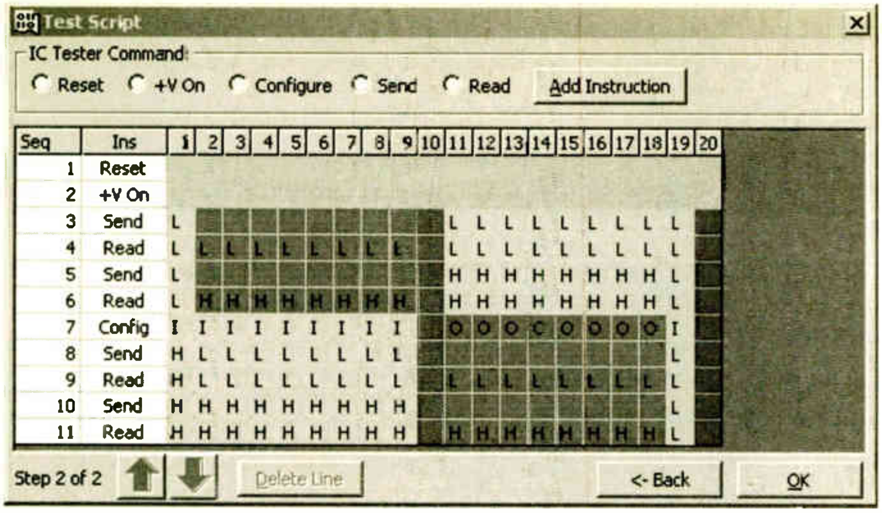


Photo 11. Example of a profile screen being set for multiple function pins.

Sequence 4 – Read. We now read back the logic levels from the i.c. being tested. We expect pins 1, 2, 4, 5, 9, 10, 12 and 13 to be low since we have set them low in the previous instruction. However, we must now indicate which logic levels are expected on each output pin. According to the truth table we looked at for a NAND gate earlier, all gates should return a high logic level. We now continue sending logic levels to the i.c. being tested and then reading back the actual logic levels from it.

There is no need to send a Config command in the above sequence since the PC software sends the required configuration based on the profile information you specified on the first screen during the profile creation.

MULTIPLEXED PINS

Some i.c.s, however, have pins that can be either an input or an output, depending on the logic level of some other pins, and the 74245 is an example of this (see Photo 11).

At Sequence 7, a Config command has been inserted. This enables the tester to be reconfigured and specify which pins are inputs or outputs. Testing resumes from Sequence 8.

Select the Reset command and click Add Instruction. A new line will be added to the display. Do the same for +VE On. Next, insert a Send command. This is the binary pattern we want to present to the i.c. under test. Logic levels are changed by clicking the cell on the new line that you want to change.

Normally, after a Send command, you will perform a Read. But this is not always the case. For the Read, you can specify that a pin designated as an output should have either a High or Low logic level or that it doesn't matter ("X").

Once the required instructions have been created, press OK to save the profile.

The up and down arrow buttons allow lines to be moved up and down in the execution order. The Delete Line button allows instruction lines to be removed from the profile.

CONFIGURATION OPTIONS

The configuration options can be selected from the main menu and are located under Tools, Configuration (see Photo 2 earlier). When selected, there are five groups of configuration settings that can be changed.

The first group deals with the serial interface characteristics. The COM port and interface speed are changed here. At the bottom of the screen there is a Timing Adjustment button. In certain circumstances, it is possible to under-run the PC's serial buffer. Increasing this value forces the PC software to wait longer for incoming data, the drawback being that the software will run slightly slower.

To check that this setting is correct, insert a known good i.c. into the tester and set for continuous testing. If after the default 999 tests no failures have been reported then the setting is correct. If any failures are detected then this value should be increased by a value of 1 and the test performed again.

The next group allows the information display colours to be changed. Clicking any of the coloured panels brings up the colour picker dialogue.

The Paths groups allows the default location of the Data Models (i.c. types) storage path to be specified. Clicking the ellipsis button on the right (the one with . . .) allows you to explore the available disk drives and folders and locate the location of the data model files.

The settings groups allow some display options and the DIP switch type and usage to be specified. The Show Tool Bar and Show Status Bar options allow the Tool and Status bars to be shown or hidden, which is useful if screen real estate is scarce.

In some cases, the software attempts to gain the user's attention by flashing messages on the screen. The option Allow Flashing Text controls whether these messages flash or are static.

The option Always Warn About Test IC Power Pin Configuration controls how the software warns the operator about the power pin configuration of the i.c. under test. If On, the software always issues a warning. If Off, the software only issues a warning when either the first i.c. of the session is to be tested or a new i.c. type has been selected that has a different power configuration from the previous type tested.

The DIP Type options control the look of the graphic used for showing the d.i.l. switch settings. Select the type that best matches your d.i.l. switch type. The switch bank size defaults to 4-Way. If this is changed to 8-Way, indicating that you have opted to fit the 8-way switch for S1, the Setup DIPS ("DIPS" referring to the other name, dual-in-line-package, by which d.i.l. switches are sometimes known) button will be enabled.

Selecting Setup DIPS allows you to specify how you have wired the additional four switches.

The printer icon allows a template to be printed that contains all the texts required to label the Digital I.C. Tester. Also, a custom legend is printed that can be affixed next to the d.i.l. switch S1.

All configuration options are saved and automatically used the next time the PC software is started.

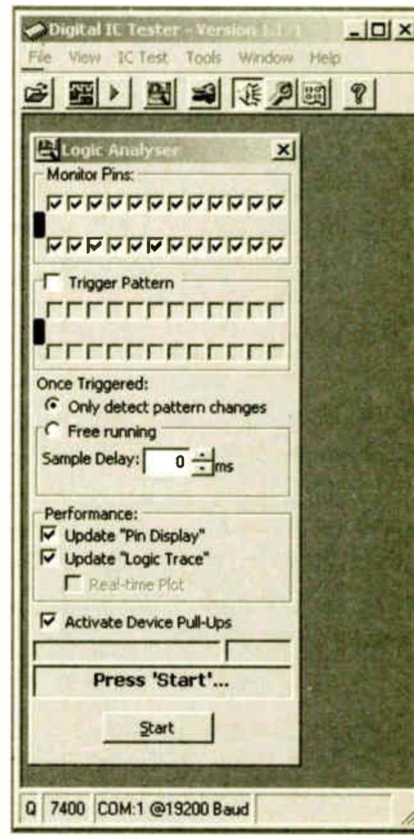


Photo 12. Logic analyser experimental screen.

It is worth noting that, in most cases, holding the mouse pointer over a control or button will provide some additional information on its use.

EXTERNAL LOGIC ANALYSING

An additional feature was added to the software to experiment with displaying logic states for i.c.s running in-circuit on other p.c.b.s, and this has been left in the published software for reader's own experimentation purposes (see Photo 12).

A test connector, consisting of an i.c. test clip, connected to a piece of ribbon cable and terminated with a 24-pin i.c. header plug, allows the Digital I.C. Tester to be connected to the in-circuit i.c. Once connected the Logic Analyser function can be selected from the Tools menu.

The Logic Analyser monitors and reports the logic levels on between 1 and

24 pins. The pins to be monitored are selected in the Monitor Pins panel. An optional trigger pattern can be specified if required. A "tick" indicates a high logic state and the absence of a tick indicates a low logic state. When all monitored pins have the specified trigger pattern, the Analyser is triggered.

There are two primary modes of operation for the Analyser. The mode Only Detect Pattern Changes displays each new logic pattern as it changes. Free Running grabs the logic levels as fast as possible. If Free Running is selected, an optional delay can be specified from 0 to 9999ms between each sample being made. Update Pin Display and Logic Display work as previously discussed. The Activate Device Pull-Ups controls whether the s.i.l. pull-up resistor modules (RM4 to RM6) have their common connections powered or not.

When the logic analyser starts, it instructs the PIC to "grab" logic level status information as fast as possible and transmit this to the PC. The PC then attempts to process and display this information. Because of this, the analyser has several practical limitations.

Firstly, due to the hardware design and the way the PIC operates internally, the PIC's I/O ports are read at slightly different times. This means that when changing logic levels are trying to be captured, there is a possibility of inconsistent or unexpected results being displayed.

Also, no matter what settings you select, the PIC frantically transfers data as fast as it can to the PC and does not store any of the results internally. This means that the capture speed is limited to the maximum speed of the serial interface, making it quite slow in relation to today's computer speeds.

CONCLUSION

The Digital I.C. Tester has successfully tested a variety of i.c.s without any problem, including 74, 74F, 74LS, 74HC and CMOS 4000 series. The only slight exception to this was with the HC series. These refused to test correctly with the original prototype which used 330Ω buffer resistor modules (RM1 to RM3). These were swapped for 100Ω ones, as specified for this published version, and then the offending i.c.s tested fine.

The design aims to give a go/no-go logic report on the i.c. being tested. It is beyond the scope of the tester to attempt to measure the i.c.'s analogue operational parameters and compare them with its technical specification. Perhaps when a PIC is available with 24 onboard analogue-to-digital converters, the author will revisit the design.

ACKNOWLEDGEMENT

The author would like to thank his brother Peter for supplying a large selection of "test subjects", most of which looked like they belong in the Science Museum!

RESOURCES

All software for this project is available for free download from the *EPE* ftp site, or on CD-ROM (for which a charge applies) from the *EPE* Editorial office, see the *EPE PCB Service* page for details. The PIC program software is supplied in MPASM format (.ASM and .HEX). See this month's *Shoptalk* page for details of obtaining preprogrammed PICs.

The datasheet for the MAX232 is available from the Maxim website at **www.maxim-ic.com**.

Datasheets for the majority of TTL i.c.s can be found on Texas Instruments web site at **www.ti.com**. □

SHOP TALK
with John Becker

EPE Bounty Treasurer Hunter

Looking down the components list for the EPE *Bounty Treasure Hunter*, there is nothing in the way of electronic components that should need a treasure hunter to find them! Although the author preferred to use the SGS-Thomson HCF40106, in an application such as this any hex Schmitt inverter having the code 40106 in its identity will perform the job. Ignore the prefix, that's only the manufacturer's code. By and large, with any digital logic i.c., it's only the number itself which is important, not the manufacturer. Make sure, of course, that the device is one having normal pins that go into a p.c.b., and is not a surface mount device.

The hardware may present you with a bit more of a search requirement, this is where your large local DIY stores come in handy – and you enjoy browsing those anyway, don't you!

I.C. Tester

Once again, there are no components that are unusual in the *I.C. Tester*, with the possible exception of the MAX232 RS-232 line driver. If your favourite stockist doesn't have it, we know that **ESR** do, their advert is on page 706. It is also stocked by **Maplin**, code number FD92A, they describe it as an RS-232 Transmitter-Receiver (same thing as an RS-232 line driver). ***Tel: 0870 264 6000. Web: www.maplin.co.uk.***

It's worth shopping around for the ZIF socket as these can vary considerably in price between sources (quality-wise, of course, you get what you pay for!). See later for details of obtaining the software. Pre-programmed PICs are obtainable from *EPE* advertisers **Magenta Electronics** (☎ ***01283 565435***, web: ***www.magenta2000.co.uk***), price £10 each (overseas add £1 p&p).

Headset Communicator

It's the TDA7052 that your local stockist may not have for the *Headset Communicator*, even though he is likely to have all the other components, which are common-place. Again we know that Maplin (see above) stock it, code UK79L (ignore the 1W power amp *module* that they also call the TDA7052).

Regarding the connectors, yes, they can seem a bit expensive, but quality is well worth paying for in this context and XLRs are the preferred connectors used by professionals in the audio world. Try **ESR** for these – their advertisement is on page 706 – they also stock the TDA7052 i.c. If funds permit, buying ready-made XLR connection leads could provide greater reliability – a fact which may well be appreciated in the type of situation in which this unit is intended to be used.

PIC-Pocket Battleships

Except for one item, all components in the *PIC-Pocket Battleships* project are perfectly standard, which we expect any supplier to keep in stock. This fun game uses a PIC microcontroller, but it is not one that appears frequently in *EPE* projects. It is the PIC16C54, which is one of the earlier PICs (long before the '84 etc) and which is not electrically erasable, requiring exposure to UV light to do so through a window set into the device. This PIC is available pre-programmed *only from the author*, Bart Trepak, 20 The Avenue, London W13 8PH. It costs £5.50 inclusive (overseas add £1 for P&P), payment made out to B. Trepak, and *only* in £ sterling and drawn on a British Bank, although UK postal orders are accepted.

Software is available separately as stated below. Note that *Toolkit TK3* is not designed for use with PIC16C54 devices.

Printed Circuit Boards and Software

Apart from *Battleships*, which is built on stripboard, this month's projects all have p.c.b.s. Their code numbers are quoted in the respective Components Lists and are available as stated on the *EPE PCB Service* page (page 763).

All the software required is available for free download from our ftp site. The easiest access route to this is via the main web page at **www.epemag.wimborne.co.uk** – use the click link at the top saying "FTP Site (Downloads)", then click on PUB, then on PICS, and then look for the appropriately named folder.

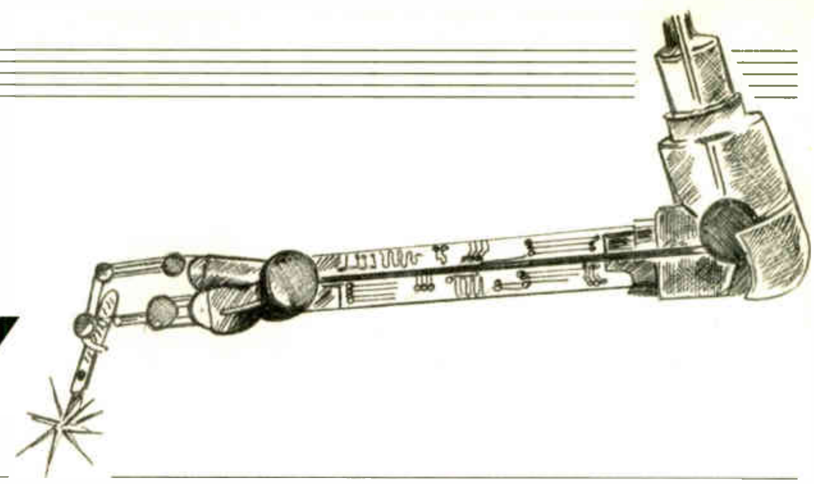
Software is also available on disk from the Editorial office. *Battleships* is on *EPE* Disk 5, but the *I.C. Tester* is on its own CD-ROM. To order these disks, see the *EPE PCB Service* page, which also gives their prices.

That's it for now, Dave will be back with you next month.

PLEASE TAKE NOTE

Ingenuity Unlimited *(July 2002)*
The locations of VR1 and R1 in the *Car Battery Trickle Charger* (page 487) should be reversed, so that R1 is placed between the output and adjustment, and VR1 between adjustment and ground.

Regular Clinic



CIRCUIT SURGERY

ALAN WINSTANLEY and IAN BELL

Our surgeons look at interfacing a simple remote control with external logic and they answer the question, why do so many of our projects use 9V when low voltage chips are widely available?

Toggle CMOS Interface

Our thanks to *Alister M. Bottomley* of Glasgow who wrote with a problem regarding the remote control of lighting or similar on/off applications. This month we start by looking at interfacing the remote control system using a discrete logic system, outlining the potential pitfalls of "toggle" controls. Alister writes:

I recently purchased a two-channel 418MHz remote control system, the idea being that one channel could operate the pump and the other the lighting in a small fish pond. The output from the receiver is an open collector pnp *transistor capable of supplying 500mA at up to 16V.*

However, I now realise that the output is non-latching, so I would need one channel to "latch" the device and the other to break it, although this means I would not be able to turn both circuits on and off. My idea was, therefore, to use a relay on the output, momentarily switching the input to a CMOS 4013B configured as a toggle switch. I would welcome advice as to the interface between the open collector and the input of the 4013.

From your description we assume that the circuit at the receiver is basically as shown in Fig.1. You are correct in thinking that a 4013 CMOS dual D-type flip-flop could be used to implement a toggle operation.

In principle this is very straightforward – the open collector output is easily turned into a logic output simply by replacing the load with a resistor. The logic circuit can then drive another *pnp* transistor (TR1 in Fig.2) (or a Darlington transistor – see last month's *Circuit Surgery*) to switch the load.

The value of resistor R1 is not too critical; you need to make sure that you get a good logic 1 voltage when the output transistor is on and a good logic 0 when it is off, so about 10 kilohms should do. A supply decoupling capacitor (C1, typically 100nF) should be placed close to the logic device(s).

There is a potential source of problems with this arrangement. Because you are using *edge-triggered* clocking of a logic circuit as a *control* input rather than as a "proper" clock signal, any glitches or other unwanted transitions on the receiver output can cause the load to switch in sympathy (see Fig.3). This would be perceived as unreliable or erratic behaviour (e.g. the on-off switch only works some of the time, or the load seems to switch on or off on its own accord).

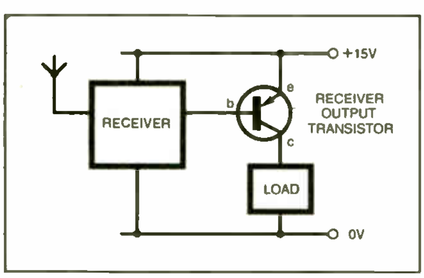


Fig.1. Receiver with open collector output.

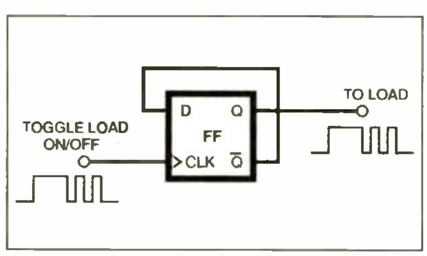


Fig.3. Using a clock as a toggle control seems like a great idea – until you get glitches or switch bounce.

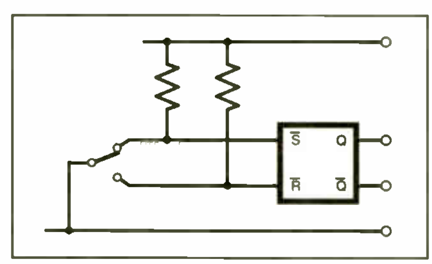


Fig.4. A switch debouncer which removes unwanted transitions from the signal.

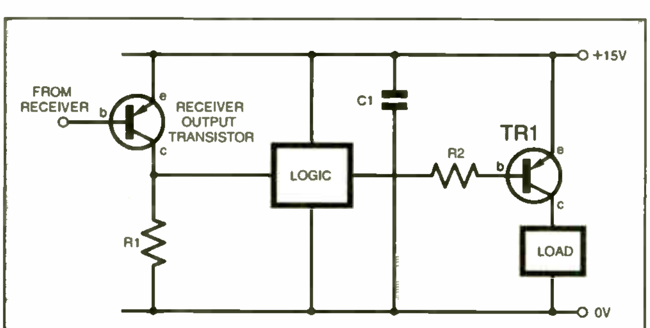


Fig.2. Open collector receiver output interfaced using logic to an open collector output transistor.

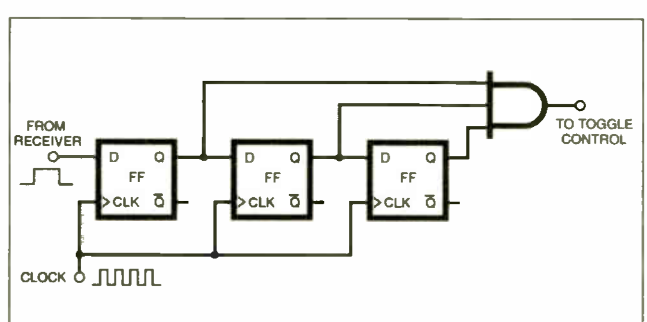


Fig.5. Using a minimum pulse width to ignore glitches.

Glitch Free

In our reader's case there may or may not be problems, depending on how "clean" the output from the receiver is. If the switch on the transmitter is not debounced though, it is possible that the receiver will faithfully replicate the switch bounce – you will have to check this and debounce the switch at the transmitter if necessary.

The classic switch debounce circuit is shown in Fig.4. Note that in this arrangement you need to use a changeover (two-way) switch with two pull-up resistors as shown.

If the receiver output has glitches then you will need to remove these before they can interfere with the toggle's clock signal. One way of doing this is by only letting through pulses that are longer than a certain period. The circuit in Fig.5 shows a possible implementation. A clock (e.g. from a CMOS oscillator or 555 circuit) drives a shift register.

The configuration of the AND gate means that the output is only Logic 1 if the input was Logic 1 for 3 clock cycles – simply set the clock rate to a suitable one. In the case of a light switch, for example, you could make the clock quite slow so that you would have to hold the switch down say for half a second before it took effect.

The circuit in Fig.5 can be made a little more sophisticated by using another AND gate on the $\overline{Q}$ *($\overline{Q}$ = NOT Q – ARW)* outputs and combining the two AND gate outputs to control a SR flip-flop which in turn drives the toggle clock.

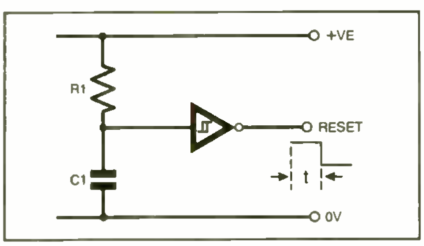


Fig.6. Power-on reset.

Lastly, another issue with toggling circuits is that they may power up in a random state unless you provide a power-on reset (POR). A POR circuit is shown in Fig.6 – when the power is first applied the capacitor is discharged (so the output would be 1).

In the moments after the power supply is switched on the capacitor charges up though the resistor, eventually crossing the logic threshold of the inverter and switching the reset signal to its inactive state (0 in this example). Schmitt trigger gates are designed so that they are able to cope with slowly changing inputs, which cause problems for normal logic gates that expect a fast transition from 0 to 1 and 1 to 0.

I hope that helps. *IMB.*

Troublesome UV Timer

I built a small ultraviolet box for exposing my own printed circuit boards, using a dual fluorescent lamp base and a timer circuit, but I've run into a problem with the relay and lamps not "holding on". The problem is that as soon as the pushbutton is released, the whole thing turns off.

The circuit uses a transformer that is 22V off load, falling to 12V on load, which is ideal for the lamps. I tried to increase the smoothing capacitor from 1,000µF to 10,000µF but no cure. Am I overloading the transformer, which is why it's dropping so low? Thanks from **Chris Brown** in the *EPE Chat Zone.*

We don't have a circuit diagram for guidance, so try these general pointers. If the supply voltage drops alarmingly when you close a switch, then start by checking the obvious things first.

Look at the wiring and component values around the push switch. If you have the wrong components then perhaps you are shunting part of the circuit with a low resistance value – observe the resistor colour stripes and confirm that the correct resistors have gone into the right locations.

Transistors and diodes also cause problems if they have been inserted the wrong way round. Are the i.c.s (if any) inserted the right way round?

Look at the soldering as well, checking for dry (grey) joints or shorts. Otherwise, perhaps it relates to the quality or rating of the mains transformer, or even a problem with the relay coil specification. It does sound as though there isn't enough "juice" to power the relay coil adequately but it is hard to be more specific.

Some years ago *EPE* published my own design for a UV exposure timer unit, based on a 555 monostable. A timer helps to ensure you get consistent results when developing and etching the board. Underexposure is the worst problem because it is often impossible to align (register) the artwork again and re-expose for a further period, so a timer helps avoid that problem.

However, during prototyping it was found that the timer would re-trigger after timing out, which was caused by spikes outputted from the mains-operated fluorescent lighting. A combined delta-capacitor and choke suppressor was inserted between the timer's output and the UV box by building an in-line suppressor unit, and this cured the problem. *ARW.*

Battery Eliminator

Why do people keep using 9V batteries in projects? They are the most expensive way to power any circuit. I use AAA cells which are slightly larger but it does not make the project any less portable.

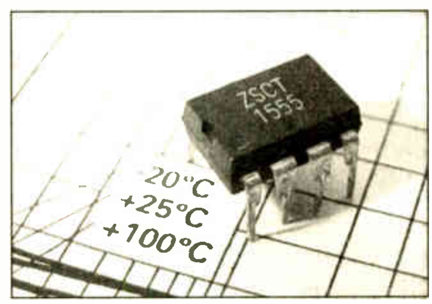
I say, ban 9V batteries from magazine projects. Why use 9V on so many circuits anyway? Most i.c.s. are either 5V or 3V aren't they? ***Bob Biglan*** in the *EPE Chat Zone.*

It's certainly true that modern devices run at ever lower voltages (e.g. the Philips 74LV logic range runs at 3·3V), but we seldom need to be involved with miniaturisation or with state of the art low power chips, so we unashamedly use 9V batteries for portable projects. Many constructional projects are not intended to be classed as "low power" and they use traditional discrete components anyway, leaving the designer with little choice for the battery supply.

You only have to look at the shrinking size of mobile phones or Mini Disc players to know that commercial chips are getting smaller and more heavily integrated, as are the custom-designed Li-ion batteries that power them. Inevitably, they use low power surface mount parts and techniques that render them generally beyond the scope of hobbyists. A clue for catalogue readers is the letters "SO" (small outline) near a part number, meaning that it's surface mount.

On the subject of chip voltage, some "hobbyist-friendly" chips were specially designed for low voltage operation – the wonderfully clever and sadly missed LM3909 l.e.d. flasher by National Semiconductor was one example, packaged in an 8-pin d.i.l. chip it could flash an l.e.d. for many months on a 1·5V cell. It was great fun to use, but industry needs miniaturisation, and chip manufacturers need mass production, and the LM3909 went the way of many other interesting chips.

The Zetex ZSCT1555 is a bipolar low voltage 555 equivalent that is described as a precision single cell timer. A supply operation of just 0·9V is guaranteed by the makers, but to get the best out of the chip you will need to be skilled in low power design. The maker's data sheet shows a 1·5V to 5V voltage converter circuit that an average reader could build.



The Zetex ZSCT1555 was specially designed as a low voltage equivalent for the 555, and is claimed to operate at 0·9V.

For a traditional discrete 5V logic circuit, there are several ways of powering it from batteries: the crudest way would be with a Zener diode, perhaps running from 6V, except that Zeners have relatively poor tolerances and are wasteful of energy. The 6V battery pack does not provide much "headroom" either, so it isn't long before the total power supply voltage falls below 5V anyway.

A better way might be to use a 5V fixed voltage regulator, but unless a low-dropout type is used these devices have a typical dropout voltage of 2V to 3V or so (dissipating valuable battery power in the process), implying a battery voltage of 7V to 8V d.c. or more is required. A 9V battery would then be the most obvious choice because it will take longer before the supply falls below a useful level.

The bottom line is that for typical discrete projects, there isn't much choice about the type of battery. We would be very happy to see energy efficient low-voltage projects using, say, a couple of coin cells on p.c.b. holders, which strikes one as a sensible way of powering projects that a hobbyist could perhaps assemble. Our series of solar-powered projects (*Perpetual Projects, EPE* July 2001 onwards) illustrates what can be done with simple low power designs. *ARW.*

New Technology Update

Ian Poole comments that laser light could be used as "optical tweezers", and new materials could allow superconductors to become more widely used.

THIS month there are two items of new technology, each in a different area but both related to electronics. The first is a fascinating new technique used to move minute particles around using a light beam. The second relates to superconductors.

Moving Particles

In some recent developments it has been shown that it is possible to manipulate minute particles using laser beams. It is anticipated that this could have applications in the manufacture of semiconductors and it is of particular interest and importance because particles as small as molecules, or even atoms could be moved using the new technique. It may also have other applications in non-electronics fields, including biomedicine, where the process could be used as a form of "optical tweezers" to pick up viruses and cells.

The work, by Bath University researchers, was reported in a number of papers, the latest of which was presented at the Laser and Electro Optic/Quantum Electronics and Science Show in May 2002. In this presentation the researchers outlined that they had been able to move and guide particles in a hollow core photonic crystal using laser light. However, work on the concept has been progressing steadily for a number of years.

Photonic Crystals

One of the key elements in the research is what are termed photonic crystals. These form light waveguides and have been known about for a few years. They were first demonstrated by the members of the Physics department at the University of Bath. They are unique because they enable a beam of light to be trapped inside a narrow bore hollow tube of glass. This is a remarkable because it appears to reverse the laws of physics. In a tube of this nature light propagates by undergoing total internal reflection. However, this only takes place when a ray of light passes from a more dense to a less dense medium, and this is not the case with a hollow glass tube.

Normal optical fibres consist of solid glass and the light is contained within the glass itself, so total internal reflection can take place as the glass is more dense than the surrounding air.

For the new fibres that are a hollow tube the researchers have been able to overcome the problem of the light passing from a less dense to a more dense medium by using what is called a photonic band gap. This is a phenomenon that can be observed if the glass used in the new hollow optical fibre has tiny air holes spaced throughout its length in a carefully determined crystalline pattern. The actual operation of this is quite complicated, but enables the light to be contained within the fibre. As the fibre is hollow it is used to trap both the light and the particle to be moved. In this way the particle can be moved over distances up to several metres, including around corners.

Particle Movement

The fact that light can move small particles results from the forces that are set up when the laser light strikes the particle in the tube. When a beam strikes a small transparent particle, the rays of light obey Snell's law and they are refracted accordingly. If the light is more intense on one side of the particle than the other, as is most likely to be the case, then some of the energy is transferred to the particle moving it in the direction of the light beam.

In a vacuum, the particles are able to move more freely, but in air, the molecules damp any movement and it is found that the particle settles in the middle of the light beam, which is in the lowest energy position. Momentum is also transferred to the particle in the direction of the laser beam, causing it to accelerate. These two forces permit particles to be held in suspension, cancelling the effects of gravity, and in this way it can effectively be used as a pair of optical tweezers.

The process is now being optimised. In some of the early experiments light leaked through the capillary tubes and reduced the efficiency. This problem has now been solved and photonic crystal fibres confine the light to the centre of the tube. Using the new fibre and an 80mW laser, polystyrene spheres that were $5\mu m$ in diameter have been moved at a velocity of 1·1cm/s. It has also been possible to move particles over the full fibre length of 150mm.

Although work is still progressing on developing the technique, it is expected to find uses in the semiconductor industry where the push to achieve smaller dimensions is forcing the need for new techniques such as this. It will be interesting to see how this develops in the coming years.

New Superconductors

Superconductors have been known for many years. Despite the fact that they are well established, they still appear to contradict the basic laws of electricity by having their resistance fall to zero when the temperature is reduced far enough. Although many new substances that exhibit superconductivity are being discovered, superconductors are only used in a limited number of applications. One of the reasons for this is cost. New high temperature superconductors have been discovered, but they are very expensive to manufacture. Even low temperature types are still reasonably expensive and require costly refrigeration plants. The combined cost makes them appear not to be viable in many applications.

However, it has been calculated that the cost of electricity for running a motor used in an industrial pump may be over 100 times the cost of the motor itself when the whole life of the motor is taken into account. This means that methods of reducing running costs are far more important than many people realise. In addition to this, superconducting machines can be made far smaller than their conventional equivalents.

Large Scale Applications

A new start-up company in the UK named Diboride Conductors is set to exploit a material called magnesium diboride that promises to bring superconductivity to large scale commercial applications. For many large applications it is expected that magnesium diboride will be far cheaper than the high temperature superconductors, and it will also cost less than a third of a machine using copper when all the life time costs are included.

Conductors are made by filling a metal tube, possibly an iron or copper tube, with magnesium diboride powder. The tube is then drawn in length, using a similar process to that used when manufacturing ordinary wire. During this process the powder is crushed so that it becomes very much finer. Once prepared the wire can be incorporated in the machine as required.

The one drawback of the material is that it requires temperatures around 20°K for it to operate as a superconductor. Whilst this is too low for liquid nitrogen, coolers using liquid helium can be used and, when all costs are considered, the solution is more cost effective than other machines using conventional wire, or even superconductors using more established superconducting materials.

Development is under way to improve its resistance to magnetic fields. It is expected that this will increase the number of applications for which it can be used, although it is still viable for use in many motors, generators and pumps. With the distinct cost advantages it should be interesting to see what take up there is of the new material in the years to come.

Further information about new technology as well as information in general about radio and electronics can be found at **www.radio-electronics.com**.

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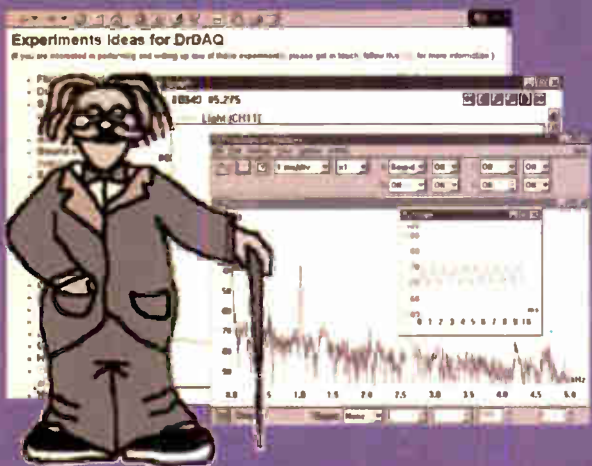

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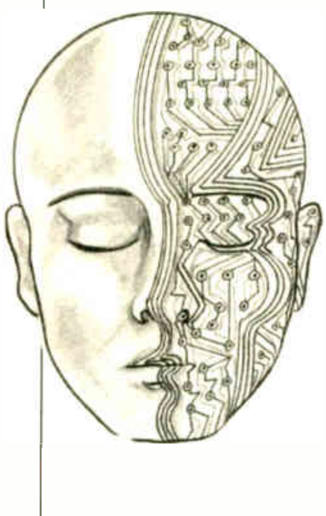

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One-Second Crystal Clock – A Second Source

THE One Second Crystal Clock circuit diagram shown in Fig.1 was devised through necessity. A simulator was required for a Bio-Botanical experiment at home. The requirements were for a cheap and quick construction, portability, low voltage/current, and a means of recording expired time periods.

The solution consists of a sensitive pick-up coil L1 placed close to an analogue quartz clock. The flux surrounding its motor is detected by the coil and fed to a two-transistor amplifier consisting of TR1 and TR2. The output from the amplifier is then coupled through capacitor C3 to a string of six CMOS inverters, IC1a to IC1f, to square up the pulse from the coil.

The output from the inverters is shaped by a capacitor-resistor-diode network C4, D1 and R6 which is used to trigger IC2, a CMOS 555 monostable timer. The timing period was set for 100 milliseconds: which was the required stimulus pulse. The monostable was fed to a transistor/l.e.d. circuit, which acts as a driver and indicator output stage.

Coil

The coil L1 consists of about 2,500 turns of 40s.w.g. (38 American Wire Gauge) of enamelled copper wire on a ferrite rod 10mm (3/8in.) dia. × 45mm (1 3/4in.) approximately The coil was placed in close proximity to the small quartz-driven clock which was purchased for 99p! It would be possible to take the signal direct from the stepper coil in the clock, something that some experimenters might like to try.

In my case, by noting the time of switching the system on and off a record of the number of stimulus pulses was obtained. It would also be possible to further divide, or multiply the pulses to suit individual applications.

