JUNE 1995

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EPE HiFi VALVE AMPLIFIER

Valve sound hifi at a reasonable price

PIC Light Chaser

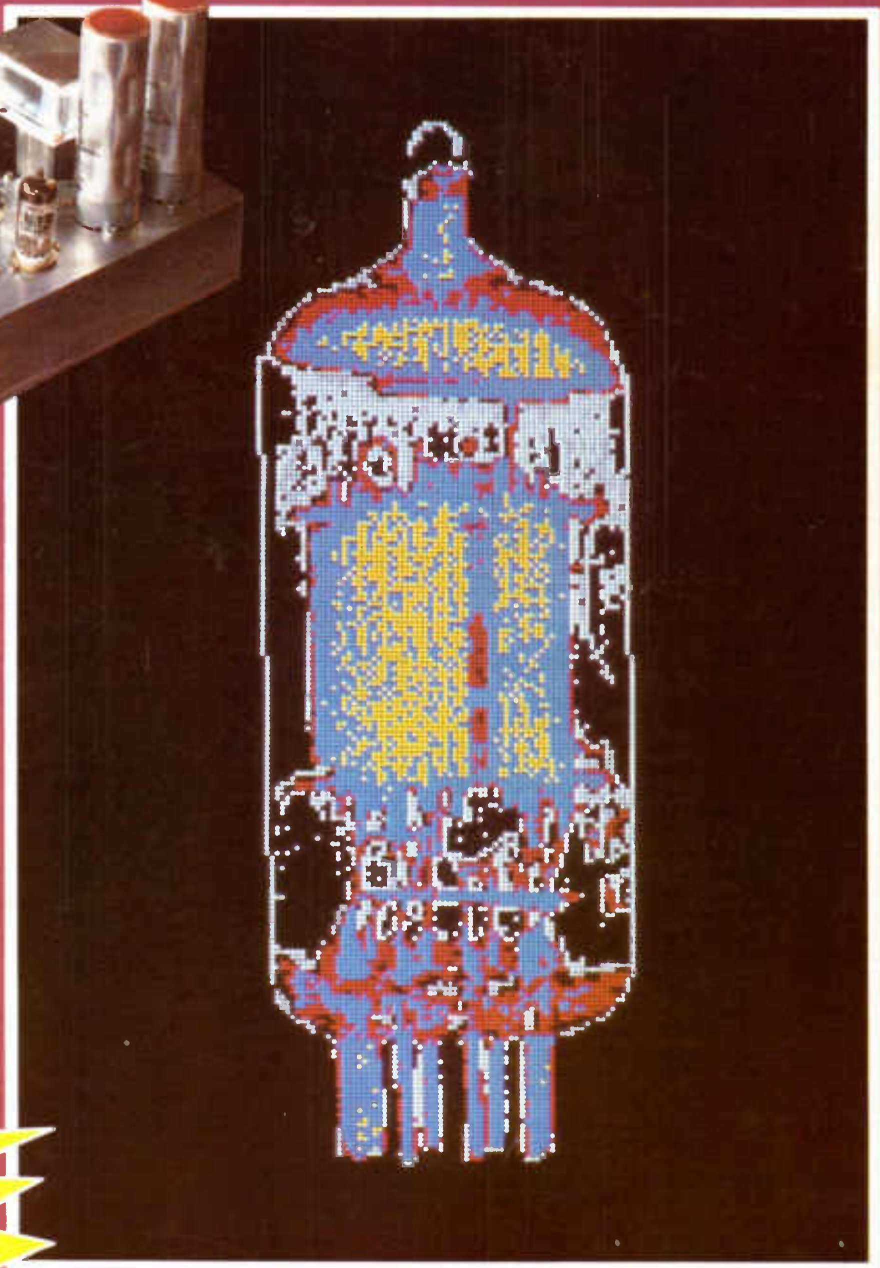
Generate your own light patterns

AA to PP3 Battery Converter

Save money on battery costs

Smart Cards

Barry Fox investigates



FREE WITH THIS ISSUE
THE BUDGET CD & TAPE CO. CATALOGUE
UK issues only

THE NO. 1 INDEPENDENT MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

06
9 770262 361065

NEW BULL ELECTRONICS STORE IN

WOLVERHAMPTON

55A WORCESTER ST. - TEL: 01902 22039

A4 DTP MONITORS Brand new, 300 DPI. Complete with diagram but no interface details.(so you will have to work it out!) Bargain at just £12.99 each!!!!

OPD MONITORS 9" mono monitor, fully cased complete with rasterboard, switched mode psu etc. CGA/TTL input (15way D), IEC mains. £15.99 ref DEC23. Price including kit to convert to composite monitor for CCTV use etc is £21.99 ref DEC24

PC CONTROLLED 4 CHANNEL TIMER Control (on/off times etc) up to 4 items (8A 240v each) with this kit. Complete with Software, relays, PCB etc. £25.99 Ref 95/26

COMPLETE PC 300 WATT UPS SYSTEM Top of the range UPS system providing protection for your computer system and valuable software against mains power fluctuations and cuts. New and boxed, UK made Provides up to 5 mins running time in the event of complete power failure to allow you to run your system down correctly. **SALE PRICE just £119.00.**

RACAL MODEM BONANZA! 1 Racal MPS1223 1200/75 modem, telephone lead, mains lead, manual and comms software, the cheapest way onto the net! all this for just £13 ref DEC13

HOW LOW ARE YOUR FLOPPIES? 3.5" (1.44) unbranded. We have sold 100,000+ so ok! Pack of 50 £24.99 ref DEC16

BRITISH TELECOMM MULTIMETERS SA9083 These are 'returns' so they may have faults but look ok. Complete with new leads and leather case. Price for two meters & 1 case is £10 ref DEC89

5mw LASER POINTER. Supplied in kit form, complete with power adjuster, 1-5mw, and beam divergence adjuster. Runs on 2 AAA batteries. Produces thin red beam ideal for levels, gun sights, experiments etc. Cheapest in the UK! just £39.95 ref DEC49

SHOP WOBBLERS! Small assemblies designed to take D size batteries and 'wobble' cardboard model signs about in shop windows! £3.99 Ref SEP4P2

RADIO PAGERS Brand new, UK made pocket pagers clearance price is just £4.99 each 100x40x15mm packed with bits! Ref SEP5

BULL TENS UNIT Fully built and tested TENS (Transcutaneous Electrical Nerve Stimulation) unit, complete with electrodes and full instructions. TENS is used for the relief of pain etc in up to 70% of sufferers. Drug free pain relief, safe and easy to use, can be used in conjunction with analgesics etc. £49 Ref TEN/1

COMPUTER RS232 TERMINALS. (LIBERTY) Excellent quality modem units (like wyse 50,s) 2xRS232, 20 function keys, 50 thro to 38,400 baud, menu driven port, screen, cursor, and keyboard setup menus (18 menu's). £29 REF NOV4

OMRON TEMPERATURE CONTROLLERS (E5C2). Brand new controllers, adjustable from -50 deg C to +1,200 deg C using graduated dial, 2% accuracy, thermocouple input, long life relay output, 3A 240v o/p contacts. Perfect for exactly controlling a temperature. Normal trade £50+, ours £15. Ref E5C2

ELECTRIC MOTOR BONANZA! 110x60mm. Brand new precision, cap start (or spin to start), virtually silent and features a moving outer case that acts as a fly wheel. Because of their unusual design we think that 2 of these in a tube with some homemade fan blades could form the basis for a wind tunnel etc. Clearance price is just £4.99 FOR A PAIR! (note-these will have to be wired in series for 240v operation Ref NOV1

MOTOR NO 2 BARGAIN 110x90mm. Similar to the above motor but more suitable for mounting vertically (ie turntable etc). Again you will have to wire 2 in series for 240v use. Bargain price is just £4.99 FOR A PAIR!! Ref NOV3

OMRON ELECTRONIC INTERVAL TIMERS.

Minature adjustable timers, 4 pole c/o output 3A 240v,

HY1230S, 12vDC adjustable from 0-30 secs. £9.99
HY1210M, 12vDC adjustable from 0-10 mins. £9.99
HY1260M, 12vDC adjustable from 0-60 mins. £9.99
HY2460M, 24vAC adjustable from 0-60 mins. £5.99
HY241S, 24vAC adjustable from 0-1 secs. £5.99
HY2460S, 24vAC adjustable from 0-60 secs. £5.99
HY243H, 24vAC adjustable from 0-3 hours. £8.99
HY2401S, 240v adjustable from 0-1 secs. £9.99
HY2405S, 240v adjustable from 0-5 secs. £9.99
HY24060m, 240v adjustable from 0-60 mins. £12.99

PC PAL VGA TO TV CONVERTER Converts a colour TV into a basic VGA screen. Complete with built in psu, lead and s/ware. £49.95. Ideal for laptops or a cheap upgrade. We also can supply this in kit form for home assembly at £34.95 ref EF54

DRINKING BIRD Remember these? hook onto wine glass (supplied) and they drink, standup, drink, standup ETC! £4 each Ref EF1

EMERGENCY LIGHTING UNIT Complete unit with 2 double bulb floodlights, built in charger and auto switch. Fully cased. 6v 8AH lead acid req'd. (secondhand) £4 ref MAG4P11

GUIDED MISSILE WIRE. 4,200 metre reel of ultra thin 4 core insulated cable, 28lbs breaking strain, less than 1mm thick! Ideal alarms, intercoms, fishing, dolls house's etc. £14.99 ref MAG15P5

300v PANEL METER 70X60X50MM, AC, 90 degree scale. Good quality meter. £5.99 ref MAG 6P14. Ideal for monitoring mains etc.

ASTEC SWITCHED MODE PSU BM41012 Gives +5 @ 3.75A, +12@1.5A, -12@ 4A. 230/110, cased, BM41012. £5.99 ref AUG6P3

TORRODIAL TX 30-0-30 480VA. Perfect for Mosfet amplifiers etc. 120mm dia 55mm thick. £18.99 ref APR19

AUTO SUNCHARGER 155x300mm solar panel with diode and 3 metre lead fitted with a cigar plug. 12v 2watt. £9.99 ea ref AUG10P3

FLOPPY DISCS DSDD Top quality 5.25" discs. these have been written to once and are unused. Pack of 20 is £4 ref AUG4P1

ECLATRON FLASH TUBE As used in police car flashing lights etc, full spec supplied, 60-100 flashes a min. £9.99 ref APR10P5

24v AC 96WATT Cased power supply. New. £13.99 ref APR14

MILITARY SPEC GEIGER COUNTERS Unused anstraightfrom Her majesty's forces. £50 ref MAG 50P3

STETHOSCOPE Fully functioning stethoscope, ideal for listening to hearts, pipes, motors etc. £6 ref MAR6P6.

OUTDOOR SOLAR PATH LIGHT Captures sunlight during the day and automatically switches on a built in lamp at dusk. Complete with sealed lead acid battery etc. £19.99 ref MAR20P1

ALARM VERSION Of above unit comes with built in alarm and pir to deter intruders. Good value at just £24.99 ref MAR25P4.

CARETAKER VOLUMETRIC Alarm, will cover the whole of the ground floor against forced entry. Includes mains power supply and integral battery backup. Powerful internal sounder, will take external bell if req'd. Retail £150+, ours? £49.99 ref MAR50P1.

TELEPHONE CABLE White 6 core 100m reel complete with a pack of 100 clips. Ideal 'phone extns etc. £7.99 ref MAR8P3.

MICRODRIVE STRIPPER Small cased tape drives ideal for stripping, lots of useful goodies including a smart case, and lots of components. £2 each ref JUN2P3

SOLAR POWER LAB SPECIAL You get TWO 6"x6" 6v 130mA solar cells, 4 LED's, wire, buzzer, switch plus 1 relay or motor. Superb value kit just £5.99 REF: MAG6P8

SOLID STATE RELAYS Will switch 25A mains. Input 3.5-26v DC 57x43x21mm with terminal screws £3.99 REF MAG4P10

BUGGING TAPE RECORDER Small voice activated recorder, uses microcassette complete with headphones. £28.99 ref MAR29P1

ULTRAMINI BUG MIC 6mmx3.5mm made by AKG, 5-12v electret condenser. Cost £12 ea, Ours? just four for £9.99 REF MAG10P2

RGB/CGA/EGA/TTL COLOUR MONITORS 12" in good condition. Back anodised metal case. £79 each REF JUN79

ANSWER PHONES Returns with 2 faults, we give you the bits for 1 fault, you have to find the other yourself. BT Response 200's £18 ea REF MAG18P1. PSU £5 ref MAG5P12

SWITCHED MODE PSU ex equip, 60w +5v @5A, -5v@ 5A, +12v@2A,-12v@ .5A 120/220v cased 245x88x55mm IEC input socket £6.99 REF MAG7P1

PLUG IN PSU 9V 200mA DC £2.99 each REF MAG3P9

PLUG IN ACORN PSU 19v AC 14w, £2.99 REF MAG3P10

POWER SUPPLY fully cased with mains and o/p leads 17v DC 900mA output. Bargain price £5.99 ref MAG6P9

ACORN ARCHIMEDES PSU +5v @ 4.4A. on/off sw uncased, selectable mains input, 145x100x45mm £7 REF MAG7P2

GEIGER COUNTER KIT Low cost professional twin tube, complete with PCB and components. Now only £19 REF AUG19

9v DC POWER SUPPLY Standard plug in type 150ma 9v DC with lead and DC power plug. price for two is £2.99 ref AUG3P4

AA NICAD PACK encapsulated pack of 8 AA nicad batteries (tagged) ex equip. 55x32x32mm. £3 a pack. REF MAG3P11

13.8V 1.9A psu cased with leads. Just £9.99 REF MAG10P3

PPC MODEM CARDS. These are high spec plug in cards made for the Amstrad laptop computers. 2400 baud dial up unit complete with leads. Clearance price is £5 REF: MAG5P1

INFRA RED REMOTE CONTROLLERS Originally made for hi spec satellite equipment but perfect for all sorts of remote control projects. Our clearance price is just £2 REF: MAG2

200 WATT INVERTER Converts 10-15v DC into either 110v or 240v AC. Fully cased 115x36x156mm, complete with heavy duty power lead, cigar plug, AC outlet socket. Auto overload shutdown, auto short circuit shut down, auto input over voltage shutdown, auto input under voltage shut down (with audible alarm), auto temp control, unit shuts down if overheated and sounds audible alarm. Fused reversed polarity protected, output frequency within 2%, voltage within 10%. A extremely well built unit at an excellent price. Just £64.99 ref AUG65.

UNIVERSAL SPEED CONTROLLER KIT Designed by us for the C5 motor but ok for any 12v motor up to 30A. Complete with PCB etc. A heat sink may be required. £17.00 REF: MAG17

MAINSCABLE Precut black 2 core 2 metre lengths ideal for repairs, projects etc. 50 metres for £1.99 ref AUG2P7

COMPUTER COMMUNICATIONS PACK Kit contains 100m of 6 core cable, 100 cable clips, 2 line drivers with RS232 interfaces and all connectors etc. Ideal low cost method of communicating between PC's over a long distance. Complete kit £8.99.

MINICYCLOPS PIR 52x62x40mm runs on PP3 battery complete with shrill sounder. Cheap protection at only £5.99 ref MAR6P4

ELECTRIC MOTOR KIT Comprehensive educational kit includes all you need to build an electric motor. £9.99 ref MAR10P4

VIEWDATA SYSTEMS made by Phillips, complete with internal 1200/75 modem, keyboard, psu etc RGB and composite outputs, menu driven, autodialler etc. £18 each Ref EF88

BOOMERANG High tech, patented poly propylene, 34cm wing span. Get out and get some exercise for £4.99 ref EF83

AIR RIFLES .22 As used by the Chinese army for training puposes, so there is a lot about! £39.95 Ref EF78. 500 pellets £4.50 ref EF80

PEANUT TREE Complete kit to grow your own peanuts! full instructions supplied. £3 Ref EF45

PLUG IN POWER SUPPLYS Plugs in to 13A socket with output lead, three types available, 9vdc 150mA £2 ref EF58, 9vdc 200mA £2.50 ref EF59, 6.5vdc 500mA £3 ref EF61

VIDEO SENDER UNIT. Transmits both audio and video signals from either a video camera, video recorder, TV or Computer etc to any standard TV set in a 100' range! (tune TV to a spare channel) 12v DC op. Price is £15 REF: MAG15. 12v psu is £5 extra REF: MAG5P2

***FM CORDLESS MICROPHONE** Small hand held unit with a 500' range! 2 transmit power levels. Reqs PP3 9v battery. Tuneable to any FM receiver. Price is £15. REF: MAG15P1

LOW COST WALKIE TALKIES Pair of battery operated units with a range of about 200'. Ideal for garden use or as an educational toy. Price is £8 a pair. REF: MAG 8P1. 2 x PP3 req'd.

***MINATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range of up to 2km in open country. Units measure 22x52x155mm. Including cases and earp'ces. 2xPP3 req'd. £30.00 pr. REF: MAG30

COMPOSITE VIDEO KIT. Converts composite video into separate H sync, V sync, and video. 12v DC. £8.00 REF: MAG8P2.

LQ3500 PRINTER ASSEMBLIES Made by Amstrad they are entire mechanical printer assemblies including printhead, stepper motors etc etc In fact everything bar the case and electronics, a good stripper! £5. REF: MAG5P3 or 2 for £8. REF: MAG8P3

LED PACK of 100 standard red 5m leds £5 REF MAG5P4

UNIVERSAL PC POWER SUPPLY complete with flyleads, switch, fan etc. Two types available 150w at £15 REF:MAG15P2 (23x23x23mm) and 200w at £20 REF: MAG20P3 (23x23x23mm)

GYROSCOPE About 3" high and an excellent educational toy for all ages! Price with instruction booklet £6 Ref EF15.

FUTURE PC POWER SUPPLIES These are 295x135x60mm, 4 drive connectors 1 mother board connector. 150watt, 12v fan, iec inlet and on/off switch. £12 Ref EF6.

VENUS FLYTRAP KIT Grow your own carnivorous plant with this simple kit £3 ref EF34

PC POWER SUPPLIES (returns) These are 140x150x90mm. o/ps are +12,-12,+5 and -5v. Built in 12v fan. These are returns so they may well need repairing! £3.50 each ref EF42

***FM TRANSMITTER KIT** housed in a standard working 13A adapter!! the bug runs directly off the mains so lasts forever! why pay £700? or price is £15 REF: EF62 Transmits to any FM radio. (this is in kit form with full instructions.)

*** FM BUG KIT** New design with PCB embedded coil for extra stability. Works to any FM radio. 9v battery req'd. £5. REF: MAG5P5

***FM BUG BUILT AND TESTED** superior design to kit. Supplied to detective agencies. 9v battery req'd. £14 REF: MAG14

TALKING COINBOX STRIPPER originally made to retail at £79 each, these units are designed to convert an ordinary phone into a payphone. The units have the locks missing and sometimes broken hinges. However they can be adapted for their original use or used for something else?? Price is just £3 REF: MAG3P1

TOP QUALITY SPEAKERS Made for HI FI televisions these are 10 watt 4R Jap made 4" round with large shielded magnets. Good quality. £2 each REF: MAG2P4 or 4 for £6 REF: MAG6P2

TWEETERS 2" diameter good quality tweeter 140R (ok with the above speaker) 2 for £2 REF: MAG2P5 or 4 for £3. REF: MAG3P4

AT KEYBOARDS Made by Apricot these quality keyboards need just a small mod to run on any AT, they work perfectly but you will have to put up with 1 or 2 foreign keycaps! Price £6 REF: MAG6P3

HEADPHONES Ex Virgin Atlantic. 8 pairs for £2 **REF: MAG2P8**

DOS PACKS Microsoft version 3.3 or higher complete with all manuals or price just £5 REF: **MAG5P8** Worth it just for the very comprehensive manual! 5.25" only.

GAS HOBS Brand new made by Optimus, basic three burner suitable for small flat etc bargain price just £29.95 ref EF73

GAT AIR PISTOL PACK Complete with pistol, darts and pellets £12.95 Ref EF82 extra pellets (500) £4.50 ref EF80

CHRISTMAS TREE KIT Start growing it now! £3 ref EF53

DOS PACK Microsoft version 5 Original software but no manuals hence only £5.99. 3.5" only.

PIR DETECTOR Made by famous UK alarm manufacturer these are hi spec. long range internal units. 12v operation. Slight marks on case and unboxed (although brand new) £8 REF: MAG8P5

MOBILE CARPHONE £5.99 Well almost! complete in carphone excluding the box of electronics normally hidden under seat. Can be made to illuminate with 12v also has built in light sensor so display only illuminates when dark. Totally convincing! REF: MAG6P6

ALARM BEACONS Zenon strobe made to mount on an external bell box but could be used for caravans etc. 12v operation. Just connect up and it flashes regularly) £5. REF: MAG5P11

6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. Bargain price just £5.99 ea REF MAG6P12

FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99 ref MAG5P13 ideal for experimenters! 30 m for £12.99 ref MAG13P1

HEATSINKS (finned) TO220, designed to mount vertically on a pcb 50x40x25mm you can have a pack of 4 for £1 ref JUN1P11.

STROBE LIGHT KIT Adjustable from 1 hz right up to 60hz! (electronic asssembly kit with full instructions) £16 ref EF28.

ROCK LIGHTS Unusual things these, two pieces of rock that glow when rubbed together! belived to cause rain! £3 a pair Ref EF29.

NEW HIGH POWER LASERS

15mW, Helium neon, 3 switchable wavelengths .63um, 1.15um, 3.39um (2 of them are infrared) 500:1 polarizer built in so good for holography. Supplied complete with mains power supply. 790x65mm. Use with EXTREME CAUTION AND QUALIFIED GUIDANCE. £349+Vat.

WE BUY SURPLUS STOCK FOR CASH

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1995 100 PAGE CATALOGUE NOW AVAILABLE, 45P STAMP OR FREE WITH ORDER.

PORTABLE RADIATION DETECTOR WITH NEW COMPUTER INTERFACE.

£59.00

A Hand held personal Gamma and X Ray detector. This unit contains two Geiger Tubes, has a 4 digit LCD display with a Piezo speaker, giving an audio visual indication. The unit detects high energy electromagnetic quanta with an energy from 30K eV to over 1.2M eV and a measuring range of 5-9999 UR/h or 10-99990 Nr/h. Supplied complete with handbook. Ref. NOV 18.

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

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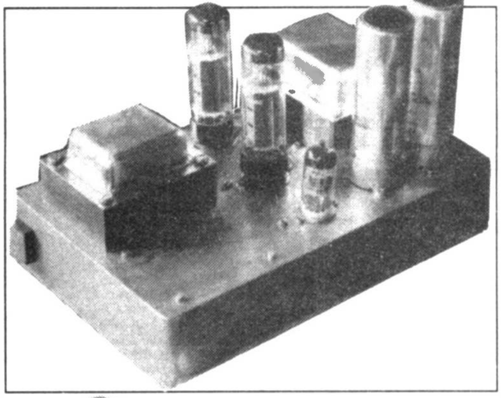
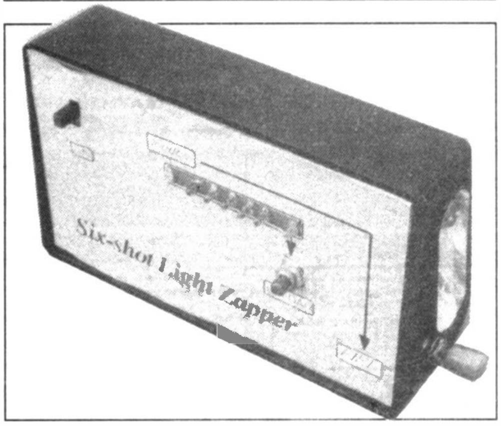
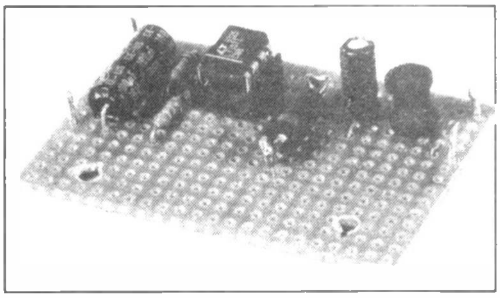
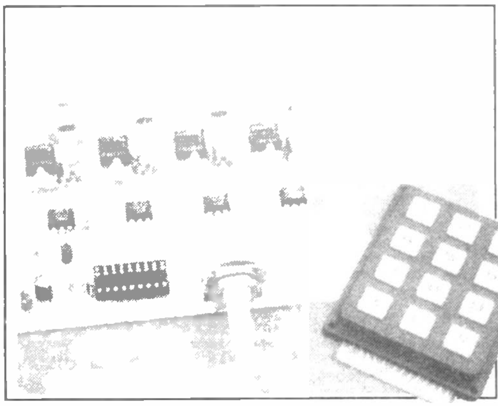








Projects

Series

Features

FREE

THE BUDGET CD & TAPE CO. CATALOGUE

Banded to UK copies

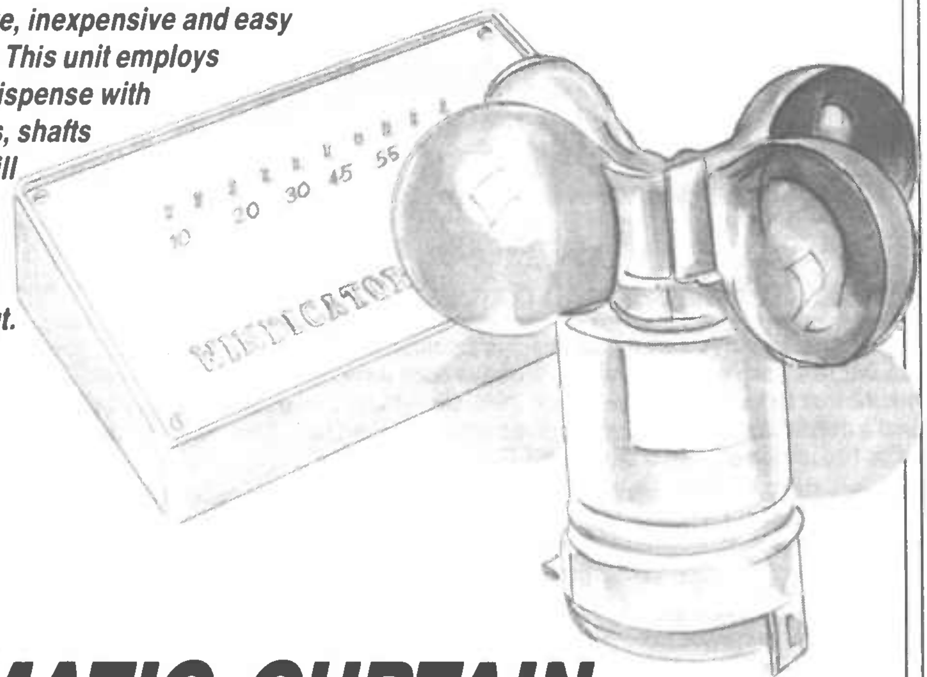
Our July '95 issue will be published on Friday, 2 June 1995. See page 423 for details.

Cover photo: Alfred Pasieka/Science Photo Library

NEXT MONTH

WINDICATOR

A reasonably accurate, inexpensive and easy to build anemometer. This unit employs an electric motor to dispense with complicated bearings, shafts and transducers. It will indicate windspeed from 10 to 75 m.p.h. on an l.e.d. bargraph or moving dot readout.



AUTOMATIC CURTAIN WINDER

Automatically opens and closes curtains at preset light levels. Can be used with almost any corded system. An infra-red remote control transmitter and receiver will also be described and the unit could be interfaced to a computer control system if so desired.

RAMP GENERATOR

A professional quality ramp generator aimed at the intermediate to advanced constructor. This high quality design has a multitude of uses including: oscilloscope calibrator, plotter timebase, curve tracer, frequency response analyser and spectrum analyser.

★ Plus all the regular features.

★ Don't miss out place an order with your newsagent or take out a subscription NOW!

EVERYDAY With PRACTICAL ELECTRONICS

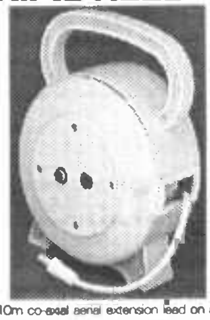
JULY ISSUE ON SALE FRIDAY, JUNE 2

LOADS MORE SUPER SURPLUS OFFERS!

HIGH VOLT CAPS

X3216 33µF 250V size 25x16 5/£1.00
X3191 100µF 160V size 40x25 3/£1.00
X3189 100µF 400V size 31x25 DP 3.89 £2.00
X3221 150µF 385V size 48x36 DP 3.88 £2.00
X3190 470µF 350V size 51x30 DP 6.00 £3.00

AERIAL REEL

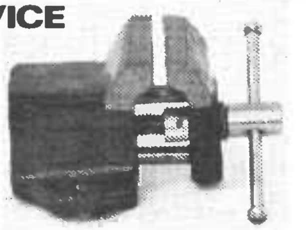


T1048A 10m co-axial aerial extension lead on a compact wind-on reel. Reel contains a built-in TV/radio splitter. Usually £5.95. **NOW £3.50**

IONIZER

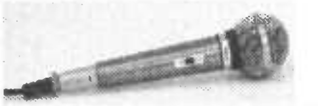
B047E A compact, stylish ionizer and air purifier designed specifically for car, truck and bus use with a coverage volume of 14m3. Removes unpleasant smells, airborne dust, bacteria, tobacco smoke, etc. Supplied with a double sided self adhesive pad. Power 12Vdc 1.8W. Dims: 110x65mm. **Price £2.95**

VICE



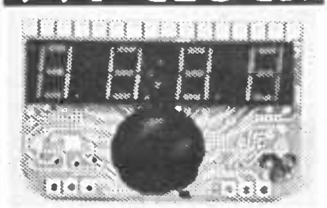
YO10AC Cast steel miniature bench vice. 65mm jaws open to 60mm. Two bolt fixing to bench. Red enamel finish. Dims 100x65x70mm. **Only £4.95**

MICROPHONE



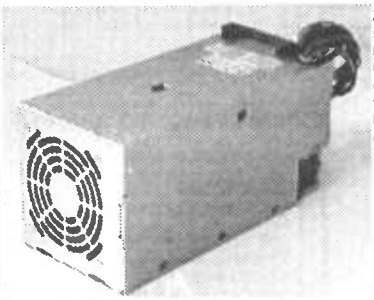
Z5964 Audix HM230S/Tact UDM100 professional dynamic mic with on/off switch and cardoid characteristics. 5m lead with XLR skt fitted mic end. Impressive spec! Supplied with clip and adaptor, individually boxed. List price £44.06. **Our Price £19.95**

99P CLOCK



Z3873 Super Offer! A complete clock in a 40x25mm module. 9V operation with sleep & snooze, 24hr alarm, PM, colon and alarm indicators. Simple fast/slow setting controls. 5 display modes, 12/24hr selectable, display brightness control. Full info supplied. **All this for 99p!**

POWER SUPPLIES



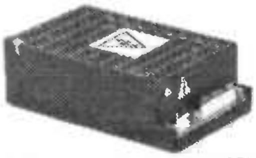
Z9157 One of the best power supplies we've seen for the money - this 397 watt switch mode beauty is one of the highest quality, made by Delta Electronics Inc. Removed from equipment, but in excellent condition (less than a year old!) the unit is totally enclosed in a steel case 340x152x152mm. It has an IEC mains inlet with suppressor fitted and on/off mains rocker switch, and all outputs are on leads with power connectors. Now for the spec: **Inputs: 100-120V @ 10A or 200-240V @ 6A. Outputs +5V @ 40A; +12V @ 15A; -5V @ 1A; -12V @ 1A switchable on front panel.** A 12Vdc 120x120mm fan is fitted at the rear of the case. Current distributor price of a unit of this ilk would be around £400. **Save 92%**

Our Price £29.95

+ This Month! FREE one year subscription to Greenweld Guardian

Another fine selection of SMPSUs recently arrived. These are all ex-equip, but in perfect working order. All are 115/230 Vac input. Do not exceed maximum wattage when loading outputs.

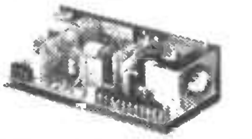
ZS5961 Astec AC9232 50W unit. +12V 2.5A; +5V 6A; 5V 0.5A; 12V 0.5A. **£12.95**
Z5952 Astec SA70A-3400 70W unit. +5V 8A; +12V 3.5A; -12V 1A; -5V 0.7A. **£14.95**



Z5966 Farnell NO55P210 55W unit. +5V 2.5A; +12V 1A. **£4.95**

Z5963 Hitron HSG40-31 40W unit +5V 3A; +12V 0.5A; -12V 0.5A. **£14.95**

Z5957 Astec SA40-1304 44W unit. +5V 5A; +12V 2A; -12V 0.2A **£4.95**



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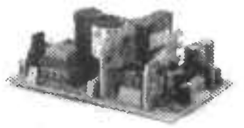

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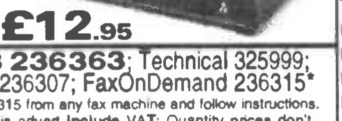

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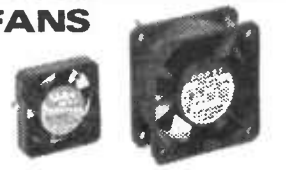

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PRICE HIKE

Wandering around an Antiques Fair over the Easter weekend, my attention was captured by a working Bakelite cased radio, an unusual, rather ugly, design with pushbutton tuning – it was obviously from the early Fifties and turned out to be of American origin (115V a.c.). The most interesting feature was the price – just over £200! I am told that some early radios, those made by Marconi in the very early days of radio, can cost thousands of pounds.

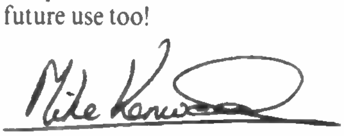
I started to wonder if any item of modern equipment might command such interest in forty years' time. It seems doubtful that many of our present day products could be refurbished to full working order as any custom chips, microcontrollers and programmed memory would be difficult to reproduce. However, if you look at some mundane items which are now becoming collectable, it makes you wonder if we should be hoarding personal cassette players, radios, etc. No doubt the most interesting working designs of such things will become collectors items, possibly made more valuable because of the difficulty in repairing them in the future.

COLLECTABLE

Jake Rothman, who has designed our *EPE HiFi Valve Amplifier* admits to having a weakness for old transistor radios, of the type that Bush put out in the Seventies. Jake has bought and restored a number of these and is threatening us with an article on how it's done – anyone interested? I guess we should all start collecting and restoring now so we can retire on the proceeds in years to come! Incidentally we expect to publish a *High Voltage Capacitor Reformer* project next month – very useful to anyone refurbishing valve equipment.

The specialist knowledge and ingenuity needed to refurbish items using "blown" chips can, of course, be gained by the hobbyist and, providing a replacement "blank" chip is available, it is not beyond the ability of the enthusiast to write new software from a knowledge of the operation and circuitry of the original product and thus blow a new device.

Our *PIC-DATS* (last month) and follow up PIC Light Chaser articles will give you an excellent start in this rewarding operation. So, perhaps we should also be hoarding some of the most popular programmable chips for future use too!



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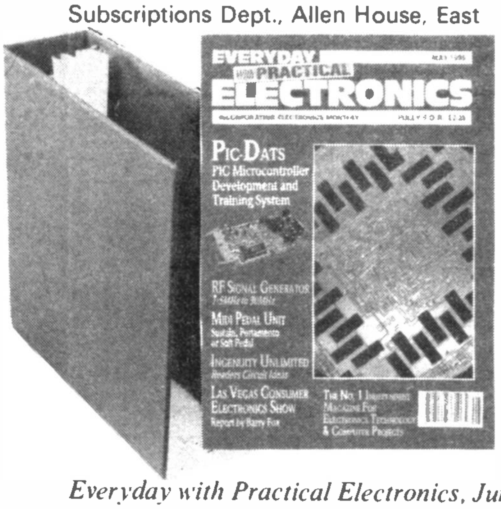

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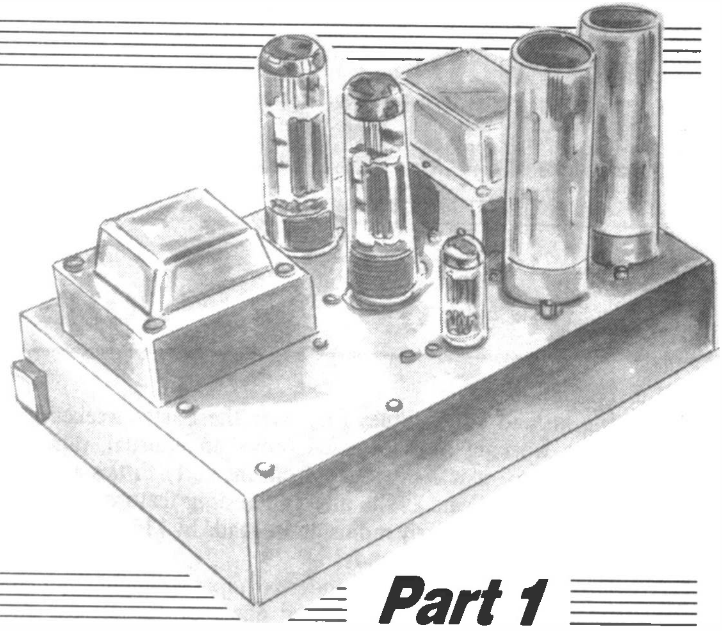
Constructional Project

EPE HiFi VALVE AMPLIFIER



JAKE ROTHMAN

Part 1

Riding on the wave of the "valve revival", Jake presents his own design so that constructors can create the valve sound, without suffering "antique dealer" prices!

• 30W r.m.s. into 8 ohms • 20Hz to 20kHz, ±0·2dB • Input Sens. 300mV for full output • less than 0·1% t.h.d. at 15W into 8 ohms • Hybrid design for minimum valve count • Monoblock design (two required for stereo) • Optimised for use with CD •

HERE, at last, is the promised *EPE* HiFi Valve Amplifier. Designed to sound at least as good as the Quad II power-amp described in the February 1994 issue.

The design is not a rehashed 1950s circuit. It is based around a brand new hybrid topology combining the positive attributes of vacuum and solid-state technologies. This amp enables the valve sound to be obtained without suffering "antique dealer" prices.

IN COMPARISION

In terms of "pounds-per-watt" valve amplifiers cost around five to twenty times more than equivalent power solid-state designs, so why use valves? The answer lies in the type of distortion produced, generally valve type distortion sounds subjectively better, even if it is much higher on the "spec sheet."

Audio distortion is a complex subject, inevitably intertwined with psychoacoustics. The human ear produces its own distortion which tends to increase smoothly with level and comprises mainly low-order harmonics.

It does not seem surprising therefore that studies have shown distortions very dissimilar to this are much more noticeable, humans may prefer to hear distortions they are familiar with! Unfortunately the distortions produced by standard Class-AB solid-state designs are almost the opposite to that of the human hearing, tending to suffer increasing distortion at low-levels and hard clipping at overload.

Often distortion is at a minimum just before clipping and the harmonics produced tend to be high and of an odd-order such as 5th and 7th. This tends to manifest itself as a lack of clarity in the top end and low-level reverberation. Characteristic distortion curves for the two different technologies are shown in Fig. 1 and Fig. 2.

SYSTEM SYNERGY

More astute readers may have realised that the transistor amplifier distortion curve in Fig. 1 is very similar to that produced by digital recording media. CDs

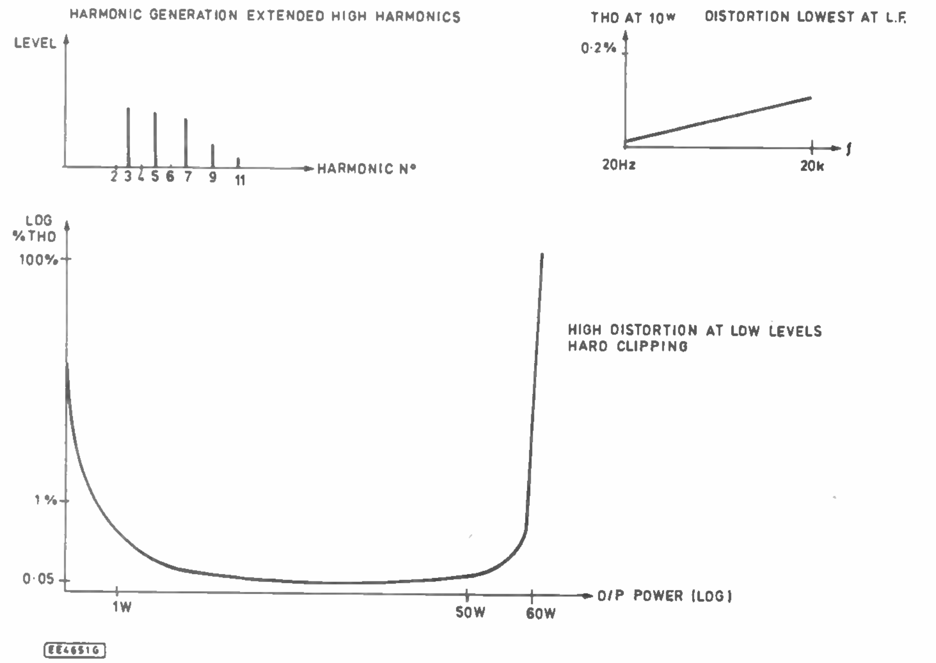


Fig. 1. Solid-state distortion – Class-AB

exhibit a distortion rise at low levels simply because there are fewer bits to convey the information.

One could be excused for thinking this means there is no point in using a valve amplifier with CDs. There is – because for some unknown reason, the distortion curve of the valve amplifier seems to hide that of the CD player and make the system sound better.

What matters is the overall distortion pattern (with regard to harmonics and level) and the frequency response of the complete hi-fi system. This effect of hi-fi components complementing each other is known as synergy. This effect has also been used in studios for many years, where valve condenser microphones and guitar processors are common place, complementing digital recording and sampling. A few years ago a CD player was introduced that had valves following the DAC!

NEGATIVE FEEDBACK

Another aspect to amplifier sound is the use of negative feedback. Feedback is necessary to reduce distortion and flatten frequency response.

Where a lot of feedback is used clipping tends to be much harder and sudden. The distortion harmonics although much reduced, are pushed up to higher orders. Soft clipping or gradual overload is subjectively less unpleasant and is akin to the effect of hitting a string or soundboard harder.

There is a school of thought in hi-fi that believes that any feedback is bad. This aim is very difficult to achieve in practice, since the only amplifying devices linear enough to not need feedback are a select few triode valves.

Generally speaking the less linear an amplifying device is, the more feedback is required. Phase shift limits the amount of feedback that can be applied before oscillation occurs. Valve amplifiers generally employ coupling capacitors and output transformers which limit the amount of feedback to a maximum of around 20dB (open-loop gain reduced by × 10).

OUTPUT IMPEDANCE

The output impedance of valve amplifiers is generally higher than transistor amps because of the smaller amount of negative feedback used, the high output impedance of valves themselves and the resistance in the transformer windings. A high output impedance means that the loudspeaker damping factor is lower, often giving the impression of better bass.

This often makes small closed-box speakers sound better. The BBC designed LS3/5a is such a design and is often seen partnered with Quads (synergy again).

Table 1 compares the linearity of various output devices. It is interesting to note that MOSFETs are the least linear, it even says in the Hitachi data book that a MOSFET output stage produces ten times more distortion than a comparable bipolar stage.

Fortunately, MOSFETs have such a high bandwidth that massive amounts of negative feedback can be used to give acceptable distortion.

A BETTER CLASS OF AMPLIFIER

Another reason for the good sound of valve amplifiers is not that they use valves *per se*, but that they are usually Class-A designs. Class-A amplifiers run at full power even with no signal, with the output devices never out of conduction throughout the whole cycle. This means there is no low-level or crossover distortion.

Valves are very effective at dissipating heat so it is simple to run them in Class-A. With solid-state devices massive heatsinks and thermal stabilisation are needed, so Class-A is rarely used.

HOW IT WORKS

The block diagram of the *EPE* HiFi Valve Amplifier, with an op.amp based phase-splitter followed by a triode driver stage feeding an ultra-linear EL34 output stage, is shown in Fig. 3. The ultra-linear output stage is based on the Mullard 5-20 design.

Table. 1: Linear comparison of output devices

Device	*Note*
Triode	Most linear, least distortion, lowest efficiency. e.g. 2A3, 300B
Beam Tetrode (in ultra-linear mode)	Slightly more distortion but almost as efficient as pentodes. e.g. 6L6, KT66, EL34, 5881. Used in 5-20 and Williamson design.
Pentode (in ultra-linear mode)	Used in Leak Stereo 20. Distortion between triode and pentode. e.g. EL84
Pentode	Good for guitar amps. Third harmonic distortion predominates. e.g. Vox AC30 using EL84s.
Bipolar Transistor	Cheapest. Difficult to use in Class-A due to thermal runaway risk. Most efficient. e.g. 2N3055.
MOSFET	Most reliable, best h.f. response but least linear. e.g. 2SK135 and 2SJ50.

