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JULY 1995

INCORPORATING ELECTRONICS MONTHLY

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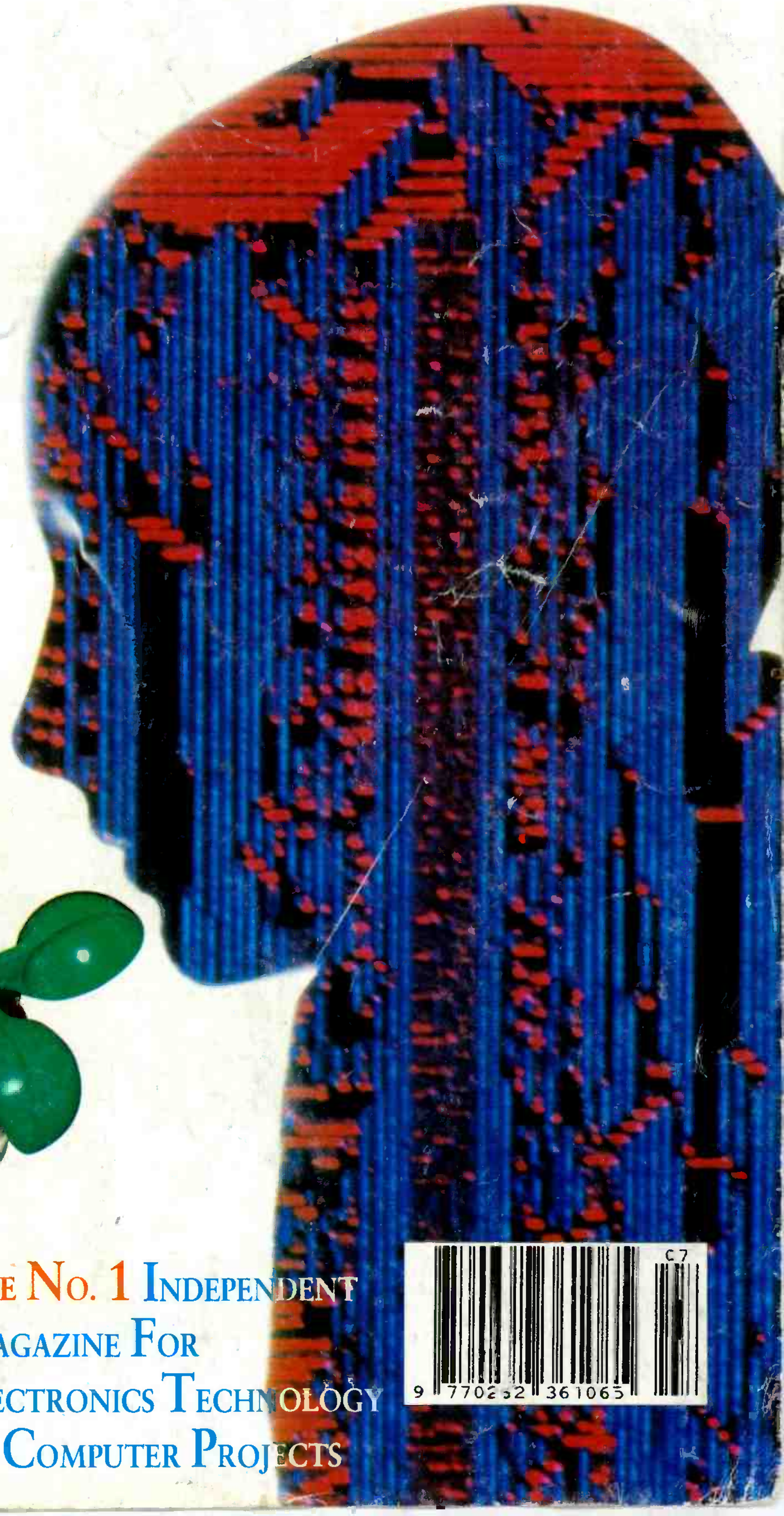

RAMP GENERATOR
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With add-on remote control

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

ENERGY BANK KIT 100 6"x6" 6v 100mA panels, 100 diodes, connection details etc. £69.95 ref EF112.

CCTV CAMERA MODULES 46X70X29mm, 30 grams, 12v 100mA. auto electronic shutter, 3.6mm F2 lens, CCIR, 512x492 pixels, video output is 1v p-p (75 ohm). Works directly into a scart or video input on a tv or video. IR sensitive. £79.95 ref EF137.

IR LAMP KIT Suitable for the above camera enables the camera to be used in total darkness! £5.99 ref EF138.

PASTEL ACCOUNTS SOFTWARE, does everything for all sizes of businesses, includes wordprocessor, report writer, windowing, networkable up to 10 stations, multiple cash books etc. 200 page comprehensive manual. 90 days free technical support (0345-326009 try before you buy!) **Current retail price is £129, ours? just £29** ref EF134. SAVE £100!!!

MINIMICRO FANS 12V 1.5" sq just £3.99 each. Ref EF199.

C ITOH PRINTERS 80 col, 9pin matrix, serial/parallel, NLQ/draft, 3 mth warranty, good condition, £49 ref EF133.

MICROSOFT TRACKBALL AND MOUSE Combined unit with 4 buttons and trackball, PS2 type connector. Complete with storage bracket. Our price just £11.99 ref EF201.

REUSEABLE HEAT PACKS. Ideal for fishermen, outdoor enthusiasts elderly or infirm, warming food, drinks etc, defrosting pipes etc.reuseable up to 10 times, lasts for up to 8 hours per go, 2,000wh energy, gets up to 90 degC. Price is £12 ref EF129. rrp £37!

1.44MB 3.6" DISC DRIVES Returns from a top PC manufactuer so they may need attention. bargain price £8.50 ea ref EF203.

1.2MB 5.25" DISC DRIVES Again returns so may need attention, bargain price is £8.50 ref EF204. (1 of each 1.2+1.44 £14.99 ref ef205

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 £7.99 each!!!! Ref EF186

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 £21.93 ref DEC24.

12V 2AMP LAPTOP psu's 110x55x40mm (includes standard IEC socket) and 2m lead with plug. 100-240v IP. £8.99 ref EF200.

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

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' signs about in shops! £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 modern 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 0 deg C to +100 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.

*******NEW LOW PRICES TO CLEAR!!!********

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

HY1230S, 12vDC adjustable from 0-30 secs. £4.99
HY1210M, 12vDC adjustable from 0-10 mins. £4.99
HY1260M, 12vDC adjustable from 0-60 mins. £4.99
HY2460M, 24vAC adjustable from 0-60 mins. £2.99
HY241S, 24vAC adjustable from 0-1 secs. £2.99
HY2460S, 24vAC adjustable from 0-60 secs. £2.99
HY243H, 24vAC adjustable from 0-3 hours. £2.99
HY2401S, 240v adjustable from 0-1 secs. £4.99
HY2405S, 240v adjustable from 0-5 secs. £4.99
HY24060m, 240v adjustable from 0-60 mins. £6.99

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

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

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.

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 forcred 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 STRIPPERS Small cased tape drives ideal for stripping, lots of useful goodies including a smart case, and lots of components. £2 each ref JUN2P3. Box of 10 just £9.99 ref EF207.

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

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

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 well built unit at an keen 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.

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.

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 up to 2 km 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.200w at £20 REF: MAG20P3 (265x155x125mm).

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. How ever 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

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.

DOS PACK Microsoft version 6 with manual £9.99 3.5" ref EF209

WINDOWS 3.1 3.5" with manual £24.99 ref EF210.

NOVELL NTEWARE LITE (network s/ware) £24.99 ref EF211.

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 car phone 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

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.

AMSTRAD GX4000 games machines, returns, untested, sold as seen. Just £2.99 ref EF186.

NEW HIGH POWER LASERS

15mW, Helium neon, 3 switchable wave lengths .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.

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PORTABLE RADIATION DETECTOR

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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. ref NOV18

*SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

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VOL. 24 No. 7 JULY 1995

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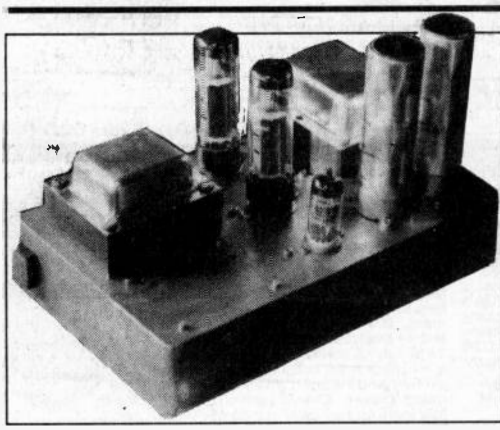

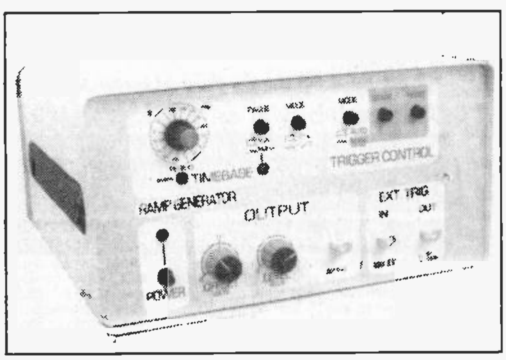

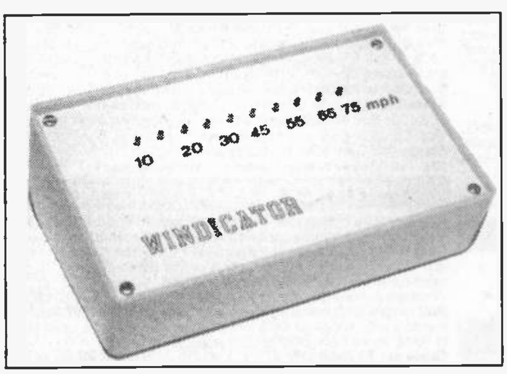

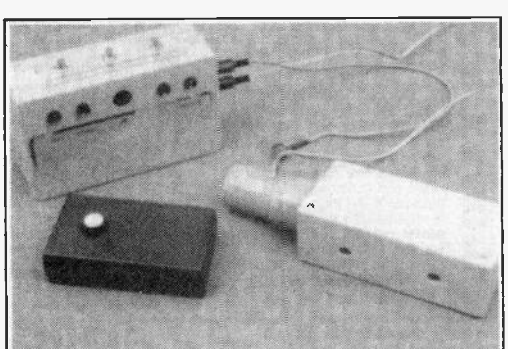

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NEXT MONTH

PERSONAL PRACTICE AMPLIFIER

Keep the family cordial while you strive for chords harmonial – this inexpensive stereo unit can combine your guitar's output with two backing-tracks, e.g. rhythm generator plus taped melody track, feeding the mixed signal into powerful 8-ohm stereo headphones.

MICROCONTROLLED 3-DIGIT TIMER

From racing games and TV turn-off to parking meters and chairman's speeches, this PIC-Microcontrolled design can time them all. Includes pushbutton switches, 3-digit display, buzzer and relay.

STATIC

Static electricity is a problem becoming increasingly important in electronics. Understand what it is, how it occurs, and how you can guard against it. Essential knowledge for anyone involved in modern electronics.

SOLAR SEEKER

Self-powered motorised solar panel follows the sun to recharge NiCad batteries more efficiently throughout the day. Do your bit for the environment!

★ Plus all the regular features.

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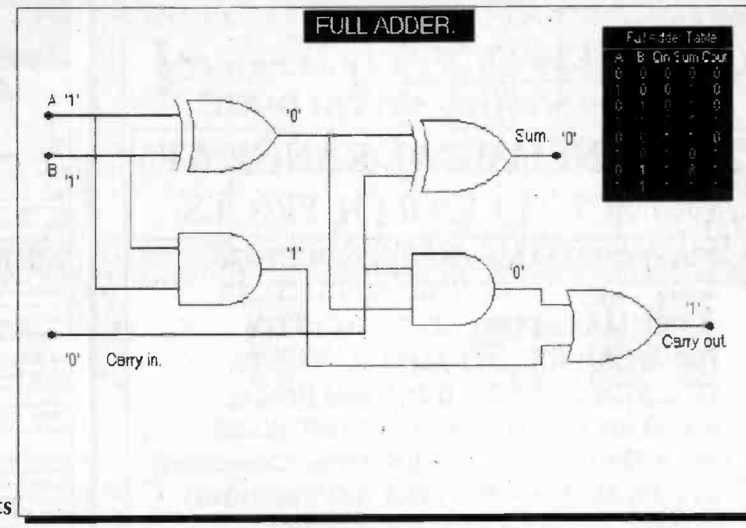
ELECTRONICS SOFTWARE



If you are looking for a means of improving your knowledge of the basics of electronics then this software is for you.

ELECTRONICS PRINCIPLES 2.0

★ Insulators, Conductors, Resistance ★ D.C. Circuits
★ Capacitance and Inductance ★ A.C. Series Circuits
★ A.C. Parallel Circuits ★ Reactance and Impedance
★ A.C. and D.C. Power ★ Frequency and Tuned Circuits
★ Using Numbers ★ Complex Numbers, Phase Angles
★ P.N. Junction Diode ★ Bi-polar and MOSFET Transistors
★ Operational Amplifiers ★ Logic Gates ★ Digital Number Systems
★ Combinational Logic ★ Flip Flops ★ Counters and Shift Registers
★ Memory ★ Microcomputer operation

Electronics Principles 2.0 is a major revision of the successful original version currently used by electronics hobbyists, schools, colleges, and for training within industry throughout the UK and overseas. A fully interactive electronics program where the user selects from over 200 analogue and digital topics. Circuit diagrams, wave forms, phase angles, voltages and currents or logic states are shown, drawn to scale, in full colour. Formulae are given demonstrating all the calculation steps, exactly as in a textbook, using your input values.

An 'on screen' electronics package including circuit theory to enable a learning through doing approach to encourage experimentation. For the young student, mature hobbyist or the engineer that just needs to keep up-to-date in an easy and enjoyable way.

Having reviewed a dozen, or more, educational software packages designed to "teach" electronics, I was more than a little sceptical when I first heard about Electronics Principles: *there seemed to be little that could be done that has not been done elsewhere. When I started to use the package my views changed. Indeed, I was so impressed with it that I quickly came to the conclusion that readers should have an opportunity to try the package out for themselves!* – MIKE TOOLEY B.A. Dean of Faculty of Technology, Brooklands Technical College.

Complete package **Only £49.95**

GCSE ELECTRONICS VERSION 2.0

Designed to complement the *EPE Teach-In No. 7* publication, which contains a complete electronics course aimed at GCSE and A Level students, this software can also be used as a stand alone learning package for everyone interested in electronics. From simple d.c. current flow and Ohm's Law it covers the whole GCSE syllabus including a.c., semiconductors, op.amps, digital electronics, radio and fibre optic communications, digital numbering systems and goes on to look at microprocessor c.p.u.s, 6502 addressing modes and instruction sets. It even produces a program listing, which can be saved or retrieved from hard disk, when any of the instructions from the listed instruction set are input, thus allowing the user to monitor the registers for each of the addressing modes.

The original version is now widely used in schools and colleges throughout the UK.

An interactive, user friendly medium which assists learning in an enjoyable and interesting way.

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For more information call us on 01376 514008

ELECTRONICS PC TOOLBOX VERSION 2.0

An extended and improved version of the popular Toolbox software. Presents commonly used formulae in a way that makes calculations easier thus encouraging experimentation in circuit design.

Covers D.C. Calculations from Ohm's Law to Loading a Potential Divider; Further D.C. Calculations from Power Ratio Decibels to Kirchhoff's Laws; A.C. Calculations from Average Peak Current to Filters and Admittance; Capacitance Calculations from Values to RC Time Constants; Inductance Calculations from Values to Selectivity; Binary Calculations from Addition to 2's Complement; Numbers and Phase Angles from Addition to Polar to Rectangular; Operational Amplifiers from Inverting Op.Amp to Op.Amp Differentiator.

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GCSE MATHS

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AD736JN	£7.56
AD795JN	£7.29
AD797AN	£9.26
AD811N	£9.53
AD812AN	£6.44
AD813AN	£10.73
AD817AN	£4.50
AD820AN	£3.75
AD822AN	£6.05
AD826AN	£6.72
AD829JN	£8.50
AD830AN	£7.10
AD847JN	£7.19
AD9696KN	£12.45
ADEL2020AN	£4.54
ADM222AH	£3.55
ADM232AAN	£3.55
ADM485JN	£2.57
ADM690AN	£4.59
ADM691AN	£5.91
ADM695AN	£5.91
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AMP04FP	£21.02
BUF04GP	£10.02
CA741CE	£0.28
CA747CE	£0.39
CA3046	£0.37
CA3059	£1.16
CA3080E	£0.72
CA3130E	£0.98
CA3140E	£0.56
CA3189E	£1.22
CA3240E	£1.12
DG211CJ	£1.49
DG212CJ	£1.55
DG411DJ	£3.11
DG412DJ	£4.19
EL2020CN	£4.99
EL2030CN	£5.67
ICL7106	£2.80
ICL7611DCPA	£1.06
ICL7621	£1.70
ICL8038	£5.25
ICM7555	£0.43
ICM7556	£0.98
L165V	£2.63
L272M	£1.89
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L297	£6.37
L298	£6.99
LF347N	£0.86
LF351N	£0.43
LF353N	£0.42
LF356	£0.84
LM301A	£0.25
LM308N	£0.42
LM311N-8	£0.28
LM318	£1.28
LM319N-14	£0.96
LM324	£0.30
LM335Z	£1.52
LM339N	£0.24
LM348N	£0.31
LM358N	£0.27
LM377	£2.57
LM380N-14	£1.12
LM381N	£2.70
LM382	£2.30
LM386	£0.79
LM387	£1.60
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NE555N	£0.25
NE556N	£0.36
NE565	£1.84
NE566N	£0.90
NE567N	£0.39
NE571N	£2.47
NE592	£0.62
NE5532N	£0.80
NE5534N	£0.60
OP07CN	£1.42
OP27CN	£2.49
OP77GP	£3.12
OP90GP	£4.14
OP97FP	£4.02
OP113GP	£4.04
OP176GP	£2.30
OP177GP	£2.49
OP183GP	£3.78
OP200GP	£6.81
OP213FP	£6.38
OP275GP	£2.84
OP282GP	£2.63
OP283GP	£5.81
OP290GP	£6.24
OP295GP	£5.54
OP297GP	£7.56
OP400GP	£13.56
OP467GP	£15.90
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PM1012GP	£6.38
RC4136	£0.90
SAA1027	£4.52
SG3524N	£1.08
SG3543	£6.88
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TL064CN	£0.72
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62256-10	£5.35
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AD7545AKN	£15.18
AD7581JN	£26.99
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AD7845JN	£18.06
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ZN425E	£5.94
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7915	£0.38
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78L08	£0.23
78L12	£0.24
78L15	£0.24
78L24	£0.39
79L05	£0.28
79L08	£0.28
79L12	£0.28
79L15	£0.28
79L24	£0.30
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L296	£8.13
L387A	£3.24
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LM338K	£5.52
LM723	£0.29
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MAX666CPA	£3.76
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IN916	£0.06
1N4001	£0.06
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1N4003	£0.07
1N4004	£0.07
1N4005	£0.07
1N4006	£0.08
1N4007	£0.08
1N4148	£0.05
1N4149	£0.06
1N5400	£0.09
1N5401	£0.09
1N5402	£0.10
1N5404	£0.11
1N5406	£0.12
1N5407	£0.14
1N5408	£0.15
BA157	£0.10
BA158	£0.10
BA159	£0.10
BY126	£0.13
BY127	£0.11
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2N3054	£0.90
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2N3440	£0.50
2N3702	£0.09
2N3703	£0.10
2N3704	£0.10
2N3705	£0.10
2N3706	£0.10
2N3771	£1.44
2N3772	£1.51
2N3773	£1.79
2N3819	£0.39
2N3820	£0.66
2N3904	£0.10
2N3905	£0.10
2N3906	£0.10
2N4036	£0.34
2N5245	£0.80
2N5296	£0.57
2N5321	£0.57
2N5322	£0.57
2N5401	£0.11
2N5551	£0.11
2N6107	£0.60
2N6491	£1.58
2SB548	£0.30
2SD1730	£1.44
AC126	£0.44
AC127	£0.50
AC128	£0.40
AC187	£0.48
AC188	£0.48
ACY17	£3.84
AD149	£1.67
AD161	£0.92
AD162	£0.92
BC107	£0.16
BC107B	£0.15
BC108	£0.14
BC108A	£0.14
BC108C	£0.16
BC109	£0.17
BC109C	£0.17
BC114	£0.41
BC115	£0.41
BC116	£0.41
BC118	£0.41
BC132	£0.36
BC134	£0.36
BC135	£0.36
BC140	£0.25
BC141	£0.27
BC142	£0.31
BC143	£0.34
BC149	£0.21
BC154	£0.36
BC157	£0.12
BC159	£0.12
BC160	£0.28
BC170	£0.16
BC170B	£0.16
BC171	£0.11
BC171B	£0.16
BC172	£0.13
BC172B	£0.13
BC177	£0.18
BC178	£0.18
BC179	£0.17
BC179A	£0.17
BC182	£0.08
BC182A	£0.11
BC182B	£0.08
BC182L	£0.08
BC182LB	£0.08
BC183	£0.08
BC183L	£0.08
BC183LB	£0.08
BC184	£0.08
BC184L	£0.08
BC186	£0.33
BC204C	£0.72
BC206B	£0.72
BC207B	£0.74
BC208	£0.72
BC209A	£0.72
BC212	£0.08
BC212L	£0.08
BC212LB	£0.08
BC213	£0.08
BC213B	£0.08
BC213LC	£0.08
BC214	£0.08
BC214L	£0.08
BC225	£0.15
BC237B	£0.09
BC238B	£0.09
BC238C	£0.09
BC239C	£0.10
BC250A	£0.10
BC251	£0.13
BC252	£0.13
BC261B	£0.24
BC262B	£0.24
BC267B	£0.30
BC307	£0.10
BC308	£0.10
BC319C	£0.13
BC327	£0.10
BC327-16	£0.10
BC328	£0.10
BC328-16	£0.10
BC337	£0.10
BC337-25	£0.10
BC338	£0.10
BC338-25	£0.10
BC348B	£0.14
BC357	£0.25
BC393	£0.73
BC414C	£0.13
BC441	£0.40
BC461	£0.40
BC463	£0.29
BC478	£0.32
BC479	£0.32
BC490	£0.24
BC516	£0.22
BC517	£0.20
BC527	£0.20
BC528	£0.20
BC537	£0.20
BC546B	£0.08
BC546C	£0.08
BC547B	£0.09
BC547C	£0.09
BC548C	£0.08
BC549C	£0.10
BC550C	£0.10
BC556A	£0.08
BC557B	£0.08
BC557C	£0.08
BC558C	£0.08
BC559C	£0.08
BC560A	£0.09
BC560B	£0.09
BC637	£0.21
BC638	£0.21
BC639	£0.21
BC640	£0.21
BCY70	£0.21
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BD124P	£6.86
BD135	£0.20
BD136	£0.21
BD137	£0.23
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BD140	£0.25
BD150C	£0.82
BD165	£0.42
BD166	£0.35
BD187	£0.39
BD201	£0.40
BD202	£0.40
BD203	£0.40
BD204	£0.40
BD222	£0.58
BD225	£0.42
BD232	£0.38
BD237	£0.32
BD238	£0.32
BD240C	£0.37
BD243B	£0.50
BD244A	£0.53
BD244C	£0.53
BD245C	£1.18
BD246	£1.18
BD246C	£1.18
BD283	£0.61
BD284	£0.61
BD400	£0.79
BD441	£0.41
BD442	£0.41
BD534	£0.47
BD535	£0.50
BD536	£0.65
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BD646	£0.52
BD648	£0.52
BD650	£0.53
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TIP42C	£0.38
TIP47	£0.48
TIP48	£0.62
TIP50	£0.53
TIP121	£0.35
TIP122	£0.40
TIP125	£0.46
TIP127	£0.40
TIP132	£0.46
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µF	16v	25v	63v	100v	450v
0.47	---	---	£0.05	£0.07	---
1.0	---	---	£0.05	£0.06	£0.15
2.2	---	---	£0.05	£0.06	£0.18
4.7	---	---	£0.05	£0.08	---
10	£0.05	£0.05	£0.06	£0.08	£0.44
22	£0.05	£0.05	£0.09	---	---
47	£0.06	£0.06	£0.11	---	---
100	£0.06	£0.09	£0.11	---	---
220	£0.09	£0.12	£0.31	---	---
470	£0.15	£0.19	£0.57	---	---
1000	£0.22	£0.29	---	---	---
2200	£0.37	£0.57	---	---	---
4700	---	£1.11	---	---	---