H.King, Manchester

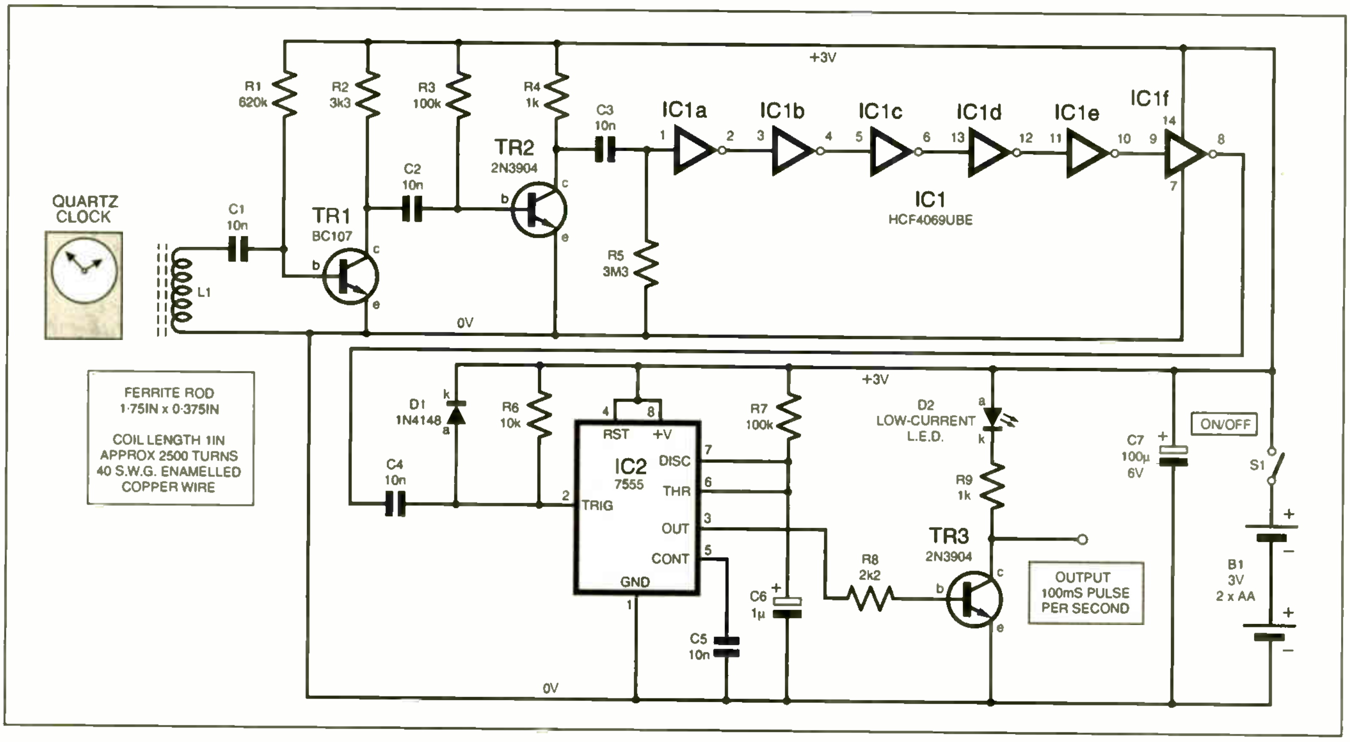

Fig.1. Circuit diagram for the One-Second Crystal Clock. Some clocks without seconds-hands do not impulse every second.

L.E.D. and Fuse Checker – Handy Unit

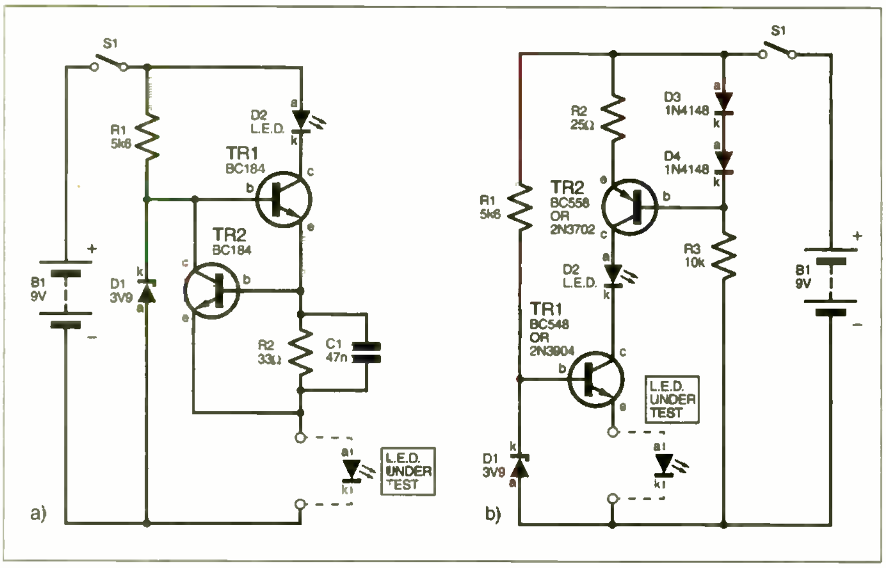

Fig.2. Circuit diagrams for the L.E.D. and Fuse Checker.

THE circuits shown in Fig.2 were designed for testing light emitting diodes (l.e.d.s) and also act as a continuity or fuse tester. A light-emitting diode can be tested with a 3V battery and series 39 ohm resistor, but the tester here has some advantages. It has its own l.e.d. indicator, which is useful in gauging the comparative brightness of an l.e.d. under test.

In Fig.2a, R1, D1 and TR1 form a voltage regulator giving about 3 volts at TR1 emitter, with TR2 acting as a standard current limiter, shunting from the Zener to lower the voltage and limiting TR1 current to about 20mA. Capacitor C1 was found necessary to stop oscillation. The transistor types are not critical and may be any small signal type such as the BC184.

The circuit shown in Fig.2b was devised after further experiment and performs the same function. TR1 is the voltage regulator and TR2 limits the current. Since the current limiting resistor is not in series with the output it gives a slightly higher output voltage.

The 3V level was chosen as this is the rating for the l.e.d.s in a digital display connected in reverse, the lowest rating likely to be encountered. This may not be enough voltage to test blue l.e.d.s so a 5·1V Zener diode could be used instead, with the 3·9 volt Zener switched in parallel by a "high/ low" switch. Low brightness "dud" l.e.d.s or super-bright types can easily be distinguished.

Of course, the l.e.d. indicator used in the circuit should be of known quality to allow meaningful comparisons. The tester can also be used for tests on fuses or filament lamps.

Colin Menear,
Birmingham

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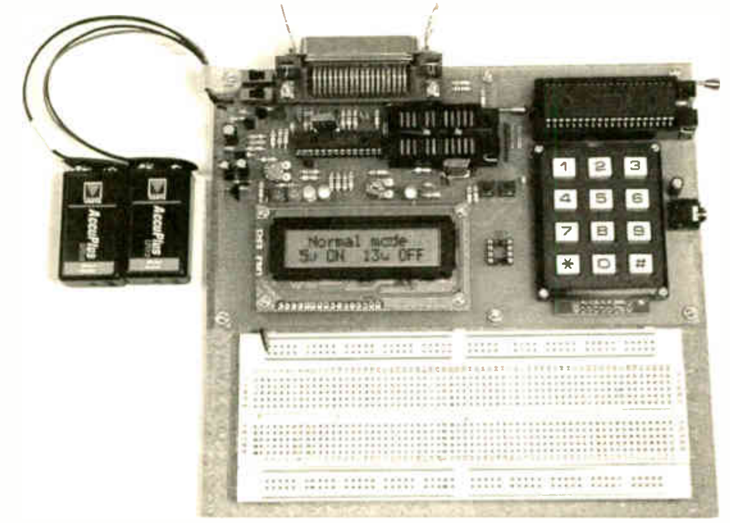

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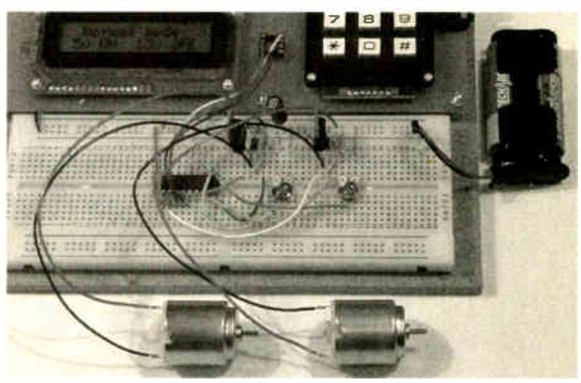
Hardware required

All systems in this advertisement assume you have a PC (386 or better) and a printer lead. The experiments require no soldering.



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FREE SUPPLEMENT

Collecting and Restoring Vintage Radios

By Paul Stenning

OVER the last few years, collecting and restoring vintage radio and other electronic equipment has become much more popular. I think this has been helped and encouraged by the growing popularity of the Internet as a means of communication.

Vintage radio collecting is not yet popular enough for mainstream publishers to produce magazines for general newsagent distribution (although, of course, *EPE*'s sister publication *Radio Bygones*, which is available on subscription – details later – covers this fascinating subject). At present the Internet fills that gap by allowing collectors around the world to communicate on their own terms. The time is now right to reintroduce the subject to the newsagent's shelves, via this special supplement to *EPE* magazine.

WHAT TO COLLECT

Some collectors specialise on sets from certain manufacturers, specific eras or design features. You may wish to collect a representative selection of models across the whole vintage radio era. Alternatively, you may prefer to collect whatever becomes available, that you like and can afford.

You are not limited to just broadcast receivers. Professional, military and ham radio equipment is very popular. Some people collect early television and video equipment, record players, tape recorders, car radios, hi-fi equipment, telephones, computers etc. Displays can be supplemented with valves, valve boxes, books, publicity material and other related items.

Radio Bygones magazine, a sister publication to EPE – *see page 15 for details.*

In this article I will concentrate on valve broadcast receivers. More specifically, I will discuss post-war circuit techniques. Post-war sets (in particular 1950's sets) are more readily available at reasonable prices, and are ideal for those new to valve radio repair. Circuit design tended to be more standardised as manufacturers tried to reuse chassis and sub-assemblies across a number of models. This means that you will be more likely to find suitable spare parts in scrap sets. However, much of the information in this article can also be applied to earlier sets and to other vintage electronic equipment.

BUYING RADIOS LOCALLY

You could scour the local car boot sales, antique dealers, junk shops, auctions and newspaper adverts. It is possible to find decent sets at reasonable prices by this means, but you are more likely to find lots of overpriced junk.

Try placing a "wanted" advert in the local newspaper. This will bring lots of enquiries, but you could waste a lot of time and petrol, viewing sets that turn out to be nothing like the descriptions.

Some collectors have had success at the local recycling centre. Speak to the person who runs the place. They may already have standing arrangements with local traders, but you could be lucky.

VINTAGE RADIO DEALERS

There are several specialised valve radio dealers, who have a stock of sets available. Most dealers will sell by mail order, although the carriage charges can add significantly to the cost.

Past Times Radio and Wireless Works offer a good range of reasonably priced sets, both restored and as-found, while On The Air specialise more at the top end of the market. I have had good dealings with these three suppliers and am happy to recommend them. They have websites, which show their current stock.

Note: Full contact details for all the companies mentioned in this supplement are given on pages 15 and 16.

SWAPMEETS, FAIRS AND AUCTIONS

The Radiophile and the British Vintage Wireless Society organise swapmeets and auctions of sets and related items. The prices paid at these events are generally fair, and it is possible to pick up some bargains, particularly later sets that need restoration. Many of the sets in my collection were purchased at these events.

Many dealers and private sellers attend the twice-yearly *National Vintage Communications Fair* (NVCF) at the NEC in Birmingham. This is the largest such event in the UK, so prices tend to be fairly high, but tatty unrestored sets can still be obtained for fair prices, particularly later in the day. (The next Fair is on September 15th 2002.)

INTERNET

Online auction sites, such as eBay, are a relatively recent way of buying vintage radios. A lot of items seem to sell for excessively high prices compared to swapmeets etc. I have seen sets sold at auctions that then appear on eBay within a few days and sell for a lot more. You are relying on the honesty of the vendor's description of the goods. The best advice I can give is to be wary, and also to remember that the carriage has to be paid separately.

Look for sales and wanted adverts on vintage radio websites. Malcolm Bennett's Vintage Radios has a section containing dozens of adverts. I have bought a couple of items through this route successfully.

There are also a couple of online discussion lists – such as the *Radio Bygones* message board – which sometimes have adverts from private collectors selling or even giving away sets. *Radio Bygones* also carries a Free Readers' Adverts page in each issue.

ASSESSING THE OVERALL CONDITION

Look at the general condition of the set, in particular the tuning scale, speaker fabric, knobs, cabinet, trim and back. If some of these are damaged or missing, you may have problems finding replacements or satisfactory alternatives.

In general, you should consider the appearance of the set above the electrical condition. Electrical problems can normally be overcome or worked around, whereas some cosmetic problems can be very difficult, or impossible, to resolve.

You may wish to remove the back and look inside. Always ask the seller or auction organiser first.

Remember that the set is between 40 and 80 years old, so do not expect it to look like new. Always consider the asking price when examining a set. You won't get a first-class set for a fiver (or ten dollars!). At auction viewings, decide how much you would pay, note it down and try not to get carried away when bidding.

SCRAP SETS

Do not disregard sets that are not worth repairing since they can be good as a source of spare parts. These can often be picked up for a couple of pounds in auctions (perhaps with badly damaged cabinets) which is less than you would pay for one of the valves or a couple of knobs. At swapmeets and fairs look under the tables – that's where the junk tends to be!

REPLACEMENT VALVES

Many valves are still available. There are still a lot of New-Old-Stock (NOS) valves appearing from old workshops and local TV and radio shops that are closing down. These tend to be available through specialist valve dealers like Wilson Valves or Valve and Tube Supplies.

Most of the new valves from such dealers will be NOS, although some genuinely new valves are still manufactured (mainly in the former Soviet Union by companies such as Svetlana, for the hi-fi market). New and NOS valves are normally guaranteed for three months, but this guarantee is void if the valve is damaged by a set fault.

If a new replacement valve is not available or is too expensive for your budget, many dealers sell used-tested valves. Wilson Valves and Valve and Tube Supplies each have a vast range, with many costing less than five pounds.

Do not assume that all valves are available. Some earlier valves can be more difficult to come by – which will be a problem if your interest is sets from the 20s and early 30s. However, most replacements for 40s and 50s sets should not present any problems.

OTHER COMPONENTS AND PARTS

Generally, the main problem areas are items of cabinet trim, speaker fabric, tuning scales and knobs. Sid Chaplin supplies a selection of modern replacement fabrics as well as Rexene, brass clips and hinges, handles etc.

There are often boxes of knobs at swapmeets, with a typical price of around 50p per knob. As mentioned above, scrap sets are a good source of components. Obviously, you need to be selective and to choose scrap that is similar to the sets you collect.

SERVICE INFORMATION

Unless the work required is minimal, it is worth obtaining a copy of the relevant Service Sheet. I have produced three *Vintage Radio Service Data* CD-ROMs (containing information on approximately 3,000 different receivers), which may be of interest to those who repair sets regularly. These are available through the *Radio Bygones* (*RB*) *Bookshelf.* For more occasional or one-off jobs I also offer a low cost Service Data by email facility via my website.

There are a number of suppliers of photocopied service data. Savoy Hill Publications claim to have the largest collection of service manuals in the UK, and will supply a comprehensive service data pack for around £12. Other suppliers are listed at the end of this article.

The Newnes *Radio and Television Servicing* books, published annually from 1953, contain circuit diagrams and basic service information for many sets produced in the year of publication. These are often available at swapmeets and fairs for a few pounds each, and may still be available at your local library.

If you cannot find the exact data for your set, look for data on similar models from the same manufacturer. Often the circuit design did not vary greatly from one year to another.

Some manufacturers produced sets under more than one brand name, especially in later years as companies merged. For example, Philips made sets under the Mullard and Cossor brands.

VALVE DATA

A valve data book is useful, particularly if you do not have the service sheet for a set. *Radio Bygones* offer reprints of Bernard's Valve Data books for very reasonable prices. It is also worth looking out for original data books – particularly Mullard and Brimar publications.

I have also produced a Valve Data CD-ROM, which contains scanned copies of a number of useful publications, including Mullard, Mazda and Brimar valve data books, together with manuals and data charts for several valve testers, again available through the *RB Bookshelf.*

Data CD-ROMs available from the RB Bookshelf.

There are also a few websites offering valve data on-line. Duncan Amplification has a useful database program for Windows (giving basic characteristics and pinouts) available for free download. A wide range of original valve data is available for download at Nostalgia Air.

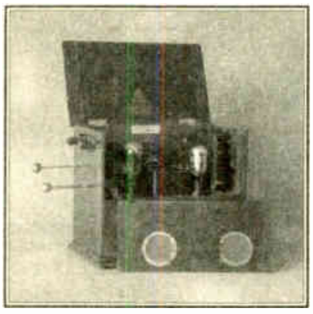
TOOLS AND TEST EQUIPMENT

Many readers of this magazine will probably already have a good electronics toolkit, containing a soldering iron, desoldering tool, screwdrivers, cutters, pliers, adjustable spanner, etc. You will probably want to add nut spinners to suit 2BA, 4BA and 6BA nuts. You may also need to buy a more substantial soldering iron, rated at around 40 or 50 watts for working on large tagstrips etc.

The only item of test equipment I would regard as essential is a multimeter. A basic

DESIGN, AVAILABILITY AND PRICES

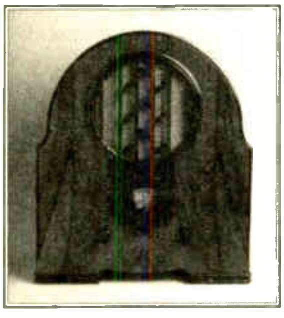
Up to about **1926**, radios look like scientific equipment and have wooden boxes, ebonite panels, and valves sticking out, exposed to danger. These sets are very desirable and a crystal set will usually cost over £100, with the early valve stuff being between £50 (home-made) and a couple of grand (commercial, rare, and very tidy).

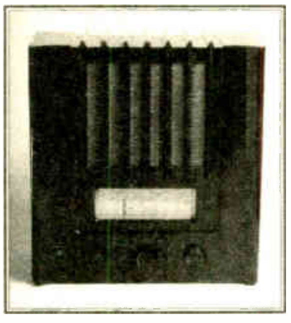


A Marconiphone V2A set from 1922/23 (left) and a Ethophone Junior Crystal Set Mk II from 1923. (Courtesy *Radio Bygones*)

From about **1926** to **1932**, they look like boxes with things inside, often under lift-up lids. Home made here £20 to £100, and commercial probably £20 to £1000 depending on how scrumptious. There is almost nothing available from this era – only what comes from the dispersal of a deceased collector's hoard.

From **1932**, there was a sea change in styling, and the sets become styled as radios, because all of a sudden, a radio is important enough and confident enough to make its own style. It's an Art Deco box with guts inside and a few well-chosen controls made available to the punter who bought it. It's becoming furniture that talks rather than scientific instruments. Until 1934 you find small dials, wild Deco cabinets, TRF circuits, great rarity and desirability, and £50 to £500 should be the bracket.





A Philips 'Superconductance' Model 634A from 1933 (left) and the Murphy AD94 from 1940. (Courtesy *Radio Bygones*)

After **1934** things began to settle down to a superhet circuit in a cabinet with a big, clear, back-lit dial, and slightly less Deco styling to the cabinets. Some TRFs (Tuned Radio Frequency sets) left, and these always a little more desirable (more fun to fix) and slightly higher price, but 1934 to 1937 sets sell for £50 to £250 normally. The major exception being the round Ekcos (AD55 – 1934, AD36 – 1935, AD76 – 1935, AD75 – 1940, AD22 – 1945) which now fetch very high prices – or mental prices if they are the original (beware of fakes) in special colours.

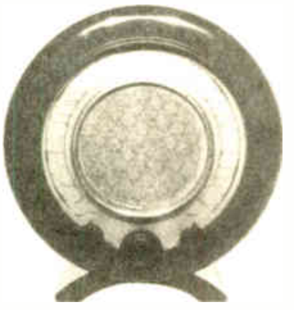
1938 was an exceptional year. Huge sets with loads of valves, push-pull, press-buttons, magic eyes, lovely veneered cabinets, maybe even motor tuning. In my opinion, we never made better sets, before or since – the pinnacle of achievement in the field of AM domestic sets. Motor tuners and sophisticated sets £100 upwards.

Most of the good stuff has been found, and snapped up into collections. Most of the really rough stuff has been thrown away or broken up for scrap. Some nice things are still turning up, but mostly it's just fairly run-of-the-mill things.

1939, back to earth with a bump. Some push-buttons, but not many, and almost no motor tuners. Some adventurous souls going to European Side Contact valves (i.e. Pye, Ekco), much simpler circuits and far fewer valves. 1940 more of same. 1941 almost nothing made. Radios from this period are hard to find. Prices start at £70, with very few seriously expensive, except Murphy AD94 (few hundred pounds).

No sets until about **1944**, when we get the Wartime Civilian Set. These are £20 to £150 depending on how well it's been looked after and/or restored. Some of the late Civvies made in **1945** had three knobs and LW coverage added, which can add a few pounds to the value.

The sets made in the war were not made in big numbers and are not common but they are still turning up from time to time, and not always just from collectors who have passed away.



A Wartime Civilian set (left) and the Ekco A22 from 1945.

1945 to **1949**. Sets of post-war vintage in general vastly improved in terms of ease of servicing. They had quite austere square woody cabinets in general, because of shortage of materials and labour. Some 1945 sets are literally the same tooling as the 1939 sets, pressed back into production as quick as possible, with new sets in 1946. Some of this stuff is getting harder to find, but in general there is enough to go round. Pay £10 to £150 in general, but for the Ekco A22 a lot more!

1950 to **1954**. Smaller valves. Even the table models which are quite large are not so deep front to back and will stand on a shelf, not a big table. All are buyable at £10 to £100, no need to go mad, although the classic Bakelites are harder to find and to pay for. Some of this stuff looks older than it is, passing for a 1930s set easily enough, though some of it is ultra-modern for its day and looks 1960s. We had lighter woods, outlandish Bakelite shapes and colours for the ultra-modern types, and dark wooden cabinets for the more traditional customers.

1954 onwards, FM comes along. FM sets more useful to the general punter, but harder to fix for the amateur, so no particular upward pressure on prices, as users want FM, restorers want it older or AM only in general, so each to his own. All are still available; there is no need to spend mental money.

1960s valve sets are quite scarce, as most sets used transistors, and these might get pricey in the end, like the 1940 sets, due to lack of numbers. Plenty of this sort of age around still. You can get given these if you're lucky. There is a school of thought that says that 1960s valve radios are rarer than 1930s valve radios, but a lot cheaper, and therefore well worth collecting.

Transistor sets are finding a ready market because a lot of younger collectors have never been taught how a valve works, even if we are graduates in Electronic Engineering, so it's easy to collect the trannies and not bother with the valves. They are smaller as well, so the house takes longer to fill up!

An excellent book which carries hundreds of photos plus details of sets is *Radio! Radio!* by Jonathan Hill. This book will aid the identification and dating of sets from the 1920s through to the 1960s, plus listing of nearly 3,000 different transistor models. It has become the bible of UK vintage radio.

digital type is ideal, and has the advantage of a high impedance input. Some repairers hate digital meters, and swear by analogue types. If you want to go for analogue, choose a model with a large, clear scale. A small cluttered scale will put you off analogue meters for life!

Period service data often quotes measured voltages assuming a fairly low input impedance analogue meter. A digital meter may give higher readings for some measurements because it loads the circuit less, and you will need to make allowances for this.

A loudspeaker in a wooden cabinet is useful when testing a chassis that has been removed from the cabinet. This allows you to get the radio cabinet off the bench and out of the way.

Eventually you will need to realign the RF and IF circuits of a set, and for this you need an RF signal generator, covering the range 150kHz to 100MHz, with an option to amplitude-modulate the output with an audio tone. I have a Heathkit unit which cost me about five pounds in an auction. After a couple of basic repairs it works fine.

If you already own an oscilloscope you will find it useful occasionally, but it is not really worth buying one for valve radio work alone.

Another optional item is a valve tester. These are available from the same auctions and swapmeets as radios, and sell for between £50 and £100 typically. Note that valve testers will sometimes condemn valves that actually work fine in a set.

SAFETY

It is essential to realise that vintage sets do not comply with the latest electrical safety regulations and also often work at very high voltages – *350V DC* for the high tension line is not unusual. Such sets can also have live chassis and hence can be very dangerous to work on – beware, a shock from such a set can kill you.

An *essential* safety item is a Residual Current Device (RCD) or Earth Leakage Circuit Breaker. These are available as adapters for use with power tools etc. Plug this into a wall socket, and power the set you are working on *plus* the test equipment from it, via a four-way extension lead.

For improved safety, I would strongly recommend the use of an isolating transformer. A 100VA type is adequate for most domestic sets. An isolation transformer is *essential* if you need to connect earthed test equipment to an AC/DC radio.

Neither an RCD nor a transformer will provide protection against a shock from a charged capacitor, so sensible precautions must always be taken.

When working on live equipment, always use one hand only (put your other hand in your pocket) to prevent shock current from passing through your body and across your heart. Ensure the chassis is supported steadily, so you don't need to steady it with your other hand while working on it. When checking voltages, always clip the negative terminal of your meter to the chassis so voltages can be measured using only one hand.

Switch off the supply and allow the capacitors to discharge before connecting or disconnecting anything, and before handling the chassis.

Many sets were of the live chassis type, where the chassis is connected to one side of the mains. Before operating these, ensure that the chassis is connected to the neutral side of the mains, as this is generally within a few volts of earth potential. Some sets have a single pole mains switch, and this does not always break the live mains lead – rewire it if necessary.

Another danger is the high temperatures of the valves and high power resistors. Rectifier and output valves, in particular, can become hot enough to cause nasty burns.

Be careful

DISASSEMBLY

Often the first stage of any repair and restoration is to remove the chassis. With some sets, reasonable access can be obtained without disassembly (via an access plate in the bottom of the cabinet), but if you are planning to do anything more than a basic repair the chassis will have to come out anyway, so you might as well do it before you start.

Disassembly should be carried out with care, so as not to cause further damage. It is worth sorting the various screws and small parts into separate containers, and making notes or sketches so that you can remember how it all goes back together. Photographs from a digital camera are also useful if you have one.

REMOVING THE KNOBS

It will often be necessary to remove the knobs before the chassis can be withdrawn. This is usually easy, but a little corrosion in the wrong place can cause real problems.

The most common fixing method is grub screws, accessible through small holes in the side of the knobs. Sometimes the screw passes through a hole in the shaft, so complete removal is needed. The grub screw hole in the knob may be filled with wax or a second plastic grub screw. **This is a safety precaution on live chassis sets and it is imperative to replace the filling when the set is reassembled.**

If the grub screw will not shift relatively easily, squirt a *small amount* of WD40 into the hole and leave it for half an hour. Often this will penetrate sufficiently to allow the screw to be removed.

If the grub screw still refuses to budge, or the screwdriver slot is damaged, you may have no choice but to drill it out. This is a last resort however, because of the risk of damage to the knob. Flexible drill chuck extensions are available which can help. Use a low speed battery drill and take it steadily.

If there is no grub screw hole, the knob is either a push-on type or is retained by an internal screw, accessible either from inside the cabinet or through holes in the base.

Push-on knobs can be difficult to remove. If you cannot pull it off with your fingers, lay the set so that the knobs are uppermost. Wrap a length of strong cord or fabric strip around the base of the knob two or three times to form a loop and gently pull the knob off. *Never* use a screwdriver to lever the knobs off, you will damage the case or break the knob.

In some cases, the control knobs will be on the glass tuning scale. If so, loosen the chassis mounting screws and move the chassis slightly. If the tuning glass moves too, it is attached to the chassis so it is not necessary to remove the knobs at this stage.

REMOVING THE CHASSIS

In most wooden and heavier Bakelite cased sets, four screws or bolts on the underside of the cabinet retain the chassis. The cabinet feet may cover the screw heads. On some lighter sets, particularly AC/DC sets, the chassis fixing screws may be internal.

You may have to disconnect the leads from the loudspeaker or output transformer before you can remove the chassis, and possibly remove the dial lamps. Before disconnecting any wires, note their positions carefully. Sometimes the leads are fitted with plugs or terminals to enable easy disconnection, but more usually, they will be soldered.

TESTING AN UNKNOWN SET

Don't just plug in the set and see what happens! Several things could happen, and most of them are not desirable. Some systematic checking will pinpoint many problems before any harm is caused, and a cautious approach when you do show it some power will reduce the risk of anything you've missed causing serious harm.

Examine the chassis carefully. Look for signs of previous repairs or "bodging". Check anything that is not original manufacture against the service sheet. Tidy and correct anything that is wrong or badly done.

Look for signs of trouble. Burnt-out resistors, swelling ends on electrolytic capacitors, wax-paper capacitors that are dribbling wax or have blown themselves apart, Hunts capacitors that are falling apart, and anything else that just doesn't seem right. If you read the later sections of this supplement detailing the circuit operation, you will have a good idea of what you are look for.

In AC/DC sets, if there is a capacitor connected directly across the mains input and it hasn't already blown itself apart, remove it. It is very likely to go off with a bang when you apply power, particularly if the set hasn't been used for some time. You can fit a replacement later.

I normally disconnect the output valve grid coupling capacitor and connect a temporary replacement at this stage.

Check the primaries and secondaries of the mains and output transformers with a meter. The service sheet gives the actual resistances, but you can be generally happy if they are not open-circuit. On AC/DC sets, check the dropper resistor.

Measure the resistance across the HT line. It will probably start low and climb as the smoothing capacitor charges. If it stays low (below about 10kΩ), something is probably wrong and should be investigated. A leaky smoothing capacitor is a likely suspect.

On sets that do not have an isolating transformer, make sure the chassis is connected to the neutral side of the mains.

Check the valves are the right types in the correct sockets. If any of the valves have what looks like a milky white deposit on the inside of the glass, the vacuum has been lost and the valve must be replaced.

Check the dial lamps (if fitted) and replace if necessary. Refit the knobs so that you don't have to touch the metalwork with the set powered. Reconnect the speaker, output transformer and anything else you disconnected previously. If the set does not have an internal aerial, connect a few feet of wire to the aerial socket.

APPLYING POWER FOR THE FIRST TIME

For the initial tests, the set should be powered with a 100W lamp in series with the live mains connection. If the set is consuming the right amount of current, the lamp will scarcely glow and the set will receive close to the full supply voltage. If there is a problem that causes it to draw

The Pye P131MBQ "Jewel Case Portable", a four-valve AC mains and battery set from the late 50s.

The Bush MB60, a mains/battery valve portable from 1957. Various transistor models such as the popular TR82 also used this case and it is now available new as a re-creation of the original set.

HOW DO VALVES WORK?

To those of us who have been brought up with transistors, valves (called tubes in the USA) can seem unnecessarily complex. I will attempt to explain the workings of the valve in a clear simple manner – without the atomic theory and the maths!

A BRIEF HISTORY LESSON

In 1883, Thomas Edison was experimenting with electric lamps. In his early experiments, the glass bulb was becoming dull, and he wondered if this was due to particles being given off by the filament. He fitted a metal plate inside the bulb to attract these particles, and found that if the plate were at a positive potential a current would flow from the filament.

Later Professor Flemming found that current only flowed when the plate was positive, and that the arrangement could be used to rectify an alternating voltage. He patented this in 1904.

Lee de Forest discovered that, by placing a wire between the filament and plate, the current could be controlled. Thus, he invented the triode (or Audion as he called it) – the first electrical amplifying device.

THERMIONIC EMISSION

When a metal is heated to a sufficiently high temperature in a vacuum, it will give off electrons. These will be attracted to any electrode that is at a more positive potential.

Most metals will melt by the time they are hot enough to emit a significant amount of electrons. Tungsten is an exception, which gives good emission at 2300 to 2500 degrees Centigrade, and melts at 3380 degrees Centigrade. This would glow almost as bright as an electric lamp, which was a characteristic of early "Bright Emitter" valves.

In later valves, the tungsten was coated with an oxide (such as barium or strontium), which gives good emission at around 700 degrees Centigrade.

In most valves, the emitting conductor is a separate component to the heating filament. The emitting conductor is known as the cathode, and is normally in the form of a thin tube. The heater passes inside the cathode and is electrically insulated from it. This is known as an indirectly heated cathode. However, most early valves, and those intended for battery operated radios, have directly heated cathodes, where the heater and cathode are the same component.

ELECTRON FLOW VS. CONVENTIONAL CURRENT FLOW

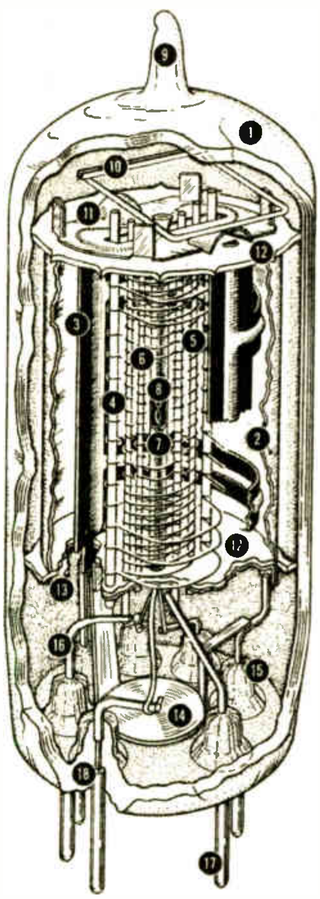
We are now used to thinking of current flowing from positive to negative. However, current is actually a flow of electrons in the opposite direction. This anomaly is the result of an incorrect assumption by early scientists, which has become established – hence we have the separate terms Electron Flow and Conventional Current Flow.

To avoid confusion (hopefully!), think in terms of electron flow when considering the actual workings of the valve, and conventional current flow when thinking about the circuit.

THE DIODE

The electron collecting plate is known as the anode. It normally consists of a cylinder or rectangular box of metal around the cathode, a few millimetres away.

When the anode is positive, the (negative) electrons emitted by the cathode are attracted to the anode and hence there is a current flow.



Structure of a Miniature Valve

1 – Glass Envelope. 2 – Internal Shield. 3 – Anode. 4 – Grid No. 3 (Suppressor Grid). 5 – Grid No. 2 (Screen Grid). 6 – Grid No. 1 (Control Grid). 7 – Cathode. 8 – Heater. 9 – Exhaust Tip. 10 – Getter. 11 – Spacer Shield Header. 12 – Insulating Spacer. 13 – Spacer Shield. 14 – Inter-Pin Shield. 15 – Glass button-Stem Seal. 16 – Lead Wire. 17 – Base Pin. 18 – Glass-to-Metal Seal.

However, when the anode is negative the electrons are repelled from the anodes and hence no current flows. This is useful for detection and rectification, but is obviously incapable of amplification.

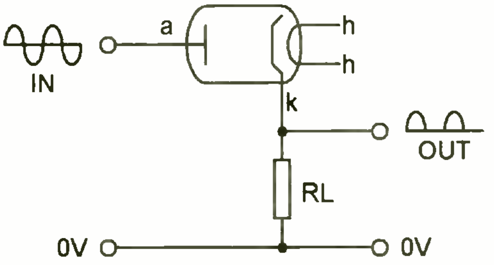


Fig.1. Basic valve rectifier circuit.