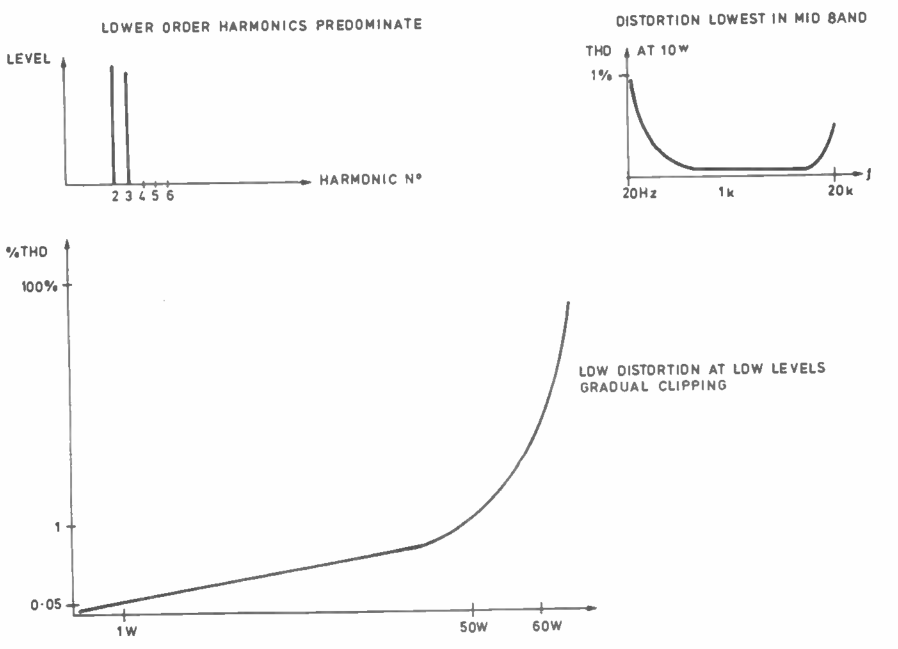


Fig. 2. Typical valve distrotion – Class-A.

Phase-splitter

A phase-splitter is always necessary in push-pull valve amplifiers because complementary valves are not available. All valves are like *n.p.n.* devices, so unless someone can invent a positron emitting electrode using some kind of anti-matter, the *p.n.p.* valve is a long way off.

Single-ended vs Push-pull operation

Single-ended valve amplifier designs do not need a phase-splitter at all and have a nicer sound because the second harmonic distortion is not cancelled, which can leave remaining third harmonics exposed, as with push-pull amplifiers. The drawback with the single-ended approach is that the output transformer is a pig to design because there is a net d.c. current flow.

In push-pull, the d.c. current flows of both output valves are in opposite directions cancelling any generated steady-state flux in the transformer core. In single-ended designs a gap is required in the core to prevent saturation which makes good inductance figures hard to achieve.

The end result is that single-ended output transformers start at four times the price of an equivalent push-pull type. If cost is no object, single-ended triode designs give the nicest sound, but a push-pull ultra-linear amp gives most of the attributes of valve sound for the lowest cost.

Op.amp Phase-splitter

The op.amp phase-splitter was chosen because it is more stable, avoiding the drift that occurs with valve based designs. Since it operates at low levels, it operates in Class-A and clips long after the output valves clip, avoiding any solid-state type sonic signatures. It also provides a low impedance balanced input of the type used in top studio technology to avoid hum pick-up (most valve amplifier inputs are very high impedance and unbalanced).

Since the amplifier is intended to be used with CD players, which almost invariably use 5532 op.amp i.c.s in their output filters, it is felt from an engineering point of view that one extra will not be perceived. Incidentally, 80 per cent of top selling albums are mixed on SSLs which use at least thirty 5534s in the signal path.

A pair of differential op.amp stages with their inputs wired in parallel anti-phase form the basis of the phase-splitter. This configuration was popularised by Ted Fletcher of the Alice mixer company to obtain an equal impedance on both inputs, since the standard single differential amp has unequal impedances, which impairs the common mode rejection ratio. The circuit also gives additional anti-phase output making it ideal for use as a phase-splitter.

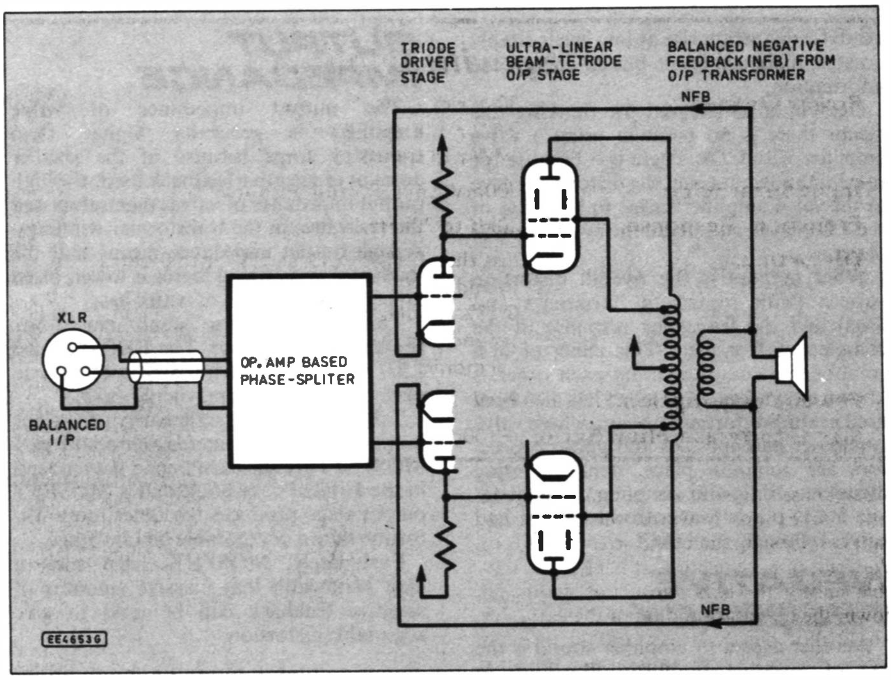


Fig. 3. Block diagram of the EPE HiFi Valve Amplifier.

CIRCUIT DESCRIPTION

Looking at the phase-splitter circuit in more detail, the full circuit diagram of the *EPE* HiFi Valve Amplifier is shown in Fig. 4. The phase-splitter circuit has a gain of four times, sufficient to fully drive the valves, but not so high that it clips with full CD level signals.

To ensure maximum headroom the rail voltage is 33V to 36V. The differential stages are band limited to 40kHz by capacitors C3 and C5. These also serve to prevent r.f. breakthrough.

Both op.amps are biased to half-rail (16·5V) for single-rail operation. This necessitates the use of blocking capacitors C1 and C4 at the input and C7 and C8 at the output.

DRIVER STAGE

An ECC83 triode valve (V1) is used to amplify the outputs of the op.amps to over 25V r.m.s. to fully drive the output stage. Using a 400V h.t., anode resistors R26 and R29 and cathode resistors R15/R16 and R11/R12, the ECC83 sections deliver almost their maximum gain of around 50 times.

To prevent oscillation the grids (pins 2 and 7) are fed by stopper resistors R25 and R28. The grids are held at 0V potential by pull-down resistors R24 and R27. Negative feedback is applied in a balanced fashion from the output transformer secondary to cathode resistors R16 and R12.

To make up the total 2·2 kilohm cathode resistance required for correct biasing at 2V, two kilohm resistors R15 and R11 are included in series with R16 and R12. These resistors are bypassed by capacitors C11 and C9 to ensure maximum open-loop gain.

Finally, the output of the driver valves are fed via capacitors C15 and C17 to the output stage. Since the ECC83 anodes (pins 1 and 6) sit at 205V it is essential that low-leakage 400V capacitors, such as polycarbonate or polypropylene, be used here.

The ECC83 valve was chosen for its high gain and availability. More adventurous constructors may wish to use a higher power valve such as the 6SL7, or better still the 12BH7, to get lower distortion.

OUTPUT STAGE

A pair of EL34 valves (V2, V3) in the standard Mullard ultra-linear configuration will give around 20W at 0·8 per cent total harmonic distortion (t.h.d.) open-loop. The valves operate in pure Class-A up to around 15W and after that point the system operates to some extent in Class-B and this is given the classification AB1.

The maximum output power just before clipping into 8 ohms is 24W r.m.s. Only when the amp is driven beyond clipping are the valves pushed to full cut-off. This point is visible on the 'scope and it looks like a crossover kink in the middle of the waveform when the amp is clipped hard.

When this occurs the output valves are being driven into "grid current". Grid current flows when the grid is driven more positive than the cathode, causing it to act like an anode picking up some of the electron stream. In the case of the EL34 the cathode voltage is around 32V so the input voltage would have to exceed this figure to give rise to grid current.

Grid current can cause problems in that it tends to charge up the coupling capacitors which, because of their long time constant in association with the discharge paths, can cause slow shifts in the d.c. bias. This can manifest itself as "speaker pumping" when the amp is driven hard with pulsed signals.

To prevent parasitic oscillations, resistors R35 and R31 are used as grid stoppers on the control grids of the output valves. Resistors R34 and R30 hold V2 and V3 grids (pin 5) at ground potential. Their value is the highest allowable to reduce loading on the driver stage.

The ultra-linear taps on the output transformer are connected via resistors R37 and R33 to the suppressor grids, pin 4. These help maintain linearity at high levels and are also wired close to the valve socket to help act as grid stoppers.

BIASING

The cathode resistors R32 and R36 have to dissipate high power and thus MUST be a high power type. These resistors generate the necessary bias for the output valves by making the cathode positive with respect to the grid, which has the same effect as making the grid negative with respect to the cathode.

Indeed, some amplifiers employ a separate negative power supply for the grid bias. This system of biasing is called "fixed bias" as opposed to cathode bias and can be used to obtain higher continuous power ratings.

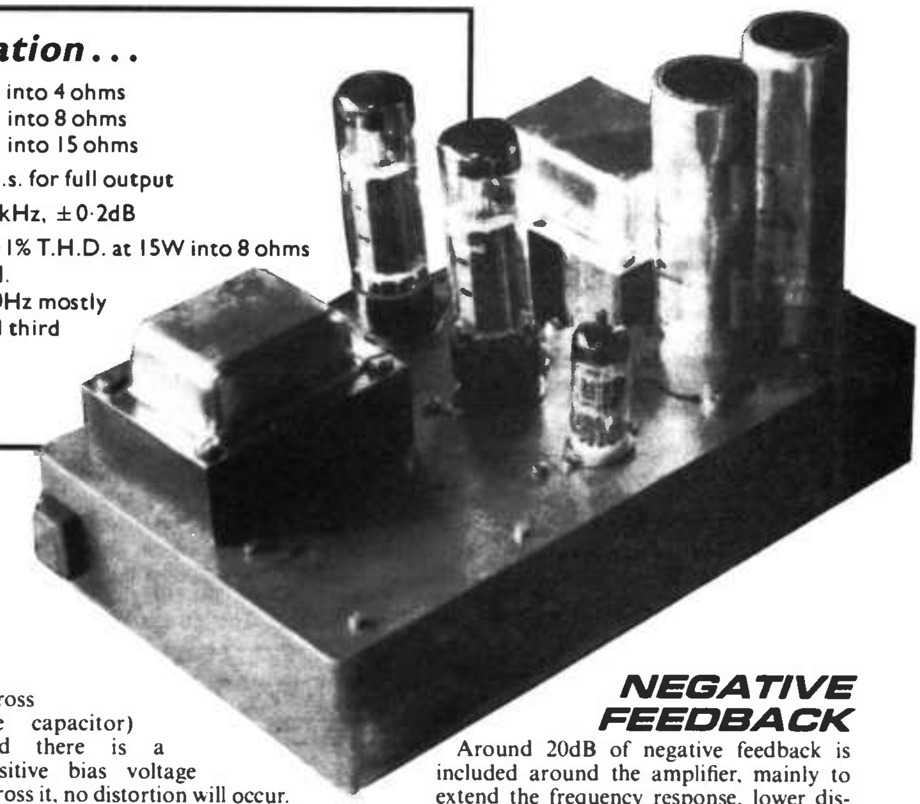
SAFETY WARNING
This project is NOT for beginners

Not only is there mains voltage in this amplifier, there is also 450V h.t. which is even more dangerous because it is d.c., which means that muscles may "freeze". Always use *well insulated* probes when testing and always check if switched off.

It should be pointed out that the l.e.d. is extinguished when the h.t. fuse has blown, this means that the bleeding function is also disabled and the capacitors could still be holding a lethal charge. The same applies if the amplifier is operated with the phase-splitter board removed.

Specification . . .

Power Output:	30W r.m.s. into 4 ohms 24W r.m.s. into 8 ohms 17W r.m.s. into 15 ohms
Input Sensitivity:	300mV r.m.s. for full output
Frequency Response:	20Hz to 20kHz, ±0·2dB
Distortion:	less than 0·1% T.H.D. at 15W into 8 ohms in midband. 0·25% at 50Hz mostly second and third harmonic
Power Consumption:	95W
Signal-to-Noise/Hum Ratio:	−100dB



For pulsed type music signals found in hi-fi applications however, the power advantage is insignificant and so only tends to be found in guitar amps. It is also less reliable since if the bias power rail should go down, the direct grounding of the cathodes would allow a huge current to flow through the output valves and transformer, possibly resulting in expensive failures.

To prevent localised negative feedback stopping the output valves being fully driven, the cathode resistors are bypassed with electrolytic capacitors C16 and C18. Proponents of fixed bias would no doubt argue that the elimination of these electrolytics would be beneficial. However, as with all electrolytics used in audio signal positions, if the value is made big enough (so no signal voltage appears across the capacitor) and there is a positive bias voltage across it, no distortion will occur.

It is possible to use a single cathode resistor and capacitor common to both valves, as used in the Quad, but this is a false economy since it means matched valves then have to be used.

NEGATIVE FEEDBACK

Around 20dB of negative feedback is included around the amplifier, mainly to extend the frequency response, lower distortion to below around 0·1 per cent and help mitigate the effects of any valve mismatching. The feedback is taken from the output transformer secondary and applied in a balanced form to the driver stage

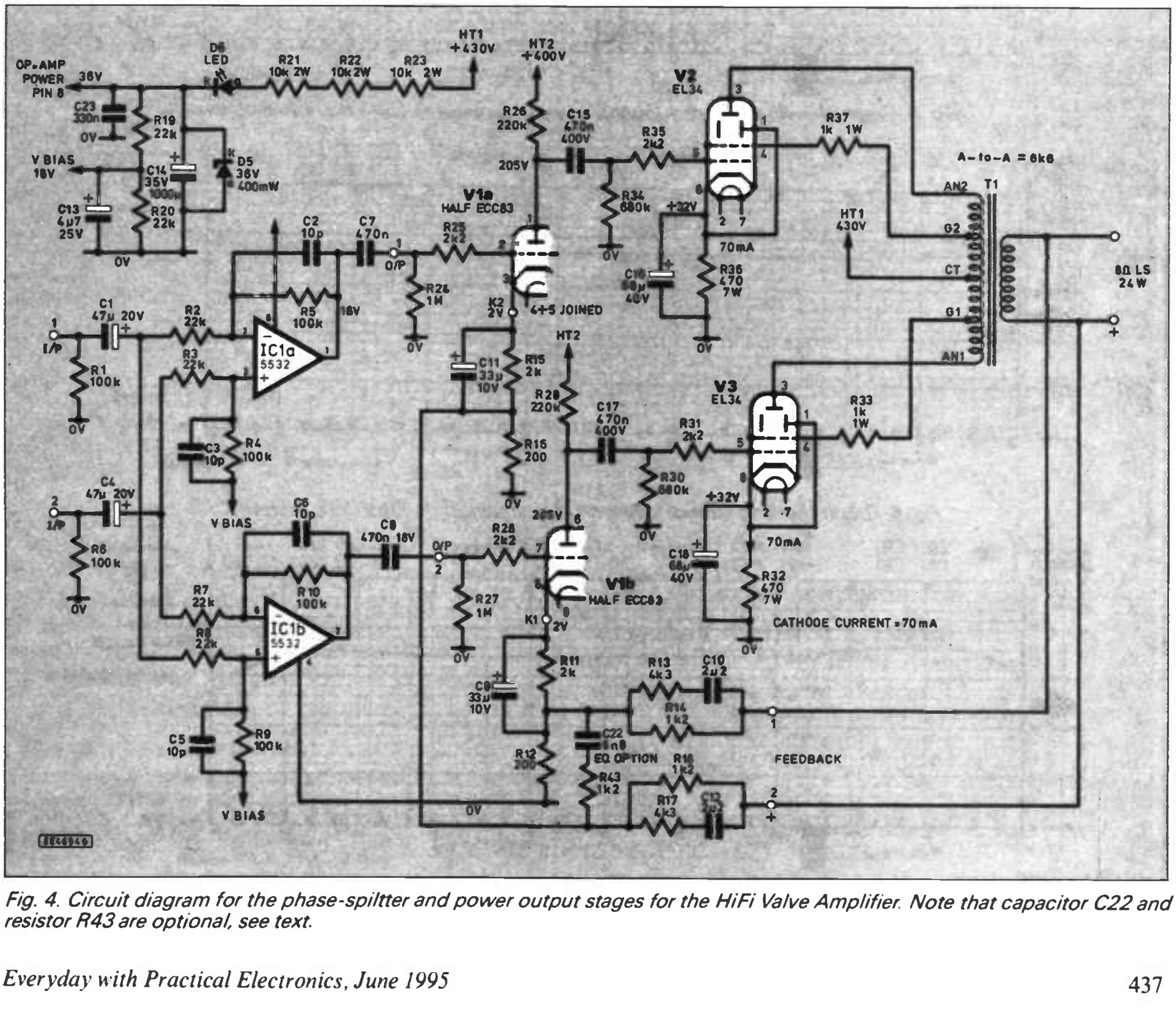


Fig. 4. Circuit diagram for the phase-spiltter and power output stages for the HiFi Valve Amplifier. Note that capacitor C22 and resistor R43 are optional, see text.

where it is developed across R12 and R16, the unbypassed cathode resistors in the driver stage. It was not considered desirable to include the op.amp in the overall feedback loop, since this would have made the open-loop gain too high, resulting in hard clipping.

The level of feedback is set by resistors R14 and R18, with optional low frequency compensation provided by the *RC* networks comprising resistors R13 and R17 and capacitors C10 and C12. The total feedback resistance must not be reduced below one kilohm or there is a risk of low frequency instability setting in.

High frequency compensation was not found to be necessary, but it could easily be included using the p.c.b. positions occupied by R14, C10, R17 and C12. Another option is afforded by C22 and R43 which allow a little high frequency boost to be included if desired. Note that these components are such a rare option that there are no holes for them on the p.c.b., they will have to be soldered across the ends of resistors R14 and R18.

The open-loop frequency response of the amplifier, which exhibits −1dB points at 30Hz and 15kHz, is shown in Fig. 5. With negative feedback the response is flat from 20Hz to 20kHz as shown in Fig. 6.

The feedback network can be used to provide a degree of frequency response manipulation to compensate for speaker deficiencies etc. Fig. 7 shows such a curve where a little boost at 50Hz and 12kHz has been applied to give a better balance with a pair of small bookshelf speakers.

In this case capacitors C10 and C12 were made 470n while C22 was 6n8 and R43 was given a value of 1·6 kilohms. To avoid excessive lift at extreme l.f., the phase-splitter input coupling capacitors C1 and C4 were reduced to 1µF.

POWER SUPPLY

It was mainly the power requirements of valves compared to transistors that led to their demise in the 1960s. The power consumption of this amplifier is very high, with 21W (3·3A at 6·3V) being used for heater power alone. The h.t. current is 140mA at 430V or 60W, giving a total of around 95W including transformer losses! This is even when the amplifier is just idling since it is basically Class-A.

The complete power supply circuit diagram, based around Maplin's "High Power Valve Mains Transformer", is given in Fig. 8. This transformer was used in Maplin's valve amp design to power two stereo channels. In the authors opinion it ran much too hot for long-term reliability, so in this design, an individual transformer should be used for each channel. This allows the amplifiers to be constructed as monoblocks (two for stereo), simplifying "earth loop" and crosstalk considerations.

Original power supplies for valve amplifiers used valve rectifiers and smoothing chokes. A valve rectifier was abandoned in favour of silicon since they are expensive, wear out like any valve and consume extra heater power. Another advantage of the silicon rectifier is that it is easy to use as a bridge.

Most valve rectifiers are of the double diode type which needs a centre-tapped

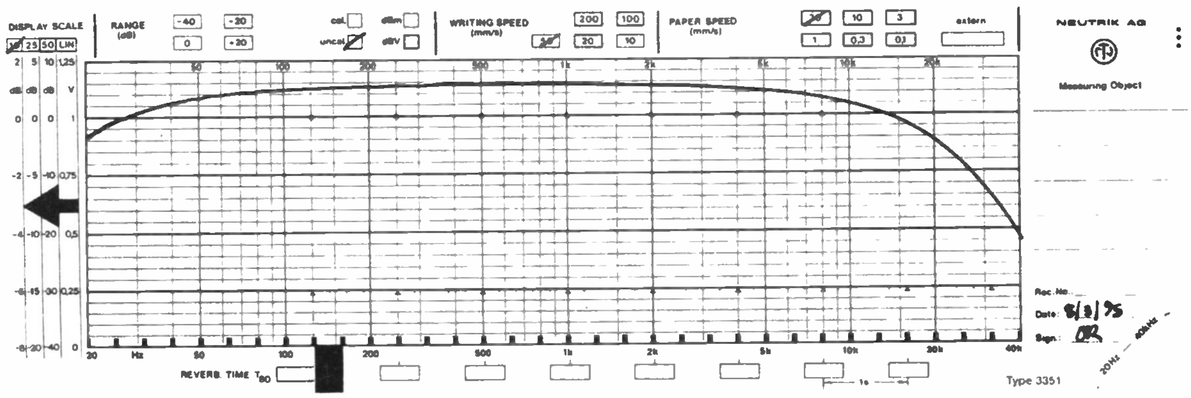


Fig. 5. Graph showing the open-loop frequency response at 15V r.m.s. into 8 ohms.

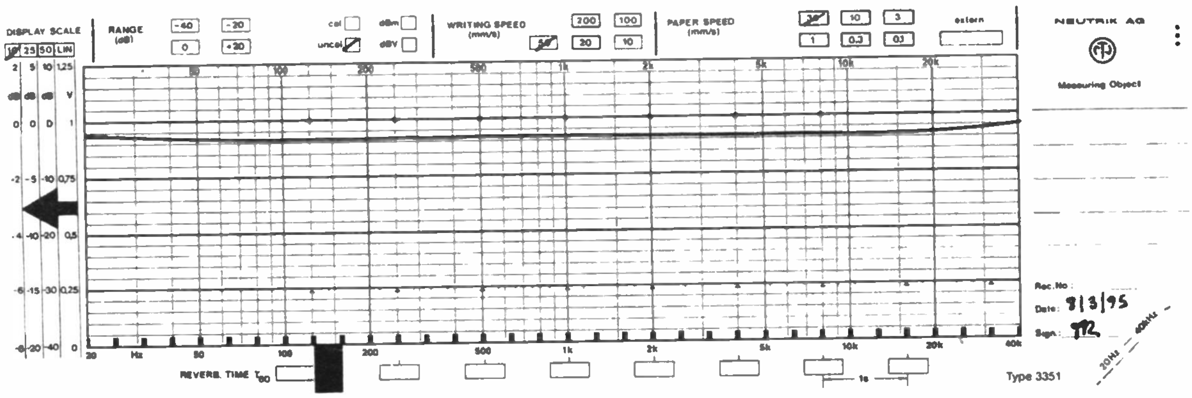


Fig. 6. Graph showing closed-loop with l.f. compensation (15V r.m.s. 8 ohms).

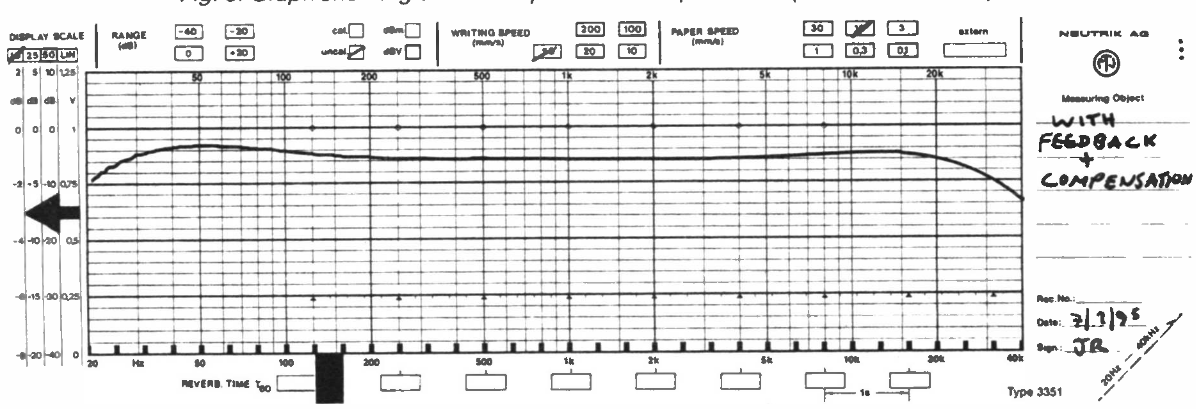


Fig. 7. Graph showing the closed-loop with response equalisation.

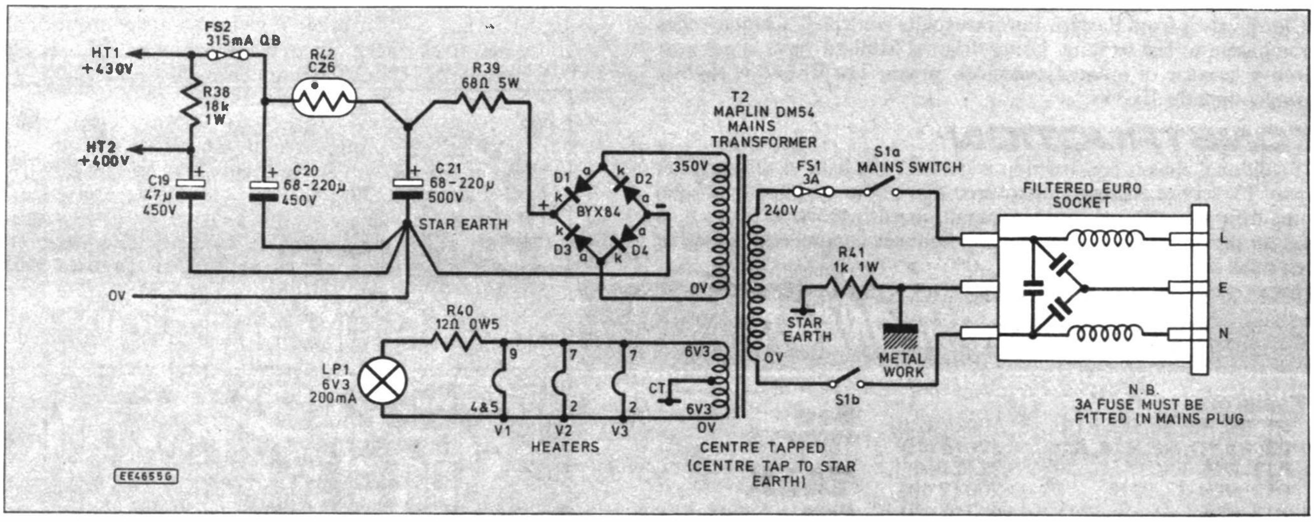


Fig. 8. Circuit diagram for the amplifier Power Supply section.

secondary on the power transformer with twice the voltage. A silicon bridge saves money on the mains transformer and makes it more reliable because the voltage stress is lower.

However, there is a problem with solid-state rectifiers and that is their immediate turn-on, whereas a valve rectifier slowly warms up and applies the h.t. voltage to the circuit gradually. The slow turn-on characteristic of valve rectifiers protects capacitors from destructive surges, but more importantly, prevents cathode stripping in the valves where the full h.t. is present but the cathode has not yet warmed up. The mechanism involved is fairly complex but is basically due to the electrons being pulled from the barium oxide coating on the cathode, resulting in reduced emission in the long term.

To minimise the problem of cathode stripping, a Brimistor (R42) is used. This is a special type of thermal resistor (thermistor) formerly made by Brimar and later STC, which has a high resistance when cold which reduces to a low value when hot.

The type used in this design is the CZ6, which has a resistance of four kilohms cold and 300 ohms hot. This is not as good as the valve rectifier which is an open circuit when cold, but it certainly helps.

If the thermistor cannot be obtained, a standby switch is an alternative. It is even possible to wire a valve rectifier, such as a GZ37, in series with the bridge rectifier with both sections connected in parallel. This would then still obviate the need for a centre-tapped secondary.

In the days when electrolytic smoothing capacitors were only available up to 16µF, additional smoothing was needed and this was achieved by using a smoothing choke. Unfortunately, with the passing of time, capacitance has become a much cheaper commodity, while the cost of inductors has increased in line with inflation.

Since it is now possible to buy standard smoothing caps up to 220µF, we can dispense with the choke and use resistance in its place. In this case, the Brimistor forms the resistive smoothing element and a surge resistor R39 protects the first smoothing capacitor and the rectifier from the switch-on surge. Note that the first capacitor C21 *must* be a 500V type because the no load voltage at turn-on is around 480V.

For safety the chassis is Earthed *directly* to the mains earth, while the "signal earth" is only connected to the mains earth via resistor R41 to prevent ground loops. The "star" earth point for the amplifier is formed from a thick piece of tinned copper wire strapped between the two smoothing capacitors C20 and C21. To avoid the charging current pulses causing buzzing, the output of the rectifier is wired directly to the terminals of C21.

Further smoothing and decoupling for the driver stage is provided by R38 and C19. Since the driver stage only consumes around 1·8mA, this rail can be used to power external pre-amps etc. if desired. Resistor R38 will have to be reduced accordingly to compensate for the extra current drawn.

HEATER POWER

All the heaters are run on a.c. straight off the mains transformer T2. D.C. heater power is not needed since all the valves run at relatively high signal levels.

The heater winding is centre-tapped to ground (0V) which reduces hum, by balancing any residual electron emission from the heaters.

OP.AMP POWER SUPPLY

The relatively low voltage of 33V to 36V needed for the op.amps was a bit of a headache, in that almost 400V needed to be dropped. This meant that around five watts needed to be dissipated in a "dropper resistor". This would normally be considered unacceptable in an efficient solid-state design, but where the output valves are dissipating around 75W, this seemed to be only a minor problem.

In the end, the dropper resistor solved two additional problems: it provided a bleeder resistor function for the h.t. rail, preventing shock risk from residual charge in the smoothing caps. Secondly, by placing an l.e.d. in series, a reliable power indicator was provided, which also showed when the h.t. rail had discharged (see Fig. 4).

The dropper resistor is composed of three 10 kilohm 2W resistors R21, R22 and R23. However, the board will accommodate a single *wirewound* type if this can be obtained. A more reliable choice would be a metal-clad type bolted to the chassis to aid cooling.

A simple Zener diode regulator (D5) holds the rail voltage at 36V and capacitor C14 filters out any ripple and Zener noise. The half-rail bias for the op.amp is derived by resistor R19 and R20 wired as a potential divider. Decoupling of the bias is provided by capacitor C13.

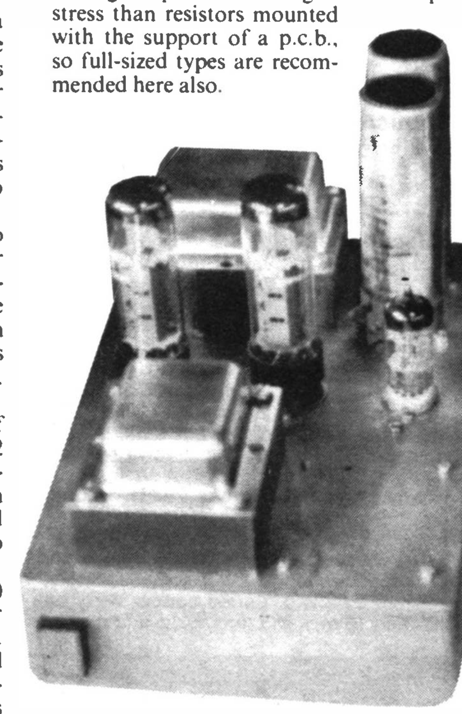
COMPONENT SELECTION

Components are under much greater temperature stress in valve equipment. Electrolytic capacitors tend to dry out, especially the small ones used for cathode bypasses and coupling because they have a large surface area-to-volume ratio.

Fortunately, the smaller cathode electrolytics can easily be replaced by solid electrolyte types, such as solid tantalum and solid aluminium types. Solid aluminium types (made by Philips and Rifa) are even more reliable than tantalum.

The high wattage resistors are under considerable stress and metal-oxide types such as Vishay FP1 and FP2 are recommended for the film types. For the wirewound resistors, Welwyn W22 series vitreous types are very reliable.

The driver anode load resistors are under high voltage stress and physically small resistors, such as Maplin's 0·6W commercial rating (0·25W industrial rating) metal-film types, will not be robust enough. Use a full-size industrially rated type such as the 0·5W metal-film types. Resistors mounted on tag strips are under greater lead-pull stress than resistors mounted with the support of a p.c.b., so full-sized types are recommended here also.



Cheap valves from Eastern Europe usually work well, Chinese tubes do not seem to last as long. Using original Mullard types is not cost effective because of inflated collector's prices. The EL34B is slightly stronger than the EL34S.

CONSTRUCTION

Traditional chassis construction is used for the bulk of the amplifier (many TV service engineers discovered that power output valves soon burnt their way through printed circuit boards!) However, a p.c.b. is used for the op.amp phase-splitter and feedback components in view of their small size.

COMPONENTS

See SHOP TALK Page

Resistors

R1, R4, R5, R6, R9, R10	100k (6 off)
R2, R3, R7, R8, R19, R20	22k (6 off)
R11, R15	2k (2 off)
R12, R16	200 (2 off)
R13, R17	4k3 (2 off)
R14, R18	1k2 (2 off)
R43	1k2 optional
All 0·25W 1% metal film (for p.c.b.)	
R24, R27	1M (2 off)
R25, R28, R31, R35	2k2 (4 off)
R26, R29	220k (2 off)
R30, R34	680k (2 off)
R40	12 (depends on lamp LP1 current)
All full-size 0·5W 1% metal film	
R33, R37, R41	1k (3 off)
R38	18k
All 1W 5% carbon film or 2% metal oxide FP1	
R21, R22, R23	10k (3 off) (can be replaced with single 33k 7W WW)
All 2W 5% carbon film or 2% metal oxide FP2	
R32, R36	470 (2 off)
R39	68
All 7W 5% wirewound Welwyn W22	
R42	CZ6 Brimistor (thermistor) – see text

Capacitors

C1, C4	47µ axial tantalum, 20V (2 off)
C2, C3, C5, C6	10p polystyrene 2·5% (4 off)
C7, C8	470n 5mm polyester 10% (2 off)
C9, C11	33µ tantalum or solid aluminium, 10V (2 off)
C10, C12	2µ2 polyester 20%, 63V (2 off)
C13	4µ7 tantalum bead, 25V
C14	1000µ radial elect. 35V
C15, C17	470n 400V axial polycarbonate or polypropylene, 10% Wima MKB3 (see text) (2 off)
C16, C18	68µ axial solid aluminium (type 123), 40V (2 off)
C19	47µ 450V axial
C20	68µ to 220µ 450V
C21	68µ to 220µ 500V
C22	6n8 polyester (eq. option)
C23	330n polyester

Valves

V1	ECC83 triode
V2, V3	EL34 beam tetrode (2 off)

Semiconductors

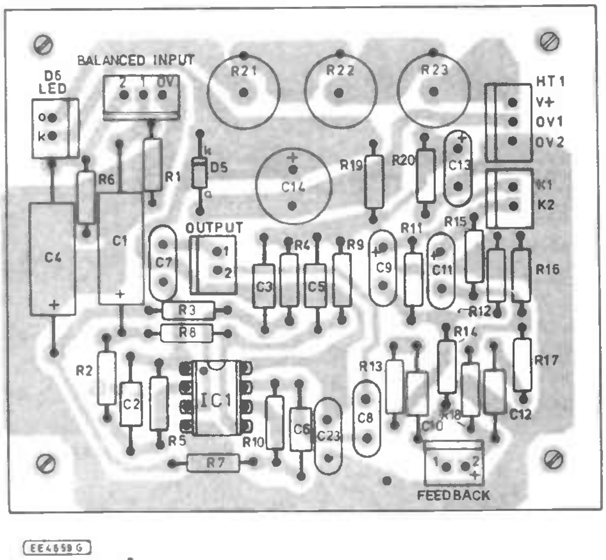
D1 to D4	BYX84 or 1N4007 1000V p.i.v. 1A rec. diode (4 off)
D5	36V or 33V 400mW Zener diode
D6	5mm red diffused l.e.d. 20mA
IC1	NE5532N dual low noise op.amp

Miscellaneous

T1	Valve output transformer, primary anode-to-anode impedance 6k6
T2	240V a.c. mains transformer, with 350V 250mA secondary and 6·3V 7·5V centre-tapped valve heater winding
SK1	filtered mains IEC socket
S1	d.p.d.t. mains toggle switch, with indicator lamp
FS1	3A cartridge fuse, with panel fuseholder
FS2	315mA quick-blow 20mm fuse, with panel fuseholder

Diecast box, size 273mm x 172mm x 51mm; printed circuit board (phase-splitter) available from *EPE PCB Service*, code 941; 8-pin d.i.l. socket; chassis-mounted B9A valve holder; chassis-mount octal valve holder (2 off); 3-pin XLR chassis socket; loudspeaker terminals; l.e.d. holder; 2-pin Molex assembley (4 off); 3-pin Molex assembly (2 off); 6-way tag strip, plus two "earth" mounting tags; 2-way tag strip, plus three "earth" mounting tags; capacitor clips (2 off); small cable ties (3 off); stick-down plastic cable tie mounts (3 off); p.c.b. mounting pillars plus bolts (4 off); multistrand connecting wire, 7/0·1 for Molex connectors; 3-core mains lead; mains wire 7/0·2 for valve heaters; approx. 250mm length twin-screened cable; 102mm length 16 s.w.g. tinned copper wire; 102mm 22 s.w.g. tinned copper wire; one metre silicone sleeving; M4 nuts, bolts and washers (8 off); M3 nuts, bolts and washers (9 off); screw locking compound; solder etc.

Approx cost guidance only **£110**



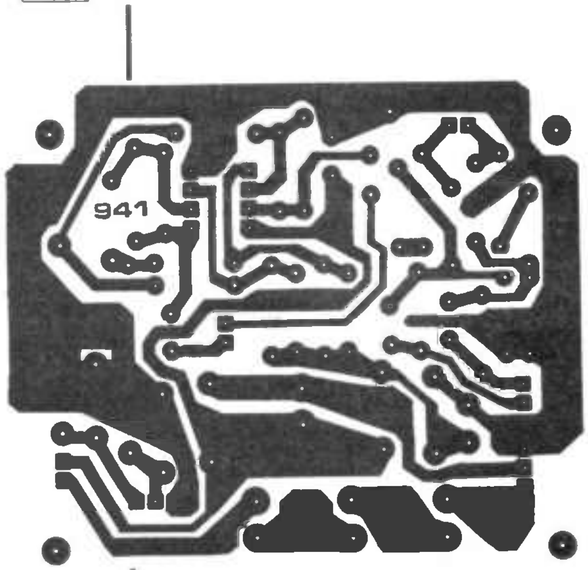


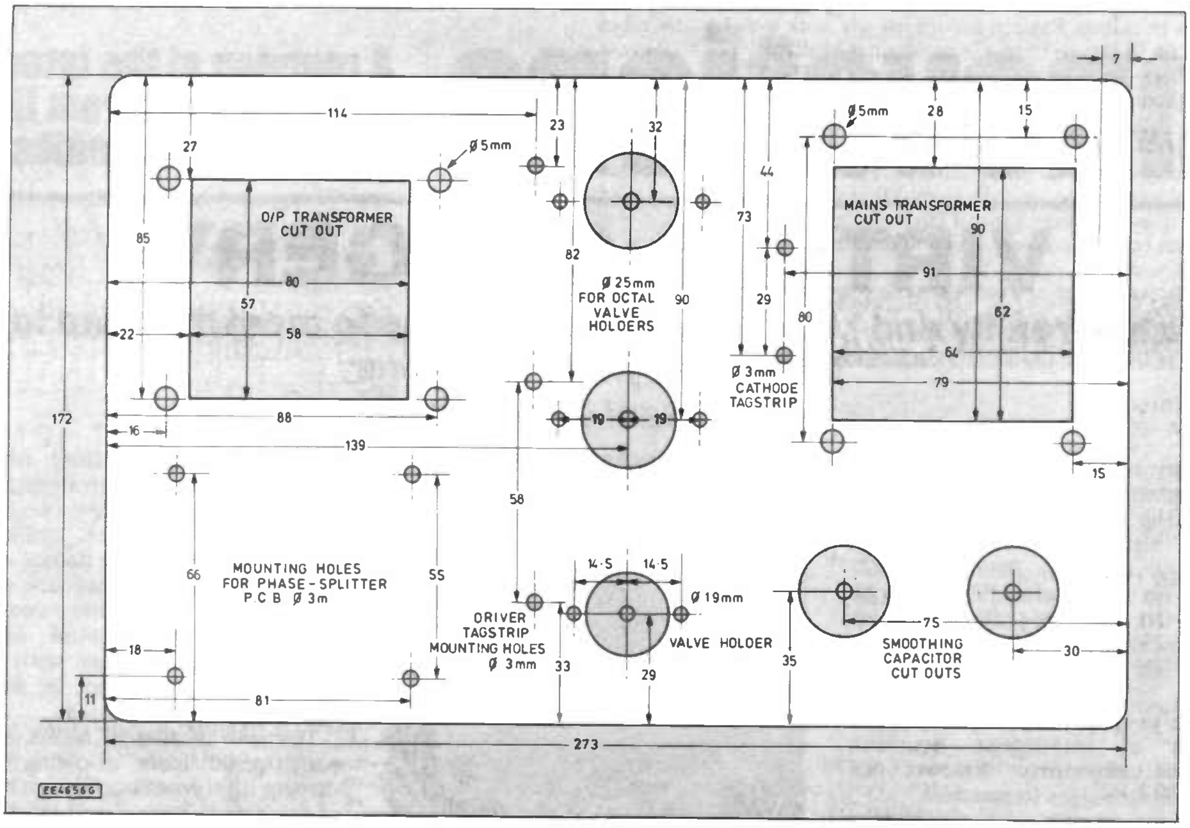
Fig. 9. Phase-splitter printed circuit board component layout and full size underside copper foil master.

Before we undertake the traditional task of "chassis bashing" associated with valve work, we can first tackle the more familiar operation of constructing the printed circuit board (p.c.b.). The top side component layout and full size underside copper foil master pattern are shown in Fig. 9. This board is available from the *EPE PCB Service*, code 941.

Commence construction of the Phase-splitter p.c.b. by mounting components in height order starting with resistors first, but leave the semiconductors until last. Be especially careful to get the polarities of the electrolytic capacitors, Zener diode and the op.amp i.c. the right way round on the board.

The dropper resistors R21, R22 and R23 should be soldered in a clamped fashion onto the track by firmly bending the lead over. This is because components that "run" hot put additional thermal stress on the soldered joints. The resistors should also be spaced away from the p.c.b. by ceramic beads, if possible, to prevent scorching.

Make sure that the straight pin p.c.b. connectors are soldered on the board with



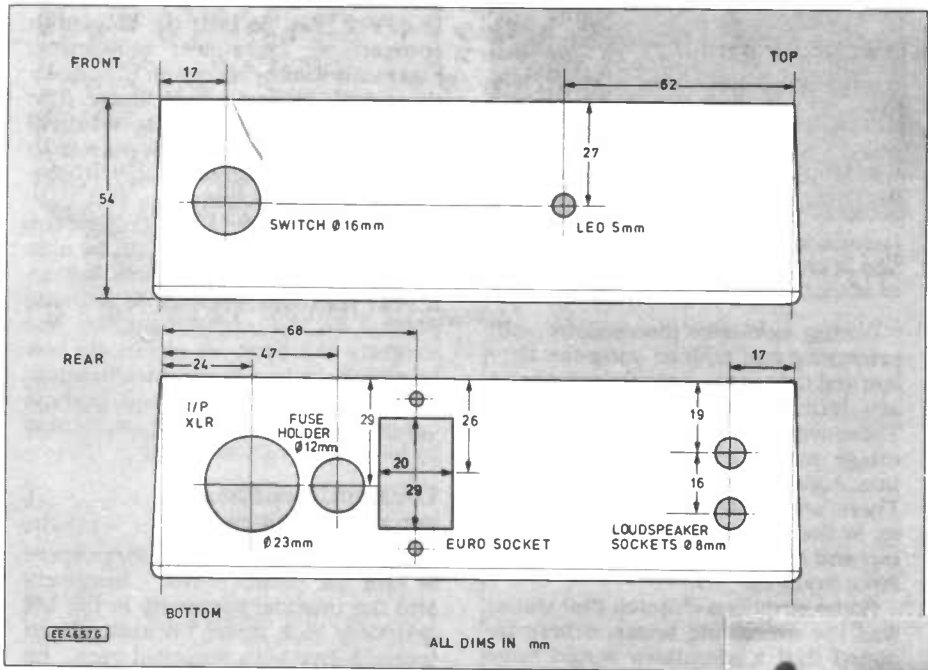


Fig. 10. Chassis top, front and rear component layout, drilling details and dimensions.

their locating "friction lock" headers correctly positioned, see Fig. 9. The make up of the interconnecting plugs is shown next month.