Electrolytic Axial Capacitors

µF	16v	25v	63v	100v	450v
0.47	---	---	---	£0.15	---
1.0	---	---	£0.10	£0.10	£0.19
2.2	---	---	£0.10	£0.10	£0.22
4.7	---	£0.09	£0.10	£0.10	£0.34
10	---	---	£0.12	£0.12	£0.48
22	---	£0.12	£0.13	£0.17	£1.06
47	£0.10	£0.11	£0.16	£0.20	---
100	£0.10	£0.13	£0.21	---	---
220	£0.13	£0.18	£0.42	---	---
470	£0.21	£0.24	£0.69	---	---
1000	£0.33	£0.40	£1.05	---	---
2200	£0.52	£0.64	---	---	---
4700	£0.90	---	---	---	---

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9 x 12"	£6.93	£7.77	£5.19	£6.36
10 x 12"	£8.87	£9.81	£6.78	£8.30
12 x 12"	£9.09	£10.19	£6.83	£8.34
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160 x 100mm	£1.94	£2.20	£0.70	£0.74
203 x 114mm	£2.52	£2.78	---	---
220 x 100mm	£2.58	£2.88	£1.00	£1.05
233 x 220mm	£5.67	£6.41	£2.38	£2.52
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VOL. 24 No. 7 **JULY '95**

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DIVERSITY

One of the things which makes electronics such an interesting subject is the diversity of possible applications. Take this issue for instance; we have a very simple circuit with a rather unusual application – the *Windicator* – and a fairly complex circuit for a sophisticated piece of test gear – the *Ramp Generator*.

The fascinating thing is that just about every hobbyist at any level of ability can find something to suit them and it's not always the simple items that interest only the beginners. The *Windicator* is quite simple to build but I guess there will be plenty of experienced hobbyists or professionals who will find it a worthwhile project – myself included.

There is one "simple" unit in this issue which is definitely *not* for the beginner – the *H.V. Capacitor Reformer*. This unit outputs a high d.c. voltage and needs to be treated with due respect. Items of this type, and that includes the *EPE HiFi Valve Amplifier*, can kill and should not even be considered as projects unless you are sure you know what you are doing. A similar message must go with any mains powered project, 230V a.c. is dangerous so don't build a mains powered project, or experiment with circuits like those in our feature *Bridge Rectification Enhanced* until you have the necessary experience and *always* have a healthy respect for electricity.

PLANNING

The chart we use to plan what will go into each issue of EPE has a dozen different project headings ranging from "Photographic" through "Test Gear", "Audio", "Car", etc., to "Features" and "PCs." The section with the most article titles in is often "Miscellaneous" where various items like the *Windicator* or next month's *Solar Seeker* get listed. So, even with all those categories, many projects defy a straightforward listing – it just goes to show how diverse the range is.

Mike Kenward

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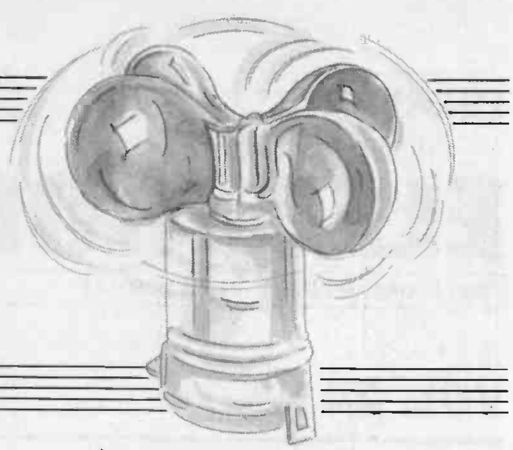
Constructional Project



WINDICATOR

ALAN WINSTANLEY

LED to the bar for a good measure gets you simply blowing in the wind!

ONE of the more entertaining and interesting requests which came the author's way recently was an appeal for a wind speed indicator which had to be reasonably accurate but above all, simple to build. Quite a tall order! A good deal of experimenting has resulted in this simple design – a project nicknamed the "*Windicator*" – which the designer hopes will fit the bill precisely. Having shown the design to many ordinary non-electronics folk, they have been quite fascinated to see this simple project in action, so it's sure to have a wide appeal and will be especially useful for its educational and interest value.

You will probably have seen a wind speed measuring device – an *anemometer* – in use at one time or another, perhaps at an airport or a weather station. Those rotating cups whizzing round at a fair lick are propelled by gusts of wind from any direction and the rotating shaft drives a transducer to generate an electronic signal. This data has to be decoded ultimately to produce an intelligible measure of wind speed, which requires precision measuring equipment.

This Windicator design is not at all intended to be a precision device although the unit has been calibrated to give a surprisingly effective display of prevailing wind speeds. It is guaranteed to provide many hours of interest and entertainment for all ages, being simple and fun to build – and you don't need a personal computer to use it!

Of great importance to mariners, the *Beaufort Scale* is a measure of wind speed. Named after the Royal Navy Admiral Francis Beaufort (1774-1857), it was accepted in the late 1800s and was further adjusted in the 1920s to its present scale. A scale of zero is classed as Calm whilst at the other extreme, a reading of 12 signifies Hurricane Force, something very rarely witnessed in the United Kingdom, mercifully!

The basic relationship between wind velocities and the effects that varying levels of wind have on the environment is shown later in Table 1.

WINDICATOR CONSIDERATIONS

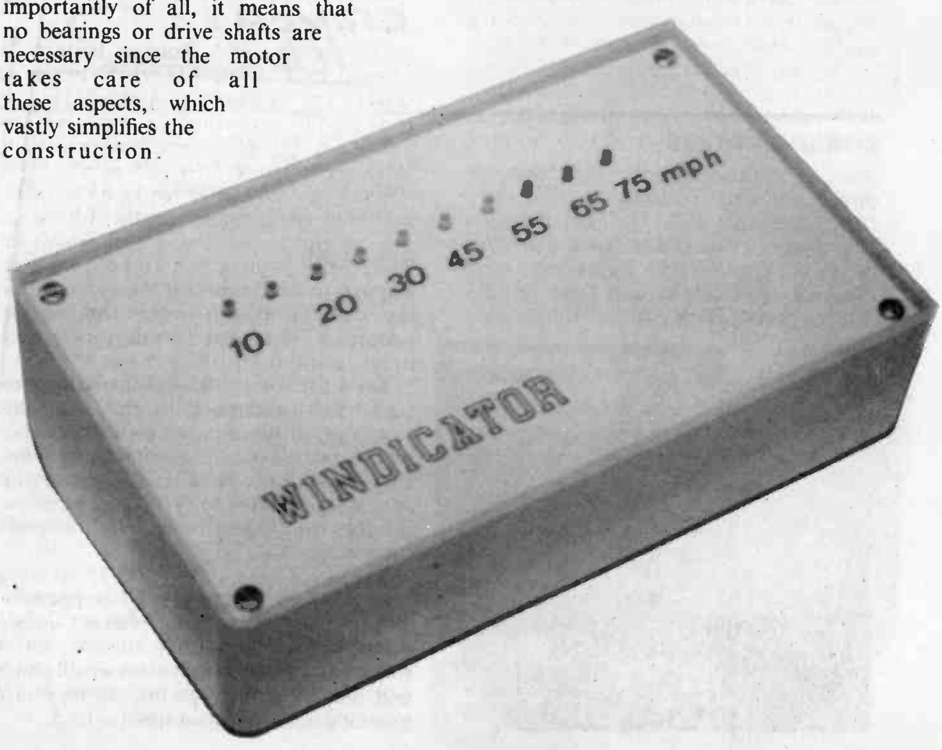
Having given the project some thought, it soon became apparent that the major problem likely to be encountered by constructors would be *mechanical* rather than *electronic* in nature. The idea of using rotating cups to detect velocity from any direction seemed the best approach, but implied that a rotating shaft assembly would need to be used somewhere along the line, perhaps being guided in bearings to ensure smooth running.

It is certainly possible to purchase all the required materials – ball-bearing races and round bar in plastic – from several specialist engineering or modelmaker's sources but having priced up such a design, it was not in the least cost-effective and parts would not be readily available to most readers. Also the success of the finished unit would ultimately rely on one's ability to construct the rotating cup assembly to quite a high degree of workmanship and accuracy.

SIMPLY CYCLING

A more economical and simple design was therefore called for. The final design is straightforward and does not require any complicated bearings or shafts, so that almost *anybody* can construct it. At the heart of the design is a good quality d.c. electric motor, used as a form of a wind-powered dynamo. As every schoolboy knows, when the shaft of an electric motor is rotated, this induces a voltage in the motor windings which can be used to power a load – just like a bicycle dynamo.

The use of the specified motor will give very effective results, but most importantly of all, it means that no bearings or drive shafts are necessary since the motor takes care of all these aspects, which vastly simplifies the construction.



An anemometer assembly can be made from four ordinary plastic measuring scoops, and these are used to spin the motor shaft directly. It is simple but highly effective. (Visions of ping-pong balls, cut in half, also sprang to mind but were quickly eliminated.)

WINDY CIRCUIT

The circuit diagram for the Windicator is shown in Fig. 1. Component M1 is a quality 6V d.c. electric motor. This is used as a wind-powered dynamo, which has a rotating cup assembly fitted directly to its drive shaft.

Tests during the early days of development showed that the output is relatively linear – although not perfectly so it is considered more than adequate in this application to produce an acceptable display. If the specified motor is used readers will be able to build this design and use the calibrations copied from the prototype, so absolutely *no* calibration is needed (later, you are shown how to test the circuit by comparing it against a car speedometer).

GOOD MOTOR

Earlier prototypes used a simple cheap d.c. model motor but the output characteristic was very poor – generating only about 100mV at high wind speeds – and this necessitated further buffering and amplification. The arrival of a much better quality d.c. motor dispensed with the need for any initial amplification, since the d.c. output of the specified motor is so good that this can be used directly with very little

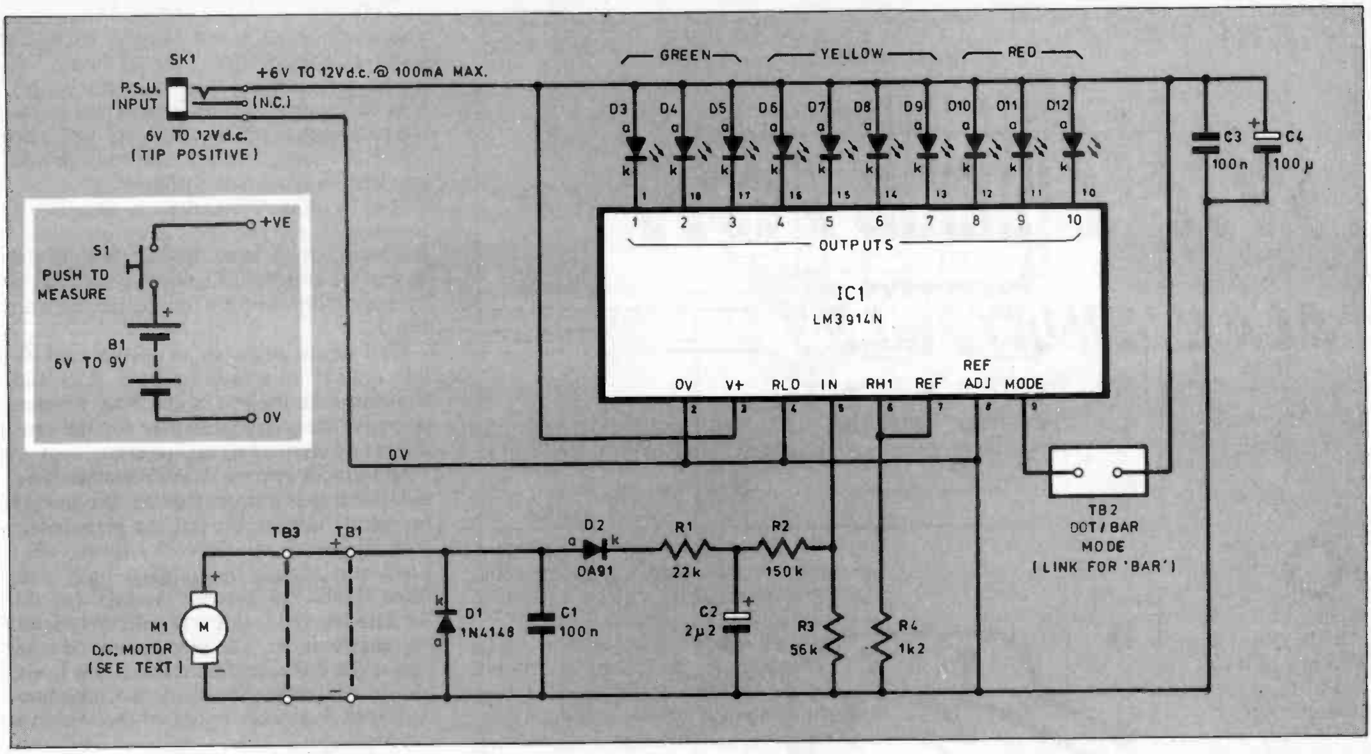


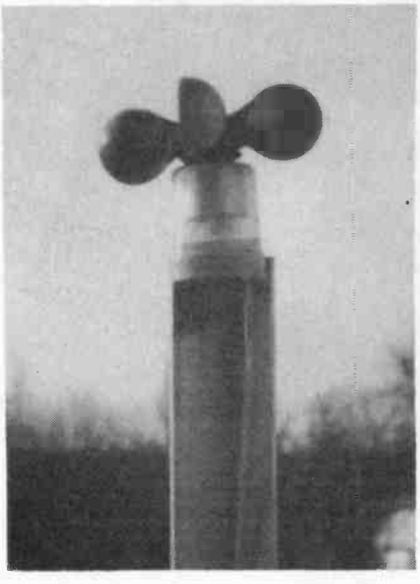
Fig. 1. Complete circuit diagram for the Windicator. See text regarding inset figure on the left.

further processing. The final circuit was a simplified version of earlier attempts, and works extremely effectively.

The output voltage generated by the motor is proportional to the prevailing wind speed. A motor voltage of up to 6V d.c. or more (as measured) is produced with varying levels of wind velocity. The back e.m.f. generated by the motor is shunted by rectifier D1 and noise spikes are filtered by capacitor C1.

Diode D2 is a *germanium* diode which has a 0·2V forward voltage drop (unlike a silicon type which is typically 0·6V). Again, the motor output voltage proved so high in use that the voltage drop across the diode had no particularly significant effect on the results. Resistor R1 and capacitor C2 form a pump in which C2 is progressively charged up by the voltage generated by the motor. Diode D2 prevents the capacitor (a tantalum type) from discharging anywhere except into resistors R2/R3.

The only drawback with the use of diode D2 is that motor voltages lower than 0·2V cannot cause C2 to charge, since the diode's forward voltage has to be overcome. In practical terms, this means that the minimum wind speed which the Windicator displays is approximately 10 miles per hour. It was thought there was little point in trying to make the circuit more sensitive in an effort to detect speeds under 10 m.p.h., though.



The result is that the potential across C2 rises when the motor rotates and decays again when the motor halts. The time constant here is quite low – well under half a second, so the circuit is quite responsive to changes in wind speed. Resistors R2/R3 actually form a voltage divider, with values selected for the motor, which steps down the generated voltage. Trials showed that the output voltage across R3 equated to an average of 200mV at a speed of 10 m.p.h., all the way up to roughly 1·5V at 70 m.p.h.

BARGRAPH DRIVER

This varying d.c. voltage is directly coupled to IC1, an LM3914N bargraph driver. The Windicator display is in the form of a multi-coloured array of ten light-emitting diodes, representing average wind speeds from 10 to 75 m.p.h.. This popular i.c. will power ten l.e.d.s directly, using just one external resistor (R4) to set the current levels flowing through them. The i.c. has an input buffer amplifier which is quite robust – protected for inputs ± 35V d.c – and so absolutely no further signal processing is needed in this very simple application.

The LM3914N offers an internal precision 1·25V reference at its pin 7, and this is connected across a series of ten comparators within the device. Pin 6 represents the "top end" of the comparator chain which is connected to the 1·25V reference: the "bottom" of the chain is pin 4 which is connected to 0V.

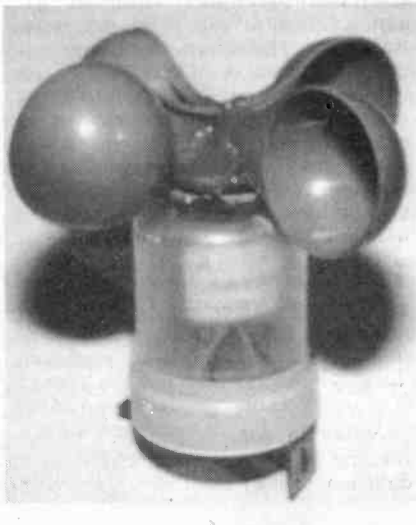
For each 125mV rise (1·25V /10) in input voltage at pin 5, an internal comparator will switch on, causing the relevant output pin to go *low*. The outputs (pins 1 plus 10 to 18, noting their order) are normally high and only when they go low do they sink current and enable the respective l.e.d.

SELECTABLE DISPLAY

Another useful feature of which the Windicator takes advantage is the ability to produce either a bargraph or "moving dot" display. If IC1 pin 9 is left open circuit, only one led will be on at a time. By linking it to the positive rail using TB2 (see later), a bargraph display will be produced. Capacitor C2 helps ensure that the display does not flicker too much.

To improve the display, the l.e.d.s on the prototype were colour-coded. The first three (D3 to D5) are green to indicate "normal" (up to 20 m.p.h.); D6 to D9 are yellow (up to roughly 55 m.p.h.) whilst the last three indicators, D10 to D12, are red (up to 75 m.p.h./ let's get out of here!).