A rectifier valve has larger, more substantial electrodes than a detector diode, to cope with the much greater currents involved. Fig.1 shows a rectifier valve circuit with an AC input and a half-wave rectified DC output.

A smoothing capacitor would normally be connected across the load (RL) to give a relatively steady DC supply. The load would normally be the remainder of the circuit rather than a single resistor.

The valve electrodes are indicated by the normal abbreviations – *a* for anode, *k* for cathode and *h* for the heater connections. A heater supply is not shown in the diagram for simplicity.

THE TRIODE

By adding a spiral of wire or a wire mesh between the cathode and the anode, it is possible to control the current flowing between them. This additional electrode is known as the control grid.

Referring to Fig.2, if a varying signal is applied to the control grid (g1) via C1, the anode current will vary in sympathy. By placing a resistor (RA) between the anode and the positive supply, the varying current will be converted to a varying voltage on the anode.

In normal use the control grid will not be at a positive potential relative to the cathode, otherwise it will act as another anode and draw current (known as grid current). It is normally biased a few volts negative. In very early radio sets, a separate grid bias battery was used, often having several tappings to give different bias levels – but this was quickly superseded.

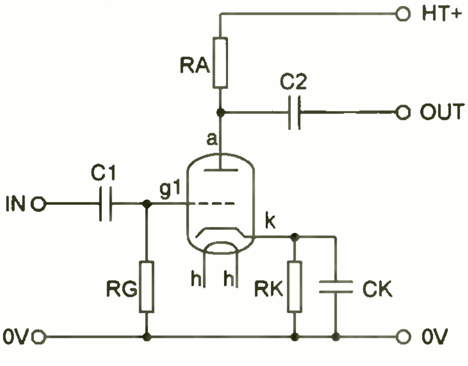


Fig.2. Basic triode valve amplifier circuit.

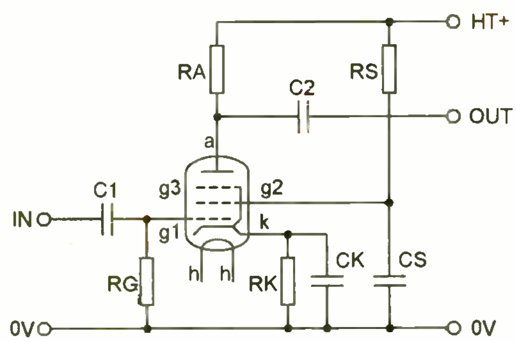


Fig.3. Basic pentode amplifier stage.

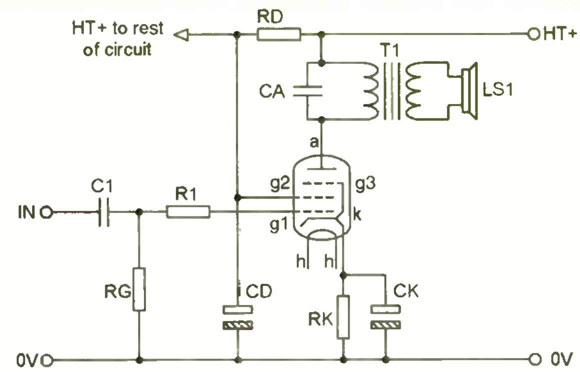


Fig.4. A typical Class-A pentode valve output stage.

Usually cathode biasing will be used. Instead of connecting the cathode directly to ground (0V), it is connected via a low value resistor (RK). This will drop a few volts, so the cathode will be a few volts positive. The control grid is at high impedance and draws virtually no current. It is normally connected to ground via a high resistance (RG), and the signal is coupled via a capacitor (C1).

If CK is omitted, the voltage at the cathode will vary with the anode current. This causes negative feedback, which gives a reduction in gain (and also reduces distortion). CK is fitted to obtain the maximum gain from the stage, and has a low impedance over the signal frequency range.

Triode valves are mainly used for low-level audio amplification. Their use is limited at radio frequencies because of the capacitance between the control grid and the anode. Although this is only a few pF, the "effective capacitance" is approximately equal to this value multiplied by the stage gain. This effective capacitance becomes the input capacitance of the stage, and has a drastic shunting and detuning effect on a radio frequency signal.

THE TETRODE

The tetrode was a development of the triode, designed to overcome the effective capacitance problem. A second grid is placed between the control grid and the anode. It is known as the screen grid, and acts as an electrostatic screen, the purpose being to minimise the capacitance between the control grid and anode.

For this to work it must be connected to ground at signal frequencies. If it were connected directly to 0V it would act as another control grid and greatly reduce the anode current. It is therefore often connected to the HT rail via a resistor to drop some voltage, and decoupled to 0V with a suitable capacitor.

The tetrode solves the capacitance problem allowing operation at high frequencies, and also gives greater gain. However, it introduces another problem – limited output voltage swing if distortion is to be avoided. This is caused by secondary emission, which is too involved to describe in this brief article. Consequently the use of the tetrode is generally confined to 20s and early 30s sets, but it is included here because it is an important stage in the development of a better solution.

THE PENTODE

As its name implies, the pentode has five electrodes. Four of them are the same as those in the tetrode, namely the cathode, control grid, screen grid and anode.

To suppress the secondary emission a further grid, known as the suppresser grid, is added. This is normally connected to the cathode, sometimes internally within the valve envelope, otherwise a separate connection is provided.

The result is a valve that retains the advantages of the tetrode – high gain and operation at high frequencies – without the distortion. Pentodes are commonly encountered in RF and IF amplifier stages, and in amplifier power output stages.

The circuit of Fig.3 shows a basic pentode amplifier stage. This is fairly similar to the triode circuit discussed previously, with the addition of the connections to the screen and suppresser grids (g2 and g3).

VARI-MU VALVES

It is often necessary to be able to control the amplification (gain) of a valve either manually or automatically. This is commonly required in the AGC (Automatic Gain Control) circuits in radio receivers.

To achieve this the spacing of the wires that make up the control grid are varied, being closer together at the centre and wider apart at the ends. By varying the negative voltage on this grid, the gain can be adjusted.

PENTODE POWER AMPLIFICATION

The circuit in Fig.4 shows a typical Class-A pentode output stage. The anode load resistor is replaced with the primary of the output transformer (T1), which drives the loudspeaker (LS1). The purpose of the transformer is to convert the relatively high anode impedance of the valve to the low impedance of the speaker.

Since the output transformer is inductive, its impedance varies with frequency giving an uneven frequency response. A capacitor (CA) is often connected in parallel with the transformer primary, which corrects this to a great extent (this is sometimes referred to as tone correction). In some cases more than one capacitor is used, together with series resistors to give correction that is more accurate.

The screen grid (g2) is shown connected to the HT supply after a decoupling resistor (RD). This is a common arrangement in valve radio receivers.

A resistor, referred to as the "grid-stopper", may be placed in series with the control grid (g1). This works in conjunction with the input capacitance of the valve to attenuate the high frequencies (above the audio range) to ensure stability.

Many hi-fi amplifiers and some more expensive valve receivers use a Class-B push-pull output stage. This is an involved subject in its own right and will not be covered in this brief article. A higher quality output transformer is normally used in conjunction with negative feedback, which makes impedance correction capacitors (such as CA) unnecessary.

OTHER VALVE TYPES

A number of special-purpose valves have been produced with a greater number of electrodes. For example, hexodes, heptodes and octodes (containing six, seven and eight electrodes respectively) are sometimes used in mixer-oscillator stages. The operation of these valves is rather complex and I will not attempt to describe them here!

COMBINED VALVES

Often more than one valve section is contained in a single glass envelope. These sections normally share the same heater connections and are sometimes interconnected.

The mixer-oscillator valve in radio receivers often consists of a hexode (or similar) and triode sections in the same envelope. The triode is used as the oscillator section and the hexode acts as the mixer and amplifier. The two sections may be connected internally within the valve, or externally.

The first AF stages generally use valves containing several diodes plus a triode in one glass envelope.

FURTHER READING

Those requiring a more detailed discussion of valve operation are advised to refer to the book by Chas E. Miller entitled *Valve Radio & Audio Repair Handbook* (see page 16).

excess current, the bulb will glow brighter and the voltage applied to the set will be reduced. It gives a degree of protection to the set, and a warning that all is not well to you. Once you are happy that nothing is seriously wrong the lamp should be removed from the circuit.

Arrange a safe mains connection, with the lamp in series, positioned so that you can switch it off quickly if necessary, without leaning over the chassis. Connect a test meter on an appropriate DC voltage range across the HT (if in doubt set it to 1000V DC).

Switch the power on. After several seconds, all the valve heaters will start to glow, and the dial lamps should illuminate. The valve heater is in the centre of most valves and can usually be viewed from the top. Note that the valves in a battery set will probably not glow visibly. The same situation will also occur if battery type valves are used in a mains or mains/battery set. Some valves are coated or have metal cases such that the innards cannot be seen.

If nothing happens, the power switch may not be switching reliably. Operating the switch a few times with the power applied will often burn through the tarnishing and get the switch working.

If the heaters seem OK, leave the set on for a little longer and watch the HT voltage reading closely. After maybe ten to thirty seconds the HT should start to rise, and will reach a maximum of perhaps 220V to 350V after a further five to fifteen seconds. The voltage will then begin to drop again, by between ten and fifty volts, as the output valve warms up.

VOLTAGE CHECKS

Check the service information for the correct voltage on the cathode of the rectifier valve. The actual voltage can vary by about 10%, but any greater discrepancies should be investigated. If you are running the set through a series lamp, all the voltages will be a bit low.

If you have a digital meter with a high impedance input, measure the voltage directly across the control grid resistor of the output valve. It should be virtually zero or slightly negative. If there is a positive voltage here (more than about half a volt), the coupling capacitor is probably leaky, or the valve may be faulty.

In AC/DC sets, you may see a gentle wisp of smoke from the dropper resistor as the dirt burns off. This may continue for several minutes. As long as it remains just a gentle wisp, don't worry about it.

After a few minutes, carefully feel the case of the smoothing capacitor can (***switch off first***). It should be cold. Any warmth suggests that the capacitor is leaky.

If you are really lucky you may hear something from the speaker – but do not worry too much if you cannot. If you can tune in stations and the sound quality is OK, there probably is not too much wrong!

The series lamp should be scarcely glowing. Normally the filament will be glowing a gentle orange only. If it is brighter than this, there may be a fault that is causing the set to draw excessive current. Once you are happy that nothing dramatic is going to happen, switch the lamp out of the circuit so that the set is working from the full supply voltage. Some sets will not work correctly from the reduced voltage supply via the lamp. However, the purpose of the lamp is to help us confirm there are no major problems in the power supply and output stage. Once this is done, it is no longer needed.

QUICK CHECKS

If the set does not work properly, a few simple tests and observations may help to narrow down the faulty section.

If you get a loud humming noise from the speaker, or the stations sound like they are broadcasting from under water, one of the main electrolytic smoothing capacitors has probably failed.

If the set seems dead, listen closely to the speaker for signs of life. If you can hear some sort of hum or noise, albeit faintly, then the power supply and amplifier are probably doing something. If it is completely silent, check the connections between the output transformer and speaker. The primary of the output transformer may be open-circuit.

Turn the volume right up and touch a screwdriver blade on the centre tag of the volume control potentiometer. If the amplifier is working you should hear a buzzing from the speaker. This would confirm that the amplifier and power supply are alive.

If there is background hum but no buzzing when the volume control tag is touched, the fault may be in the audio pre-amplifier stage. The anode load resistor for this will sometimes be found to be open-circuit.

With the volume turned up, operate the wavechange switch. If there are healthy crackles from the speaker, the IF and detector sections are probably alive. Confirm that the set is definitely dead on all wavebands. If some wavebands are working, the fault is narrowed down to those components or circuits that are used only on the faulty bands.

On VHF sets, the VHF band will often be dead while MW and LW work OK. The usual cause is low emission valves on the VHF tuner assembly.

If the IF seems OK, try connecting an aerial or a length of wire to the control grid of the mixer-oscillator valve. If this produces some sort of noise or even stations, the connections and coupling between the valve and the aerial socket or ferrite rod aerial may be suspect.

If noise is heard which alters in note and volume as the set is tuned across the band, this may indicate that the local oscillator is not working.

CIRCUIT OPERATION

In this section, I will give a brief overview of the circuit operation of AM and FM valve radios, highlighting common fault areas. Due to space restrictions, this will be limited to the more common circuit arrangements. This subject is covered in much greater detail on my website and in some of the recommended books – see later for details.

POWER SUPPLY CIRCUITS

There are two basic power supply arrangements, depending on whether the set is designed for use on both AC and DC mains or on AC mains only.

AC only sets use a transformer to power the valve heaters and the full-wave HT rectifier (Fig.5). The valve heaters and dial lamps are connected in parallel and powered by a low voltage winding, often 6.3V. The rectifier heater may be powered from a separate winding and may be a different voltage. The transformer normally provides isolation from the mains, allowing the chassis to be earthed for safety if required.

In AC/DC sets, the valve heaters are connected in series and powered via a high power dropper resistor directly from the mains input (Fig.6). The heater current is 100mA in many later sets. The dropper resistor often has to drop around 100V and runs fairly hot, and thus failure is not uncommon. This component often contains several resistance sections for voltage selection etc. The normal repair is to bridge the faulty section with a wire-wound resistor of suitable resistance and power rating.

Dial lamps (where fitted) are connected either in the heater chain or in the neutral connection to the whole set, and are

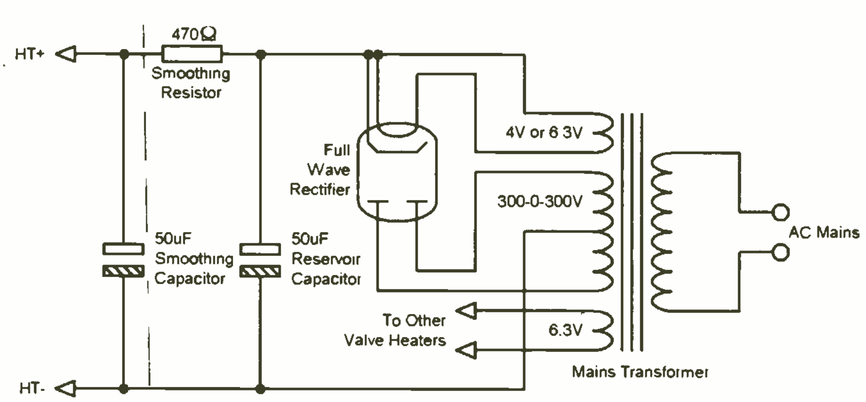


Fig.5. Power supply of a typical AC set.

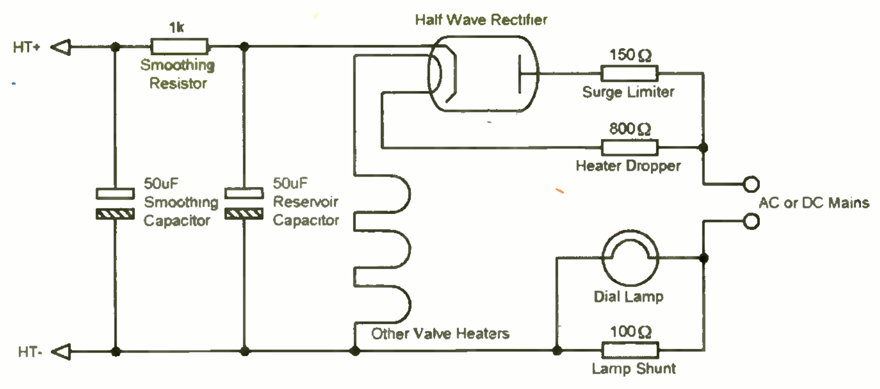


Fig.6. Power supply arrangement for a typical AC/DC set.

normally shunted by a parallel resistor or thermistor to keep the set running if a lamp fails. The HT is derived by half-wave rectifying the mains. The chassis is therefore connected directly to one side of the mains (hopefully neutral!). AC/DC sets should therefore be regarded as *more dangerous to work on than AC only models.*

Often a capacitor is connected directly across the mains input of AC/DC sets. The purpose of this is to prevent modulation hum (a hum or buzz when the set is tuned to a strong signal). This capacitor will often be found to have blown itself to pieces, and should *always be replaced with a Class X2 suppression component.*

Some sets use a combination of AC and AC/DC techniques. Circuit operation is usually evident by examining the circuit diagram. It should be noted that some of these sets use an autotransformer and thus *do not* provide isolation. ***Therefore, the fact that a set has a mains transformer should not be taken to mean that the chassis is isolated from the mains.***

With all power supply arrangements, it is important to ensure that the voltage selector is set to the appropriate position to suit the mains supply voltage in your area (usually 230V/240V in the UK). Incorrect setting can result in valves and other components being over-run, considerably shortening their lives.

SMOOTHING

Whatever type of power supply is used, the rectifier will be followed by a smoothing capacitor. There will normally be further stages of smoothing and decoupling for the earlier circuit stages. The smoothing and decoupling capacitors are high voltage electrolytics of 8μF to 50μF. Two or three capacitors are normally contained in a single can. With age and lack of use, these often become electrically leaky and low capacitance. If the seal is swelling or there are signs of the electrolyte leaking out the capacitor is unusable.

Electrically leaky electrolytics may reform themselves when the set is powered, but if they are too bad they could become very hot and possibly explode. The use of a 100W bulb to limit the mains current when initially testing a set will give you sufficient time and warning to switch the set off if the HT current is excessive.

The electrolytic cans are (generally) no longer available. The usual repair method is to disconnect the faulty capacitor but leave the can in place so that it looks right. Suitably rated modern electrolytics can be installed below the chassis, ensuring that the leads are kept as short as possible, to give steady mounting, and are adequately sleeved. Axial capacitors are generally a better choice.

Some repairers like to cut the faulty can open and fit the replacements inside. The cut is concealed underneath the capacitor-mounting clip. Radial capacitors would be a better choice for this. Do not use higher capacitance replacements, as these would unduly stress the rectifier valve.

AUDIO STAGES

Some sets have a method of disconnecting the internal speaker when using an external speaker. This could be a switch, plug or screw, and is often the cause of silent sets.

The vast majority of sets use a Class-A output stage (Fig.7), with a single valve (normally a pentode or beam-tetrode) driving the output transformer. The output transformer primary is in the anode circuit. The anode current is typically 40mA, and the transformer primary drops between 15 and 40 volts DC. A small resistor (hundreds of ohms) in the valve cathode circuit gives a small positive voltage on the cathode. The resistor is often bypassed with a small electrolytic capacitor, typically 25μF to 50μF. The control grid is biased to 0V via a high-value resistor (500kΩ to 1MΩ), thereby giving the correct negative bias relative to the cathode.

The audio signal is coupled to the output valve control grid from the preceding stage via a capacitor. This capacitor will very often be found to be electrically leaky, putting a positive voltage on the control grid. This causes the output valve to draw excessive anode current. This will probably be noticed initially as distortion and a low HT voltage. Continued operation this way can result in damage to the valve, output transformer and other components.

Therefore, as soon as an unknown set has power applied, the voltage on the output valve control grid must be checked with a high-impedance digital meter. It should be zero or slightly negative. If there is any positive voltage here, the capacitor must be replaced. A similar symptom can occur due to internal leakage within the valve. This is more common on later valves, in particular the UL41. If a replacement capacitor does not eliminate the positive voltage on the grid, try a replacement valve.

In either case, check the value and condition of the cathode resistor and any bypass capacitor, since the excess voltage and current may have damaged them.

The output transformer can fail, with the primary becoming open-circuit (often as a result of the above problem). The best replacement is one from a scrap set using the same output valve.

RS Components stock a suitable transformer, stock number 210-6475. This has several tappings on the primary and secondary, and the catalogue gives details of the connections for various primary and speaker impedances. The primary impedance is the *Ra* figure for the valve (taken from a valve data book), and the speaker impedance is generally three ohms.

There are often one or more capacitors and possibly resistors in the output valve anode circuit, either in parallel with the output transformer primary or between the anode and chassis. These components are intended to correct the non-linear frequency response of the output transformer. These capacitors live a hard life, because of the large AC signals on the anode. Replacements must be rated at 600V DC or higher (I normally use 1000V components).

The output stage is normally preceded by an audio amplifier stage, usually a

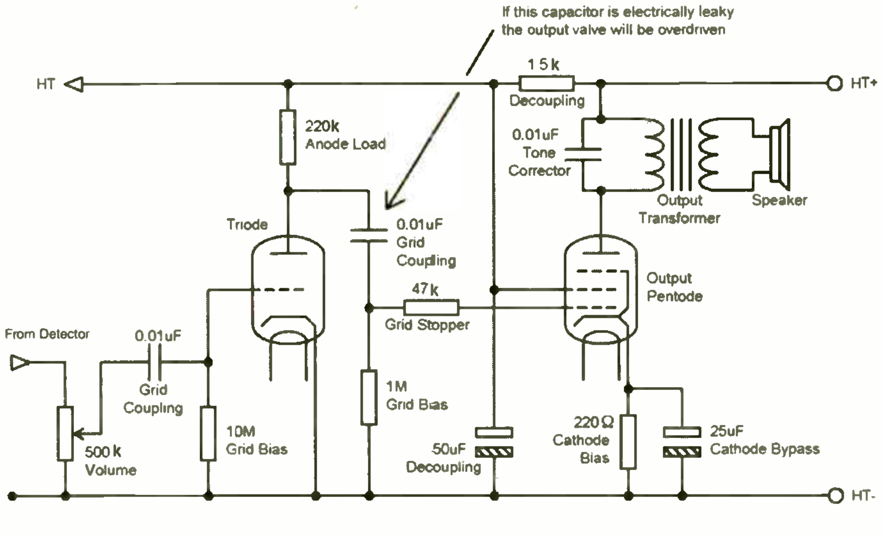


Fig.7. Typical Class-A output stage.

triode. It is normally self-biased and has a very high grid bias resistor (10MΩ). This is coupled to the wiper of the volume control potentiometer via a capacitor. In most sets, the triode is combined with two detector and AGC diodes in a single envelope. In some later sets it is combined with the output pentode, and the diodes are combined with the IF amplifier valve.

This stage is generally reliable. The anode load resistor (around 220kΩ) occasionally goes high or open-circuit, resulting in no audio. A few sets built on p.c.b.s suffer from leakage in this area of the board due to the heat build-up. This normally shows as excessive hum. The only solution is to isolate the valve holder pin from the p.c.b., remove the tracking, and then rewire the connections from the volume control in a point-to-point manner.

Sets without this stage of amplification are known as "short superhets". The output valve is generally a high-slope (high gain) type to partly compensate for the missing amplifier. This type of set was sold for use on more local and powerful transmissions and can perform very well with a reasonable aerial.

The tone control in most sets is a simple top-cut arrangement (treble control). This consists of a pot and capacitor in series, between the audio signal and chassis.

Noisy volume and tone controls can often be fixed with a shot of contact cleaner *(do NOT use WD40 as this damages the resistive track)*. If this is not successful, the control can be removed, dismantled and carefully cleaned with contact cleaner and cotton buds. Increasing the tension on the moving contacts often helps too. Alternatively, a replacement control can be fitted. If the replacement is 1MΩ and the original was 500kΩ, fit a 1MΩ resistor in parallel.

AM (MW AND LW), RF AND IF STAGES

The MW, LW and SW dials of virtually all British valve radios will be marked in wavelengths (metres) rather than frequencies. To convert from one to the other, divide 300,000 by the known figure (this conversion works both ways).

MW/LW superhet sets from the later 1950s generally use a ferrite rod aerial. Some sets from the mid 1940s onwards use an internal frame aerial, but many sets rely on an external wire aerial. The aerial circuit is tuned by one section of the variable tuning capacitor, before being coupled to the control grid of the mixer section of the mixer-oscillator valve.

The other section of this valve oscillates at a set frequency above (or occasionally below) the tuned frequency. The frequency is controlled by the other section of the variable tuning capacitor. The mixer stage combines the received signal with the oscillator signal. The result is a difference signal, which consists of a carrier at the difference between the oscillator and received frequencies, modulated by the received audio. Since the frequency of the difference is constant, it can be amplified by a fixed tuned amplifier circuit.

This difference frequency is known as the Intermediate Frequency (IF), and is generally 465kHz in later British sets. Other frequencies such as 455kHz and 470kHz may be encountered in post-war sets, while pre-war sets often have a lower IF around 110kHz to 130kHz. The actual figure is given on the service data, and is only of importance if you need to realign the set.

The advantage of superhet circuits of this type over earlier TRF arrangements is that the signal passes through several stages of sharp tuning, which gives good selectivity and sensitivity. Since the IF is at a fixed frequency, the IF tuning is fixed. This is much more straightforward and reliable than attempting to keep several variable tuning stages in line with each other across the waveband.

Most sets have a single IF amplifier stage and two tuned IF transformers (one before and one after the IF amplifier). Some later Bush sets had an additional amplifier stage and transformer, although it is questionable whether this makes much difference.

The IF stage is followed by the detector, which extracts the audio signals from the IF. Since MW and LW transmissions are amplitude-modulated (AM), detection can be achieved with a single diode to remove one polarity of the signal, together with filtering to remove the IF, leaving just the required audio. This passes to the volume control and on to the audio amplifier already described.

AUTOMATIC GAIN CONTROL

The strength of the received signals can vary widely, with local or powerful stations blasting through and possibly overloading the receiver. The automatic gain control (AGC) circuit brings about some order to this situation.

As well as producing the required audio signal, the detector output can be passed through a low-pass filter to give a DC voltage proportional to the received signal strength. The types of valve used for the mixer-oscillator and IF amplifier stages are "vari-mu", which means their gain can be controlled by altering the DC biasing on their control grids. The DC level from the detector, known as the AGC signal, is used to reduce the gain of the valves when stronger signals are received.

The arrangement just described is simple AGC, as used in many cheaper sets. The drawback with this is that even a weak received signal will produce an AGC voltage and reduce the gain of the set. Better sets use delayed AGC, whereby the AGC does not come into play until the received signal is above a set level. Thus, weaker signals have the benefit of the full gain of the receiver, while larger signals are kept under control. A separate diode is used to derive the AGC voltage in sets having delayed AGC.

The AGC line is at high impedance, and is normally decoupled by one or two capacitors of around 0·05μF or 0·1μF. Any leakage in these capacitors can prevent the AGC from working properly, resulting in distortion on stronger signals. If this occurs, the relevant capacitors should be replaced and the associated resistors checked.

The screen-grids of the mixer-oscillator and IF amplifier valves are normally connected to HT via resistors and decoupled to chassis by capacitors. The cathodes are also decoupled to chassis by capacitors. Failure of these decoupling capacitors can result in whistles and instability or low gain.

FM (VHF) RF AND IF STAGES

Because of the much higher frequencies in VHF sets, the tuner and mixer-oscillator sections of a VHF receiver are normally contained in a separate screened case. The signal from the aerial first passes through a stage of RF amplification. As well as providing some gain, this prevents the local oscillator signals from getting back onto the aerial.

The mixer-oscillator works in a similar manner to that already described, however the whole operation is achieved with a single triode or pentode valve. The IF is normally 10·7MHz, although higher IFs were used on a few early VHF sets.

In many VHF sets, the RF amplifier and mixer-oscillator are a single dual-triode valve, often an ECC85 or UCC85. Some sets use two RF pentodes such as EF80 or UF80, or individual triodes.

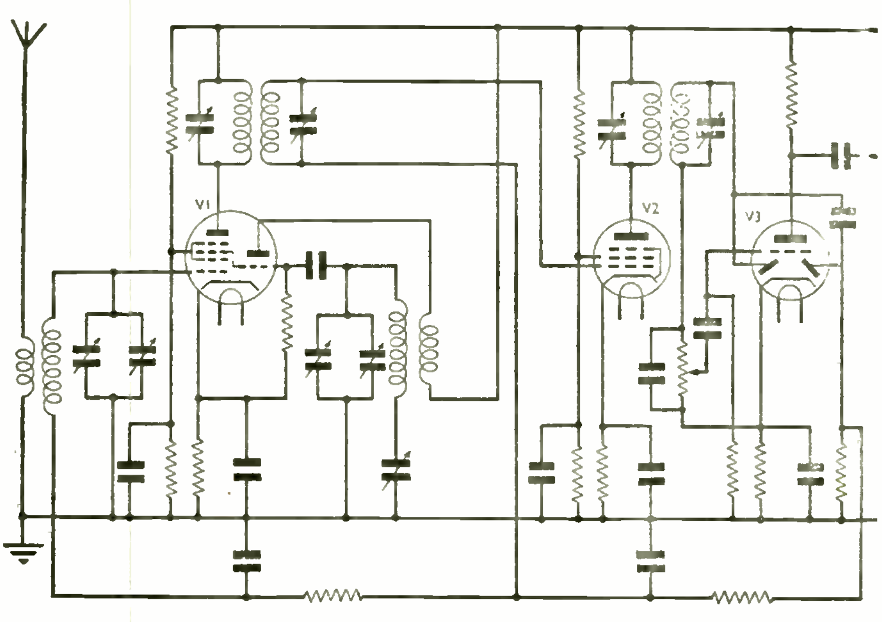


Fig.8. RF, IF and AGC stages of a typical superhet receiver.

In AM/FM sets, the mixer section of the AM mixer-oscillator valve is used as the first IF amplifier on FM. The oscillator triode is normally disabled, although in a few sets it is used as an additional audio amplifier on FM. The AM IF amplifier becomes the second IF amplifier on FM. FM-only sets will have two stages of IF amplification.

Because VHF transmissions are frequency-modulated (FM), the bandwidth of the IF amplifiers needs to be broader than for AM. Such amplifiers cannot have as much gain as tightly tuned AM IF stages, so an additional stage is needed to get the same amount of overall gain.

In AM/FM sets, there will be two IF transformers in parallel between each stage, one for AM and one for FM. The waveband switching sometimes bypasses the unwanted transformer, particularly in the earlier stages.

The FM detector is rather more complex than that for AM. The type of circuit used is known as a "ratio detector" and uses two diodes from a centre-tapped IF transformer secondary. The audio is extracted from the centre-tap, and the two diodes are coupled by a small electrolytic capacitor across which the AGC voltage is developed.

The diodes are often contained in a triple-diode-triode valve such as the EABC80 or UABC80, which also contains the AM detector and audio amplifier. If these diodes are low-emission VHF reception may be distorted. Incorrect adjustment of the final IF transformer will also cause severe distortion.

The AGC requirements for FM receivers are simpler than for AM sets. It is the variation in frequency not the variation in amplitude that matters. It is actually advantageous to drive the final IF stage into limiting, so that there are no amplitude variations on the detector input to cause distortion. The AGC therefore only needs to control this such that earlier stages are not overloaded and the limiting is not excessive.

The condition of decoupling capacitors is even more important on FM than on AM. It is not uncommon to have a set that works fine on AM but is distorted and unstable on FM. Replacement capacitors will often be all that is required.

Some sets feature a "magic-eye" tuning indicator. The control signal to this is derived from the AGC line.

ALIGNMENT

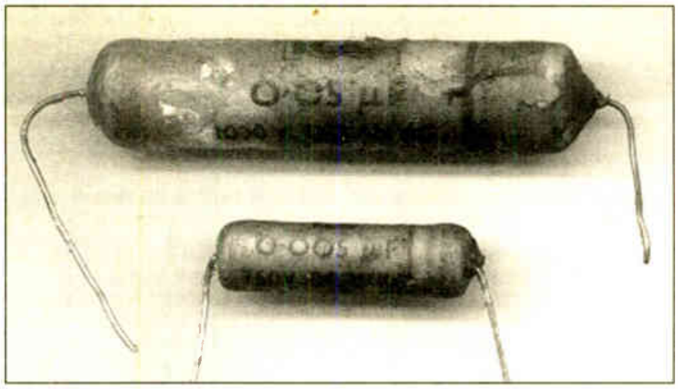
Alignment is the process of adjusting the IF and RF circuits for best reception (sensitivity, selectivity and absence of whistles) and accurate indication of the frequency/wavelength on the tuning scale. The set will have been properly aligned when it was manufactured but could require realignment either due to component ageing and drift or because somebody has been fiddling with the adjustments previously.

Before considering realignment, make sure there are no other causes of the poor reception. In particular, faulty decoupling capacitors in the IF and RF stages (as mentioned above) can give symptoms that might be confused with poor alignment, such as instability or low gain.

To align a set properly you need an RF signal generator, some means of monitoring the output level, appropriate tools for altering the adjustments, and some patience! If the alignment is only slightly out, it is possible to make some minor adjustments on stations, but this should be done with great care to avoid making the situation worse. No harm will be caused to the set if the alignment is out, although the set may not be performing as well as it could. If in doubt, *leave it alone!*

The adjustment procedure varies with different makes and models of set. The best advice I can give here is to obtain the service sheet and follow the instructions carefully. Some alignment instructions call for specialist equipment. If you do not have the right equipment, some adaptation of the instructions may be necessary.

For more detailed information on alignment, the book by Chas E. Miller entitled *The How and Why of Alignment* is recommended.



Troublesome wax coated paper capacitors.

CAPACITORS

If you have read the sections above, you will already realise that faulty capacitors can account for a lot of faults with valve radios. The main culprits are those with values between $0{\cdot}001\mu F$ and $0{\cdot}5\mu F$. Some repairers replace all the capacitors in this range in sets regardless. Others prefer to change only those capacitors that they have diagnosed to be the cause of the faults encountered. You need to make your own decisions, based on the initial state of the set, the number of capacitors, and the time you have available. There are various types of capacitor used, and some are worse than others.

Probably the most common and the most troublesome are the wax coated paper types. These are tubular components, with a distinctive sticky yellow coloured wax coating (usually turned brown with age and dirt). Most of these capacitors will be found to be leaky, and I usually replace them all.

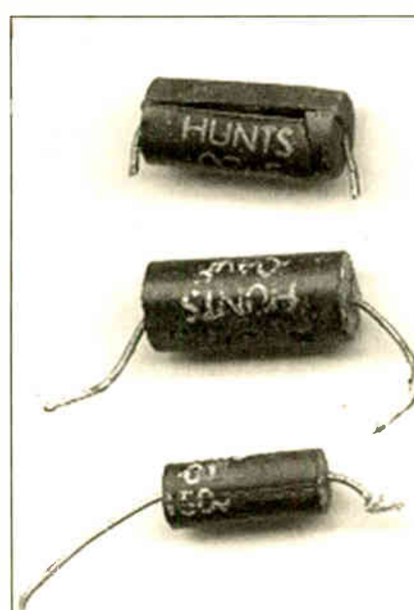
Many later sets use small Hunts capacitors. These are small brown or black tubular plastic components, although a few have white paper labels around them. They are typically about 15mm long and 6mm in diameter. They are very unreliable. If the case is cracked or fractured it must be replaced, otherwise it may be OK but many restorers replace these on sight.

Many Philips sets use black capacitors coated in a substance that looks like tar. They are similar in size to the waxed paper variety. From my experience these capacitors in a set are usually either all OK or all faulty. The value marking on these is sometimes difficult to decode, in which case the service sheet is especially useful.

There are a few modern types of capacitor that will be good replacements. My favourites, and the most expensive, are the yellow LCR metalised polypropylene axial types. These are rated at 1000V DC, and are similar sizes to the wax-coated paper types. They are available from most major component suppliers.

A good general-purpose replacement is the yellow polyester axial capacitors made by Vishay-Roderstein. These are available in 63V, 250V and 400V DC ranges, the 250V and 400V types being the most suitable for our needs. They are fairly small so ideal for replacing the small Hunts capacitors. These are stocked by RS Components.