Once the Phase-spilitter board has been constructed it should be put to one side until the diecast box chassis drilling has been completed.

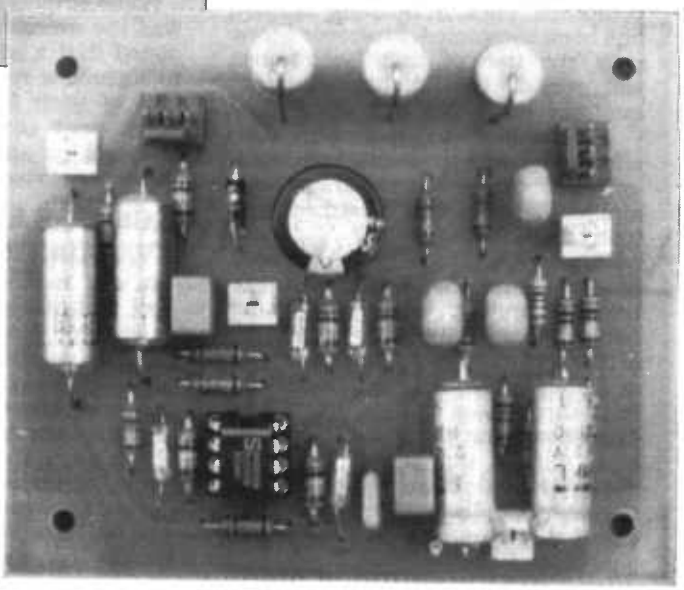
CHASSIS CONSTRUCTION

A diecast box is used for the chassis because they have nice looking rounded edges and are easy to drill. Do *not* use *steel* for the chassis since this will spread the magnetic field of the mains transformer around.

Chassis layout dimensions and drilling details, with the position of all the components having been worked out to ease the wiring, minimise hum and prevent undesirable coupling, are shown in Fig. 10. One of the basic considerations to minimise hum is that the two transformers have been placed as far apart as possible with their cores at *right angles* to each other. Another is that the low-level part of the circuit, the phase-splitter, has been placed as far away as possible from the power transformer.

The smoothing electrolytics are away from the drying heat of the output valves and the output wiring is kept separate from the input wiring by running each on *opposite* sides of the case. Since it is desirable for aesthetic reasons to have all the connecting leads coming out of the rear of the chassis the main input lead has to be a screened cable, since it runs near the power supply electrolytics.

Next Month: We conclude with all the interwiring and final testing.



The completed Phase-splitter board showing the component layout. Note the high wattage resistors are stood on-end and have ceramic beads keeping the resistor bodies clear of the p.c.b.

Innovations

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

VIRTUAL SURGERY

Virtual reality and l.c.d. holography combine to meet the need for training keyhole surgeons

– by Hazel Cavendish

URGENT need for a method of training "keyhole surgeons" in conducting laser operations has opened up a world of medical opportunity to Professor Bob Stone's Virtual Reality (VR) team at Salford. He has recently taken on the role of Director of Virtual Reality Studies for the North of England Wolfson Centre for Minimally Invasive Therapy, and heads the VR Division of Intelligent Systems Solutions (formerly known as Advanced Robotics Research).

In recent months the media has drawn attention to public anxiety about key-hole surgery, leading to a call for action in improving the training of surgeons graduating from conventional open surgery to the more remote techniques of laser telesurgery.

OPERATIONAL RESEARCH

Because live animal-based training is prohibited by UK regulations, primary key-hole surgical experience is presently fostered through the remote handling of "dolly mixtures", grapes, raw chicken tissue, plastic tubing and foam-mounted balloons. It is now realised that provision of even a basic virtual human simulator will help to develop specific surgical skills.

VR has the potential to reproduce the natural and fluidic characteristics of human anatomy, requiring only a re-setting of the host computer, once a training session has been completed. Professor Stone says the use of their techniques will provide the "flight simulator" qualities surgeons are demanding – the ability to generate cost-effective *what-if* scenarios, such as insufflation failures, anatomical ambiguities, patient distress and instrument failure.

With support from the Department of Health and the Wolfson Foundation, a project was initiated at Salford University integrating the skills and talents of a number of academic and small company teams from throughout the UK, backed by know-how from the VR team. In the early part of the project the team observed and recorded the work of the surgeon by visiting operating theatres and using video and digital endoscopy.

Laparoscopic Cholecystectomy operation in progress. Courtesy of University of Manchester.

During extensive discussions with practising and trainee surgeons they learned that medics would not accept any form of head-mounted displays. These were deemed unacceptable for image quality, in-theatre communication, ergonomic and hygiene reasons. There was a 50-50 split in opinions as to the need for stereoscopic viewing and the importance of tactile and force feedback.

Some surgeons claimed that vision was the overriding sense; others insisted that a simulator would have to include a reasonable representation of such features as elasticity, instrument constraints within the body cavity, and varying degrees of movement "viscosity".

HOLOGRAPHIC EVALUATION

It was necessary to adopt a display technology which did not require any form of head or face-mounted peripheral to achieve the necessary stereoscopic effect. A solution was offered by the Richmond Holographics autostereoscopic display system which uses conventional l.c.d.s combined with Holographic Optical Elements (HOEs).

HOEs are devices made using similar techniques to those used for making holograms, and are recordings of the interference pattern which results when two or more laser beams intersect. Unlike ordinary holograms, they do not contain an image: instead they are used to bend, focus and otherwise modulate light in unusual and frequently complex ways, with optical properties that cannot be achieved with conventional optics.

The use of special HOEs make it easy to fabricate a display which directs light from one image into one of the viewer's eyes and light from a second image into the other eye. Both images can be displayed on one l.c.d. The HOE permits the display to compensate for viewer movement; binocular fusion occurs to produce a three-dimensional whole image. The Richmond Holographics system will allow Wolfson Centre researchers to evaluate the necessity for three-dimensional endoscopy.

In due course the VR system means that a practice operation will be able to be carried out in the same way as a real one, but instead of a living patient on the operating table, the surgeon will have an electronic box in which to insert his instruments. Then, as in a conventional keyhole operation, surgery will be performed by looking at a TV monitor.

OVERCOMING SCEPTICISM

Yet Professor Stone declares there is still an uphill battle: "Surgeons and the medical fraternity in the UK generally look upon VR and related technologies with sceptical eyes," he says. "Also, for some reason (and with one notable exception), the larger VR hardware and software companies in Britain seem to have written-off the medical area as being a non-lucrative market.

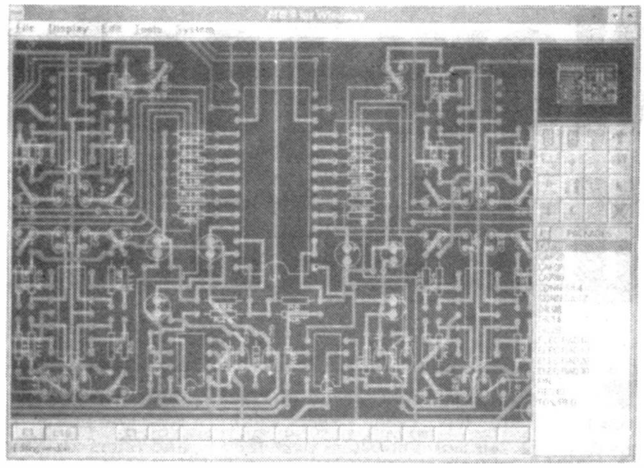
At present, the cost of VR technologies is totally unjustifiable for medical training; up to £150,000 for the computing platform alone. Nevertheless, rapid advances are being made in the development of much cheaper, high-performance graphics processors for PC platforms. It is highly likely that computers delivering the performance required by the medical fraternity will become available at a more realistic in-hospital price within two to four years.

WINDOWS P.C.B. PACKAGES

CADPAK and PROPAK for Windows have recently been introduced into the Labcentre range of software products. CADPAK for Windows includes both schematic drawing and p.c.b. drafting tools but as an entry level product, there is no netlist link between them. CADPAK is especially suited to hobby, educational and small scale schematic and p.c.b. design. PROPAK for Windows adds netlist based integration, automatic power plan generation and a powerful auto-router.

Both of these packages for Windows are based on well proven existing Labcenter products (which run from DOS). At the same time, the new products make full use of Windows features such as on-line help. PROPAK autorouting runs as a true 32-bit application – making it faster than 16-bit products.

CADPAK and PROPAK for Windows are priced at £149 and £495 respectively. Contact Labcenter Electronics, 53-55 Main St., Grassington, N. Yorks BD23 5AA. Tel: 01756 753440, Fax: 01756 752857 for more details of these products and upgrades from existing Labcenter products.



EVENTS

ON AIR

The Amateur Radio, Electronics and Computer Club (AREC Club) of Malta are organising an "on the air" activity to mark Victory in Europe Day. The call sign is 9H50VE and operation, on a 24 hour basis, will continue during May 6th, 7th and 8th. Frequencies, subject to interference and propagation, will be 3·775MHz, 7·044MHz, 14·225MHz, 21·25MHz and 28·55MHz SSB.

AREC Club, PO Box 114, Valletta CMR01 Malta.

CLACTON

CLPK have joined forces again with Sharward Promotions (the Shows and Exhibitions Division of Sharward Services) to undertake the organisation of The East Coast Amateur Radio and Computer Rally, which this year will be held on August Bank Holiday Sunday, 27th August. The venue is the Clacton Leisure Centre, Vista Road, Clacton-on-Sea, Essex.

Major suppliers and manufacturers of radio equipment, computers and computer software, accessories, antennas and secondhand gear will be at the Rally. There will also be a "Bring and Buy" sale.

The show runs from 10.30 a.m. to 4.00 p.m., with the bar and cafeteria available from 11.00 a.m. There is a Free car park.

For further details please contact the organisers: Sharward Promotions, Upland Centre, 2 Upland Rd., Ipswich IP4 5BT. Tel: 01473 272002, Fax: 01473 272008.

Also organised by the same company is the Ipswich Computer Show, Saturday May 20, 10 a.m. to 4 p.m. At Willis Carroon Sports and Social Club, The Street, Rushmere St. Andrew, Ipswich.

LONGLEAT

The 38th Longleat Amateur Radio Rally is at Longleat House (not the Safari Park) on Sunday 25th June from 9.30 a.m. to 5 p.m. Further information from Gordon Lindsay G0KGL, 66 Jubilee Crescent, Mangotsfield, Bristol. Tel/Fax: 0117 940 2950.

VINTAGE

The fourth National Vintage Communications Fair will take place in the Pavilions Hall of the NEC in Birmingham on Sunday, May 14 and will feature thousands of rare and collectable vintage technology items with special emphasis on early radios, television receivers, gramophones, telephones and classic 1950s hi-fi. In attendance will be over 300 specialist dealers from the UK, the Continent and the USA. For the seasoned collector, it's the event of the year.

The fair is presented annually by the *Sound and Vision Yearbook* which is a comprehensive reference guidebook to over one hundred sound and vision collecting hobbies from Amateur Radio through Classic Audio, Theatre, Cinema and other Organs TV and Radio Related Collectables etc., to Vintage Wireless. For early arrivals at this year's Fair, the £5 admission price includes – while stocks last – a free copy of the latest edition of the Yearbook.

More information and copies of this fascinating little Yearbook (£3.50 post free) are available from Sunrise Press, 2-4 Brook St., Bampton, Devon EX16 9LY. Tel: 01398 331532.

SCHOOLS ONLINE

A pilot scheme to help more secondary schools get on-line to Internet was recently launched by Tim Eggar, Minister for Industry and Energy with £250,000 of DTI backing.

"We are working with the information technology and communications industries who are going to "adopt" local schools, providing equipment, line connection and training. Industry will be contributing about £350,000, over half the total cost. DTI will provide a help desk and project management, and will ensure that suitable educational material is available," said Mr. Eggar.

"The companies are close to identifying the 50 schools who will participate in the project. These are either near the companies' own plants or are amongst those who have been ringing asking to be involved.

"If the pilot stage is a success, and if enough schools sign up to the initiative, then the scheme will be extended with DTI committing another £750,000 for a full programme in 1996."

The companies involved have come together to form a "National Information Infrastructure (NII) Task Force". Based on the Federation of the Electronics Industry, these companies include GPT, IBM, and Lucas Systems as well as a number of smaller companies such as Softwright Systems, the independent software company.

Ian Taylor, the DTI Technology Minister responsible for coordinating multimedia matters, has recently established a Multimedia Industry Advisory Group. "The Group will monitor progress of the Online project", said Mr Taylor, "and assess its contributions to education.

"We are aware of concerns about information on the Internet. It will obviously be important to provide adequate protection against undesirable material, and this issue is under consideration by members of the Schools Online Project."

VIRTUAL PA

A digital answerphone which can also store faxes, operate as a high speed modem and automatically forward messages is now available from Andest Ltd.

The Virtual PA (V.PA) can be accessed from anywhere in the world to retrieve voice messages or redirect faxes to any fax machine. The standard unit contains 1Mbyte of memory, enough to store 20 minutes of voice or approximately 50 fax pages, but this can be expanded to 8Mbytes if needed.

The unit can be easily programmed using the built in five button key pad and l.c.d. screen or it can be linked to a PC. The standard version operates at 2400bps for data and 19200bps for fax and costs £399.

Contact Andest Ltd., Chancery Court, Lincoln Rd., High Wycombe. Tel: 01494 429309, Fax: 01494 538598, Bulletin Board – Fax Back Service: 01494 510560.

New Technology Update

Ian Poole investigates the intense development of flash and ferro-electric memories which promises enhanced endurance, speed and density, while cavities replace gutters in research to improve silicon purity.

MEMORIES are one of the most important areas for development at the moment. There has been phenomenal growth in the sales of computers over the last ten years. This has resulted in a greater need for smaller and more portable systems, which in turn has meant that the requirements being placed on memories are becoming even greater.

In a Flash

One development to hit the market in recent years has been the flash memory. This provides many improvements over other memories which are available at the moment because the technology consumes less power and has a very high density.

Some manufacturers are even using these memories to make replacements for disk drives. Although they are more expensive than a standard disk drive they offer the advantage of being far more robust, and much smaller.

There are many other uses for these devices and as a result a large number of manufacturers are entering the market. This increased competition has forced the development of these devices ahead. Intel now manufacture a 16Mbit device and no doubt other companies will follow suit in due time.

Another area of development of flash memories is in increasing their life time. The memories have a limited number of write/erase cycles and some of the first devices to hit the market only had a lifetime of about a thousand cycles or so. Now development has improved their performance quite considerably and most devices will offer an endurance of 100,000 cycles and there is a growing trend for figures of 1,000,000 cycles to be quoted.

Obviously cost is an important factor. Current flash devices are roughly three times the cost of an equivalent EPROM. This reduces sales and Intel are currently working towards making flash the cheapest form of memory on the market. This will ensure that it is in a commanding position for the next few years.

Ferro-Electric Memory

Despite the enormous interest in flash technology and the great amount of coverage it is receiving in the electronics press it is not the only new memory technology about. Over ten years ago a company called Ramtron put forwards the idea for a ferro-electric memory. Now they have over forty patents granted for the idea and a number of others pending.

Supporters of this type of memory describe it as the ideal solution for portable equipment. It combines many of the features required by today's designers. It is very low power, high density, high speed, and offers an almost unlimited number of write/erase cycles.

The technology uses the property of certain crystals in which magnetic dipoles align in different directions according to the electric field which is applied. When the electric field is removed the dipoles stay in place and the data is stored almost permanently. The other advantage of ferro-electric memories is that the life of the cells is measured in hundreds of millions of write erase cycles instead of around a million for flash memories.

Another advantage is that their power requirement is around ten times less than an equivalent flash memory. This is a distinct advantage for portable applications where many of these memories are likely to be used.

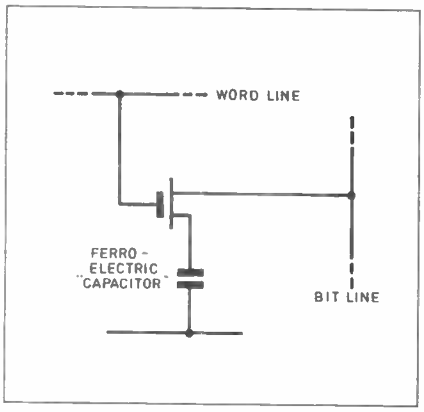


Fig. 1. A cell in a "ferro-electric" memory.

Despite these advantages, ferro-electrics still have a way to go before they catch up with flash. One of the main areas where they are behind is in their density. It is expected that the first 256K devices will be made this year and there are rumoured to be plans for 1Mbit memories sometime in the future, although no dates are known. This is a far cry from the 16Mbit flash devices which are currently being manufactured by Intel. Nevertheless ferro-electric development is forging ahead.

For the long term, ferro-electrics appear to provide many exciting possibilities. However, the technology is still very much in its infancy and we will have to wait a few more years to see if they come up with the goods.

Purer Silicon

One of the key features which has enabled today's semiconductor technology to progress as far as it has is the purity of the semiconductors. The main reason why f.e.t.s were not introduced any earlier was simply the fact that it was not possible to produce silicon which was pure enough to enable them to work reliably.

Now with feature sizes many orders of magnitude smaller and much more stringent demands being placed on the device performances, semiconductor material of the highest grade has to be used. Often when yields fall and devices do not come up to their specification the reason is that the base semiconductor was not pure enough. Even very low levels of impurity can have a marked effect.

In preparation of the basic silicon for semiconductor crystals a technique known as zone refining is used. This removes most of the impurities, but even though this method has been improved it is still not always capable of reducing impurity levels by the degrees necessary.

Impurities can be wide ranging, and a scheme called "guttering" is commonly used to reduce their levels. To perform this an unused portion of the wafer, normally the back or underside is roughened using a coarse etch. This breaks up the crystal lattice creating many sites for the impurities to lodge as metal silicides. As the chosen portion of the wafer is unused they can remain here without any ill effects on the remainder of the chip.

The process works reasonably well but as demands on the purity of silicon increase, it is not sufficient for many of the latest processes. It does not remove all the impurities and the silicides sometimes form in areas where they are not wanted. Copper, one of the most troublesome impurities can be reduced to much lower levels by a process in which some microscopic cavities are created just below the surface of the wafer.

The cavities are formed by implanting helium atoms into the wafer. The wafer is then heated forcing out the helium atoms but leaving microscopic cavities or voids which have nanometre dimensions. These serve to trap the copper by forming areas where the copper atoms can migrate. Once the copper atoms have migrated into the voids they become bonded to the silicon. As in the guttering process the voids are formed in areas of the silicon not used for the active circuitry.

The use of these voids has a number of advantages. Once within the voids the copper is held more firmly than if guttering had been used. In fact the voids are stable to temperatures over 1100°C; sufficiently far above most of the temperatures which would be needed in any of the subsequent processes. In addition to this the voids are capable of holding a relatively large number of copper atoms, making the process useful when impurity levels are high.

THE NAME OF THE GAME
STAR-STRUCK!

ROY BEBBINGTON

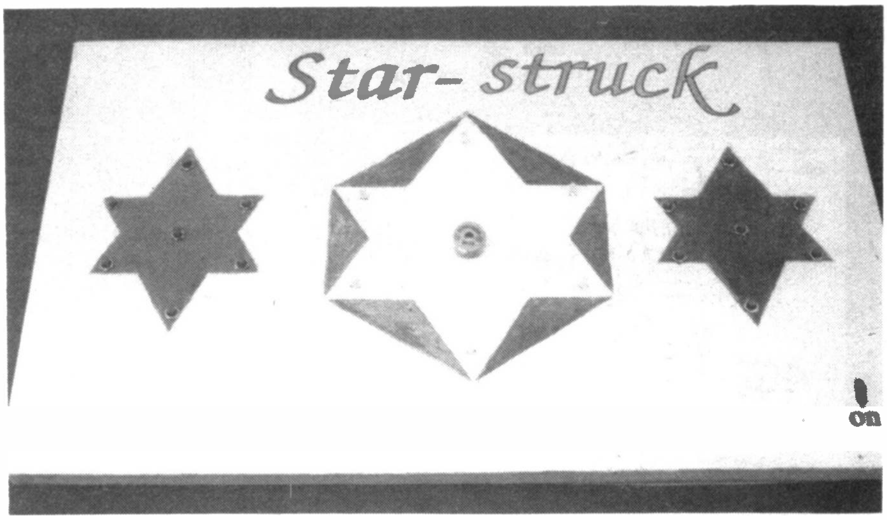
PART 4

THE Name of the Game is a series of electronics projects based on party games or TV quiz games. Featuring something old, something new, there are electronic versions of popular, well-established TV games such as *Countdown* and *Catchword* with alphanumeric displays, new games employing electronic word-making, and games of skill.

In the final part this month, we aim for the stars with both Star-Struck! and Six-Shot Light Zapper, and find hidden attraction with a touch of wander-lust.

IN this game, a large star displaying six tri-colour light emitting diodes (l.e.d.s) at its points is mounted on a board. To its sides are two smaller stars, one painted red and one painted green. The smaller stars are the targets and their six points are fitted with pushbutton switches.

Initially, the central star displays three red l.e.d.s and three green ones. During play, the red and green contestants stand in front of the board and simultaneously throw soft rubber balls at the pushbuttons of their star. As each switch is hit, the l.e.d. at the same point on the large star changes colour according to which star has been struck. The aim is to make all six l.e.d.s change to the same colour: a red team contestant aims to get an all-red star, and his green opponent aims to get an all-green one.



BATTLE STABLES

The tri-colour l.e.d.s are activated by six bistable (flip-flop) circuits, which can be reset by a central pushbutton switch on each of the target stars to display three red l.e.d.s and three green ones. This switch also offers a bonus target during play to enable a player to recapture three l.e.d.s at once.

In the heat of battle, it may not be obvious when one player has succeeded in turning all six l.e.d.s on to the same colour, especially if one (or more) of the l.e.d.s is almost immediately reversed by the opponent. A useful addition is an optional "six-light indicator" buzzer circuit, which sounds immediately l.e.d.s are displayed as either all red or all green. The buzzer signals the end of the round, or the end of the game if there are only two contestants.

As seen in Fig. 1, the Star-Struck! circuit mainly consists of the six identical bistable multivibrators, or flip-flops as they are commonly called. As the name implies, a bistable has two stable but opposite output states: when one output is high, the other is low and vice versa. Each time a bistable is suitably triggered, its outputs change to their opposite states.

For the purposes of this game, two switches are used to trigger each bistable, and a tri-colour l.e.d. indicates its output states. Although bi-colour l.e.d.s are available, in this circuit the author found that tri-colour l.e.d.s were easier to use because of their common cathodes. The author also preferred to use flip-flops designed around transistors rather than using integrated circuit flip-flops. (Designer's "spares" boxes often have discrete components which can be used in place of more sophisticated devices!)

FLIPPING FLOPS

Taking the circuit formed around transistors TR1, TR2, and their associated components as an example, the operation of a transistorised flip-flop is as follows: At power switch-on, depending on circuit parameters, component tolerances etc., one of the transistors will switch on in preference to the other. If TR1 is on, current from resistor R1 flows from its collector (c) to its emitter (e) and then through the "red" anode (a) to the cathode (k) of l.e.d. D1, so turning it on.

The collector of TR1 is connected via resistor R2 to the base (b) of TR2. Thus, when the collector of TR1 is low so too is the base of TR2, consequently the latter transistor is held off, and its associated l.e.d. D1 "green" is inactive. In this stable state of the flip-flop, pressing switch S8, which takes the base of TR2 to the 0V line, will have no effect as the base is already low.

Pressing switch S1, however, will now take the base of TR1 low, so switching off this transistor. As a result, l.e.d. D1 (red) is turned off. The collector of transistor TR1 is now held high and current passes via resistors R1 and R2 to the base of TR2, so turning on both it and its associated l.e.d. D1 (green).

The operation of the other five flip-flops (TR3/TR4, TR5/TR6, TR7/TR8, TR9/TR10 and TR11/TR12) is basically identical to that of flip-flop TR1/TR2. The three flip-flops around TR1 to TR6 are considered as "Green's" flip-flops, whilst "Red's" are those around TR7 to TR12. Both groups of flip-flops can be reset to their "home" colours by switches S7 and S14 respectively.

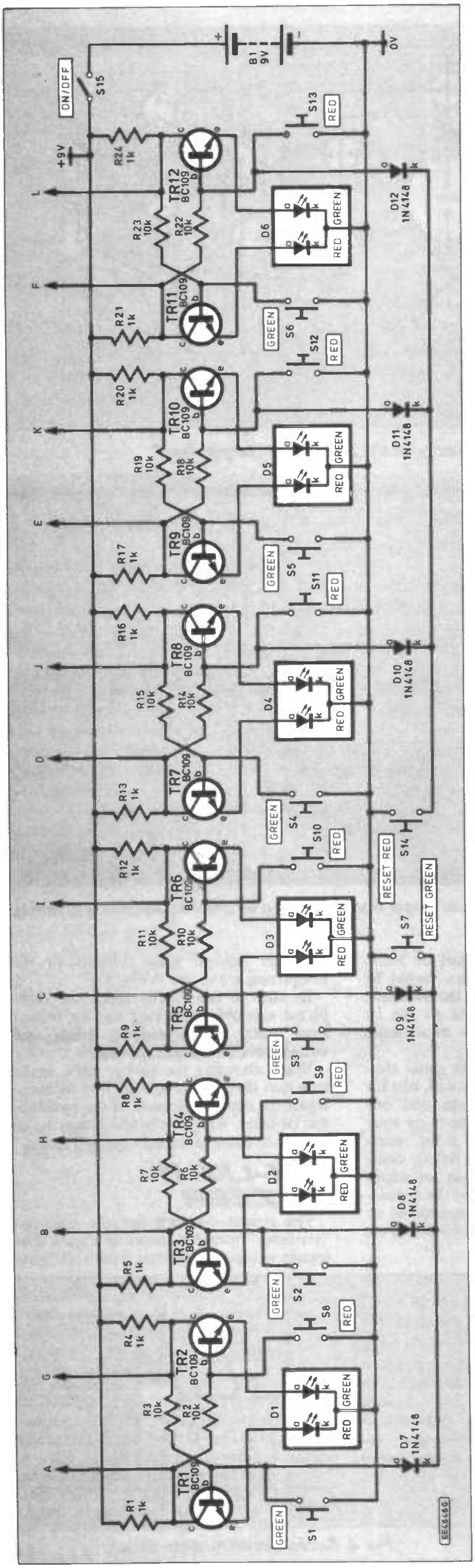


Fig. 1. Circuit diagram for the six flip-flop stages of the Star-Struck! game.

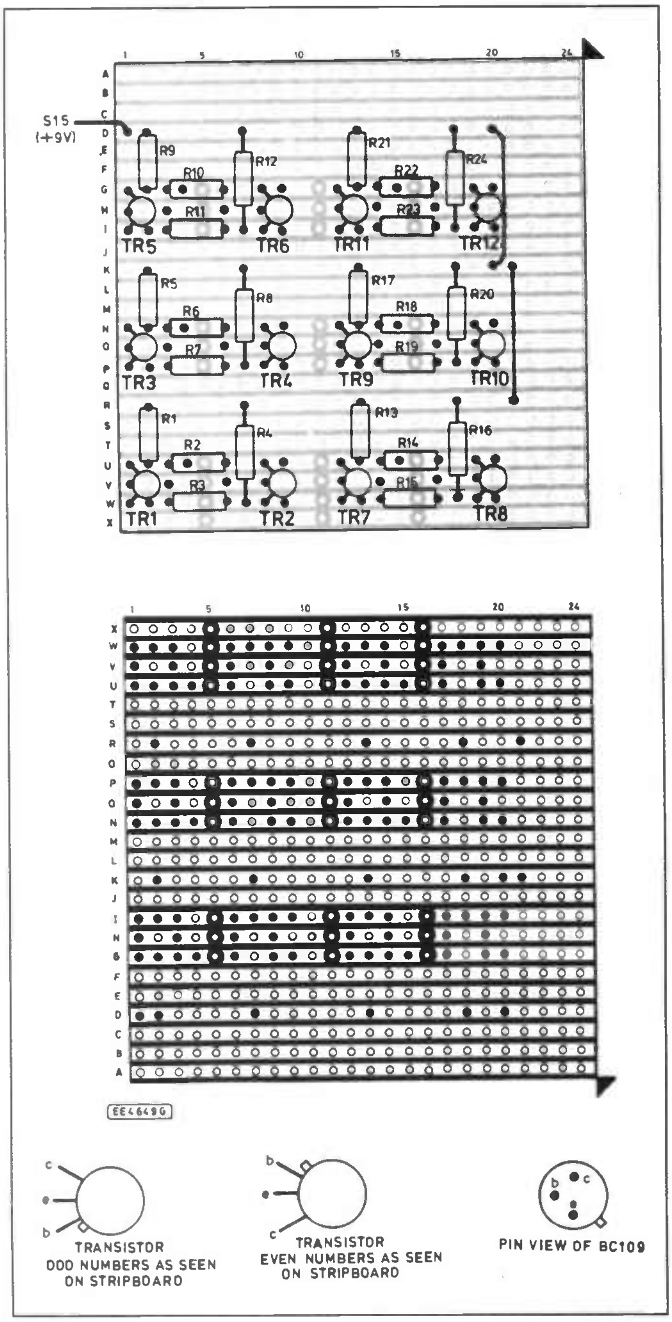
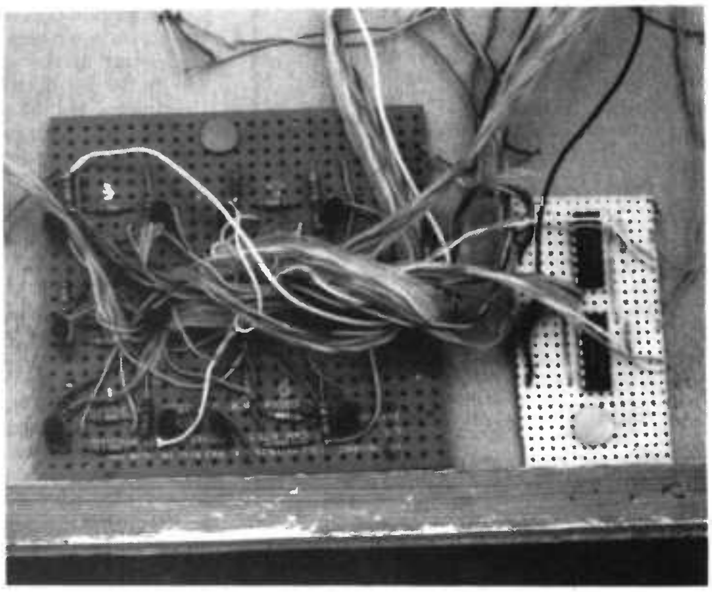


Fig. 2. Topside component layout and underside stripboard track cuts and solder joints for the Star-Struck! game.



Assembled stripboard modules for Star-Struck! and its opptional buzzer circuit mounted on the back of the target board.

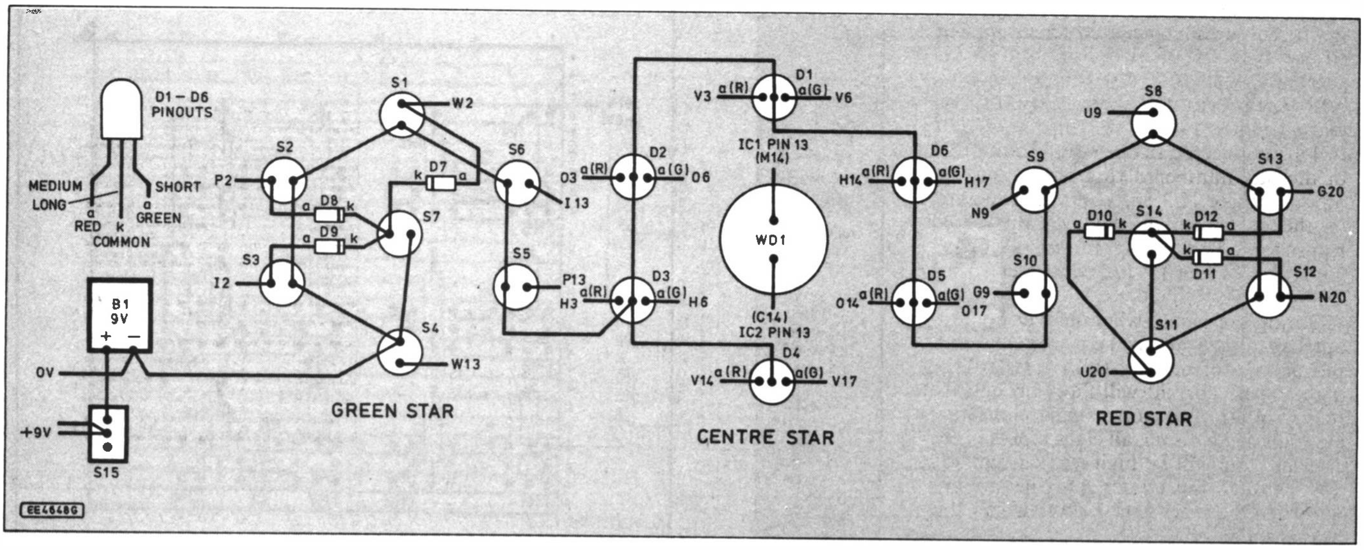
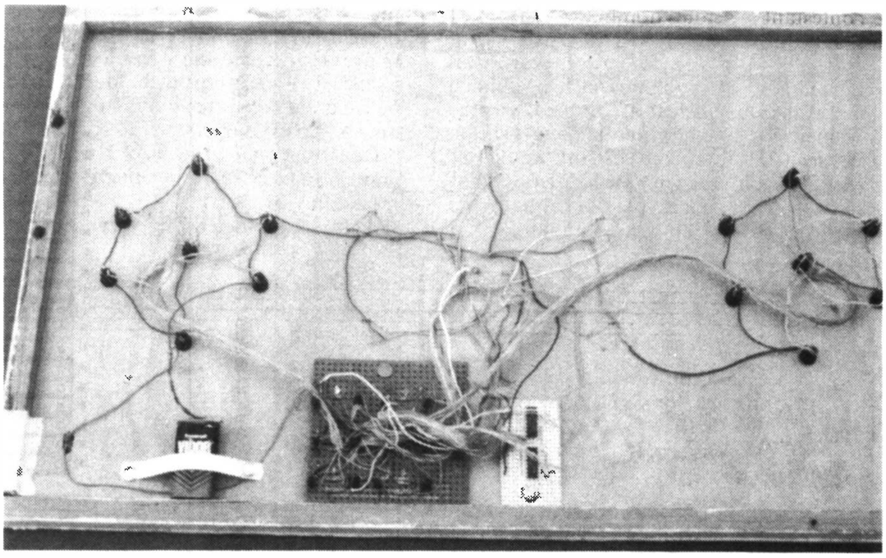


Fig. 3. Wiring details for the components mounted directly on the Star-Struck! target board.

Pressing the "*Reset Green*" switch S7 takes to ground the bases of TR1, TR3 and TR5, via diodes D7, D8 and D9. This action bypasses switches S1, S2 and S3 but has a similar effect to pressing all three together, causing the three flip-flops to switch to the state in which the green l.e.d.s of D1, D2 and D3 are turned on. Pressing the "*Reset Red*" switch S14 has a similar effect on the other three flip-flops, turning on the red l.e.d.s of D4, D5 and D6.

STARRING CONSTRUCTION

The Star-Struck! game was built on a sheet of 3-ply plywood measuring 15in. × 24in. (381mm × 610mm), but the base material and its size can be varied according to individual requirements. For stability, and to protect the components behind it, the board was edged by 5/8in. (16mm) square battens. Holes should be drilled in the board to suit the switches, l.e.d.s and the buzzer. The l.e.d.s can be mounted via a row of three small holes drilled for their lead-out wires.



Rear view of the Star-Struck! target board showing all the components and wiring in their relative positions.

The author constructed his game electronics on two pieces of stripboard, one for the circuit of the six flip-flops and one for the buzzer circuit. The flip-flops were constructed on a piece of 0·1in. pitch stripboard (24 strips × 24 holes), component layout assembly details for which are shown in Fig. 2. Note that the transistors need their pins to be re-orientated so that they correspond with the notations on the stripboard layout.

INTER-STELLAR

Connections between the l.e.d.s and the pushbutton switches of the stars are best made using rigid wire which, providing care in positioning it is observed, need not be insulated. Connections back to the stripboard should then be made using stranded and insulated flexible wires. Details of the interwiring are shown in Fig. 3.

Be sure to thoroughly check the completed assemblies, looking out for missed track cuts, badly soldered joints and wrongly orientated components.

When choosing the rubber balls, make sure that they are sufficiently firm to counteract the contact pressure of the pushbutton switches. Avoid balls which may be so hard as to damage the switches and l.e.d.s.

SIX-LIGHT BUZZER

The circuit diagram for the optional "six-light" buzzer is shown in Fig. 4. The circuit is used to announce that all lights

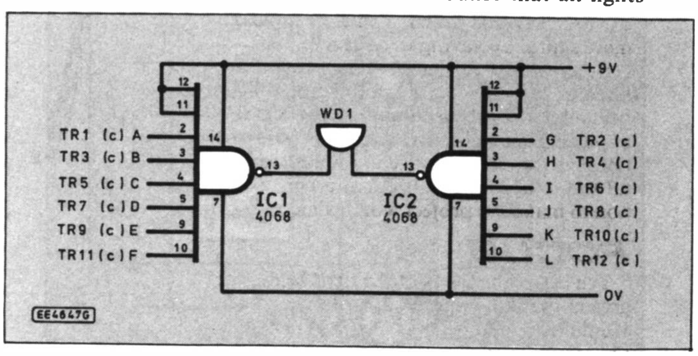


Fig. 4. Buzzer circuit for Star-Struck!

COMPONENTS

STAR STRUCK! See SHOP TALK Page

Resistors
R1, R4, R5, R8, R9, R12, R13, R16, R17, R20, R21, R24 — 1k (12 off)
R2, R3, R6, R7, R10, R11, R14, R15, R18, R19, R22, R23 — 10k (12 off)
All 0.25W 5% carbon film.

Semiconductors
D1 to D6 — l.e.d., tri-colour (6 off)
D7 to D12 — 1N4148 signal diode (6 off)
TR1 to TR12 — BC109 or similar *npn* transistor (12 off)
IC1, IC2 — 4068B 8-input NAND gate (2 off) (see text)

Miscellaneous
S1 to S14 — s.p. push-to-make switches (14 off – see text)
S15 — s.p.s.t. min. toggle switch
WD1 — piezo buzzer (see text)
Stripboard 0·1in. pitch (see text); plywood panel (see text); wood battens for frame (see text); R6 size 1·5V cells (6 off) and battery box; single-core and stranded connecting wire; solder, etc.

Approx cost guidance only **£18** *excl. wood* of one colour have been switched on. The circuit consists of two 8-input NAND gates, IC1 and IC2, one for each colour, both feeding to the same non-polarised piezo sounder, WD1. Six inputs of gate IC1 are connected to each of the collectors of the odd-numbered transistors, and six inputs of gate IC2 are connected to each of the collectors of the even-numbered transistors. The two spare inputs of each gate (pins 11 and 12) are connected to the +9V line.

During the game, when neither contestant has gained all six l.e.d.s *on*, the output pins 13 of both NAND gates will be high and no current will flow through the buzzer WD1. As soon as one contestant gains all six l.e.d.s *on*, all eight inputs of the relevant gate will be high and current will flow through the buzzer into the still-low output of the other gate. Consequently, the buzzer will buzz!

Usually, when the buzzer sounds the display will immediately show which contestant's colour dominates. In a fast moving game, though, it is possible that balls may continue to hit the switches immediately after the buzzer has sounded and it may be unclear as who really is the winner. To avoid potential aggravation between players, the circuit could be modified so that each gate is fitted with its own buzzer, each possibly having a different tone, or being mounted far enough apart so that direction will verify the winner's identity. In this case one lead of each buzzer is connected to pin 13 of its relevant gate, and the other lead is taken to the +9V line. This technique may also be used if readers have difficulty locating non-polarised buzzers.

Construction of the buzzer circuit was made on a piece of 0·1inch pitch stripboard measuring 20 strips × 15 holes. The assembly layout details for this board are shown in Fig. 5. Both circuits may, of course, be assembled on a single piece of stripboard. Be sure, though, to cut the tracks between the two circuits.

It is preferable that sockets should be used for the two CMOS NAND gates, IC1 and IC2. The current consumption of the piezo sounder WD1 should not exceed 10mA, the maximum output current available from the CMOS 4068 NAND gates.

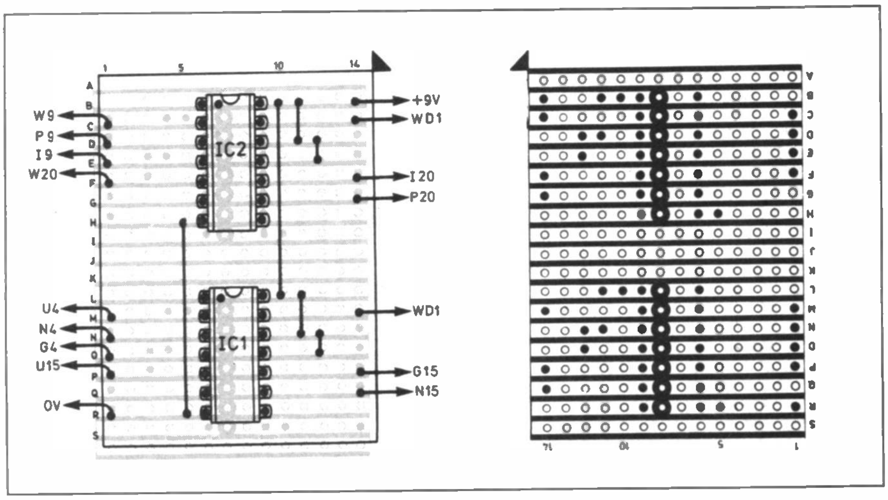


Fig. 5. Stripboard assembly details for the Star-Struck! buzzer circuit.

SIX-SHOT LIGHT ZAPPER

Throwing light on the war-games count-down.

THIS project is basically a light gun that can be used for games either having light-dependent resistors (l.d.r.s) as targets or that can be adapted for them. For instance, the Star-Struck! project previously described could be easily modified to use l.d.r.s instead of the pushbutton targets; i.e. the targets would be "beamed" instead of "struck". In this case, because of the spread of the light beam, it would be better to space out the l.d.r.s to make the game more skilful by having to re-aim.

Other ideas for using this zapper are referred to later. The idea of aiming a light beam to fire at a target is particularly appealing as light rays travel in straight lines. However, there are a few fundamental technical points to take into consideration to make the project worthwhile.

FOCUS

The better the focus of the light beam, the greater the skill required to strike the target. If a diffused light beam is used to direct on to the target l.d.r. then the intensity may not be sufficient to activate whatever sensor is

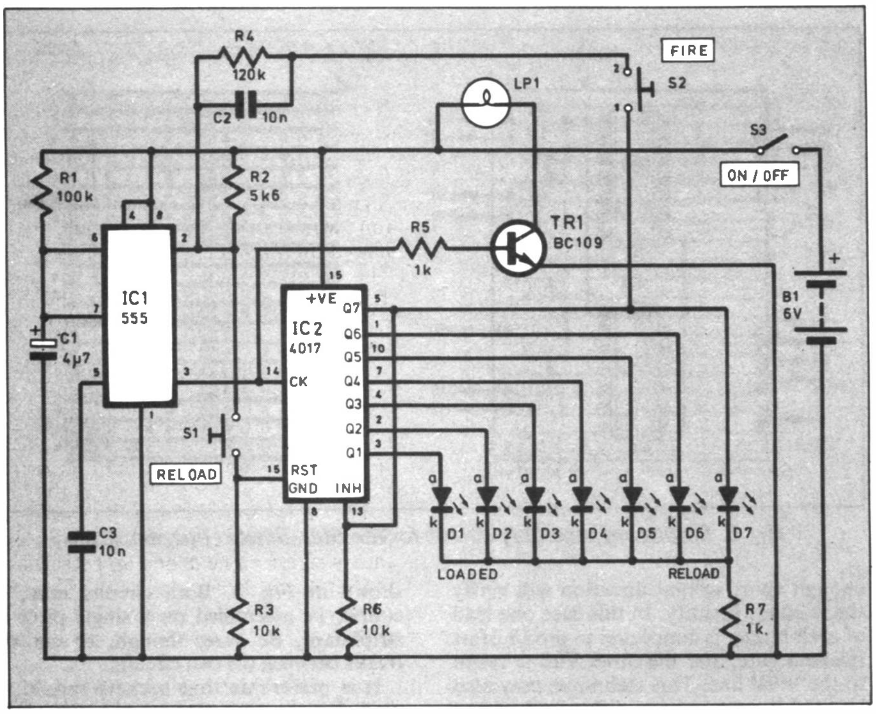


Fig. 1. Circuit diagram details for the Six-Shot Light Zapper.

COMPONENTS

LIGHT ZAPPER – MAIN UNIT

Resistors — **See SHOP TALK Page**

R1	100k
R2	5k6
R3, R6	10k (2 off)
R4	120k
R5, R7	1k (2 off)

All 0.25W 5% carbon film.