At this point readers should be made aware that the calibrations shown on the prototype (see photographs) are the result of comparing various prototypes against a car speedometer when driving around deserted country lanes in calm weather. This was thought the most realistic and practicable way of simulating various speeds, since wind tunnels are a bit hard to come by. The calibrations are the averages taken from several test runs and are as



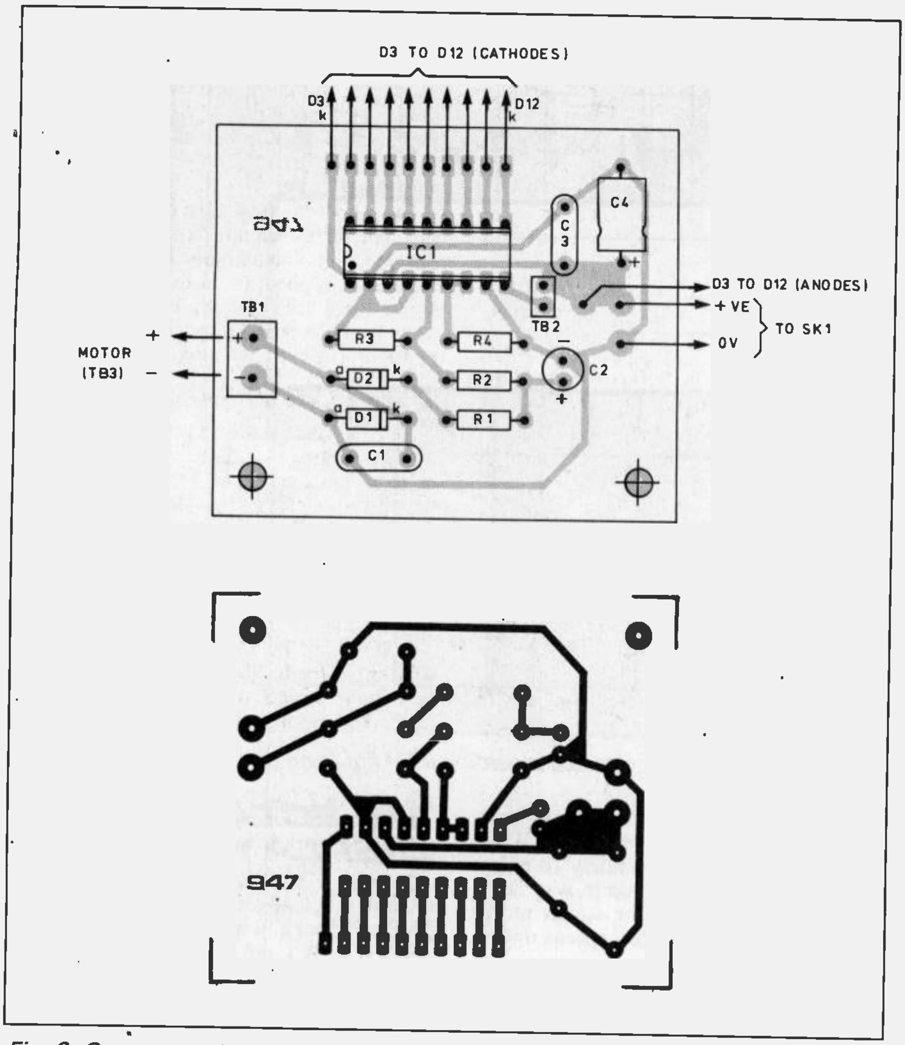


Fig. 2. Component layout and full size copper foil track master for the Windicator printed circuit board.

accurate as possible. The prototype was fitted to a car and the l.e.d. display was calibrated against the Speedo across the entire range of velocities shown. Naturally, a co-pilot was employed to jot down the readings, and speed limits were strictly adhered to!

The results which readers will obtain depend on their choice of motor. If you follow the details of the prototype as closely as possible and use the specified components then *there is no need to have to calibrate your own unit as the scale shown on the prototype unit should prove perfectly adequate.*

Finally, rather than build a separate mains power supply, the prototype Windicator uses an ordinary cheap 6V d.c. mains adaptor to run from the mains continuously. This is connected via the jack socket SK1. Capacitor C4 helps decouple the power supply, although the LM3914N is none too fussy about the quality of the d.c. rail. Correct polarity of the power supply is absolutely essential of course, or the bargraph chip will be permanently damaged. The supply voltage level is not critical and between 6V and 12V should be fine.

The unit could run directly from a 6V d.c. battery pack but then a continuous display will not be feasible (the Windicator may draw over 100mA maximum in bargraph mode) unless you use a set of NiCad rechargeable cells. As shown in the inset diagram of Fig. 1, a series pushswitch is the best option if using a battery, as is selecting "moving dot" mode (TB2 open circuit) to economise on battery life.

CONSTRUCTION

Assembly is very straightforward. The circuit is built onto a small printed circuit board (p.c.b.) size 61mm × 51mm available from the *EPE PCB Service*, Code No. 947. The Windicator was housed in an economical sloping-front case size 161mm × 96mm × 39/57mm, which had an aluminium front panel. There is plenty of room in the specified case to house the p.c.b., remembering that a power supply may be brought in from an external mains adaptor. Alternatively, the case will also house a battery (four × AA size) should you wish to run it from batteries.

Start by using the empty p.c.b. as a drilling template for the two 3mm diameter mounting holes, which need drilling through the base of the enclosure. Continue construction by assembling the p.c.b. in accordance with Fig. 3.

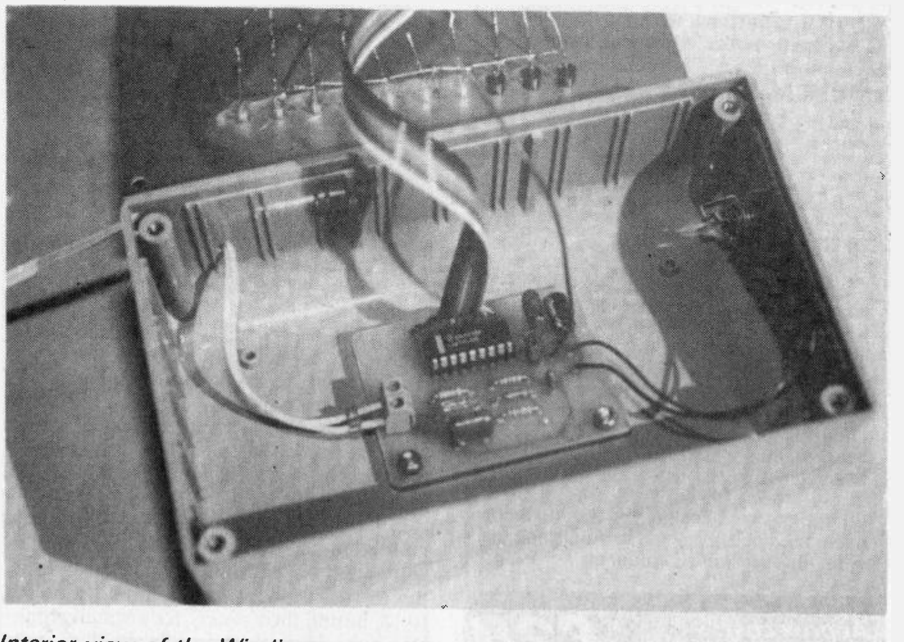
First of all, solder in an 18-pin dual-in-line (d.i.l.) i.c. socket to hold IC1, and continue with the rest of the discrete components, observing polarities for the tantalum and electrolytic capacitors.

The diodes require special mention: the polarisation of silicon rectifier D1 should be readily identifiable but the germanium glass diode D2 may be tricky to sort out. Look very closely at the glass body and there should be a band marked around the cathode end – this was extremely faint on the prototype. The germanium diode is also quite delicate: do not bend the leads too closely to the glass body and take care to solder it quickly into position without overheating it.

A two-way screw terminal block (TB1) was used to provide the connections for the twin-core motor wire (see motor details later). The bar/dot mode selector link (TB2) was a s.i.l. (single-in-line) header with push-on link. You might choose to hard-wire this with a link (bargraph display mode), or just use two short lengths of tinned copper wire – twist them together to produce a bargraph.

Lastly, fit IC1 into place. The chip is a bipolar type and does not need any particular anti-static handling precautions. As always, one end of the i.c. is identified by a notch or a dimple next to pin 1 (or both). It *must* go in the right way round or it will be damaged on power-up.

The flying leads for the ten l.e.d. cathodes (k) were formed with a short length of 10-way ribbon cable which was soldered directly to the board, and all other flying leads are made with standard hook-up wire. For added interest, the l.e.d. display was multi-coloured, as



Interior view of the Windicator assembled electronic components. Note how the l.e.d.s are connected.

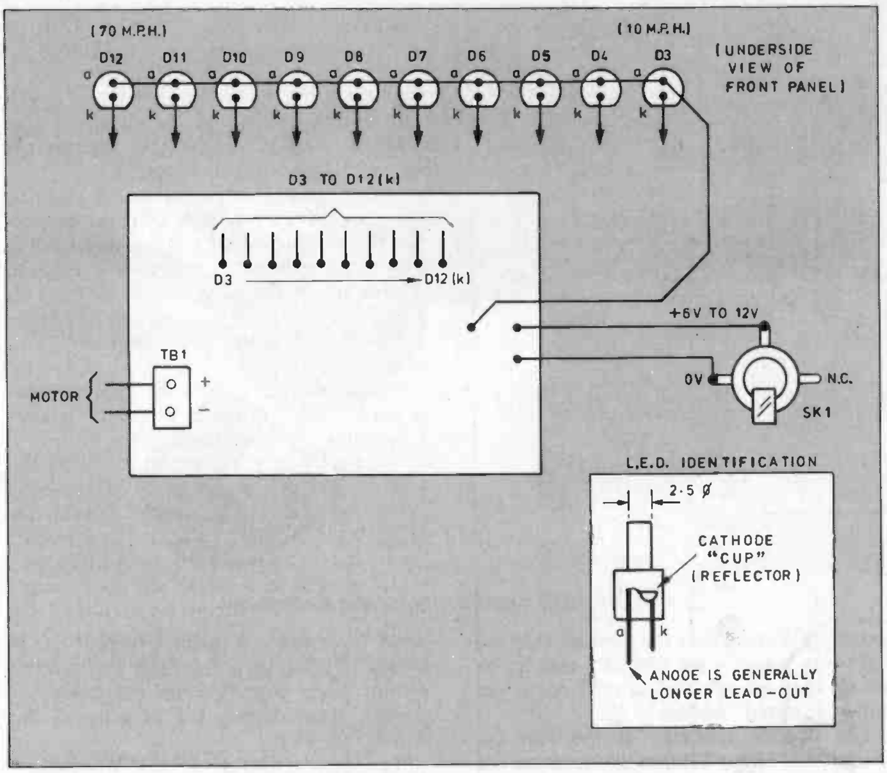


Fig. 3. Interwiring details for the Windicator.

After drilling the holes, they can be de-burred with a larger diameter twist drill or a special tool, before the display is marked with the calibrations shown in the photographs. Ordinary rub down lettering is used to number the display, followed by a coat or two of protective spray-on lacquer.

On the prototype, the l.e.d.s were pushed through from behind, as a form of "invisible fixing". Small blobs of hot melt glue were also applied as an extra measure to secure them but the overall display is quite strong and appealing to look at. Needing no mounting clips, it's also cheap.

INTERWIRING

The interwiring is very straightforward and is depicted in Fig. 3. The l.e.d. anodes (a) can all be hard-wired together simply by bending their lead-outs carefully to make contact with those of their neighbours, then they can be soldered. The display is in effect a common anode arrangement and one separate wire connects the anode "rail" to the p.c.b.

It shouldn't be necessary to use any insulation as the hard-wired assembly should be relatively rigid and safe from short-circuits. The main point is of course to correctly orientate the l.e.d.s!

If in doubt, look through the translucent package: the "Cup" (reflector) is usually the Cathode. (One yellow l.e.d. resolutely refused to work in an early prototype – the l.e.d. had been moulded with the identification "flat" next to the anode!) Then solder the 10-way ribbon cable from the p.c.b. to the appropriate l.e.d. cathodes (k).

The case is finished off with a 0·25 inch diameter hole for the jack socket SK1 (if used), and a suitable hole to accept the connecting lead from the motor, for which a grommet should also be used.

COMPONENTS

See SHOP TALK Page

Resistors
R1 22k
R2 150k
R3 56k
R4 1k2
All 0·25W 5% carbon film

Capacitor
C1, C3 100nF polyester (2 off)
C2 2μ2 tantalum bead 16V
C4 100μ min. axial elect. 16V

Semiconductors
D1 1N4148 silicon diode
D2 OA91 germanium diode
D3 to D5 green l.e.d. (3 off)
D6 to D9 yellow l.e.d. (4 off)
D10 to D12 red l.e.d. (3 off)
IC1 LM3914N bargraph driver

Miscellaneous
M1 d.c. electric motor Matsushita MHN-5RG4E (see *Shoptalk*)
TB1 2-way p.c.b. terminal block
TB2 2-pin s.i.l. header with jumper (see text)
TB3 2-way electrical terminal block
SK1 3·5mm jack socket

Printed circuit board, available from the *EPE PCB Service*, code 947; sloping plastic housing, size 161mm x 96mm x 39mm/57mm; M3 p.c.b. mounting hardware; 18-pin d.i.l. socket; motor mounting hardware and plastic enclosure 35mm dia. x 50mm; plastic scoops, 15ml capacity approx. (4 off); plastic V-pulley 30mm dia. with grub screw hub; 6V to 12V d.c. 300mA unregulated mains adaptor; materials for mast; twin core zip wire, to suit; hook up wire, glue, grommet, solder etc.

Approx cost guidance only **£28**

mentioned earlier. The author chose 2·5mm diameter "flat top" types, for which a series of 2·5mm diameter holes were drilled in a line through the front panel.

A keen, sharp twist drill is needed for this method though, and it's essential to centre-punch the drilling spot beforehand, to prevent the drill from wandering about.

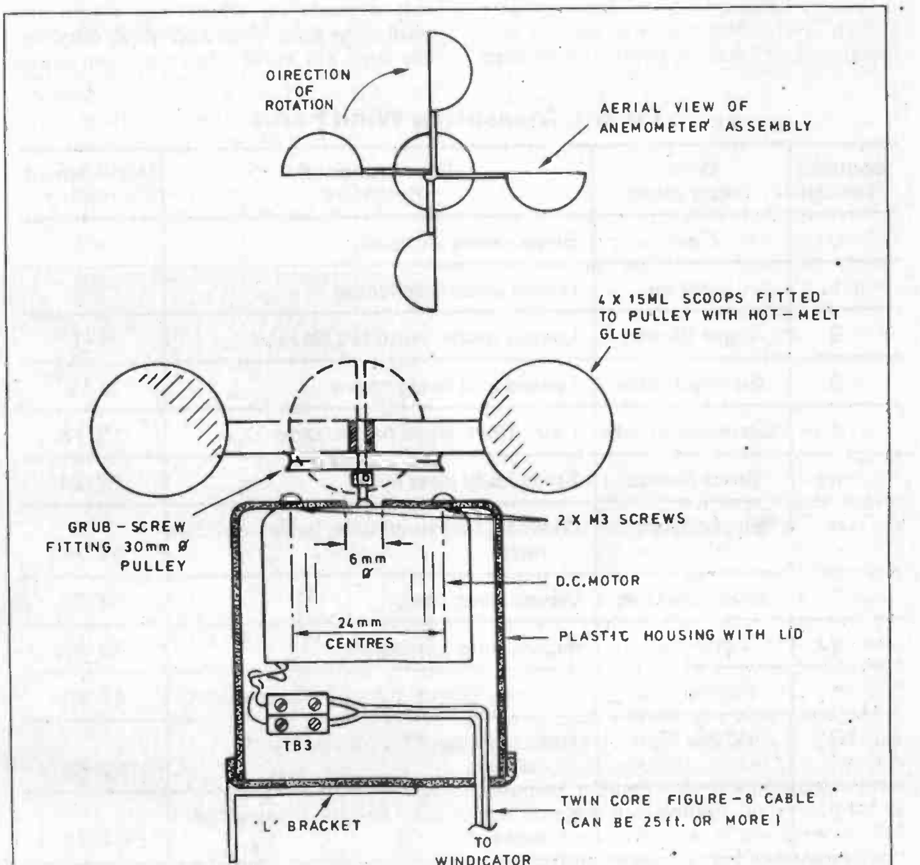
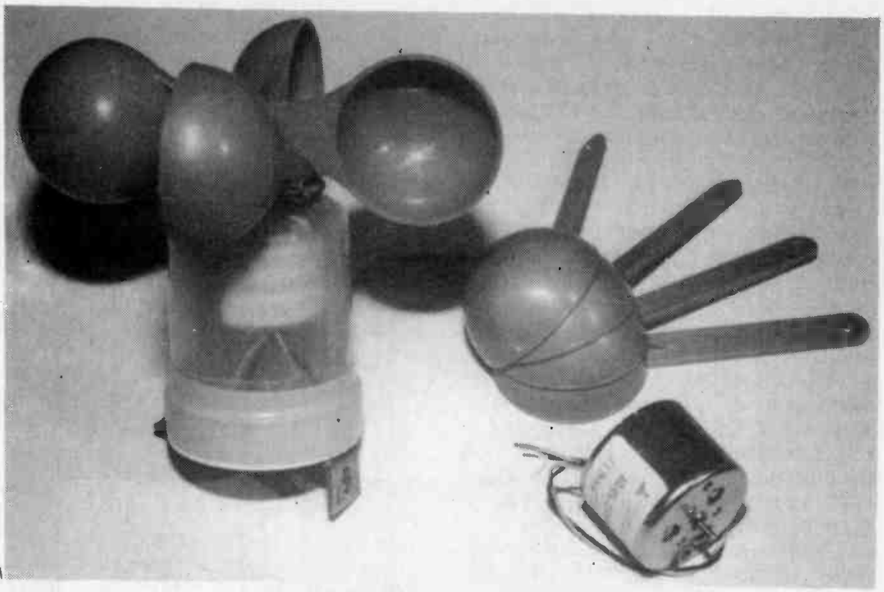


Fig. 4. Mechanical assembly of the wind cups and motor.

At this stage, the display can be quickly tested without using the motor. Link TB2 to select "bar" mode. Then ensuring that the power supply is of the correct polarity, apply a d.c. voltage (6V to 12V) to the power supply inlet. The light-emitting diodes will *all* illuminate when the LM3914N input pin 5, or even D2 cathode, is temporarily hooked up to the positive supply rail using a jumper lead. If some glow but not others, you've probably reversed the l.e.d. connections somewhere. With the main unit complete, attention turns to the anemometer section.



The principle ingredients for the aneometer.

MOTOR-HEAD

The high output d.c. electric motor tested and approved by the author (see *Shoptalk* page) measures 30mm diameter × 25mm deep, with a 1·5mm diameter, 5mm long drive shaft. It is smooth running and generates a usefully high voltage. Fig. 4 summarises the assembly details for the prototype motor and wind-cup unit. A round plastic container with screw-on lid was used as a housing; you could perhaps improvise with a large Aspirin container or something slightly larger than a 35mm film container, to protect the motor from the elements.

Carefully drill the end of the container with three holes as shown – one 6mm diameter for the shaft along with two 3mm clearance fixing holes. The motor body can be secured end-on using two M3 × 6mm screws. Do not overtighten them or the plastic housing will eventually crack. A little light lubricant (the author used a Teflon-based cycle lube) applied near the shaft is likely to repel water and improve the smooth running.

The anemometer cups were formed from four 15ml plastic measuring scoops, with the "handles" slightly shortened. These were affixed to a plastic pulley (30mm diameter) using plenty of hot-melt glue (which is virtually the only way to glue certain plastics such as nylon or polythene together). Ensure that the cups all face the right way round – see photos – and try to ensure they are all level in relation to the pulley, to avoid "wobble".

The overall diameter of the cup assembly was about 120mm diameter on the prototype. Also, the pulley must have a *grub-screw* type fixing so that it can be screwed onto the motor shaft. Although the length of the motor shaft is minimal, it proved adequate enough to produce a very secure assembly. Obviously you can test to see how the motor assembly runs by applying a d.c. voltage.

A two-way terminal block (TB3) terminates the motor leads, this also fits within the round plastic housing. At this point, it's necessary to determine the polarity of the motor output, given that this depends on which way round the motor has been wired and which direction the cups will move when they spin in the wind. Save work: A quick practical test is simply to hook up a voltmeter and test the output when you blow on the (concave) scoops, then identify the polarity of the connecting wire.

You may wish to try the Windicator display by temporarily hooking up the motor to the p.c.b. (observe polarity). Blowing hard on the anemometer unit should cause probably four or five l.e.d.s to illuminate in bargraph mode; also try the dot mode. It will test your lung capacity if nothing else!

Lastly, ordinary cheap twin-core "zip" wire is all that's needed to hook up the motor once it has been sited in its resting place, and this wire could easily be 25 metres long or more. The connecting lead passes through a hole in the base of the housing, to the main Windicator unit.

The completed prototype motor assembly was fitted to a length of aluminium angle with a small L-shaped bracket screwed into the removable lid of the plastic housing, with insulation tape sealing the lid before the finished device was finally secured at the rear of the author's house. The unit shown in the photographs has been subjected to the most atrocious weather conditions (typical British weather, in fact!) over many months and is still operating perfectly.

Table 1. Measuring Wind Force

Beaufort Number	Wind Description	Environmental Indicators	Wind Speed (m.p.h.)
0	Calm	Smoke rises vertically	<1
1	Light air	Rising smoke deflected	1-3
2	Light Breeze	Leaves rustle; wind felt on face	4-7
3	Gentle Breeze	Leaves and twigs move	8-12
4	Moderate Breeze	Litter, dust, small twigs move	13-18
5	Fresh Breeze	Small leafy trees sway	19-24
6	Strong Breeze	Overhead wires whistle; large branches move	25-31
7	Moderate Gale	Whole trees sway	32-38
8	Fresh Gale	Twigs break off trees	39-46
9	Strong Gale	Chimney pots and roof tiles dislodged	47-54
10	Whole Gale	Trees uprooted. Major structural damage	55-63
11	Storm	Serious structural and environmental damage	64-75
12	Hurricane	Catastrophic damage to the environment	75+

SITE SEEING

The final location of the motor head is quite important and may be the subject of trial and error. Fortunately, a convenient balcony was available at *Chez Nous* and the motor was fixed to the railings, much to the intrigue of the neighbours. Earlier efforts produced poor results, and this was attributed to the house actually sheltering the anemometer from prevailing winds in certain directions. An open aspect away from walls and buildings, is a must.