The cheapest option is p.c.b. mounting dipped polyester capacitors. The 250V DC and 400V DC types are suitable electrically, but the leads will often need to be extended. They are cheap and work OK, but are fiddly to use and look untidy. I use these for "cheap" jobs, such as low cost sets with rough cabinets that are never going to be brilliant but that I want to work. Most major component suppliers stock the BC Components (formerly Philips) 368



Hunts plastic capacitors – many restorers replace these on sight.

series. Some suppliers also stock a cheaper version made by Samwah.

For any position where a capacitor is connected across the mains or is subjected to similar AC voltages, Class X or X2 suppressor capacitors must be used.

The replacement capacitors may not be available in exactly the same capacitance values as the original components. Fit the closest available. For example, a new $0{\cdot}047\mu F$ component could be used to replace a faulty $0{\cdot}04\mu F$ or $0{\cdot}05\mu F$ capacitor.

Some restorers like to fit the modern replacement capacitor inside the case of the old one, which leaves the underside of the chassis looking original. I have never attempted this because I feel it is really not worth the effort. It is only practical when the original is fairly large and in good external condition.

REPLACING RESISTORS AND CAPACITORS

Any replacement components must follow, as closely as possible, the path and position of the originals. In particular, this applies to those close to the chassis and those in the RF stages. The original layout would have been planned and optimised to avoid instability, so it is best not to deviate from this. Any component lead that is close to another component or the chassis should be sleeved with PVC sleeving to avoid any risk of short circuits.

There is always a risk of damage by applying heat for a long time while trying to desolder the component lead and unwrap it from around the terminal. To avoid this, I normally cut the old component leads close to the relevant tags. I then fit the new component by wrapping the leads around the tags and soldering. If there is a lot of solder on the tag, it is worth removing some with a desoldering tool (or solder wick) first.

Another option is to cut the leads close to the faulty component, then solder the new component onto the old leads.

VALVEHOLDER FAULTS

A fairly common problem, particularly on cheaper sets, is poor contact between the valve and the valve holder. This could occur anywhere in the set, although it tends to occur more often with rectifier and output valves.

Try applying some contact cleaner, then plugging and unplugging the valve a few times. This is often sufficient to clean the contacts. If the contacts in the holder have lost some of their spring tension, they can often be tightened by carefully pushing a small jeweller's screwdriver between the contact and the body of the valveholder to close the contact.

Sometimes the contacts will be found to be broken, or will break when you try to tension them. Don't panic! There is an easier solution than replacing the holder, particularly if only a couple of contacts are damaged.

With some types of valve holder it is possible to remove individual contacts once they are unsoldered and the tag straightened. If you have a similar valveholder in a scrap set, you can use contacts from this for replacement. If not, you might be able to use a couple of unused contacts from other valveholders in the set. If you are concerned about causing damage when you unsolder all the connections, just cut the tag from the old holder and remove the contact. Insert the new contact, and solder the original tag, complete with all the connections, onto it. It's a bit messy, but it works.

MAINS WIRING

If the mains cable is not double insulated PVC flex with the modern colour code, it should be replaced. The only exception to this is if the cable contains ballast resistance, i.e. the lead itself drops the voltage to the set (beyond the scope of this article).

If one side of the mains flex connects (directly or indirectly) to the chassis, use two-core 3A cable, making sure the neutral (blue wire) connects to the chassis. If the set is an AC only model with an isolating transformer and neither side of the mains connected to the chassis then I prefer to use three core 3A mains flex and earth the chassis.

The cable must use the current colour code of brown (live), blue (neutral) and green/yellow (earth). The mains plug should be fitted with a 1A fuse. If the set only has a single pole mains switch, make sure it breaks the live connection. If it has a double pole switch, it should break both live and neutral.

Make sure the mains cable is securely fixed to the chassis so that there is no strain on the connections if it is pulled or twisted. In many sets, the original cable passes through a grommet and then has a knot tied in it to stop it from pulling out. If possible, do something better (maybe using cable ties or a P-clip), you should never tie a knot as it may damage the cable. Replace the grommet if it is not in good condition.

Check the voltage selector. If it is accessible externally for safety reasons, you will either have to relocate it or disconnect it. It is often easier to disconnect it and wire the set permanently to the appropriate voltage setting.

TUNING DRIVE CORD

The tuning drive cord often breaks or becomes weakened. Replacement cord used to be available from component suppliers, but is now difficult to obtain. Try linen cord or fishing yarn.

Normally the broken cord will retain some of its shape, and this should be carefully noted before disturbing it. On many sets, the drive cord arrangement is fairly simple, but a few can be more complex. If you cannot work it out, obtain the service sheet for the set.

The tuning pointer can be repainted if necessary. Enamel paint intended for plastic construction sets (such as Airfix or Humbrol paint) is ideal for this. You may also wish to repaint the plate behind the tuning scale using spray paint.

TUNING SCALE

The printing on the tuning scale glass is usually very soft and can easily be removed if the wrong cleaning product is used. The best approach is not to clean the printed side at all unless it is really necessary and you are sure the printing is sound. Even then, you should only use a dry duster or possibly a tissue slightly dampened with water. Be very careful, as a replacement tuning scale will be almost impossible to obtain.

If the printing is flaking off, spray it with a clear lacquer to hold the printing that remains in place. Try a small amount in a corner first to make sure it does not soften the printing.

If some of the printing is missing, and you are reasonably artistic, you may like to repaint it. Remember that you are working backwards, and that the first layer of paint is the one that will be seen.

You may be able to scan the remaining pattern into a computer and recreate the missing parts in a photo-editing program. This could then be printed onto transparent film using an inkjet printer, and fitted behind the original glass.

The outside of the scale can be cleaned with a household or car glass-cleaning product. Make sure this does not get onto the printed side.

LOUDSPEAKER

If the cone of the loudspeaker itself is damaged or coming away from the frame, it can be repaired with a contact adhesive that dries to a rubbery consistency, such as EvoStick. If the speaker is badly damaged you will probably need a replacement.

If the cone is distorted, so that the speech coil is scraping against the magnet, you may be able to cobble a "repair" by lodging a wad of tissue paper between the cone and the frame at a suitable point. This is hardly an ideal solution but it may be the best option if a suitable replacement speaker is not available, or as a temporary measure while you are waiting for a replacement to arrive.

SPEAKER FABRIC

It is difficult or near impossible to clean dirty speaker fabric. One option is to wash it in cold water, using fairly strong detergent (such as Woolite). The water must be cold to reduce the risk of shrinking. While it is still wet, stretch it back to the right size and clamp it in place while it dries. You could also experiment with car upholstery cleaning products.

You are very unlikely to be able to obtain an exact replacement fabric since it is no longer manufactured. Sid Chaplin carries stocks of modern fabrics and reproductions that will act as reasonable replacements in some cases. Other suppliers (often from the USA) sometimes attend the NVCF.

CLEANING THE CHASSIS

Remove the valves, and carefully clean the glass envelopes with a dry tissue (such as kitchen towels). Breathing on the

A chassis during restoration. (Courtesy *Radio Bygones*) glass – as though you were cleaning spectacles – may help. *Take great care not to remove the markings*, which are often very soft.

Over the years, the chassis will accumulate a layer of dust and grime, which needs to be removed without damaging the components. Foam Cleanser is good for this, but it should be sprayed onto the cloth and *not* the chassis. A toothbrush or cotton buds are useful for getting into the awkward gaps.

PRINTED CIRCUIT BOARDS

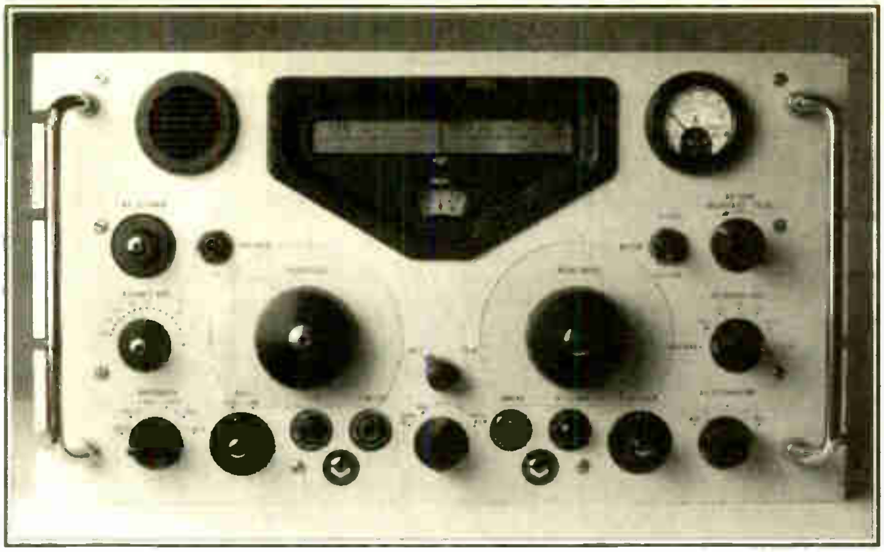
P.C.B.s are more of a problem to clean, because the cleaning products can cause damage to the components. Initially try using a dry toothbrush to remove the dust and grime. Patches of wax can be carefully scraped away with a small screwdriver, but if it is not doing any harm, you could just leave it there!

If the p.c.b. is particularly filthy, you can try using Electrolube Ultrasolve or a similar p.c.b. cleaning solvent. Take care to avoid rubbing the components, since it may remove the markings from some resistors. Cotton buds are useful for this.

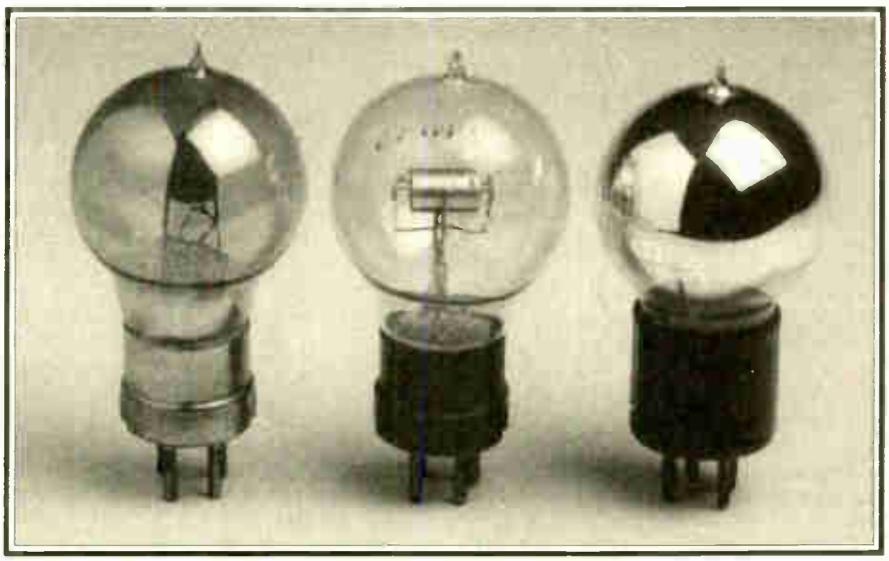
REPLACEMENT BACKS

If the original back to the set is missing you should arrange an alternative. This is essential if the set is to be used, to prevent little fingers finding their way onto live terminals. If you have a supply of scrap sets, you may have a back that can be modified to suit.

A suitable replacement back can be made from hardboard or thin plywood. Once it has been cut to size, drill or punch a large number of 1/4 inch (6mm) holes for ventilation. In particular, there should be holes near the output and rectifier valves, and any high power resistors. Drilling hardboard gives a rather tatty finish, which can be tidied somewhat with medium grade sandpaper. The back can then be sprayed with black aerosol paint if desired. Obviously it is much better if the set is complete with the original back when purchased.



Some collectors specialise in communications equipment like this Racal R17 receiver from the late 50s. (Courtesy *Radio Bygones*)



A selection of early valves from the collection of Bill Journeaux. (Courtesy *Radio Bygones*)

CABINET RESTORATION

Before embarking on the restoration of the cabinet and chassis, you should consider carefully what you are trying to achieve. This will vary with different sets, and everybody has their own preferences.

Many restorers do not try to make the set look like new, as this can appear artificial. The normal aim is to restore the set to the condition it would be in if it had been kept on a sideboard since it was new, and lovingly dusted occasionally. Small scratches and chips are signs of general wear and tear, and should generally be accepted as such.

Consider the value of the set, and the likely impact to this caused by any work you decide to do. If the set is worth next-to-nothing before you start, you really have nothing to lose, and could gain a nice-looking set! However, if the set is rare or valuable – say over £100 – you should take expert advice before doing anything that could affect the appearance and value.

DISMANTLING

Before attempting to clean and restore the cabinet, it should be dismantled as far as possible. Normally the speaker baffle board is a separate assembly and is held in place with screws or clips. Trim and manufacturers logos are often held in place with nuts, clips or bent-over pins on the inside, or possibly glued in place. The tuning scale glass is normally held with a few metal fixing plates, fitted with rubber pieces to protect the glass.

These items can usually be readily removed, and then cleaned and restored individually. Also, remove the speaker from the baffle board. Do not try to separate glued items unless it is absolutely necessary.

On many Bakelite sets, the baffle board and other components are held in place with spring clips pressed over pillars. Sometimes there is a flat side on the pillar, in which case the clip can be removed by turning it so that one of the gripping sections is next to the flat. Otherwise, grip the sides of the clip with long nosed pliers and rotate it back and forth, as you pull it off – taking care not to break the pillar.

KNOBS AND TRIM

Plastic, Bakelite and metallic parts can initially be cleaned with warm water and washing-up liquid. The water should not be too hot, as very hot water can cause plastic parts to soften and distort. Leave the parts to soak for a few minutes. An old toothbrush is ideal for cleaning the parts and removing the grime from the finger-grips of the knobs. Once the parts are clean, rinse them in clean running water to remove the detergent, and leave them to dry.

Brass items can then be polished using Brasso or a similar product. You will often find that they have been coated with a lacquer, which has become chipped and stained. Once you have a good polished brass surface, it should be protected with lacquer to prevent it becoming tarnished and dull.

Chrome plated items can be carefully polished with Brasso, taking care not to remove the plating. If the plating is already badly chipped and damaged, you may have to paint over it. Chrome paint is available, but generally looks fairly awful.

Plastic and Bakelite knobs can be wax polished in the same manner as for Bakelite cabinets (described later). If the knobs have printing that is lightly recessed, and some of this is missing, it can be replaced with suitable colour model paint. Any paint on the surface can be removed with Brasso once the paint is completely dry (24 hours).

CLEANING BAKELITE

The Bakelite or plastic cabinet can be washed with warm water and washing-up liquid. A washing-up brush and a toothbrush are useful for getting the muck out of the corners and recesses. When the cabinet is clean, rinse it in clean water and leave it to dry naturally.

The best finish can be obtained by using a specialist Bakelite polish. Bake-o-Bryte is available from The Radiophile for £2 plus 50p postage, and gives excellent results.

Alternatively, a good quality wax polish such as Colron Finishing Wax (available from DIY stores) can be used. If the surface is dull and cloudy, it can be improved with the gentle application of a slightly abrasive polish such as Brasso or T-cut.

REPAIRING BAKELITE

Clean cracks and breaks can be successfully (but not invisibly) repaired with a little superglue. The version with a small brush in the lid is recommended. Clean the broken edges carefully, then piece them together and secure with masking tape on the outside to hold them close. Apply the glue to the inside of the cabinet and let it work its way into the crack by capillary action. Once the glue is thoroughly dry (allow several hours), any excess on the outside can be gently removed with a razor blade or modelling knife.

Superglue is only suitable for repairing clean breaks, and is unable to fill gaps. If the broken parts do not fit cleanly together, you will need to use an adhesive that fills the void. An epoxy resin such as Araldite (the standard type, not the fast drying) is suitable. Any excess can be removed with a modelling knife once the glue has dried completely (at least 24 hours). More major rebuilding work can be carried out with two-part car body repair filler such as Davids Isopon P38.

The only problem with these repair techniques is that the epoxy or filler is not the same colour as the cabinet. You may be able to mix appropriate coloured Bakelite filings (removed from an old knob or scrap cabinet with a file) with the filler to disguise the repair. This will only work if the cabinet is a single colour, and it may be difficult to get an exact match.

PAINTING

The easier solution is to paint either the whole cabinet or just the repaired area with suitable colour car spray paint. If you want a deep brown Bakelite colour, Vauxhall Brazil Brown is a good match. Car aerosol paint is also ideal for repainting the painted sections of cabinets. For off-white sections, Ford Sierra Beige or Lada Cream are often suitable. Bakelite should be primed first using the recommended colour primer for the paint being used.

Clean the cabinet thoroughly with white spirit or meths to remove any grease. Anything that should not be painted must be protected with newspaper and masking tape.

Spraying should be done outdoors on a dry still day. If you are working in a covered area such as a garage, leave the door fully open to let the fumes out.

Shake the can thoroughly before use. Spray painting needs practice to obtain good results. Each coat should be just thick enough that it has an even wet look. If it looks powdery, you need to spray it a little thicker, and if you are getting runs, it is too thick. With practice, and a bit of luck, you can sometimes do the job in one coat. If you need additional coats, they should be applied at about half-hour intervals.

Remove the masking tape and newspaper about half-an-hour after the final coat, then leave the cabinet to dry thoroughly for at least 24 hours. The paint finish will probably be fine as it is, but it can be polished with a household spray polish if necessary. Do not use car polish as it gives an artificially glossy finish. If the painted finish is too glossy, it can be dulled by gentle rubbing with fine steel wool.

RESTORING WOOD

This section details some of the more straightforward methods of repairing and restoring wooden cabinets. If you are feeling more ambitious it would be worth finding a good book, magazine or website about furniture restoration.

Some of the suggestions given here may result in a finish that does not look the same as the original. This could be a problem, particularly if you are restoring the set for someone else or intend to sell the restored set. This would also drastically affect the value of the set. If you are in any doubt, contact an experienced furniture restorer.

WOODWORM

If the cabinet shows any signs of woodworm, this must be treated before continuing. If you are not able to do this straight away, wrap the set in a plastic rubbish sack and leave it somewhere cool and away from other sets, furniture or timber structures. Any signs of woodworm must be taken very seriously.

Remove the chassis and any other removable parts if you have not already done so. Cuprinol Woodworm Killer is available in an aerosol can with a pointed nozzle for squirting into the woodworm holes. Treat the cabinet in accordance with the instructions and safety warnings on the can.

After treatment, wrap the cabinet in a plastic rubbish sack (do not seal the top of the sack) and leave it in a warm place for several days. If there is any further sign of woodworm activity, such as new holes or wood dust, treat it again. Wait at least a week for the woodworm killer to thoroughly dry out before carrying out any repair or restoration work on the cabinet.

CABINET REPAIRS

Wooden cabinets sometimes come apart at the joints, which are normally held together with glue alone. Apply a little Evostick Woodworking Adhesive to the gap, and use a scrap of cardboard to spread the glue well in. Hold the joint tightly closed with clamps or heavy items while the glue dries. Any glue that oozes out should be wiped off with a damp tissue.

If the layers of the plywood come apart, they can be repaired in a similar manner. The plywood should be clamped firmly between two solid boards while the glue is drying to ensure the result remains flat.

CLEANING

The build-up of dirt, household polish and nicotine on the surface of a wooden cabinet can often be removed with white spirit. If this does not work, try foam cleaner. Warm water and washing-up liquid is also effective, but *you should not submerge the cabinet and do not allow it to become too wet* – just use a dampened cloth and dry it off quickly. The aim is to remove the grime without disturbing the original finish. However, some dirt, particularly in corners etc., is a sign of age, which should not be disturbed.

STRIPPING

If the original polish or varnish is in a poor state, you may have no option but to strip it and start again. Do not rush into this, as it can be difficult to get a finish similar to the original.

If the cabinet has a wax polish finish you may be able to remove it with methylated spirits. Normally however you will need to use a varnish-stripping product such as NitroMors Varnish Remover. Use this with medium grade wire wool in accordance with the instructions and safety warnings on the tin. Once the varnish is removed, the cabinet should be thoroughly cleaned with methylated spirits or white spirit.

PREPARING

If the wood colour is too light, it can be darkened at this stage with Colron Wood Dye. The colour obtained is often slightly lighter than the shop display would suggest, so choose a fairly dark colour such as walnut. Any woodworm holes and other blemishes can be filled with plastic wood. This also dries lighter than expected.

The exposed wood should then be protected and sealed with Colron Wood Reviver. This is rubbed into the surface with a soft cloth and allowed to dry.

If the cabinet had a shiny lacquered finish, it may be sprayed with two or three coats of aerosol lacquer. The type sold in car accessory shops for use on metallic paint finishes is ideal. Do not use a brush-on product, as it is very difficult to get a smooth finish.

TOUCHING UP

If a polished finish is scratched or chipped, the blemishes can be masked to some extent with Colron Liquid Scratch Remover. This is supplied in a bottle with a small brush, and is applied to the scratch and allowed to dry before buffing.

Scratches in lacquered cabinets can be repaired with car lacquer. Use the touch-up pot with a small brush in the lid. Several layers may be needed to build up the depth. Test in a hidden corner first, to ensure that the lacquer does not affect the original finish.

REGULAR USE

Having repaired and restored your set, you should use it and enjoy it. Periodic use will keep the set in good order and dry out any damp. I would suggest that the set should be used for at least one hour every month. One hour or more allows the set to warm up properly, which is better for the valves than brief periods of operation.

ABOUT THE AUTHOR

I have been collecting and restoring valve and early transistor radios since the mid-80s. I prefer smaller Bakelite and plastic post-war sets, partly because they are much easier to accommodate than larger wooden cased models. I am also quite keen on early transistor sets, so a number of those are finding their way into my collection.

I have been running a website entitled Vintage Radio Repair and Restoration for about five years. I have also produced several CD-ROMs of service data and valve data, which are now available through the *RB Bookshelf*.

ACKNOWLEDGEMENTS

The author would like to thank Rob Rusbridge at Wireless Works for his considerable assistance with the "Design Availability and Prices" section. He would also like to thank Jon Evans for checking and proofreading this supplement.

CONTACT DETAILS

The following list contains a selection of suppliers of vintage radio sets, information and components. If you have Internet access, you can find a comprehensive directory of suppliers at **http://www.radiocraft.co.uk/directory/directory.htm**.

Please note that some of these businesses are run from the proprietor's homes, so please limit telephone calls to reasonable weekday business hours. In addition, some may not be open to callers, or may only be open by appointment so always check before travelling.

VINTAGE RADIOS

The Wireless Works (Rob Rusbridge), 40 Fore Street, Bugle, St Austell, Cornwall, PL26 8PE
Web – **http://www.wirelessworks.co.uk**
Email – **rob@wirelessworks.co.uk**
Phone/Fax – 01726 852284

Past Times Radio (Richard Booth), School House, Old School Lane, Wadworth, Doncaster, DN11 9BW
Web – **http://www.pasttimesradio.co.uk**
Email – **richard@pasttimesradio.co.uk**
Phone – 01302 858468
Mobile – 07971 701380

On the Air (Steve Harris), The Vintage Technology Centre, The Highway, Hawarden, Deeside, CH5 3DN
Web – **http://www.vintageradio.co.uk**
Email – **info@vintageradio.co.uk**
Phone/Fax – 01244 530300
Mobile – 07778 767734

Radiocraft (Steve Ostler), Main Street, Sedgeberrow, WR11 7UF, United Kingdom.
Web – **http://www.radiocraft.co.uk**
Email – **steve@radiocraft.co.uk**
Phone – 01386 882280
Mobile – 07876 296019

Radio Renaissance (Colin Boggis), Ruckholt Lodge, Ringwood Road, Bransgore, Christchurch BH23 8AE
Web – **http://www.radio-renaissance.co.uk**
Email – **colin@radio-renaissance.co.uk**
Phone/Fax – 01425 674925
Mobile – 07714 750918

Malcolm Bennett's Vintage Radios (Online Sales and Wanted adverts)
Web – **http://www.valve.demon.co.uk**

eBay (Online auction – look in "Collectables – Radio")
Web – **http://www.ebay.co.uk**

VALVE AND SERVICE DATA

Note: The service data and valve data CD-ROMs mentioned in this supplement are available from the *Radio Bygones Bookshelf* – see "Magazines And Organisations".

Savoy Hill Publications (Paul & Alex Ollivier), Fir View, 7 Rabys Row, Scorrier, Redruth, Cornwall, TR16 5AW
Email – **paul.pollivier@virgin.net**
Phone – 01209 820771

Chevet Supplies Ltd., 157 Dickson Road, Blackpool, FY1 2EU. Also sell books, reprinted manuals, hardware and components
Email – **chevet@globalnet.co.uk**
Phone – **01253 751858**
Fax – **01253 302979**

Mauritron Technical Services, 8 Cherry Tree Road, Chinnor, Oxfordshire, OX39 4QY
Email – **enquiries@mauritron.co.uk**
Web – **http://www.mauritron.co.uk**
Phone – 01844 351694
Fax – 01844 352554

Duncan Amplification (Online Valve Data)
Web – **http://www.duncanamps.com**

Nostalgia Air (Online American radio schematics – click the "Riders Online" link)
Web – **http://www.nostalgiaair.org**

Frank Nostalgia Air (Online Valve Data)
Web – **http://frank.nostalgiaair.org**

VALVES

Valve and Tube Supplies (Rod Burman), Woodlands Vale House, Calthorpe Road, Ryde, Isle of Wight, PO33 1PR
Web – **http://www.valves.uk.com**
Email – **rod@valves.uk.com**
Phone – 01983 811386
Fax – 01983 563730

Wilson Valves (Jim Fish), 28, Banks Avenue, Golcar, Huddersfield, Yorkshire, HD7 4LZ
Email – **wilsonvalves@surflink.co.uk**
Phone – 01484 654650
Fax – 01484 655699

Kenzen (Ken Bailey), Unit 9, 16-20 George Street, Balsall Heath, Birmingham, B12 9RG
Phone – 0121 446 4346
Fax – 0121 446 4245

COMPONENTS AND SPARES

Traditional Radio Grilles (Sid Chaplin), 43 Lime Avenue, Leigh on Sea, Essex, SS9 3PA
Email – **sidney@tradradgrilles.freeserve.co.uk**
Web – **http://www.vintage-radio.com/trg/**
Phone – 01702 473740

Sowter Transformers, The Boatyard, Cullingham Road, Ipswich, IP1 2EG
Web – **http://www.sowter.co.uk**
Email – **techsupport@sowter.co.uk**
Phone – 01962 620135
Fax – 0870 458 1700

Variable Voltage Technology Ltd., Unit 24R Samuels Whites Estate, Cowes, Isle of Wight, PO31 7LP.
All types of transformers for all types of circuits including specialist valve units and for restoration of vintage radios
Web –**www.vvttransformers.co.uk**
Email – **rb@vvt-cowes.freeserve.co.uk**
Phone – 01983 280592
Fax – 01983 280593

RS Components – telephone or web site orders with a credit card only.
Web – **http://rswww.com**
Phone – 01536 444079

For general radio components and spares, the suppliers under "Vintage Radios" above will also be able to help.

MAGAZINES AND ORGANISATIONS

Radio Bygones, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset, BH22 9ND. Subscriptions – 1 year (six issues) UK £18.50; Europe £20.50 (airmail); Rest of the World £24.50 (airmail).
Web – **http://www.radiobygones.co.uk**
Online **http://www.radiobygones.com**
Email – **radiobygones@wimborne.co.uk**
Phone – 01202 873872
Fax – 01202 874562

British Vintage Wireless Society, c/o Vintage Wireless Museum, 23 Rosendale Road, West Dulwich, London, SE21 8DS
Web – **http://www.bvws.org.uk**
Email (membership enquiries – Graham Terry) – **g.terry@virgin.net**
Email (chairman – Mike Barker) – **MurphyMad@aol.com**

The Radiophile, Larkhill, Newport Road, Woodseaves, Staffs, ST20 0NP
Web – **http://www.radiophile.co.uk**
Phone/Fax – 01785 284696

National Vintage Communications Fair (Sunrise Press), Spice House, 13 Belmont Road, Exeter, Devon, EX1 2HF
Web – **http://www.angelfire.com/tx/sunpress/index.html**
Email – **sunpress@eurobell.co.uk** or **sun.press@btinternet.com**
Tel – 01392 411565

Morsum Magnificat, The Poplars, Wistanswick, Market Drayton, Shropshire TF9 2BA
Web – **http://www.morsemag.com**
Email – **subscribe@morsemag.com**
Phone – 01630 638306
Fax – 01630 638051

RECOMMENDED WEBSITES

Vintage Radio Repair and Restoration (the author's website – includes repair and restoration information, repair stories and full details about the service data and valve data CD-ROMs)
http://www.vintage-radio.com

Radio Bygones (includes information about the magazine plus subscription ordering and a message board. Also links to the *EPE/RB* Online Shop where you can order a wide range of books/CD-ROMs/videos/back issues etc.)
www.radiobygones.co.uk

Radio Bygones Online (the web based version of the magazine. Log on, pay by credit card ($9.99 US for six issues) and download the magazine instantly – a free issue is also available, as are a number of back issues).
www.radiobygones.com

Jonz Valve Page (an interesting collection of radios, televisions and test gear, as well as some more technical information about valve workings etc)
http://www.TheValvePage.com

Allan's Virtual Radio Museum (radio collection, true stories, grumbles, "Radio and Television Servicing" radio index, IF frequencies etc.)
http://www.thorneyhill.freeserve.co.uk

Vintage Radio World (lots of good repair and restoration information)
http://www.burdaleclose.freeserve.co.uk

Wireless Works (good repair and restoration information in the "Information" section)
http://www.wirelessworks.co.uk

Alan Lord's Vintage Radio Collection (also offers a good discussion forum)
http://www.dundeecoll.ac.uk/Sections/CS/Staff/al_radio/

Dave's Rust 'n' Dust Homepage (lots of info about Murphy radios)
http://www.murphy-radio.co.uk

Vintage Wireless Database (may help you identify that unknown radio)
http://www.classaxe.com/wireless/data/

Marconi Calling (online history of Guglielmo Marconi presented by Marconi PLC)
http://www.marconicalling.com

Old Telly's Website (lots of good vintage TV repair information)
http://www.penders.cwc.net/otindex.html

RECOMMENDED BOOKS

Vintage Radios (Collecting – Servicing – Restoring) by Tony Thompson, ISBN 0-9538218-0-3, £12.95.

Radio! Radio! by Jonathan Hill, ISBN 0 951448 71, £39.95.

Comprehensive Radio Valve Guides (five books plus Master Index) £15.00.

Electronic Classics by Andrew Emmerson, ISBN 0-7506-3788-9, £21.75

Valve Radio and Audio Repair Handbook by Chas E. Miller, ISBN 0-7506-3995-4, £20.50

All the above are available by mail order, or via the shop on the web site, from *Radio Bygones* – address details on page 15. Prices correct at time of writing, they include UK post and packing, please enquire about overseas postage or order from the web site – **www.radiobygones.co.uk**.

Also: *Rapid Radio Repair – Standard Superhets* by Chas E Miller, £2.95. Available directly from The Radiophile – address details on page 15.

Rapid Radio Repair – The Why and How of Alignment by Chas E. Miller, £2.95. Available directly from The Radiophile – address details on page 15.

HEADSET COMMUNICATOR

TERRY de VAUX-BALBIRNIE

Portable three-channel communication system

THIS communication system was originally designed to help in the production of short commercial videos. With it, the "director" is able to hold a two-way conversation with any one of up to three camera operators. It is also possible to speak to all the operators simultaneously.

No doubt, such a system could find many other uses, such as in amateur stage work, concerts and sports events etc.

WIRED FOR SOUND

In the prototype arrangement, the director sits at a small desk console and the remote operators wear units clipped on to their belts. Cables, which may be of any reasonable length, link the remote stations to the main unit.

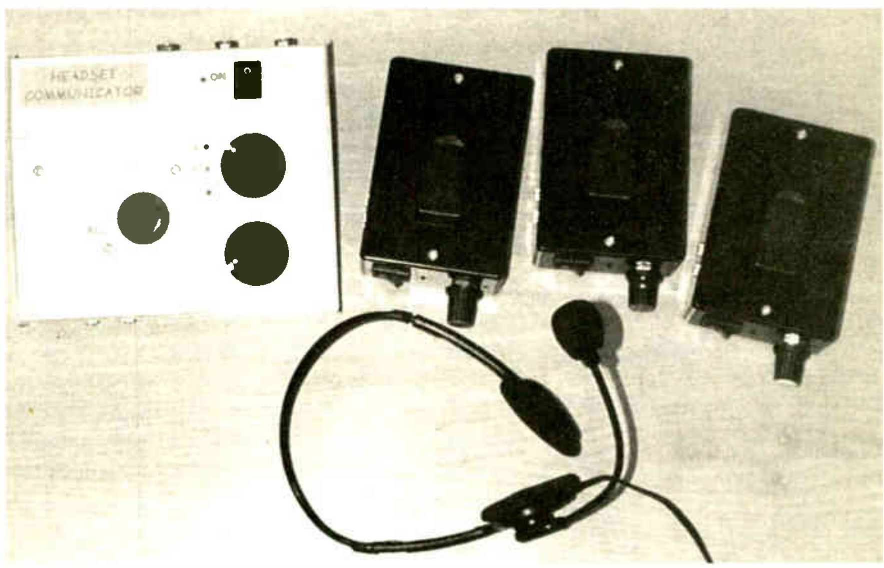
The director ("Master") and remote ("Slave") operators wear headsets which are plugged into their units. These headsets consist of a pair of headphones (or a single headphone) having a small boom microphone attached (see photograph).

FREE SPEECH

For the target applications, headsets are more convenient than loudspeakers. They provide "hands free" operation and allow the remote operators to move around freely (within the limits set by the interconnecting cables). Incoming speech cannot enter any microphone used to pick up the sound of the performance and cannot be heard by the audience.

Headsets (while worn) are free from acoustic feedback (the howling noise which is produced when the sound from a loudspeaker re-enters a microphone and builds up in a loop). The close proximity of the microphone to the speaker's mouth provides very clear communication even when there is a lot of extraneous sound or when he or she only whispers.

Power is supplied using four AA size alkaline cells housed inside each unit. The current requirement is 25mA approximately (40mA for the master unit) and the specified batteries should provide at least 50 hours of operation. ***For safety reasons, the system MUST NOT be operated using a mains-derived supply such as a plug-in adaptor.***



The Headset Communicator system units showing (left to right) the master unit, three slave units and a headphone with "boom" mic.

MASTER UNIT

The Master unit is built in a sloping front instrument case (see photograph). The headset is plugged into a pair of sockets on the front and sockets on the rear panel connect the cables leading to the slave units.

On the top, there is an on-off switch and associated l.e.d. (light-emitting diode) "On" indicator. There is also a three-position Slave Select rotary switch (S2) which selects which slave (A, B or C) is to be placed "on line", a momentary-action push-button switch which provides the "Talk to All" function and a Volume control.

Rotary switch S2 has three associated l.e.d.s (Red, Yellow and Green) which confirm the slave unit selected. These will be found useful when the unit is being used under dim conditions. Note that while the "talk to all" switch (S3) is being operated, only the remote station set by the S2 can be heard.