Capacitors

C1	4μ7 axial elect. 10V
C2	10n disc ceramic

Semiconductors

TR1	BC109 *n.p.n.* transistor
D1	l.e.d. yellow 3mm or 5mm
D2 to D7	l.e.d. red 3mm or 5mm (6 off)
IC1	555 timer
IC2	4017BE decade counter/divider

Miscellaneous

S1, S2 s.p. push-make switch (2 off)
S3 s.p.s.t. min. toggle switch
Plastic box to suit torch used (see text), 6V torch assembly (see text); stripboard 0.1 inch pitch (11 strips x 25 holes); 6V battery; connecting wire, solder, etc.

Approx cost guidance only **£10**
excl/ torch and case

used, e.g. to trigger the bistable in the Star-Struck! project. Also, as less skill is required the game will lose its appeal. A suitable lens is therefore essential to narrow the beam of light. The easiest way is probably to press into service an old spotlight torch, just using its bulb and lens holder.

TRIGGERED LOADING

In the interests of skill, it is important that the trigger action is controlled. Using an ordinary torch as a light gun has other drawbacks as well as its diffused area of light. After switching on, it is all too easy to locate the target by using the beam to correct the angle – what might be called "spraying the target".

For this reason, when triggered the light gun should ideally give one flash for a fixed period independent of the length of time for which the trigger is pressed. The light gun described here gives a fixed flash of about 0·5 seconds, but the circuit parameters can be changed to suit individual requirements. If you're a John Wayne and quick on the trigger, then split-second timing is a must!

To make the game competitive all marksmen and markswomen need to have the same number of "shots in their lockers", and to hold with tradition, this light gun has been designed as a six-shooter. It gives a visual indication of the number of shots fired and will not fire any more shots after the sixth, unless the *Reload* switch is pressed.

CIRCUIT DIAGRAM

Circuit diagram details for the Six-shot Light Zapper are shown in Fig.1. To obtain six, and only six pulses all of the same length when the light gun is fired, the circuit employs a 555 timer (IC1) in monostable mode and a 4017 decade counter (IC2) limited to seven outputs.

Referring to timer IC1, output pin 3, discharge pin 7 and threshold pin 6 are normally pulled low internally and timing capacitor C1 is held discharged. When the *Fire* pushbutton switch S2 is pressed, logic 0 is applied from IC2 output pin 5 to IC1 input pin 2, and as a result IC1 output pin 3 is triggered high. The monostable is now in its unstable state.

Capacitor C1 now starts to charge up via resistor R1. When C1 has charged to approximately two-thirds of the supply voltage, IC1 pin 6 and pin 7 are triggered low. This discharges C1 again and also sets IC1 output pin 3 to its low state. IC1 has now been returned to its stable state and is ready to receive the next trigger pulse.

The stated values for capacitor C1 and resistor R1 give an output pulse length of about 0.5 seconds. To reduce the pulse length, reduce the value of either, or both, of these components.

Between them, capacitor C2 and resistors R2 and R4 shape the short initial trigger

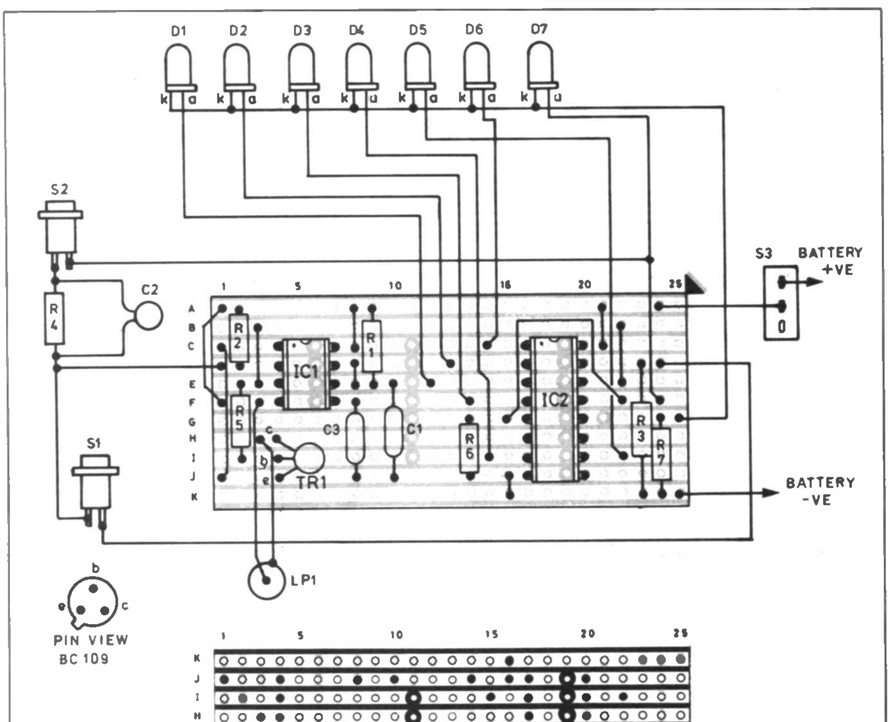
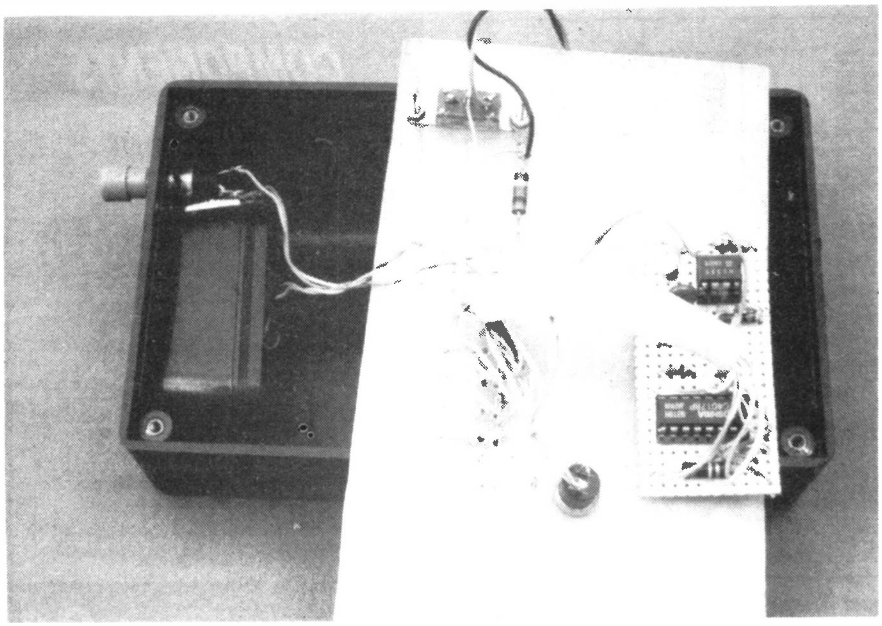


Fig. 2. Stripboard component layout, wiring and track cutting details for the Six-Shot Light Zapper.



Interior detail of the assembled and cased Six-Shot Light Zapper.

pulse required by IC2 when the *Fire* switch S2 is pressed. In this way, the flash has the same duration no matter how long S2 is held down. (The trigger pulse to IC1 must be shorter than the output pulse timing.) Resistor R4 in parallel with C2 provides a discharge path across it, allowing S2 to be rapidly re-fired.

This fixed-length output pulse from IC1 pin 3 serves two purposes: via resistor R5 it provides a "one-shot" base current to transistor TR1, turning it on and so lighting lamp LP1 for the duration of the pulse. Secondly, it triggers decade counter IC2 via its clock input pin 14. Each of the first seven outputs of IC2 is connected to a light emitting diode (l.e.d.), D1 to D7.

Each time the *Fire* switch S2 is pressed, the resulting output pulse from IC1 sequentially triggers high the outputs of IC2 in turn, causing the respective l.e.d. to be switched on. As each output goes high, the preceding one goes low. The display thus advances from D1 (*Loaded* position) through to D7 (*Reload* position). Resistor R7 limits the current through the l.e.d.s.

The *Reload* l.e.d. D7 is turned on by the logic 1 on IC2 output pin 5 when triggered after the sixth shot. Simultaneously, switch S2 pin 1 is held at logic 1 by IC2 pin 5 and so the switch cannot generate a negative-going pulse with which to trigger timer IC1. A further connection is taken from IC2 pin 5 to IC2 clock enable pin 13. The high logic on this pin now holds the counter inhibited and l.e.d. D7 stays on.

Counter IC2 remains inhibited until the *Reload* switch S1 is pressed, an action which connects the +9V rail to IC2 reset pin 15, so resetting the counter to zero. The now-active "zero" output on IC2 pin 3 lights the "*Loaded*" l.e.d. D1 making the circuit ready for the next six shots.

CONSTRUCTION

The circuit is built on a piece of 0·1 inch pitch stripboard which carries IC1, IC2 and their associated components. The layout of the two sides of the stripboard showing components, connections, track cuts and solder points are shown in Fig.2. Normal precautions to protect the i.c.s from static should be observed and d.i.l. sockets for them are recommended. The i.c.s themselves should be fitted last after the wiring and soldering has been thoroughly checked.

With a little ingenuity, the light zapper could look like a futuristic space-gun complete with sights. In the prototype, as shown in the photograph, the bulb-holder and lens of a 6V torch were fitted to one end of a small plastic case. The seven l.e.d.s were mounted in line on the front panel, together with the *On/off* and *Reload* switches, S3 and S1. The *Fire* switch S2 was mounted below the lens at the end of the box, in a convenient position for the trigger finger.

Although the photo shows the case to have a sloped front, in reality, any case shape or size will do provided it can have the torch assembly and small stripboard mounted in it. The layout of the front panel is not critical. The panel can be labelled with rub-down lettering and protected under a clear plastic cover.

The quiescent current is only about 10mA, but the bulb used will dictate the current consumed during the flash period. Suitable 6V m.e.s. bulbs are readily available with a current consumption of only 40mA. The use of a lower voltage bulb is not recommended. The unit should be powered by a 6V battery, preferably a long-life type. It may be powered by a 9V battery if the bulb voltage rating is increased accordingly.

ZAPPING IDEAS

As a suggestion for a game with the Six-Shot Light Zapper, a very simple target could be made by wiring up just one of the "Star-Struck!" project's bistable circuits (see its Fig.1), e.g. TR1, TR2 and associated components. Each of the pushbutton switches S1 and S8 should be replaced by a light dependent resistor (l.d.r.). The l.d.r.s can then be used as targets. To encourage re-aiming, these should be widely spaced either side of a tri-colour l.e.d.

An interesting variation on this idea is to make individual "zapper targets" that can be attached to a gaming participant like a badge. The Aim of the Game, so to speak, is for people in a team to get zapped! For instance, in subdued lighting the Light Zapper can be aimed by a member of one team at the red glows of six opponents, each wearing an l.e.d. and an l.d.r., aiming to change the glows to green (or vice versa). There are endless possibilities, but a suggested circuit for another zapper target is given in Fig.3.

This circuit is a further variation on the Star-Struck! bistable. Here switch S1 is replaced by an l.d.r. (R5), switch S2 is the same as S8 in the original circuit. Tri-colour l.e.d. D1 has its twin anodes (a)

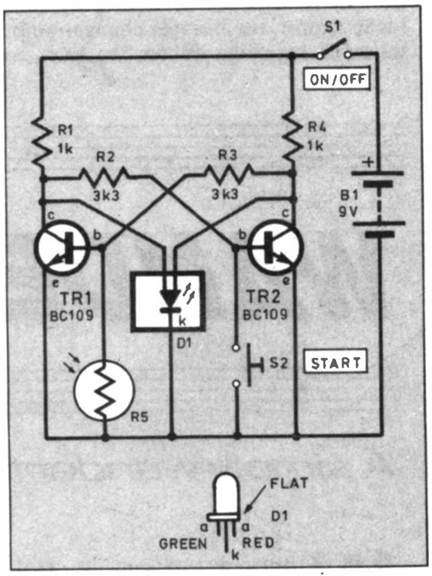
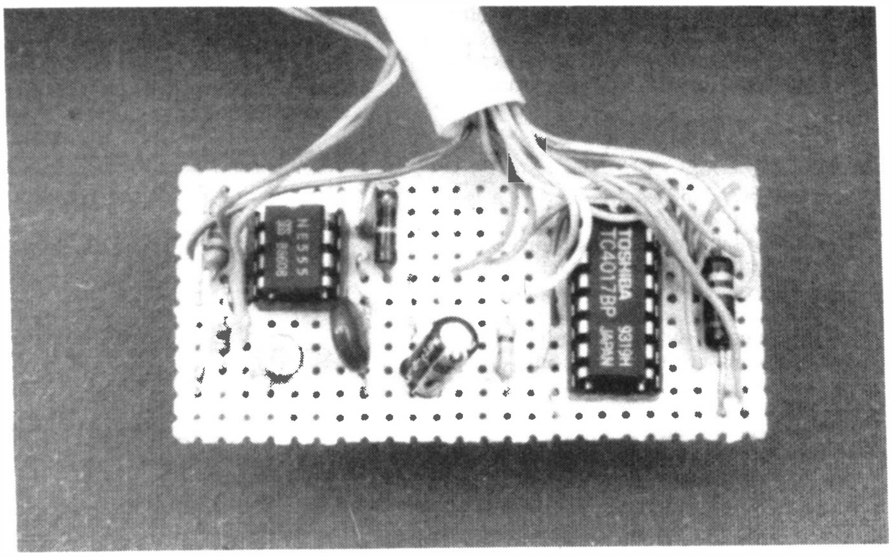


Fig. 3. Suggested circuit for a "Target Badge".



Close-up details of the stripboard assembly of the Six-Shot Light Zapper.

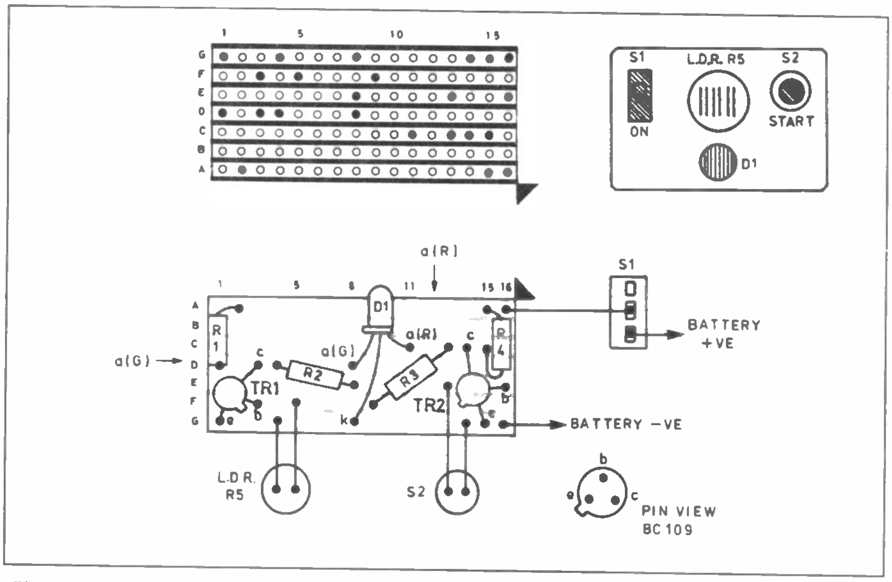


Fig. 4. Stripboard layout details for the "Target Badge" circuit. The inset shows a possible "Badge" layout.

COMPONENTS

TARGET BADGE

Resistors

R1, R4	1k (2 off)	
R2, R3	3k3 (2 off)	
R5	ORP12 (or similar) l.d.r.	

See SHOP TALK Page

Semiconductors

D1	l.e.d. tri-colour
TR1, TR2	BC109 (2 off)

Miscellaneous

S1	s.p.s.t. min. slide switch
S2	s.p. push-make switch

Stripboard 0·1in. pitch (7 strips x 16 holes), rigid badge material (see text).

Approx cost guidance only **£4**

connected respectively to the collectors of transistors TR1 and TR2. As before, the common cathode (k) is grounded.

To start the game, switch S2 is pressed to bring on the red l.e.d. within D1. When l.d.r. R5 is "zapped" by a correctly aimed Light Zapper, the bistable changes output states, so switching off the red l.e.d. and switching on the green one. The starting and "zapping" colours can be changed by swapping over the two anode connections of D1.

The suggested stripboard layout for the small circuit is shown in Fig.4. There are no track cuts required on this board. Be sure to observe the correct polarities of l.e.d. D1 and transistors TR1 and TR2. A suggested "Target Badge" layout and its wiring detail is shown in Fig. 4. The badge can be made from any rigid material sized to your choice. This sub-circuit can be powered by a 9V battery.

WANDER WANDS

A simply wanderful way to keep the party colourful.

WANDER WANDS can be used to "break the ice" at children's parties. No, they are not pick-axes: they look like small white batons which arriving guests will be curious to find out what they are. They serve as a talking point and are something to hold in the hand, but in fact they are much more than that!

WANDERING INSIDE

Each Wander Wand comprises a length of plastic tubing which contains a bi-colour light emitting diode (l.e.d.) at one end, two small batteries, a reed switch, a current limiting resistor, and a permanent magnet. The circuit diagram of the Wander Wand tube is shown in Fig.1. Its equivalent schematic physical layout is shown in Fig.2.

In Fig. 1, resistor R1 limits the current through the bi-colour l.e.d. D1. The stated value for R1, 150 ohms, gives an l.e.d. current of about 20mA. When the magnet of another Wander Wand is held near reed switch S1, the switch contacts close and one of the two l.e.d.s within D1 is turned on. With the battery polarity connected as shown, current will flow through the red l.e.d.

Turning the battery polarity round the other way will cause the current to flow through the green l.e.d. Alternatively, the l.e.d. polarity can be changed at the constructional stage. When the l.e.d. is not energised, it is impossible to tell whether it is connected for a red or a green display.

CONSTRUCTION

The plastic case for the Wander Wand can vary in shape or size, largely depending on the type of batteries used. The author's prototype, which was powered by two AAA-size batteries, was cut from a length of white, half-inch diameter plastic tubing of a type obtainable at most d.i.y. stores.

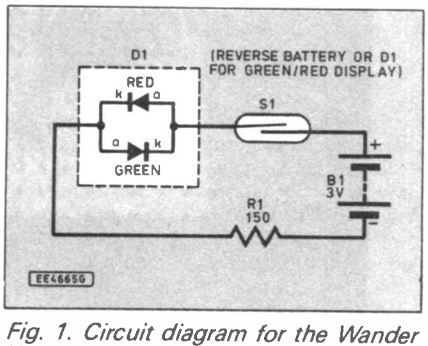


Fig. 1. Circuit diagram for the Wander Wand.

As shown in Fig. 2, the batteries were held under tension from their negative end by a small spring soldered to the point of a drawing pin pushed through a small slice of dowel. Similarly, dowelling and a drawing pin were also used for the positive battery contact.

The AAA-size batteries were a fairly tight fit in the tube, but there was sufficient space for a single length of enamelled copper wire to link the far end of the two batteries via resistor R1 to one side of the l.e.d. The point of the drawing pin, from the positive end of the batteries, was soldered to one terminal of the reed switch. The other reed switch terminal was soldered to the other side of the l.e.d.

The two legs of the l.e.d. were fed through two small holes drilled in another piece of dowel, which was a push-fit in the end of the tube. Finally, a small bar magnet was located in the other end and secured by a fourth piece of dowel.

COMPONENTS

WANDER WAND

See **SHOP TALK** Page

Resistor
R1 150Ω 0·25W 5% carbon film

Semiconductor
D1 l.e.d. bi-colour (red/green)

Miscellaneous
S1 reed switch
Battery, AAA-size (2 off); plastic tube (see text); dowelling; small spring; drawing pin (2 off); small bar magnet; connecting wire; solder etc.

Approx cost guidance only **£3** excl. batteries

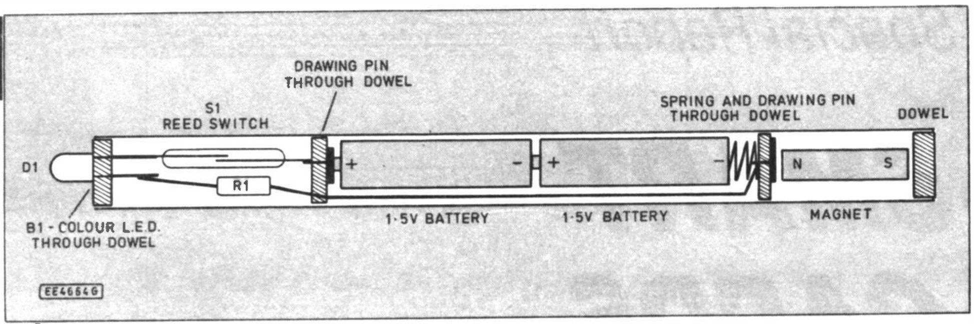


Fig. 2. How the Wander Wand components are assembled inside the tube.

WAYS WITH WANDS

There are countless ways in which the Wander Wands can be used. Here are some of the more obvious ones:

On arrival, guests can be armed with a wand and first of all establish to which team colour they belong: touch the l.e.d. (reed switch) end of one wand against the magnet end of another wand and it will glow either red or green, as appropriate. Wands can also be used as batons in team games and relay races, e.g. a baton must first be made to glow before the next team member can proceed.

Charts or lists of questions placed around the room are useful as party starters, e.g. magazine clippings of famous personalities to identify, adverts to recognise, etc. These can have a magnet secreted somewhere behind them: point to the right answer and the wand will glow to score a point for that team colour.

A quiz board could even have its own indicator display, using the same circuit as shown in Fig. 1. In this case, the magnet end of the wand would be used to activate the reed switch, or switches if several circuits are used.

A firm favourite at parties is searching for treasure on a large map. Small magnets can be secreted behind the map at strategic places. Copies of the treasure map can be distributed with clues to help players search out and sense these hidden magnets. An adult can keep a tally of the number of green or red wands activated when the treasure is located.

No doubt other games with Wander Wands will come to mind once several have been built. □

Ohm Sweet Ohm

Max Fidling

Plumb Crazy

Being a bit of a do-it-yourselfer, there's not much in the Fidling household which has escaped the attention of my handyman activities. Not content with my multi-purpose screwdriver set which has seen me through many a scrape, I recently added a set of pliers and wire cutters which I spotted on a market stall.

I think it was possibly the colour of the hot-dipped plastic handles which most attracted me to them, since I like to colour co-ordinate everything like the professionals do, and generally impress my friends. If they do actually "ply" or cut wire, then that's a bit of a bonus as far as I'm concerned! As I was to discover, much to my dismay, they neither plied nor cut . . . I'd hoped for much better at £1.49 the pair.

One spring morning I happened to be ferreting around in the attic, in the general vicinity of the cold water tank. Strange rusty-looking ring-like patterns had started to appear in the freshly applied white emulsion of the ceiling down below, and I had been summoned to investigate. If I hadn't recently painted the ceiling, I pondered, it would probably not have happened, and obviously my five litres of vinyl silk had tempted fate too far.

The attic is the one place I know where Piddles won't enter (pity, because we have a mouse or two and so the moggie could do some good for a change) so he was sat at the bottom of the step ladder peering up into the loft entrance and waiting for events to unfurl.

Staring through the gloom using my faltering plastic torch, I soon saw the problem – the water tank's level had risen too far and so it had started to drain through the overflow pipe. This pipe had recently been refitted by yours truly after I thought I would try my hand at plumbing. No problem except that sadly, the overflow itself had, er, a slight gap where I'd joined it to another pipe, and so water was dribbling out and ruining the ceiling below!

Back at the workshop, I started thumbing through my comprehensive library of ancient electronics magazines, looking for inspiration. I had in mind a water level alarm or moisture detector which could warn me when the water tank level was getting too high.

Not the most earth-shattering application of electronics, but one which even I should be able to implement without doing too much damage! Anyway, having repaired the paintwork I was still in "hot water" with the Boss so I needed to make a few smart moves, so eventually I designed a simple unit which was a conglomeration of several published designs.

A foot too far

I'd pressed a 555 timer chip into service, since I always had these littered around the place. Using an old telephone earpiece as a loudspeaker, an audio oscillator was soon soldered together on some stripboard, running from some old pen-cell batteries. Add a transistor switch and two old wire coat hangers with a terminal block, and voila!

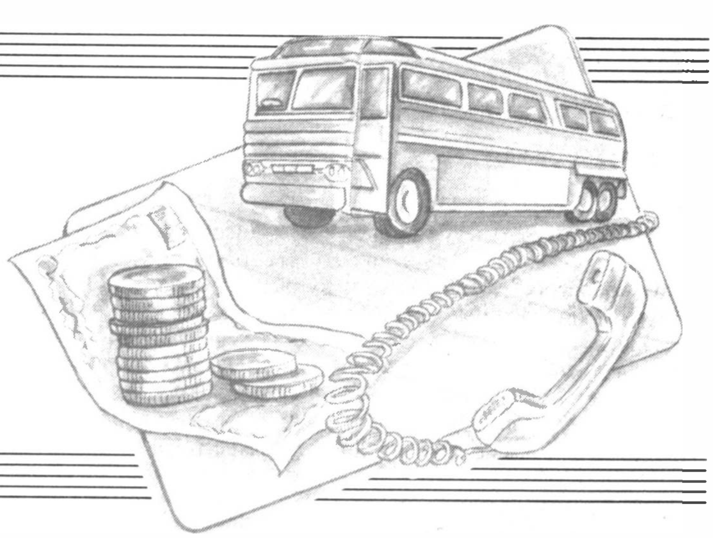
When the two coat hangers were dipped into water, a mechanical hum emanated from the earpiece, not dissimilar to a G.P.O. dialling tone, actually. It wasn't quite loud enough, so I adopted plan B which was to jack up the supply voltage until either something blew up or threshold of pain sound level was reached, whichever came first . . .

Piddles accompanied me back to the step ladder and I clambered up into the attic, carrying my latest brainchild, with its battery hanging loosely on the end of a PP3 clip. I perched precariously astride two rafters, and started to beaver away happily, humming a tune. Unfortunately, the wire coat hanger "probes" proved too long and so I needed to bend them to shape and shorten them to just-above-water level.

Looking in my toolbox, my eyes lighted on my new chromium-plated Pliers & Wire Cutter Set ("Qty. # 2 pcs.", as it said on the pack) so now would be the acid test. Grabbing the wire cutters, I set about the wire coat hangers gleefully, with all the skill of an electronics hobbyist who's also not very good at plumbing.

Much to my dismay, the quality of the old wire coat hangers seemed to excel that of the wire cutters, as one jaw pinged off, ricocheted off the wooden roof beams and plopped into the water tank! This rather caught me by surprise and I pirouetted deftly before temporarily losing my balance – worse was yet to come as I accidentally raised one foot and shoved it straight through the newly re-painted ceiling below! Now I really was in deep water! Typically, through the gaping hole I could see a certain cat peering up at me, tail swishing and looking not at all surprised.

SMART CARDS



BARRY FOX

What they are, how they work, where they are going, are they secure? Before long most of us will be using Smart Cards of one type or another, in this feature Barry looks at the present and future Smart Card scene paying particular attention to security.

THE Smart Card or cashless society is coming. Westminster Bank is testing Mondex, a system that replaces traditional magnetic stripe credit cards with an electronic purse that looks like a stripe card but incorporates a microprocessor chip and memory to store and process cash data.

Shell petrol stations have stopped giving drivers paper tokens for Air Miles (without telling us how to convert them into travel) and are now giving us smart cards which store electronic Air Miles (unfortunately still without telling us what exactly to do with them). The government's plans for health and idendity cards all rely on smart card technology.

Smart Move

British Telecom will soon start converting all its payphones from optical to smart card working. This is a massive commitment. BT introduced the optical phonecard in 1981 and now has a network of 35,000 card phones. "We have taken the technology as far as we can go", says Les King of BT. "Moving to smart card technology gives us freedom for future development".

All existing optical card phones will be replaced with smart card readers and new payphones will be designed to read smart cards as well as credit cards. The cards will not be rechargeable and BT has "no plans yet" to collect old cards and recycle them.

The new phone cards will cost customers the same as existing cards even though it is far more expensive to produce smart cards than optical cards. But the volume in which BT will buy smart cards (from Gemplus and GPT) to sell through 50,000 retail outlets across the UK, will drive the manufacturing costs down to similar levels.

Magnetic cards will not disappear overnight, but they are likely to be used only where the data is secured by a magnetic watermark or vetted by online checking every time the card is used. For added security the two technologies may be combined.

All this paves the way for a cashless society, where electronic credits are transferred instead of cash. Because smart cards have a far greater memory capacity than magnetic cards, an "electronic purse" can double as an identity card. Inevitably there will be objections from those who see it as an intrusion into personal liberty and privacy. Criminals will see it as an opportunity to earn even more from fraud. For hackers the smart card society represents a new challenge.

To get a handle on the debate, it pays to understand the technologies involved.

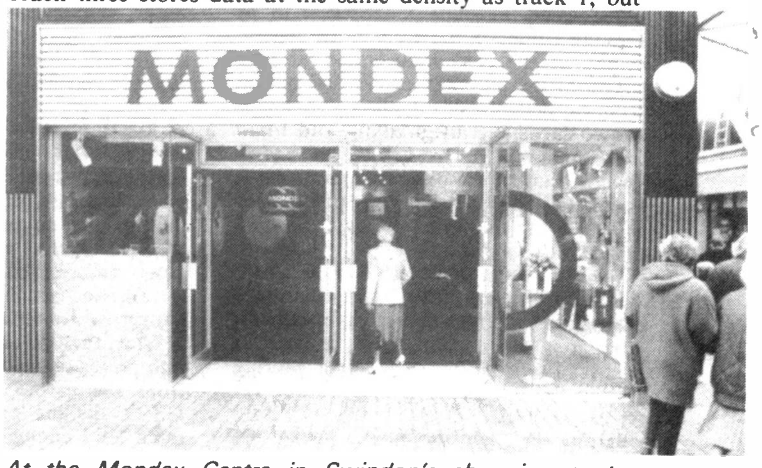
The use of plastic cards as a replacement for cash dates back to the early 50s when the Diners' Club and American Express Company in the US started to issue members with cards which vouched for their creditworthiness. European banks started issuing cards in the 60s, with Barclaycard and Visa from Barclays, and Access from Lloyds, National Westminster and the Midland banks.

The banks then started installing ATMs (automatic teller machines), popularly known as "hole-in-the-wall" cash dispensers. This followed a technical specification set by ISO the International Organisation for Standardisation (this is correct full name, not International Standards Organisation). The ISO 7810 series of standards ensure that any card with a magnetic stripe can physically be read by any check-out till or ATM, anywhere in the world.

Security

The banks have traditionally refused to discuss any aspect of security, on the grounds that it helps criminals. But with even the bankers' own trade body, the Association for Payment Clearing Services (APACS), generating publicity for the wildfire spread of card fraud, it is clear that criminals already know all they need to know about card technology. Prisoners in jail pass on the secrets, and at least one DIY manual on card fraud has been circulated. The banks are now reluctant to discuss security because they do not want to trigger a rush of claims from customers who say they have lost money through technology loopholes.

The stripe on a magnetic card is divided into three parallel tracks, like a three channel stereo sound recording. Tracks one and two contain data, written or pre-recorded on the card prior to issue. The data on track one is more tightly packed (at 210 bits/inch) than the data on track two (at 75 bits/inch). Track three stores data at the same density as track 1, but



At the Mondex Centre in Swindon's shopping centre, cardholders can transfer funds from their bank account directly "into" their Mondex card using special BT phones.

allows the card reader to record data on the card as well as read it.

The banks use mainly track two, which is in the centre of the stripe. Track three is used to carry a number which checks against the personal identification number or PIN, which only the legitimate owner of the card should know. Critics of bank security argue that up until two years ago, it was possible for anyone with expert knowledge, for instance an ex-bank employee, to decode the PIN from a stolen card (much as it is possible to decode a driver's sex and birth date from the innocent-looking number a the top of their driving licence) and then use the PIN IT to draw cash from an ATM.

The banks' formal line is that this is, and always has been, impossible, and that there has never been sufficient code on a card to allow extraction of the *full* PIN. The banks claim that the PIN can only be derived from data which is securely stored by the bank.

Although some members of staff will have access to PIN data, the banks' policy is to restrict the number of staff with access to a carefully selected few. The source of any breach of security can immediately be narrowed to a very small group of employees. The theory then is that this group will work together to identify any one of their members who has stolen data.

But critics say that service engineers working with ATMs, and system progammers working on the bank's computers, may have access to PIN data.

Skim Head

Because all magnetic cards follow the ISO standard, anyone can easily obtain blanks. They are given away by Supermarkets and Petrol Stations, for customer loyalty schemes. Any data on the card is just wiped off with an ordinary magnet. Criminals can then buy the card readers and writers which are sold for legitimate business use.

It is not even necessary to know how to decode a PIN from supposedly secret data. An expert witness in a recent card fraud case told a Court in Suffolk how he had personally manufactured a card, using data obtained from a discarded ATM transaction slip and a PIN observed over the card owner's shoulders.

Although many ATMs have now stopped printing out card details, fraudsters have in the past used binoculars to collect PINs, and then matched them by time of transaction to discarded slips. More recently criminals have stolen PINs at mock auctions, by persuading cardholders to swipe them through a reader, and enter their PINs into a keypad with hidden memory.

There are also several ways to transfer owner identification data from a borrowed or stolen card to a blank. If two magnetic tapes are sandwiched together and pressed with a hot iron, the magnetic pattern on one will transfer to the other. But the more elegant solution is to use a device called a "skimmer" which any electronics enthusiast can build from standard components, costing only a few pounds.

A skimmer has two magnetic heads, like those in a tape recorder. One head can read the magnetic field from a card and the other can generate a magnetic field and so write to a card. The two heads are connected together by an amplifier.

Two cards, one original and one blank, are laid side-by-side on the surface of the skimmer and then by hand moved as a pair over the two heads. As the read head picks up data from the original card, the record head writes it to the blank card. Skimming a card takes literally seconds, and produces a perfect copy of the original.

Audit Trail

There is no need for today's cards to be so insecure. The ISO standard allows for the reader to write to the third track and so record a code which identifies the last ATM at which the card was used. When the card is next used, this code is read by the ATM before a new code is written. This gives the bank the chance to build an audit trail of where a card has been used and should thus let the bank know immediately whether disputed transactions have been made by a customer's own card, or a skimmed copy.

The banks have been cagey about discussing this valuable security check. One explanation could be that the audit trail will in some cases prove that the bank's security has been breached; another is that some banks have been slow to invest in the system modifications needed to exploit the track three write option.

Although Mercury uses magnetic cards for its payphones, a clever system of on-line checking stops people playing the obvious trick and using a skimmer to add new units to an expired card. When the caller puts a card in a Mercury payphone, the system checks its previous usage with an on-line database, and rejects any card that has mysteriously increased in value instead of decreasing. A similar system could, if the banks wished to implement it, sound an alarm as soon as anyone tried to use a stolen card in an ATM.

Hot Number

Although the banks have now tried to make cards more secure by embossing a hologram patch in the surface, enterprising criminals have now found a way round this trick too. They collect stolen cards and use heat or solvents to flatten out the embossed details of the legitimate owner. Then they use an embossing tool to imprint details of a new owner. These details are readily available from credit card transaction slip copies and carbons which owners discard or which restaurants and shops throw in their dustbins.

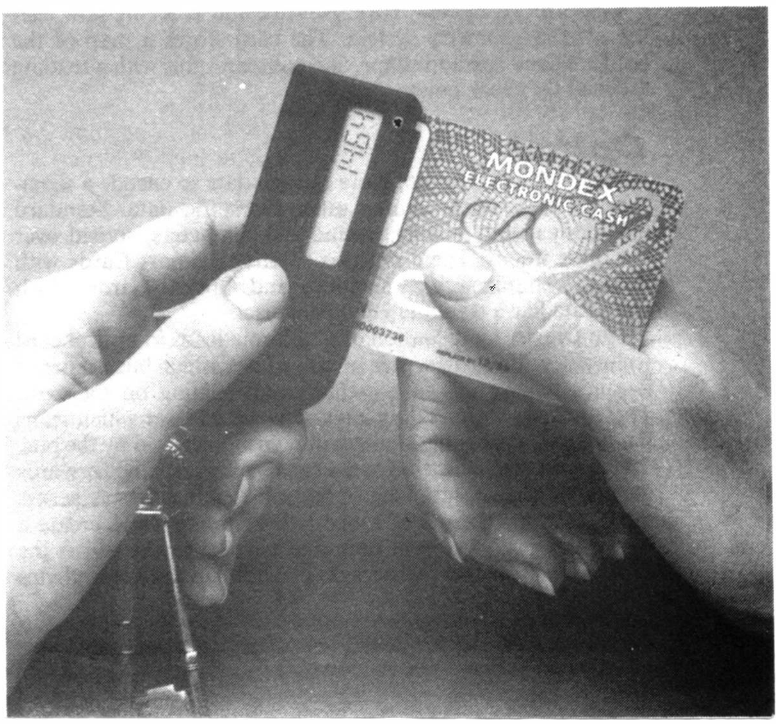
Criminals without their own embossing tools can now simply telephone orders to the new wave of copy shops in the Far East which make cards to order. The legitimate card owner only finds out that their card has been copied when they get their next bill.

These cards need not even have valid magnetic data in their stripes. The magnetic stripe on legitimate cards often wears, or becomes de-magnetized, so staff in shops and restaurants are not surprised to find that some customers' cards refuse to work in a reader. Even if they phone for approval, the embossed details on the card will be correct so the transaction will be authorised.

In the early 90s APACS had found that 75 per cent of all card fraud was taking place at the point of sale. Criminals do not waste time buying groceries, or cinema tickets, with stolen cards, they use them to buy VCRs, camcorders and computers which can quickly be re-sold for cash.

One trick is to swipe a stolen card through a credit card payphone and see if it is accepted. If it is, then the card is not yet registered as "hot" and can safely be used in a shop. A new variation on this trick is for people who run shady premium service phone lines (like sex lines) to run up bills on stolen cards by dialing the service and leave the phone off the hook. BT then has to pay the service a percentage of the charged amount.

The pocket size Mondex card reader.



Cardowners are often their own worst enemies. When choosing a PIN, people take a simple number, like a birthdate, to make it easier to remember. The first thing a thief with a stolen wallet does is look for a note of the owners's birthday and try it with any credit cards. Some cardholders choose a long number but then, because they cannot remember it, write it on a piece of paper in the same wallet, or even the back of the card.

Two years ago, at a conference organised by trade body the Radio, Electrical and Television Retailers Association, John Carnegie-Brown, of Barclays Merchant Services, told dealers "The cost of putting photographs on cards is greater than the fraud it eliminates. We do not feel we can cope with it at this time". But TSB and The Royal Bank of Scotland think it is worthwhile and have now been using photo-cards.

Biometric Technique

The major banks are more interested in biometric techniques. The card stores a template which it checks against the carrier. In its simplest form this template can be a passport photograph, which is checked against a video image shot at the checkpoint.

Every human eye has a characteristic pattern of blood vessels in the retina. The card can store a map of this pattern which is checked by asking the cardholder to peer into the lens on a video camera at the check point. Although suitable for the military, eye checks at the Supermarket would not be popular.

The card can also store a voice print, which logs the frequency content of the holder's speech. But this is unreliable. A common cold changes the human voice drastically.

Electronically sensing signatures is more attractive, and the new generation of Personal Digital Assitants, like Apple's Newton, are already designed to convert handwriting into electronic signals. But signatures vary, not just from day to day but from hour to hour. Rolls Royce and the British Technology Group have separately worked out their own ways of tracking these changes, but even the cleverest technology cannot cope when shoppers have to sign on a crowded counter at an awkward angle.

Surprisingly the best bet may prove to be the most secure identification system of all, finger printing. At the point of sale, cardholders put their fingers on a pad, which optically scans the tips of the fingers with a laser, similar to the scanners now widely used to read bar codes on Supermarket goods.

Low key market research by the banks suggests that only around two per cent of cardholders have strong objections, preferring finger printing to loss of money through fraud. But the few people who do object, do so vehemently. They also object to the idea of being photographed, or having their signatures electronically recorded. So no bank will dare make biometric identification mandatory. Also, manual workers often have unreadable fingerprints.

Two airports in New York, Newark and JFK, are now testing a hand geometry system. The card stores a map of the holder's hand size and shape, and compares this with a reading taken at the check point.

Optics

Magnetic cards cannot store enough data to encode a signature, or fingerprint, or any other biometric data. Standard memory capacity is only around 200 characters, spread over the three tracks. There are two solutions, Smart Cards with built-in computer chip memories and Optical Cards which store data like a stationary compact disc.

The Drexler Corporation of California leads in optical card technology. The card writer houses a laser which burns lines of five micrometre pits into a thin metal coating on the card. These pits are then read by a lower powered laser which scans the surface, sensing the changes in reflection caused by the pits.

Precision mechanics move the card backwards and forwards under the laser optics. The optics must step sideways across the card in increments of around 10 micrometres to create a horizontal grid of several thousand parallel tracks across the card width. Together these tracks can hold up to six megabytes of data in digital code, equivalent to four high density computer floppy discs.

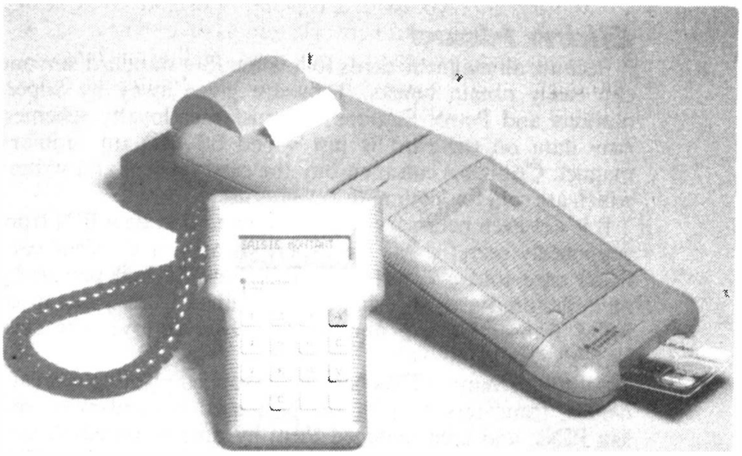
The optical card is relative cheap (under $5 in bulk). It is secure in that data cannot be altered or copied or read. But if the card surface is scuffed it may become unreadable. And the reader must be expensive, costing several hundred dollars.

British Telecom has been testing Drexler cards as a means of storing medical records for expectant mothers attending the West London and Chelsea and Westminster Hospitals in London. US Government agencies are now using optical megabyte cards for storing sensitive information.

French Innovatron

The favourite technology for the future, however, remains the Smart or IC (integrated circuit) card which was invented and patented by French journalist Roland Moreno and his company Innovatron, in the early 70s. Innovatron then licensed Bull, Schlumberger and Philips to develop working cards. The difficulty of building a microprocessor and solid state memory into a credit card which is only 0·76mm thick and is sufficiently flexible to be sat on, should not be underestimated.

The French government has backed smart card technology, seeing it as a national asset and means of modernising the country's telephone and banking systems. Since 1992 all bank cards in France have been smart. The ISO 7816 series of standards ensures compatibility between cards and readers.



The very latest card reader terminal from the inventors of Smart Cards, Innovatron of Paris, France.

Cost is kept down because not all cards are equally smart. The standard card contains an 8-bit microprocessor, and then a wide range of memory options. This has let designers launch new systems with cards which use the bare essentials of memory and intelligence, then use more intelligence and memory as the system demands it.

This is what has happened with satellite broadcaster BSkyB. The scrambling system for the movie channels uses a smart card to authorise decoding, Each new issue of cards has been progressively smarter, and more expensive, as hackers have discovered new ways of breaching the security of the entry level system.

Memory capacity ranges from 1 to 64 kilobytes, in a mix of ROM (Read Only Memory) and EPROM (Electrically Programmable Read Only Memory) which is pre-programmed to store the control codes for the microprocessor, RAM (Random Access Memory) which acts as a temporary buffer when the card is powered by a reader and EEPROM (Electrically Erasable Programmable Read Only Memory) which stores data written into the card by the reader, without the need for battery back-up.

Smart IC cards fall into two broad types; those with a cluster of electrical contacts which make direct connection with mating contacts in the reader, and contactless cards which rely on wireless communication.

Contact cards are cheap, now costing a dollar or so each in bulk, with the reader hardware costing only a few dollars more. Contact cards are only suitable for use where the card remains in the reader most of the time e.g. in a satellite decoder, and there is no risk of the contacts getting too dirty for the contacts in the reader to wipe clean.

Where cards are intended to be carried by the owner, dropped in the mud, and used in a variety of readers to pay for goods or services, they must work without contacts. The connection is then made by radio link. The reader emits a signal which the card converts into power and uses to transmit data back to the reader.

Travel Cards

The power and frequency of the reader's signal determine the range of operation. For some applications, short range connection is essential, for instance to prevent one passenger's travel card paying for another passenger's journey. British company GEC is making the contactless cards which London Transport is now trialling on buses working in Harrow, North London. The same technology is used in Manchester.

The Harrow test involves contactless cards on nineteen bus routes. London Transport has equipped 200 vehicles with smart card readers and around 25,000 passengers are now regularly using cards to pay for journeys. The cards work like ordinary travel cards, but store time information to give free travel for a week or a month. When passengers get on a bus they wipe the card over a reader. If the time has expired, a light warns the driver.