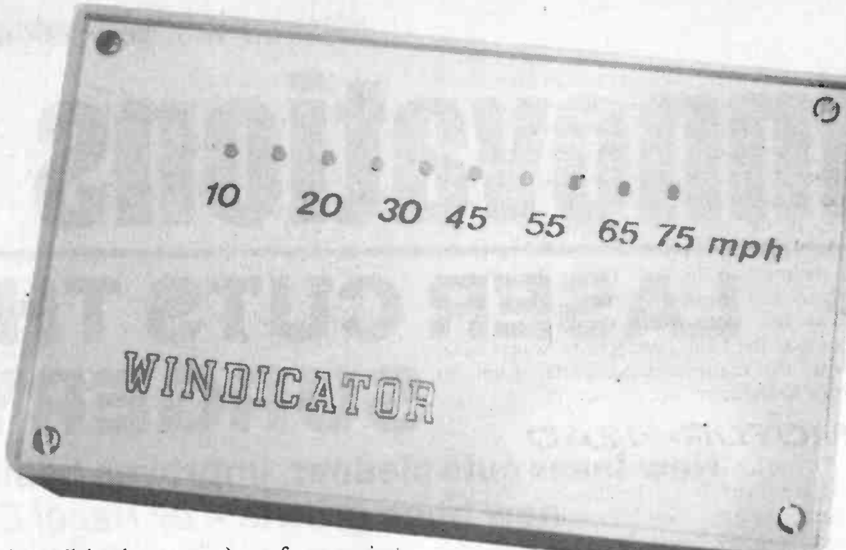
It is probably a good idea to experiment with the finished project for a week or two, running it on a temporary basis before committing yourself to installing it permanently. The largest difficulty facing readers is the practicality of running a cable through into the house, or wherever the Windicator is to be used.

In the author's case, it was very easy to pass the twin-core wire through a wooden window frame, but others may not be so lucky (that's uPVC windows for you). Consider running the wire through door or window frames, TV aerial inlet holes, air bricks, ventilator outlets, or up through the eaves. The twin-core cable is then screwed to TB1 on the p.c.b. and the main unit can be closed up. Then, unless you have the powers of Thor, you have to wait for a windy day!

The finished prototype Windicator will generally illuminate the 10 m.p.h. and 15 m.p.h. l.e.d.s when slight breezes are detected, and so far up to six l.e.d.s (45 m.p.h. gusts) have glowed during rough weather, with the colour-coded display proving invaluable. The display also gives an idea of wind patterns, responding well to gusts before settling down again. So, the Windicator will give you an at-a-glance idea of how the wind's blowing – but its responsiveness is very much determined by the positioning of the motor unit and you might need to experiment with this to get the best out of the design.

If you use an alternative high-output motor, or want to calibrate your own constructed unit, then one practical way is to compare the Windicator against a car speedometer. A calm day and deserted roads are essential; a sun-roof and an assistant would be handy too! Power the unit from a fresh 6V to 9V battery pack (to avoid supply voltage droop when all l.e.d.s. are on), or from a cigar lighter adapter. Starting at 10 m.p.h., note the l.e.d. numbers (1 to 10) which illuminate as the car gradually increases speed towards a maximum of say 60-70 m.p.h.; perhaps make half a dozen test runs or more, and then take the average of all readings and calibrate your l.e.d. display accordingly.

The Windicator should last many years, with perhaps the odd squirt of light lubricant helping to maintain performance. As the author has found, the most enjoyable aspect is probably when everyone asks, "What's that, then?" as they see the Windicator in full swing! □



Ohm Sweet Ohm

Max Fidling

Cat Flapping

Rummaging around in the workshop the other day, I happened across a piece of white painted plywood propped up beside the bench, roughly two feet square and painted gloss white. It was no coincidence that there was a square hole of exactly the same dimensions in the kitchen door.

Although I'm an avid "Do-It-Yourself" fanatic, one thing I don't need, so I keep fooling myself, is exercise of any form. I'd much rather spend my spare hours beavering away in the workshop, constructing my latest brainchild or building a magazine project which might have caught my eye. Hence the eventual need to ensure that Piddles, my feline fun-filled assistant, was totally self sufficient so he could travel hither and thither unimpeded.

You see, I was forever having to open and close the kitchen door to allow Piddles back in after his daily round of mousing. By a perverse scheme of association behaviour, the moggie had learned that if he sat by the door and whined loudly enough at a particularly nerve-shattering frequency, I would eventually tire of this racket and *ouvre la porte* for said cat, who would then march through the door triumphantly, making a bee-line for his bowl!

Such behaviour, he had learned, was remarkably effective if I happened to be in the middle of soldering up a board in the nearby workshop, well within earshot of his cringe-worthy din. It was no good, this shenanigans kept interrupting top priority domestic electronic research! Something would have to be done. But what?

Cycling to my local DIY store next day, I spotted a cat flap for sale. *Perfect!* This would stop the pesky puss from pestering me, and I could then solder on in peace!

Eager to tackle this latest challenge, I'd soon marked out a square of suitable dimensions, using a felt-tip pen to outline where the cat flap would go on the back door. The thick black lines marked the route for me to tackle with the electric jigsaw.

As I started to slice through the woodwork, I had a brainstorm. Why not customise the cat flap so that Piddles could come and go as he pleased, but otherwise the flap would remain firmly shut? A plan formed, as I pondered the practicalities of another electronic labour-saving idea.

Reed on . . .

I propped up the resultant square of wood against the bench in the workshop, and started to root around for inspiration. Recently I had taken an old speaker to pieces and thus I had acquired a nifty magnet.

Stripped of the voice coil, it seemed to have pretty awesome pulling abilities. Now if I used this to operate a reed switch, and the reed switch drove a simple solenoid circuit, and the solenoid acted as a lock on the cat flap, we would be in business!

Thus was my reasoning as I returned to the scene of the crime and finished screwing the cat flap into place. The next week was spent in a futile effort to get Piddles accustomed to nosing his way through the cat flap – not one of my better moments.

In between times I developed a simple circuit which would respond munificently to the magnet. A surplus solenoid had been discovered on a shelf and I pressed it into service. Waving the rather large and powerful magnet near it, like Merlin casting a spell, the solenoid clicked over like a good'un, for a predetermined period derived from a 555 timer, before springing back into place.

Just for good measure I added an l.e.d. and this blinked brightly whenever the solenoid was timing. If only it could speak, I mused, it would probably say "Quick, Moggie, Move It Or Else!" or words to that effect. Sadly, voice synthesis was beyond my abilities.

The cat flap then acquired some electronics which I don't think the manufacturers had quite anticipated when they designed it. D-Day came when at last I'd perfected the circuit and it was time for a trial run.

Piddles had just finished his breakfast and was feeling pretty content with life, i.e. he wouldn't know what had hit him until it was too late, I calculated. I'd fitted the magnet to a spare collar which I swiftly whisked around him, and then opened the kitchen door and encouraged him out with a gentle nudge or two.

Looking a bit like one of those Army-trained Dolphins carrying a homing beacon, I expected the magnetic moggie to trigger the timer and spring through the cat flap Mark Two any second now, accompanied by a flashing l.e.d. and throbbing solenoid! Nothing happened, though, except that I heard a metallic "CLANG!" from outdoors.

Hmmm, not what I expected . . . Peering out, there was the moggie all right, the magnet on his collar pinning him firmly to the steel dustbin!

Innovations

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

LASER CUTS THROUGH SURGERY

New laser cuts cleaner, improves healing and encourages new bone growth – *by Hazel Cavendish*

THE merging of physics with electronics has resulted in an exciting advance in laser technology at Manchester University, where the development of a remarkable new laser holds the promise of enhanced surgical achievements.

A team headed by Terry King, professor of physics at the University, has developed a laser called the Erbium-YAG which can cut through bone with an exactitude of positional accuracy as yet unachieved by conventional surgical saws. Research has proved that the new laser gives a cleaner cut and causes less secondary damage than other lasers with which it was compared.

The crystal heart of the Erbium-YAG laser is made from the chemical element erbium mixed with yttrium, aluminium and gallium and grown as a high purity garnet of very clear optical quality. This acts as the laser medium by absorbing light and emitting laser radiation.

Originally, researchers believed that healing was slowed down by laser surgery, but experiments in Manchester have shown that the new laser can actually promote faster healing.

Of great value to the surgeon is the potential for more precision in delicate brain surgery, and the repair of facial injuries caused by motor accidents. In surgery, particularly to the facial bones, the accurate positioning of bones is often achieved by fixing mini-bone plates. Laser techniques enable the surgeon to drill accurate holes which enhance the stability of plates and screws.

FEARS DISPROVED

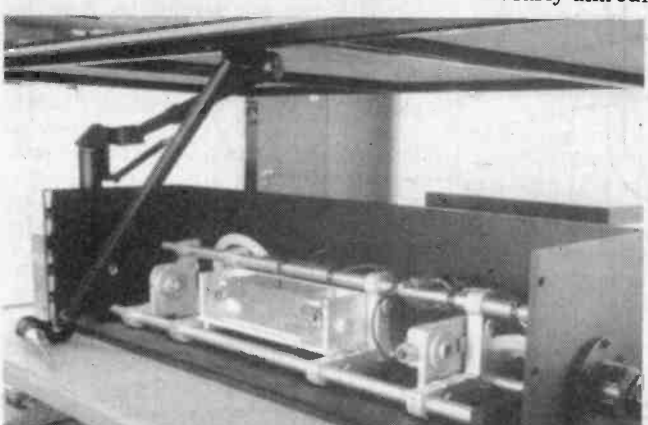
Surgeons had feared that in brain surgery, laser-cutting into the skull might damage the brain, but the new laser appears to disprove these fears. Professor Tony Freemont at the University explained that, since the new laser beam stops when it hits water, and as the brain is surrounded by water, damage to tissue is prevented.

"The greatest energy wavelength of the Erbium-YAG is concentrated in a very narrow band of 2·94 micrometres, which happens to be the peak energy absorption point for water", he explained.

In an experiment on anaesthetized rats, in which the laser was compared with a conventional water-cooled electric drill system, the laser was operated in free-running, fixed Q mode and produced macro-pulses of 250 microseconds duration. Each macro-pulse consisted of a series of micro-pulses with a duration of a few microseconds.

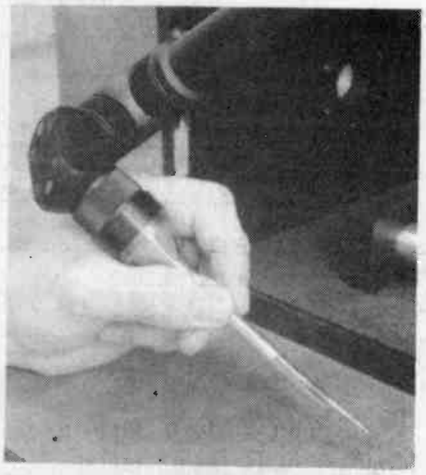
ARTICULATION

Operations will also be greatly aided by the mobility and reduced size of the laser. Its articulated arm is connected to a handpiece the size of a pen. Professor Freemont explained that the articulated arm was developed to enable a surgeon to direct the laser in areas of the body where it was particularly difficult to reach.



The Erbium-YAG laser which could increase the sophistication of keyhole surgery.

"There are two ways of delivering the laser: one by the articulated arm, which has a series of mirrors which bounce the beam round corners, and the other by use of a fibre-optic system. Unfortunately, the Erbium-YAG can only be directed down certain types of fibre-optic cable, such as Zirconium-fluoride, which tends to break if it is repeatedly bent.



The business end of the articulated arm for the Erbium-YAG laser.

"The mirror system is better, except that energy is lost because there is a certain amount of light absorption by the mirror." Even so, the beam can be concentrated in a very localised fashion with less than 100 micrometres of damage. This is an important consideration when working in a constricted environment, such as in neuro-surgery.

PAIN RELIEF

Professor Freemont also commented: "Elderly people can experience pain due to the over-growth of bone causing compression of nerve roots. These outgrowths could be removed by the new laser as it can cut into bone to a clearly defined depth with such precision that it would neither damage the nerve nor cause more than minimal tissue damage."

In experiments with rats, the team also made the surprising discovery that they were able to stimulate the growth of new bone by using the laser. "That really is a discovery for *Tomorrow's World*", said Professor Freemont. "It has given us the signal that we may be able to stimulate bone marrow and turn it into new bone.

The new technology was unveiled at the Institute of Physics Annual Congress held at Telford this Spring.

YOUNG ELECTRONIC DESIGNER AWARDS

TWENTY-ONE finalists, aged from 14 to 25, gathered at the home of scientific achievement at the Science Museum in London to display their electronics based projects and to hear if they had been successful in their efforts to carry off the prize of *1995 Young Electronic Designer Award.*

Co-sponsored this year by Texas Instruments and Mercury Communications, this annual competition has been running since 1985 and is open to all students, between the ages of 12 and 25, in secondary schools, colleges and universities. The competition aims to encourage and challenge young designers to invent and produce a novel electronic device that meets everyday needs.

Under the patronage of His Royal Highness The Duke of York, the competition is governed by The YEDA Trust, a registered charity. The Duke of York makes his own personal award to the contestant who he considers as "having the most innovative idea in the competition."

This year, the "Duke of York's Award for Creative Technology" was presented to Richard Earthrowl (16), of Ravens Wood School, Bromley for his "Sava-Siren" distress beacon for hikers, bikers, skiers and pot-holers. Richard received a crystal bowl trophy (held for one year) and, for his school, a TI TravelMate notebook computer.

It was the view of the judges that Martin Johnstone (17), from Kingussie High School, Highland, should receive the Texas Instrument Prize of £2,500 for, in their opinion, the most commercially viable product. Martin's entry was the "MJ Switch" a device for indicating the turning and braking of a vehicle while carrying bicycles on the rear.

The judges could not decide on an outright winner for the Mercury Planet Award of £2,500, for the most socially or environmentally helpful project, so they made a "joint first" award to Sarah Preston (16) from Blyth Ridley High School for her "Poor Circulation Monitor", and to Steven Maher (17) of Cheltenham College for his "Asepsimeter", a digital expiratory-flow meter.

The use of ultrasonics won Lars Blackmore (14), Sevenoaks School, the first prize of £500 in the Junior category for his low-cost reversing and obstacle indicator for cars.

All finalists were presented with certificates and TI calculators, and their schools or colleges each received Mercury compatible telephones.

The 1995 Young Electronic Designer Award category winners (from left to right): Martin Foley, Sarah Preston, Steven Maher, Richard Earthrowl, Lars Blackmore and Martin Johnstone.

Ravens Wood School student Richard Earthrowl who won The Duke of York's Award for Creative Technology is seen here receiving his prize from His Royal Highness.

Martin Foley of Brunel University winner of the Senior Category with his keyboard emulator for the seriously disabled.

AWARD WINNERS

The Duke of York's Award for Creative Technology:
Richard Earthrowl (16) – Ravens Wood School, Bromley, Kent
"Sava-Siren" – a distress beacon for hikers, bikers, skiers and pot holers

The Texas Instruments Prize (£2,500) for the most commercially viable project:
Martin Johnstone (17) – Kingussie High School, Highland
The "MJ Switch"

The Mercury 'Planet' Ward (£2,500) for the most socially or environmentally aware project:
Joint Winners:
Sarah Preston (16) – Blyth Ridley High School, Blyth, Northumberland
"PCM" – Poor Circulation Monitor
Steven Maher (17) – Cheltenham College, Cheltenham
"Asepsimeter" – an improved electronic digital peak expiratory flow-meter

Senior Category (18-25 years inclusive)

1st (£1,000)	Martin Foley (22) – Brunel University, Egham, Surrey "Freeboard" – a multi-access computer keyboard emulator for disabled PC users
2nd (£500)	Christopher Kirkham (24) – Brunel University, Egham, Surrey "Nautilus" – a sailboat race starting aid for race officials
3rd (£250)	Alison Chappell (24) – Brunel University, Egham, Surrey A card operated street condom vending machine

Intermediate Category (15-17 years inclusive)

1st (£750)	Steven Maher (17) – Cheltenham College, Cheltenham "Asepsimeter" – an improved electronic digital peak expiratory flow-meter
2nd (£400)	David Wilson (16) – Merchiston Castle School, Edinburgh "RAPP" – Remotely Activated Power Points
Joint 3rd (£200)	Mark Edgerton (16) – Colston's Collegiate School, Bristol, Avon "Peak-Charge" – a new design NiCad battery charger Timothy Munn (16) – Sandown High School, Sandown, Isle of Wight A foghorn operation system for small boats

Junior Category (under 15 years)

1st (£500)	Lars Blackmore (14) – Sevenoaks School, Sevenoaks, Kent A low-cost reversing indicator for cars using ultrasound
2nd (£250)	Ross Adams (14) – Coleraine Boys' School, Coleraine, Northern Ireland A device which deters able-bodied drivers parking in spaces allocated for disabled drivers
3rd (£150)	Colm Miskelly (14) - St Mac Nissis College, Carnlough, Northern Ireland "Velcrouse" – an electronic board game based on house building

New Technology Update

Ian Poole puts us in the picture on the problems associated with photolithography techniques of producing and manufacturing i.c.s for the future.

PHOTOLITHOGRAPHY is one of the key processes in i.c. manufacture. It enables the complicated shapes and patterns generated by the designers to be transferred to the silicon or other semiconductor surface. In turn this allows the individual components to be fabricated on the i.c. by the other processes used in the manufacturing cycle.

It is possible to produce feature sizes of less than one micron, and very small levels of defects in the photographic processes.

Basic Process

The basic idea of the process is quite simple. First the patterns which need to be transferred to the i.c. surface are generated by the designers. Today this will obviously be accomplished by computers, but in the early days of i.c.s, the shapes were produced manually.

Once the required shapes have been produced they are reduced in size many times and also repeated so that many i.c.s can be produced from the same wafer. This stage requires the use of very high grade photographic equipment, costing very large sums of money. The resultant "mask" is then ready for use in manufacture.

During manufacture of the i.c. a silicon oxide layer (or other semiconductor oxide layer) is first built up onto the substrate. Once this has been completed the substrate is covered with a very thin layer of a light sensitive material called photoresist.

To ensure a thin but even layer of the resist, the wafer is spun at a high speed and some resist is dropped onto the centre of the wafer. The centrifugal force pushes the resist out from the centre, covering the whole of the wafer in a uniform even layer.

Good Exposure

When the resist has hardened the next stage is for it to be exposed. A glass photographic mask containing the required pattern is brought into contact with the wafer. Light is then made to shine onto the wafer through the mask so that areas of the photoresist are exposed to the light as shown in Fig. 1.

Having exposed the photoresist, it is developed to remove the relevant areas of resist. With some resists the exposed areas are removed during developing whereas with others the non-exposed areas are removed.

The next stage in the process can be to etch away the areas of exposed silicon oxide to expose the basic silicon underneath. A variety of etches can be used, but it must not etch the photoresist of the silicon to any degree. When this has been completed, areas

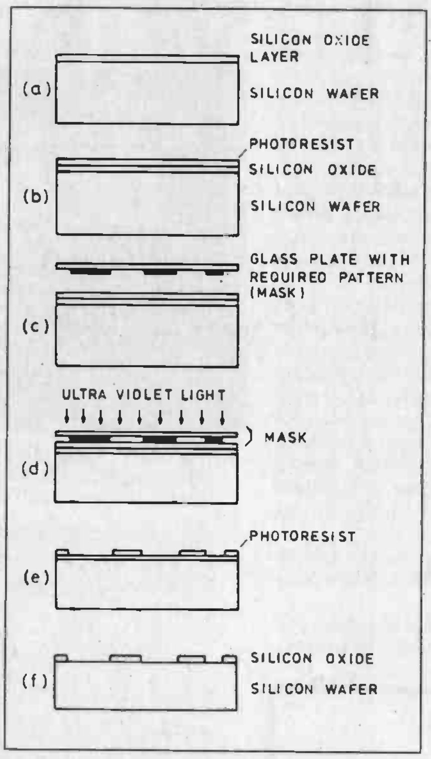


Fig. 1. Stages used in photolithography: (a) silicon oxide layer grown on to wafer, (b) photoresist added, (c) mask positioned, (d) photoresist exposed, (e) photoresist developed, (f) oxide etched and photoresist removed.

of silicon are then exposed for diffusion of *n*-type or *p*-type impurities.

This series of process outlines has to be repeated a number of times to build up the required areas to make an i.c.. Often as many as twenty stages or more are required to complete the circuit.

Limitations

However, there are a number of limitations to the process. One of the major ones is the size of the features which can be produced. Today sizes of just less than a micron can be produced. To achieve this special collimators are required for the light used in the photolithographic stages. The quality of the mask also needs to be exceedingly high.

Unfortunately, the ultimate definition is limited by the wavelength of the light which is used. It is for this reason that ultraviolet light is normally used because it has a shorter wavelength than visible light.

With the ever increasing demand for more complicated and smaller i.c.s, sizes need to become even smaller. This puts the pressure on researchers to devise methods of improving the processes.

Deep UV Light

One of the methods of improving the definition attainable is to shorten the wavelength of the light used even further and use what is called "deep ultra-violet light". Using this approach it is expected that feature sizes of 0·1 micron can be achieved, although much work still remains to be done.

To be able to work with deep ultraviolet light a number of modifications need to be made to existing processes. First, it is necessary to develop a new range of photoresist materials. Currently there are a number of materials which respond to ultra-violet light beyond that normally used. However those for the projected wavelength are still being developed.

New optical arrangements are also needed. The collimators used for ordinary ultra-violet light use a series of lenses. With deep ultra-violet light lenses do not work.

As a result specially fabricated mirrors are needed. These have to be finished to an exceedingly high degree of accuracy. It is necessary for the surfaces to be accurate to within 5 Ångstöms (5Å); five hundred-millionths of a centimetre.

Fortunately some work has already been performed into making mirrors of this nature. This came out of the "*Star Wars*" or Strategic Defense Initiative inaugurated by President Reagan in the 1980s.