SLAVE UNIT

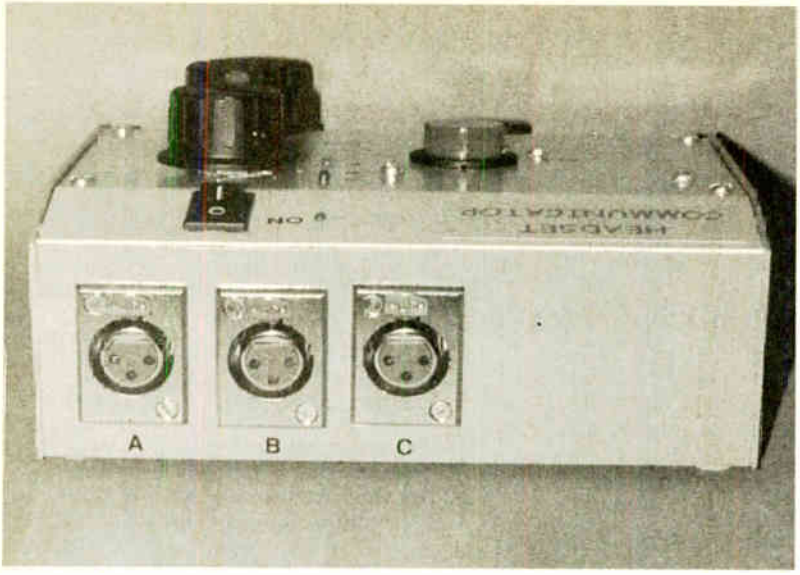
Each slave unit is built in a small plastic box having a belt clip attached (see photograph). As well as sockets for the headset and the cable leading to the master unit, there is an on-off switch, l.e.d. "on" indicator and volume control.

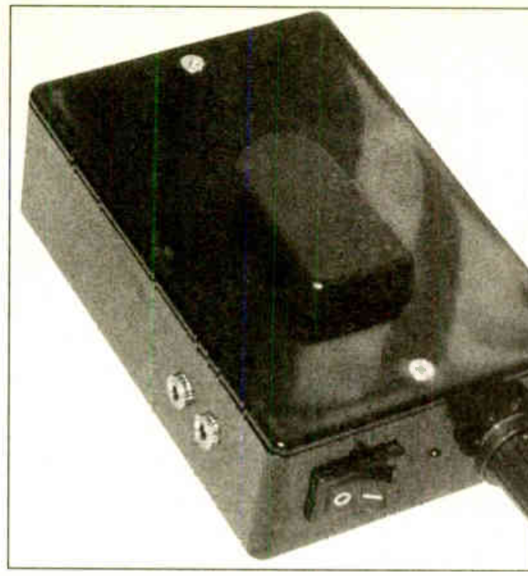
One particular feature of this circuit is that the operator's voice is heard in his or her own headphones. This practice is used in telephony and helps the speaker to regulate his or her voice level. It also allows the user to hear someone speaking direct without the muffling effect of the headphones. The amount of voice feedback may be adjusted for each station at the setting-up stage. It may even be reduced to zero if required.

HOW IT WORKS

The basic circuit for the Headset Communicator is shown in Fig.1 and this is the same for both Master and Slave units. Each unit may be considered as having one input and one output – the Listen (L) and Talk (T) lines respectively – plus a common "Earth".

By linking the talk line of one unit to the listen line of another and the listen line of the first to the talk of the other and also making the common earth connection, two-way communication would be established. Of course, additional switching is





Rear panel shows the three XLR type sockets for connecting up the Slave units.

Completed Slave unit with belt clip attached to the lid.

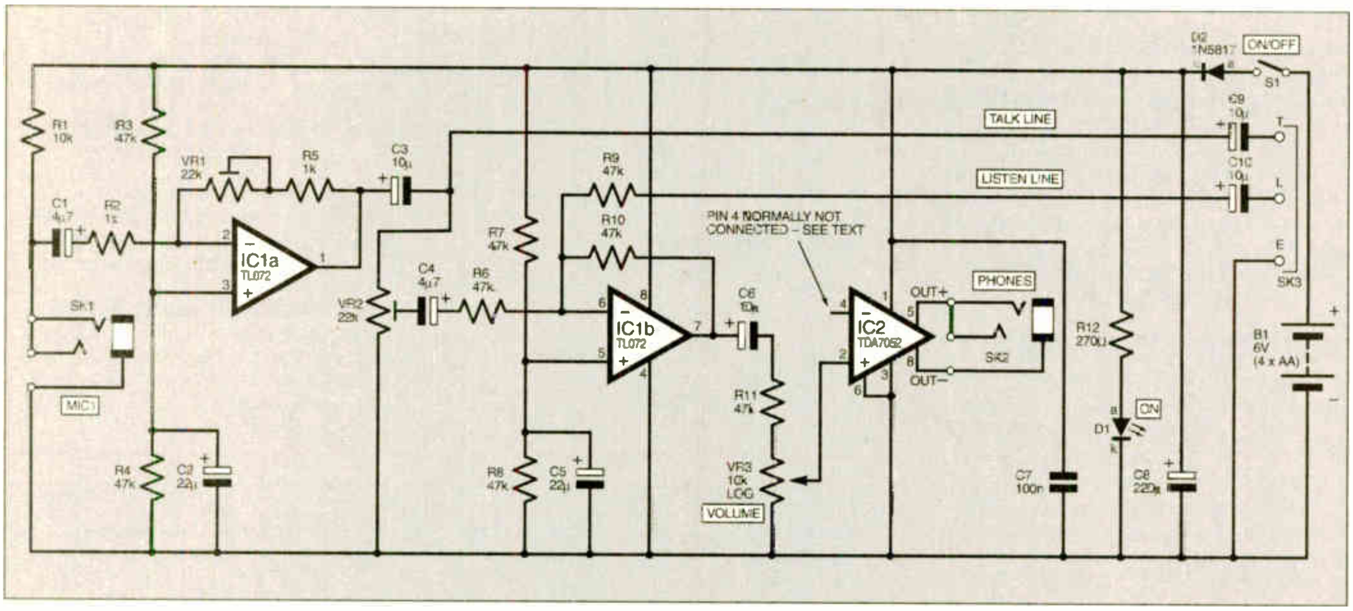


Fig.1. Circuit diagram for the Headset Communicator. This is the same for both the Master and each Slave unit.

needed in the Master unit to select the slave unit to be communicated with. This aspect of operation is looked at later.

Six-volt battery B1, supplies current through On/Off switch S1 and diode D2. The diode provides reverse-polarity protection. Thus, if the supply were to be connected in the wrong sense, D1 would fail to conduct and no current would flow, thus preventing damage to semiconductor devices.

Note that a *Schottky* diode is specified for D2. This introduces a smaller forward voltage drop than a conventional diode.

Capacitor C8 provides a reserve of energy and allows peaks of power to be delivered especially when the battery is nearing the end of its useful life. Light-emitting diode, D1 is the *on* indicator and operates through current-limiting resistor R12.

. The microphone section of the headset, MIC1, is connected to the circuit via socket SK1. This microphone is of the electret type and so requires a power supply for its internal preamplifier. This is derived from the nominal 6V supply through resistor R1.

The speech signal is applied, via capacitor C1 and input resistor R2, to the inverting input (pin 2) of operational amplifier (op.amp) IC1a. This is one half of a dual unit. The function of the other section, IC1b will be looked at presently.

COMPLETELY BIASED

The non-inverting input of IC1 (pin 3) is connected to a nominal 3V reference derived from the potential divider comprising fixed resistors R3 and R4 working in conjunction with capacitor C2. Since the op.amp is powered from single supply rails (+6V and 0V), this procedure allows for a "false zero" to be set allowing both the positive and negative half-cycles of the input waveform to be amplified.

Fixed resistor R5 and preset VR1 connected in series apply negative feedback between IC1 output (pin 1) and the inverting input (pin 2). The value of the feedback resistance divided by that of input resistor R2, determines the gain.

With preset VR1 at minimum adjustment this will be unity and when at maximum 23. In fact, these values are *negative* but this has no practical consequence here. Preset VR1 will be adjusted at the end of construction to provide a suitable gain for the particular microphone used. If tests prove the gain to be too small, the value of resistor R2 could be decreased.

TALK TO ME

The output signal from IC1a flows, via capacitors C3 and C9, to the Talk (T) pin of input/output socket SK3. In addition, some of this signal flows through preset potentiometer VR2. The sliding contact selects a fraction of this and passes it, via capacitor C4 and resistor R6, to the inverting input (pin 6) of IC1b. The non-inverting input (pin 5) biasing arrangements are the same as for IC1a, using fixed resistors R7 and R8 in conjunction with capacitor C5.

A further signal arrives at IC1b inverting input from the Listen (L) pin of socket SK3 through capacitor C10 and resistor R9. This has been derived from the "talk" output of the remote unit.

Op.amp section IC1b may be regarded as a mixer for the local and distant signals and since feedback resistor R10 is equal in value to input resistors R6 and R9, the gain is unity (actually –1). The level of the local (own voice) signal may be adjusted using preset VR2.

VOLUME CONTROL

The output of IC1b (pin 7) is applied, via capacitor C6, to the top end of the potential divider comprising fixed resistor R11 connected in series with panel-mounted potentiometer VR3. A fraction of the signal is obtained from the sliding contact and applied to the input (pin 2) of power amplifier IC2.

This device has been designed to allow an 8-ohm loudspeaker to be connected between its outputs (pin 5 and pin 8) to develop one watt approximately. Here headphones are used and, since these have a higher impedance than a loudspeaker (30 ohms approximately), the available power is reduced.

However, only a small amount of power is needed to drive the headphones at full volume so this method works well. The headset volume may be adjusted using VR3.

The specified power amplifier (type TDA7052 – having no suffix) does not require a connection to pin 4. However, there are variants of this device having a suffix and which have a "d.c. volume control". If one of these must be used, then pin 4 will be used to control its gain.

To match the characteristics of the specified unit, it would be necessary to impose a voltage greater than 1·5V on pin 4 which sets it to maximum. This could be done using a potential divider and more will be said about this later.

MASTER SECTION

How the Master console is connected to the slaves is shown in Fig.2. The master Listen and Talk lines are directed to one of sockets A, B or C using switch S2. This switch is a 4-pole 3-position type.

The talk and listen lines are connected via switch S2a and S2b respectively while the l.e.d. corresponding to the chosen socket receives current via S2c and current-limiting resistor, R13. Pole d is not used.

The "All Talk" function (enabling the Master to speak to all slave units simultaneously) is provided by connecting the master talk line to all three sockets. This is

COMPONENTS

Approx. Cost Guidance Only **£30** *(Master + one Slave) excl headset, leads, case & batts*

ALL UNITS
(Master and Slaves – as required)

Resistors

R1	10k
R2, R5	1k (2 off)
R3, R4, R6, R7, R8, R9, R10, R11	47k (8 off)
R12	270Ω
Rx	56k
Ry	22k

(Rx and Ry not needed if IC2 is as specified – see text)
All 0·25W 5% carbon film.

See SHOP TALK page

Potentiometers

VR1, VR2	22k sub-min. enclosed preset, vertical (2 off)
VR3	10k min. rotary carbon, log.

Capacitors

C1, C4	4μ7 radial elect. 16V (2 off)
C2, C5	22μ radial elect. 16V (2 off)
C3, C6, C9, C10	10μ radial elect. 16V (4 off)
C7	100n ceramic
C8	220μ radial elect. 16V

Semiconductors

D1	3mm red l.e.d.
D2	1N5817 1A Schottky rectifier diode
IC1	TL072 dual op.amp
IC2	TDA7052 (no suffix) power amplifier (see text)

Miscellaneous

S1	s.p.s.t. rocker or toggle switch
SK1, SK2	3·5mm stereo jack socket (or as required for headsets used) – see text regarding headphone socket (2 off)
B1	6V alkaline battery pack (4 x AA), with holder and connector clip

Printed circuit board available from the *EPE PCB Service*, code 369; headset having electret microphone and an earphone or earphones (impedance 30 ohms approximately); 8-pin i.c. socket (2 off); commercial XLR leads (or home-made leads) – total of 3 required; connecting wire; small fixings; solder, etc.

ADDITIONS FOR MASTER

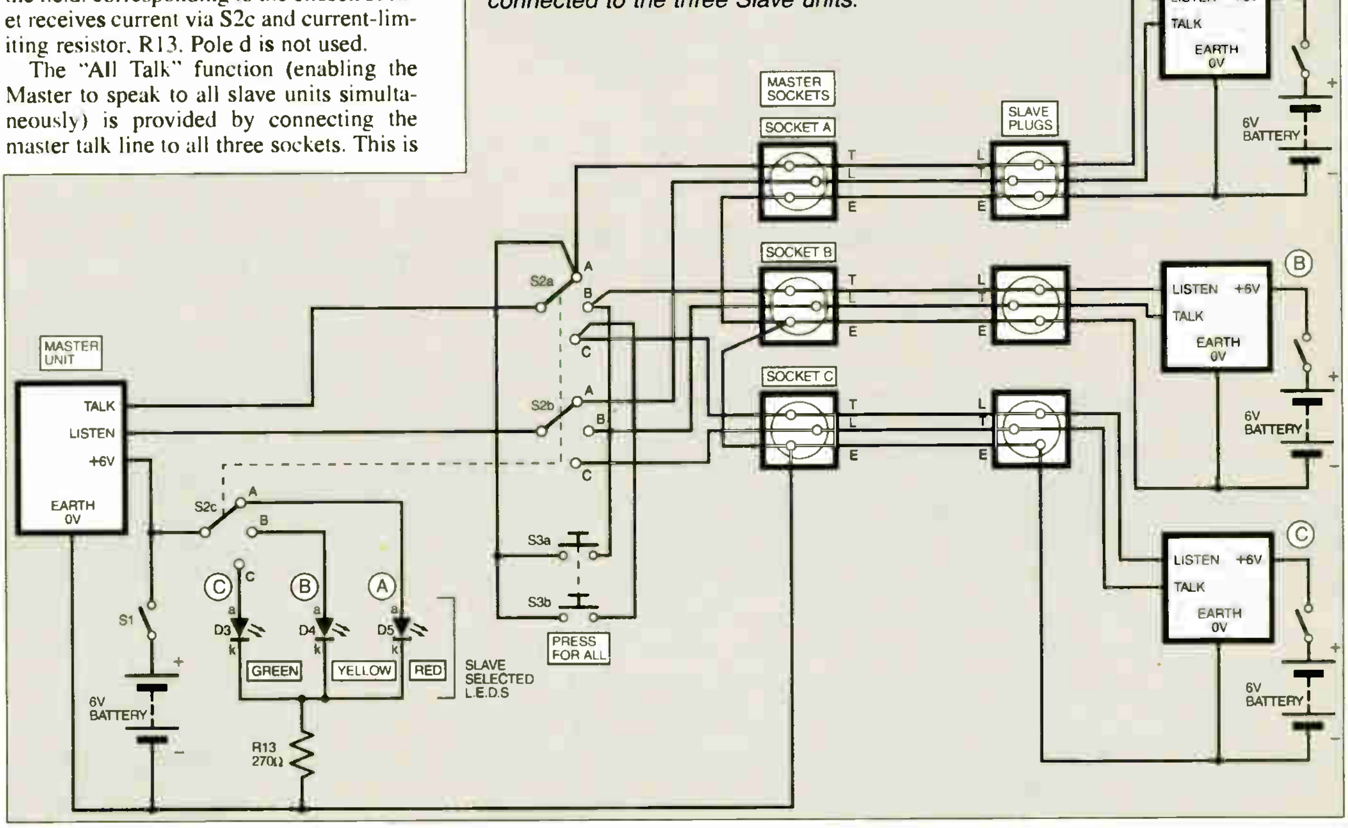
R13	270Ω 0·25W 5% carbon film
S2	4-pole 3-way rotary switch
S3	d.p.s.t., momentary action, push-to-make switch
D3 to D5	3mm l.e.d.s, one each red, yellow, green

Sloping front instrument case with aluminium top and plastic sides, size 170mm x 143mm x 55/31mm; XLR panel mounting socket (3 off); plastic feet; solder tag.

ADDITIONS FOR EACH SLAVE

Plastic box size 114mm x 76mm x 38mm; panel mounting XLR plug; belt clips if required; 6V alkaline battery pack (4 x AA) with holder and connector clip.

Fig.2. How the Master console unit is connected to the three Slave units.



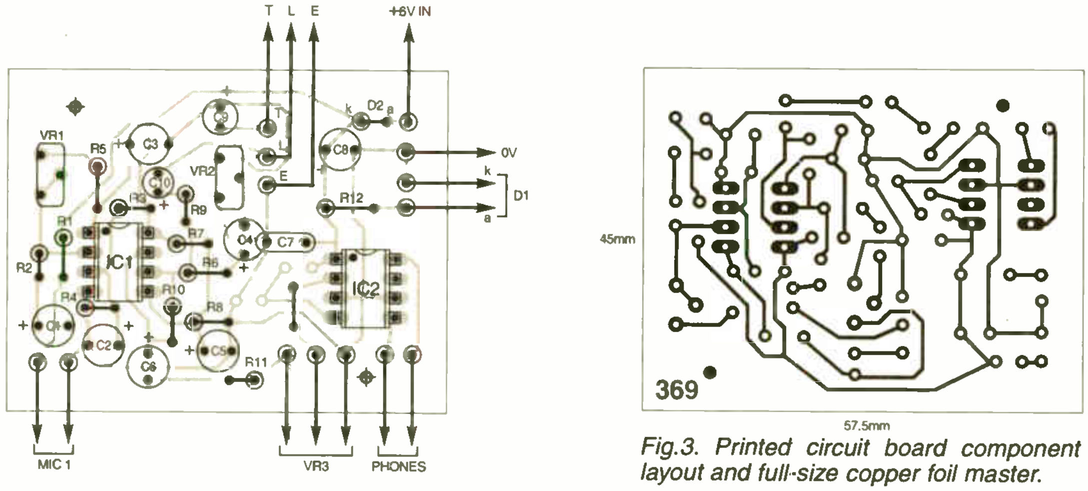


Fig.3. Printed circuit board component layout and full-size copper foil master.

carried out using a double-pole momentary action switch S3.

TAKING THE LEAD

In the prototype system, the interconnecting leads were of the commercial variety fitted with a 3-pin XLR line plug on one end and a matching line socket on the other. These connectors are widely used in the industry and are normally used for balanced audio applications. Before purchasing XLR leads, check that they are of the standard pattern.

Some cheap cables intended for unbalanced microphones, have only one inner conductor with the screening connected to two of the pins. For this circuit, you need two available inner conductors plus the screening. You could, of course, use home-made leads constructed using two-core screened wire and stereo-type jack (or XLR) connectors.

CONSTRUCTION

Construction of the Headset Communicator is based on four identical single-sided printed circuit boards (p.c.b.s). This, of course, assumes that three slaves are required. These boards are available from the *EPE PCB Service*, code 369.

The p.c.b. topside component layout and full-size underside copper foil master pattern are shown in Fig.3. Begin construction of each p.c.b. by drilling the two fixing holes as indicated.

Next, solder the i.c. sockets in position, also the link wire connecting IC2 pin 2 with Volume control VR3 sliding contact, all resistors (including the presets) and the capacitors. Apart from C7, the capacitors are all electrolytics so take care with their orientation. Note that there are four holes which will have been left empty – see later.

Now solder pieces of stranded connecting wire to the talk (T), listen (L) and earth (E) points on the completed p.c.b. Connect similar pieces of wire to the MIC1 and VR3 positions. Use different colours to avoid errors later. Adjust presets VR1 and VR2 to approximately mid-track position.

TESTING

It is advisable to check the operation of *each* circuit board at this stage because it is then much easier to correct minor problems. Solder the battery connectors to the +6V and 0V p.c.b. pads, taking care over the polarity (red wire for +6V).

Solder jack sockets (or the required type to match the headset) to the MIC1 and Phones wires. Note that the *sleeve* of the microphone plug *must* connect to *right-hand* MIC1 wire on the p.c.b. – that is, the one connected to the 0V line. In the prototype unit, the microphone plug was a 3·5mm *stereo* jack type but either "tip" connection could be used because they were connected together internally.

The prototype headphones were also wired to a 3·5mm stereo jack plug. In this case, each tip connection was responsible for one unit while the "sleeve" was common to both. This enables the headphones to be used individually for stereo applications.

Here, both tips need to be connected together so that the units appear in parallel and provide mono operation. The common tips connect to one wire and the sleeve to the other. This procedure may need to be modified depending on the plugs fitted to the headsets.

Referring to Fig.5, the Slave unit wiring, solder potentiometer VR3 tags to its wires in the sense shown. Adjust it to approximately mid-track position.

Insert the i.c.s into their sockets. Since these are CMOS devices, they could be damaged by static charge which may have accumulated on the body. *To avoid possible problems, touch something which is earthed (such as a metal water tap), before unpacking them and handling the pins.* Do not throw away the packaging because it will be needed again later.

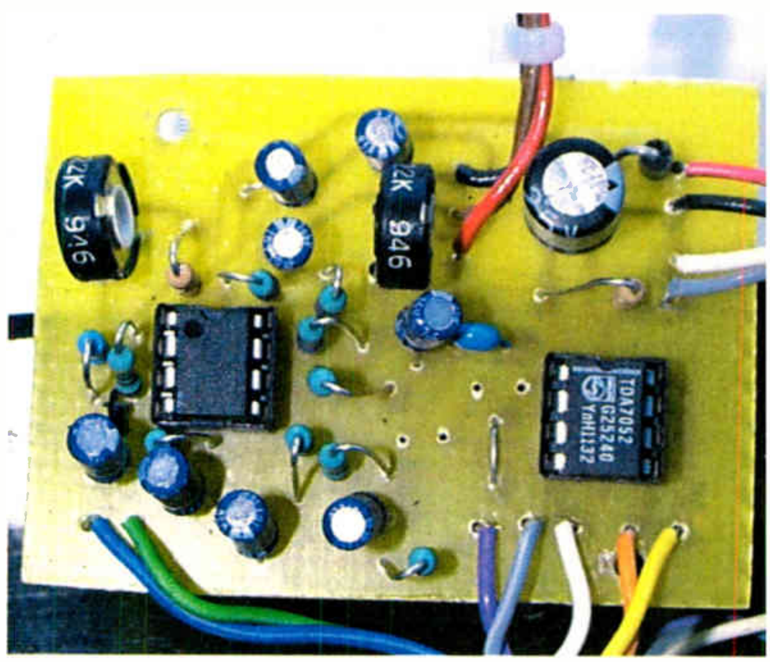
IT'S WORKING

Do not put the headset on initially in case of sudden loud clicks and other noises. Satisfy yourself on this point before putting it on.

Connect the battery and note that the On l.e.d. operates. If acoustic feedback is evident (which should not occur when the headphones are worn) adjust Volume control VR3.

Listen to the headphones and speak into the microphone. If you can hear your voice clearly, the circuit is working. If it is obvious that the microphone gain is too small (quiet sound even with VR1/VR2/VR3 set to maximum) reduce the value of resistor R2 to 560 ohms (after switching off and removing the i.c.s).

Repeat all this with the other circuit boards then, observing the anti-static precautions mentioned earlier, remove the i.c.s from their sockets and replace them in their anti-static packaging. De-solder the jack sockets, potentiometer and positive battery connector lead. Connect a piece of stranded wire to the +6V p.c.b. point instead.



Completed prototype circuit board.

MASTER BOX

The sloping front aluminium instrument case used for the prototype Master unit gives a professional appearance, see photographs. There is an advantage in using a box that is of part plastic construction. This is because a case made entirely of metal will need additional insulation on the Phones output socket.

Find the best positions for the switches, panel potentiometer, l.e.d. indicators and sockets. The headset socket should be located on a *plastic* part if possible.

Decide whether commercial XLR leads are to be used or whether leads are going to be made up so that the appropriate connectors may be chosen. In the prototype, XLR sockets were used in the master with a matching plug on each slave unit. Drill holes for all these parts.

Mark out and drill the holes for mounting the p.c.b., battery holder and any remaining parts, including one for the solder tag (in a metal part). Drill small holes to correspond with the anti-rotation tabs on the rotary switch and potentiometer. This prevents their bodies possibly turning in service and breaking off soldered connections.

INTERWIRING

Attach all internal components and, referring to Fig.4, complete the interwiring to off-board components. Note how resistor R13 is connected. Apply some sleeving to the joints at the l.e.d. leads and any bare wires to prevent short circuits. Using a multitester, check that the solder tag makes good contact with the metal part of the case. The wires connected to it should be twisted together and hooked through the hole before soldering.

Note that neither Phones socket connection may make contact with 0V (earth) – that is, any metal part of the case. If, as in the prototype unit, the socket is mounted on a *plastic* part, there will be no problem.

If the socket must be mounted on metal, the best approach would be to use a *fully-insulated* jack socket. Unfortunately, most types make automatic connection of the sleeve to the case.

If necessary, you will need to make an insulating sleeve (or a shouldered plastic bush) and use plastic washers to isolate it from the metalwork. Use a multitester to check that the sleeve does not make electrical contact with "earth" before proceeding.

Take care to wire up the Listen/Talk selector and the Talk to All switches correctly. The pole lettering and contact tag numbering (see inset dia.) is as shown on most switches of this type.

If using XLR connectors, pin 1 should be connected to Earth (0V) along with the solder tag which connects to the metal body. In the prototype, pin 2 and pin 3 are used for the Talk and Listen connections respectively.

All the wires connected to these sockets will need strain relief. In the prototype, this was done by means of a cable tie passed through slots in the bottom of the case. This will help in preventing the wires from breaking free in service.

MICROPHONE WIRING

The microphone input socket may be mounted on a metal part because its sleeve

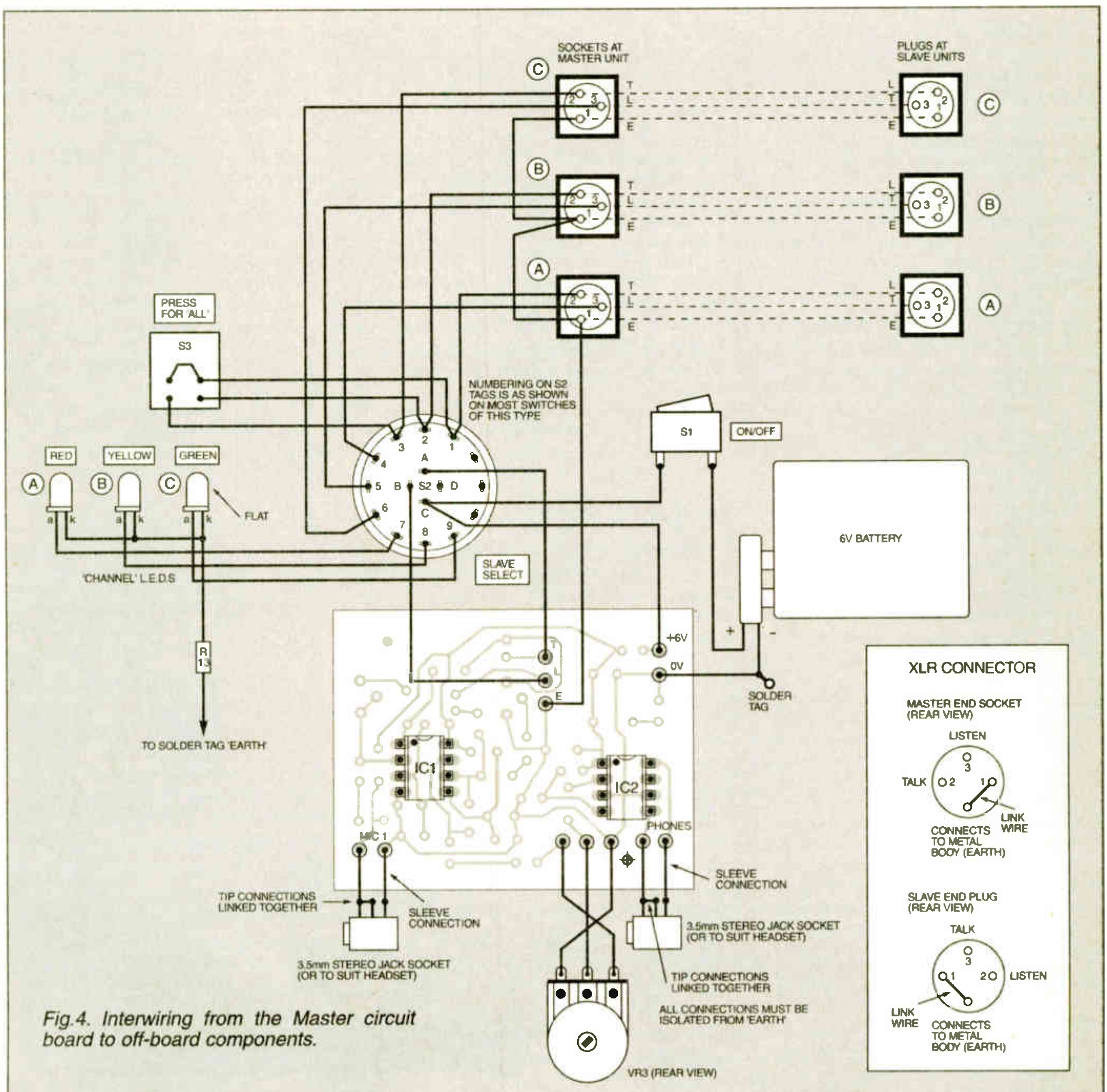
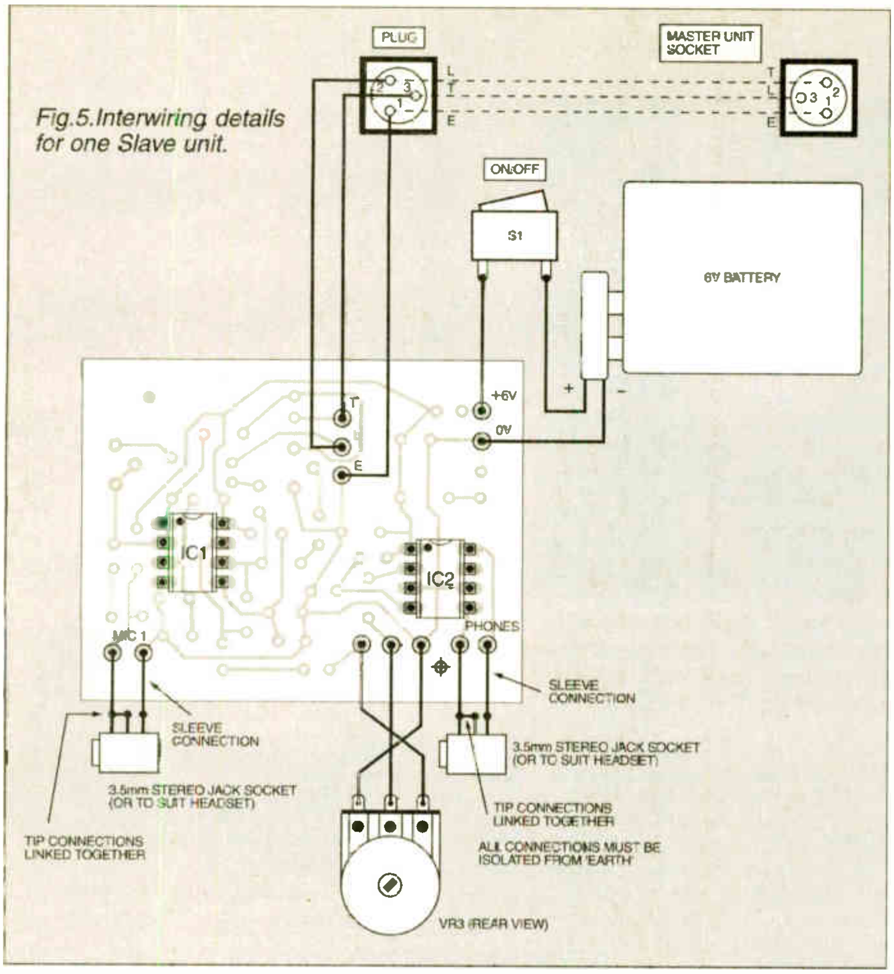
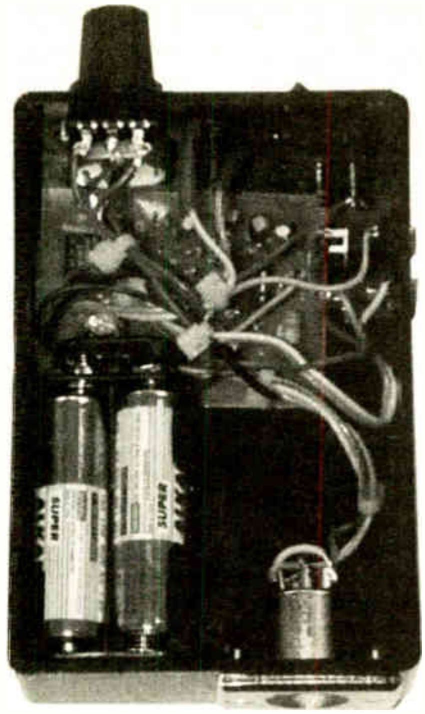


Fig.4. Interwiring from the Master circuit board to off-board components.





Packing the components into the Slave unit.

must be connected to earth (0V). However, it will probably be mounted next to the phones socket for cosmetic reasons. If it is on plastic, you will need to hard wire its sleeve connection to the solder tag.

Note the sense of the wiring to the Volume control (VR3) potentiometer tags. This gives conventional operation – clockwise rotation increasing the volume.

Note also that only one current-limiting resistor, R13, is needed for the slave indicator l.e.d.s. This is because only one l.e.d. can be illuminated at a time.

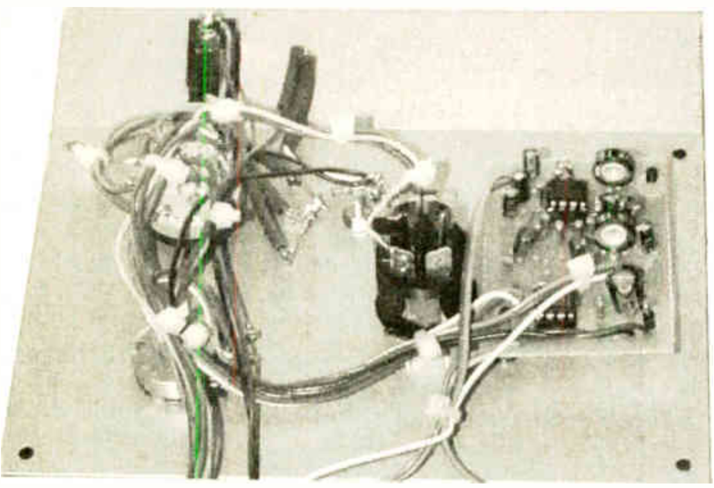
SLAVE UNITS

Choose plastic boxes of appropriate size for the Slave units and fit the belt clips if required. Check the layout of internal parts and drill holes for them. Do not forget the small hole needed for the Volume control potentiometer anti-rotation tab.

Attach all slave parts and, referring to Fig. 5, complete the internal wiring leaving plenty of slack in the wires. Note that certain connections will be close together so make sure they do not touch and cause a short-circuit. Use additional insulation as necessary.

Check that the connections to the plug pins allow the interconnecting lead to make the appropriate connections (Talk to distant Listen and Listen to distant Talk). In the prototype, pin 2 was used for listen and pin 3 for the talk. Connect pin 1 to the solder tag on the plug that connects to the metal body. Take care over the sense of the connections to the potentiometer tags.