If the trials are successful LT plans to extend the system throughout London's bus network, and use the same cards to pay for station car parking and buy from vending machines.

Although middle-aged passengers still fumble, schoolchildren no longer bother even to take the cards out of their pockets. They just brush their jacket pocket against the reader.

LT has had to delay the second phase of its trial, which expands the scheme to stored-value fare cards. These will work like an electronic purse, storing £10 worth of travel units which the reader sucks out in return for a ticket. Around 200 shops in Harrow already have the equipment needed to re-charge cards in return for cash.

LT blames "mundane" reasons for the delay. The first cards were not strong enough. Whereas people treat their credit cards carefully, they put travel tickets in a back pocket and sit on them. Also bus gearboxes often vibrate when waiting at a bus stop. This has been fooling the reader. When this happens the travel cards can be be checked visually, like ordinary cards. But the purse cards only work electronically.

Similar trials are underway in Bolton. If successful the Greater Manchester Transport Executive will extend the scheme county-wide to buses, trains and trams, with passengers able to use the same cards to buy goods.

Some 2500 people are now using smart cards on 120 of Bolton's buses. The Greater Manchester Passenger Transport Authority plans to extend the scheme across the whole county, over the next three years. The GMPTA cards already work as electronic purses, storing a number of flat rate concessionary fare payments. Each time a passenger uses a card the reader sucks out another 30p. Cardholders can then go to re-chargers installed at Supermarkets, Schools and Bolton Town Hall to pay cash for an electronic top-up.

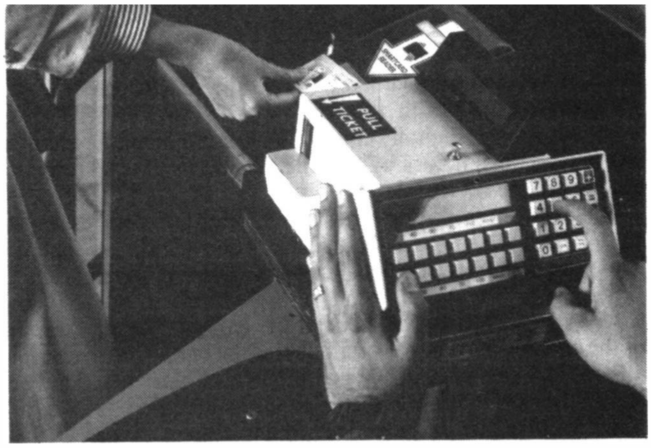
"The main complaint", say the organisers "is from people who get on buses which do not yet have a card reader".

The long-term plan is to encourage local shopkeepers, and sandwich bars, to install readers and so let cardholders pay for goods with their travel cards.

Call for SIM

The new digital cellphones now available for Mercury's One-to-One and Hutchison's Orange networks (and on Cellnet and Vodafone's new GSM services) rely on similar (but sometimes cut-down) cards called Subscriber Identification Modules. Without a SIM, the cellphone cannot be used to make or receive calls. Once the SIM is plugged in, the phone springs to life, making calls which are billed to the SIM-owner's account.

The card also stores a library list of the telephone numbers which the subscriber most frequently calls. If an Orange subscriber gives Hutchison a written list of numbers, an operator will key them into a transmitter which sends them to the phone where they are stored in the SIM. When the SIM is plugged into another cellphone it can immediately read the library list of numbers, make calls on the SIM-owner's account and receive calls dialled to the SIM-owner's number. If a cellphone goes wrong, the owner just slots the SIM in a replacement, which behaves just as if it were the original.



On entering the bus, passengers wipe their "contactless" card across the reader and the driver verifies a valid card.

SmartCard

French payphones use smartcards, 70 million of them a year, even though telephone services in most other countries cut overheads by using cheap magnetic or holographic cards from which credits are erased or burned away by the payphone reader.

Most French salaries are paid by the month into a bank. So virtually everyone has a bank account. In France all cards are debit cards, and the Groupe Cartes Banqueres (comparable to the Association for Payment Clearing Services in the UK) represents all the banks which issue the cards, and runs a scheme whereby each bank honours every other banks cards for all transactions. Any French national using a bank card must now use a smart card. This has cut fraud inside France to almost non-existent levels.

The GCB estimates are that at least half this fraud occurred because the electronic point of sale, EPOS, equipment worked "off line". It collected information on all transactions during the day and sent it to the bank for processing at night.

All 21 million bank cards in France are now smart. Direct "on line" connections with the banks let the EPOS terminals check a smartcard's validity, against a personal identification number or PIN entered by the customer, in under two seconds. If the PIN does not match the card, the reader displays a message to the shop staff, telling them to pick up and keep the card. Soon the readers will be able to send a signal into a suspect card to make it useless.

The only fraud on French cards now is abroad, where people travel to other countries where there are no smart card readers, and use the cards like conventional credit cards. This is possible because French smart cards also have magnetic stripes like ordinary credit cards.

Smart World

AT and T, Bull, Hitachi, Mitsubishi, Motorola, Philips, Schlumberger, Siemens and Thomson now all make smartcard chips and cards. Most countries are running tests to find out what else the technology can do, and how reliable they are.

A test in Helsinki lets travellers use the same smart card to pay for bus or taxi travel. Dublin Bus is testing contact cards as part of a research project funded by the European Commission. The same card can be used in Irish car parks and payphones.

The Japanese Government is storing the medical records of 300 mothers and young children on smart cards, in Awaji Island, Hyogo Prefecture. The British Department of Health is comparing different card types for storing patients' medical details.

In the US President Clinton's plans for health care and the electronic delivery of benefits to replace food stamp coupons has excited companies which smell the market potential. The

State of Wyoming looks likely to be the first to experiment with smart card health records. Hughes Aircraft will soon start transmitting digitally coded TV entertainment, direct into North American homes by satellite. Viewers will need a smart card to decode the signal.

In the UK, Wessex Water has been testing smart cards in the city of Bath. The householder has a Water Card and charges it with cash credits at a local shop or water company office. When the card is slotted into a household meter, it opens the valve to pass water to the value of the credits. The intelligence of the card lets it run up a small debt if the credits run out over a Bank Holiday weekend. When the householder next pays to top up the card the debt is settled at the same time.

British Gas has developed a similar system, called Quantum, for charging its customers for gas. The householder slots a card into the Quantum meter to load it with credits and pass gas. At the same time the meter loads information about the householder's gas use into the card. When the cardholder takes it to a retailer, a card reader displays an estimate of how much it will cost to charge up the card for another month of similar use. At the same time the reader can relay a message from the meter which warns the retailer if the meter has been tampered with. The meter also sucks enough extra credits from the card to pay the quarterly standing charge.

At least fifteen countries around the world, including Denmark, Switzerland and Taiwan are planning or testing electronic purse systems which rely on the extra storage capacity and intelligence of a smart card to control cash debits and credits. Britain's National Westminster Bank has proposed the most ambitious scheme of all, Mondex.

Ambitious Mondex

Mondex will allow two cardholders to exchange cash units directly, without clearance through a central control system, just as if they were five pound notes. As one purse at a shop check-out gains credits, another, from a customer's wallet, loses them. The cardholder can then fill up the card again by slotting it into an automatic teller machine which delivers electronic credits instead of cash, while debiting the holder's bank account. The credits can also be sucked into the card down a telephone line by calling the bank. Or the credits can be sent down the line into someone else's card.

Because the Mondex card stores cash credits, anyone can use it to make a purchase from any shop which has a Mondex reader. So losing the card is the same as losing cash. Security comes with an electronic wallet, like a pocket organiser, which locks the card's memory with a PIN.

The Mondex card will be loaded with credits at an ATM or by connection to a phone line. So Mondex immediately becomes a target for criminals who will want to get money out of a card without it losing value, or get money into a card without debiting an account, or make copies of cards to spend the same money several times over. Westminster's security experts are confident that Mondex will resist these attacks.

The Mondex personal wallet.

Liberty

Liberty, formerly the National Council for Civil Liberties, has so far lobbied successfully against the Government's plans to use smart cards as a weapon against football hooliganism. The idea, which came from Margaret Thatcher while she was Prime Minister, was for football grounds to install turnstiles that opened only when a spectator waved a valid smart card. The card would store identity details along with any black mark for bad behaviour.

The organisation was particularly worried because the cards would have to be contactless, to work reliably in all weathers, and after dropping into the mud. So a powerful reader could have secretly interrogated a card while still in the owner's pocket. Although Liberty's policies and position come across as rather muddled, the organisation does have a loud voice.

Says Atiya Lockwood, of Liberty, "We don't mind cards for specific uses. But we don't want to see too much information stored on one card, because then it becomes an identity card. You may be quite happy for a doctor to get details of your medication or allergies from a card, but you would not want your doctor to be able to read about your criminal record from the same card."

Watermark

Thorn EMI's Central Research Laboratories has been watching the collapse of confidence in magnetic card technology, and the trend to smart cards, with special interest. It is now 25 years since CRL developed a method of watermarking magnetic tape. The original intention was to distinguish between original and pirate music recordings, but the record industry was not interested. In 1978 Swedish banks started using the system to distinguish between genuine and copy magnetic bank cards. Since 1980, every banking transaction in Sweden has been unambigiously tied to the card used for that transaction. But outside Sweden no-one was interested.

"The idea was too early for its time", says Hugh Tarrant, Managing Director of Thorn Secure Science International, a new company formed in Swindon to make watermarked tape which card makers bond to ISO cards.

Tarrant has watched the explosion of fraud on all types of magnetic card change attitudes. In 1986 South Korea adopted watermarking to stop an explosion of fraud when people found out how to clone telephone cards. The same system is used in Australia to control poker gaming by phone line and by the House of Commons, Windsor Castle and the Ministry of Defence to control access to secure areas. The door locks are triggered by magnetic cards that look for the watermark and reject any counterfeit copy. TSSI now sells enough tape for a thousand million bank, phone and identity cards each year.

In addition to the standard three ISO tracks, watermarked magnetic cards have an extra track, numbered zero, nearest the edge of the card. So a watermarked card is recognisable by its wider than usual magnetic stripe.

TSSI reveals that at least one major bank tried and rejected the system ten years ago, even though the price of watermarking is only around 10 US cents per card. Card fraud was then still a rarity.

The National Westminster and Barclays banks have since last October been quietly running consumer tests in Northampton, with Visa International, now the largest consumer payment system. The two banks have each issued 15,000 watermarked cards and a Safeway store and 12 ATMs have been equipped with readers which can trap anyone attempting to use a copy card.

Hugh Tarrant has an interesting view of the future. He acknowledges that magnetic cards can never have enough memory capacity to serve as electronic purses. But he also believes that smart card technology will prove a lot less secure than some of its proponents promise.

"But a system that combines both watermarked magnetic stripe and an embedded chip, would give a mix of analogue, chemical and digital technology," says Tarrant. "Now that would be the most secure system of all". □

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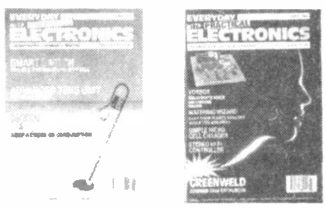

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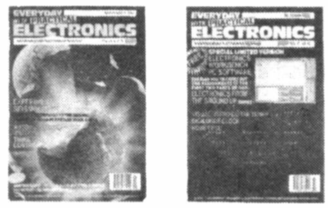

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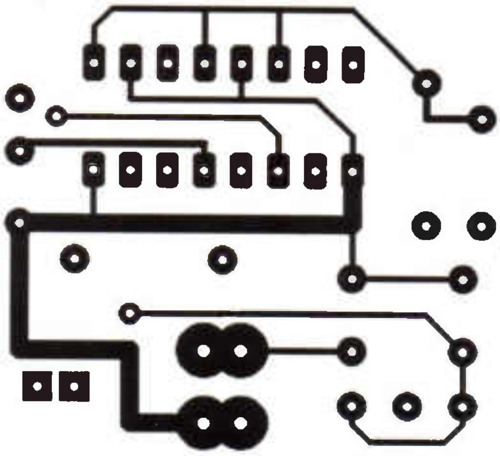

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PIC-DATS 4-CHANNEL LIGHT CHASER

MARK STUART

Part 2

Highlighting the PIC microcontroller, Mark Stuart channels your attention onto how its elegant development system can be used to good effect.

In Part One of the PIC-DATS article last month, the PIC microcontroller was introduced and the principles of its use and programming described. This second part follows on, introducing the practical operation of the PIC-DATS system and demonstrating its use in the development of a typical hardware project.

The project chosen is a 4-Channel Light Chaser controller. The main reason for the choice is that such a project demonstrates how to read switch (digital) and potentiometer (analogue) inputs, and how to control low voltage and mains power devices. The programming described involves timing loops and demonstrates timed control of the outputs, which is necessary for "Zero Volt Switching" of the mains power devices.

OTHER APPLICATIONS

Although the originally intended use of the project is as a Light Chaser, it can also be used for many other general purpose applications where computer control of mains powered devices is needed. For example, random switching of house lights and appliances for security purposes, central heating control and greenhouse watering systems.

It can also be modified to provide low voltage control outputs for operating model motors, solenoids, and other motion control devices. Inputs from other types of sensor may also be applied instead of switches, allowing a wide range of "stand alone" applications to be developed.

The design is such that program development and simulation can be done without any mains voltage being applied. There is also total mains isolation so that the system may also be operated and further developed with mains power applied, **provided due care is taken.**

As the main purpose of this article is to cover PIC programming and the PIC-DATS system, the description of the hardware and construction of the project will be kept to a minimum. The circuitry is all on a single printed circuit board (p.c.b.), but any mechanical construction, casing, etc. is left to the user.

MAINS POWER SECTION

The circuit diagram for the complete 4-Channel Light Chaser is shown in Fig. 1. The circuit is divided into two parts: the Mains Power section, and the low voltage Control section. Between the two circuits there is complete electrical isolation.

Mains power is controlled by four triacs, CSR1 to CSR4. These devices can switch up to 600 volts and five amps (provided they are fitted with heatsinks and there is adequate ventilation). Each channel is provided with a fuse, which will protect the circuit in the event of an overload or "short". It is unlikely that the fuse will protect the triac, however, as the short time it takes to blow a triac is a lot less than the time needed to blow a fuse.

The triacs are switched on by applying a voltage between their MT1 and Gate (g) terminals. This voltage is supplied by transformer T2, rectified by REC2 and smoothed by capacitor C6. Although it is a low voltage, one side must be connected to Mains Live (so that current can flow between MT1 and Gate) and so it **MUST be treated as Mains Voltage.** Resistor R18 is used to link the low voltage supply to the Mains.

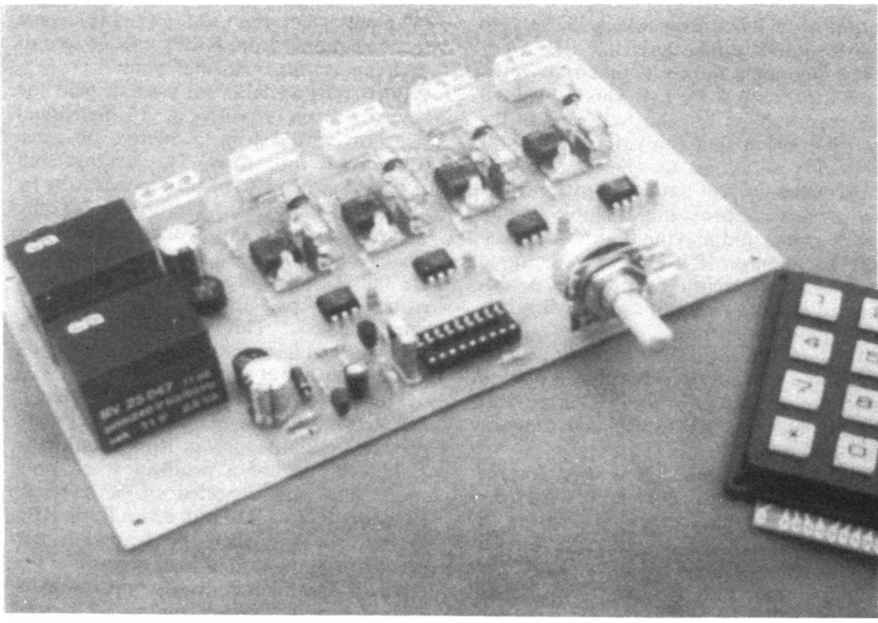
Gate voltage is applied to the triacs via opto-isolators IC2 to IC5. Each opto-isolator has a phototransistor at its output and an l.e.d. at its input. Light from the l.e.d. makes the phototransistor conduct. Resistor R14 limits the gate current to CSR1, and R19 reduces the sensitivity of the triac to spurious electrical pulses and interference that may be carried on the incoming mains supply. Resistors R15 to R17, and R20 to R22 do the same for the other triacs.

A separate fuse, FS1, is provided in the supply to the two mains transformers.

As the only path through the opto-isolators is for light, there is no electrical connection, and so the input l.e.d.s are free of mains voltage.

CONTROL SECTION

The Control section of the circuit is powered by a second mains transformer, T1. The low voltage output is rectified by REC1 and smoothed by capacitor C1. Diode D1 is added so that an unsmoothed



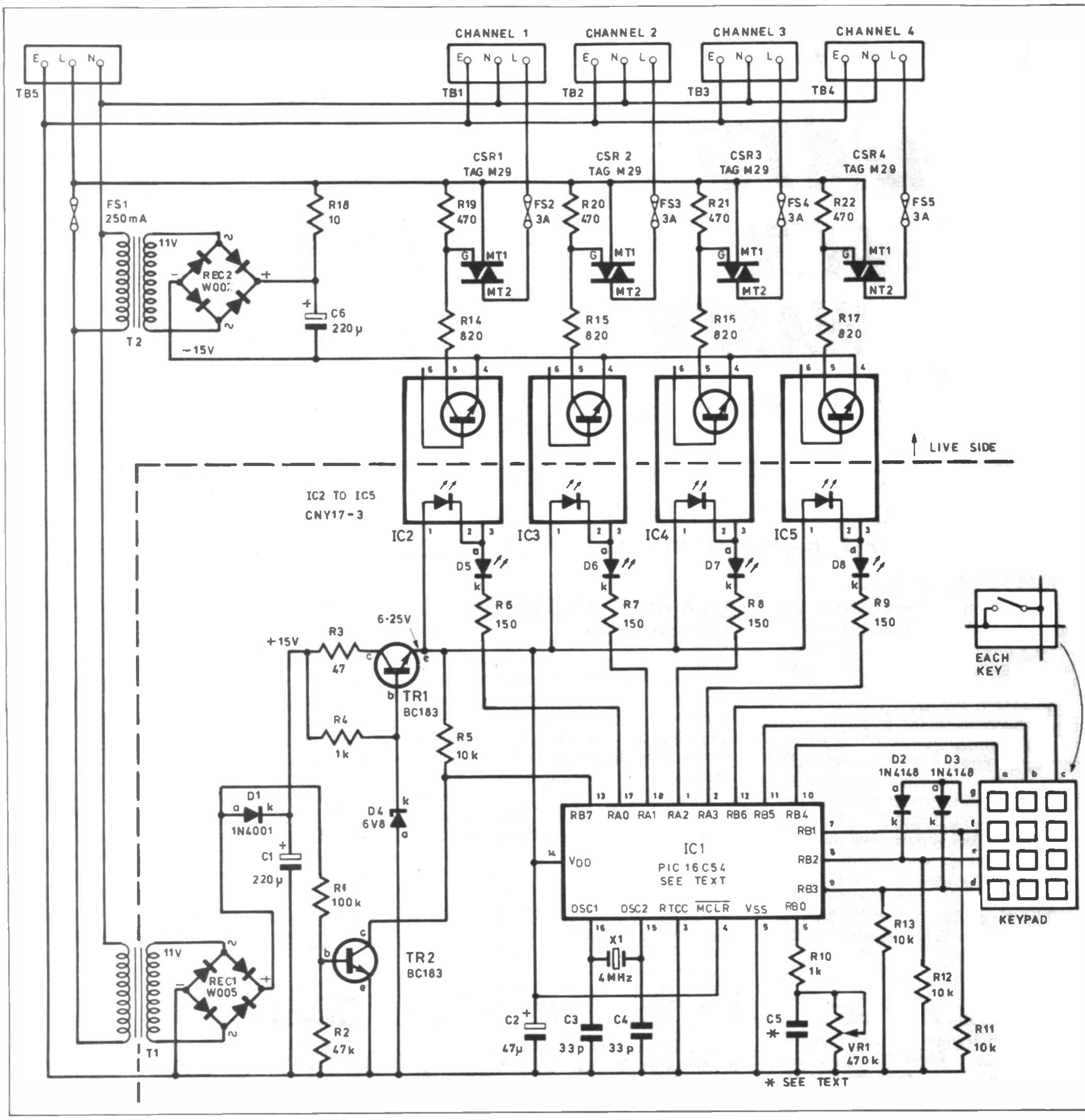


Fig. 1. Circuit diagram for the complete PIC-DATS 4-Channel Light Chaser.

output is available from which mains zero crossing points can be derived.

The smoothed output is taken via resistor R4 to Zener diode D4. This provides a reference voltage for the base of transistor TR1, which acts as a voltage regulator producing 6·25V on its emitter. Resistor R3 provides current limiting and short circuit protection, providing a stable limited power source and making it almost impossible to damage IC1 even if it is fitted backwards. Capacitor C2 provides decoupling to maintain a clean supply when IC1 draws pulses of current.

IC1 is a PIC16C54 microcontroller. Its 4-bit Input/Output (I/O) Port RA is used to drive the opto-isolator l.e.d.s via current limiting resistors R6 to R9 and monitor l.e.d.s D5 to D8.

The 8-bit I/O Port RB is used for the remaining functions. Port RB0 senses the setting of potentiometer VR1, using it along with resistor R10 and capacitor C5 as a simple analogue to digital converter (ADC) circuit. Port RB7 picks up pulses from the collector of TR2, which is turned off briefly when the unsmoothed full wave rectified supply from REC1 falls to zero at each mains "zero crossing" point.

Ports RB1 to RB6 are used to read the keypad which consists of 12 individual switches arranged in a matrix of three columns of four rows. This arrangement allows 12 switches to be read individually by only seven connections. Unfortunately, only six are available in this circuit, and so it has been necessary to use a trick and add diodes D2 and D3. These diodes give the top row of switches (*g*) pull-up lines from *d* and *e* simultaneously. This allows them to be distinguished from the other keys which pull up only one line at a time.

The drawback to this method is that it can give false Row *g* outputs if keys are pressed simultaneously in Row *d* and Row *e*, but this is not a problem when only single keys are expected to be pressed. Resistors R11 to R13 pull down Ports RB1 to RB3 so that when the keypad is not pressed all three read as logic zeros.

All of the microcontroller operation is carried out at a speed determined by the on-chip clock oscillator. The frequency is determined by resonator or crystal X1. C3 and C4 provide the correct capacitive loading for the oscillator circuit.

CONSTRUCTION

The circuit is built on a single printed circuit board, which is available from the *EPE PCB Service*, code 942. This board can be assembled to different levels as required. For basic program development it is necessary only to fit the components around IC1.

The opto-isolators can be omitted if their pins 1 and 2 are shorted together to provide a current path to light l.e.d.s D5 to D8. The power supply section T1, D4 etc. can also be omitted, and instead of mains power, a 6V battery (easily provided by four AA cells in a holder) can be connected across C2.

Leave resistor R5 in position so that Port RB7 is always pulled up to a logic 1 level. This is the ideal set-up whilst first experimenting as it is completely safe and allows simple programs to be checked with ease. The battery may also be used if the

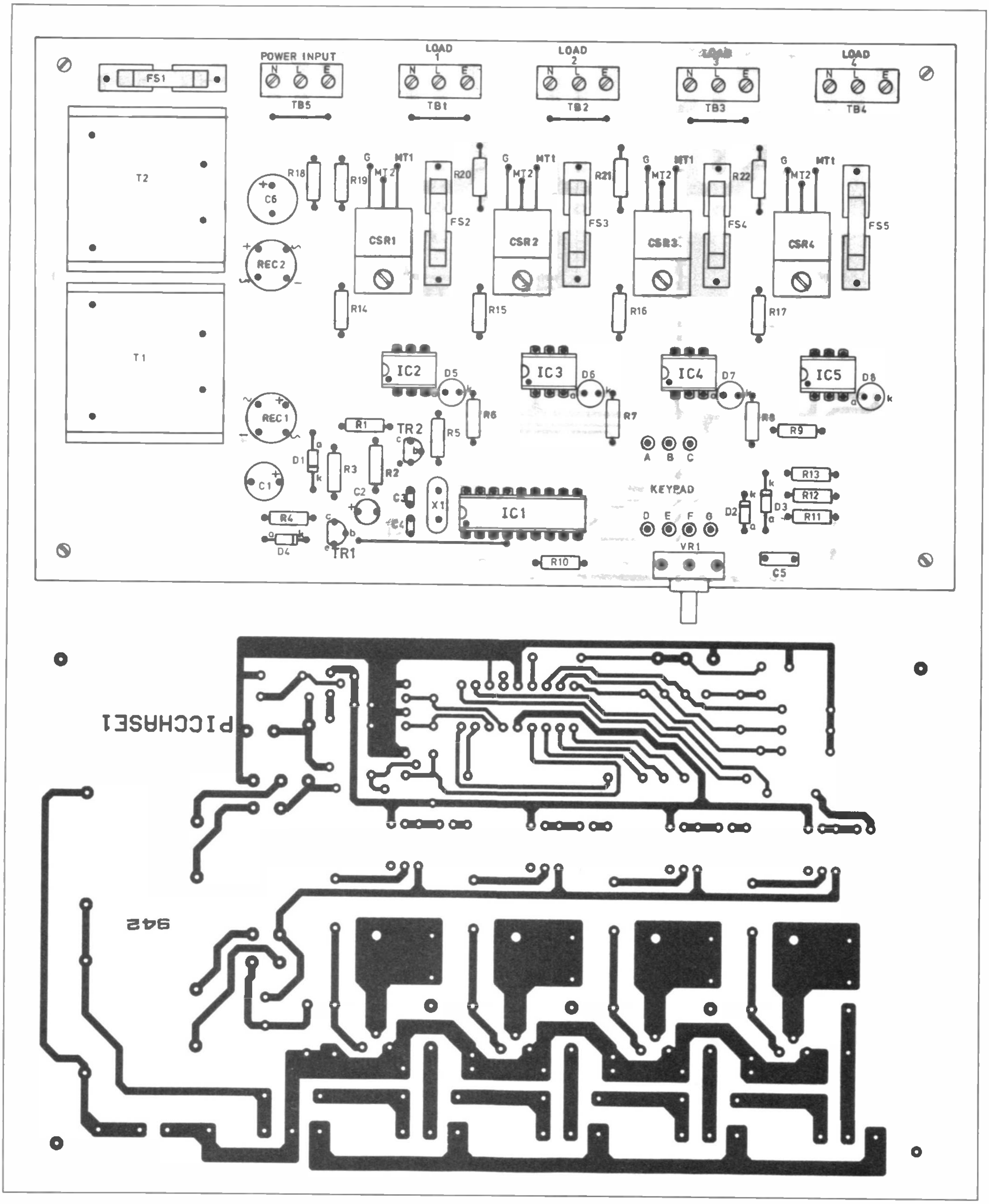


Fig. 2. Component layout and full size copper foil track master for the PIC-DATS 4-Channel Light Chaser.

power supply section has been assembled, **provided the mains input is unplugged.**

All of the components are fitted as shown on the component layout drawing in Fig. 2. DO NOT use sockets for opto-isolators IC2 to IC5 as the distance between the socket pins is less than that between the pins of the opto-isolators and would reduce the clearance distance below that required for safe isolation. Opto-isolators are reliable anyway, and so there is no reason to have them in sockets – but do make sure before soldering that they are fitted the right way round!

The socket for IC1 can be a turned pin type or an ordinary one. Turned pin sockets are more durable.

Assembly of the mains side of the circuit is conventional. Use a nut and bolt to hold each triac tab down to the board, and take care to keep all of the soldering tidy to avoid accidental track bridges.

Insulated wire links are needed to join the Mains Neutral connections across to all of the output terminals. These should be made with 16/0·2 wire insulated with sleeving.

It helps alignment when fitting the fuseholders if a fuse is clipped into them before soldering.

TESTING

It is essential to make checks for solder bridges, dry joints, and incorrectly fitted components before applying power to the board. If battery power is being used, connect a 6V supply across capacitor C2. This is best done by soldering a pair of 7/0·2 connecting wires to the track side of the board where the pins of C2 are fitted. Do not yet insert IC1.

Using a short length of connecting wire,

COMPONENTS

Resistors
R1 100k
R2 47k
R3 47
R4, R10 1k (2 off)
R5, R11 to R13 10k (4 off)
R6 to R9 150 (4 off)
R14 to R17 820 (4 off)
R18 10
R19 to R22 470 (4 off)

See SHOP TALK Page

Potentiometer
VR1 470k rotary carbon lin.

Capacitors
C1, C6 220μ radial elect. 16V (2 off)
C2 47μ radial elect. 10V
C3, C4 33p 2.5mm ceramic (2 off)
C5 see text

Semiconductors
D1 1N4001 rectifier diode
D2, D3 1N4148 signal diode (2 off)
D4 6V8 400mW Zener diode
D5 to D8 3mm red l.e.d., standard diffused
REC1, REC2 W005 bridge rectifier (2 off)
TR1, TR2 BC183 *npn* transistor (2 off)
CSR1 to CSR4 TAG M29 triac, isolated tab
IC1 PIC16C54 microcontroller (see text)
IC2 to IC5 CNY17-3 opto-isolator (4 off)

Miscellaneous
X1 4MHz crystal or resonator
FS1 250mA fuse, 20mm
FS2 to FS5 3A fuse, 20mm (4 off)
T1, T2 11V 0·8VA transformer, p.c.b. mounting, Magenta TX0811 (2 off)

Printed circuit board, available from the *EPE PCB Service*, code 942; 20mm fuse clips, p.c.b. mounting (5 off); 3-way terminal block, p.c.b. mounting, mains rated (5 off); mains connectors, to suit application (5 off); case, to suit application (see text); 18-way d.i.l. socket; insulating pillars and screws (4 off); keypad, 4 x 3 matrix; connecting cable; wire; solder, etc.

Approx cost guidance only **£40**

link pin 5 of the i.c. socket in turn to pins 1, 2, 17, and 18. This should light the corresponding l.e.d.s D5 to D8 and will be activating the opto-isolators if they have been fitted. If the l.e.d.s do not light, check their polarity, and that of the opto-isolators.

If a fully built mains powered circuit is being built, the above battery test can still be used before applying the mains.

FOR TESTING UNDER MAINS POWER, BE EXTREMELY CAREFUL. MAINS CIRCUITS MUST ONLY BE CONNECTED BY FULLY COMPETENT USERS. IF IN ANY DOUBT - DO NOT APPLY MAINS POWER: TEST THE CIRCUIT UNDER BATTERY POWER ONLY.

If you *are* competent to use the mains powered version, it is strongly recommended that the p.c.b. is screwed down to a substantial piece of wood before testing. This holds it in place, and takes away the temptation to pick it up with bare hands. Use an insulated test bench, and plug in to a circuit powered via an RCCB (residual current circuit breaker). An RCCB is essential for this and other electronics work using mains power and greatly reduces any hazard.

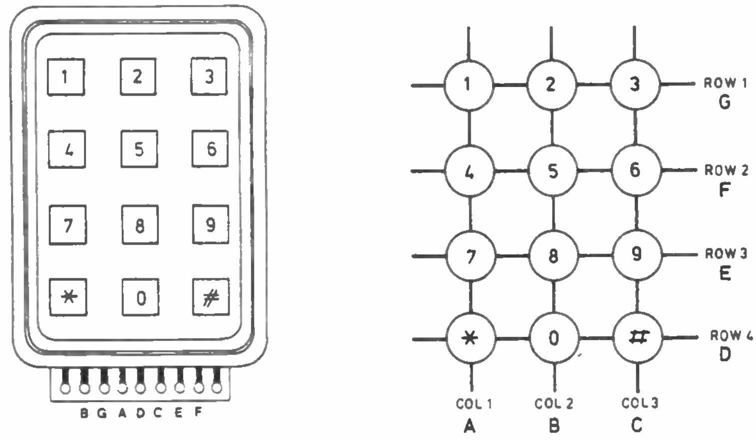


Fig. 3. Keypad connections and keying logic.

Once mains power is applied, check the regulated supply from the emitter of TR1, which should be close to 6·25V. Check the operation of l.e.d.s D5 to D8 as before, and that the triacs are being triggered when the l.e.d.s are lit. This is best done using a low wattage lamp as a load on each output.

Once this has been done, and power has been switched off, the circuit is ready for the PIC chip to be inserted. First, though, it has to be programmed!

OUTPUT ARRANGEMENT		
OUTPUT PIN No.		SYMBOL
	1	
B	2	COL 2
G	3	ROW 1
A	4	COL 1
D	5	ROW 4
C	6	COL 3
E	7	ROW 3
F	8	ROW 2
	9	

PIC OPERATION

The PIC program can range from simple to very complicated. To make an easy introduction, the PIC-DATS will first be used with some very simple examples, starting with a program to turn on just one of the outputs in response to the pressing of one key on the keypad.

The program will then be extended in several small stages until a simple light sequencing program is developed. This procedure will have supplied the basic tools - further programming development is left to the individual to exercise his or her mind. Those new to PICs will be surprised at the ease with which simple working programs can be written, and how simple steps can be combined into larger programs.

All of the programs shown, and some more complicated ones, are supplied on the disk referred to last month, and in this month's *Shop Talk*.

CONNECTING UP

The outputs from the PIC SIM system, described last month, are connected to a 40-way IDC plug on the end of the board. Most of the connections are not used, but it is difficult to fit individual wires, and so a 300mm length of 40-way rainbow (colour coded) ribbon cable should be used. The pins required are:

DATS PIN	FUNCTION	IC1 PIN
39	Ground	Target pin 5
40	Ground	Target pin 5
15	PORT RB0	Target pin 6
17	PORT RB1	Target pin 7
19	PORT RB2	Target pin 8
21	PORT RB3	Target pin 9
22	PORT RB4	Target pin 10
20	PORT RB5	Target pin 11
18	PORT RB6	Target pin 12
16	PORT RB7	Target pin 13
23	PORT RC0	Target pin 17
25	PORT RC1	Target pin 18
27	PORT RC2	Target pin 1
29	PORT RC3	Target pin 2

Port RC is being used since Port RA is not available on the PIC-DATS. It is, however, a simple matter to change over when programming the final chip so that Port RA is used.

The ends of the ribbon cable must now be connected to the Light Chaser board. As this board is the one for which the final code is being developed, it is referred to as the "target system". The lead connecting the PIC-DATS to the target system is known as the "probe connecting lead" and the connector used to make contact with the socket of IC1 is the "target probe".

The ideal means of connecting the ribbon cable to the socket of IC1 is to use an 18-way d.i.l. (dual-in-line) header which is an IDC connector whose pins plug directly into an 18-way i.c. socket.

There is a difficulty with this, though: the ribbon cable from the PIC-DATS is not in the correct order to fit directly. To overcome this, either solder the wires individually to the d.i.l. header pins, taking care not to melt the plastic connector body, or fit a separate ribbon cable into the d.i.l. header and make individual soldered and sleeved joints between the appropriate wires.

Alternative probe arrangements are possible, including the simple but effective method of soldering the ribbon cable directly to the track side of the p.c.b. underneath the socket for IC1. If this method is used, take care to unplug the 40-way connector from the PIC-DATS when the time comes to fit a programmed PIC into the socket.

For the PIC-DATS simulation control of this target circuit, **DO NOT** connect the PIC-DATS control cable to pins 3, 4, 14, 15 or 16 of the socket for IC1.

Once the target probe connections are made, and have been double checked, plug in the 40-way connector, connect the PIC-DATS power supply and power up the target system using a 6V battery.

PROGRAMMING

One of the best aspects of the PIC-DATS software is the way it is able to switch to and from the Text Editor and Cross Assembler programs. To achieve this it is necessary to edit a simple file called PICSIM.INI which indicates the directories and paths through which to access the two programs.

The file can be changed easily if necessary using a word-processor. If the PIC-DATS program has been loaded in the standard way, and assuming it is to be run from a hard disk on drive C, the first line will read:

C:\PIC\MPASM.EXE

The second line is the path to the Text Editor. The prototype was developed using a word-processor package called PCWrite which uses the command ED.EXE to start. It is located in a directory called PCW1. The second line reads:

C:\PCW1\ED.EXE

Users who only have floppy disk drives will need to make alternative entries, but provided the disk capacity is sufficient the system can be run successfully. It is useful to have a compact word-processor as the programs need to be written in very simple ASCII code.

Assuming the software has been correctly loaded and the serial lead is connected between connector PL2 and the computer, enter the PIC directory, and run PICSIM5X. Remember to enter PICSIM5X 2 if the serial lead has been connected to the COM 2 port of the PC instead of COM 1.

If all is well, the PIC-DATS will sign on and the COMMAND prompt will appear. If not, check the lead and power supply. If necessary switch off the PIC-DATS power, and then switch on again to reset.

Once in Command mode, experiment with some commands to see their effect. The manual supplied with the software gives full details of each command, and only the bare essentials are provided here:

```
ORG     0X00    indicates where the next line of code should be loaded
MOVLW   0X00    loads the value 00 to W, which is the working register
TRIS    07      copies the value in W to the Port RC control register - which
                determines whether the port bits are inputs or outputs loading
                00 sets all Port RC bits to output

MOVWF   0X07    loads the value 00 into Port RC setting all lines LOW
MOVLW   0XFF    loads the value FF into W
MOVWF   0X07    loads the value FF into Port RC setting all lines HIGH
GOTO    START   sends the PIC back to the first line so that the program loops

ORG     1FF     indicates where the next line of code should go
GOTO    START   located at 1FF. This is the first thing the PIC reads and so it
                immediately jumps to START which is at address 00 and begins
                running the instructions from there
```

Listing 2. Explanation of the commands used in Listing 1.

Key B switches alternately between decimal and hex numbering. Hex is the more usual system for programming and should be selected.

Key M switches through the range of processors covered. Select 16C54.

Key P steps through the available register file pages, this should be set for page 0.

Key W allows the watchdog timer to be enabled - the watchdog timer is an independent counter that automatically resets the PIC if the program runs away due to an unforeseen programming bug. Its use can be complicated, and it is not necessary in the current application so set function W to "disabled".

The other commands are either obvious, such as Q for Quit, or are better explained by example as programming proceeds.

PROGRAM FILES

As with all types of programming, there are rules that must be obeyed, and commands that will only be recognised in the correct places. The MPASM Cross Assembler that is being used is not unfriendly, but cannot work if it does not understand the programmer's intentions. The easiest way to start is to modify a known working program - some simple examples of which are supplied on the software disk.

The first lines in a PIC program are to tell the MPASM Cross Assembler program which type of PIC the program is for, which numbering system is being used (Hex, Decimal, Binary etc.) and where to locate the code in memory.

A simple program which sets Port RC to operate as an output port and then switch the eight outputs alternately between logic 0 and logic 1 is shown in Listing 1.

This file, PICA1.ASM, is included on the software disk, but should be typed in as an exercise to show how the system works.

The name of the file in which the re-typed program is stored is not important, but it must have the suffix ".ASM" (pronounced "dot A-S-M") and be in pure ASCII code, that is, it must not contain any printer control or other non-text codes. Most word-processors are able to work in this mode without difficulty.

Take note of the columns used for the various statements in the .ASM file, in particular the way that the label "START" begins in column one. Note also the semi-colons (;) which indicate that the following words on that line are comments.

Line by line the program works as described in Listing 2.

The two ORG statements are very important as they determine the starting address (ORiGin) for the code. The main part of the code starts from 0000, but the PIC16C54 always starts at 01FF following switch on or Reset so a simple command is written and inserted directing the PIC to the label START for its next instruction.

The use of a label allows a particular piece of code to be found by the program no matter where it is in the memory. START could be at location 00FC and the program would still find it correctly. Note also that the word BANANA or any other word (apart from a few reserved words such as LIST that would cause confusion) made from up to six letters and numbers, could be used instead of START.

The .ASM program cannot be run directly as it is, but must first be "Assembled" into the correct form to be loaded into the PIC chip. This is done by the MPASM.EXE program. It takes the .ASM file and produces two other main files, one is a listing file (suffix .LST) which contains all of the original information and adds the addresses and PIC instruction codes.

The other is the code file for programming into the PIC processor (suffix .HEX). If there are errors in the original .ASM file which cannot be converted into code, a third file is produced with the suffix .ERR containing details of each error and the reason it cannot be interpreted.

The listing file generated from the .ASM file in Listing 1 is shown in Listing 3. It contains in columns one and two details of the location and contents of the code that would be loaded into the PIC processor. For example, memory location 0000 will contain the code 0C00, and so on.

These codes are the "machine code" equivalents of the statements entered in the .ASM file. The listing file also shows the amount of memory used, the date and time of assembly and a table of labels and their addresses. If errors have been made in the .ASM file, these will be shown in the .LST file with details that help with their correction.

```
        PROCESSOR 16C55

        RADIX HEX

        TITLE   "PICA1.ASM"

        LIST

        ORG     0X00
START   MOVLW   0X00            ;LOAD W WITH 00  (BINARY 00000000)
        TRIS    07              ;COPY W INTO TRIS C SET PORT C AS O/P
        MOVWF   0X07            ;COPY W INTO PORT C TO SET ALL 0s
        MOVLW   0XFF            ;LOAD W WITH FF  (BINARY 11111111)
        MOVWF   0X07            ;COPY W INTO PORT C TO SET ALL 1s
        GOTO    START           ;LOOP BACK TO BEGINNING

        ORG     1FF             ;RESET ADDRESS
        GOTO    START           ;GO TO START POINT
        END
```

Listing 1. PICA1.ASM: simple program which sets Port RC to operate as an output port.

```
The PICA1.LST file:

MPASM 01.02 Released  C:\PICA\PICA   4-16-1995  20:20:10        PAGE  1

PICA1.ASM

ADDRESS  CODE  LINE  SOURCE TEXT

               0001         PROCESSOR 16C55
               0002         RADIX HEX
               0003         TITLE   "PICA1.ASM"
               0004
               0006
               0007         ORG     0X00
0000     0C00  0008  START  MOVLW   0X00  ;LOAD W WITH 00  (BINARY 00000000)
0001     0007  0009         TRIS    07    ;COPY W INTO TRIS C SET PORT C AS O/P
0002     0027  0010         MOVWF   0X07  ;COPY W INTO PORT C TO SET ALL 0s
0003     0CFF  0011         MOVLW   0XFF  ;LOAD W WITH FF  (BINARY 11111111)
0004     0027  0012         MOVWF   0X07  ;COPY W INTO PORT C TO SET ALL 1s
0005     0A00  0013         GOTO    START ;LOOP BACK TO BEGINNING
               0014
               0015
               0016         ORG     1FF   ;RESET ADDRESS
01FF     0A00  0017         GOTO    START ;GO TO START POINT
               0018         END
               0019
               0020

MPASM 01.02 Released  C:\PICA\PICA   4-16-1995  20:20:10        PAGE  2

PICA1.ASM

SYMBOL TABLE

LABEL                              VALUE

START                               0000

MEMORY USAGE MAP ("X" = Used,  "-" = Unused)

0000 : XXXXXX---------- ---------------- ---------------- ----------------
0040 : ---------------- ---------------- ---------------- ----------------

0180 : ---------------- ---------------- ---------------- ----------------
01C0 : ---------------- ---------------- ---------------- ---------------X

All other memory blocks unused.

Errors   :   0
Warnings :   0
Messsges :   0
```

Listing 3. The Listing file generated for the program in Listing 1.

The .HEX file is much shorter, and is practically unreadable except by the PIC programming software. Thus the PICA1.HEX file would read:

:08000000000C07002700FF0CB3
:040008002700000AC3
:0203FE00000AF3
:00000001FF

This file contains the code that will be loaded into the PIC when it is programmed, and other information giving the memory locations to be used, and a checksum so that any errors in the file can be detected as it is downloaded.

PROGRAM FILES

Program .ASM files can be written with almost any text editor (word-processor) software. The file can then be assembled by running MPASM.EXE to produce .LST and .HEX files (and a .ERR file if there are errors). This arrangement can be used without PIC-DATS itself and is useful for checking program ideas and learning the basic rules for the .ASM files.

The PIC-DATS system is much more effective for code development, however, as it allows the code to be run and developed in hardware as well as software. Provided the PICSIM.INI file has been set up correctly, the PIC-DATS program allows easy access to and from the text editor and assembler.

To write a .ASM file from the PIC-DATS software environment, press E and then select the file from the list provided. If a new file is to be written press "Esc" and the text editor program will start up as usual. When the file is complete, save in the usual way and exit. A single keypress will then return to the PIC-DATS system.

To run the cross assembler, press XA and select the .ASM file from the menu. The MPASM program will run, and report any errors. A single keypress will again return to the PIC-DATS. If there are errors, press E and enter the file name with suffix .ERR to see the error report. Alternatively, enter a .LST suffix and find the errors in the listing file. The error explanations and their solutions are often simple, but the more complicated ones will need some thought and reference to the PIC data sheets (supplied with the PIC-DATS kit).

Once the code is correct, return to the PIC-DATS program and use the L command to load the assembled .HEX file from the menu.