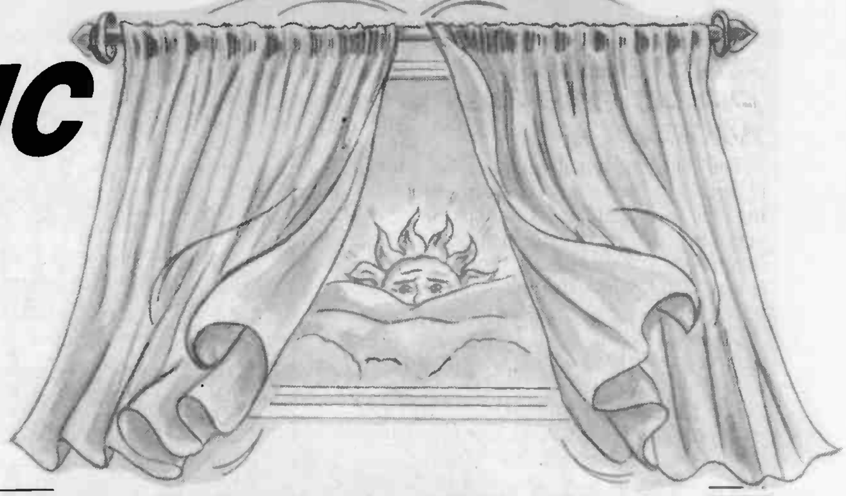
As the i.c.s manufactured with this process are likely to be much more complicated, there are going to be more manufacturing stages which also multiplies the wafer alignment problems. To help overcome this alignment problem a special frictionless mount is being developed. This involves the use of magnetic levitation techniques which will give full freedom of movement whilst still retaining complete control of the position.

Into The Next Century

As a result timescales well into the next century have been set for the final completion of the work, and the availability of a usable system for mass manufacture of small feature i.c.s.

In fact, the first prototype system is expected to be working by 1998. This will only be experimental, and used for making limited numbers of circuits for evaluation.

After this the correct semiconductor technology to use has to be selected and experiments performed. This work is likely to take a number of years and it is not expected that volume production will commence until about 2006.



AUTOMATIC CURTAIN WINDER

MAX HORSEY **P.C.B. Design by Philip Clayton**

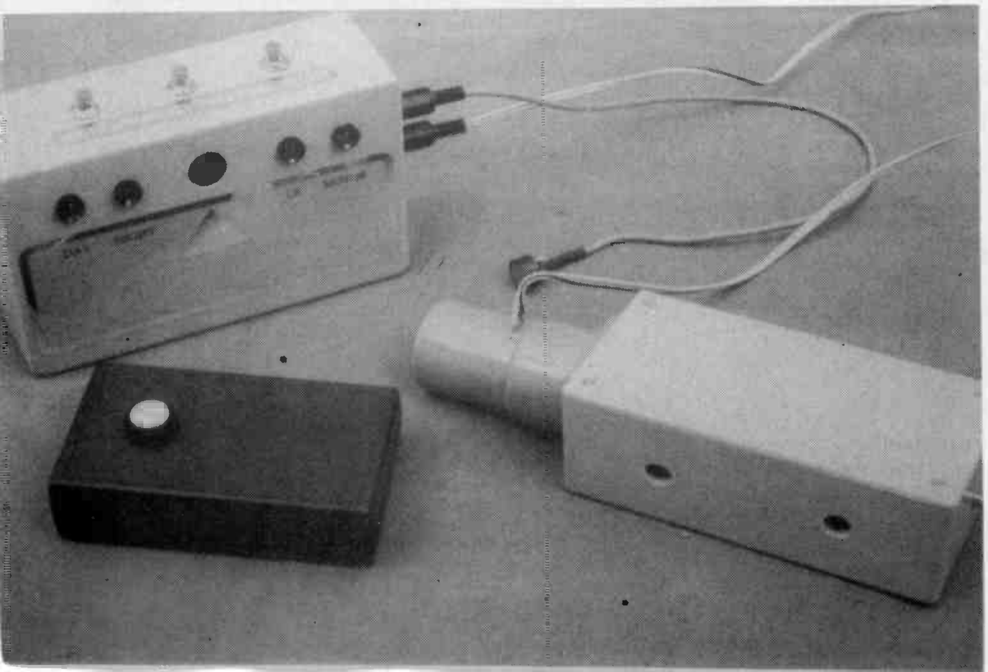
Automatically opens and closes curtains at dawn and dusk at preset light levels. Can be added to almost any existing "corded" system. A single-button Infra-Red Remote Control is also included (next month) which will enable disabled people to control the system.

The Remote Control produces a coded infra-red signal which makes it ideal for additional applications, such as alarm systems, door openers, light controllers etc.

MANY readers will have seen the advertisements on TV featuring automatic curtain winders. They are particularly valuable during holiday periods, since open curtains at night and closed curtains during the day are sure indicators that the occupants are away from home.

The curtains winding system to be described here can be added to any existing corded system, *providing it runs freely;* there is no need to purchase expensive curtain tracks, as required for some commercially available systems.

The Automatic Curtain Winder System showing the Control Unit, Motor housing and the Infra-Red Remote Control hand-set (next month).



AUTOMATIC CONTROL

The trigger for opening/closing of the curtains is the level of "daylight". A timing system was considered, but it is surprising how quickly the point at which the curtains should be closed or opened changes during Autumn and Spring. A daylight triggered system also allows for overcast or sunny weather.

Both the opening point and the closing point can be independently set, and a Schmitt trigger circuit ensures that the curtains will not react to slight changes of daylight caused by passing clouds. Full manual override is included, and the curtains stop automatically at the ends of their travel without the need for awkward sensing switches.

REMOTE CONTROL

Systems which are available in the shops make much of being able to operate the curtains by remote control. An Infra-Red Remote Control Transmitter and Receiver system will be described in Part Two (next month), and this will allow the curtains to be opened/closed or stopped in any position by means of a single pushbutton switch.

To sum up, the system includes the following:

1. *Uses an l.d.r. (light dependent resistor), fixed to the inside of a window to detect the level of light outside. At dusk and dawn the curtains will close/open. The motor will switch off at the end of the travel.*
2. *Although there is provision for stop switches to detect when the curtains are fully open or fully closed, the circuit also features an* automatic "current sense" stop system *so that stop switches are unnecessary.*
3. *Manual override is provided which will:*
   (a) Stop the curtains in any position
   (b) Close or open from any position.
4. *The circuit is powered by means of a 12V 1A regulated mains adaptor.*
5. *Provision for adding a Remote Control Unit, (featured next month).*

6. The circuit can be easily interfaced to any controlling system, such as computer control.

LIGHT SENSOR AND SENSOR PROCESSING MODULE

The system block diagram is shown in Fig. 1. An l.d.r. is used for sensing the daylight; it is inexpensive and very sensitive, and its sluggish performance (compared with a photo diode) is of no consequence when dealing with changing daylight.

This is followed by a 741 op.amp comparator, complete with Schmitt trigger action to avoid hesitation at the changeover points between day and night. In fact, two 741 comparators are used, one for sensing the falling degree of light in the evening, the other for the morning. This enables completely independent control of the open/close points.

The circuit diagram showing the input sensor and amplifier section appears in Fig. 2. Employing two l.d.r.s (one for each comparator) would be inconvenient and cumbersome and so both comparators are connected to the same l.d.r. circuit. Of course, one comparator is inverting, and the other non-inverting.

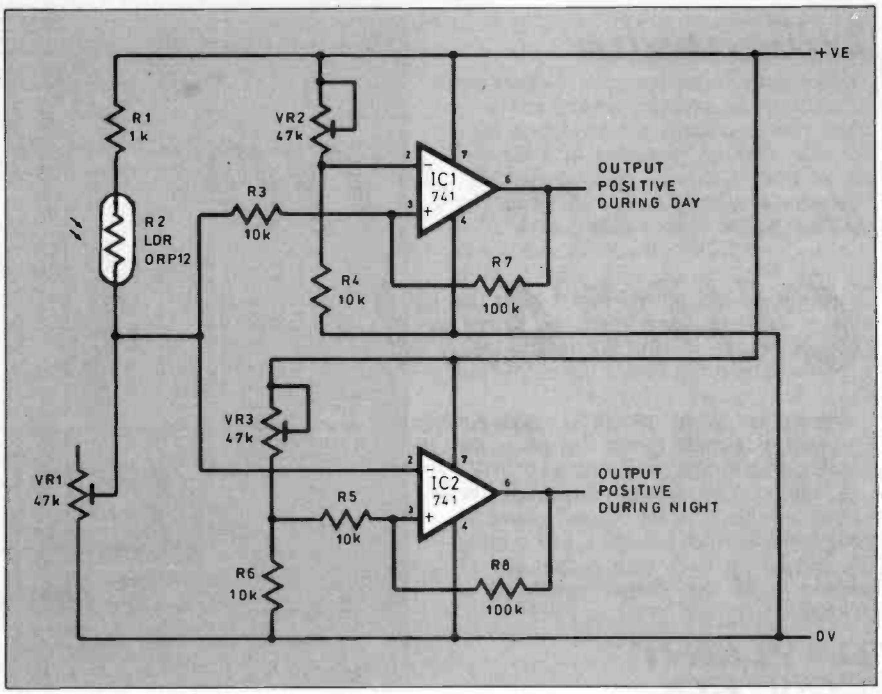


Fig. 2. Circuit diagram for the light level input sensor and amplifier section. The use of two comparators (741s) enables independent control of the curtain open/close points.

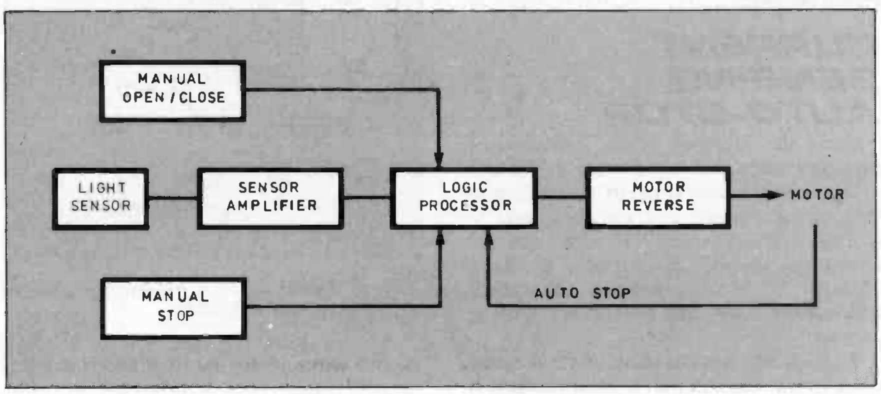


Fig. 1. System block diagram for the Automatic Curtain Winder.

Resistor R1 prevents damage caused by excessive current if the l.d.r. is exposed to bright sunlight (making its resistance very low), and if preset VR1 is set to a low resistance. The variable resistor VR1 provides overall control of both open/close points.

The voltage at the junction between the l.d.r. R2 and VR1 rises as the level of daylight increases. This voltage is used to control the non-inverting input of IC1 and the inverting input of IC2.

These i.c.s are connected as *comparators*. In other words they compare the voltages at their inverting (pin 2) and non-inverting (pin 3) inputs. Note that in this instance the + and − signs indicate non-inverting and inverting respectively, *not* positive and negative.

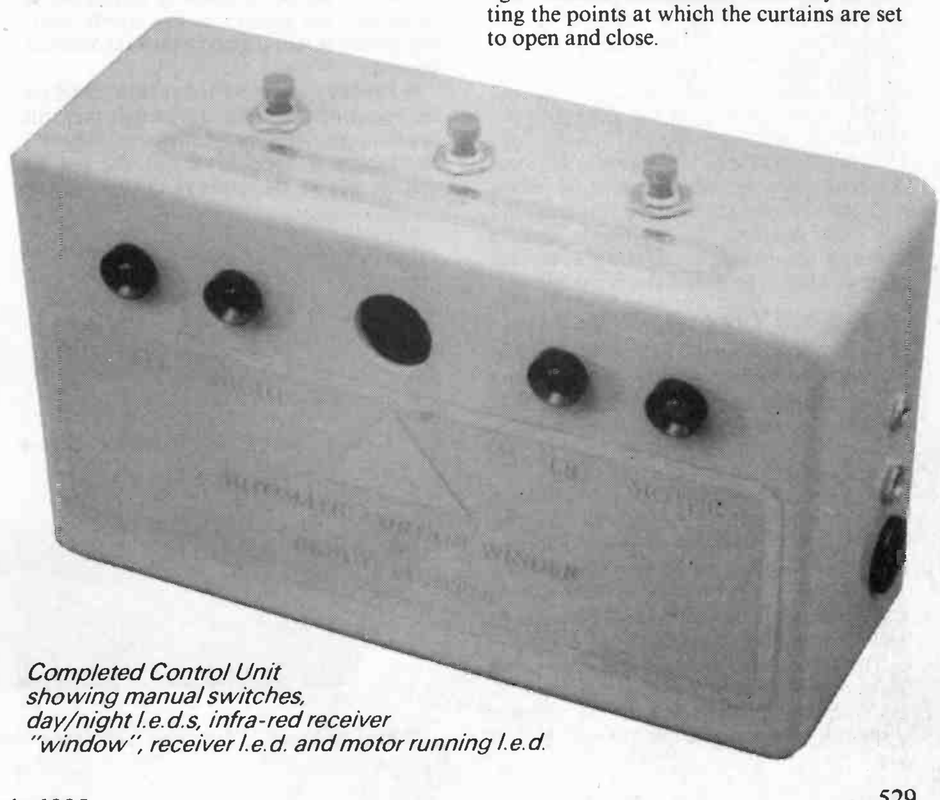
CURTAINS OPEN CIRCUIT

The preset potentiometer VR2 (wired as a variable resistor) together with resistor R4 forms a potential divider which sets the point at which IC1 reacts to the changing level of light. The output (pin 6) from IC1 switches to positive when the amount of daylight increases sufficiently to make the voltage at pin 3 (IC1) rise above the voltage at pin 2 which is set by VR2. The change of voltage at pin 6 triggers the logic circuit, as described later.

Feedback resistor R7 together with R3 cause the circuit to act as a Schmitt trigger. This makes the i.c. less sensitive to changes in light level, and less prone to trigger the curtains due to passing clouds etc. The ratio of R7 to R3 sets the degree of hysteresis – or in this context, and in plain English, the degree of insensitivity.

CURTAINS CLOSE

There is a similar circuit around IC2 except that the output switches to positive when the light level falls beyond a point set by preset VR3. The use of a completely separate circuit to detect the falling level of light enables considerable flexibility in setting the points at which the curtains are set to open and close.



Completed Control Unit showing manual switches, day/night l.e.d.s, infra-red receiver "window", receiver l.e.d. and motor running l.e.d.

LOGIC PROCESSOR

Since pushbutton operation is required in addition to daylight control and possibly, remote control, the maximum flexibility is achieved by means of a bistable circuit. That is, a circuit which can be "set" by means of a single pulse, and "reset" by means of a pulse at a separate point.

A double R-S bistable circuit, comprised of four NOR gates, with pins 1 to 6 forming one bistable, and pins 8 to 13 the other is shown in Fig. 3. When the "Open" switch S2 is pressed, pin 1 is forced to logic 1 (positive), and this causes the output pin 4 to switch and *latch* at logic 1.

Pressing the "Stop" switch S1 causes pin 6 to switch to logic 1, and this resets the bistable, with output pin 4 returning to 0V.

A similar arrangement surrounds the second bistable, with the "Close" switch S3 making pin 8 switch to logic 1, and causing the bistable to latch with output pin 11 positive, until the "Stop" switch S1 is pressed.

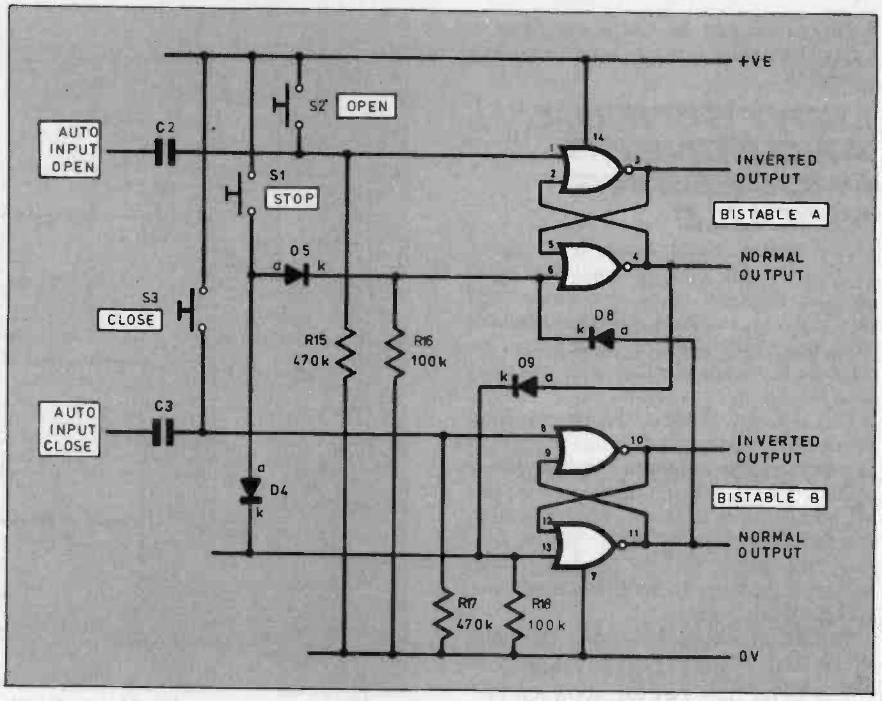


Fig. 3. Dual RS-bistable Logic Processing circuit and Manual switching arrangement.

DAYLIGHT CONTROL

Since the processor latches in the appropriate state until a reset pulse is received there is no need to hold down any controlling switch. In fact, a switch which remained on would prevent the bistable resetting. So the processor needs a positive *pulse* rather than a constant logic 1. Such pulses are easily obtained by briefly pressing a push-to-make switch.

However, the daylight sensor of the input module is likely to remain at logic 1 throughout the day, and likewise the darkness sensor will remain at logic 1 throughout the night. We need a circuit which will convert this steady state into a short pulse at the moment when the logic level changes from 0 to logic 1.

A series capacitor achieves this; hence the output from the daylight rising sensing circuit (IC1) is connected to the bistable via capacitor C2. The daylight falling circuit (IC2) is connected to the other bistable in a similar manner via C3.

This method of connection provides considerable flexibility in the control of the Logic Processor. It is possible to use the manual control switches to override the daylight control circuit at any time, but at the appropriate time the daylight control circuit will automatically resume control of the curtains. A Remote Control Receiver (next month) can also be added without affecting the existing controls, and any other interface idea is possible, such as opening the bedroom curtains automatically at a signal from the alarm clock!

MANUAL STOP

The "Manual Stop" button S1 is wired to both bistables, the diodes D5 and D4 preventing accidental resetting. It is possible to use curtain rail stop switches, although the current sensing stop system described later is a better alternative.

If curtain rail stop switches *are* used, they must be connected *individually* to each bistable as shown in the final circuit diagram, since one or other will be held closed when the curtains are fully open or fully closed. Clearly we could not allow *both* bistables to be locked into a "reset" state.

The two curtain rail stop switches could be connected, via a coupling capacitor, to provide a pulse; however, if the curtains were fully open when the "Open" button was pressed, they would try to open further, resulting in damage to the motor etc. The same danger would exist in the fully closed position.

CURRENT SENSING AUTO-STOP

Using the "current sensing" method of detecting when the curtains are at the end of their travel is mechanically much simpler than using curtain rail switches, and is strongly recommended. It also has the advantage that if the curtains meet an obstacle or become tangled the motor will automatically cut out before causing damage.

When a motor runs at its normal speed the current used is much smaller than if the motor is forced to slow down. If a resistor of about 10 ohms is connected in series with the motor (see Fig. 4), the voltage across it will depend upon the current flowing.

A 10 ohm resistor will have little effect on the speed of the motor (although this will depend upon the type of motor employed – experiment if necessary), but the rise in voltage across the resistor caused by the motor being forced to slow down is sufficient to trigger an op.amp comparator. The output from the op.amp can in turn be used to reset the bistables.

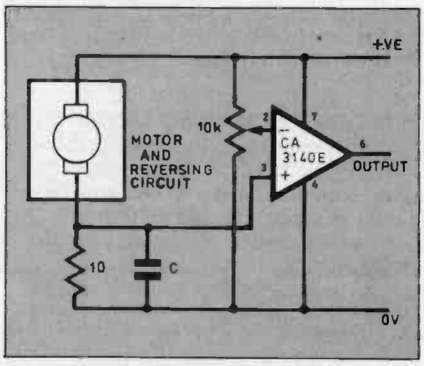
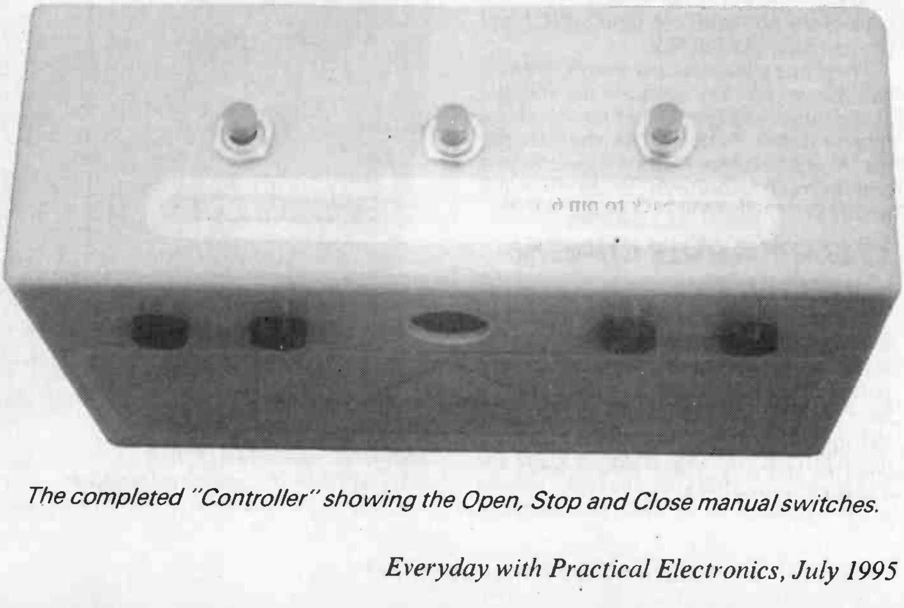


Fig. 4. Basic current sensing or motor stalling circuit diagram.