Attach the control knobs to the spindles of the switches and potentiometers in all units. Leave the lids removed from the cases for the moment to allow presets VR1 to be adjusted. Observing the usual anti-static precautions, insert all the i.c.s into their sockets taking care over the orientation.



General layout of components on the Master unit metal front panel.

FINAL CHECKS

Begin final checking with all the units switched off. Fit the batteries then plug in the interconnecting leads and headsets, with integral microphone "booms". Turn all the Volume controls to minimum and switch the units on.

The l.e.d. On indicators should operate. The headphones should be listened to with caution in case the Volume controls have been wired in the wrong sense and a sudden loud noise develops.

Test the operation between the Master and each Slave unit. Preset VR1 should be adjusted in each unit so that the maximum volume set by VR3 is not too great and that there are no signs of instability. Adjust preset VR2 in each unit for the preferred degree of voice feedback. Check the "talk to all" function.

When satisfied, attach the lids of the cases and label the controls. You will know when the batteries need to be replaced because the sound will become weak or distorted and the l.e.d.s will glow less brightly.

In use, always start with the volume turned down to minimum and switch on all units before wearing the headsets. This will avoid any loud clicks.

ALTERNATIVE POWER AMPLIFIER

If it is impossible to obtain the specified power amplifier (i.e. a TDA7052 *without* a suffix letter) and you must use one having a "d.c. volume control", its gain will need to be configured to maximum to match the characteristics of the specified unit. This may be done by soldering resistors Rx and Ry in the unused positions on the p.c.b. Resistor Rx will be in the upper position which connects to IC2 pin 1 and Ry to the lower position which connects to IC2 pin 4.

Resistor Ry may need a 1µF capacitor connected in parallel with it. This could be placed on the underside of the p.c.b. Note that this set-up has not been tested and some experimentation may be needed to obtain correct operation. □

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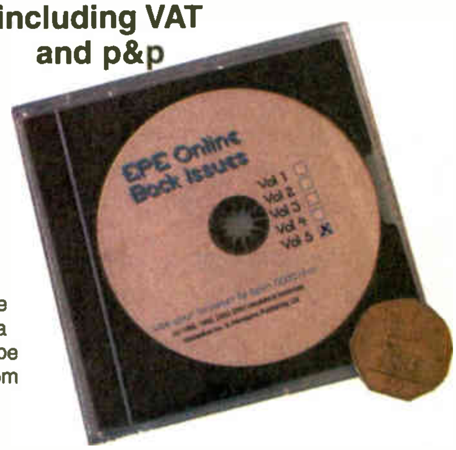

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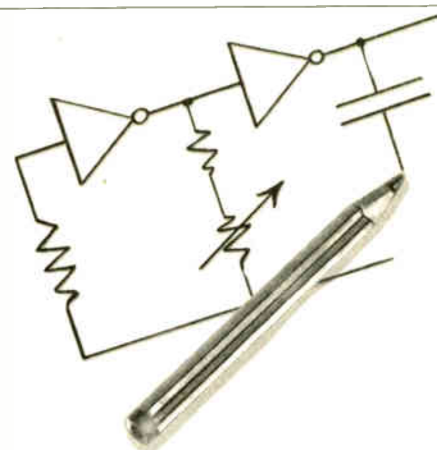
LOGIC GATE INVERTER OSCILLATORS



GEORGE HYLTON

Part Two

A compendium of practical oscillator circuits for the creative experimenter, all based on inverting logic gates.

LAST month we examined the basic principles which allow CMOS inverters to be used as oscillators, concluding with an example of a Colpitts oscillator. We conclude this two-part series by first examining a ccrystal oscillator circuit.

CRYSTAL OSCILLATOR

The high frequency crystals used to set the clock frequency in computers can replace L in the Colpitts circuit of Fig.10. The circuit is then sometimes called a Pierce oscillator (Fig.11), although this nomenclature is dubious.

Since a crystal blocks d.c., a resistance (R1) must be added to allow d.c. negative feedback to set the working point. This resistance should be high enough not to impair the oscillation.

Crystal manufacturers specify the value of shunt capacitance needed to trim the frequency to its nominal value. In the pi-network, the two capacitances are effectively in series so each should be twice the quoted shunt capacitance. The frequency can be fine tuned by adjusting one or both of them.

It is possible that oscillation may be too violent. A feedback control (VR1) may also be used as with the Colpitts oscillator. Crystal manufacturers may specify a safe operating voltage and VR1 can be set to ensure that it is not exceeded. Generally speaking, it is sufficient to set VR1 so that reliable oscillation (in the face of falling supply voltage, etc.) is just feasible.

For crystals designed to generate frequencies below about 1MHz, or above about 10MHz, special circuit arrangements may be needed. Consult the manufacturer's data sheet.

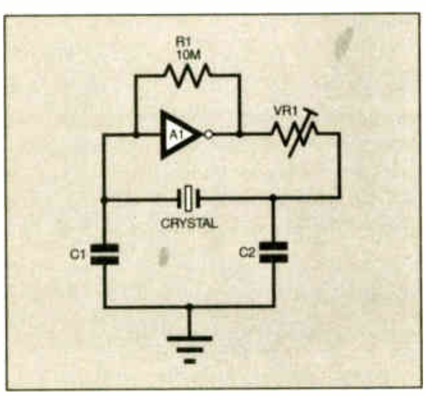


Fig.11. Pierce crystal oscillator. Here the crystal replaces L in the Colpitts circuit.

TWO-TERMINAL LC

The need for transformers or twin capacitors can be avoided by using a so-called two-terminal oscillator circuit. This means that the frequency-determining LC circuit can be connected by just two leads, those marked X in Fig.12.

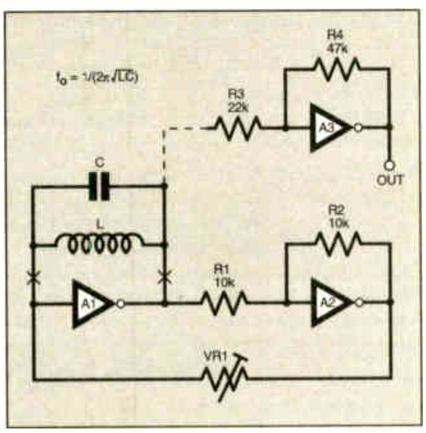


Fig.12. Two-terminal LC oscillator. A2 provides the required phase inversion. A3 can be added as a output buffer.

With R1 = R2, A2 has a gain close to one, so it is just a voltage inverter. Then A1 must provide the gain needed for oscillation. The critical condition is that VR1 should be just less than the effective resistance of the LC circuit at its resonant frequency f_0.

The effective resistance is called the dynamic resistance and is Q times the reactance of L or C at f_0. For a usable coil the Q "quality factor" is unlikely to be less than five, and may be several hundred.

Good sine waves are obtainable at the LC circuit when VR1 is considerably less than the critical value, but to get a pure waveform at A2 output, VR1 must be set so that the circuit just oscillates. It may be simpler to pick off a sine wave output at A1 and extract it via buffer A3. This has a gain of R4/R3. The circuit may be used up to about 1MHz.

If VR1 is calibrated it can be used to obtain a reasonably accurate indication of the dynamic resistance of the LC circuit. Simply adjust VR1 to the maximum value for oscillation. Then VR1 is the dynamic resistance. From this the Q can be calculated:

Q = dynamic resistance / reactance of L or C at f_0

This circuit has overall d.c. positive feedback. It would latch up if the d.c. gain of A1 exceeded one. Fortunately, the low d.c. resistance of L keeps gain well below one, so it is d.c. stable.

Resistors R1 and R2 set the gain of A2 to unity (−1). Driving A2 directly would cause over-violent oscillation, The ratio R2/R1 could be increased to up the loop gain but this is not necessary with typical LC values.

In A3, R3 and R4 set the gain and working point and R3 also provides some buffering. With VR1 set correctly there is no protection-diode conduction. This implies a VR1 of slightly less than the dynamic resistance $2\pi f LQ$ or $Q/(2\pi fC)$. However, VR1 can be less than optimum without seriously impairing the sine wave at the LC.

WIEN BRIDGE SINE WAVE OSCILLATOR

The reactive (RC) arms of a Wien bridge (Fig.13) can be used to set the frequency of a sine wave oscillator formed around an op.amp (Fig.14). In a Wien bridge, when R1 = R2, C1 = C2 (the usual case) balance (zero output) is obtained when V2 = V3, in which case C then has a reactance equal to R.

This occurs when the input frequency f_{in} is $1/(2\pi CR)$, usually called f_0. Tuning is conveniently effected by using a two-gang potentiometer for the two controlling resistors (R1 and R2) so that they are always equal. In this way balance is maintained as these resistors are adjusted.

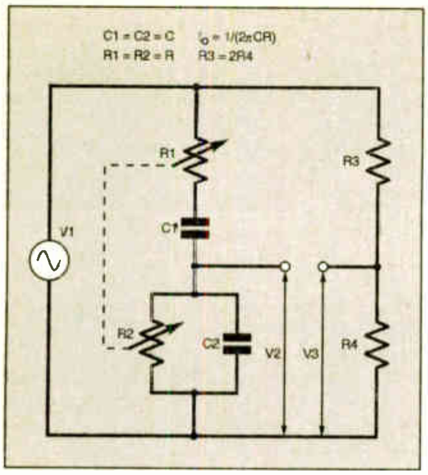


Fig.13. Wien bridge.

In oscillators, use is made of the fact that RC arms of the bridge form a frequency-selective voltage divider whose output is greatest at f_0. At frequencies away from f_0, output falls. When this network is used as a positive-feedback path in an amplifier (Fig.14) and the gain is just sufficient for oscillation, a sine wave at f_0 is generated.

Unfortunately, the Wien network is only very weakly frequency-selective. It does a poor job of discriminating against harmonics produced by the amplifier overloading. The waveform is distorted.

A solution used in commercial Wien oscillators for audio work is to provide a distortionless means of automatically restricting gain to be just sufficient for oscillation. Very pure sine waves can then be obtained. A common method is to use a negative temperature coefficient (n.t.c.) thermistor for the R3 resistance. As oscillation builds up the signal warms the thermistor whose resistance falls. This increases the negative feedback to the inverting input terminal, damping down the oscillation.

The standard circuit (Fig.14) does not translate into inverter-oscillator form because an inverter has only one input terminal. It can, however, be adapted to a 2-inverter circuit, as illustrated in Fig.15.

Inverters A1 and A2 are used in their "linear" mode and the parallel-RC arm now creates negative feedback to A1 while the series RC arm conveys positive feedback from A2 to A1. The circuit oscillates at f_0 when the gain of A2 (adjusted by VR2) slightly exceeds two. An extra preset

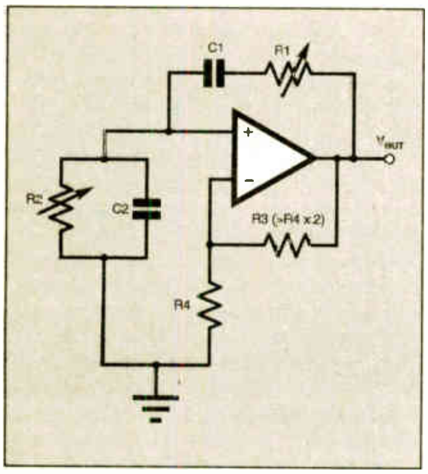


Fig.14. Wien bridge oscillator using an operational amplifier.

resistance, VR1, has been added. Without it the circuit would cease to oscillate as R is reduced towards zero. The oscillation frequency is:

$$f_0 = 1/(2\pi C(R + VR1))$$

In fact, there is a hidden component in the series arm: this is the output resistance of inverter A2 and it must be compensated for by an increased resistance in the parallel arm. If this is not done, feedback varies as R is adjusted and it is impossible to obtain a good waveform over the tuning range.

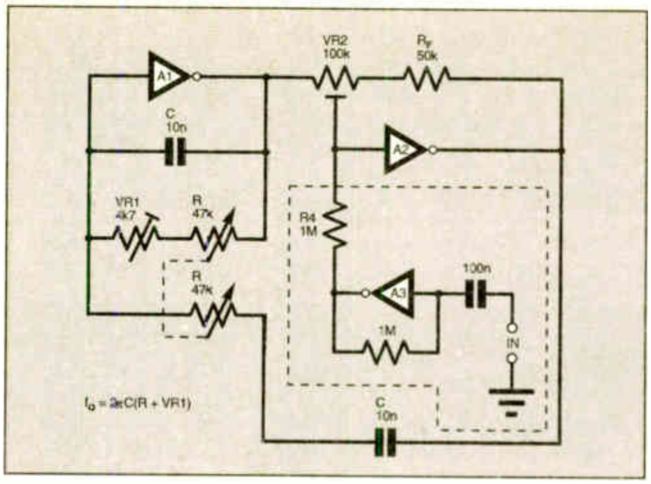


Fig.15. Inverter gate version of Wien oscillator. The A3 section can be added to inject an external synchronising signal.

AMPLITUDE LIMITING

No device for automatic amplitude limiting is shown in Fig.15. The job could be done by substituting a thermistor for the feedback resistance across A2 as in Fig.16. VR2 would then provide oscillation level adjustment and should have a mid-value equal to the working thermistor resistance.

Unfortunately, there are really no suitable thermistors available to the average hobbyist. The sub-miniature bead thermistors needed are very expensive. Cheap types are physically too bulky and do not heat up enough at the small signal levels in the circuit.

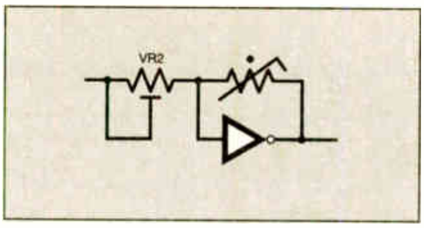


Fig.16. Using a thermistor in place of R_F in Fig.15.

V_{out} must drive enough current through the thermistor to reduce its resistance sufficiently to obtain low distortion. Since CMOS inverters cannot deliver much current it is desirable to keep the thermistor resistance fairly high, say 10k. The a.c. voltage across it is unlikely to exceed about 3V r.m.s. The power available to warm the thermistor is then 0·9mW. For reliable operation over a range of ambient temperature this amount of power must cause a temperature rise of at least 20°C.

If very low distortion is not required, a fairly good sine wave can be obtained from the circuit as shown in Fig.15 if set-up carefully, as follows:

Set R to maximum. Set VR2 for "just oscillating". Set R to minimum (zero). Without altering VR2, set VR1 for "just oscillating". Repeat this procedure then, if necessary, make minor adjustments so as to obtain the best compromise performance over the tuning range.

The final result will depend on how well the two sections of the potentiometer are matched. Linear-law two-gang pots are usually better than log-law, but give tuning scales which are very cramped at the high-frequency end. Frequency sweeps (max./min.) of 10 are then a practical limit, though the circuit will oscillate over a wider sweep.

The circuit can be used as a selective amplifier with input injected via a high-impedance buffer A3. In this case VR2 is a sharpness control and for greatest selectivity is set for "just not oscillating". The buffer amplifier may also be used, if required, to inject a frequency-locking signal into the oscillating circuit.

An injected signal of a few mV can synchronise the oscillator. How long it stays synchronised depends on the frequency stability of both the oscillator and the sync input. Injecting a larger signal increases the locking range but at the risk of false locks where one frequency bears some fractional relation to the other. (Often the waveform then shows some periodic distortion.)

Multi-band operation is possible by switching-in different pairs of capacitors C. For consistent performance each pair must be very accurately matched.

DUAL INTEGRATOR OSCILLATOR

An inverter with feedback from output to input via a capacitor (as with A1 and A3 in Fig.17) has a gain which falls off as the frequency is raised. In a sine wave oscillator this reduces the harmonics which result from distortion. The ability to yield good sine waves without special amplitude control circuitry is especially useful at very low frequencies, where conventional control using thermistors is difficult. (The resistance of the control device varies over the oscillation cycle and causes distortion.)

An inverter with capacitive feedback produces a phase shift. Two inverters, each giving a phase shift of 90° in the same direction, give a total of 180°, which is phase inversion. When cascaded with a simple inverter and connected in a ring, the overall feedback is positive at the 90° frequency. Here this is the frequency for which the reactance of C equals R.

An inverter with capacitive feedback is often referred to as a Miller integrator, or just an integrator. The frequency generated by the type of circuit in Fig.17 is the same as for a Wien network oscillator (f_0 = 0·16/(RC)). With the values shown the

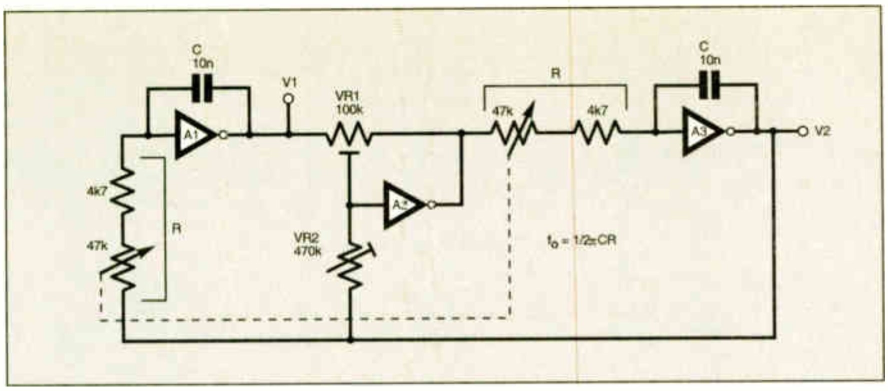


Fig. 17 Dual-integrator oscillator. Oscillation level is set by VR2. The two outputs V1 and V2 are equalized by VR1 and are 90° apart in phase.

range is roughly 300Hz to 3300Hz. The range can be switched by substituting other pairs of capacitors, accurately matched.

When R is in megohms and C is in microfarads, the frequency is in Hertz (Hz). Because of the good discrimination against harmonics it is easier to achieve a respectable sine wave than with the Wien oscillator.

The circuit also has the useful property of yielding two equal output voltages (V1 and V2) phased 90° apart ("in quadrature"). On the other hand setting up to achieve a good performance over the tuning band (by adjusting VR1 and VR2) involves using an oscilloscope and doing a fair amount of fiddling.

Start with VR1 and VR2 set halfway. Trim VR1 to equalise V1 and V2. Trim VR2 for the best waveform. The tuning range is somewhat affected by these settings. To achieve the best amplitude stability one of the fixed resistances in series with the tuning resistances may need to be trimmed (at the h.f. end of the band).

RING OSCILLATORS

The three inverters of Fig.18a are connected in a loop or ring. If the input to A1 is positive then the output of A3 is negative. Since this is fed back to A1, it opposes the positive input. The ring is a negative feedback loop with total feedback and (accidents barred) it will be stable. Accidents do happen, though, as will be shown later.

Referring to Fig.18b, if we now interpose between successive stages networks which produce 60° phase shift to signals at some frequency then, going round the loop, the three phase shifts add up to 180°. This is inversion.

The reactance is twice the resistance for series C, shunt R, and the reverse for series R and shunt C.

The fed-back signal at A1 is now in step with the original signal. Feedback is therefore positive and the circuit oscillates. If the 180° phase shift occurs at only one frequency then that will be the frequency of oscillation.

PHASE SHIFTERS

Two standard ways of achieving phase shift are shown in Fig.18c to Fig.18d. The first is passive – the required 60° shift occurs at the frequency at which the series arm has twice the impedance of the shunt arm. At that frequency the attenuation factor is two (i.e. half the voltage is lost). This is likely to be much less than the gain of an inverter so the circuit oscillates strongly.

Unfortunately, the strong oscillation drives the internal protection diodes into conduction. The effect is to raise the frequency spectacularly but unpredictably. It would be possible to add swamping resistances but a better alternative is to use the circuit in Fig.18d. Here the phase shifting is done by incorporating the RC network into an integrator, the amplifier being one of the inverters. The inverter input terminal is now a virtual earth point and the signal level there is low enough to avoid the worst effects of protection-diode conduction. In a ring of three such integrators each produces a lagging phase shift of 60°. The oscillation frequency is theoretically

$$f_o = 0{\cdot}08/(CR)$$

As before, f_o is in Hertz when CR is in megohms times microfarads and so on.

RING VCO

If, in circuits using Fig.18c, the resistances and capacitances are reduced to zero the circuit reverts to that in Fig.18a. It might be expected to display a stubborn stability. Far from it! It oscillates, but at a high frequency.

The explanation is simple. We may have removed *our* Rs and Cs but the circuit has its own built-in equivalents. R is now the output resistance of each inverter and C the input capacitance of the following one.

In a particular case R might be 10kΩ and C might be 10pF. These act like those in Fig.18c. The 60° frequency is:

$$f_o = 1/(\pi RC) = 3\text{MHz approximately.}$$

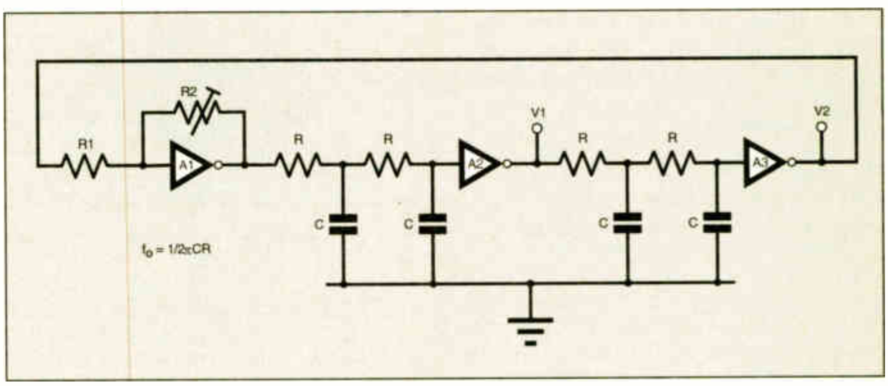


Fig.19. Dual-quadrature oscillator. Each twin RC network produces 90° shift at f_o.

Both the output resistance and the input capacitance of an inverter are affected by the operating voltage. The output resistance is especially strongly affected.

In experimental tests using a CMOS 4069 inverter, biased to operate in the linear region of the input/output curve, the output resistance measured 16kΩ when V_{CC} was 5V, falling to 5kΩ when V_{CC} was 15V.

This means that the "zero component" ring of Fig.18a is in reality a voltage-controlled oscillator, with V_{CC} as its control voltage. Oscillation may be possible at V_{CC} down to 2V, where the frequency is quite low. At high V_{CC} it may be tens of megahertz.

Note that there is a real risk, at high V_{CC}, of the current drawn becoming excessive and overheating the chip. Note also that while standard CMOS i.c.s like the 4069

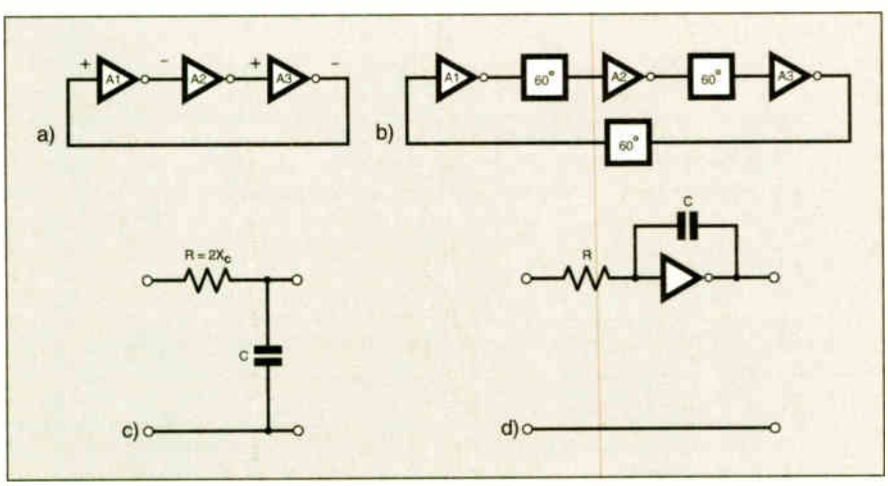


Fig.18. (a) Three-inverter ring. (b) With added phase-shift circuits. (c), (d) Alternative phase shift networks.

are rated to work at up to 15V their modern "equivalents" like the 74HC04 have much lower maximum V_{CC} ratings.

It is possible to bring down the frequency while retaining voltage control. Add real capacitors for C while leaving R at zero.

4-PHASE SHIFT RING

A ring with three equal phase shifters (Fig.18b) is a neat means of generating a three-phase signal. But suppose you need some other number of phases. Any number over two can be provided, with one precaution. The total number of inverters in the ring must be *odd*. If it is *even* there is overall d.c. positive feedback and the circuit latches up.

If you need an even number of phases you have to add one plain inverter (with no associated phase shift components) to keep the d.c. feedback negative.

One potentially useful arrangement is to have four shifts of 45° each. This enables outputs to be selected at multiples of 45°, notably 90°. The necessary fifth inverter can be used as a gain-adjustable stage to set the oscillation level. The frequency is that at which R and C have equal impedances, i.e. $f_o = 1/2\pi CR$.

The loop shift must be 180°. For a 3-section phase shift the average per section must be 60°, for four sections 45°, and so on.

It is also possible to generate outputs phased 90° apart with a 3-inverter ring (Fig.19). Here two pairs of double RC networks each generate a 90° shift. The frequency is about $1/(2\pi RC)$.

PHASE SHIFTING

In theory, three or more RC (or CR) networks can be cascaded to give an overall phase shift of 180°. A single inverting amplifier can then maintain oscillation, see Fig.20.

These circuits are usually referred to as "phase shift oscillators" (though of course phase shifting is involved in all the oscillators we have just been discussing).

Phase shift oscillators may look neat but they have two major disadvantages which stem from the fact that the second RC section loads the first, the third loads the second and so on. This greatly increases the attenuation at f_o. For a network with three cascaded RC or CR sections, all with equal R and C, the gain needed to sustain oscillation is nearly 30. For a four-section network it is nearly 20. A single inverter may not provide enough gain.

The second snag is that it is no longer possible to pick off outputs evenly spaced-out in phase. Also, the voltage diminishes at each successive section.

A third problem is that the gain is not readily adjustable. If, however, one inverter provides more than enough gain a reduction can be made by shunting off some of the current into a second inverter (Fig.21), which presents a load of R1 and can be used as an output buffer. (This trick can be used with other oscillators.)

For a three-section RC network f_o = 0·39/RC. For a four-section RC network f_o = 0·19/RC.

Attenuation can be reduced by "tapering" the networks. Successive resistances are multiplied by a factor N and successive capacitances divided by N. As N is made very large the 3-section attenuation factor falls towards eight and the 4-section towards four. Making N = 10 achieves most of the improvement and even N = 2 is worthwhile.

The RC network discriminates against harmonics and even if the input to a multi-section network is a square wave the output is a fairly pure sine wave. However, it occurs at a high-impedance point and can only be used if picked off by a very high impedance buffer. This adds its own quota of distortion.

FORMIDABLE

Phase shift oscillators are fascinating circuits which over their long history (they go well back into the valve era) have elicited from circuit analysts some formidable feats of mathematics. But if you need a low-distortion oscillator you will be well advised to leave them alone and stick to Wien or dual-integrator circuits!

Whilst we have concentrated on the use of basic CMOS inverter gates, the principles can equally well be applied through the use of dual-input inverting gates, such as NAND and NOR. □

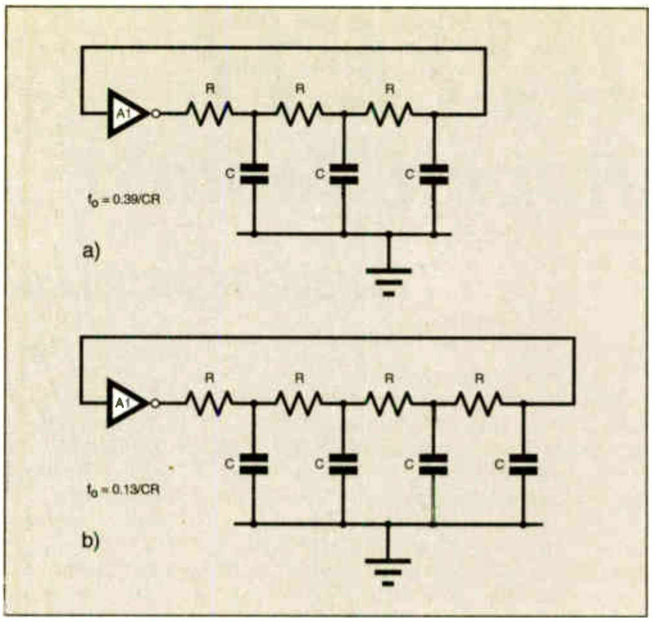


Fig.20. Phase-shift oscillators. (a) Three-section RC. (b) Four-section RC.

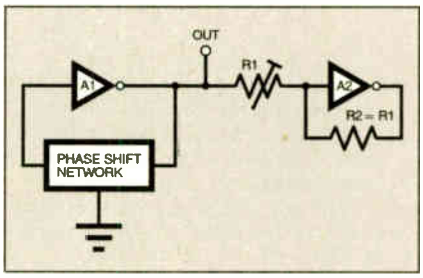
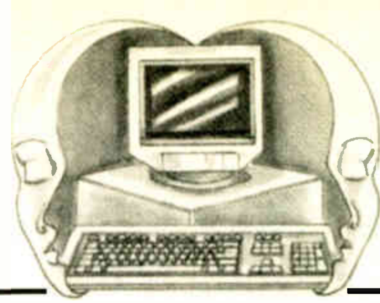


Fig.21. Gain-adjustment circuit. R1 acts as a load on A1.

INTERFACE



Robert Penfold

Adding MSCOMM Active-X control to your PC

THE two previous *Interface* articles were devoted to the use of the MSCOMM ActiveX control to permit serial communications with Visual BASIC programs. The advantage of this method is that it will work with any 32-bit Windows operating system, including Windows XP without the need for any third-party add-ons.

The main drawbacks are that this control is not included with anything less than the Visual BASIC Professional Edition, and it is something less than straightforward in use.

MSCOMM and VBA

Software topics usually produce a certain amount of feedback from readers, and the pieces on MSCOMM are certainly no exceptions. A few readers pointed out that this control is included with Microsoft Word and Excel as part of VBA (Visual BASIC for Applications).

On checking two PCs that had Microsoft Office installed but had never been loaded with Visual BASIC Professional, one had MSCOMM and the other did not. VBA is not only included with Microsoft applications, it is also provided with some software from Corel, Autodesk, etc. However, VBA is not always installed when the "Typical" option is chosen during installation. It is sometimes necessary to return to the installation disk in order to add VBA.

The presence or absence of MSCOMM probably depends on the exact software installed on the PC. The more upmarket the software the greater the chances of success. It would certainly seem to be the case that it is not included with all versions of Microsoft Office.

It is not difficult to ascertain whether MSCOMM is present on a PC. Launch Windows Explorer and then use the search facility to scan the hard disk for a file called MSCOMM.OCX. The MSCOMM ActiveX control is not installed if this file is not present on the hard drive. If this file is present, it would probably be possible to use it with one of the free versions of Visual BASIC as well as with VBA.

Same Difference

VBA is not really intended for producing normal software, and its usual role is in the production of extra commands for applications programs. However, "at a pinch" it can be pressed into service as a means of producing software for use with PC based projects.

The first task is to launch VBA from within the host application, and it is normally accessed via the Tools menu. With Microsoft Word for example, it is launched by selecting Macro from the Tools menu and choosing Visual BASIC Editor from the submenu.

No form is produced when VBA has finished loading, but a form can be added by selecting User Form from the Insert menu. You then have something like Fig.1, which is similar to the normal arrangement in Visual BASIC.

The next task is to go in search of the MSCOMM control, and the first step is to choose Additional Controls from the Tools menu. This brings up a window like the one of Fig.2, and it is then a matter of scrolling through the list looking for MSCOMM. It will not be called MSCOMM in this list though, it is more likely to be called "Microsoft Communication Control version 6.0" or something similar to this.

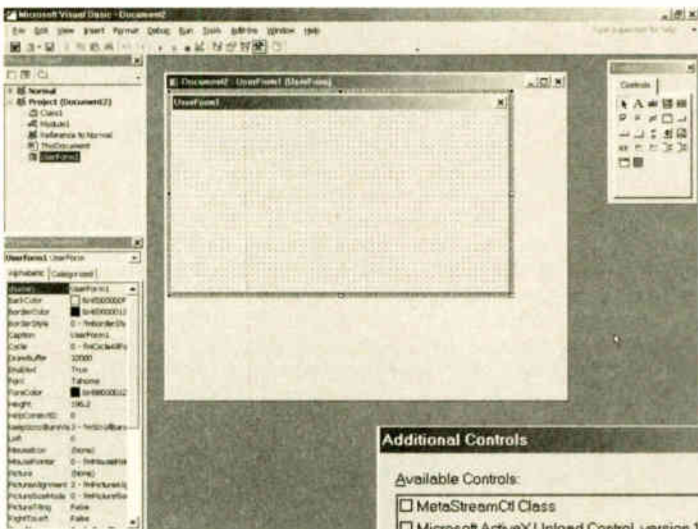
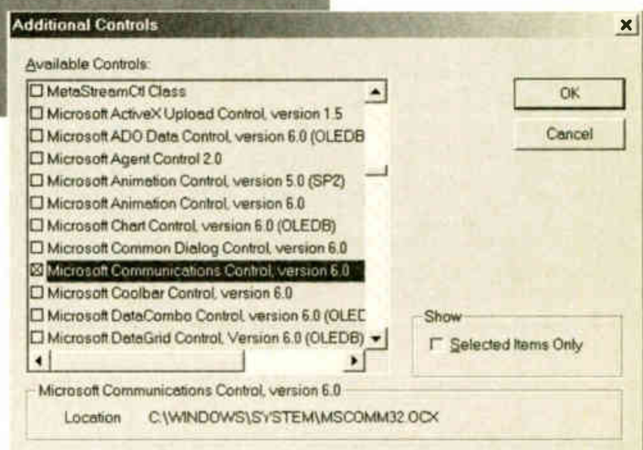


Fig.1 (above). The Visual BASIC for Applications (VBA) set up and ready to use.

Fig.2 (below). Adding MSCOMM, if it is available.



Having found the right entry in the list, tick its checkbox and then operate the OK button. A yellow telephone icon should then appear in the Toolbox, and this enables MSCOMM to be added to the form in the usual way.

VB or not VB

Although VBA seems to be widely regarded as identical to Visual BASIC, there are differences. The fact that VBA is not designed to produce standalone programs enforces a few changes, but there are differences in the code, such as the exact structure of conditional routines.

Programs written for Visual BASIC will usually require at least a small amount of rewriting in order to make them work with VBA. This point is demonstrated in the first VBA listing (Listing 1), which is for a simple program that reads single bytes from a serial port and displays them on a label component.

In addition to MSComm and a form, it requires two buttons and a label. The captions for buttons one and two (CommandButton1 and CommandButton2) are respectively changed to START and EXIT.

Listing 1

```
Private Sub UserForm_Click()
End Sub

Private Sub CommandButton1_Click()
MSComm1.PortOpen = False
End
End Sub
```

```
Private Sub CommandButton2_Click()
MSComm1.RThreshold = 1
MSComm1.InputLen = 1
MSComm1.Settings = "9600,n,8,1"
MSComm1.CommPort = 1
MSComm1.InputMode =
                    comInputModeText
MSComm1.PortOpen = True

End Sub

Private Sub MSComm1_OnComm()
If MSComm1.CommEvent = 2 Then
Label1.Caption = Asc(MSComm1.Input)

End Sub
```

Operating the START button switches on communication with the serial port, selects the required port, and sets the required operating parameters. This works in the same way as the code for the Visual BASIC version described in a previous *Interface* article.