STEPPED MONITORING

Now the real fun begins! Assuming the target system is connected to the PIC-DATS and powered, the code can be stepped through one instruction at a time using the S command. As the state of the I/O ports is changed, the l.e.d.s on the target system will turn on and off. Note that in this circuit, the l.e.d.s are turned on by a logic 0 and off by a logic 1.

Press Q to end the single stepping, and then press T. The program will now run on its own and the l.e.d.s will appear to be constantly lit, although they are actually flashing on and off very quickly. The speed at which the program is now running is much slower than the final speed of the PIC device. This is because the PC computer has to operate the PIC-DATS via a serial link, and update the screen after each instruction. For testing programs, however, it is fast enough, provided there are no time

```
        PROCESSOR 16C55

        RADIX HEX

        TITLE   "PICA_B.ASM"

        LIST

        ORG     0X00

START   MOVLW   0X00                 ;LOAD W WITH 00  (BINARY 00000000)
        TRIS    07                   ;COPY W INTO TRIS C SET PORT C AS O/P
        MOVWF   0X07                 ;COPY W INTO PORT C TO SET ALL 0s

CHASE   MOVLW   B"11111110"          ;LOAD CHASE PATTERN 1 INTO W
        MOVWF   0X07                 ;COPY W INTO PORT C TO SET OUTPUTS

        MOVLW   B"11111101"          ;LOAD CHASE PATTERN 2 INTO W
        MOVWF   0X07                 ;COPY W INTO PORT C TO SET OUTPUTS

        MOVLW   B"11111011"          ;LOAD CHASE PATTERN 3 INTO W
        MOVWF   0X07                 ;COPY W INTO PORT C TO SET OUTPUTS

        MOVLW   B"11110111"          ;LOAD CHASE PATTERN 4 INTO W
        MOVWF   0X07                 ;COPY W INTO PORT C TO SET OUTPUTS

        GOTO    CHASE                ;LOOP BACK TO BEGINNING OF CHASE

        ORG     1FF                  ;RESET ADDRESS
        GOTO    START                ;GO TO START POINT
        END
```

Listing 4. Program listing for PICA_B.ASM, which generates a simple chase lighting sequence.

```
        PROCESSOR 16C55
        RADIX HEX
        TITLE    "PICA_C.ASM"

        LIST

        ORG      0X00

START   MOVLW    0X00            ;LOAD W WITH 00  (BINARY 00000000)
        TRIS     07              ;COPY W INTO TRIS C SET PORT C AS O/P

        MOVLW    B"10001111"     ;LOAD W WITH BINARY 10001111
        TRIS     06              ;COPY W INTO TRIS B TO SET PORT
                                 ;B6, B5, AND B4 AS O/P OTHERS AS I/P

        MOVLW    0X00            ;LOAD W WITH 00
        MOVWF    0X07            ;COPY W INTO PORT C TO SET ALL 0s
        MOVWF    0X06            ;COPY W INTO PORT B TO SET ALL 0s

                                 ;CHECK THE SWITCHES IN COLUMN A
SWCOL1  BSF      0X06,4          ;SET BIT 4 OF PORT B TO LOGIC 1
        BTFSS    0X06,3          ;TEST BIT 3 OF PORT B
        GOTO     TNOFF           ;IF IT IS 0 GO TO TURN OFF CODE
        BCF      0X07,0          ;IF IT IS 1 PREVIOUS LINE IS SKIPPED
                                 ;AND SET C0 TO 0 TO TURN ON LED
        GOTO     SWCOL1          ;LOOP

TNOFF   BSF      0X07,0          ;BUTTON IS NOT PRESSED SET C0 TO 1
                                 ;TO TURN OFF LED
        GOTO     SWCOL1          ;LOOP

        ORG      1FF             ;RESET ADDRESS
        GOTO     START           ;GO TO START POINT
        END
```

Listing 5. Program to read the hash key and operate Channel 1 l.e.d.

critical applications, or long delay loops which will cause tedious boredom!

Modify the .ASM file so that 0XF1 is loaded instead of 0XFF, run the XA program again, then press L to reload, and again repeatedly press S to single step through the new code. This time only one of the four l.e.d.s will turn on and off. Try other changes, possibly including some deliberate errors and see the codes generated in the .ERR file.

PROGRAM INSTRUCTIONS

The codes such as MOVLW are instructions that the PIC16C54 carries out. There are only 33 of these, but as almost one million can be executed in one second (using a 4MHz clock speed), they can be made into powerful combinations.

This article is intended only to illustrate some of the basic options so that the PIC-DATS system can be operated, and code can be written, assembled, corrected (debugged) and run. The real work of learning the instructions, their limitations and applications, is down to the user.

Having produced a program which turns the outputs on and off, its development into one which produces a simple chase sequence is relatively simple, as is illustrated by the program PICA_B.ASM, shown in Listing 4.

The listing file .LST is not printed here to save space, but it can be produced by running MPASM as before.

A program which reads the # (hash) key on the unit's keypad and then switches the Channel 1 l.e.d as necessary is illustrated by PICA_C.ASM, shown in Listing 5.

This uses BSF and BCF instructions to set (make logic 1) and clear (make logic 0), respectively. It also uses the BTFSS instruction, which tests the state of an I/O port line and skips one instruction if the I/O line is set to logic 1.

By following these examples, and those on the software disk, it will be possible to increasingly understand the nature of the programs and how they are built up. With the PIC-DATS system it is possible to experiment with the whole range of instructions and so build up a working knowledge in an efficient and easy manner.

The other keys on the unit's keypad are read in a similar way, as is the Zero Volt Crossing signal. The reading of the setting of potentiometer VR1 is more complicated, however. This is done by first setting Port RB0 as an output port and charging capacitor C5 to +5V, the logic 1 level. RB0 is then programmed as an input port and read by the software. At first it reads a logic 1 as C5 is fully charged, but gradually C5 discharges at a rate determined by VR1 until RB0 reads as logic 0. The time for this to happen indicates the setting of VR1.

In the Chaser Lights application, the time is used directly to set the chase speed, but the setting of VR1 could be used for other purposes in different programs. This process is only a simple and not very accurate analogue to digital converter (ADC), but it's cheap!

PROGRAMMING CHOICES

The PIC-DATS system comes with a built-in programmer. This allows the code which has been developed, or any other .HEX code files, to be programmed into any of the chips in the PIC16C5x family of microcontrollers.

The low-cost versions of the PIC16C5x chips are fully enclosed plastic devices and although they contain EPROM, cannot be erased. This makes them One Time Programmable devices (OTP). However, an alternative UV-Erasable type is available, and it is highly recommended that at least one of these is obtained. Such devices are not very expensive and are essential for serious programming where the cost of wasted OTPs with out-of-date programs could soon build up. (It should be noted that the PIC-DATS system cannot program the PIC16C84 electronically erasable (EEPROM) devices.)

To operate the programming part of PIC-DATS, first Quit the PICSIM5X program, and run the PICPROG program. As with PICSIM5X if Com 2 port is being used, it is necessary to type PICPROG 2.

Once running, the PICPROG program produces a screen display which has a number of self explanatory functions which can be selected by mouse or cursor keys. The commands can be explored one by one to see their effect (without using the "program" option).

There are several "CONFIGURATION" settings to be made. These allow the type of oscillator to be set up – normally select XT for 4MHz crystal or resonator operation, and the Watchdog timer to be Enabled or Disabled – set this to Disable.

The Code Protection option, if selected, makes it impossible for the code to be read out of the chip once it has been programmed. It is an important security feature, but when code is being developed it is useful to Disable the protection so that the code can be checked and identified. It is possible to Enable just the Code Protection later on, once a prototype has been tested.

Before using the PIC-DATS as a programmer it is essential to disconnect any other hardware by removing the 40-way IDC header connector. This must be done before inserting any devices into the programming sockets.

PROGAMMING THE PIC

To program a PIC chip, first insert the device into the appropriate socket - taking care to put it the right way round. Then set up the required configuration and select the wanted file. The file is found in the same way that PICSIM5X finds its files and so is dependant upon the correct setting of the .INI file.

The device being programmed is not powered until the program or read commands have been entered. Up until then the socket is "cold" and the chip can be inserted or removed without danger of damage (provided normal anti-static handling precautions are observed).

Downloading the program into the chip is fast and is indicated by an l.e.d. (D2) next to the programming sockets. The screen display shows the result of the programming.

When program downloading has been completed, make sure the target system is switched off, and plug in the programmed PIC device. Switch on, and if all is well the hardware will come to life and operate as a stand alone system.

After many years experience in the use of microcontrollers, it still delights (and sometimes surprises!) the author when a Target System suddenly takes on its own new personality and springs to life.

It is hoped that this same satisfaction will be achieved by all readers who are prepared to put in the necessary time and effort.

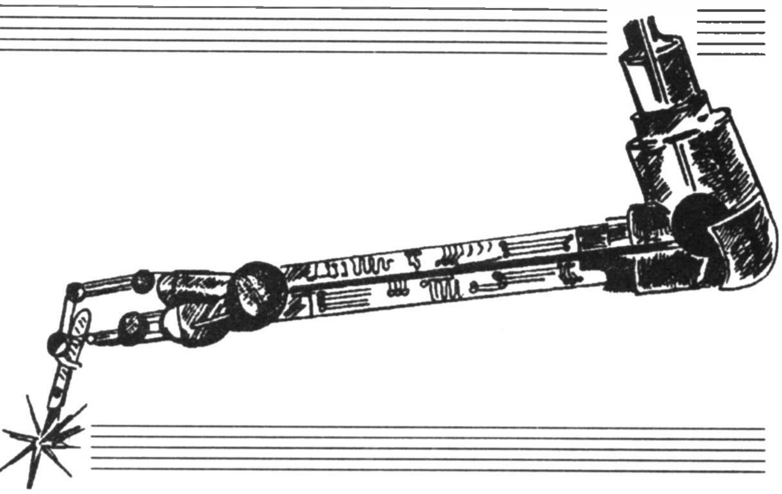
CORRECTION

In Fig. 4 last month the pin notations for transistors TR1 and TR3 should read in order of *b, c, e* (top to bottom).

Resource

See *Shop Talk* page for details on how to obtain a complete kit, the software programs and pre-programmed PIC microcontroller for this project.

CIRCUIT SURGERY



ALAN WINSTANLEY

Our two-way "Surgery" of readers' questions and comments looks at a "message reminder" function for the popular Voxbox project. We also take the lid off diode terminals with some typical diode applications. Finally, the Surgery gets wired and goes on the Internet!

WELCOME to this month's *Circuit Surgery*, our two-way column full of advice, hints and general info. to share amongst the readership. Let's dip straight into the post-bag with this enquiry from ***Barry Timms*** of Vermillion, South Dakota, USA who posed a couple of questions to the Surgery.

Voxbox Upgrade

I have two technical questions and would be grateful if you could supply a response to both. Firstly, concerning the Voxbox *project of July 1994. It's mentioned that the addition of an l.e.d. to the circuit could indicate that a message is stored. I'm building this project and wondered if you could tell me where to connect the l.e.d. to provide this function.*

Secondly, could you clarify why you designate the terminals of a standard diode the way you do? I know that the polarities of most diodes and small rectifiers are indicated by a band marked around the cathode (k). Current flows through the diode from anode to cathode, but most textbook definitions of the cathode and anode electrodes seem to me to imply that current actually flows in the opposite direction!

Your *Voxbox* "Message Waiting" Indicator query first. This highly popular project was designed jointly by GEC-Plessey Telecomms engineers *Guy Dance and Jeremy Austin as their excellent contribution to the *Technology in Action Day* event, which aims to encourage engineering disciplines in British schools.

To recap, *Voxbox* is a fully solid-state recording unit which stores up to 20 seconds' worth of speech – a kind of talking memo pad! It uses the ISD1016 (16 seconds) or the ISD1020 (20 seconds) integrated circuit at its heart: the latter has a lower frequency sampling rate, so reproduction isn't quite as good.

The idea of a "jogger" l.e.d. to warn that a message is stored, might appeal to those who've already built this project. The authors' initial idea for an l.e.d. reminder was to simply use an on-off switch and an l.e.d., arranged to illuminate when the switch was in the "on" position.

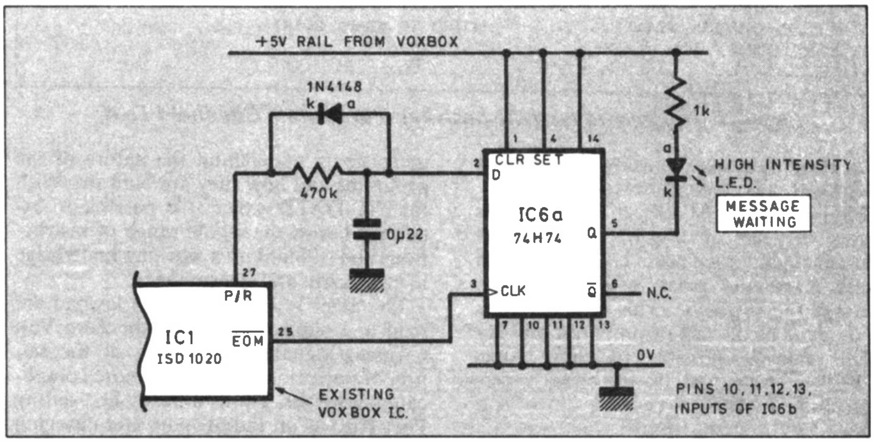


Fig. 1. Voxbox "Message Waiting" indicator modification.
(Courtesy Guy Dance and Jeremy Austin).

What they had in mind was that the user would record a message and switch on the l.e.d. as a reminder to others to play it back. The recipient switches it off again after inwardly digesting the *Voxbox's* pithy comments!

A high-efficiency l.e.d. could be used to reduce current consumption. Alternatively, you could try building a separate l.e.d. flasher circuit based on something like the LM3909 custom l.e.d. oscillator chip, driven by a separate 1·5V cell for economy.

Our project designers have subsequently proposed an "automatic" version which illuminates an l.e.d. when you record a message, and extinguishing it after it's been listened to. They suggested using a single D-type latch for this idea, see Fig. 1. The logic state of the record buttons is loaded into the latch when the "End of Message" (EOM) pulse is generated. In record mode, the EOM signal is initiated by the release of the Record button.

An *RC* network adds a short delay in the signal to allow the latch to catch the record signal. Thus, starting the recording mode will clock a Logic 0 into the latch and light the l.e.d., playback clocks a Logic 1 and extinguishes it again. The authors tried this idea and it seems to work OK, they say, but it's only intended for *single* messages since the l.e.d. indicator circuit obviously resets itself as soon as the first message is played back.

Looking at the mechanical side, the constructor could use half of a 74HC74 dual D-type flip-flop to implement this idea. The "extra" chip can be grafted into the circuit by mounting it on, say, a small piece of stripboard and simply soldering the connections over to the main p.c.b. using hook-up wire to connect to the copper track side.

It's best to link any unused inputs (e.g. on the unused half of the logic chip) to 0V for safety, rather than leave them floating. Again, try a high-efficiency l.e.d. for improved performance. Incidentally, the *Voxbox* printed circuit board is available from the *EPE PCB Service*, Code 885 £6.90 – see our *PCB* page elsewhere in this issue. My thanks to Guy and Jeremy for helping out.

**Guy was recently presented with a special award at the* Young Engineers Awards to Industry *in recognition of the active support and help he has given to the Young Engineers Club at Poole Grammar School.*

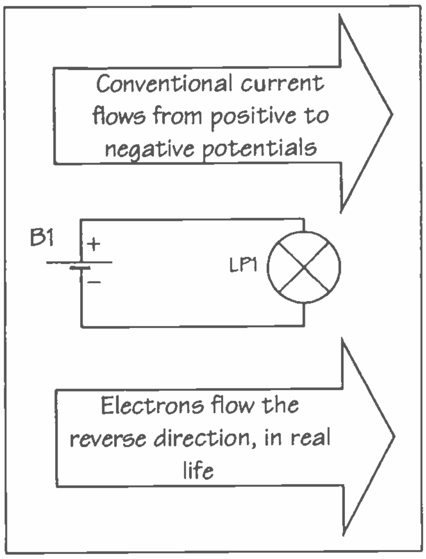


Fig. 2. Conventional current and electron flow.

Darned Diodes!

Turning to Barry's second question on diode markings, this highlights a common dilemma facing those involved with other science disciplines such as physics or chemistry. Just which way ***does*** electric current flow?

Consider a battery powered flashlight bulb, see Fig. 2. You can be forgiven for thinking that electric current flows from positive to negative. You might, however, be aware that in *real life*, current actually flows the other way, from the negative to the positive terminal of the battery.

Perhaps the pioneers seemed to assume from "Day One" that current flowed from the positive to negative poles. This has left us with a problem – the fact that what happens in our circuit diagrams is exactly the *reverse* of what a chemist or a physicist would expect!

Without delving too deeply into the physics, we now know that electrons *hold* a negative charge, and so they will flow out of the ***negative*** terminal and through the bulb ***towards*** the positive terminal (to which negative electrons are attracted). So, electric current flows towards the most positively-charged electrode, in real life. We call this "true life" current *electron flow*.

In our own context, though, it's only in such disciplines as atomic physics or electrochemistry that we would start to worry about real-time electron flow. Everybody in electronics still talks generally in what we call "*conventional current flow*" terms, where old-fashioned conventions have it that current is deemed to flow from positive to negative potentials. In other words, we're all fooling ourselves in electronics because in reality, electrons flow in the *opposite* direction, but this doesn't affect our use of components or our understanding of electronics at all.

> ***Stop Press!*** Mr. Timms subsequently advised by Internet (see later) that he'd succeeded with the *Voxbox* add-on as illustrated. He replaced the l.e.d. with a flashing type to achieve a noticeable visual signal for the message recipient.

One interesting way of looking at this is to compare the semiconductor diode and also its thermionic valve (vacuum tube) predecessor, see Fig. 3. In the case of an old-fashioned thermionic diode valve – probably easier to understand than a semiconductor one – what happens is that when heat is applied to the cathode by the heater filament, negative electrons "boil off" the cathode. These free electrons will be attracted towards the anode if a suitable ***positive*** "bias voltage" is applied to the anode: then, an *electron flow* is carried from cathode to anode. However, by tradition we would deem the *conventional current* to be flowing through the valve the other way, from anode to cathode.

On your marks...

Our standard markings for diodes and rectifiers are summarised in Fig. 4. Nearly always, the cathode is readily identifiable by a band or stripe at the cathode lead-out.

Occasionally, you see diodes marked with a series of stripes – a real nuisance if you're not familiar with them! A common striped component is the faithful 1N4148 diode, which may arrive colour-coded Yellow/ Brown/ Yellow/ Grey. This actually borrows from the resistor colour code for "4148" and the first *yellow* stripe indicates the *cathode*.

As an aside, when I was putting the finishing touches to a constructional project – actually a prototype "*Windicator*" Wind Speed Indicator (*to appear next month – Ed.*) – one light-emitting diode resolutely refused to light. It turned out that the l.e.d. (a standard 0·2in. type) had in fact been moulded wrongly, and the cathode identifying "notch" was actually next to the anode! Has that ever happened to any reader?

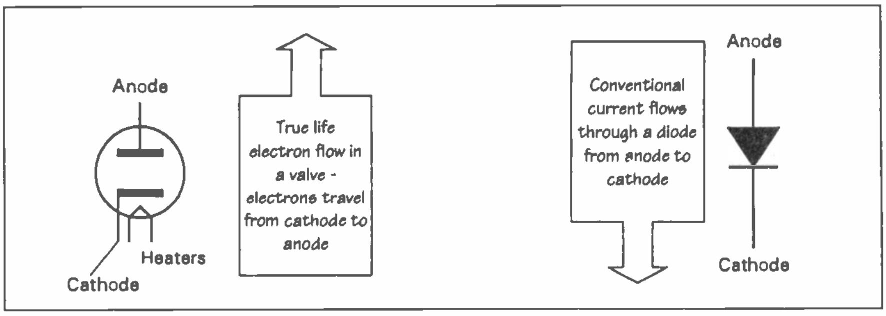


Fig. 3. Current flow through a thermionic diode valve and a semiconductor diode.

Any semiconductor physics book will tell you in more detail how current is carried by "holes" and electrons gathered within a semiconductor diode device, and how to bias them into operation correctly. As you probably know, it's necessary for the anode to be about 0·6V more positive than the cathode, before (conventional!) current can flow through a silicon diode at all.

Which way, and how, to mark the terminals of a diode, is perhaps a bit subjective. At one time – years ago now – we did mark the cathode terminal with a + symbol, but now we letter each pin-out with "a" and "k", to help the novice to remember which terminal is which. Perhaps it was too confusing when the cathode was marked as positive – since the direction of conventional current flow implies that this is the "negative" electrode.

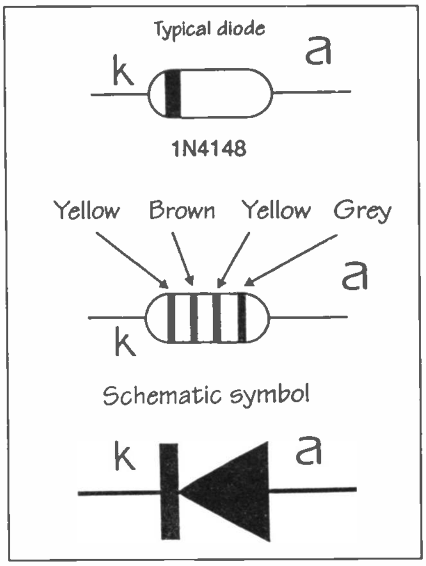


Fig. 4. Diode identification diagram.

If you come across an unusual l.e.d. such as a special-shape type, you can often identify the cathode by peering through the body of the l.e.d. and examining the l.e.d. chip assembly (if its body is transparent). You'll see that the light-emitting chip is mounted onto a tiny saucer-shaped reflector. The lead connected to this is the *cathode*. Look even closer, and you'll possibly just see a very fine wire jumping from the anode termination over to the l.e.d. chip in the reflector.

Clip Joint

Yes, my sub-titles get worse. My thanks to ***Mr. Charles Hill*** of Carmarthen, Wales who dropped us a line with the following question, again concerning the application of diodes. Mr. Hill sketched a typical demodulator circuit as depicted in Fig. 5.

I often see a reverse-connected diode used in a circuit but don't quite understand why it's necessary. I assume that the diode D1 is a form of rectifier, but why the reverse-biased diode D2. Could you shed some light on this, please?

Certainly – thanks for the letter. Everyone will have seen a diode reverse-connected across an inductive load such as a relay. This acts against the reverse voltage spike ("back e.m.f.") generated by the relay coil when it switches out of circuit.

The pulse can easily be *several hundred volts* instantaneous peak, which will

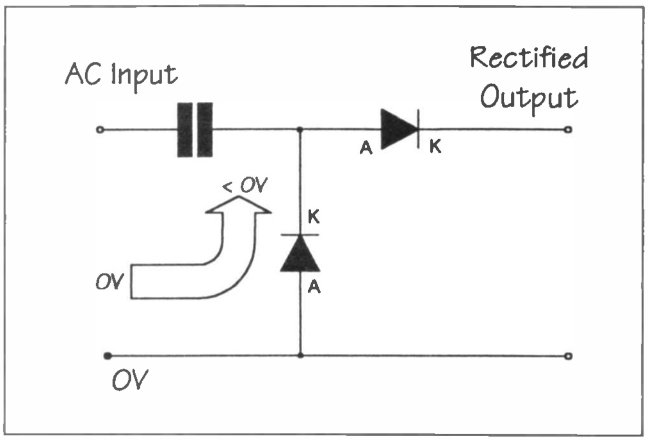


Fig. 5. Diode demodulator circuit.

destroy any sensitive semiconductors on the same circuit, so the diode shunts this away before any harm can arise. Anyone who followed our *Teach-In* series (featuring the *Mini Lab* and *Micro Lab*) might recall the back e.m.f. graphs we managed to capture on a storage C.R.O. (oscilloscope) and print out (*Teach In '93*, December 1992 issue showed a peak 300V reverse voltage generated by a 12V relay!)

In your circuit. Mr. Hill, diode D1 will rectify the signal and if the input signal then falls ***below*** 0V the "redundant" diode D2 will swing into action. The 0V rail is then in effect more positive than the signal voltage, so eventually the diode will become forward biased and clip the signal away.

Obviously this can only happen once a sufficient forward voltage has been reached. It might be included just as a safety precaution to prevent any transistors or i.c.s from receiving a reversed input voltage, or there could be a particular need to clip or detect the signal this way.

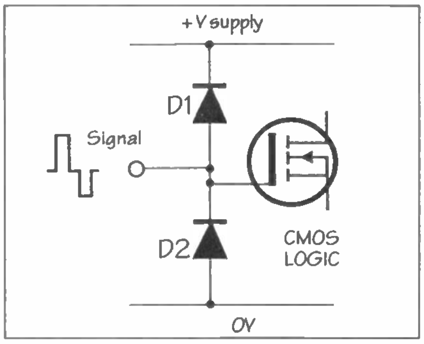


Fig. 6. CMOS Input protection diodes.

Exactly the same protection principle is utilised by CMOS i.c. manufacturers. Constructors will be aware of the well-known dangers of excess static electricity accumulation, since this can damage CMOS circuits, the electrostatic discharge punching a hole straight into the metal-oxide silicon chip and permanently killing it (I recently killed a small MOSFET this way, when I forget to use the anti-static wrist strap!). CMOS circuits mainly incorporate an *input protection diode* circuit on the input circuit which guards against excess electrostatic voltages.

For example, two diodes may be used in an arrangement which I simplified in Fig. 6. D1 would conduct if the input voltage exceeds the supply rail, whilst D2 will shunt away any input voltages which fall below the 0V rail. Under normal circumstances, neither diode would conduct. They're not foolproof "catch-alls", though, and you still need the usual anti-static precautions.

alan@ Internet

As I type this month's column into my PC, ready to download the article to "Headquarters", I'm pleased to announce the introduction of a new E-mail/Internet connection. This will be especially welcomed by many of our overseas readers. Now anyone with an E-mail connection can post queries to *Circuit Surgery* via the Internet.

You need a PC (or Mac, Amiga, Archimedes, etc.) which is fitted with a suitably compatible modem (these are dropping in price all the time: a decent BABT-Approved 14·4K type is less than £100 now) and a connection to an ordinary phone line. Users need to sign up with a service provider if they don't already have access via a workplace, college or University. There are several providers available in the UK and many more across Europe and the United States. Preferably choose one having a dial-in hub in your "local" phone area, so you only pay for cheap local rate calls.

Circuit Surgery is playing its modest part on the Internet, helping out with queries posted into various electronics UseNet newsgroups: these are open discussion areas where anyone can chip in with information, in answer to a query or comment. It's often a rewarding experience – recently a simple query brought forth replies and friendly help and advice from folks at the U.S. Johnson Space Center (NASA), not to mention Hewlett Packard, IBM and several Universities around the world! For our own part, for example, we solved an electronics query in Canada and received an enthusiastic "thank you" from a highly delighted student over there!

Here's the bit you've maybe been waiting for: you can now E-mail *Circuit Surgery* on **alan@epemag.demon.co.uk.** Whilst the speed of your message may be instantaneous (almost), *please* don't expect an *immediate* reply from your hard-pressed scribe, who does his best! Watch this space for news of future developments.

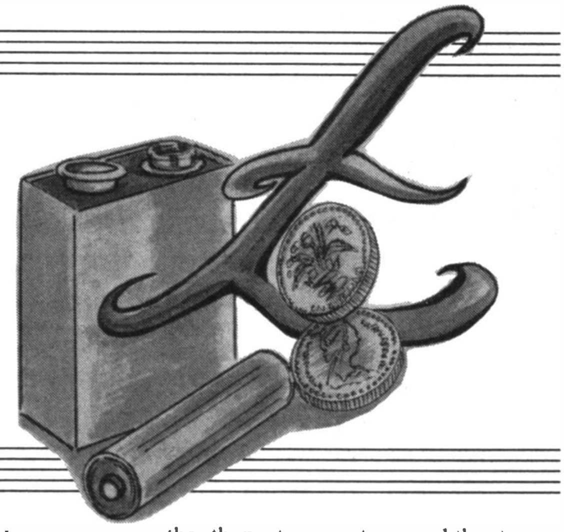
If you have any queries or questions which you would like us to investigate, or any advice, hints and tips which you think other readers would appreciate, you can now contact *Circuit Surgery* by writing to: Alan Winstanley, Circuit Surgery, Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset, BH21 1PF; or by E-mail/Internet, as above.

The usual conditions apply – as always, we cannot guarantee an individual reply unless material is to be published in this column though we'll always try our best to help.

Next time: an investigation of a precision rectifier with *no* forward voltage drop! Also, more news from our Internet feed. See you soon!

Constructional Project

AA TO PP3 CONVERTER



ROBERT PENFOLD

A low voltage d.c.-to-d.c. converter that provides a 9V output from one or two AA cells.

THE humble PP3 battery has for many years been a popular method of powering electronic projects. It represents a safe means of powering small electronic gadgets, and at one time it also represented a very inexpensive way of powering circuits that required only modest amounts of current (up to about 8mA).

Whereas electronic gadgets have tended to become more complex but relatively inexpensive over the last twenty years or so, the batteries to power them have become ever more expensive. In "real terms" batteries are probably no more expensive now than they were in the past, but relative to the devices they power, most batteries are now much more expensive.

This has led to circuit designers looking for lower cost methods of providing battery power. This has resulted in the increased use of AA (HP7) size cells in electronic gadgets.

Many radio sets, personal stereos, etc. now use low voltage circuits powered from two or three AA size cells. AA batteries provide a given amount of power much more cheaply than PP3s, or any of the other 9V layer type batteries.

In terms of amp/hour capacity an AA size cell typically has about five times more capacity than a PP3 battery, but at one sixth of the output voltage. A single AA cell therefore has slightly less capacity than a PP3 size battery, but is generally about 75 per cent to 80 per cent cheaper than an equivalent PP3 battery.

STEPPING UP

Where it is practical, simply designing circuits to operate on low supply voltages is the best method. This is not always possible though, and circuits must then be powered from a 9V battery, or a 9V supply derived from a 1·5V or 3V battery via a step-up circuit. This second method incurs the additional cost of the d.c. to d.c. converter circuit which provides the boost from 1·5V/3V to 9V, but due to the reduced running costs this additional outlay should be more than recouped in the medium term.

There are a number of small switching regulator integrated circuits which, on the face of it, would be ideal for this application. However, a careful look at the specifications of some common switching regulator chips reveals that few are capable of operating with an input voltage as low as 3V, and none can operate with an input voltage of around 1V to 1·5V. Fortunately, there are now a few switching regulator devices that are specifically designed for operation with an input provided by one or two 1·5V batteries.

REGULATED STEPS

The step-up regulator featured here is based on the LT1073CN8 switch mode regulator chip. It will operate with a 1·5V supply provided by a single AA cell, or a 3V supply provided by two AA cells in series.

The circuit is exactly the same in either case, with the regulator action of the device ensuring that the output voltage remains at about 9V regardless of which input voltage is used. The circuit will operate with output currents of up to about 15mA or so, even if the power source is only a single cell.

Bear in mind though, that the voltage step-up is obtained at the expense of a current step-down. Using a 1·5V input there is a voltage step-up by a factor of six.

When the input voltage falls somewhat due to ageing of the battery, the output voltage is maintained at about 9V due to the regulator action of the circuit. This gives an actual voltage step-up by a factor of about seven. Due to losses through the circuit the input current is likely to be closer to ten times the output current.

An output current of 15mA could therefore result in an input current of around 150mA, which would not give a very long operating life from even a "high power" AA battery. For output currents of more than about 7mA it is better to use two AA cells in series to provide an input potential of 3V (and a current step-down of only about five times), or to use a higher capacity cell such as a C-type or D-type.

STEP-UP BASICS

A d.c. voltage step-up is effectively achieved by converting the input signal to an a.c. type, feeding it through a step-up transformer, and then rectifying the output of the transformer to obtain a boosted d.c. output voltage. In most practical d.c. to d.c. converters the input signal is converted to what is really a "chopped" d.c. signal rather than a true a.c. type, and the step-up is often provided by a simple inductor rather than some form of transformer.

There is no obvious way in which a simple inductor can provide a voltage step-up, but it is actually possible. The point to bear in mind here is that a high *reverse* voltage is generated across an inductor if the current flowing through it is suddenly removed. This is caused by the rapidly decaying magnetic lines of force moving through the turns of wire on the inductor. It is the same effect that causes a high voltage to be produced across a relay coil when it is de-energised, necessitating the use of a protection diode.

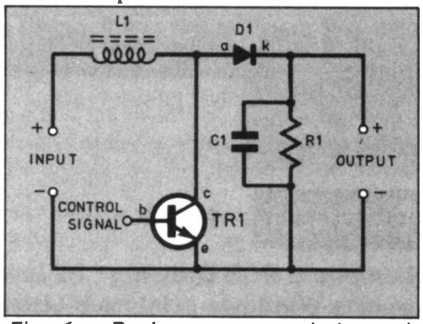


Fig. 1. Basic step-up switch mode circuit diagram.

The reverse voltage generated can be many times higher than the forward voltage used to energise the inductor, and a tenfold step-up is easily produced. Of course, you do not get something for nothing, and like a voltage step-up through a transformer, the boost in voltage is gained at the expense of reduced output current.

BACK TO BASICS

The basic configuration for a switch mode power supply that provides a voltage step-up is shown in Fig. 1. Transistor TR1 is the electronic switch, and the control signal is normally a squarewave signal, or something not too far removed from a squarewave signal.

The operating frequency of the circuit is generally much higher than the 50Hz mains frequency, and is typically about 20kHz. This relatively high operating frequency makes it easier to obtain high efficiency, and also enables a small inductor to be used.

However, the inductor must be a type intended for operation at about 20kHz. An r.f. choke will not give a worthwhile level of performance, and neither will an inductor intended for operation at the 50Hz mains frequency.

When transistor TR1 is switched on, inductor L1 is effectively short circuited across the input supply, and the current flowing through L1 rapidly rises. A high reverse voltage is generated across L1 when TR1 switches off. The left hand terminal of L1 is then negative, and the right hand terminal is positive. The voltage across L1 is therefore in series with the input supply, and is added to it.

With TR1 being repeatedly switched on and off at high speed, a rapid succession of high voltage pulses are generated at the collector (c) of TR1. These are fed to C1, which is a smoothing capacitor at the output of the circuit. Diode D1 couples the voltage pulses to C1, but it also ensures that TR1 does not short circuit the output during its "on" periods.

circuits that will work efficiently at such a low voltage.

Despite this the LT1073CN8 will operate with good efficiency at supply voltages as low as one volt. Consequently, it will work properly using a single 1·5V cell as the power source.

Furthermore, it will continue to work properly even when the battery is nearing exhaustion, and its actual output voltage is only about 1·2V. C1 is a decoupling capacitor on the input supply to IC1.

The regulator (IC1) has built-in current limiting at the input, and there is provision for a discrete current limiting resistor between pins 1 and 2. This facility is not used in this circuit though.

Pins 3 and 4 connect to the electronic switch, which is driven by an internal oscil-

COMPONENTS

Resistors
R1 390k
R2 10k
0·25W 5% carbon film

See SHOP TALK Page

Capacitors
C1 47µ radial elect. 16V
C2 100µ axial elect. 10V

Semiconductors
D1 1N5822 Schottky rec. diode
IC1 LT1073CN8 switch mode d.c. to d.c. adj. regulator

Miscellaneous
L1 100µH min. radial inductor
S1 min. s.p.s.t. toggle switch (see text)
B1 1·5V or 3V battery (see text)
Stripboard 0·1in. matrix, size 22 holes x 14 copper strips; 8-pin d.i.l. socket; battery holder; single-sided solder pins; multistrand connecting wire; case to choice; solder etc.

Approx cost guidance only **£10**

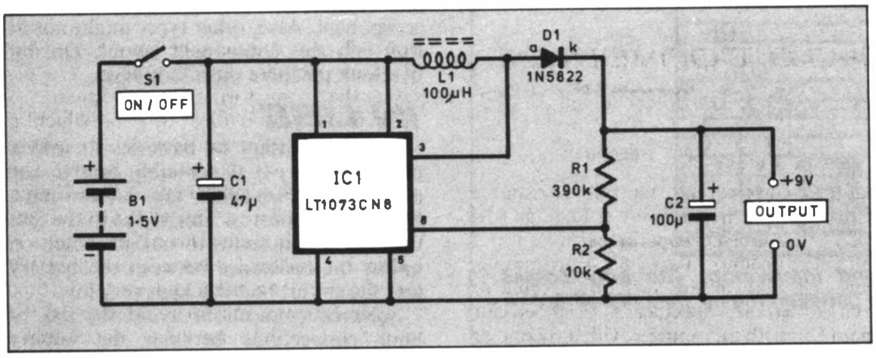


Fig. 2. Complete diagram for the AA to PP3 Converter.

With this basic configuration the output voltage is dependent on a number of factors, such as the input voltage, the switching frequency, and the precise characteristics of inductor L1. Practical switch mode power supplies are almost invariably based on integrated circuits which include a regulator circuit that provides a more predictable output voltage.

Regulator R1 is a load resistor, and it is not an essential part of the basic step-up circuit. It is required with many practical switch mode power supplies in order to ensure that there is always sufficient output current to keep the series regulator working properly. Often this resistance is provided by a feedback circuit, which is likely to be part of the internal circuit in the case of a fixed voltage regulator.

CONVERTER CIRCUIT

The full circuit diagram for the AA To PP3 Converter is shown in Fig. 2. B1 is shown as being a 1·5V battery but, as explained previously, the circuit will work just as well with a 3V supply. S1 is the On/Off switch of the unit in which the converter is used, and the addition of the converter will obviously necessitate rewiring of this switch.

The on/off switch could simply be left on the output side of the unit, since the quiescent current consumption of the circuit is under 200µA. However, this would result in some reduction in battery life, and it is safer to have the circuit switched off when it is not in use.

The LT1073CN8 device used for IC1 is a switch mode regulator which is specifically designed for this application. It is difficult to produce semiconductor circuits that will work at all on supply voltages as low as 1·5V, and even more difficult to produce

lator circuit at frequency of between 15kHz and 23kHz. Inductor L1 and diode D1 are the equivalents of L1 and D1 in Fig. 1.

In order to obtain good efficiency it is important that D1 is a high speed device, and that it has a low forward voltage drop. A Schottky rectifier diode is therefore used for D1.

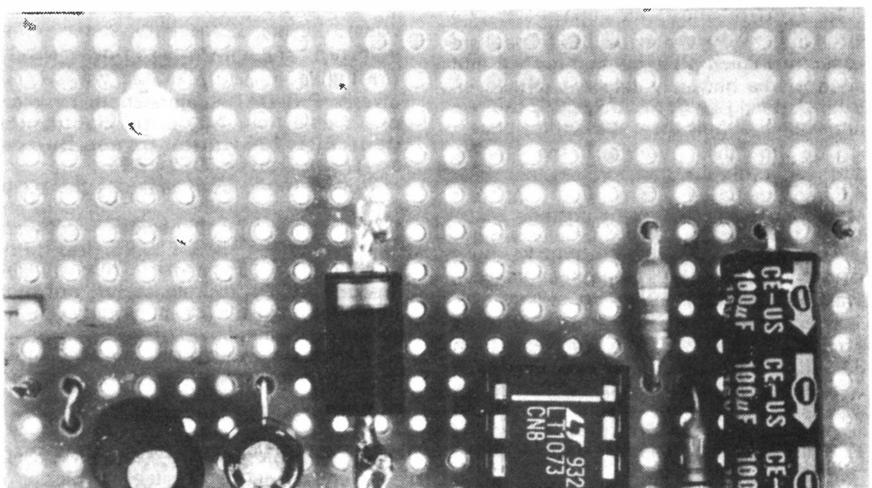
The circuit will work using an ordinary rectifier such as a 1N4002, but with greatly reduced efficiency. On the face of it, a Schottky *signal* diode would be adequate in this circuit, as it is only operating with low output currents. In practice though, a Schottky *rectifier* such as the 1N5822 gives significantly better efficiency.

OUTPUT

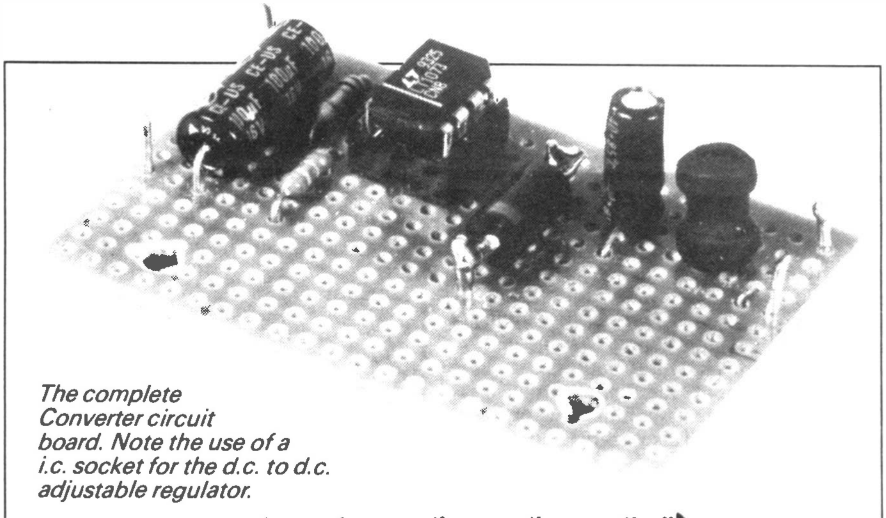
Smoothing of the output signal is provided by capacitor C2. A value of 100µF is more than adequate as the maximum output current is quite low, and the ripple frequency is relatively high. Resistors R1 and R2 provide a load across the output under quiescent conditions, and they are also the feedback network for the regulator circuit.

The output voltage is typically a little under 9V with the specified values, but there will obviously be some variation in the output voltage from one unit to another due to the component tolerances. If necessary, the output voltage can be boosted slightly by increasing the value of resistor R1 to 430 kilohms.

The built-in regulator is very efficient, and variations in output loading have very



Layout of components on the stripboard. The extra board space at the top is so that it can easily be mounted, on spacers, in a small plastic box.



The complete Converter circuit board. Note the use of a i.c. socket for the d.c. to d.c. adjustable regulator.

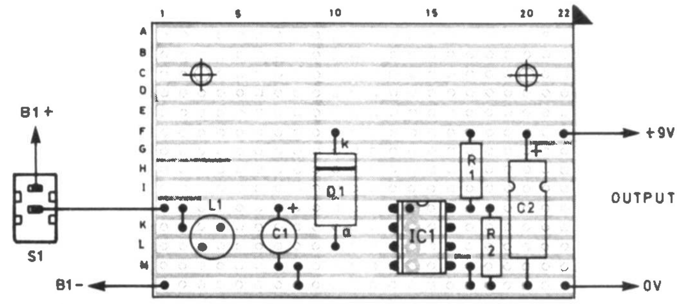


Fig. 3. Stripboard component layout and interwiring. The only breaks required in the underside copper tracks are between the i.c. pins at points J14 *to* M14.

little effect on the output voltage. In fact the output voltage is more stable than that from a real PP3 battery.

CONSTRUCTION

This simple circuit is easily built on a small piece of stripboard, and a suitable topside component layout and the four underside breaks in the copper strips is shown in Fig. 3. This layout is based on a board which has 22 holes by 14 copper strips. Construction of the board is not difficult, but there are a few points which must be borne in mind.

The 1N5822 rectifier diode used for D1 has exceptionally heavy gauge leadout wires. These are presumably designed to aid a very low voltage drop when the device is used at high currents, but they simply make the component a bit awkward to deal with in this case. D1's leadout wires are too thick to go through the holes in the stripboard!

One possible solution would be to enlarge the appropriate two holes, but it was found easier to fit these holes with single-sided pins, and then connect D1 to the pins. This does not give particularly neat results, but it works well, and is risk-free.

The choice of component for IC1 must be a plain LT1073CN8, and ***not*** an LT1073CN8-5 (which has a fixed output potential of 5V). IC1 is not a static sensitive component, but it is not a particularly cheap type either. Therefore, it is strongly recommended that an i.c. holder be used for this component.

It is also recommended that only the specified inductor be used for L1 (see *Shop Talk*). The circuit should operate well using any 100µH inductor that is suitable for operation at around 20kHz and has a reasonably low resistance, but the circuit has only been tested using the specified component. Also, other types might not fit well into this component layout. Do not overlook the three short link-wires.

IN USE

The AA battery or batteries fit into a plastic holder. It is probably best to use a holder that has solder tags rather than a PP3 style connector. This is due to the fact that the circuit seems to stall at switch-on unless the resistance between the battery and the circuit board is kept very low.

Soldered connections avoid the risk of poor connections between the battery holder and the battery clip. The terminals which connect to the battery or batteries must be kept reasonably clean and free from corrosion.

This device should work well with most projects that require a 9V supply at no more than a few milliamps. It is less than ideal for use with radio equipment though, or any sensitive circuits that could be adversely affected by the signal that is inevitably radiated due to the switching action of the step-up circuit. □

SHOP TALK
with David Barrington

EPE Valve HiFi Amplifier

It is most important that constructors undertaking the *EPE Valve HiFi Amplifier* adhere to the correct ratings of the resistors listed in the components box. Brimistors are now considered obsolete technology and are not now generally available. However, Brian J. Reed (☎ *0181 393 9055*) can, we understand, supply them at a surplus price.