The basic circuit diagram for the "current sensing" arrangement is shown in Fig. 4. The potentiometer (a small preset on the p.c.b.) is used to set the voltage at which the output from the op.amp changes state. The rise in voltage at pin 3 (non-inverting input) caused by the motor stalling, results in the output from the op.amp switching to logic 1.



The completed "Controller" showing the Open, Stop and Close manual switches.

Note the addition of a capacitor C needed to smooth out fluctuations in the voltage across the resistor as the motor spins.

In trials, this system worked so well that curtain rail switches were not used, although provision for both stopping methods has been made on the p.c.b. Note however that the value of the resistor may need to be modified according to the type of motor used and if the behaviour of the system is different under load (i.e. when driving the curtains) than when on the workbench.

The motor used in the prototype (details later) worked well with a series resistor of value 8·2 ohms. Also an f.e.t. input op.amp such as CA3140E offers better results than a 741.

MOTOR CONTROL

The motor control circuit is shown in Fig. 5 (the main circuit diagram) and has two inputs, via resistors R21 and R22. When a positive signal is applied to R21 transistor TR4 is turned on, and causes TR5 to switch off and TR6 to switch on.

Assuming that TR3 is turned off, the voltage at "B" will be positive, and hence TR7 will be on, and TR8 off. With power transistors TR6 and TR7 both on, current will flow from the positive rail, through TR7, to the motor, and to 0V via TR6 (and R27).

A similar sequence of events will occur if a positive signal is applied to R22, except that TR5 and TR8 will switch on, resulting in the motor rotating in the opposite direction. When the inputs at resistors R21 and R22 are both at around 0V, TR3 and TR4 will both be turned off, and all four power transistors will switch off, hence stopping the motor.

If a positive signal were to be applied to R21 and R22 at the same time, all four power transistors would turn on and a short circuit would occur. The diodes D8 and D9 should ensure that both outputs (i.e. from pin 4 and pin 11 of IC4) can never be positive at the same time, making this situation impossible.

Indicator D16 is a bi-colour l.e.d. which glows red when the current flows in one direction, and green when the current is reversed. Two separate l.e.d.s could be employed if preferred. Capacitor C11 suppresses voltage spikes produced by the motor, and the four diodes D12 to D15 remove voltage spikes which may damage the transistors.

Current from the motor reversing circuit must pass through resistor R27 on its way to 0V. If the motor stalls, the voltage across R27 will rise and this rise in voltage is fed through R25 to trigger the "current sense stop circuit" built around IC3.

When the voltage at the non-inverting input (pin 3) of IC3 rises above the voltage determined by the setting of preset VR4, the output pin 6 switches from 0V to positive. This causes an effect similar to pressing S1, the Stop switch. Diode D3 prevents current flowing back to pin 6, if S1 is pressed whilst pin 6 is at 0V.

Capacitor C1 delays the stopping action a little, to allow the motor to start up initially. Once the motor has stopped, pin 6 switches back to about 0V.

Note that capacitor C1 determines the speed with which the circuit reacts to the stalling motor; the circuit must be sensitive enough to detect the fully wound curtains, but not be so sensitive that the motor cannot be started initially. Fine control is provided by preset VR4.

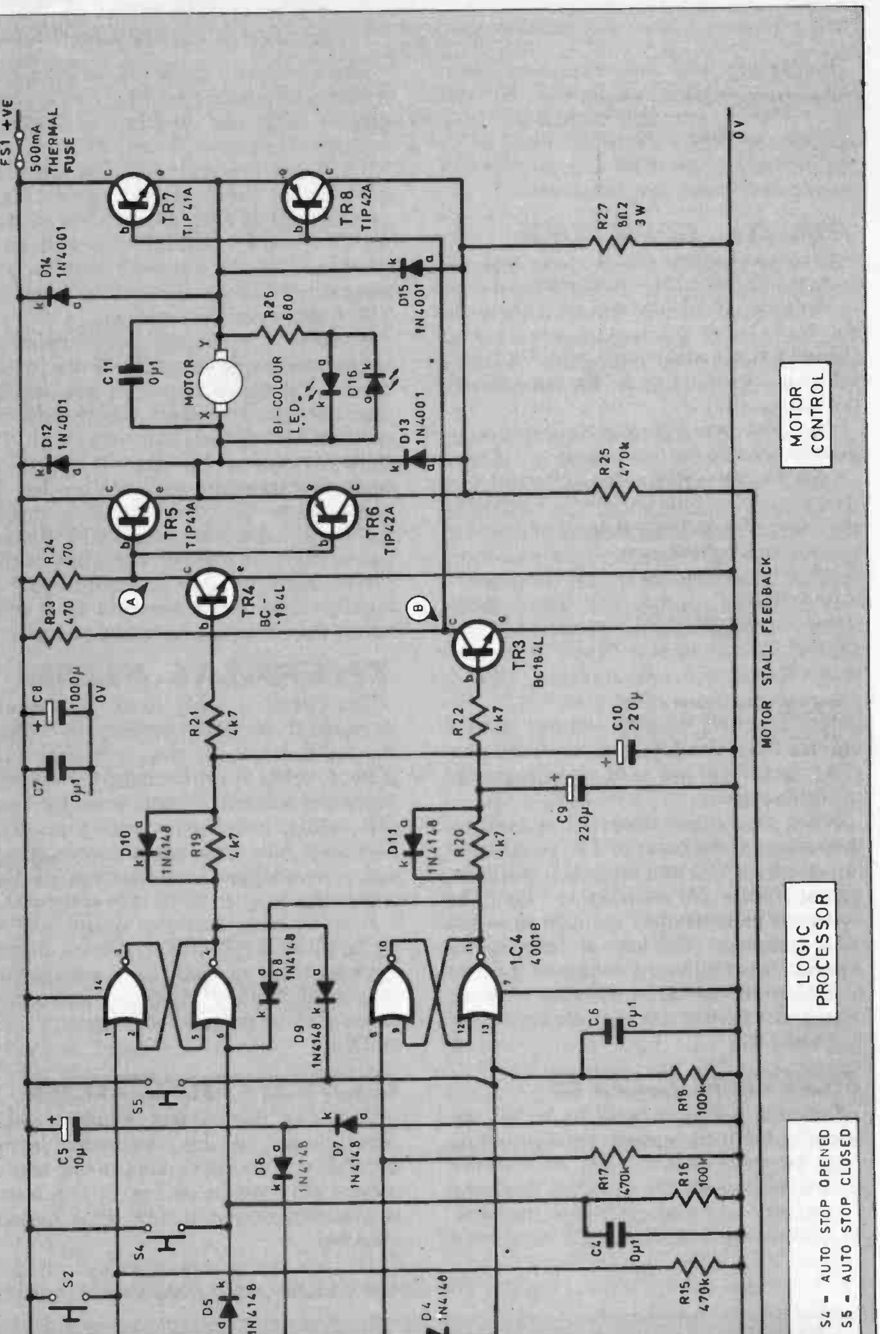


Fig. 5. Complete circuit diagram for the Automatic Curtain Winder.

In practice VR4 controls the ease with which the curtains are brought to rest. Since opening requires more force than closing, and the force required increases as the curtains open, *VR4 actually controls how far the curtains are pulled open*.

FINAL CIRCUIT

How the modules described slot together to form the complete circuit diagram for the Automatic Curtain Winder is shown in Fig. 5. Most of the components have already been described, but certain additions have been made to assist the reliability of the system.

Capacitors C4 and C6 remove any interference which may be picked up if long wires are used to link switches S4 and S5 – the optional switches which may be fixed to the curtain track if this method of stopping the curtains is preferred to the automatic "current sense" system already described.

It is helpful, particularly when adjusting the variable resistors (presets) to know whether the circuit is in "day" or "night" mode. Hence, l.e.d. indicators (D1, D2) are driven from pin 6 of IC1 and IC2. The output of a 741 op.amp will not drive a normal l.e.d. directly, and so transistors (TR1 and TR2) are used to increase the available current.

When the output from IC1 is positive, the voltage at the bases of TR1 is sufficient the switch on TR1 and hence D1. When the output from a 741 switches to "low" the voltage is unfortunately too high to switch off a transistor. The task of resistors R9 and R10 is to reduce the voltage at the base of TR1 so that it *can* be switched off when required. A similar arrangement applies for IC2 and TR2.

POWER CUTS

Since the circuit is likely to be left unattended for long periods some provision must be made in the event of a power failure, to prevent the bistables assuming a random state when power is restored. At "power up" capacitor C5 supplies a positive pulse via diode D6 to force both bistables into their reset state. D7 is necessary to allow the capacitor to discharge properly when power is removed.

The Logic Processor could be linked directly to the motor control circuit. However, instead of using a single base resistor for TR4, two 4·7 kilohms resistors in series (R19 and R21) are employed, together with a capacitor C10 and diode D10. Transistor TR3 is given similar treatment.

The reason for this additional circuitry is to prevent rapid reversal of the motor if say, the Close button is pressed immediately after pressing Stop whilst the curtains are *opening*, and visa-versa. The capacitor delays the rate at which its associated transistor can turn on, but the diode causes the capacitor to be rapidly discharged when the associated logic output switches to logic 0. The result is that the current through the motor can be rapidly stopped, but there is a short delay before the motor can be turned on again.

THERMAL FUSE

The circuit is likely to be left on and unattended for long periods. A 500mA thermal fuse was therefore included on the p.c.b. to cover any eventuality e.g. curtains becoming tangled, current sense stop system failing, major short circuit etc. This particular fuse resets when it cools down, and is in addition to a standard 1A fuse which may be fitted in the case of the unit.

It is assumed that the system will be powered by a 12V 1A *regulated* supply. Even so, there are likely to be voltage fluctuations throughout the circuit, and overall decoupling is provided by capacitors C7 and C8.

CONSTRUCTION

Details of the Curtain Winder printed circuit board (p.c.b.) component layout and full size underside copper foil master pattern are provided in Fig. 6. This board is available from the *EPE PCB Service*, code 946.

Begin work by inserting the i.c. sockets, followed by the smaller components, checking that the diodes are fitted with their bands facing the correct way. The resistors and small 0·1μF (100nF) capacitors can be fitted either way round, but the electrolytic capacitors and transistors must be the way shown. The negative end of the electrolytic capacitor is normally indicated by arrows and a shorter lead.

Fit terminal pins for the external connections. When soldering leads to the terminal pins the simplest and most reliable method is to place a little solder on each pin, then strip and tin (i.e. coat with a little solder) the end of each connecting lead, finally trimming with cutters so that only about a millimetre or two bare tinned lead are exposed. Now place the exposed end against the terminal pin whilst applying the soldering iron.

Decide at this stage if the project is to be housed in its case (described later) before the final test, so that all the external connections can be made; alternatively make temporary connections to the terminal pins to enable testing.

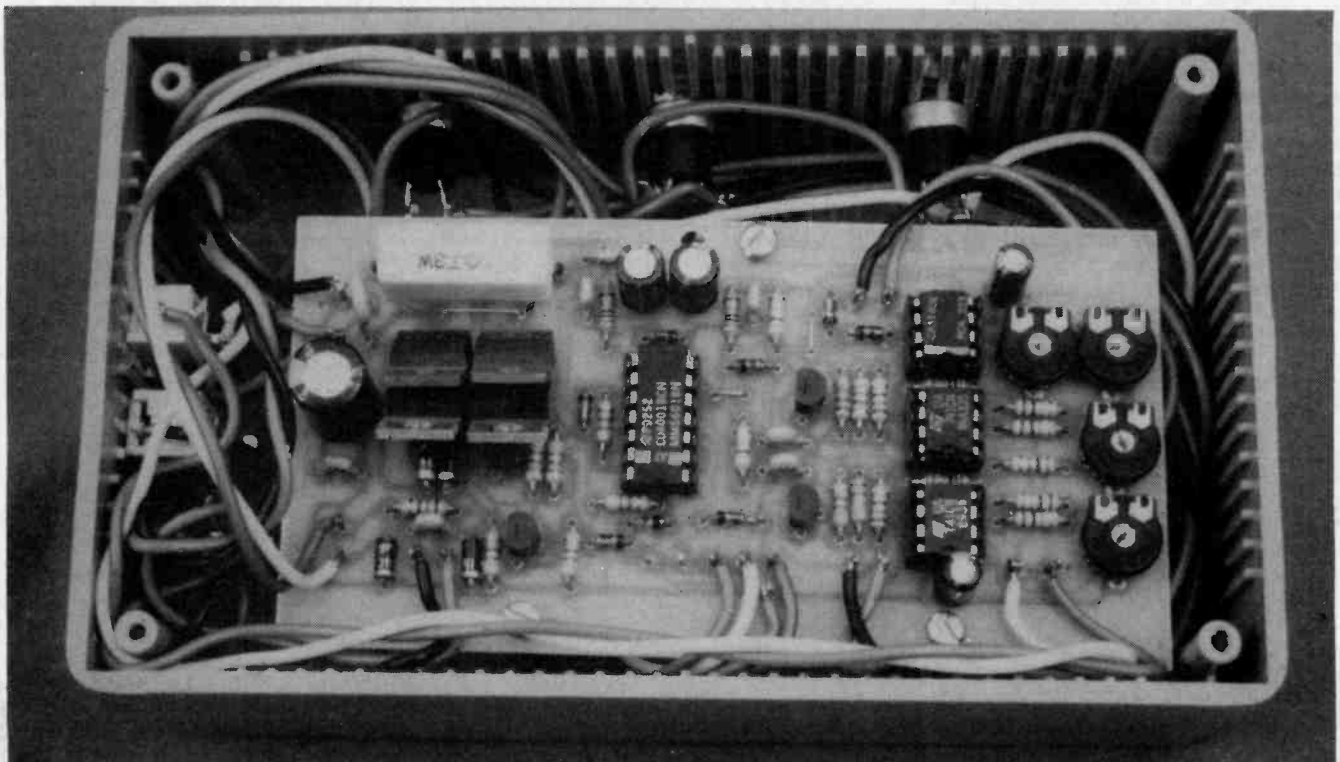
Finally, insert the i.c.s into their sockets, ***taking special care with IC3 and IC4 (since they are static sensitive) to "earth" your fingers (by touching an earthed metal object) before removing them from their protective package or foam.*** Ensure that all the i.c.s are fitted with their notches as indicated in Fig. 6.

Heatsinks were not found to be necessary in the prototype; however if a much larger motor is used, check that the power transistor tabs do not become excessively hot (they are allowed to feel too hot for comfort but should not be hot enough to cause a serious burn!).

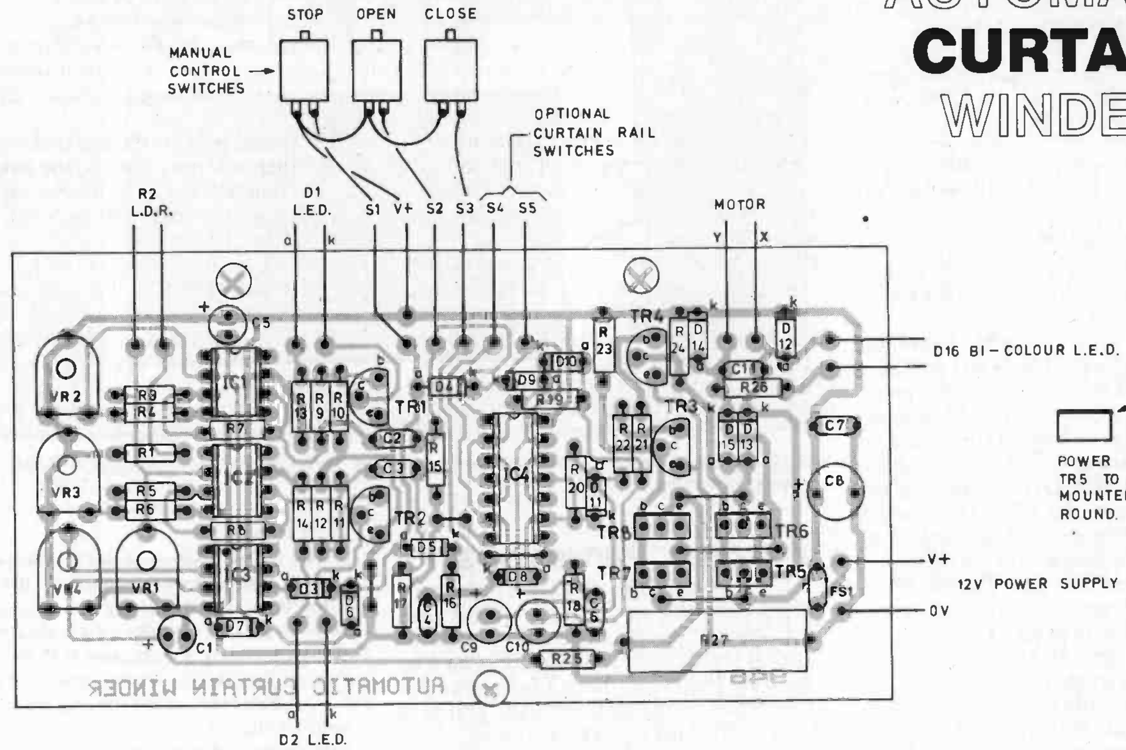
TESTING

The circuit is best tested by connecting it to a regulated and current limited 12V supply. A maximum of 100mA is ideal, assuming that the motor is *NOT* connected.

The Curtain Winder p.c.b. mounted in the control unit.



AUTOMATIC CURTAIN WINDER



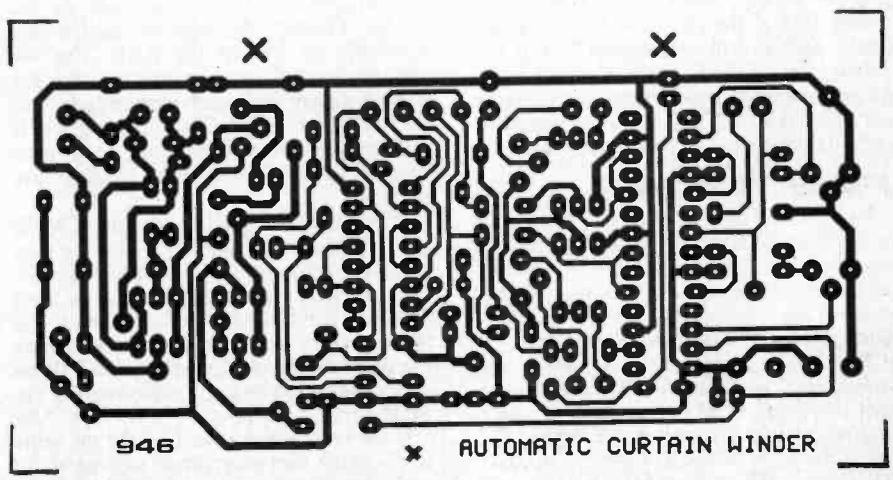


Fig. 6. Printed circuit board component layout, wiring to Manual switches and full size underside copper foil master pattern.

COMPONENTS

Resistors

R1	1k
R2	ORP12 light dependent resistor (l.d.r.) or similar
R3, R4, R5, R6	10k (4 off)
R7, R8, R16, R18	100k (4 off)
R9, R11	15k (2 off)
R10, R12, R19, R20, R21, R22	4k7 (6 off)
R13, R14, R26	680 (3 off)
R15, R17, R25	470k (3 off)
R23, R24	470 (2 off)
R27	8Ω2 3W

All 0·25W 5% carbon film, except R2 and R27

See SHOP TALK Page

Potentiometers

VR1, VR2, VR3	47k enclosed carbon preset, lin. (3 off)
VR4	100k enclosed carbon preset, lin.

Capacitors

C1	1µ radial elect. 16V or more
C2, C3, C4, C6, C7, C11	0µ1 disc ceramic (6 off)
C5	10µ radial elect. 16V or more
C8	1000µ radial elect. 16V
C9. C10	220µ radial elect. 16V (2 off)

Semiconductors

D1	5mm l.e.d. yellow
D2	5mm l.e.d. green
D3 to D11	1N4148 signal diode (9 off)
D12 to D15	1N4001 1A 50V rec. diode (4 off)
D16	5mm bi-colour l.e.d. (see text)
TR1 to TR4	BC184L *npn* transistor (4 off)
TR5, TR7	TIP41A *npn* power transistor (2 off)
TR6, TR8	TIP42A *pnp* power transistor (2 off)
IC1, IC2	741CN op.amp (2 off)
IC3	CA3140E MOSFET op.amp
IC4	4001B quad 2-input NOR gate

Miscellaneous

S1 to S3	min. non-locking pushbutton switch, push-to-make (3 off)
S4, S5	optional curtain rail switches (normally open) (2 off)
SK1	2·5mm mono jack socket and plug
SK2	3·5mm mono jack socket and plug
SK3	power input socket for power adaptor
FS1	500mA thermal resetting fuse

Printed circuit board available from the *EPE PCB Service*, code 946; plastic case, type PX3, size 109·5mm x 179·5mm x 60mm (internal); plastic case for motor and winder assembly, type PX2, size 54·5mm x 104·5mm x 42mm (external); 8-pin d.i.l. socket (3 off); 14-pin d.i.l. socket; l.e.d. panel mounting clips (4 off); multistrand connecting wire; solder terminals; solder etc.

Motor Mechanical Parts (Meccano)
Meccano: axle rod, 5 inches; short coupling, 63d; bush wheel, 24b (4 off); optional couplings, 63d (see text).

Approx cost guidance only **£26**
excluding motor, mains adaptor and curtain track

The use of a regulated 12V 100mA supply will ensure that no damage can be done to the circuit, regardless of mistakes. If such a supply is not available, take extra care, and switch off immediately if any component becomes excessively hot.