The routine used for MSComm1 reads single characters from the port, converts each one to its ASCII value, and then writes that value to Label1. In the original program an If...Then...End If structure was used to check that the right OnComm event had occurred. If the right event had occurred (i.e. a new byte of data had been received), the port was read, the conversion was made, and data was written to the label.

With VBA the If...Then...End If structure is not quite the same, and the original routine just causes an error message when used with VBA. In this case the routine can be reduced to a single line of code, with no End If statement required at the end of the routine. In fact it must be omitted or an error message will be produced.

The routine for the EXIT button simply closes communications with the serial port and closes the program. The VBA version of the program works as well as the original Visual BASIC version, and it can be seen working within VBA in Fig.3.

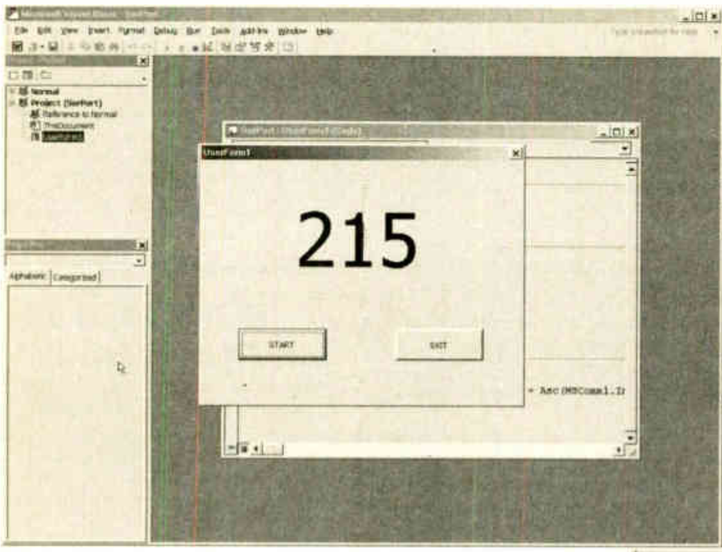


Fig.3. The serial reader program operating within VBA.

Output

The second VBA listing is for a simple serial transmission program. The form is equipped with START and EXIT buttons, as in the serial port reading program. It also has a label, but this time it is used to show the value generated by a scrollbar.

The latter is used to generate the values that are transmitted, and its MAX setting should be set at 255. It will then generate integers from 0 to 255, or single bytes of data in other words.

Listing 2

```
Private Sub CommandButton1_Click()
MSComm1.PortOpen = False
End
End Sub

Private Sub CommandButton2_Click()
MSComm1.PortOpen = True
End Sub

Private Sub Label1_Click()

End Sub

Private Sub MSComm1_OnComm()
End Sub

Private Sub ScrollBar1_Change()
MSComm1.Output =
                    Chr$(ScrollBar1.Value)
Label1.Caption = ScrollBar1.Value
End Sub

Private Sub UserForm_Click()

End Sub
```

In this case the VBA program can be much the same as its Visual BASIC equivalent. It is the routine for the scrollbar that actually transmits the data, and the new value is sent each time that a change occurs.

The Chr$ function is used to convert the value from the scrollbar into an equivalent ASCII character which is then sent to the serial port for transmission. The unprocessed value is displayed on the label component so that the user can see what values are being sent. Again, the VBA program works as well as the Visual BASIC version, and it is shown running in Fig.4.

Lockout Situation

Programs are saved using the Save Document option under the Edit menu. Once the document has saved, this option changes to Save XXXX where XXXX is the program name that you chose. Note that the main Word document can be empty, and there is no need to add any dummy text. To use the program on another occasion, load the relevant document and go to the Visual BASIC Editor again. This should contain the program.

There can be a problem when tying to run the program, with an error message appearing. This points out that Macros have been disabled and that the program cannot be run. Macros are disabled by default as a means of reducing the risk from macro viruses.

Selecting Macros from the Tools menu followed by Security from the submenu enables the security setting to be changed. A dialogue box appears and it has radio buttons that offer three levels of security.

The lowest level enables macros to be run with "no questions asked". You will be asked whether or not you wish to run the program if the middle setting is selected, and macros are blocked if the highest level is used.

If you are used to VBA and its version of the BASIC dialect, VBA programs can be a valid approach to producing software for your PC projects. Even if you do not have MSCOMM on your computer system, VBA can still be used with third party add-ons such as **Inpout32.dll** to access the serial and parallel ports.

One of the free versions of Visual BASIC probably represents a better starting point for those starting "from scratch". Either way, it is possible to get into visual programming at no cost.

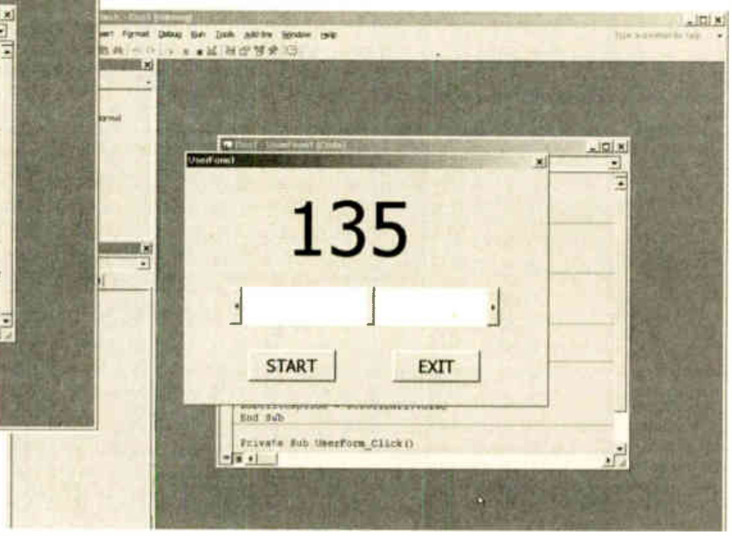


Fig.4. The serial transmission program. Values set on the slider control are transmitted from the serial port.

Binary Mode

A couple of readers have pointed out methods of using MSCOMM in binary mode so that the string conversions can be avoided. This is a subject that will be considered in detail when the problem has been investigated fully.

Strangely, the Microsoft documentation recommends that the text mode is used for all data transfers using MSCOMM. A possible reason for this is that some facilities of MSCOMM seem to disappear when the binary mode is used. The text and conversion method is a bit cumbersome, but it does have the saving grace that it actually works quite well.

EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE

ELECTRONICS CD-ROMS

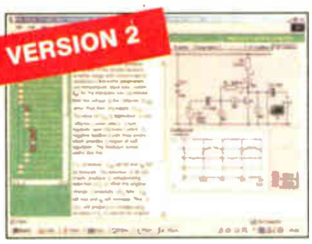
ELECTRONICS PROJECTS

Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture, circuit simulation** and **p.c.b. design** software is included.
The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

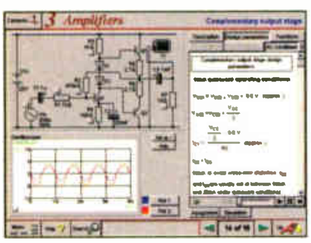
VERSION 2



Circuit simulation screen

Provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals:*** units & multiples, electricity, electric circuits, alternating circuits. ***Passive Components:*** resistors, capacitors, inductors, transformers. ***Semiconductors:*** diodes, transistors, op.amps, logic gates. ***Passive Circuits. Active Circuits.*** *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams.
Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS

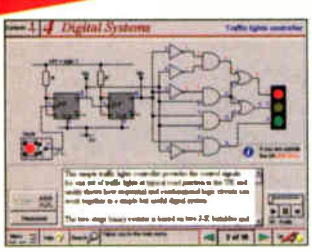


Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.
Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

DIGITAL ELECTRONICS V2.0

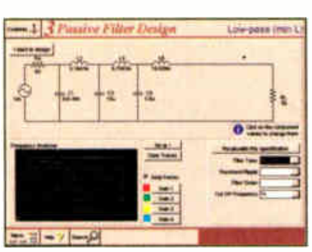
VERSION 2



Virtual laboratory – Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

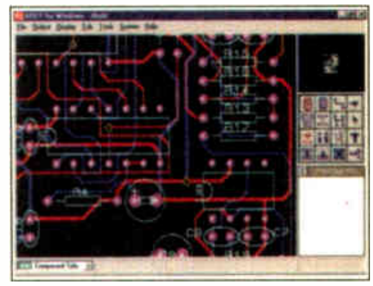
FILTERS



Filter synthesis

Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev op.amp filters.

ELECTRONICS CAD PACK



PCB Layout

Electronics CADPACK allows users to design complex circuit schematics, to view circuit animations using a unique SPICE-based simulation tool, and to design printed circuit boards. CADPACK is made up of three separate software modules. (These are restricted versions of the full Labcenter software.) **ISIS Lite** which provides full schematic drawing features including full control of drawing appearance, automatic wire routing, and over 6,000 parts. **PROSPICE Lite** (integrated into ISIS Lite) which uses unique animation to show the operation of any circuit with mouse-operated switches, pots. etc. The animation is compiled using a full mixed mode SPICE simulator. **ARES Lite** PCB layout software allows professional quality PCBs to be designed and includes advanced features such as 16-layer boards, SMT components, and an autorouter operating on user generated Net Lists.

NEW

ROBOTICS & MECHATRONICS

Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Full case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student	£45 inc VAT
Institutional (Schools/HE/FE/Industry)	£99 *plus* VAT
Institutional 10 user (Network Licence)	£199 *plus* VAT
Site Licence	£499 *plus* VAT

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

PICmicro TUTORIALS AND PROGRAMMING

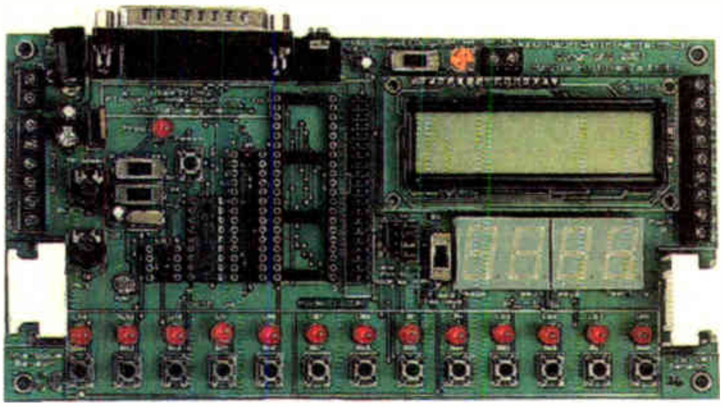
HARDWARE

VERSION 2 PICmicro MCU DEVELOPMENT BOARD

Suitable for use with the three software packages listed below.

This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

- Makes it easier to develop PICmicro projects
- Supports low cost Flash-programmable PICmicro devices
- Fully featured integrated displays – 13 individual l.e.d.s, quad 7-segment display and alphanumeric l.c.d. display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- All inputs and outputs available on screw terminal connectors for easy connection



£145 including VAT and postage

12V 500mA plug-top PSU (UK plug) £7

25-way 'D' type connecting cable £5

SOFTWARE

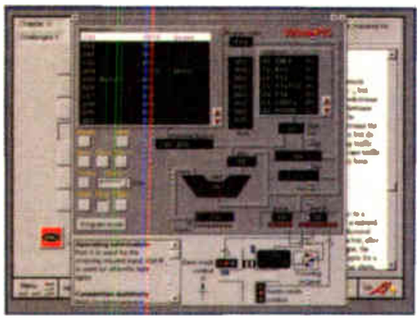
Suitable for use with the Development Board shown above.

ASSEMBLY FOR PICmicro V2

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V2.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes. The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller. This is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

● Comprehensive instruction through 39 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.



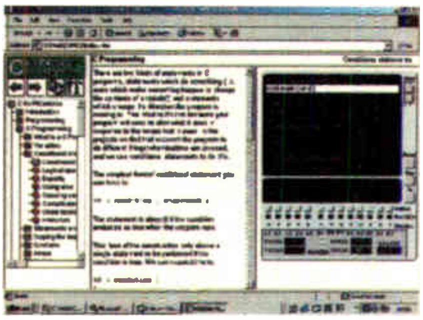
Virtual PICmicro

'C' FOR PICmicro VERSION 2

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

FLOWCODE FOR PICmicro

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex robotics and control systems in a matter of minutes.

Flowcode is a powerful language that uses macros to facilitate the control of complex devices like 7-segment displays, motor controllers and l.c.d. displays. The use of macros allows you to control these electronic devices without getting bogged down in understanding the programming involved.

Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 2 development board this provides a seamless solution that allows you to program chips in minutes.

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols (ISO5807) ● Full on-screen simulation allows debugging and speeds up the development process ● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 8, 18, 28 and 40-pin devices ● Institutional versions include virtual systems (burglar alarms, car parks etc.).

Burglar Alarm Simulation

PRICES

Prices for each of the CD-ROMs above are:

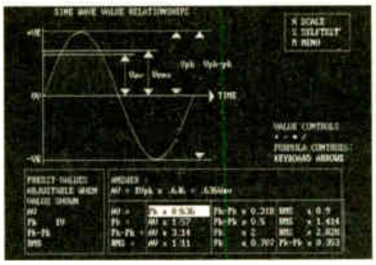
(Order form on next page)

Hobbyist/Student	£45 inc VAT
Institutional (Schools/HE/FE/Industry)	£99 *plus* VAT
Flowcode Institutional	£70 *plus* VAT
Institutional 10 user (Network Licence)	£249 *plus* VAT
Site Licence	£599 *plus* VAT

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

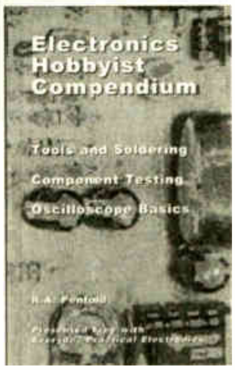
TEACH-IN 2000 – LEARN ELECTRONICS WITH EPE

EPE's own *Teach-In* CD-ROM, contains the full 12-part *Teach-In* series by John Becker in PDF form plus the *Teach-In* interactive software covering all aspects of the series. We have also added Alan Winstanley's highly acclaimed *Basic Soldering Guide* which is fully illustrated and which also includes *Desoldering*. The *Teach-In* series covers: Colour Codes and Resistors, Capacitors, Potentiometers, Sensor Resistors, Ohm's Law, Diodes and L.E.D.s, Waveforms, Frequency and Time, Logic Gates, Binary and Hex Logic, Op.amps, Comparators, Mixers, Audio and Sensor Amplifiers, Transistors, Transformers and Rectifiers, Voltage Regulation, Integration, Differentiation, 7-segment Displays, L.C.D.s, Digital-to-Analogue.



Sine wave relationship values

FREE BOOK WITH TEACH-IN 2000 CD-ROM



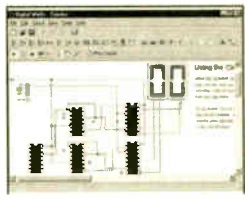
Each part has an associated practical section and the series includes a simple PC interface so you can use your PC as a basic oscilloscope with the various circuits.

A hands-on approach to electronics with numerous breadboard circuits to try out.

£12.45 including VAT and postage. Requires Adobe Acrobat (available free from the Internet – **www.adobe.com/acrobat**).

FREE WITH EACH TEACH-IN CD-ROM – *Electronics Hobbyist Compendium* 80-page book by Robert Penfold. Covers Tools For The Job; Component Testing; Oscilloscope Basics.

DIGITAL WORKS 3.0



Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability • Software for simulating digital logic circuits • Create your own macros – highly scalable • Create your own circuits, components, and i.c.s • Easy-to-use digital interface • Animation brings circuits to life • Vast library of logic macros and 74 series i.c.s with data sheets • Powerful tool for designing and learning.

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ELECTRONICS IN CONTROL

Two colourful animated courses for students on one CD-ROM. These cover Key Stage 3 and GCSE syllabuses. **Key Stage 3:** A pictorial look at the Electronics section featuring animations and video clips. Provides an ideal introduction or revision guide, including multi-choice questions with feedback. **GCSE:** Aimed at the Electronics in many Design & Technology courses, it covers many sections of GCSE Electronics. Provides an ideal revision guide with Homework Questions on each chapter. Worked answers with an access code are provided on a special website.

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Student copies (available only with a multiple user copy) £6 plus VAT
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ELECTRONIC COMPONENTS PHOTOS

A high quality selection of over 200 JPG images of electronic components. This selection of high resolution photos can be used to enhance projects and presentations or to help with training and educational material. They are royalty free for use in commercial or personal printed projects, and can also be used royalty free in books, catalogues, magazine articles as well as worldwide web pages (subject to restrictions – see licence for full details).

Also contains a FREE 30-day evaluation of Paint Shop Pro 6 – Paint Shop Pro image editing tips and on-line help included!

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MODULAR CIRCUIT DESIGN

VERSION 3

Contains a range of tried and tested analogue and digital circuit modules, together with the knowledge to use and interface them. Thus allowing anyone with a basic understanding of circuit symbols to design and build their own projects. Version 3 includes data and circuit modules for a range of popular PICs; includes PICAXE circuits, the system which enables a PIC to be programmed without a programmer, and without removing it from the circuit. Shows where to obtain free software downloads to enable BASIC programming.

Essential information for anyone undertaking GCSE or "A" level electronics or technology and for hobbyists who want to get to grips with project design. Over seventy different Input, Processor and Output modules are illustrated and fully described, together with detailed information on construction, fault finding and components, including circuit symbols, pinouts, power supplies, decoupling etc.

Single User £19.95 inc. VAT. Multiple User £34 *plus* VAT
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Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 95/98/NT/2000/ME/XP, mouse, sound card, web browser.

CD-ROM ORDER FORM

Please send me:

- ☐ Electronic Projects
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- ☐ Electronics CAD Pack
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Version required:

- ☐ Hobbyist/Student
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- ☐ Institutional 10 user
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- ☐ Teach-In 2000 + FREE BOOK
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READOUT

E-mail: editorial@epemag.wimborne.co.uk

John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

All letters quoted here have previously been replied to directly.

WIN A DIGITAL MULTIMETER

A 3½ digit pocket-sized l.c.d. multimeter which measures a.c. and d.c. voltage, d.c. current and resistance. It can also test diodes and bipolar transistors.

Every month we will give a Digital Multimeter to the author of the best *Readout* letter.

★ LETTER OF THE MONTH ★

32-BIT DIVISION

I recently asked Peter Hemsley how easy it would be to expand his PIC 16-bit/16-bit division routine (in the PIC Tricks *folder on our ftp site) to 32-bit/16-bit. He replied:*

If there is a Carry out from the Shift left then force the subtraction, as in the following. This has not been thoroughly tested but seems to work OK. By the way, a 32/32 divide would involve a 32-bit comparison and a 32-bit subtraction. A tiresome job in PIC language.

```
divide  movlw 32        ; 32-bit divide by
                        16-bit
        movwf bitcnt
        clrf remdrH     ; Clear remainder
        clrf remdrL
dvloop  clrc            ; Set quotient bit
                        to 0
                        ; Shift left dividend
                        and quotient
        rlf divid0      ; lsb
        rlf divid1
        rlf divid2
        rlf divid3      ; lsb into carry
        rlf remdrL      ; and then into
                        partial remainder
        rlf remdrH

        skpnc           ; Check for
                        overflow
        goto subd
        movfw divisH    ; Compare partial
                        remainder and
                        divisor
        subwf remdrH,w
        skpz
        goto testgt     ; Not equal so test
                        if remdrH is
                        greater
        movfw divisL    ; High bytes are
                        equal, compare
                        low bytes
        subwf remdrL,w
testgt  skpc            ; Carry set if
                        remdr >= divis
        goto remrlt
subd    movfw divisL    ; Subtract divisor
                        from partial
                        remainder
        subwf remdrL
        skpc            ; Test for borrow
        decf remdrH     ; Subtract borrow
        movfw divisH
        subwf remdrH
        bsf dividL,0    ; Set quotient bit
                        to 1
                        ; Quotient
                        replaces divi-
                        dend which is
                        lost
remrlt  decfsz bitcnt
        goto dvloop
        return
```

Peter Hemsley, via email

That's brilliant Peter! – I'll add it to PIC Tricks. *Thank you from me and all PIC Trickers!*

SHOCK HORROR 2

Dear EPE,

Regarding the Shock Horror Tale from Stan Hood in *Readout* Sept '02, I'd just like to emphasise the point that anything delivering shocks should always be properly investigated. It might be only static, but equally it might not.

A couple of years ago, I noticed I was receiving tiny shocks from our refrigerator. Subsequent investigation suggested that the actual source of the current causing these shocks was probably capacitive coupling to the motor windings – unlikely to be dangerous, but it should have been conducted to earth long before I got to feel it. Probing further, I found the mains earth connection to the fridge casing had come unscrewed and, far worse, the earth connection of the power wiring to the wall socket into which it was plugged had corroded away altogether, so nothing plugged into that socket had any earthing at all!

Soon fixed though, once discovered. Scary stuff . . . if in doubt, investigate, and if you doubt your abilities, find someone qualified to check it for you.

Andy Flind, via email

Thanks Andy – well advised. We've both had near misses! And no doubt we've both had the real thing in various ways – I vividly recall from the mid '60s, in the days before I knew anything worthwhile about electronics, buying ancient and usually unworking TVs from market stalls and trying to get them to work again. Boy-oh-boy! They can't half give a kick from their charged EHT capacitors even when the mains is unplugged! Take care of electricity at any time folks!

ENVIRONMENTAL MONITORING

Dear EPE,

I am not an electronic genius but I need one who knows the latest in remote camera and atmosphere surveillance.

I wonder if someone amongst your staff or readerhip would be familiar with the equipment I need for a research project in downtown Manhattan, NYC – USA. The goal is to capture images and atmospheric data, such as temperature, humidity, CO_2 and CO levels over a period of two years, that is before, during and after the construction of a "green roof."

I am looking for a remote system that could record images and atmospheric data to a desktop computer, and then relay these by phone. A 24-hour camera will be necessary, but we will take, say four shots and air samples per day and create a log that can give us valuable information over time. The system will be installed on the roof of my building. Images need to cover a space of 1,700 square feet. Computer server and phone line will sit in the elevator shack on the roof.

"Green roofs" is a roof surface where you plant greenery directly on the roof. The water proofing and irrigation technologies required are widely used in Germany to improve human lifestyle and the environment. We are the first private owners to employ such a system in New York (and maybe nationwide) and I am seeking to attract both written and broadcast/TV media. Therefore, I believe that capturing environmental data will further give credibility to the project as a worthwhile thing for others to do, as well. We can therefore show the actual improvement of the local environment in terms of lower temperature, moisture retention, and reduced levels of CO and CO_2.

I also have a budget constraint: I would like it all to cost (including the computer) less than $1,000 and will do the installation myself.

Rune Kongshaug, New York, via email

We are not familiar with such things, Rune, except in the context of hobbyist weather monitoring. However, in the UK we have a big environmental greenhouse-type project covering many acres called the Eden Project. *Perhaps they might use such monitoring equipment – their web address is* ***www.edenproject.com****. I've recently been there and it's fascinating.*

RELAYING INFO

Dear EPE,

I am an Electrical Engineering student at the Cape Technikon (South Africa). I was reading your magazine when I saw the types of relays that you sell. I was wondering if you could send me the information on the different applications of the relays. I need this information to finish my project.

Miss Babalwa Cosa, via email

Sorry to disappoint you, but we don't actually sell components – that's the role of our advertisers and we suggest that you contact any of those who sell relays for more information on them.

Curious how many people think we sell components – we don't! We are publishers and apart from p.c.b.s plus some CD-ROMS and videos, that's as far as we go! We've got lots of excellent advertisers, though, and it's worthwhile getting catalogues from all of them if you want to get the best out of your hobby!

UNUSED PIC PINS

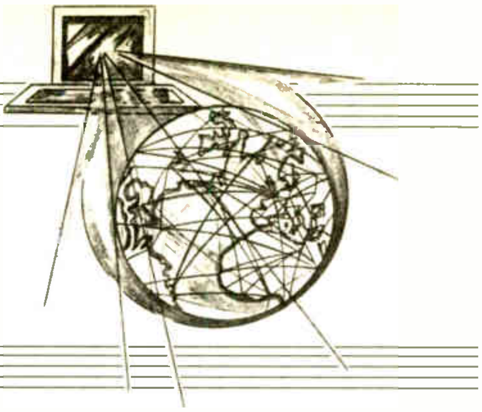
Dear EPE,

I remember reading somewhere, I can't remember where, that you should leave PIC pins which are not going to be used in a certain state. Trouble is, I also can't remember which state. Is it all set to inputs and tied to ground, or all set to outputs and tied to V_{dd} or set to something and left floating? I believe this optimum state (whatever it is!) will reduce power consumption and may make the whole thing more stable.

Gerard Galvin, via email.

It seems to be common practice to leave a PIC's unused I/O pins in an unconnected state, and in input mode. I can't actually find what Microchip say on the subject. Can anyone clarify? – and maybe tell me I'm wrong!

SURFING THE INTERNET



NET WORK

ALAN WINSTANLEY

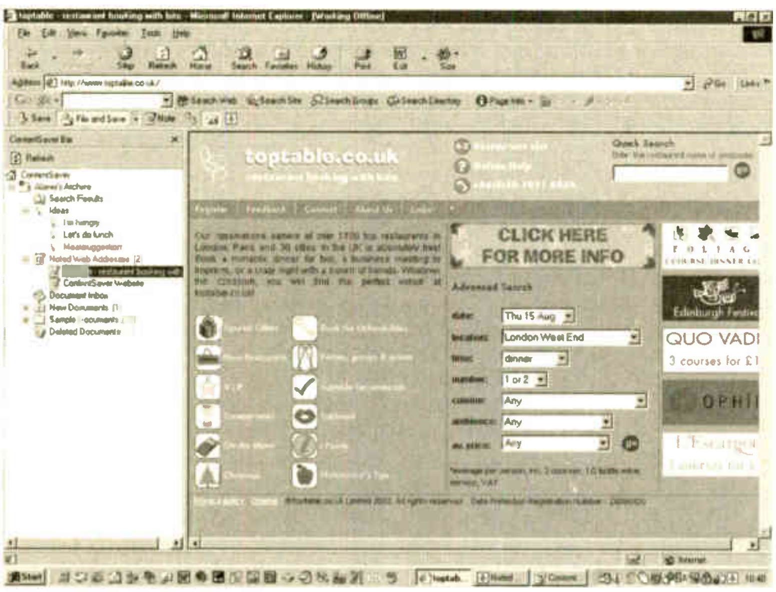
IF YOU'RE anything like the writer, you're inundated with information from all corners of the Internet, leading to the nightmare of trying to digest, save or discard mountains of data in the shortest possible time. In this month's *Net Work* we take a look at a number of programs that may help you to organise the fruits of your web browsing more efficiently.

Too Many Favorites

Usually the first thing a user does when they find an interesting web site is to bookmark it in their Favorites. Inevitably a large number of bookmarked addresses accrue over time; the tools that Microsoft include in MSIE that supposedly help you organise your Favorites are limited to dropping Favorites into suitably-named folders. (A useful tip when surfing: you can drag a web URL from Internet Explorer's address bar and drop it onto the desktop, into a suitable Favorites folder, if you keep your Favorites open on the sidebar.)

Netscape 6 offers more flexibility, plus the ability to type in a few handy reminders alongside any bookmarked address or folder. Netscape also lets you add your own choice of keywords which are fully searchable. Overall, the bookmark management of Netscape 6 is far superior to Internet Explorer, and the latest unremarkable version of MSIE has done nothing to enhance or simplify the user's task of coping with a vast amount of online information.

One tool that is a useful free download is DzSoft's Favorites Search (**www.dzsoft.com**), which can be loaded as a toolbar in MSIE. It will scan your saved URLs and help you to locate a Favorite address. For example, searching for the word "pub" lists all my bookmarked addresses containing that expression: in my case, Personal Publisher and CompuBank were turned up by the search tool. (No pubs though, unfortunately.) DzSoft's program has proved useful when trying to recall a long-forgotten bookmark, and their web site is worth checking out.



ContentSaver Professional is a versatile tool for storing and annotating web pages.

Both Netscape and MSIE allow you to go File/Save web pages to store them on disk, and of course you can try to view the site from your browser's cache by choosing File/Work Offline and then typing in the URL. However it is possible to improve the handling of offline content a lot more, by using programs designed to manage any web content that has been saved to disk.

ContentSaver

ContentSaver Professional (free demo from **www.macropool.com/en**) is a very versatile program styled like Microsoft Office, which can help you to organise your collection of browsed web sites. This quite sophisticated program lets you save any complete web pages as rendered in Internet Explorer: to get the most out of the program, you need MSIE 5.5+. The software installs a toolbar within the browser and by clicking a "Save" button, any page you are viewing is saved to a folder on your disk.

ContentSaver Professional also lets you organise your web documents into categories, and you can create notes and add comments, highlight text, jot down "Ideas" and save out images if desired. You can easily annotate web links for future reference. The program does a very good job of helping you to organise your offline files in a user-friendly way. You can also save and exchange ContentSaver documents with other users on a network, so the program goes much further than merely sending a web site URL to colleagues. If you like the Microsoft Office way of doing things, then this program is definitely worth trying, but it will take a little practice to get the best out of it.

If you want to download an entire web site, or certain parts of it, then tools such as Web Copier (**www.maximumsoft.com**) or Teleport Pro (**www.tenmax.com**) are worth investigating. A web site designer needing to take a look at a web site may use such a tool in order to fetch the site onto local disk, after which it can be examined in an authoring program such as Dreamweaver. If you have a broadband connection, you could perhaps set up scheduled downloads to fetch a web site onto disk in between busy times.

Low Interest Rates

Back to the subject of BT's thermometer (see *Net Work* last month, and **www.bt.com/broadband/**), which is their online display of the level of local interest related to having a telephone exchange converted for ADSL. Another 88 exchanges have been assigned trigger levels, but it seems that the minimum number of 200 registrations are needed before an exchange will be upgraded. In some areas, figures of 750 are shown.

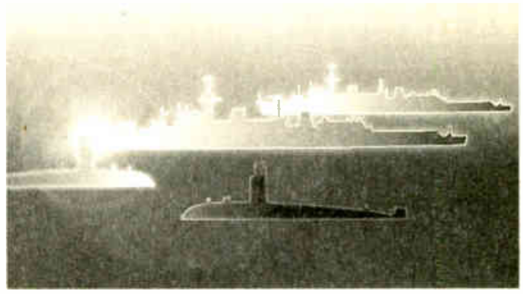
I have great news: "my" thermometer now has a reading of precisely four. What's more, the thermometer's column of mercury is halfway up the scale. Does that mean we are halfway there? I guess not: I calculate that at the current rate, we can look forward to ADSL being installed in approximately four years' time, assuming that we are lucky enough to have a trigger level of 200 assigned to our exchange.

It is worth remembering that whilst BT has done an excellent job of displaying all the related information on their web site, it just goes to prove how everyone, including BT, is becoming ever more dependent on the Internet to share complex information with the rest of us. The lack of broadband continues to strangle the development of communications and services across the United Kingdom.

Next month, it's back to the subject of spam mail once again. For the last four weeks I have been using a paid-for spam filtering service, which claims to screen your email and filter out any known spam and virus-infected mails. How well has the service done in the past month? Is it worth the money? I'll reveal the "net" results in next month's *Net Work*. You can email me at **alan@epemag.demon.co.uk**.

Constructional Project

PIC-POCKET BATTLESHIPS

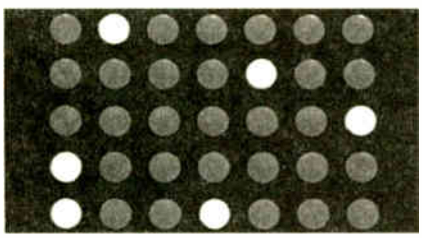


BART TREPAK

Become a Sea Lord with our interpretation of the age-old pen and paper game.

THE renowned game of *Battleships* is normally played by two players with pencil and paper. Its aim is for each opponent to sink the other's fleet before their own fleet is sunk. The ships are normally marked on a 10 × 10 grid of squares and each player calls out a grid reference in turn, to which the other player responds by saying whether it is a hit of a miss.

The variant of the game described here provides the excitement of the sea chase for just one player, who pits his wits against a PIC microcontroller as the other opponent. The position of the enemy (set by the PIC program!) is unknown and there are five merchant ships to be protected by the battleship. These six ship positions are shown on a 5 × 7 light emitting diode (l.e.d.) matrix display used horizontally.



This 5 x 7 matrixed l.e.d. display measures 39mm x 23mm.

PLAYING THE GAME

When the unit is first switched on, the positions of the five merchant ships are indicated by l.e.d.s that are lit continuously. The position of the battleship is represented by a flashing l.e.d., the "cursor". The enemy battleship is at the centre of the display but its position is not indicated.

The flashing cursor can be moved to any position on the display by means of four push-switches that control movement in the horizontal and vertical direction, one position at a time. Each time the cursor is moved, however, the unseen enemy ship can also move one square in the horizontal or vertical direction so that its current position changes and remains unknown. (Note that if the cursor is placed on the position occupied by one of the merchant ships, the l.e.d. will not flash).

When the player thinks the enemy is at the position of the cursor, the "fire" button may be pressed to try to sink the enemy. If the enemy ship is not in this position, the cursor will continue to flash and the game will continue. If the enemy *is* at this position then there are two possible outcomes of this engagement: either the player's battleship or that of the enemy will be sunk, and this is determined randomly!

If the enemy is sunk, the player wins the game (indicated by the cursor ceasing to flash) but if his own ship is sunk then a new one will appear at the start position with the enemy remaining at the position where the ship was sunk.

If the enemy warship moves into a position occupied by a merchant ship then that ship will be sunk immediately (i.e. the l.e.d. will go out) and the current position of the raider will be revealed. Of course as soon as the player attempts to move the cursor to this new position, the enemy may also move. If the merchant ship that is sunk is the last one, the game is lost and the cursor returns to its start position. To re-start the game, the unit must be reset by switching it off briefly.

NOT SUCH EASY PICKINGS

Although all the cards appear to be stacked in favour of the PIC, the raider is just as much in the dark about the position of the merchant ships as the player is about the position of the enemy. The PIC has no strategy other than to randomly move about the "sea" looking for ships, even to the extent of crossing and re-crossing the same squares.