Due to their weight, the mains and valve output transformers are best ordered/purchased from your nearest Maplin shop to save on the postage costs. These transformers were specially wound by Danbury Electronics (DB424 and DB425) for Maplin, codes DM54J (Valve Mains) and DM35H (O/P Trans.).

The "chassis" diecast box and solid aluminium capacitors were purchased from **Farnell Electronic Services *(01279 626777)***. Solid aluminium capacitors are also stocked by many of our component advertisers. **Electro Supplies (☎ *0761 477 9272*)** can supply high voltage capacitors.

The purchase of the valves can be a bit tricky as prices will depend on where you make your purchase and it is probably wise to ring round our advertisers, such as Greenweld, Cirkit, Mauritron, ESR, Bull and M&B Electrical. One of the cheapest appears to be Colomor (☎ ***0181 743 0899***). Ham radio rallies are also a good source, but don't buy from specialist HiFi suppliers unless you have a large trust fund.

The Phase-Splitter p.c.b. is available from the *EPE PCB Service*, code 941.

PIC-DATS 4-Channel Light Chaser

A full kit of parts for the *4-Channel Light Chaser*, PIC-DATS demonstration project, is available from **Magenta Electronics, Dept. EPE, 135 Hunter Street, Burton-on-Trent, Staffs., DE14 2ST.**

The kit (code 855) includes the p.c.b., a "one time programmable" PIC chip and a disk containing all necessary software. The cost of the kit is £39.95 (less case), plus £3 for post and carriage. Also available separately is the disk containing the basic software and development programs for the sum of £3.99, including p&p.

The printed circuit board is available from the *EPE PCB Service*, code 942.

R.F. Signal Generator

Several components needed for the *R.F. Signal Generator* can be classed as special items and may not be available locally.

The first and probably most expensive of these is the Jackson type-O twin-gang air-spaced tuning capacitor. This is available from **Maplin** (code FF40T) or **Electrovalue, (☎ *01784 442253*)**, code 5250/2. The epicyclic reduction drive unit and pointer were purchased from Maplin, codes RX42V and HB47B respectively.

The presets should be as specified or they will not fit on the p.c.b. These were obtained through **Electromail, (☎ *01536 204555*)**, code 186-750. The neon LP1 was also ordered from the same source and is the "slim-line" type, code 576-614.

The only listing we have found for the high frequency f.e.t. type 2N5486 has also been Electromail, code 641-910. The 3VA mains transformer has twin 15V secondaries and came from the above source, code 210-796.

Capacitor C19 **MUST** be a type rated for continuous operation across the mains supply. These are usually classified as class-X or class-Y types and are stocked by most component suppliers.

The p.c.b.s are available from the *EPE PCB Service*, code 936 (R.F./Mod.) and 937a/b (Coil and Power Supply – pair).

AA to PP3 Converter

For best results it is recommended that only the specified components be used in the *AA to PP3* Converter project.

The switch mode adjustable voltage regulator IC1 must be a plain LT1073CN8, and not one with a suffix-**5** added to the type number. This device was purchased from **Electromail (☎ *01536 204555*)**, code 265-364.

It is important that the 1N5822 Schottky rectifier diode be used in this circuit. This was purchased from Maplin, code GX30H. The circuit will work with an ordinary rectifier diode, such as the 1N4002, but with greatly reduced efficiency.

The 100µH radial inductor is listed by Maplin code AH32K and Electromail, code 240-624.

Electronics from the Ground Up

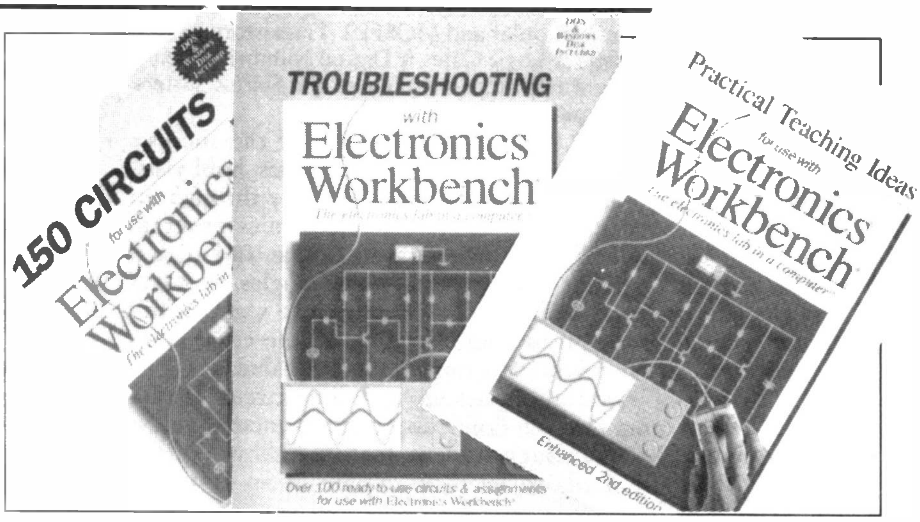
Mike Tooley, BA

Part 9

ELECTRONICS from the Ground Up is designed to provide you with a comprehensive and up-to-date introduction to the world of electronics. The series is based on *Electronics Workbench*, a remarkable software package that lets you use your PC to build and test a wide range of circuits.

In this final instalment we round-off the series by taking a brief look back at the earlier parts and suggesting some further reading for those wishing to explore the full potential of *Electronics Workbench*.

Back issues of earlier parts of this series are available – see *Back Issues* page.



A BRIEF RESUMÉ

Part One of Electronics from the Ground Up provided you with a brief introduction to electricity and electronics. Its five practical assignments aimed to familiarize you with the techniques for constructing simple circuits and making measurements with the basic test instruments provided in *Electronics Workbench (EWB)*.

Part Two dealt with d.c. and a.c. circuits and also described the use of the oscilloscope for measuring waveforms. This part also introduced capacitors and inductors and their use in a.c. and d.c. circuits.

Semiconductor diodes were introduced in Part Three. We investigated the behaviour of half-wave and full-wave rectifiers and developed these into complete power supply circuits incorporating smoothing and voltage regulation.

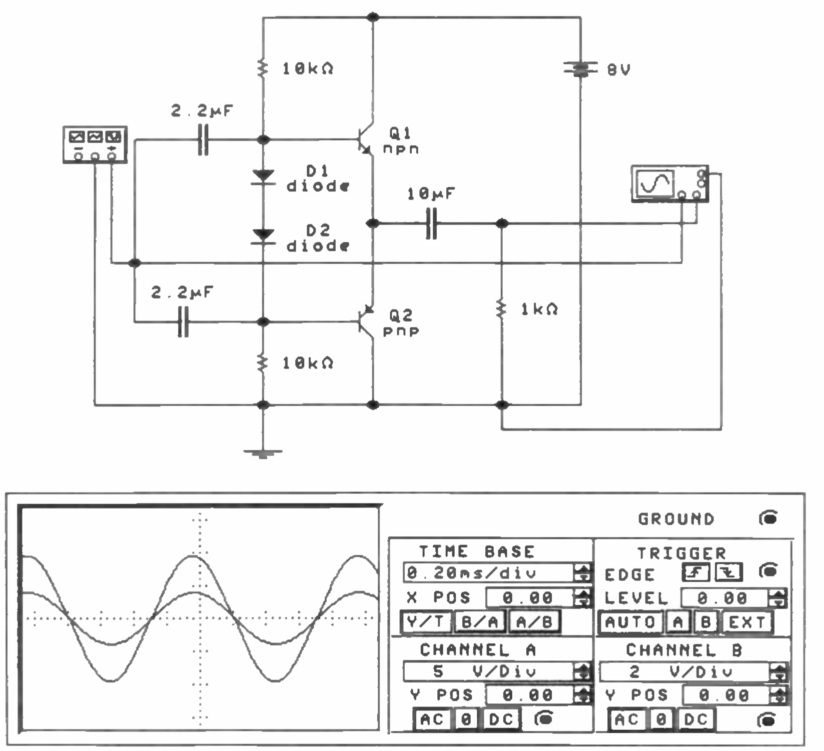


Fig. 9.1 Push-pull output stage from Electronics Workbench: 150 Circuits.

Transistors featured in Part Four where we also introduced the concept of gain and amplification. Understanding transistor operation is crucial to understanding most analogue circuits and it is worth revisiting this part if you intend to work with transistor circuits in the future (note that, to keep things simple, we did not cover field effect devices).

Integrated circuit operational amplifiers were explained in Part Five. We looked at a variety of circuit applications for operational amplifiers (op.amps) and showed how it was possible to design circuits to provide specific amounts of gain as well as an accurately defined frequency response.

Oscillators were described in Part Six where we investigated the behaviour of a variety of oscillator circuits including sinusoidal, pulse and square-wave types. Part Seven was devoted to logic gates, digital circuits, truth tables and Boolean algebra. Finally, Part Eight featured bistable elements and we illustrated their use in counters and shift registers. These last two parts are essential for those intending to work primarily with digital circuits.

FURTHER READING

Readers wishing to explore electronics further will be pleased to know that *EWB* is well supported with three books that provide information on extending the use of the package. Each book is supported with a disk containing circuit files for loading into *EWB*.

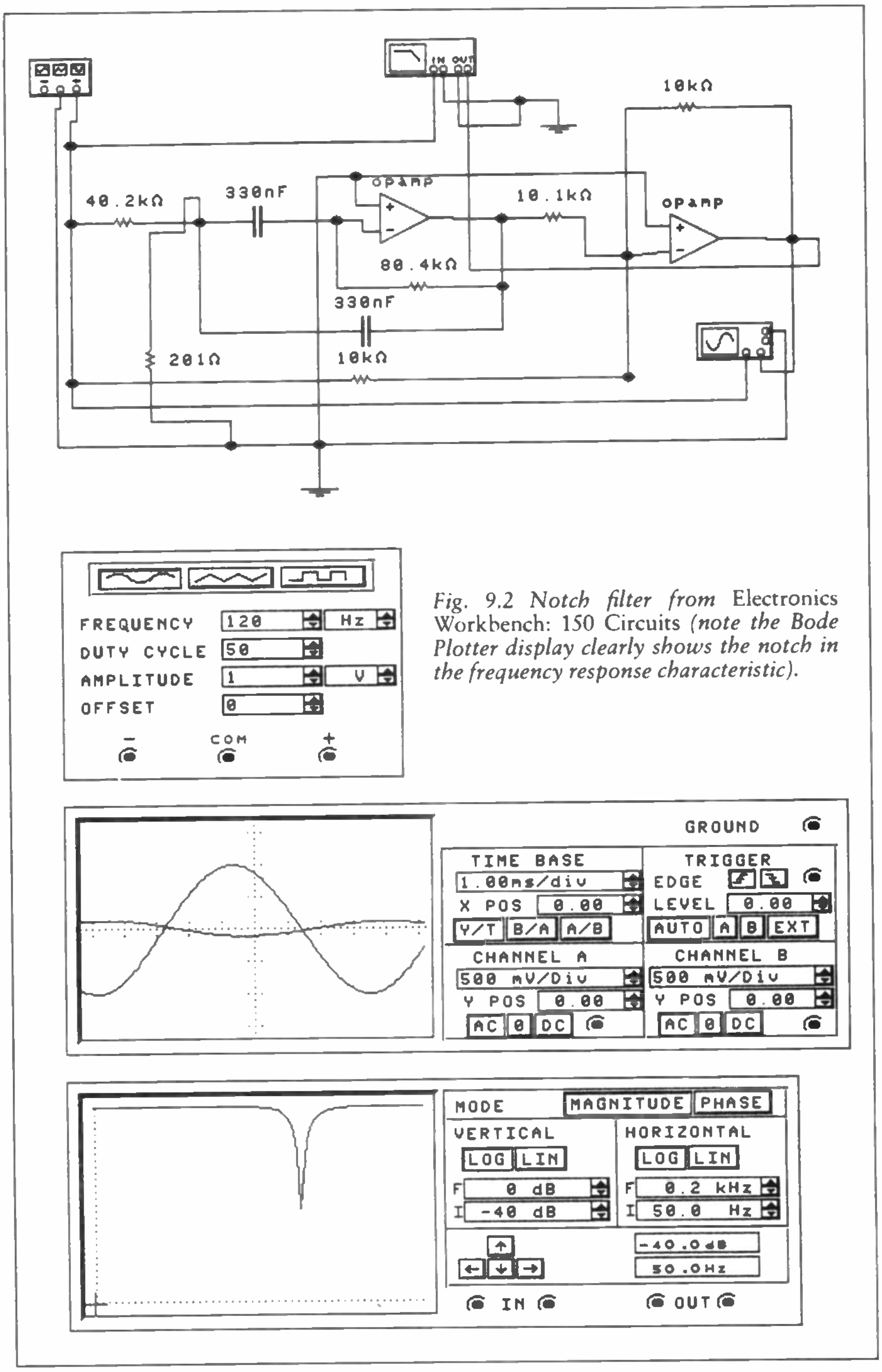
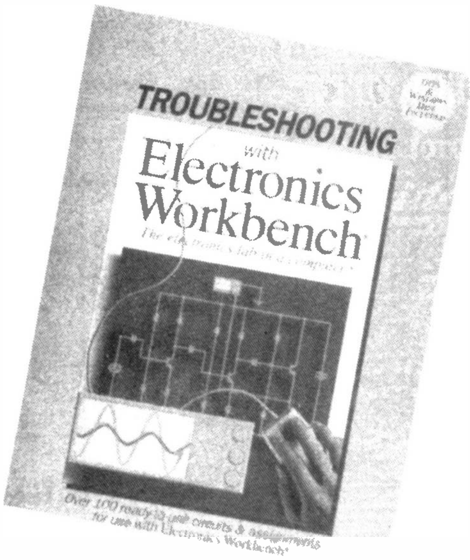


Fig. 9.2 Notch filter from Electronics Workbench: 150 Circuits *(note the Bode Plotter display clearly shows the notch in the frequency response characteristic).*



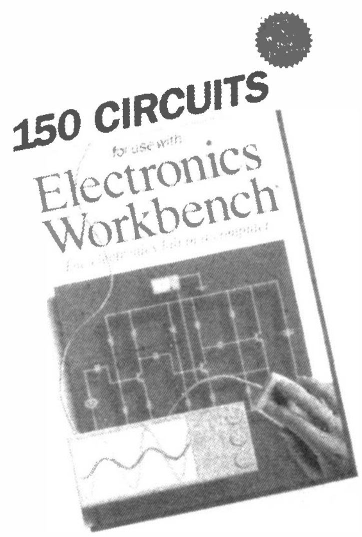
Troubleshooting with Electronics Workbench. ISBN 0-921862-27-X.

a real circuit. *Troubleshooting with Electronics Workbench* introduces the learner to troubleshooting techniques and, most important, it develops the logical thinking process that results in rapid and efficient fault finding.

Finally, *Electronics Workbench: Practical Teaching Ideas* by Allan Souder (published by Interactive, ISBN 0-921862-22-9) contains a teacher's perspective on the use of *EWB* in the classroom. Allan Souder shares his experiences with readers in the form of exercises, examples and assignments. Teachers will find this a particularly useful book as it shows how several important principles and concepts can be brought to life with the aid of *EWB*.

UPGRADING

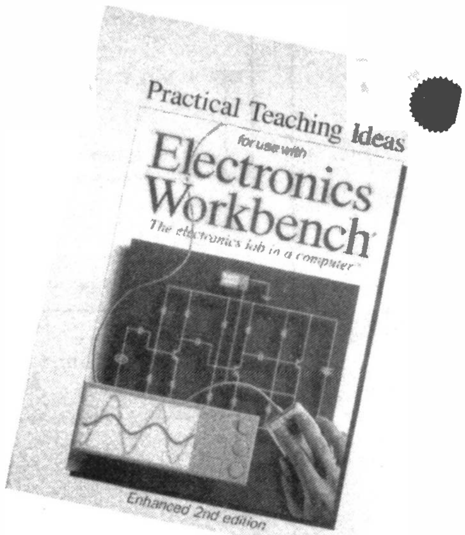
If you intend to make further use of *EWB* you should seriously consider upgrading to the full package. The full package will provide you with a full range of test equipment (including Bode Plotter and Logic Converter that were not included in the cut-down version) and an unlimited Parts Bin. The package also comes with some additional support materials, "on-line" help, and an excellent User's Guide which includes tutorials, a reference section and troubleshooting information. A



Electronics Workbench: 150 Circuits. ISBN 0-921862-24-5.

Electronics Workbench: 150 Circuits (published by Interactive, ISBN 0-921862-24-5) contains 150 of the most frequently-used electronic circuits. The book contains a typical screen shot of each circuit as supplied on the accompanying floppy disk. Test equipment settings and displays also feature as does a brief written explanation of each circuit together with some further suggestions for experimentation. In many respects, this book begins where Electronics from the Ground Up ends and provides enormous scope for further experimentation.

If you are interested in servicing or fault-finding, *Troubleshooting with Electronics Workbench* by Don Browning (published by Interactive, ISBN 0-921862-27-X) is just for you! This book contains more than 100 ready-to-use circuits and assignments. However, unlike *Electronics Workbench: 150 Circuits*, the circuit files in this book are not working! Instead, you are left to determine the cause of the fault using the test equipment exactly as you would on



Electronics Workbench: Practical Teaching Ideas: ISBN 0-921862-22-9.

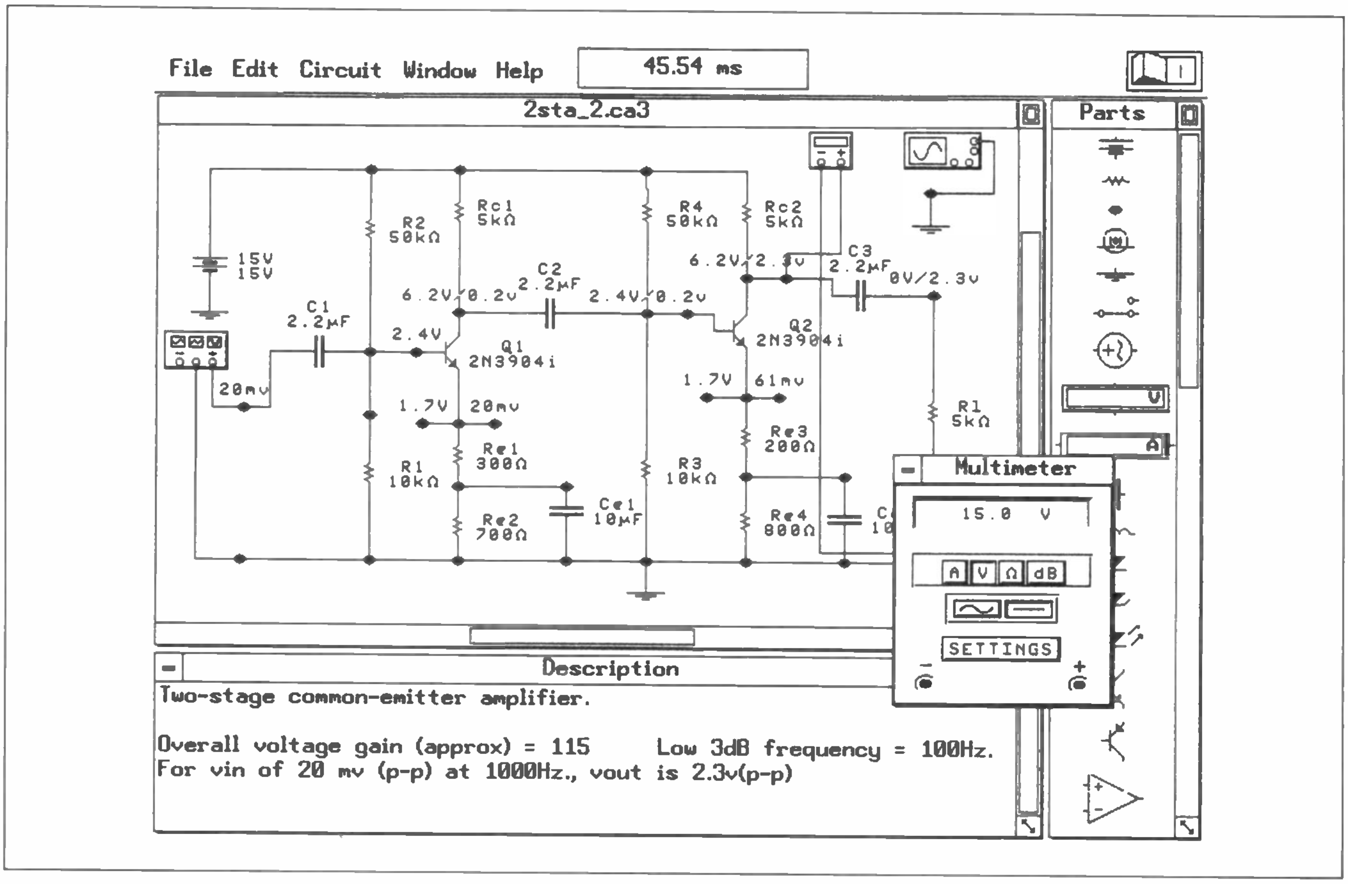


Fig. 9.3 Fault-finding a two-stage common-emitter amplifier with Troubleshooting with Electronics Workbench.

"Quick Reference Card" is also supplied. You can use this to get started, or simply keep it by you for reference.

Interactive demonstrations are included on the disk that comes with the package. These examples give you a quick overview of *EWB* and show you how to build and test circuits. Sample circuits (also supplied on the disk) include approximately 20 typical analogue and digital circuits. You can examine, test and modify them or use them as building blocks for your own circuits.

Tutorials are included within the User's Guide. These are invaluable for those who may be unfamiliar with a graphical user interface or who may have had little or no experience of building and testing electronic circuits. For registered users, there is the User Support "help-line". A Bulletin Board Service (BBS) is also available to provide the latest product information. Users can leave questions for answer via the BBS and circuits may be down or up-loaded for sharing with other users.

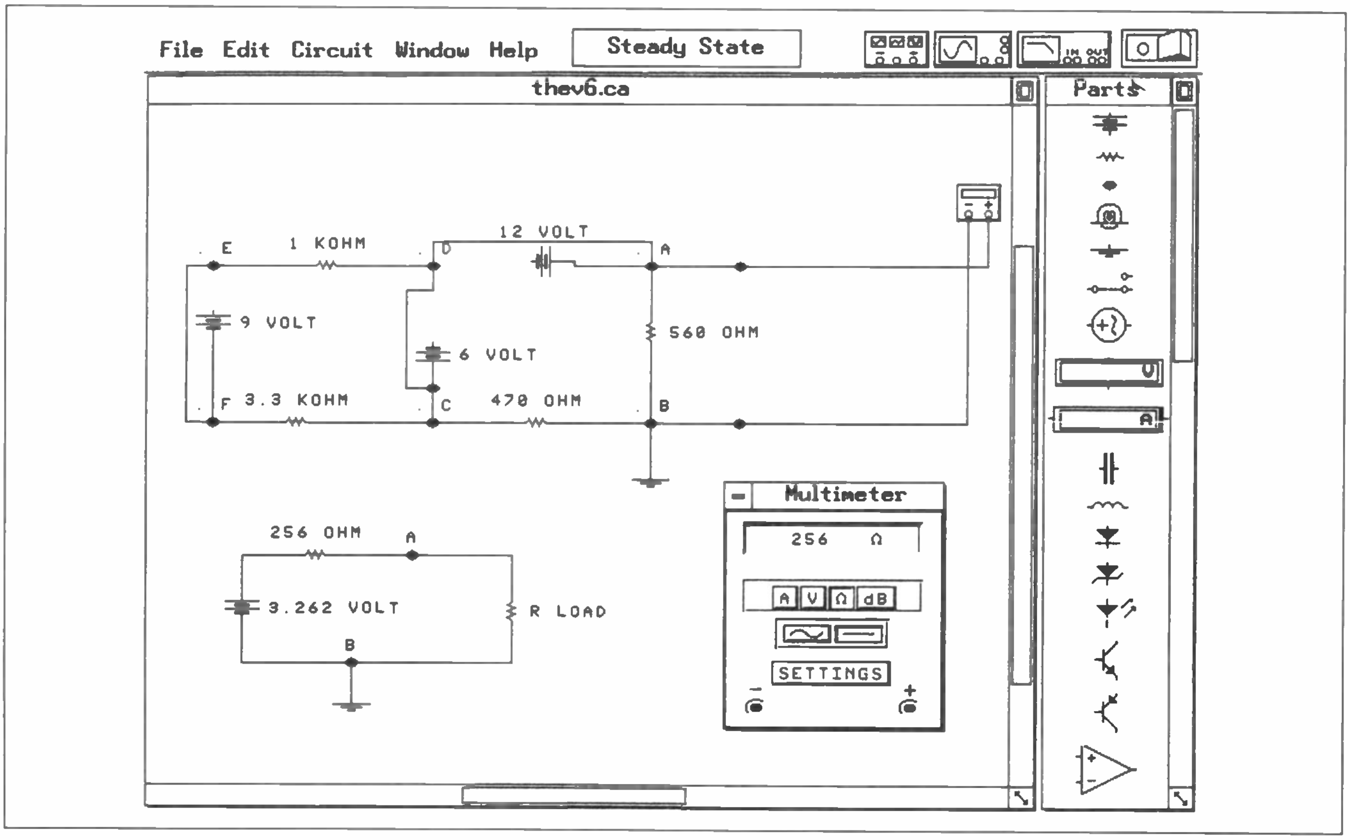


Fig. 9.4 An example of Thevenin's Theorem in Electronics Workbench: Practical Teaching Ideas.

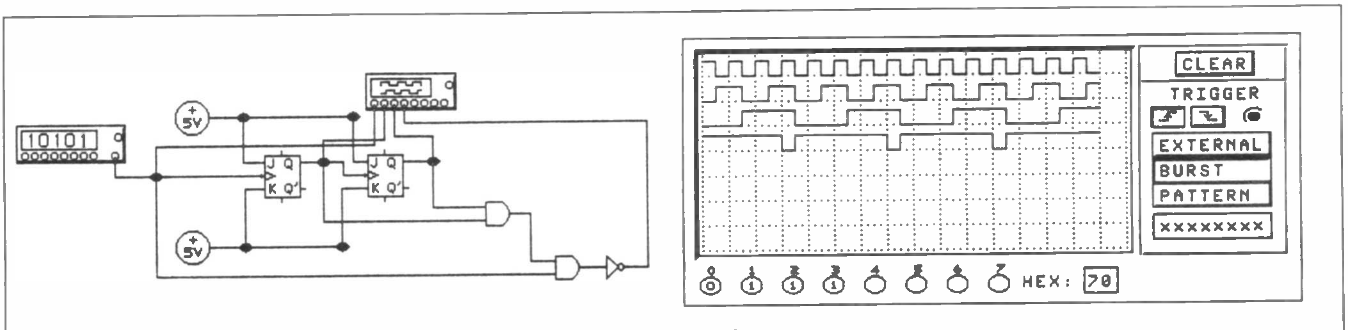


Fig. 9.5 Answer to last month's Brain Teaser.

The full version of *EWB* offers a wide choice of printing facilities. You can print the current display (exactly as it appears on your computer's screen) or print out circuit descriptions, component lists, parameters associated with the component models, circuit diagrams, and test equipment displays. You can also convert your display into a PCX file for loading into one of many popular paint, graphics, CAD or DTP packages.

Finally, it is important to note that the full version of *EWB* is copy protected and must be uninstalled if you wish to move the software to a different platform. However, if you want to use *EWB* at two different locations (for example, at work and at home), you need not delete all of the *EWB* files when uninstalling, just the authorization code.

CIRCUIT DESIGN

One of the questions asked by several readers relates to what else you can do with *EWB* once you have finished using it as a learning aid. One of the advantages of the package as far as the hobbyist and enthusiast is concerned is that it permits breadboarding of circuits before laying them out for final prototype construction. There are several stages to this process:

1. Sketch the basic circuit design and identify component values
2. Select the required components from the Parts Bin and place them within the breadboard area
3. Change the component values (from their default values to those that you require)
4. Select the appropriate models for the active components used in the circuit
5. Connect the circuit
6. Select the instruments that you require to test the circuit (often you will start with the multi-range meter in order to check supplies and bias voltages, etc.)
7. Place the test instruments on the breadboard and select appropriate ranges
8. Refine the circuit layout (i.e., move the components and test instruments so that the symbols, component legends, and wiring all fit neatly and logically within the breadboard area)
9. Test the circuit and, where necessary modify component values as appropriate
10. Evaluate the circuit and check against specification
11. Print out the circuit diagram and components list (don't forget to save the circuit for future reference!).

Answer to last month's Brain Teaser

Last month's Brain Teaser involved the design of a logic circuit arrangement that would generate a waveform with a ratio of high to low period of 7:1. Fig. 9.5 shows the solution arrived at using the full version of *EWB* together with the logic analyser display (the output waveform is the lowest trace).

OBTAINING EWB

More information about *Electronics Workbench* and its associated books can be obtained from: Robinson Marshall (Europe) PLC, Nadella Building, Progress Close, Leofric Business Park, Coventry CV3 2TF. Tel: 01203 233216.

INTERFACE

Robert Penfold

A COMPUTER operated model train controller of the pulsed variety can be quite a complex set up. Such a system can be based on a conventional pulse width modulation (p.w.m.) controller, with the control voltage being provided from an output port of the computer via a digital to analogue converter. This involves quite a lot of hardware, and is relatively expensive, but it does have a significant advantage.

The speed of the train is controlled by simply outputting suitable values to the output port. High values give fast speeds, and low values give slow speeds or stop the model train. This method of control is not particularly taxing on the computer, which can therefore be a slow machine running a slow programming language. The demands on the computer are so low that there will still be plenty of computing time left for other tasks, such as controlling signals, or providing some sort of graphics display.

On The Pulse

There is an alternative approach that requires far less hardware, and this is to use a software routine to generate a suitable pulse signal on a digital output line. The signal is then used to drive the train via an amplifier and a buffer stage. This method is quite simple to implement in theory, since the pulsed output signal is an extremely simple type.

To drive the train at half power a squarewave signal is used. With its one-to-one mark-space ratio the average output voltage squarewave is half the supply potential. Using a higher mark-space ratio gives an output signal that is high for a greater proportion of the time. This gives a higher average output voltage, and more power is fed to the motor in the train. Using a lower mark-space ratio give a lower average output voltage, and less power to the motor in the engine.

Although one might reasonably expect the pulsed signal to interfere with the correct operation of the motor, this does not actually happen. In fact a pulsed signal gives better low speed performance, with less likelihood of stalling. Pulsed control also gives more realistic starting, with no jump-starts. Very low pulse speeds must be avoided as they would result in the motor operating intermittently.

High pulse rates are also unsuitable, as they can result in strong radio frequency interference being radiated from the tracks. Also, the motor provides a highly inductive load which could have a high impedance at high frequencies. This would give an inadequate current flow. In practice, any frequency from around 50Hz to 500Hz or so is usually satisfactory.

In days gone by, this software based method was not possible using an ordinary BASIC language due to the slow operating speed of an interpreted BASIC. Producing an output signal having a suitable range of mark-space ratios was possible, but not at a high enough frequency to give good results.

However, modern computers are much faster than the 8-bit machines of about ten years ago. A few experiments using a 33MHz 80386 based PC running GW BASIC and Q BASIC programs showed that it is possible to obtain quite good results using a software generated pulse signal. Results should be at least as good using a faster PC, but it might not be worthwhile using anything less than an 80386SX based PC running at about 20 or 25MHz.

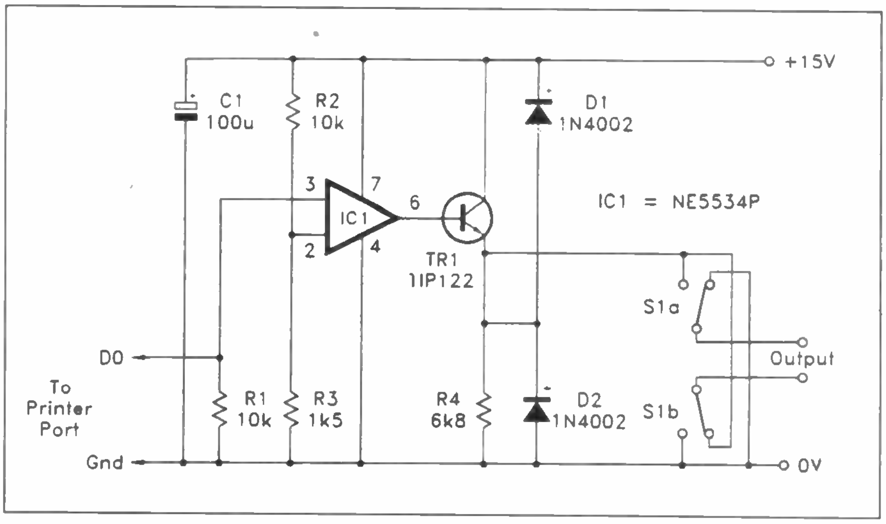


Fig. 1. Circuit diagram for the pulsed controller interface.

Hardware

The circuit diagram for the pulsed controller interface is shown in Fig. 1. IC1 is an operational amplifier, but in this circuit it is used as a voltage comparator. IC1 must be a device that can operate properly with low input voltages. The NE5534P (and NE5534AN) are suitable, but most other operational amplifiers will not work in this circuit.

Resistors R2 and R3 provide a reference potential of between 1·5 and two volts to IC1's non-inverting input. In other words, a voltage that is between the valid logic 0 and logic 1 levels. IC1's non-inverting input is fed from the digital output of the computer. Obviously any latching output will do, but it will be assumed here that the interface is driven from D0 of printer port one (LPT1).

When the digital output is high, IC1's non-inverting input is taken above the reference level, and the output of IC1 goes high. When the digital output is low, IC1's non-inverting input (pin 3) is taken below the reference level, and the output of IC1 goes low. Transistor TR1 is an emitter follower buffer stage at the output of IC1. This is a high gain power Darlington device, and although the drive current from IC1 is only a few milliamps, TR1 can drive the motor with output currents of up to two amps. Resistor R4 provides TR1 with a load resistance when the output of the controller is left unconnected. Diodes D1 and D2 suppress any high voltage transients that are generated across the inductive load provided by a small d.c. motor.

Switch S1 is the forward/reverse switch, and this can be a set of d.p.d.t. relay contacts if direction control via the computer is required. Fig. 2 shows the circuit diagram for a suitable relay driver. The relay can be any 12 volt type which has a coil resistance of about 250 ohms or more, and d.p.d.t. contacts of adequate rating. Again, this circuit can be driven from any latching digital output, but we will proceed on the assumption that it is driven from the "Initialise"

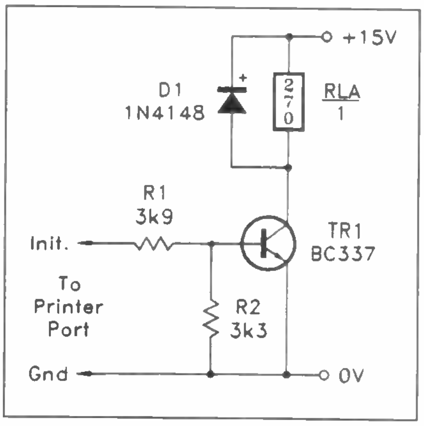


Fig. 2. Direction control relay driver.

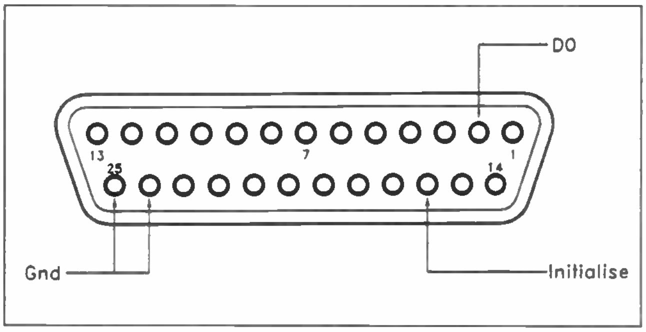


Fig. 3. Printer port connections for the pulsed train controller.

output of LPT1. Fig. 3 provides details of the connections to the printer port for both the pulse controller interface and the relay driver.

Both circuits require a 15 volt supply which must be reasonably stable and ripple-free. The maximum output voltage from the controller is about 12 volts due to the voltage losses introduced by IC1 and TR1. For small gauge trains a maximum supply current of one amp is adequate, and the mains power supply circuit of Fig. 4 can then be used. Transformer T1 should have a secondary rating of at least two amps, and FS1 should be an "anti-surge" or "time-delay" fuse.

The same circuit can be used for larger gauge locomotives that require up to two amps, but transformer T1 must then have a secondary rating of at least four amps, and fuse FS1 should have a rating of two amps. Also, diodes D1 to D4 should be 1N5402 rectifiers, and IC1 should be a 78S15 regulator (which is available from RS/Electromail). The normal safety precautions should be observed when building and using the power supply. Beginners should not undertake construction of a mains powered circuit such as this.

Transistor TR1 and regulator IC1 in the power supply must be fitted with heatsinks. For a one amp controller a couple of bolt-on heatsinks having a rating of about 10 or 12 degrees Centigrade per watt will suffice. For a two amp version it would be advisable to use larger heatsinks having a rating of about six to seven degrees Centigrade per watt. Note that the heat-tab of TR1 connects internally to its collector terminal. The heat-tab of the voltage regulator connects internally to its common terminal.

Software

The GW BASIC/Q BASIC program shown in the software listing provides speed control, and direction control as well if the relay driver circuit is included in the controller.

The first part of the program simply clears the screen and provides on-screen instructions on how to control the program. Lines from 90 to 160 produce the output waveform on output D0 of the printer port. Two FOR . . . NEXT delay loops set the high and low output times. The number of loops performed in each of these, and hence the mark and space times, are controlled by variables "M" and "S". They are each given an initial value of 50, giving a one-to-one mark-space ratio. Other values can be used at lines 90 and 100, but the two values must total 100.

The GOTO instruction at line 190 continuously loops the relevant part of the program. However, lines 170 and 180 detect key presses, and take the program into the subroutine starting at line 200. If the "A" key is pressed, "M" is increased by one, and "S" is decreased by one, giving increased output power. Pressing the "B" key has the opposite effect, with "M" being decremented by one, and "S" being incremented by one. This produces reduced output power.

Operating the "E" key brings the program to a halt at line 220. Lines 230 and 240 provide forward/reverse switching if the relay driver circuit is included. These lines detect presses of the "R" and "F" keys respectively, and set the "Initialise" output high or low. The purpose of lines 250 to 280 is to keep the values of "M" and "S" within acceptable limits.

Although the hardware and software are both pretty basic, the system provides excellent control, with smooth acceleration and deceleration. Results would probably be a bit slow and jerky using a slow PC. Using a fast 80486 or Pentium based PC it might be necessary to use higher values in the FOR . . . NEXT loops. Otherwise acceleration and deceleration might be too rapid. At minimum power the motor is not completely switched off, and it is still fed with very brief pulses. The power fed to the motor should be far too low to be of any practical significance though.

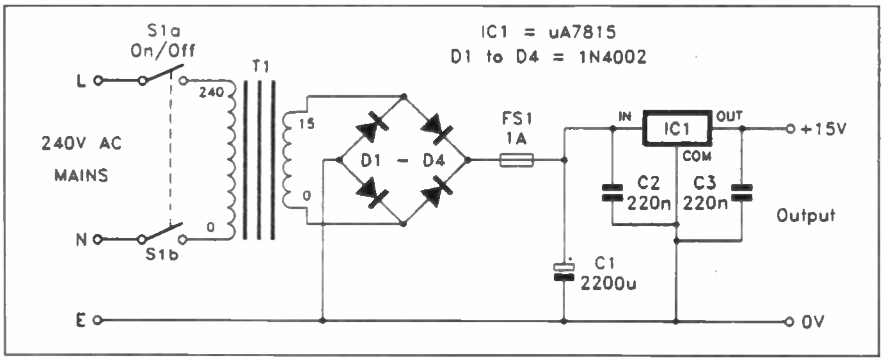
Software listing for generating pulses for Model Train Controlling.

```
10  REM SOFTWARE GENERATED
    PULSE TRAIN CONTROLLER
    PROGRAM
20  OUT &H378, 0
30  CLS
40  PRINT "PRESS 'A' TO ACCELERATE"
50  PRINT "PRESS 'B' TO BRAKE"
60  PRINT "PRESS 'E' TO END"
70  PRINT "PRESS 'F' FOR FORWARDS"
80  PRINT "PRESS 'R' FOR REVERSE"
90  M = 50

100 S = 50
110 OUT &H378, 1
120 FOR HIGH = 1 TO M
130 NEXT HIGH
140 OUT &H378, 0
150 FOR LOW = 1 TO S
160 NEXT LOW
170 A$ = INKEY$
180 IF LEN(A$) = 1 THEN GOSUB 200
190 GOTO 110

200 IF ASC(A$) = 97 THEN M = M + 1
205 IF ASC(A$) = 97 THEN S = S - 1
210 IF ASC(A$) = 98 THEN S = S + 1
215 IF ASC(A$) = 98 THEN M = M - 1
220 IF ASC(A$) = 101 THEN END
230 IF ASC(A$) = 114 THEN OUT
    &H37A,4
240 IF ASC(A$) = 102 THEN OUT
    &H37A,0
250 IF M > 100 THEN M = 100
260 IF M < 1 THEN M = 1
270 IF S > 100 THEN S = 100
280 IF S < 1 THEN S = 1
290 RETURN
```

Fig. 4 (below). Circuit diagram for the 15V mains power supply unit.




A mini FM transmitter, very high gain preamp, supplied complete with FET electret microphone. Designed to cover 88-108 Mhz but it is easy to change it to cover 63-130Mhz. Works with a common 9v (PP3) battery. 0.2W RF. £8.22 Kit no 1001.
Electronic siren kit with an impressive 5 watt power output. Ideal for car/bike alarms etc. 6-12vdc, max current 1A, tone frequency 1.2khz. £7.05 Kit no 1003.
3-30v Power supply, variable, stabilized power supply for laboratory use. Shortcircuit protected, suitable for professional or amateur applications. 24v 3A transformer is also needed to complete the kit. £16.45 Kit 1007.
Powerful 1 watt FM transmitter supplied complete with piezoelectric microphone. 8-30vdc. At 25-30v you will get nearly 2 watts!. £14.10 Kit no 1009.
FM/AM Scanner, well not quite you have to turn the knob yourself but you will hear things on this radio (even TV) that you would not hear on an ordinary radio!. Receiver covers 50-160Mhz both AM and FM. Built in 5 watt amplifier. £17.62 Kit no 1013.
Mosquito repeller, modern way to keep midges at bay! Runs for about a month on a 1.5v battery. £8.22 Kit no 1015.
3 channel wireless sound to light system, mains operated, separate sensitivity adjustment for each channel, 1,200 watt power handling. Microphone included. £16.45 Kit no 1014.
Motorbike/cycle trembler alarm, adjustable sensitivity, preset alarm time, auto reset. Could be connected to bikes horn etc. £14.10 Kit no 1011
0-5 minute timer, adjustable from 0 to 5mins, will switch up to 2A mains. Perfect for alarms, photographic laboratories etc. 12vdc. £8.22 Kit no 1020.
4 watt FM transmitter, small but powerful transmitter, 3 RF stages, microphone and an audio preamp include in kit. £23.50 Kit no 1028.
25 watt FM transmitter 4 RF stages, preamp required (our kit 1068 is suitable). Due to the complexity of the transmitter it is supplied in built up form only. £92.82 Kit no 1031.
Strobe light, adjustable frequency from 1- to 60Hz (a lot faster than conventional strobes) mains operated. £18.80 Kit no 1037.
Ultrasonic radar ideal as a movement detector with a range of about 10 metres, automate your cat flap! 12v operation so ideal for cars, caravans etc. £16.45 Kit no 1049.
Liquid level detector useful for detecting fluid levels in tanks, fishponds, baths or as a rain or leak alarm. Will switch 2A mains. £5.87 Kit no 1081.
Combination lock 9 key, easily programmable, will switch 2A mains. Complete with keypad. 9v operation. £11.75 Kit 1114.
Phone bug detector, this device will warn you if somebody is eavesdropping on your phone line. £7.05 Kit no 1130.
Robot voice, interesting circuit that distorts your voice! adjustable, answer the phone with a different voice! 12vdc £10.57 Kit no 1131.
Telephone bug, small bug powered by the telephone line, starts transmitting as soon as the handset is picked up! £9.40 Kit no 1135.
function generator, produces sinusoidal, saw tooth and square waves adjustable from 20hz-20khz, separate level controls for each shape. Will produce all 3 together. 24vac £17.62 Kit no 1008.
3 Channel light chaser, 800 watts per channel, speed and direction controls supplied with 12 leds and mains triacs, so you can use mains light bulbs if you want. 9-15vdc £19.97 Kit no 1026.
12v flourescent. A useful kit that will enable you to light 4' flourescent tubes from your car battery! (you will also need a 9v 2A transformer, not supplied) £9.40 Kit no 1069.
VOX switch, sound activated switch ideal for turning tape recorders on and off when sounds are heard. Makes the tape last a lot longer! adjustable sensitivity, built in delay. £9.40 Kit 1073.
Incar sound to light. Put some atmosphere in your car with this mini 3 channel sound to light. Each channel has 6 led's. £11.75 Kit no 1086.
7 watt HI FI power amplifier useful, powerful, ideal for intercomms, audio systems, car use etc. 12-18vdc 500mA. £8.22 Kit No 1025.
Phone call relay, useful device that operates a relay when ever the 'phone rings, could be used to operate more bells or signalling lights etc. Will switch mains at 2A. £11.75 Kit no 1122.
Lead acid charger, two automatic charging rates, visual indication of battery state, ideal for alarm systems, emergency lighting etc. 100mA 12vdc. £14.10 Kit no 1095.
Car alarm system, works on voltage drop and/or vibration, entry and exit delays plus adjustable alarm duration. Good for cars, caravans etc. £14.10 Kit no 1019.
Portable alarm system, based on a mercury switch. The alarm continues to sound until the unit is disabled by the owner. Buzzer included. £12.92 Kit no 1150.
Preamp mixer, 3 input mono mixer, separate bass and treble controls plus independent level controls. 18vdc, input sens 150mv. 100mA. £17.62 Kit no 1052.
Mini metal detector, suitable for locating pipes in walls etc, range 15-20 cm, complete with case. 9v operation. £9.40 Kit no 1022.
800 watt single channel sound to light kit, mains operated, add rhythm to your party for only £9.40 Kit no 1006.
Sound effects generator, produce sounds ranging from bird chips to sirens, complete with speaker, add sound effects to your projects for just £10.57 Kit no 1045.
Guitar preamp with tone controls, small enough to fit inside any guitar, based on TL082 IC, 9-12vdc, 50mA. £9.40 Kit no 1091.
15 watt FM transmitter, 4 stage high power, preamp required. 12-18vdc. Can use either ground plane, open dipole, or Yagi. Supplied in built form only at £81.07 Kit 1021.
Telephone amplifier, Very sensitive amplifier which uses a 'phone pickup coil (supplied) will let you follow a conversation without holding the phone. £12.92 Kit no 1059.
TOP 10 BEST SELLING KITS CORNER
1. Variable speed control kit for 12v DC motors up to 30A! (you may need a heatsink for 30A) £19.97.
2. Composite video kit, converts composite signals into separate H sync, V sync and video £9.40.
3. Geiger counter kit, contains everything you need to build a working counter £22.32.
4. Solar energy kit, contains a solar panel, motor, buzzer and cable for experiments £5.87.
5. Electronic accupuncture kit, may help with migrane, poor circulation, backache etc £8.22.
6. Electrifying apparatus kit, produces a weak adjustable high tension of 80-300v from a 9v battery, ideal for catching worms etc! £9.40.
7. Adapter bug kit, contains everything you need to build a professional bug built inside a standard 13A mains adapter! the bug is mains powered so it operates all the time the adapter is plugged in. Price is £16.45 for the complete kit including adapter. Hand tools and glue required.
8. Nicad charger kit automatic charger for cells from 1.2v to 15v, 7 settings 50600mA, transformer required 18-20v 600mA. £9.40.
9&10. Inverter kits, produce 240vac from a 12vdc supply, two versions are available a 15w one at £14.10, and an 80w version at £23.50.
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how to order......
Remember to add £1.50 p&p.
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By post with either a cheque, postal order or credit card details.
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R.F. SIGNAL GENERATOR

STEVE KNIGHT — Part 2

A high performance, relatively low cost design that covers the range 1·5MHz to 30MHz in three switched bands.