Set preset VR4 (bottom left on p.c.b.) fully anti-clockwise to cancel the auto stop. Set the other presets to about midway. Switch on. It is likely that the Open l.e.d. D1 will light.

Twist preset VR1 fully clockwise. You should find that D1 switches off and D2 switches on. Carefully adjust VR1 until it is possible to make the l.e.d.s change over by shading or unshading the l.d.r., R2. Failure at this stage should be investigated before proceeding.

Assuming all is well check the behaviour of the bi-colour l.e.d. D16. It will probably be on, and could be red or green. Try pressing S1 (Manual Stop), D16 should turn off.

Shade the l.d.r. to make D16 switch on again. Keep shading the l.d.r. whilst pressing S1 again so that D16 is again turned off. Now unshade the l.d.r. This should cause D16 to change colour. The colour of D16 indicates the direction of the motor.

Try the manual switches S2 and S3 to check that D16 can be controlled as expected. Remember to press S1 to switch off D16 after each test. If S1 is held on the circuit cannot be triggered.

If you intend using curtain rail stop switches the inputs for switches S4 and S5 could be tested by touching them briefly to positive supply. Note that S4 will only cancel D16 if the circuit is in "opening" mode, and S5 will only cancel D16 if the circuit is in "closing" mode. Keeping input S5 positive (as it will be when the curtains are fully open) will still allow the circuit to enter its closing mode, and vice versa.

FINE TUNING

Presets VR2 and VR3 allow precise and independent control over when the curtains open or close. For example, it is possible to set the curtains to close at an early (bright) point in the evening, but open at an early (dim) point in the morning or vice versa.

This flexibility may be observed by adjusting presets VR2 and VR3 and noting that it is possible at the changeover point to make l.e.d. D1 switch off *before* D2 switches on, or make D1 switch on *after* D2 switches off. Remember that D16 will not change colour unless you first trigger the Manual Stop switch S1.

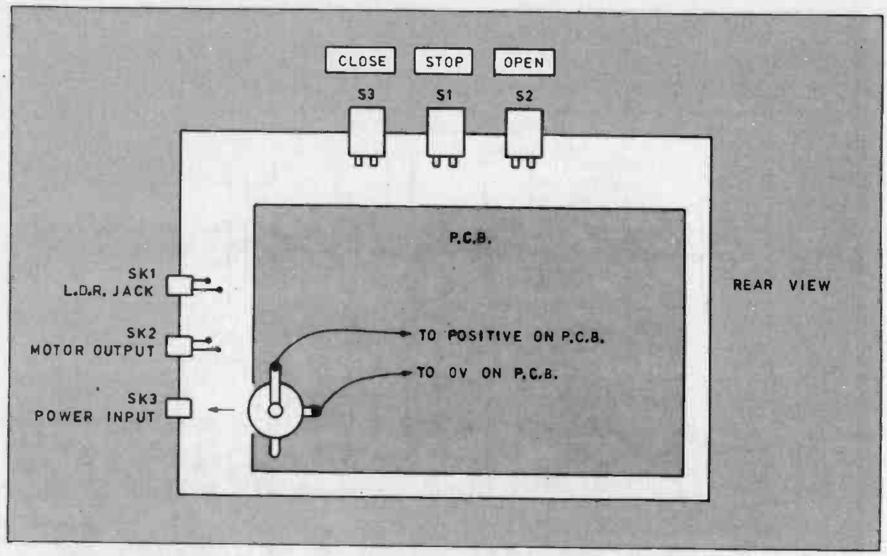


Fig. 7. Positioning the printed circuit board "off-centre" allows space for the l.e.d.s, switches and sockets.

FAULT FINDING

If the circuit fails to work as expected, check the board carefully for bridged pads (i.e. adjacent pads accidentally joined by solder) and dry joints which are caused by applying insufficient heat. Check also that the correct components are fitted, and have been inserted the correct way round.

Once the visual checks are complete, use a voltmeter to check each stage of the circuit. Connect the negative lead of the voltmeter to 0V on the p.c.b. Use the positive lead of the voltmeter to check the output voltage from each module in turn to narrow the fault to a particular area. If necessary read the descriptions about each module to check that your readings are correct.

When using a voltmeter around a CMOS i.c. (IC4) be aware that the voltmeter may affect the readings, and may cause the circuit to latch or unlatch. This can be very frustrating, but if readings are taken at the *outputs* of the gates rather than the inputs the problem should be reduced. It will be very difficult to check the pulse arriving via capacitors C2 or C3.

If the voltage from pin 6 of the op.amps is changing correctly, press and hold S2 and check that pin 1 of IC4 becomes positive. Likewise, holding down S3 should make pin 8 positive.

The motor reverse circuit can be tested by disconnecting the side of resistor R22 which joins R20, and touching the disconnected side of R22 to positive. This should make the motor turn. Disconnect R22 from positive, and try the same method with R21.

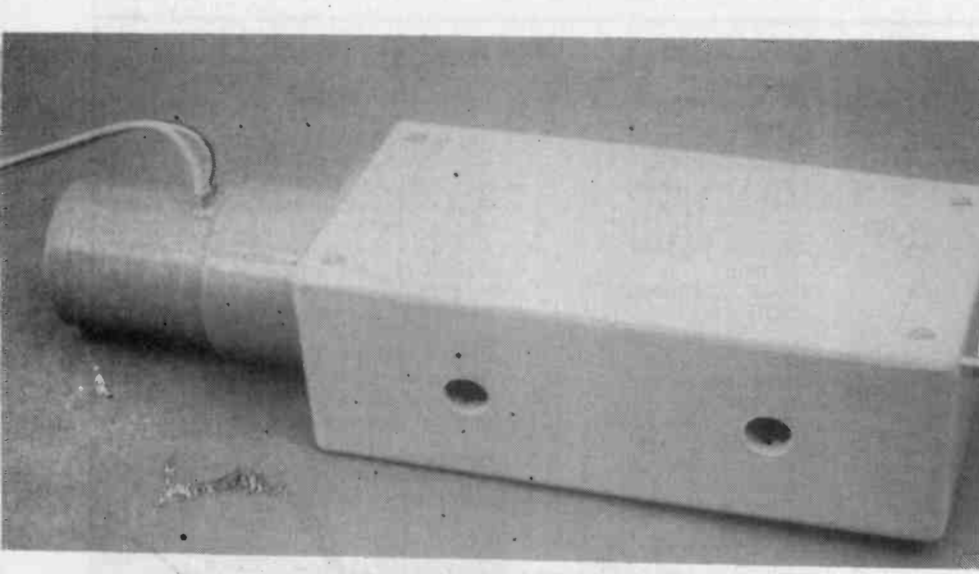
Failure of the motor reverse module may well be due to a mix up between the *pnp* and *npn* transistors. Check their codes carefully, and check that all the transistors are fitted the correct way round.

CASE DETAILS

The p.c.b. may be housed in a plastic PX3 type case, size 109·5mm x 179·5mm 60mm (internal), as shown in Fig. 7. However, it is best to decide at this stage if the Remote Control p.c.b. (next month) is to be housed in the same case, since this affects the drilling requirements.

The p.c.b. is mounted off-centre to allow space for the l.e.d.s, switches and sockets. Begin by drilling holes for the three pushswitches, three l.e.d.s, and sockets. The l.d.r., power supply, and motor supply may be linked via plugs and sockets to promote easy installation.

The p.c.b. may be mounted using self-adhesive p.c.b. supports. Note again that the Remote Control p.c.b. affects the arrangement and will eventually be fitted below the Curtain Winder p.c.b. so that the winder presets may be easily adjusted.



The completed motor drive assembly.

CHOOSING THE MOTOR

Clearly the motor is a key component in this project and will probably cost as much as the rest of the system put together. Remember that if you are using the current sense stop system, resistor R27 will remove several volts and should be rated at 3W minimum. In the prototype a 6V motor was chosen rather than a more obvious 12V type.

A good quality motor will use a conservative amount of current. The prototype used less than 100mA when under no load, peaking at 500mA. just before being switched off by the current sense circuit.

The specified motor used in the prototype model was a 60 r.p.m. 6V type, complete with gearbox (see *Shoptalk*). Its most useful feature is an output shaft compatible with Meccano shafts – ideal for those with low mechanical competence like the author!

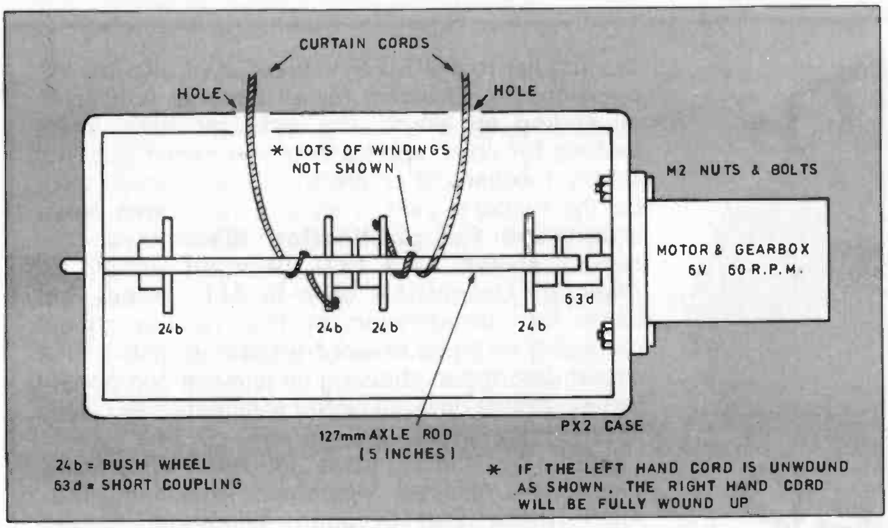


Fig. 8. The motor drive-shaft assembly and housing. The motor is bolted outside the case and the motor spindle linked to the winding shaft using Mecanno parts.

TESTING THE MOTOR

Assuming that the circuit works, and the bi-colour l.e.d. D16 functions properly, the motor may be connected. If you have been using a regulated 100mA supply, connect instead a supply capable of delivering 12V with enough current to drive the motor (say 1A). Repeat the previous tests, checking that the motor starts, stops and reverses when it should.

It will be difficult – probably impossible – to test the current sense stop circuit. Wait until the motor is driving the curtains, or substitute another non-geared motor which can be easily stopped.

If you think the motor current sense circuit is not working, check the voltage at pin 3 of IC3. There should be a noticeable voltage rise when the motor is forced to stall, and this should cause the voltage at pin 6 to switch from below 2V to around 10V. The voltage at pin 2 of IC3 should change from 0V to 12V as preset VR4 is turned.

MECHANICS

The motor discussed earlier, and used in the prototype closed the curtains in about 10 seconds, creating the effect of cinema screen curtains. Higher speed operation would demand a more powerful – and current hungry – motor.

Very heavy curtains might require slower operation. However, much depends upon the efficiency of the curtain tracks. The curtains have to run smoothly, with as little friction as possible. Clearly the tracks must be corded, and if cords are already fitted – and run smoothly – there is little more to do at this end.

The shaft of the motor was identical in diameter to Meccano axle rods, and a short Meccano coupling was used to extend the motor shaft as shown in Fig. 8. The shaft runs quite slowly and unless the curtains are very heavy, more couplers may be employed to create a fatter shaft.

This is, however, a *very* expensive way of making the shaft thicker and cruder methods may be preferred. For example, the cords could be cut longer than required and the surplus used to wind round the shaft. The motor shaft in the prototype tended to slip inside the coupling, and it is well worth filing a flat area to enable the coupling screw to grip the shaft tightly.

The curtain drive motor is bolted onto one end of a ABS plastic case, with the curtain cord drive-shaft housed inside the case (see photographs). The case specified is a type PX2 and has external dimensions of 54·5mm x 104·5 x 42mm. The case appeared to be made to measure, the Meccano couplers and motor fitting perfectly.

Begin by drilling the holes required noting that the motor already has holes suitable for small nuts and bolts. The motor shaft appears to require quite a small hole, but a much larger one is needed to allow the motor to be bolted properly against the case.

Drill a smaller hole opposite the motor shaft to locate the Meccano shaft. Two holes are required for the winding cords, and one or two mounting holes to allow the case to be mounted on the window sill or wall.

Having mounted the motor assembly, pull the curtains *fully* open, then cut the "pull to close" cord so that it can be wrapped around the shaft two or three times before being tied to the bush wheel. The motor may now be switched on to wind the curtains fully closed. Stop the motor manually at this stage.

Now attach the "pull to open" cord in the same manner, slackening the shaft retaining screw if necessary to twist the coupler until both cords are tight. Press the Open switch to wind the curtains open, then press Stop.

Close and open the curtains several times, then re-tighten the cords if necessary. Some slackness when the motor first starts to wind is acceptable providing the cord cannot become tangled.

AUTO-STOP ALIGNMENT

To set up the auto-stop position, turn VR4 (in the corner of the p.c.b.) almost fully clockwise, and check that the motor has difficulty in driving the curtains. If the motor does not readily switch off, check for faults (see the guide above) before proceeding.

If all is well adjust VR4 anti-clockwise until the curtains will wind fully, but stop when fully wound. Now make fine adjustments to VR4 to set how far you wish the curtains to be opened.

LIGHT SENSOR

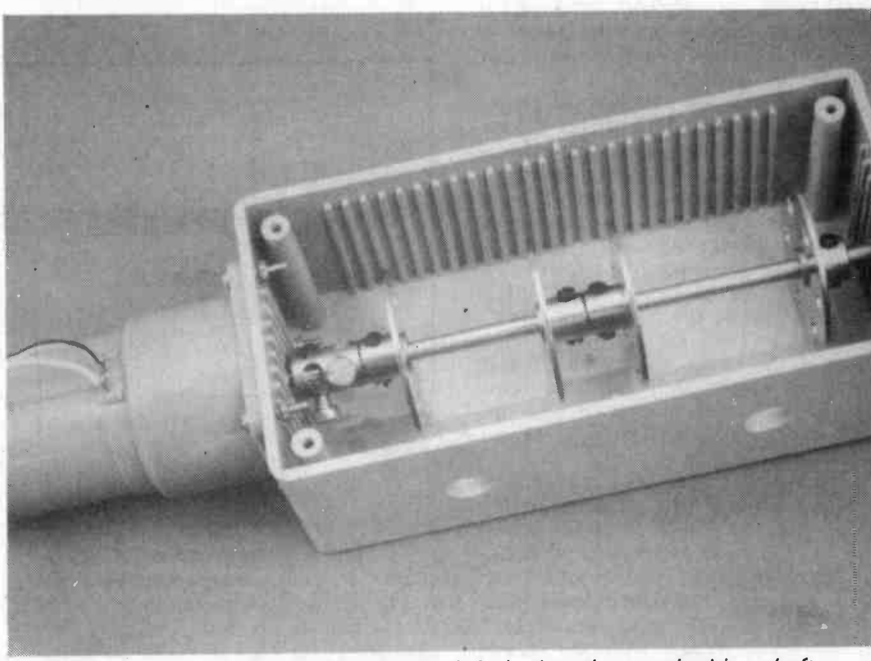
The light dependent resistor R2 should be positioned using glue or tape to fasten its wires so that the body of the l.d.r. is against the inside of a window. Try to select a position away from direct sunlight and hidden from car headlights and spotlights.

REMOTE CONTROL

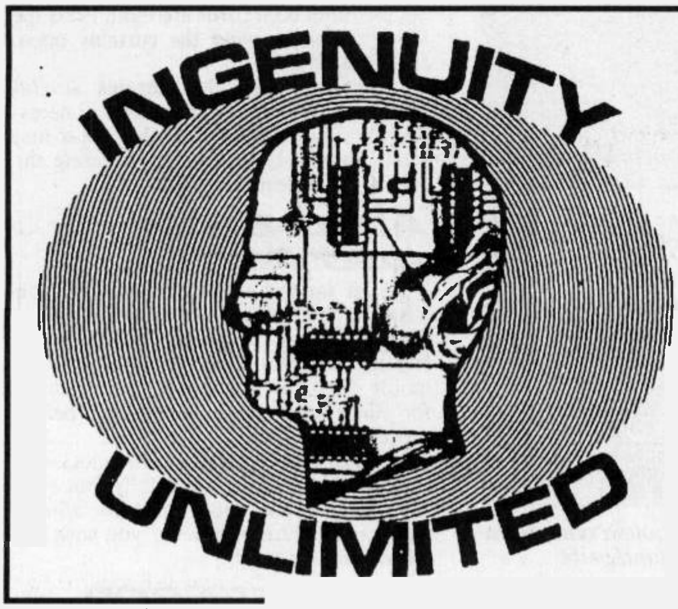
This circuit can be easily interfaced to other control circuits, the nature of the logic is to allow independent operation from a variety of sources. For example, when switch S2 is pressed a pulse is applied to pin 1 of IC4 and the curtains open. A positive pulse from any other source will achieve the same result. The same applies to S1 and S3.

The Remote Control Unit, described next month, applies pulses at these points, and includes a logic control circuit to convert a *single* command into the sequence: Open, Stop, Close, Stop etc. This logic control circuit can be extracted if single command operation is required from any other source.

Next Month: Drive your curtains with an Infra-Red Remote Control.



The motor coupling and bush wheels bolted on the curtain drive-shaft.



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Morse Tone Decoder Driver

– unscramble dots and dashes

THE circuit diagram depicted in Fig. 1 uses a decoder i.c. to act as an interface between an audible Morse code signal and an external logic circuit or relay, so that the user can start to decode Morse code heard on a radio receiver. It was decided from the start that the unit would have its own built-in microphone for ease of use and to avoid having to make connections to the circuit board within the radio receiver. Hence, this circuit is completely self-contained and enables you to synchronise a logic circuit or relay with the audio Morse code.

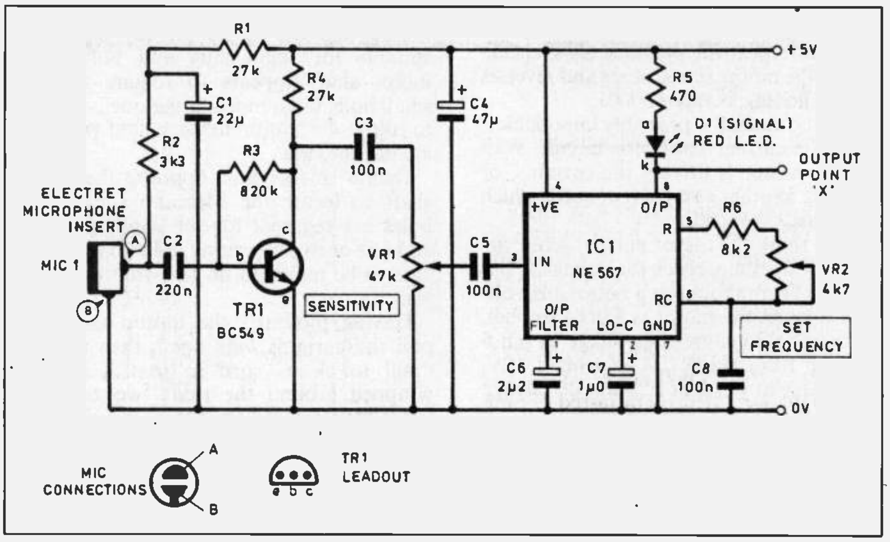

Fig. 1. Circuit diagram for the Morse Tone Decoder Driver.

Circuit

In the circuit diagram Fig. 1, MIC1 is an electret microphone which feeds the selected audio tones to a simple transistor amplifier based around TR1 and associated components. Resistor R1, R2 and capacitor C1 provide a supply for the electret microphone. Potentiometer VR1 is a Sensitivity control and the signal is coupled to IC1 input (pin 3), via capacitor C5.

The NE567 i.c. is a tone decoder phase-locked loop device which drives a load whenever a particular signal frequency is present at its input for a given length of time. Resistor R6, potentiometer VR2 and capacitor C8 set the operating frequency of the NE567 internal oscillator.

With the values shown, the circuit has a frequency range of 850Hz to 1340Hz. Within this range, the circuit will "lock" and cause the l.e.d. D1 connected at the output, to illuminate. Capacitors C6 and C7 are the output and loop filter components which were chosen to give optimum results over a wide range of Morse transmission speeds.

As quite a lot of Morse is transmitted in continuous wave (CW) it will be necessary to use the receiver's BFO to hear the Morse tones. Set the BFO to produce an audio tone of about 1kHz, then position the microphone next to the loudspeaker and adjust VR1 and VR2 until the "signal" l.e.d. flashes in unison with the Morse tones.

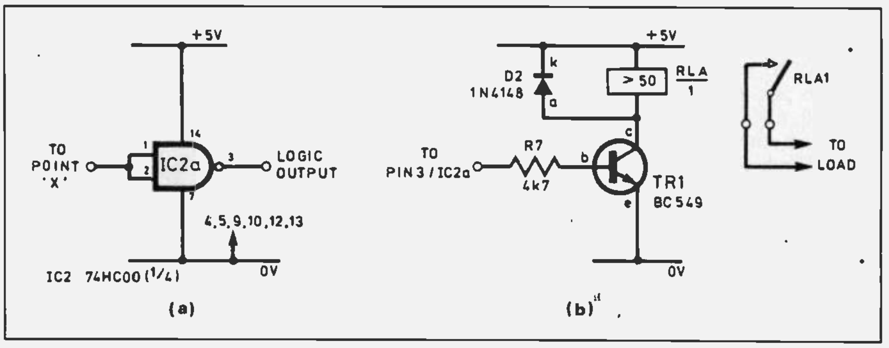

Fig. 2a. Circuit diagram for a simple logic interface.

Fig. 2b. Add-on circuit diagram for driving a relay.

Add-on Circuits

The output of the decoder is available at point "X". A simple logic interface is given in Fig. 2a which generates a Logic 1 when a Morse tone is detected. The relay driver also shown in Fig. 2b could be adapted to drive ticker-tape or solenoid marking devices, provided that the Morse speed is not too high.