If a ship is encountered then it will be sunk but, as in war, that is a matter of luck. Since the PIC has no memory of previous games or indeed even of its last move, there is no point in making the positions of the merchant ships variable or changing

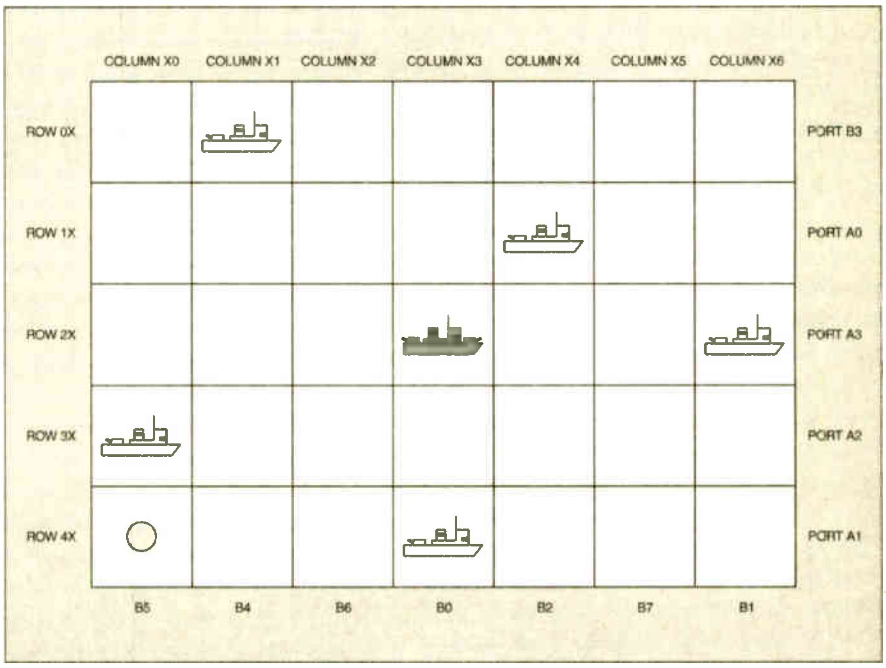


Fig.1. How the ships are positioned. The enemy battleship at the centre of the display is unseen. The circle represents your battleship and is a "moveable" flashing l.e.d.

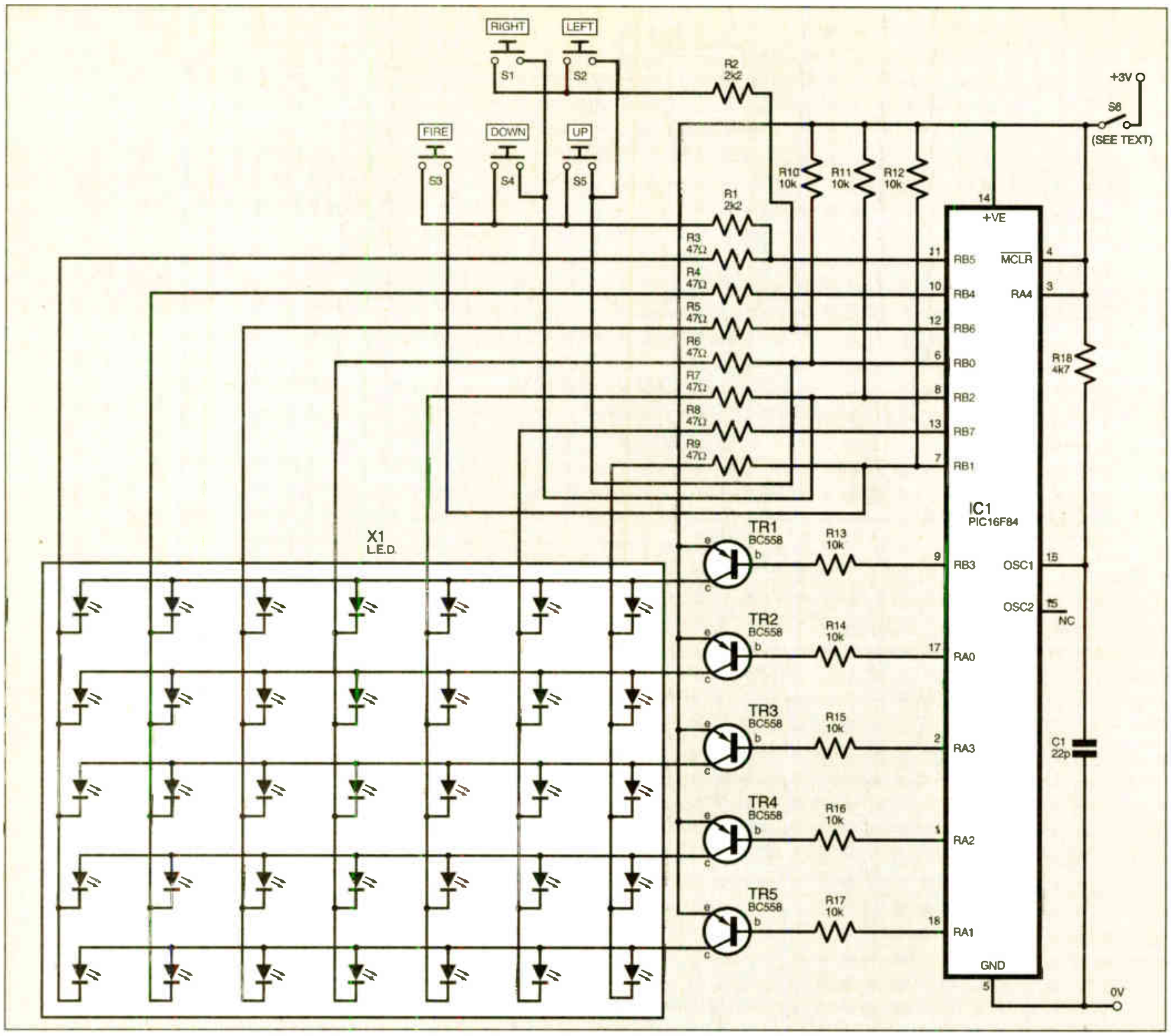


Fig.3. Complete circuit diagram for the PIC-Pocket Battleships game.

their position between or during games. These are therefore fixed by the program, as is the raider's initial position.

The "sea" is divided into "squares", each indicated by an l.e.d., with the columns numbered 0 to 6 while the rows are numbered as 0 to 4, as shown in Fig.1.

Each position is defined by one byte, shown in Fig.2, where the most significant nibble (highest four bits) defines the row while the other nibble defines the column. Thus the location at column 1, row 1, is represented by the hexadecimal (hex) number 00h. The raider's initial position is set at 23h as it will be in the third row down in the fourth column, while the positions of the merchant ships are stored as numbers 01h, 14h, 26h, 30h and 43h. The cursor position is defined in the same way, starting at 40h.

	ROW				COLUMN				
AIM	1	0	0	0	0	0	0	0	= 40 (HEX)
ENMY	0	0	1	0	0	0	1	1	= 23 (HEX)
MRCH	0	0	0	1	1	1	1	1	0 = SUNK 1 = SAILING

Fig.2. Arrangement of the program registers which hold the ship positions and their status.

At least five cursor moves are required to reach the raider's initial position, giving the enemy ship a chance to get away at the beginning of the game. The position of the enemy ship is stored in a register called ENMY and the cursor position in one called AIM.

The status of the merchant ships (i.e. sunk or afloat) is stored in register MRCH as five bits. These are set (binary 00011111) at the start of the game and individually reset to zero as each ship is sunk. These bits control the display so that a 0 in a particular position in this register prevents the l.e.d. for that ship from turning on, so that only the positions of the remaining merchant ships will be indicated.

When all five ships have been sunk, the game is lost and from the relative position of the cursor and the last ship sunk, the player will know how close he came to catching the enemy battleship.

CIRCUIT DIAGRAM

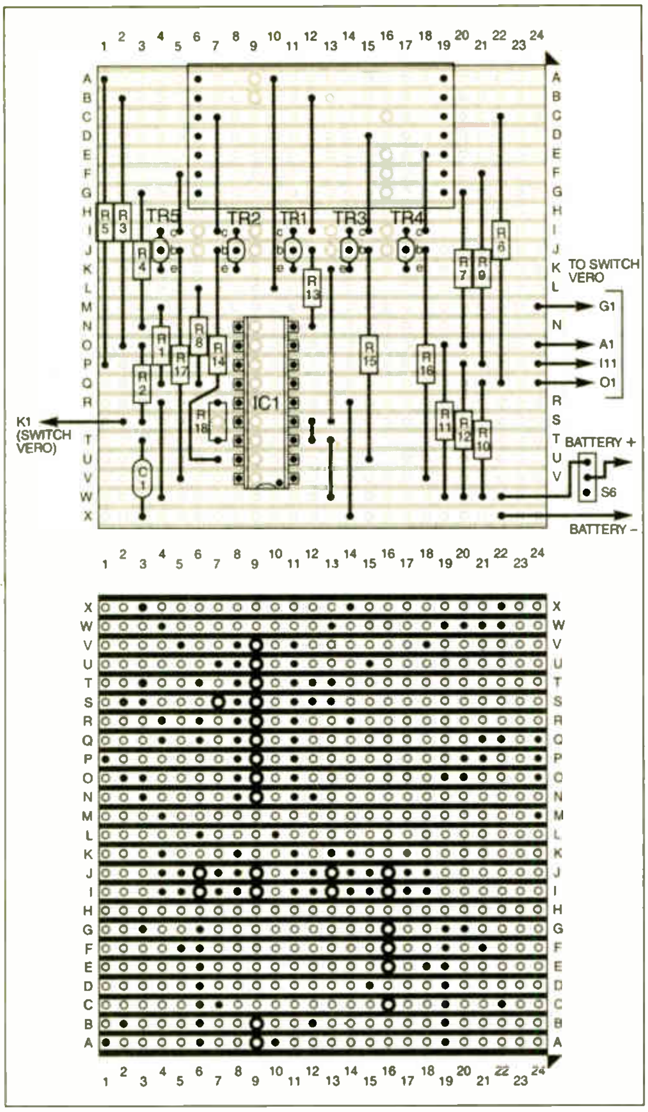
The complete circuit for PIC-Pocket Battleships is shown in Fig.3. It is based around a PIC16C54 microcontroller (one of the earlier PIC types having a UV erasable structure and window), which is operated in RC (resistor-capacitor) mode as precise timing of the software is not necessary. Resistor R18 and capacitor C1 set the PIC's clock frequency, at about 4MHz.

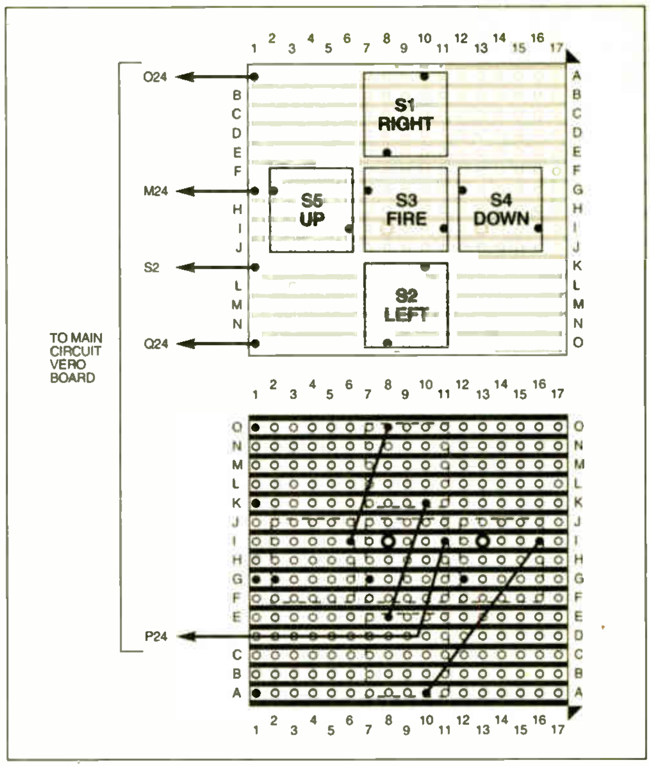
The l.e.d. display, X1, is multiplexed, which means that only one row is switched on at any one time. During this period, the appropriate column drives are activated in sequence. Only the l.e.d. at the junction of the "active" column and row is turned on.

As each row is switched on, the column drives are altered and because this is done very fast, all the "merchant ship" l.e.d.s appear to be on at once. The rows are driven via *pnp* driver transistors, TR1 to TR5, from PIC pins RA0 to RA3 plus RB3, buffered by resistors R13 to R17. To switch on a particular row, the corresponding output port goes low.

The column drives are output from the remaining lines of Port B via current limiting resistors R3 to R9. These lines also have to go low to switch on the corresponding l.e.d.

The function (game-play) selection switches S1 to S5 are also multiplexed to the lines connecting to the l.e.d. columns. They are additionally buffered by resistors R1 and R2. The PIC scans the switches to determine if a change in the cursor position is required or the fire button has been pressed. During scanning, RB7 is taken low and the three lines RB0 to RB2 are redefined as inputs and read in turn.





Component layout and stripboard track view for (Fig.4, left) the main control board, and (Fig.5, above) the optional switch board (see text).

COMPONENTS

Resistors

R1, R2	2k2 (2 off)	
R3 to R9	47Ω (7 off)	
R10 to R17	10k (8 off)	
R18	4k7	

All 0·25W 5% carbon film.

See **SHOP TALK** page

Capacitor

C1	22p ceramic disc

Semiconductors

TR1 to TR5	BC558 *pnp* transistor (or similar)
IC1	PIC16C54 microcontroller, preprogrammed (see text)
X1	SE1110, 5 x 7 matrixed l.e.d. display, row-anode (see text)

Miscellaneous

S1 to S5	min. push-to-make switch, p.c.b. or panel mounting (see text) (5 off)
S6	min. s.p.s.t. toggle switch

Stripboard, 24 holes x 24 strips; stripboard, 17 holes x 15 strips (optional, see text); plastic case to suit (see text); battery holder/connector for 2 x AA batteries; connecting wire; solder, etc.

Approx. Cost Guidance Only **£15** *excluding battery*

Transistors TR1 to TR5 are turned off during this process. This prevents switch presses from shorting out column lines and causing erroneous displays. (Pressing more than one key at a time will still cause an erroneous display, but the game is not intended to be used in this way.) The software has been written to eliminate switch-bounce problems.

The circuit is designed to operate from a 3V d.c. supply and no voltage regulation is required. **It must not be run at a voltage greater than 6V d.c.**.

The PIC consumes very little current and since only one matrixed l.e.d. is on at any one time the current consumption of the whole unit is only about 10mA. Consequently, the circuit can be powered by two series-connected AA cells (1·5V each). It can also be operated on a 2·5V supply, so that rechargeable NiCad cells with their lower terminal voltage (1·2V) could also be used. (The PIC can be run from a voltage as low as 2V, although the l.e.d.s will be far less bright.)

RANDOMISING

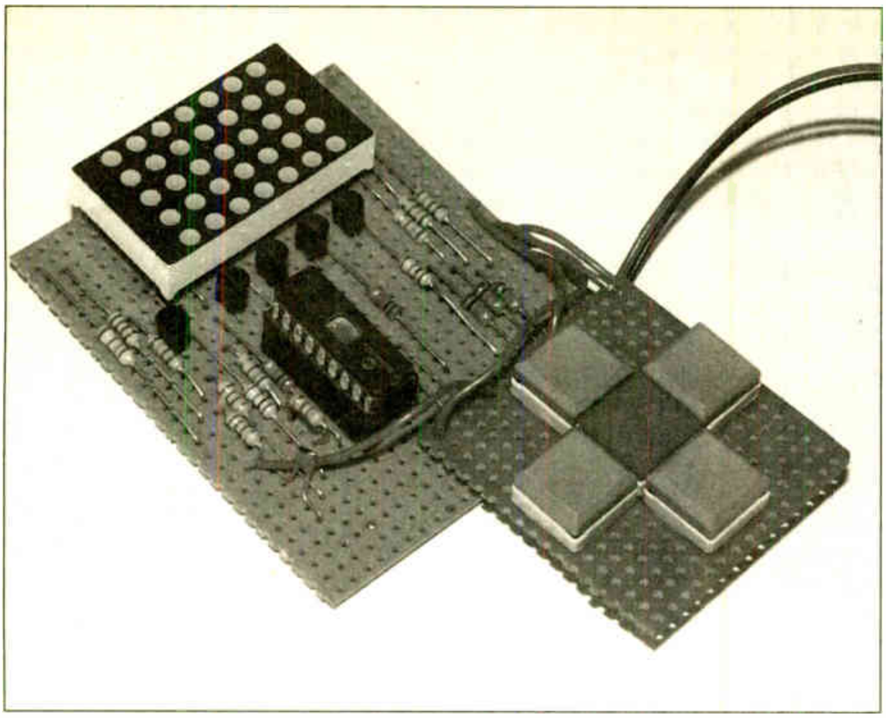
The game requires that random numbers are generated to determine the raider's next move. This is achieved by using a register which counts continuously while the program is running. The counter is read whenever one of the cursor positioning switches is pressed. Since this will occur at various time intervals, depending on the player and the fact that the count rate is very fast, the actual count reached will, to all intents, be indeterminate.

There are five possible ways that the enemy ship can move following a switch being pressed: up, down, left, right or remain in its current position. The counter is therefore programmed to count to four and when five is reached, it is reset to zero thus giving five different states. When a switch is pressed, the counter's value is read and the appropriate move is made. Bit 0 of this counter is also tested to determine the result of an encounter between the two opposing warships and thus provide an element of chance in the result.

The chances of one of these options occurring more often than the others can be increased by readers who are familiar with PIC programming. The software could be written to have more states than five and having a count of, say, one and two corresponding to the "move up" command, while three, four and five correspond to the "move left" command, for example.

Alternatively, making provision for the raider to move two squares on some of the counts could make the game more difficult. Adding or subtracting 02h instead of 01h from the enemy position register to move it horizontally, or 20h instead of 10h to move it vertically would do this.

The first part of the position controlling subroutine (EPOS) decodes the random counter (RND) and the program then proceeds, as appropriate to the decoded value, to move the enemy one square down, right, left or up, or to exit the routine without change. Adding or subtracting 10h or 01h from the current contents of the ENMY register does this and a software check is also made to ensure that the ship does not move out of the displayed area.



Thus if the enemy is at position 16h and 01h (move right) is added, the result will be position 17h which is off the screen. This is detected and 01h is subtracted again, thus leaving the enemy in position 16h. In this program, the effect of a ship trying to move out of the screen area will therefore result in a "no move" instruction and this will apply to both the enemy ship and the cursor.

The program could easily be changed so that if the above occurred, the enemy position could become 10h simply by loading ENMY with 10h when 17h is detected instead of subtracting 01h from this register. If this was made to apply only to the ENMY register and not to the AIM (cursor) register, the enemy ship would become much harder to catch. This could be done by setting or clearing a spare bit in the FLAG register (bit 4, say) and on this basis either subtracting 01h or resetting the target register to 10h as required.

Pressing the "move right" switch when the cursor is at position 16h, however, will still result in the enemy warship moving in accordance with the contents of the RND register at that instant, although the cursor will not move.

CONSTRUCTION

The PIC-Pocket Battleships' control circuit is assembled on a piece of stripboard, 24 strips long by 24 holes wide. This accommodates all of the components except the switches and the battery, which are connected to the board by flying leads. The component layout and track-cut details are shown in Fig.4.

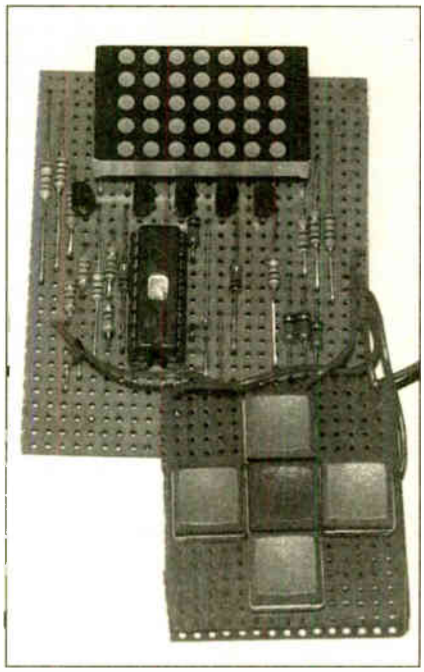
First make the 24 required breaks in the tracks, using a 2·5mm diameter drill bit, or the special tool available for this purpose. Next solder in all the link wires, noting that some go under the l.e.d. matrix position. Then insert and solder the components in any preferred order. A socket **must** be used for the PIC.

Although the transistors are specified as BC558 types, virtually any small signal *pnp* type will be suitable. Care should be taken if other types are used however, as their pinouts may vary.

The l.e.d. matrix type used in the prototype measures 39mm × 23mm, although 17mm and 50mm wide types could be used, provided that they are specified as "row-anode".

In the prototype, the display was mounted on the board by means of two 7-pin sockets obtained by cutting a standard 14-pin d.i.l. i.c. socket in half. It is positioned with its identity writing side to the right as viewed in Fig.4.

The prototype was not built into a box and the switches were mounted on a separate piece of stripboard whose assembly details are shown in Fig.5. However, the circuit could be fitted into a small handheld case which also has a battery compartment. Holes should be drilled for the switches. They should be standard push-to-make types and connected to the board by flying leads.



When the circuit is complete, and fully checked for errors and bad soldering, the preprogrammed PIC can be fitted into its socket. Ensure that this is fitted the correct way around. See this month's *Shoptalk* page for details of obtaining the software and preprogrammed PICs.

The circuit should work correctly when power is switched on, provided it has been wired correctly. There are no adjustments to be made.

PROGRAM VARIATIONS

The use of a microcontroller enables various features to be added to the game to make it more interesting and these are limited only by the programmer's imagination, especially as no extra components are required.

Some of these possibilities have already been mentioned. One promising additional idea is to limit the quantity of ammunition carried by your own warship to, say, ten firings before the ship has to return to port (position 40h) to replenish its supply. A new register defined to count the number of times the fire button is pressed could be used to control this and the register could be reset to ten (or some other value) each time the cursor went to position 40h.

A similar idea would be to limit the range of your warship to say 20 moves. When this total expired, the ship could automatically "return" to port by loading 40h into the AIM register, or perhaps need to make its way back before its "fuel" ran out. A ship that could not return to port would be lost and a new one could appear at the home port. In this case, the number of warships could be limited to say three, so that if these were lost, the enemy would win the game.

This game could also be modified so that each time the enemy ship entered the port (i.e. location 40h) one of the ships there would be sunk. In this way, some of the player's ships could be sunk before they even left port. In this version, the port l.e.d. could remain illuminated to inform the player that new ships were still available.

ENEMY HOME PORT

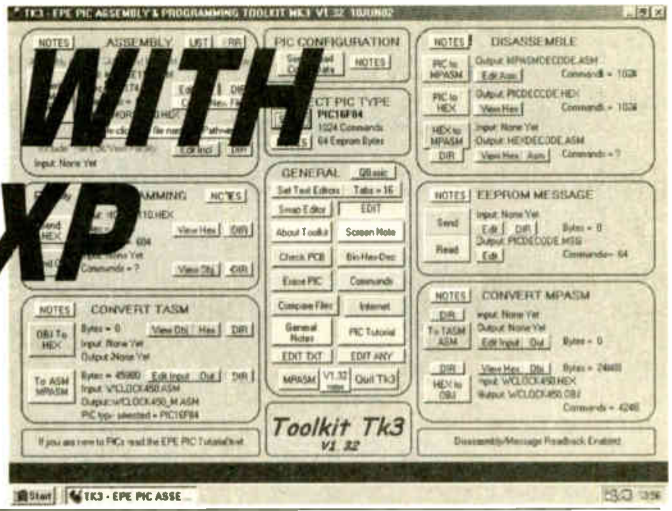
The idea of a home port could also be easily extended to a base for the enemy (location 06h for example). Here, if the enemy returned to port, the player would loose the game so that as well as trying to protect his ships, the player would be forced to patrol near the enemy base to prevent the raider from returning home.

This option could appear only after all of the merchant ships had been sunk and here the movement options of the raider could be limited to move up, move right or stay still so that it would naturally tend to head for its base at the top right hand corner of the display when no more merchant ships remain afloat.

Modifications to the software to develop other scenarios to make the game harder would form an excellent basis for a science project to give budding programmers an opportunity to exercise their programming skills! □

Special Feature

USING TK3 WITH WINDOWS XP AND 2000



MARK JONES

In answer to readers' queries – how to get EPE Toolkit TK3 operating under these other systems.

FOLLOWING a number of posts on the *EPE Chat Zone* and some further correspondence with John Becker, this article documents the process of running John's *EPE Toolkit TK3* (Oct/Nov '01) PIC programming application under Windows XP and Windows 2000 (2K).

Windows NT, 2K and XP are often criticised for not allowing applications direct access to the I/O functionality. This is due to them running the processor in Protected Mode, unlike Windows 95, 98 and ME, which do not, and for which *TK3* was written.

It is worth noting that the process described here should hold true for *any* software application that requires access to the computer's input/output (I/O) architecture.

XP BASICS

With Windows XP, to enable easier usability and command access to directories within the operating system's architecture, the first step is to obtain the **Open Command Window Here** functionality. This allows the user to utilise Windows Explorer to locate directories on the computer and then open a command window (similar to the old DOS prompt) at a chosen location, see Fig.1. This functionality is available within Windows 2000 without modification.

For Windows XP users this functionality is available within the Microsoft Windows XP Powertoys, which are available for download at:

www.microsoft.com/WINDOWSXP/home/downloads/powertoys.asp

Install the Powertoys as per Microsoft's instructions. Readers may be interested in any sub-set of the offered functionality, but the item we are interested in here is **Open Command Window Here**, so ensure that this item of functionality is selected for download as a minimum. Note that Powertoys are not available for Windows 2000.

The first step in the installation process is to install the basic program itself For the purposes of this article the installation illustrated will be from the *TK3* CD-ROM. Readers should be able to modify the step-by-step instructions below to suit their particular circumstances (e.g. installing from an *EPE* ftp site download).

Following the instructions contained in the ReadMe file on the *TK3* CD, the first step is to create a directory for installation. The easiest way to undertake this is to use Windows Explorer, which is available from the PC's Start menu.

Within Windows XP it is found by following the path:

Start -> All Programs -> Accessories -> Windows Explorer

Under Windows 2000 it is found by following the path:

Start -> Programs -> Accessories -> Windows Explorer

The default folder shown on opening Windows Explorer is your personal **My Documents** folder. For the purposes of this

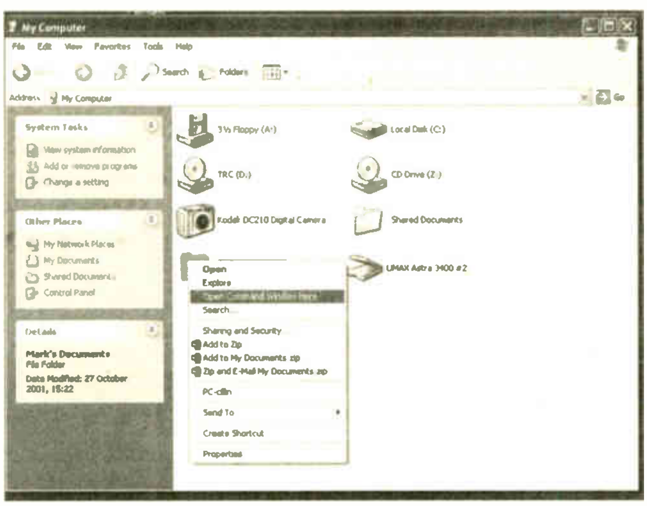


Fig.1. Windows XP Open Command Window Here functionality screen.

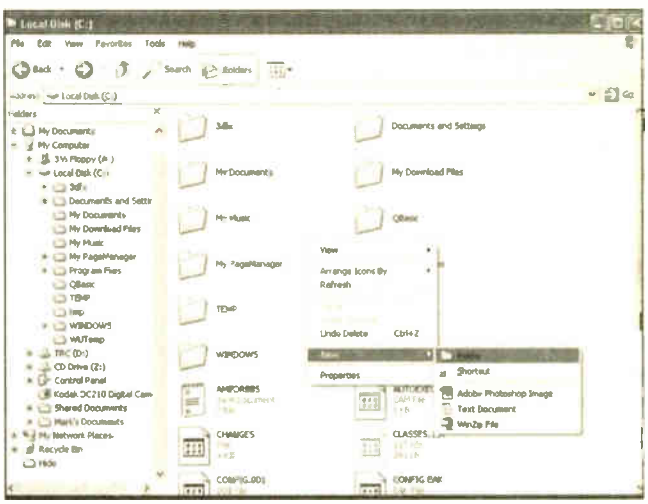


Fig.2. Creating a new folder within Windows XP.

exercise we will install the software at a higher level within the structure. Within Windows Explorer, on the left hand side of the screen click the + sign next to **My Computer** then click on **Local Disk C:** (naming may vary depending on your personal setup).

In the right hand side of the screen you now need to right click with the mouse and select **New -> Folder** and call this folder **Toolkit3**. For Windows XP and 2K see Fig.2. Within Windows 2K the graphics may differ but the process is exactly the same.

PROGRAM INSTALLATION

Follow the instructions for the *TK3* installation by unzipping the three zip files into the new folder. WinZip is a good tool to undertake this task with, and an evaluation copy of the tool is available for free download from: **www.winzip.com**.

It is imperative that older versions of WinZip should **not** be used since they might truncate file names to the old DOS limit of eight characters, which would cause *TK3* to crash.

Note that once all the files have been unzipped any immediate attempt to run the **TK3PROG** executable (.EXE) will result in an error message being generated by the operating system – for Windows XP see Fig.3, for Windows 2000 see Fig.4 (some PCs may show slightly different displays depending on other software that might be installed).

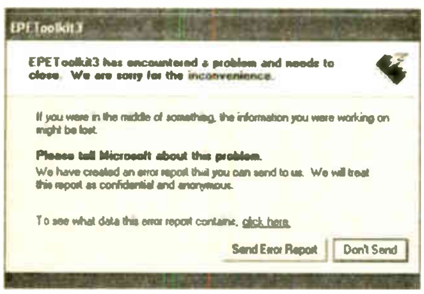


Fig.3. Error generated when running TK3PROG *under Windows XP.*

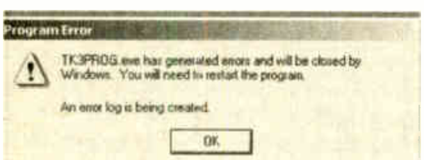


Fig.4. Error generated when running TK3PROG *under Windows 2000.*

MODIFICATIONS

The next step to getting *TK3* to run under Windows XP or 2K requires the download of a utility called **AllowIO**. This is available at:

www.beyondlogic.org/porttalk/porttalk21.zip

Once downloaded open the zip file and extract the **AllowIo.exe** file into your installation directory, in this case **C:/Toolkit3**. Also extract the **porttalk.sys** file as follows:

For Windows XP extract to:
c:/windows/system32/drivers
For Windows 2000 extract to:
c://winnt/system32/drivers

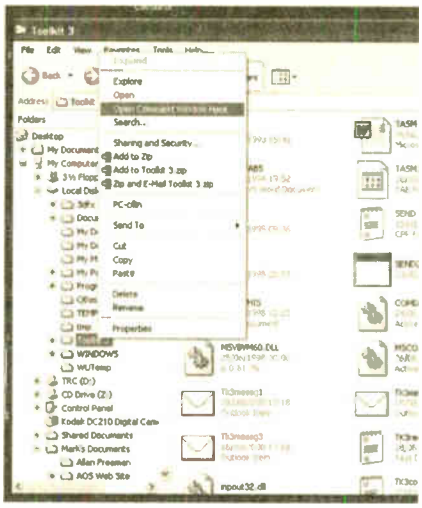


Fig.5. Opening a command window in the installation directory.

Fig.6. Executing command line instruction in installation directory.

TESTING UNDER XP

Using Windows Explorer and the newly installed Powertoys you need to open a command window in the installation directory, see Fig.5.

Once the command window has opened you need to execute the following instruction from the command line (see Fig.6):

Allowio tk3prog.exe /a

Following the execution of the above command you will have **TK3PROG** running on your Windows XP machine. It is suggested that the **Check PCB** functionality within *TK3* is used to ensure that all communications from the PC to the PIC programming hardware are working OK.

TESTING UNDER 2K

To test the installation under Windows 2000, you need to open a CMD window in the installation directory – note that this is different to a *Command* window that is available within the same operating system.

The easiest way to achieve this is to use Windows Explorer to select the installation directory, and then open a CMD window. Windows 2000 will automatically open the window at the directory selected within Windows Explorer, see Fig.7.

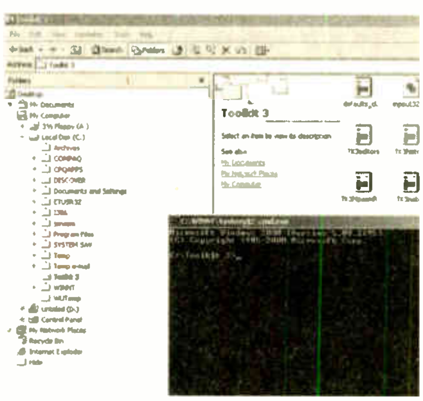


Fig.7. Opening a CMD window at a chosen location within Windows 2000 – note Toolkit3 *selected within Windows Explorer.*

To open the command window follow the path **Start -> Run** and then type **CMD** into the run line and press <ENTER>.

Once the CMD window has opened you need to execute the following instruction from the CMD line:

Allowio tk3prog.exe /a

Following the execution of this command you will have **TK3PROG** running on your Windows 2000 machine. It is again suggested that the **Check PCB** functionality within *TK3* is used to ensure that all communications from the PC to the PIC programming hardware are working OK.

TIDYING UP

To enable easy running of **TK3PROG**, a little tidying up is necessary:

First you need to create a file to issue the necessary command to the **AllowIO** executable. From Windows Explorer, browse to the installation directory and in the right hand side of the Explorer screen right click with the mouse and select **New -> Text Document** and call it **TK3PROG** (which will automatically be given a **.TXT** extension), see Fig.8 for Windows XP. Within Windows 2000 the graphics may differ but the process is exactly the same.

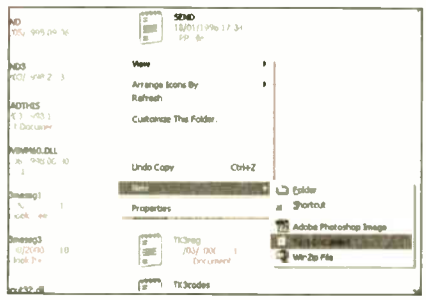


Fig.8. Creating a new text document.

Now open the new text document by double clicking on it and insert the following text:

Allowio tk3prog.exe /a

Save the file and exit your text editor (Notepad by default). Next open a Command window in the installation directory, as previously explained (depending on your operating system), and issue the following command:

Rename tk3prog.txt tk3prog.bat

Next right click with the mouse in some clear space on the Desktop and select **New -> Shortcut**.

Once the **Create Shortcut** wizard starts, the first thing to do is to browse to the now renamed **tk3prog.bat** file as the target. Once the wizard has completed, right click on the new shortcut and select **Properties**.

Then click on **Change Icon**, click **OK** to accept the message stating that the current target contains no icon information, and in the **Change Icon** window click the browse button. Now browse to the installation directory and select the **tk3prog.exe** file as the icon source, then select the only graphic offered within that file and click **OK**.

You should now have a correct-looking icon on your Desktop that will successfully run *TK3*. □

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By Clive (call me Max) Maxfield

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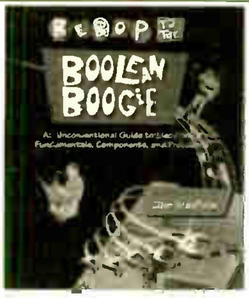

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During the Second World War, Alan Blumlein was deeply engaged in the very secret work of radar development and contributed enormously to the system eventually to become 'H2S' – blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirty-ninth birthday.

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