So far we have described the Signal Generator circuits, fabrication of the component mounting chassis and construction of the three p.c.b.s. We have also covered the drilling of the front panel and the mounting of the completed r.f. board, together with the coil bracket, on the large L-shaped mounting chassis.

Before we move on to mounting the power supply board on the case rear panel and conclude with the calibration, we should like to refer back to the front panel drilling details (Fig. 9) given last month. The distance measurement from the *left-hand* edge to holes "D", the chassis mounting holes, should be 22mm and not 12·5mm as shown.

POWER BOARD

The power supply unit is fitted to the back panel of the case. This panel, like the front one, can be completely removed to make life easier, and the positioning and fixing of the board is a simple job. Provision is also made here for the entry of the mains cable and the fuseholder FS1.

Holes for these should be drilled to suit the components you have; the mains lead can be brought directly through a grommeted hole, but must be adequately anchored down on the inner surface. If you use an appropriate plug and socket system, such anchoring is unnecessary.

Again, you have the choice here. Fig. 17 shows the board position, interwiring and suitable places for the fuseholder and mains lead entry points.

PANEL COMPONENTS

Some of the panel components, switches S1, S2 and S3, and the output potentiometer VR3 are mounted on the rear mounting chassis. The remaining pieces, two 4mm sockets, the BNC output connector and the neon indicator LP1 go onto the front panel proper.

When the panels are finally brought together, these front panel parts project *through* the corresponding holes in the rear mounting panel for internal connections to be made later. This is where accurate alignment of the holes is vital, but any *slight* deviations can be corrected with a round file.

What follows now applies to those constructors who are using the printed scale provided (see Fig. 15); this should be accurate enough for general purpose use assuming that the coils have been carefully wound to specification. For those purists who would wish to do their own calibration, suitable methods will be given later on.

Mount first of all those parts which go on the rear back mounting panel: switches S1, S2 and S3 and the output control VR3. The rotary switches have small locating lugs which when used will prevent the switch bodies rotating in use.

It is wise (but not absolutely essential) to use this facility by drilling 3mm ($\frac{1}{8}$") holes positioned about 10mm ($\frac{3}{8}$") from the centre of the main fixing hole as Fig. 13 illustrates; when the switches are fitted, these holes should accept the locating lug snugly. Using these holes also prevents unnecessary over-tightening of the locking nuts.

LINK-UP

Now, for the time being, wire up internally the coil outlets to switch S1, adjusting the wire lengths as necessary (but not tight); bring two leads from the poles of this switch down to the two nearest solder pin points on the main board (*P6* and *P7*), and connect the "tag" common connection from the coil board to the appropriate pin (*P5*) on the main p.c.b. (see Fig. 17).

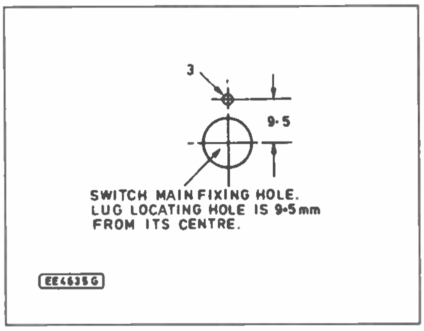
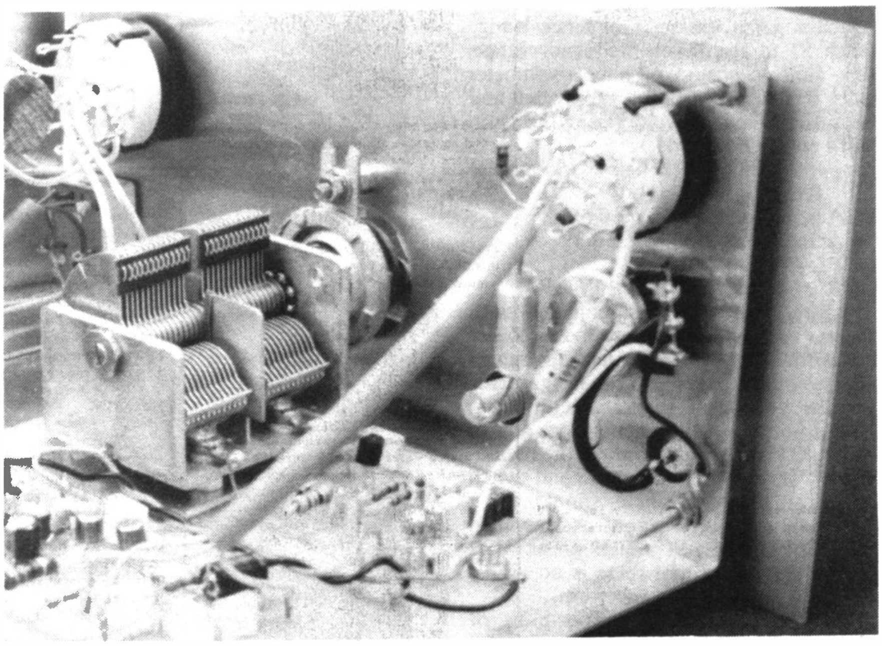


Fig. 13. To stop the rotary switches rotating during use their locating lugs are secured in small holes adjacent their main fixing holes.



The input and output sockets are mounted on the front panel and protrude through holes in the L-shaped mounting chassis so that they can be wired to the Function switch and the R.F. Level control potentiometer. Note the capacitors wired directly between the switch tags and the 4mm sockets.

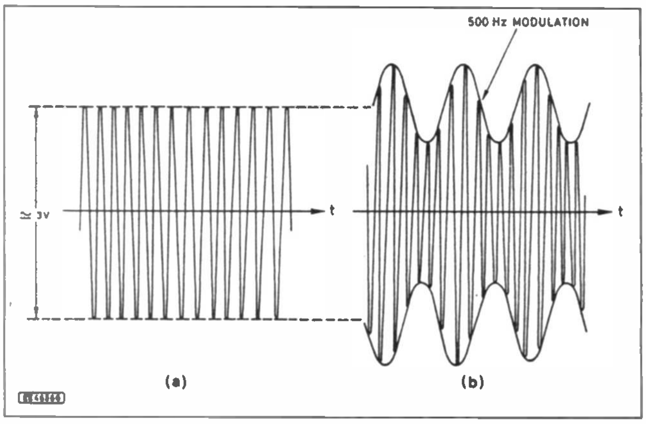
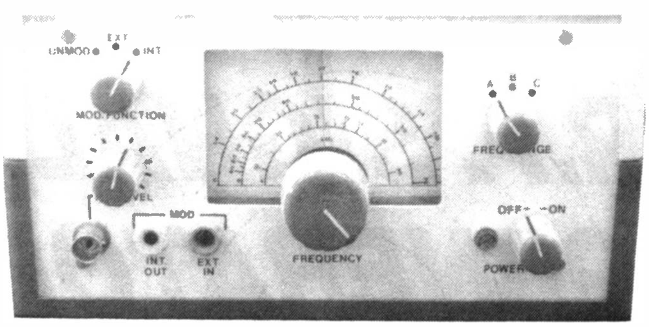


Fig. 14. Oscilloscope display of the output as unmodulated and as modulated carrier. In the modulated case the high frequency signal is not seen as individual waves.



Lettering and layout of components on the front panel of the completed R.F. Signal Generator.

Connect also two leads from the power supply unit to the r.f. board input pins *P4* and *P8*, making sure of the correct polarity. This then completes the temporary wire-up needed for test and calibration purposes.

Keep the power unit in the background by using longish connections; you cannot then touch it accidentally when doing the checks. In this condition, both testing and calibration can be completed *before* the front panel and its components are fitted to the rear mounting chassis.

Due to the presence of mains voltages on the power supply p.c.b., and also from the mains input socket and fuseholder on the back panel, extreme care MUST be taken when testing and calibrating the subassemblies. In fact, apart from "keeping the power panel in the background", it might be wise to also put it in a temporary box for additional safety.

TESTING

For comprehensive testing of the R.F. Signal Generator you will need, as mentioned earlier, a voltmeter (digital or analogue), an oscilloscope and, if you are doing your own calibration later on, a frequency meter.

Set the preset potentiometers VR1 and VR2 to mid-travel, close the tuning capacitor gang, set the Frequency Range switch S1 to the lowest frequency range, (fully anticlockwise), and have a voltmeter ready. Switch on the power supply unit and check the following voltages at the main board points indicated:

P4: About 18V (if below 16V reduce R18 in value slightly)
Across diode D1: 15V ± 0·5V
Across diode D3: 7·5V ± 0·5V
P5: About 4V ± 0·5V
P10 (collector of TR2): 13V ± 1V

Interpret these measurements with respect to the tolerances of the Zener diodes for example; very *small* differences outside of the ranges given can be ignored.

If the voltages seem satisfactory and there is no sign of discontent from any of the board components, connect the oscilloscope to the output point pin *P9* and switch to a fast timebase; there should be a continuous sinewave output as shown in Fig. 14. If necessary, adjust preset VR2 carefully to ensure that there is no visible distortion of the output waveform.

Check now on all three positions of Range switch S1 and all rotations of the tuning capacitor. There will probably be small variations in the amplitude of the waveform throughout these checks but the oscillation should not collapse.

The amplitude on the upper range particularly may well be seen to diminish as the tuning is adjusted, but this is most likely to be due to the falling response of the oscilloscope to frequencies above some 20MHz. If you can use the scope to measure the wave amplitude, this should be about 3V peak-to-peak (1·07V r.m.s.).

Now connect together, with a short piece of wire, the points *P1* and *P2*. This will enable the 500Hz oscillator/modulator section. Check with the scope switched to a relatively slow timebase that there is a sinusoidal output at the collector of TR5, point *P3*. This wave should be about 4V amplitude peak-to-peak (1·4V r.m.s.) and approximately 500Hz in frequency, though the exact value is not important; more important is that there should be no distortion.

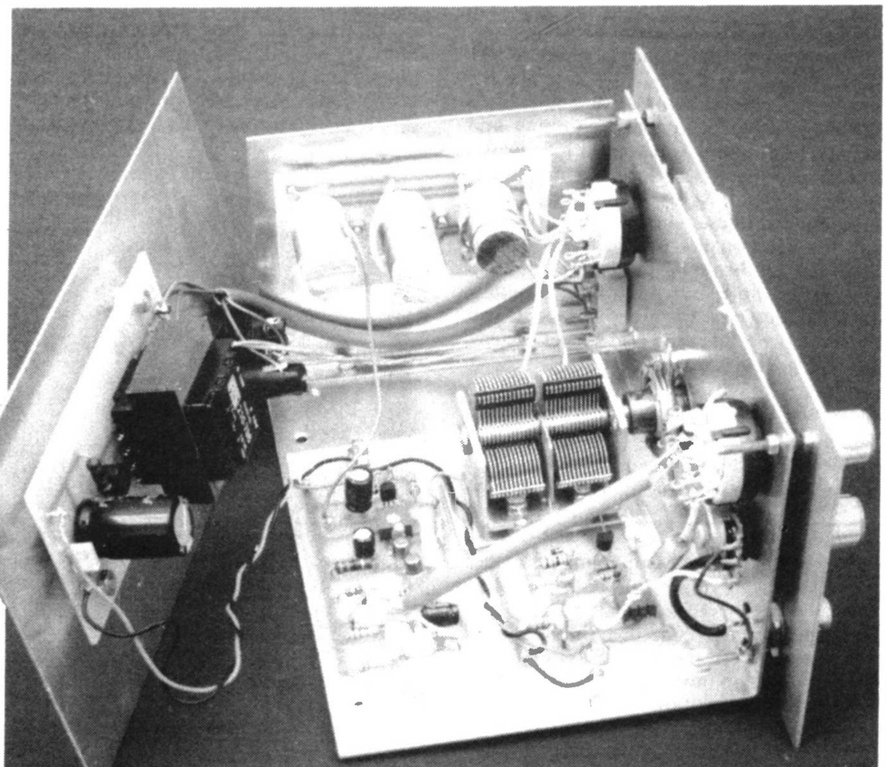
Transfer the scope to the output *P9* again and with the same timebase setting adjust preset VR1 carefully to give you a modulated output signal rather as shown in Fig. 14b. VR1 controls the depth of modulation and any "unbalance' or distortion in the modulation envelope. You should finish up with about 30 per cent modulation depth as the figure indicates but again, within reason, this is not a critical point.

If all the above checks are satisfactory, the tuning scale can now be fitted (if this is your choice) before the final assembly construction is undertaken.

FITTING THE SCALE

There are three choices available here regarding the calibration of the R.F. Signal Generator: you can use the ready prepared scale, shown in Fig. 15; you can prepare your own scale in the same form; or you can use a frequency meter connected to the generator and forgo the central paper scale altogether. In this last case, as mentioned earlier, the scale cutout will have been omitted from the front panel.

If you use the ready prepared scale, its actual accuracy will essentially depend



The positioning of the power supply p.c.b. fuseholder and mains input socket must be located on the case rear panel such that they do not short out on the coil board when they are finally brought together in the case.

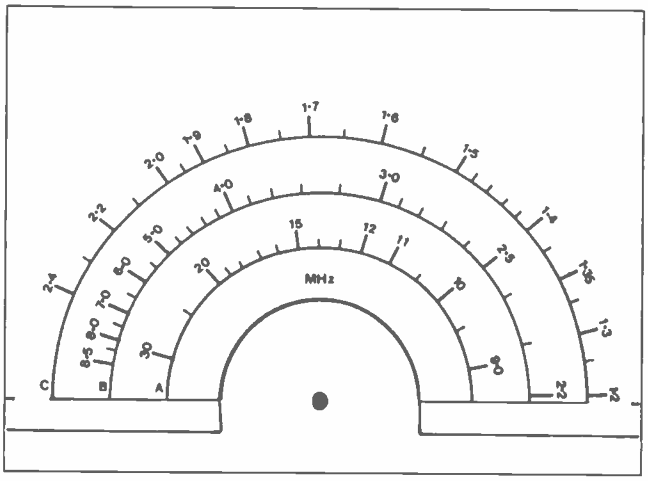
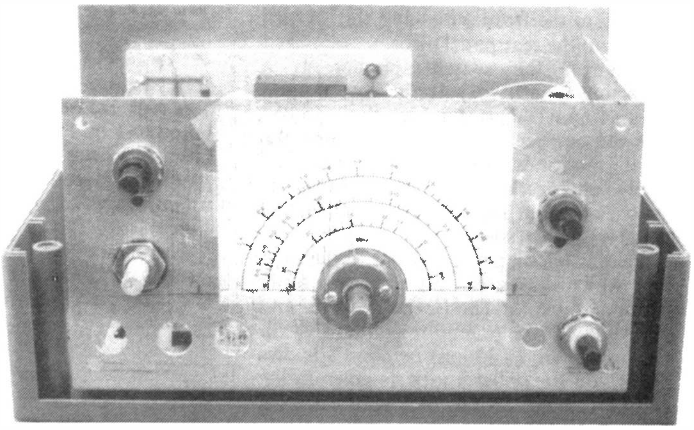


Fig. 15. Full size tuning scale with frequency markings.



The tuning scale is glued or taped to the face of the mounting chassis centrally above the ball-drive spindle – see opposite and Fig. 16.

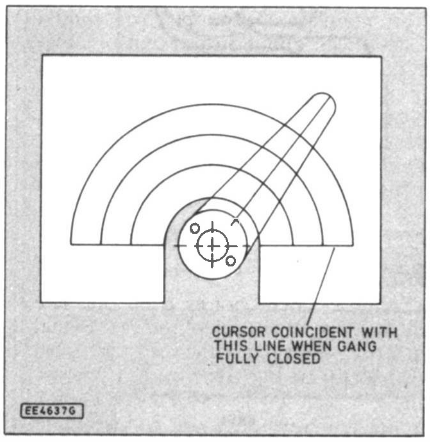


Fig. 16. How the scale is situated relative to the position of the ball-drive flange and spindle.

upon the care taken over the winding of the coils. The tuning capacitor may also contribute some slight error to the tracking but this will be small in the worst case, and the accuracy obtained will almost certainly be attributable to the inductances.

To check on this point, three sets of the coils were constructed and the error against the scale calibration done with the first set did not amount to more than about one millimetre of scale position with the other two. Averaged out, this does not make the calibration worse than ±3 per cent which is comparable with commercial instruments in the lower price ranges.

If you decide to use this scale (Fig. 15), *don't* cut the copy from the magazine as there will be a tendency for the back print to show through when it is glued in position. Get a photocopy made on to a piece of good quality paper, and trim this to the outline indicated in the diagram.

Glue the scale (or edge tape it carefully) to the face of the rear, front panel mounting chassis so that the circular cut-out is positioned centrally to the projecting ball-drive flange and the bottom scale line in effect passes "through" the centre of the drive spindle. Fig. 16 should make these points clear.

Next, cut the Perspex pointer to 57mm (2¼") in overall length and screw it with a couple of short 8BA screws to the flange face. Unlock the rear gang spindle grubscrews so that the ball-drive does not rotate the gang (vanes), close the gang fully, and turn the ball-drive until the pointer cursor line is exactly in coincidence with the bottom scale line on the *right-hand* side.

Now retighten the gang spindle grub screws and check that the pointer travels over the scale without rubbing against it and finishes up along the bottom scale line of the *left-hand* side. There may be a slight overshoot here but ignore this as there is a "dead" patch over a few degrees when the capacitor vanes are fully disengaged.

FRONT PANEL

The completion of the work is now in sight (did I hear somebody somewhere make a comment?) but first the front panel has to be finished off with the appropriate legends and the fixing of a piece of Perspex or other transparent material over the scale cutout.

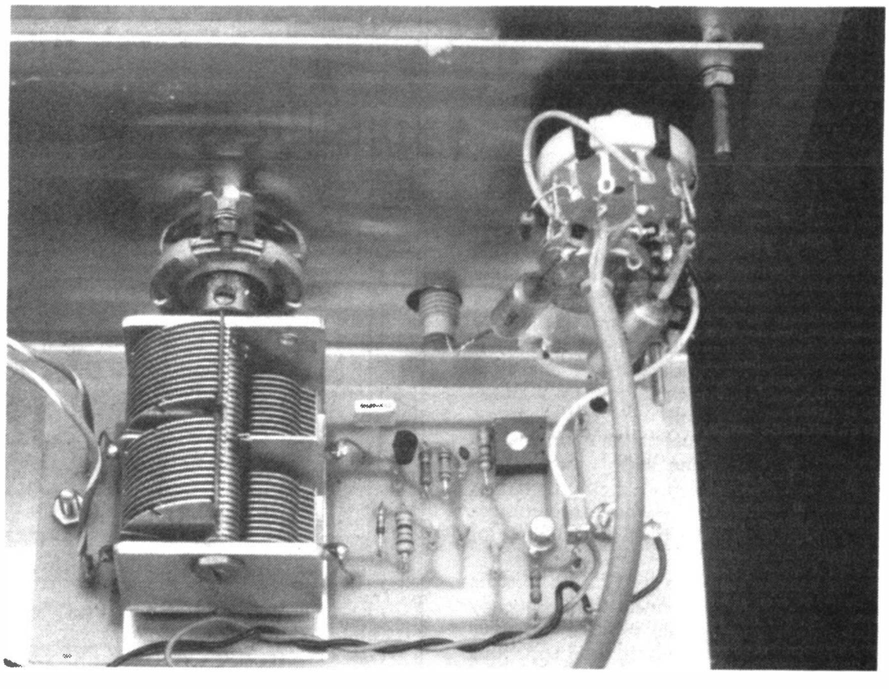
Before lettering, the front panel may be sprayed a light colour, say, white or very pale blue, if black letters are used, and black or a dark blue if white letters are used. If the panel is not unduly marked from the hole cutting earlier, it may be left in its natural brushed aluminium finish. In all cases, make quite sure that the surface is free of grease.

The required front panel marking, using rub-off lettering and assuming that the specified control knob sizes are used, can be seen in the photographs. The size of the letters should not be more than 8-point (2mm) as room is at a premium on this panel, but you can decide for yourself if you feel that in some places a 10-point (2·5mm) or larger style might be more attractive or help legibility. When the lettering is completed a thin coat of protective lacquer will make the legends resistant to scratching.

It now remains to glue a piece of thin Perspex, say, 2mm (1/16") thickness (or any other transparent sheet) over the scale cutout; this, of course, goes behind the front panel. This sheet will need a clearance hole for the drive spindle and an overlap of about 6mm (1/4") at the top and sides; it should not overlap at the bottom edge by more than 3mm (1/8") or it might foul the 4mm socket located below it. These points can best be judged when you are doing the work rather than my pouring out long sermons of explanation.

FINAL ASSEMBLY

The final assembly is quite straightforward. The remaining panel components, neon indicator LP1, the BNC output socket and the two 4mm sockets can now



The ball-drive links the tuning capacitor to the front panel tuning cursor and knob. One of the two spindle grub-screws can be clearly seen.

be fitted to the front panel and this in turn secured to the rear panel piece.

Trim off the switch spindles to a projecting length to suit the knobs used (about 10mm (3/8") is suitable), fit the knobs with the correct orientation to match the panel markings where necessary, and finally check that everything turns or switches without scraping against the panel or the frequency scale.

There is one important point to mention here which can save you spending more than you have to. The Lorlin switches and the output level potentiometer are available with 1/4in. (6·35mm) *or* 6mm spindles and if you use collet knobs as given in the parts list, make certain that you order the right size to suit the spindles you have.

Also, some switches have a flat on the spindle to accommodate grub screw fixing, but if such a method is used here, the orientation of the switches must be such that the knob pointer marks match up to those on the front panel. If you use collet type knobs this problem does not arise, hence it is advisable to get the 6mm spindle types as well as minus the flat.

WIRING-UP

The internal connections can now be made from the main board to the various panel sockets and switches; these are leads from board points *P1*, *P2* and *P3* to Mod. Function switch S2 with returns by way of capacitor C9, C10/R17 to the 4mm sockets; a lead from point *P9* to the output R.F. Level potentiometer VR3 and a short length of *screened* lead down to the BNC output socket with a return to the main board "earth" line at *P11*. The placing of these wires is not critical but keep them as neat as possible.

The front panel can now be slid into the base part of the case; the back panel with the power supply board can be similarly placed in position and connections made for the positive and negative rails to board points *P4* and *P5* respectively. The mains lead is taken by way of the fuse FS1 to the On-Off switch S3 and returned to the transformer input pads on the power supply board.

The box top can now be finally screwed into position. A short appendix follows for those who wish to do their own calibration or use a Frequency Meter directly for readout.

APPENDIX: Own Calibration

If you decide to do your own scale calibration, this can be carried out in one of two ways: either against a radio receiver which has a.m. medium and shortwave bands (a good communications receiver is really best for this purpose), or against a Frequency Counter which goes up as far as 30MHz as a minimum.

The first method, used with care, enables the work to be done with a fair degree of accuracy; the second method enables the calibration over the whole three ranges to be accomplished with a high degree of accuracy.

If you prefer to do away with a scale altogether, you can connect the Frequency Counter (or a suitable module) as your readout. As mentioned in the text, this method provides complete accuracy and saves the metal work needed for the front panel scale cutout. We will briefly examine these methods in turn.

CALIBRATION POINTER

If you are to calibrate your own scale you will need a blank copy of the scale based on Fig. 15 and a "half" pointer. This latter if fabricated from a second Perspex pointer as given in the parts list and sawing it (with great care!) to the shape shown in Fig. 18.

The cursor line now forms a calibration "edge" when the half pointer is fitted over the scale blank. A well pointed pencil can

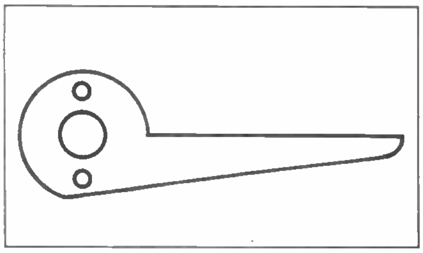


Fig. 18. Adapting a pointer for calibration purposes.

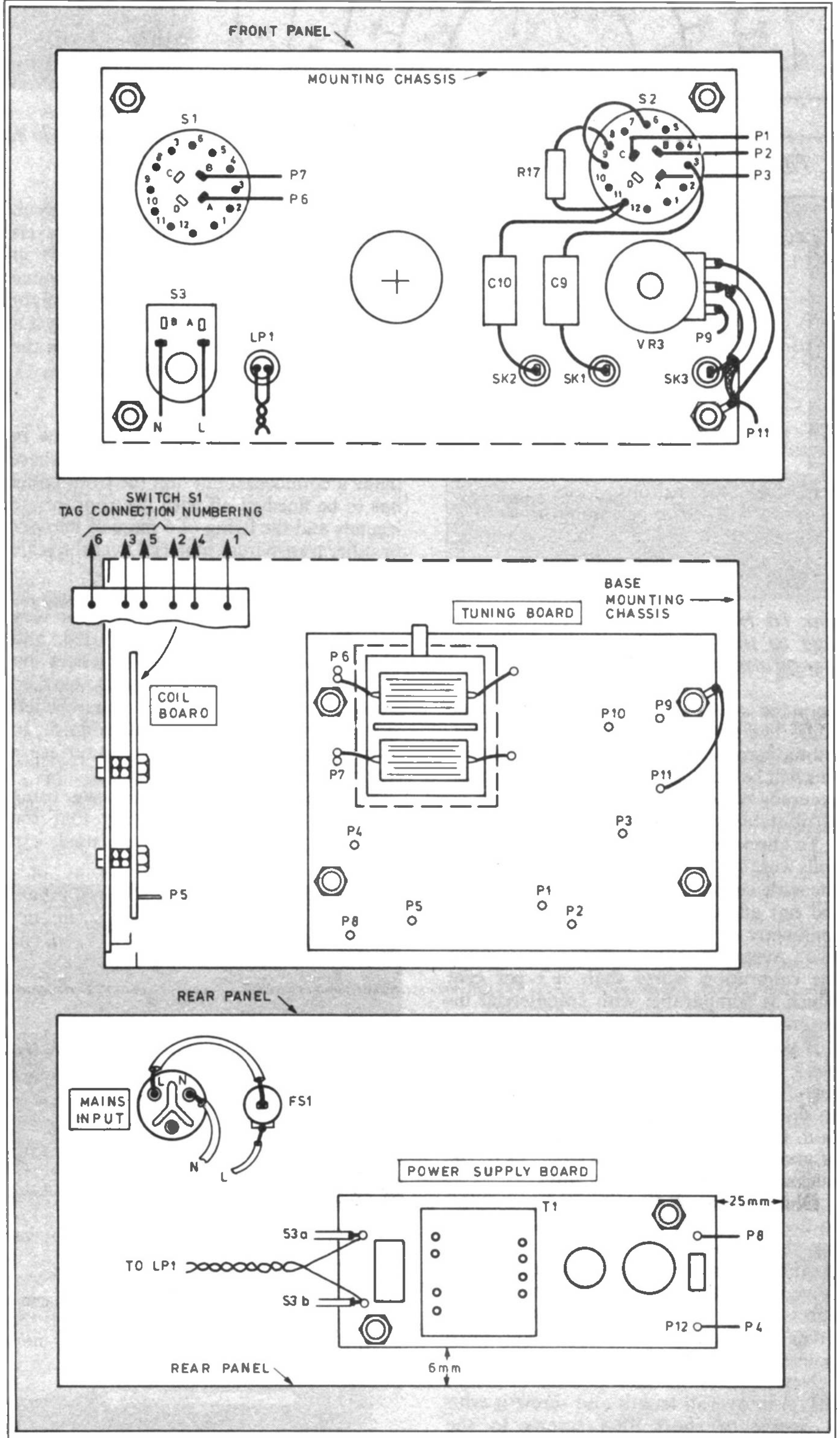
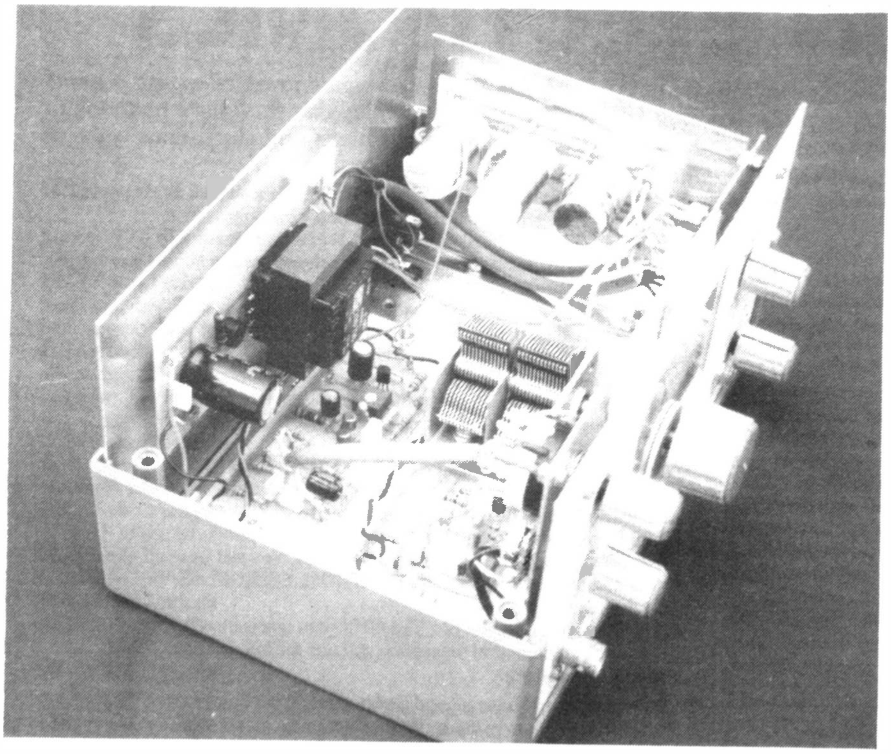


Fig. 17. The front and rear panels laid flat to show the interwiring and main circuit board connecting points. Positioning of the power supply board, mains input socket and fuse are fairly critical as they could possibly foul the coil board when the sections are brought together in the case.



The top cover removed from the completed R.F. Signal Generator to show the compact arrangement of component boards inside the case.

then make the various scale frequency positions by operating along this edge which effectively indicates the true cursor line when the full-size pointer is later fitted as described in the text.

You will, of course, transfer the pencilled scale on to a fresh piece of paper using ink and rub-off numbering to complete your final scale.

RECEIVER CALIBRATION

You will need a receiver which covers the frequency range 1·5MHz to 30MHz or wavelengths from 200m to 10m. These ranges will be found on the shortwave bands and possibly the bottom end of the medium wave band.

A few inches of unscreened wire on the end of the r.f. output cable placed close to the receiver's ferrite rod or the aerial input point will radiate enough to be picked up by the receiver; only sufficient output should be used to hear the 500Hz modulation adequately on the receiver speaker or phones. Too much will lead to confusing harmonics or swamping of the true tuning points.

Starting with the lowest frequency range, which is about 1·4MHz to 2·4MHz (215m to 125m), set the receiver to 1·5MHz (200m) and tune the R.F. Signal Generator through the band until its output is detected by the receiver. This point is now marked on the scale. The 1·6MHz point is then found in the same way, and so on.

In this way all three bands can be calibrated at the main frequency points and marking between these added by eye. It has to be admitted that this method is tedious and the accuracy only fair, but for general purposes is possibly good enough.

FREQUENCY COUNTER METHOD

The use of a Frequency Counter for calibration purposes gives very good accuracy when transferred to the scale using the half-pointer method.

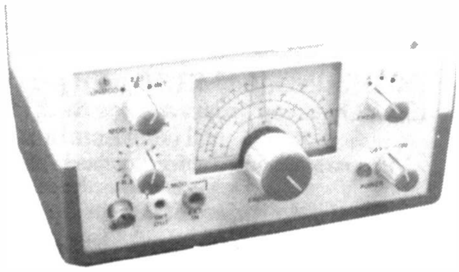
The counter can be fed from the r.f. output socket *or* from point *P10* on the main board; if you use this point, disconnect capacitor C14 or the signal level at the higher frequencies may not be adequate enough for the counter input. This point is actually useful if you build in a counter module in place of the scale.

Switch to UNMOD. on the Function switch so that an unmodulated output is obtained for the counter. Tune the Signal Generator to give as exact readings as you can hold on the counter (it is difficult to be absolutely precise); then at the frequencies 1·5MHz, 1·55MHz, 1·6MHz etc. calibrate the scale for the lowest range and repeat at convenient intervals for the other two ranges.

This is the method that was used to draw up the scale of Fig. 15. If you are not using that scale as such but calibrating you own, you will find it a convenient guide to work to.

CONCLUSION

This project is one involving a lot of careful workmanship, with quite a bit of thought given to each stage of construction. Describing its construction has also not been easy, but hopefully the article has given enough information to make a worthwhile instrument. □



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Everyday with Practical Electronics Books

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N. Kantaris
This guide is written with the non-expert, busy person in mind and, as such, it has an underlying structure based on "what you need to know first, appears first". Nevertheless, the guide is also designed to be circular, which means that you don't have to start at the beginning and go to the end. The more experienced user can start from any section.

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The Practical MIDI Handbook is aimed primarily at musicians, enthusiasts and technicians who want to exploit the vast capabilities of MIDI, but who have no previous knowledge of electronics or computing. The majority of the book is devoted to an explanation of what MIDI can do and how to exploit it to the full, with practical advice on connecting up a MIDI system and getting it to work, as well as deciphering the technical information in those manuals.
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The special requirements of live group concerts are considered, and also the related problem of instability that is sometimes encountered with large set-ups. We even take a look at some unsuccessful attempts to cure feedback so as to save readers wasted time and effort duplicating them.
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This book will help you learn the basics of computing, running applications programs, wiring up a MIDI system and using the system to good effect, in fact just about everything you need to know about hardware and the programs, with no previous knowledge of computing needed or assumed. This book will help you to choose the right components for a system to suit your personal needs, and equip you to exploit that system fully.
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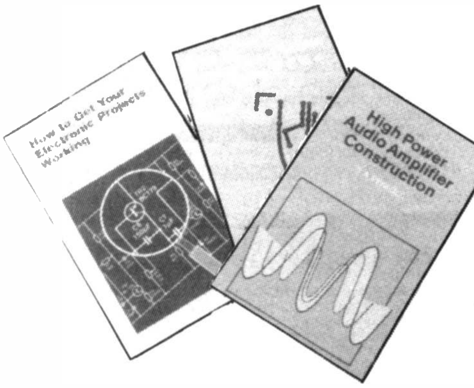

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This book is in effect more than just a dictionary of practical electronics terms, it goes a stage further in also getting down to fundamentals. Accordingly the number of terms may be limited but the explanations of the many which are included are designed to leave the reader more competent and satisfied – and this is without the use of complicated mathematics which often on first reading can be confusing.
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Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the century.
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Also included are constructional details of a number of aerial accessories including a pre-selector, attenuator, filters and a tuning unit.
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SIMPLE SHORT WAVE RECEIVER CONSTRUCTION
R. A. Penfold
Short wave radio is a fascinating hobby, but one that seems to be regarded by many as an expensive pastime these days. In fact it is possible to pursue this hobby for a minimal monetary outlay if you are prepared to undertake a bit of d.i.y., and the receivers described in this book can all be built at low cost. All the sets are easy to construct, full wiring diagrams etc. are provided, and they are suitable for complete beginners. The receivers only require simple aerials, and do not need any complex alignment or other difficult setting up procedures.
The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.
Contains everything you need to know in order to get started in this absorbing hobby.
88 pages Order code BP275 **£3.95**

AN INTRODUCTION TO AMATEUR COMMUNICATIONS SATELLITES
A. Pickford
Communications and broadcast satellites are normally inaccessible to individuals unless they are actively involved in their technicalities by working for organisations such as British Telecom, the various space agencies or military bodies. Even those who possess a satellite television receiver system do not participate in the technical aspects of these highly technological systems.
There are a large number of amateur communications satellites in orbit around the world, traversing the globe continuously and they can be tracked and their signals received with relatively inexpensive equipment. This equipment can be connected to a home computer such as the BBC Micro or IBM compatible PCs, for the decoding of received signals.
This book describes several currently available systems, their connection to an appropriate computer and how they can be operated with suitable software.
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P. Shore
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REPORTING AMATEUR RADIO

Tony Smith G4FAI

HOBBY OR POLITICS?

In 1992, an amateur station with the callsign 1B1NCC came on the air from the Turkish Republic of Northern Cyprus (TRNC) and worked several thousand other amateur stations worldwide. Enthusiasts in the TRNC had been promoting amateur radio and some UK-licensed amateurs donated transmitting equipment to help get the station established.

1B1NCC was subject to extensive and deliberate interference from other stations, mostly in Cyprus and Greece, and the Ministry of Communications of the Republic of Cyprus issued a statement asking that "under no circumstances should contact be made with this station".

Since that time, 1B1NCC has become the club station of the TRNC Amateur Radio Society and four more stations, with suffixes AA, AB, AC and AD (Class A) and one in Class B, 1B2AA, have come on the air.

The situation described arises from the division of Cyprus, following the Turkish invasion of 1974, which has been the subject of several United Nations resolutions calling for a peaceful solution to the problem and the re-creation of a united country.

Northern Cyprus has been unable to join the United Nations or its agencies, including the International Telecommunications Union (ITU), and the only country that recognises it is Turkey. Because it is not recognised by the ITU there is no legal callsign series for TRNC to use so it has taken the 1B prefix from the non-allocated list of ITU callsigns beginning with 1 or 0.

Although their stations have no international status, the TRNC ARS has persuaded its own government to amend its Radio & Telegraphy Act to cover amateur radio operation. The regulations are based on CEPT licensing requirements and IARU band plans, and licences are issued to any TRNC national who passes an amateur radio examination and a Morse test. Temporary licences are also issued to foreign nationals equivalent to their home licences.

The Cyprus Amateur Radio Society protested to the Executive Committee of the International Amateur Radio Union, Region 1, about the operation of amateur radio stations in Northern Cyprus. The EC expressed the opinion that the ITU regulations should be adhered to and that IARU Societies should inform their members that amateur radio stations should not contact stations with prefixes not issued by the ITU.

NO DXCC STATUS

In the USA, the DX Advisory Committee of the American Radio Relay League (ARRL) rejected a proposal that the TRNC be granted separate country status for DXCC purposes. Such status, if approved, would have enabled contacts with stations in Northern Cyprus to count for scoring in the prestigious DXCC Award programme, and in most contests, irrespective of the furore about them.

The TRNC ARS says that no stations have refused to work them because of the IARU recommendation, and that they take particular care to keep all of their contacts strictly non-political and relative to amateur matters.

The fact remains, however, that at present amateur stations in Northern Cyprus do not conform with international regulations, and the IARU has recommended that other amateur stations should not contact them.

The situation is complicated by the fact that radio amateurs are proud of their ability to communicate with each other on non-controversial matters irrespective of differences between their political masters. Some countries occasionally forbid contacts with specified other countries, but even at the height of the cold war it was possible to have friendly personal contacts between East and West.

The controversy over the TRNC amateur stations is clearly a symbol of the deep differences between Greek and Turkish Cypriots and there seems little possibility of amateur radio contacts between them. Amongst the rest of the world's amateur radio community there are divided opinions.

Some do take note of the the views of the IARU and will not work TRNC stations. Others, because there has been no formal prohibition, feel they should be free to talk to either party without hindrance. Much as we would like to think otherwise, amateur radio is not immune to the stresses of international politics after all!

YOUNG AMATEUR OF THE YEAR

Details of the Young Amateur of the Year Award 1995 have been announced by the Radiocommunications Agency. It is offered by the Agency in conjunction with the Radio Society of Great Britain and is open to anyone under 18 who has an interest in radio.

Applicants need not be licensed amateurs but the following areas of activity will be taken into account when assessing their applications. DIY radio construction; operation of radio; community service (e.g., assisting in emergency communications); encouraging others (e.g., through the amateur radio novice licence scheme), and school projects.

The prize for the most outstanding achievement between 1st August 1994 and 31st July 1995 will be £300 cash and the runner-up will receive £50. There may well be additional prizes for both winners provided by the radiocommunications industry. Both winners will also be invited to visit the Agency's Radio Monitoring Station at Baldock in Hertfordshire.

Further details can be obtained from the Radio Society of Great Britain, Lambda House, Cranborne Road, Potters Bar, Herts EN6 3JE, to whom applications should be sent not later than 31st July 1995.

THE STORY OF THE KEY

Many radio amateurs, and others, collect Morse keys. It is a fascinating hobby since the keys come in a variety of types, ranging from simple hand keys to modern complex electronic keyers. In some cases they go back long before radio, to the time when the electric telegraph, using a single wire and an earth return, was the "wonder of the age" spanning continents with ease.

Of interest to established collectors, and to those just thinking about starting, *Morsum Magnificat*, the Morse Magazine has just published *"The Story of the Key"*, a reprint from the magazine of an authoritative six part series by Louise Moreau W3WRE. This covers the development of the key, beginning with Alfred Vail's "Correspondent", used on Samuel F.B. Morse's triumphant Baltimore to Washington demonstration of 1844.

It outlines the first attempts to increase sending speed (and at the same time alleviate "telegrapher's paralysis" or "glass arm") leading to the "Double Speed Key", or "Sideswiper" of 1888. It goes on to tell the amazing story of the Vibroplex semi-automatic key, which first appeared in 1904, involving legal battles by the company with its many imitators and the eventual "licensing" of the so-called "bastard bugs" to permit their use professionally.

Finally it tells how, with the advent of wireless, the landline straight key was adapted for "spark" use, and was later modified again when the power of the spark was no longer a problem.

The book also includes an alphabetical list of American Telegraph Instrument Makers from 1837 to 1900, with their addresses, dates of operation and a broad indication of the types of instruments they produced.

Originally intended for existing readers of *Morsum Magnificat*, the final result is a book which will have a much wider appeal. With over 75 indexed photographs of the keys described in the text, coupled with the information available in the list of makers, it will be an invaluable and entertaining source of reference for both key collectors and today's key users.

"The Story of the Key" has 60 pages x A5 soft-cover format. It is obtainable by post direct from G. C. Arnold Partners, 9 Wetherby Close, Broadstone, Dorset BH18 8JB, price £3.95 post free (UK), or £4.25 overseas by surface mail. Please mention *EPE* when ordering a copy.

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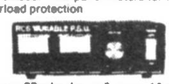

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