A +5V supply is necessary for correct operation and a standard 7805 regulator can be used to provide this from higher d.c. voltages.

Neil Dobson,
Chopwell, Newcastle-upon-Tyne.

£2 Metal Detector
– strike it lucky

WHEN tuned correctly, the Metal Detector illustrated in Fig. 3 will detect an old Victorian Penny at a depth of 10cm, although for practical purposes 5cm may be more realistic. It will detect large objects at 25cm and more. It is extremely simple and cheap to build and has minimal ground effect.

The metal detector is based on the BFO (Beat Frequency Oscillator) principle and incorporates two high frequency oscillators both running at approximately 300kHz. In Fig. 3, IC1a and IC1b oscillate at a fixed frequency whilst IC1c is a variable frequency oscillator whose frequency is highly dependent on the inductance of coil L1. The outputs of both oscillators are mixed through IC1d, producing an audible beat frequency.

Two coils were tested, one of 50 turns of 33s.w.g. enamelled copper wire 22cms in diameter, the other of 40 turns of 30s.w.g. 24cms in diameter. It was found that the winding technique for the coils was not critical. Although the circuit is stable in operation, ceramic capacitors were found to introduce instability and are therefore not suitable. Polyester types may be best.

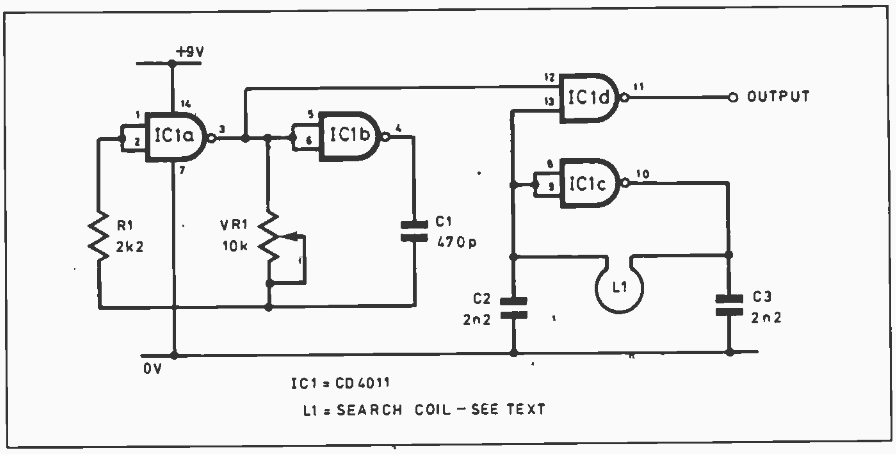

Fig. 3. Circuit diagram for the low cost Metal Detector.

The output is connected between IC1d pin 11 and the 0V rail, and may drive a set of headphones, a crystal earpiece or an amplifier. If an unclear note is heard, experiment with the values of the capacitors C1 to C3.

In order to tune the Metal Detector, adjust potentiometer VR1 to a zero beat setting (i.e. silent output) between the loudest frequency peaks. Then tune a little either way to find a low tone. A 10 ohm potentiometer in series with VR1 may simplify adjustment.

In use, a change of tone will indicate the presence of metal. With a smaller coil, this Metal Detector may also be used as a pipe or cable locator. It draws less than 10mA current from a 9V PP3 battery.

Rev. Thomas Scarborough,
Cape Town,
South Africa.

Infra-Red Repeater
– zap a VCR from afar!

MY CIRCUIT diagram shown in Fig. 4 is an Infra-Red Repeater Unit which allows equipment such as VCRs or satellite receivers etc. to be controlled from more than one room. All the work is done by IC1, a Sharp IS1U60 integrated circuit (*from Electromail, Stock Code 577-897*). This three-terminal device detects the 40kHz signals emitted by infra-red remote controllers, and provides a clean demodulated signal.

In the absence of any infra-red signal the output of IC1 is high. This drives transistor TR1 on which resets IC2, a 555 astable oscillator. When infra-red pulses are received, IC2 will oscillate at 40kHz or so.

The timer i.c. drives transistor TR2, which drives the two light-emitting diodes D1 and D2. D1 acts as a "pilot" indicator and illuminates to confirm that infra-red pulses are being received.

The infra-red diode D2 is placed in the same room as the equipment to be controlled, and placed as close as possible (I suggest within one metre) to the item of equipment. It can be connected to the

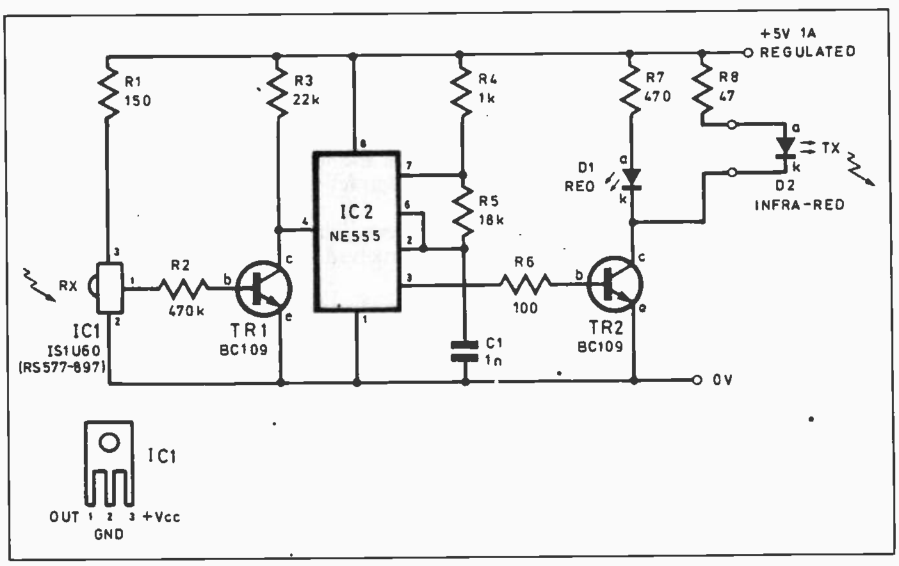

Fig. 4. Circuit diagram for the Infra-Red Repeater.

Repeater circuit with twin-core wire of suitable length.

I found that sometimes it was better to replace the 18 kilohm resistor with a 22 kilohm preset and adjust this for the most reliable operation. The supply rail to the circuit is best regulated at 5V. A cheap 7805 voltage regulator i.c. could be used, which will not need a heatsink.

Mark Skeete, London, E10.

BOOK REVIEWS

BEBOP TO THE BOOLEAN BOOGIE

Author	Clive Maxfield
Size	471 pages 256 x 220mm
Price	£30.99 Softback
Publisher	HighText Publications Inc. ISBN 1-878707-22-1

"An Unconventional Guide to Electronics Fundamentals, Components and Processes." **Clive (call me "Max") Maxfield**

OPEN many text books on electronics and they commence with the same very dry theory of the physics pertaining to the electron, gradually becoming even more desiccated. Just out in the UK, *Bebop* is an American text book which is very different, not least because of Max's dry (British) sense of humour – starting with a series of wry footnotes which brought forth many a chuckle! Off to a flying start, then, this book is not a circuit cook-book *per se* but a thoroughly researched and highly readable reference on general electronics principles, prevailing techniques and future technologies.

Max has fired a well-aimed scatter-gun at electronics basics, progressing into digital techniques, logic systems, Boolean algebra of course, memories, programmable integrated circuits and more complex digital chips, dealing with the manufacturing methods of current-technology devices as well. A good proportion of *Bebop* then considers printed circuit board technology, sprinkled liberally with well presented illustrations of commendable clarity. This will appeal to those becoming involved with p.c.b. CAD systems for the first time, for instance, since the technology behind various board fabrication methods is discussed in some depth.

The author analyses cutting edge technology including superconductors, protein switches and nano-technology – not just in passing, either, but again in a well researched, interesting and authoritative manner that's bang up to date. Still the humour keeps coming but it isn't over-done and doesn't detract from a highly informative and buoyant style.

It's hard to pigeon-hole *Bebop* because it covers many disciplines such that there's something for anyone involved in any way in electronics, whether as a mild interest or as a serious technician. Supported by a glossary, various appendices and a thorough and comprehensive index, I think the book is an excellent and invaluable resource for anyone who's ever held a soldering iron and wants to know what makes current electronics technology tick, and where it's going in the future.

The price seems a bit steep though, at £30.99 which might put it out of reach of those who would probably benefit from *Bebop* most of all. An excellent buy otherwise, and uniquely *enjoyable*. If you're not hooked after reading it you probably never will be.

A.W.

THE MODEM REFERENCE (Third Edition)

Author	Michael A. Banks
Price	£32.25 including VAT (due to floppy disk).
Size	815 pages 235 x 185mm
Publisher	Brady Publishing ISBN 1-56686-027-X

TELECOMMUNICATIONS technology is bounding ahead, leaving even this latest Edition of *The Modem Reference* a bit out of breath. Little if any mention of increasingly demanded 28·8K bps (V.34) technology or currently popular 14·4K (V.32bis) standards, this book is nonetheless a good introduction to modem technology and communications by computer. Aimed at both the beginner or professional modem user, it de-mystifies much of the jargon which anyone setting up and using a modem will undoubtedly encounter sooner or later – probably sooner!

Of American bias, there is still more than enough data to enable the UK reader to tackle his new modem with a lot more confidence, though you'll probably still need your modem instruction book to sort out any actual initialisation problems – at least you'll understand what much of the Hayes AT Command Set actually means and what's really going on, so that you can ftp and email with more confidence. Quite a proportion is given over to American on-line services and is less relevant here.

Let down by scrappy bitmap thumbnail graphics at times but includes a floppy disk with several useful utilities and Windows Terminal front ends. Generally worth having.

A.W.

SHOP TALK
with David Barrington

Automatic Curtain Winder

Clearly, the motor is a key component in the *Automatic Curtain Winder* and will probably cost as much as the rest of the system put together. In the prototype a 6V motor was chosen rather than a more obvious 12V type.

The specified, motor used in the model, is an RS type and was purchased through **Electromail (☎ *01536 204555*)**, code 336-337. This is a 60 r.p.m. 6V type, complete with gearbox.

If you are unable to obtain the Meccano parts locally, they are available, *mail order*, from **MW Models, Dept EPE, 4 Greys Road, Henley, Oxon.** Tel: 01491 572436.

The printed circuit board is available from the *EPE PCB Service*, code 946. Remember, if you are using the "current sense" stop system, resistor R27 should be rated at 3W minimum.

Windicator

The author of the *Windicator* project overcame the problem of the need for special mechanical parts by using a d.c. motor as a sensor. The specified d.c. motor, made by Matsushita (MHN-5RG4E), is supplied by **Magenta Electronics** and is similar to a cassette-player motor.

A motor different from the one specified could be used but it must be a good quality, high output type. However, the output may not be linear and you will then, of course, need to calibrate the design yourself – not so easy!

We understand that a full kit of parts for the *Windicator* is available from Magenta. The kit (code 856) comes complete with sensor motor and sensor cups, but excludes any twin-core "zip" wire. The cost of the kit is £28 and the motor is available separately for the sum of £4.80. A post and packing charge of £3 per order must also be added to the cost. **Magenta Electronics, Dept EPE, 135 Hunter Street, Burton-on-Trent, Staffs, DE14 2ST.**

The small *Windicator* printed circuit board is available from the *EPE PCB Service*, code 947.

Ramp Generator

Some of the items called up for the *Ramp Generator* need to be specially purchased if the constructor is to adhere to the published design. Other components may be used but they may not fit on the p.c.b.s and may not produce such good results.

Most of the components used in this design are RS components and were purchased through **Electromail (☎ *01536 204555*)**. Particular parts which should be as specified are as follows: potentiometers, codes 173-631 and 187-220; crystal oscillator module (16·384MHz), code 658-845; AD7845 12-bit DAC, code 263-295; mains transformer, code 208-945 and the 22,000µF electrolytic, code 127-486.

The printed circuit boards for this project are available as a pair from the *EPE PCB Service*, code 944/5. The choice of case has been left to the individual as the one used adds £52.28 to the cost!

HV Capacitor Reformer

The majority of components for the *HV Capacitor Reformer* should be readily available from your local supplier. The high voltage electrolytic (C1) maybe a little more difficult to come by, but a few phone calls to advertisers should soon provide the answer.

The small printed circuit board is available from the *EPE PCB Service*, code 943.

EPE HiFi Valve Amplifier

It is most important that constructors undertaking the *EPE HiFi Valve 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. Suppliers for the rest of the components were covered in last month's *Shoptalk*.

Note: If the amplifier is used to feed 4 ohm loudspeakers the valves will over-dissipate and their working life will be shortened. The output transformer is designed to drive 8 ohm speakers.

The Phase-splitter p.c.b. (last month) is available from the *EPE PCB Service*, code 941.

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Z5484	2011	20x1	5x7	5.2	2.30
Z5485	4021	40x2	5x7	5.2	5.00

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X3221	150µF 385V	size 48x36	DP 3.88	£1.50
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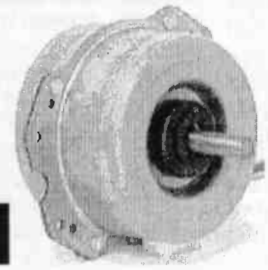
SUPER MOTOR OFFER



Z9275 An excellent opportunity to purchase a high quality 45 watt multispeed mains (250V ac) motor at well below normal price. Measuring 87mm long and 98mm dia. it has a 10mm spindle with flat 44mm long. There are four taps giving the following speeds: 1300, 1030, 900 or 650 RPM, offering a maximum torque of 1.4kg/cm. A 1.5µF 500V running capacitor is supplied. Weight 2.1kg.

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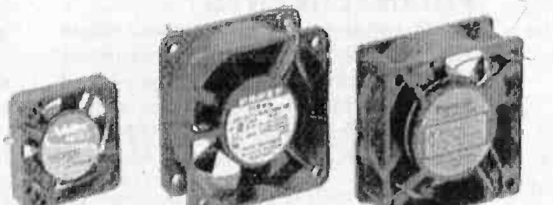

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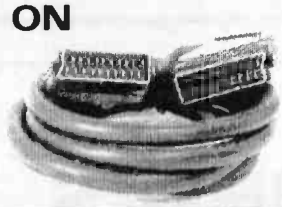

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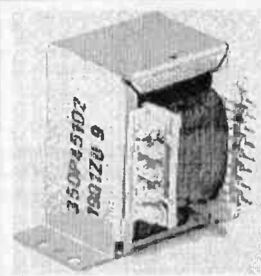

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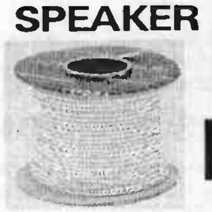

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FOX REPORT
by Barry Fox

PLAGIARISING FOX

Several times when travelling abroad I have read my own articles, reprinted in far off lands, without permission and without any extra payment. Often British newspapers and glossy mags will take the gut core of an article, and re-use it without cash or credit. One British paper even had the cheek to refer a reader's enquiry to me.

On one glorious occasion an Indian newspaper got itself sued for stealing an article I'd written. I didn't sue. Neither did the British magazine from which it had been stolen. Someone mentioned in the stolen article sued, claiming that they had been libelled by the words the paper had stolen!

It is easy to recognise plagiarism of words. The issue then becomes one of whether it is copyright theft to steal the substance of an article and dress it up with different words. In most cases the plagiarist has a free run.

PICTURE PIRACY

Now consider the case of a photographer or picture library that puts pictures on a CD-ROM as digital code and sends the disc out to someone who is paying to publish them once. Or perhaps the pictures go down a phone line to a publisher in a far off land. The same issues arise when a movie maker sends digitally coded films down a line to a subscriber who has paid for one viewing or one use.

In each case there is nothing to stop the person who has paid for one use, copying the code, re-using it or selling it to someone else.

With a feature movie, and famous stars, it is easy to prove that someone has pirated the material. Arnie looks like Arnie, whatever the pictorial context. But scenic movie material is much harder to identify, especially if the pirate has cut out a few sequences and grafted them into a different context, to save on location shoot expenses. Proving piracy of a still photograph is even harder. The pirate can crop and change the size and shape of the picture.

As more and more picture material is distributed as digital code, this problem can only get worse.

FBI INTERVENES

One solution may be a system called FBI, developed by a British company, MOR of Sutton in Surrey. Fingerprinted Bitmapped Identification buries a digitally encoded fingerprint inside any photographic image when it is stored in a computer or on a CD-ROM. The fingerprint is a string of letters, for instance someone's name or password, and there is no visible effect on the picture (except for black and white monochrome images, if they are very much enlarged).

The FBI software scans the image to bury the fingerprint and then at a later date scans it to recognise the fingerprint. If the image has been manipulated the fingerprint shows breaks in the text string. The fingerprint also shows breaks if the image has been cropped.

FBI withstands conversion from one computer file format to another. It also survives copying any number of times.

If an A-4 picture of a tiger is converted into a 30 megabyte image file, and the file fingerprinted, then even taking the eye out of the tiger will still show up on print analysis.

VIDEO VALIDATION

Early demonstrations of the software (at a seminar on CD-ROM piracy held in London recently) show that FBI works. Full trials begin this summer. Especially interesting is the claim that the same technique can be used to insert fingerprints into moving video material. It can also be used to fingerprint material sent down telephone lines, e.g. on the Internet.

Once inserted, the fingerprint cannot be stripped out, or masked, without damaging the picture. So if copyright owners mark their images, they can subsequently prove the true origin. This could help photo libraries which would like to distribute digital images by disc or line to magazines round the world, but fear their pictures will then be manipulated to disguise origin and avoid payment of copyright fees.

PROFESSIONAL CIRCUIT AND PCB DESIGN AIDS FOR WINDOWS

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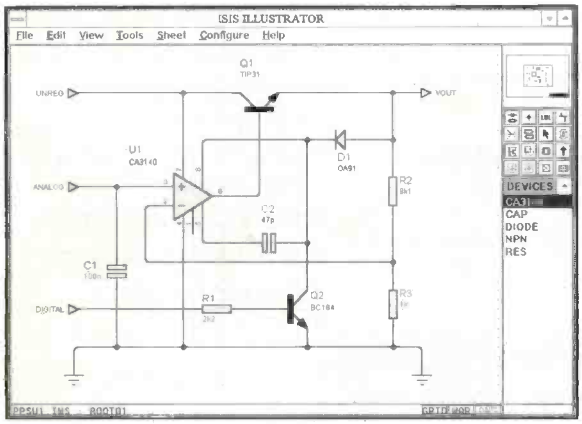
CADPAK is especially suited to educational, hobby and small scale schematic and PCB design. CADPAK includes both schematic drawing and 32-bit PCB drafting tools but as an entry level product, there is no netlist link between them.



The schematic drawing module of CADPAK, ISIS Illustrator, enables you to create circuit diagrams like the ones in the magazines.

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- *Full control of appearance including line widths, fill styles, fonts, colours.*
- *Automatic wire routing & dot placement.*
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- *Exports diagrams to other applications via the clipboard.*
- *CADPAK is also available for DOS.*

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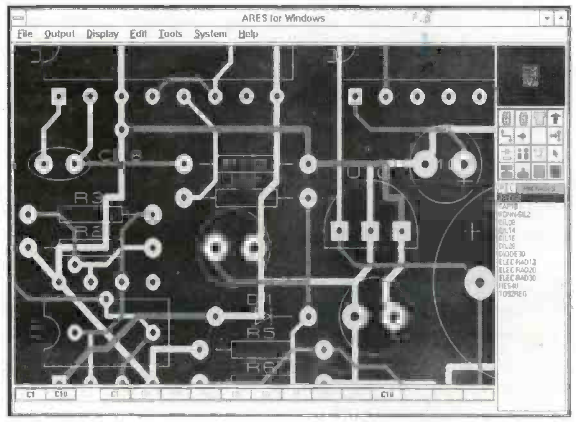

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FEATURES • Calculation Corner, Part 2 • Safety First, Part 3 • European International Audio & Video Fair.

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PROJECTS • Voxbox Voice Recording Board • Simple NiCad Charger • Watering Wizard (automatic garden watering) • Pocket Print Timer • Stereo HiFi Controller, Part 1.
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PROJECTS • Experimental Noise Cancelling Unit • Dancing Fountains, Part 1 • Charged-Up (PC battery tip) • 6802 Development Board • TV Camera Update • Stereo HiFi Controller, Part 2.
FEATURES • Calculation Corner, Part 8 • Best of British, Part 5 • I'll Be Seeing You (multimedia communications)

SEPT. '94

PROJECTS • Protector Plus Car Alarm • Greenhouse Watering System • Experimental Seismograph, Part 1 • Three-Channel Lamp Controller • Dancing Fountains, Part 2.
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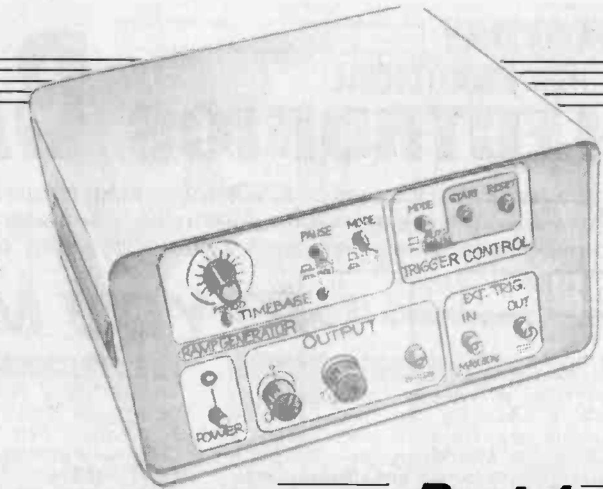


RAMP GENERATOR

NEIL JOHNSON BEng(Hons) AMIEE **Part 1**

A professional quality ramp generator aimed at the intermediate to advanced constructor.

THIS Ramp Generator project evolved from a need to expand and improve the author's range of test equipment with a versatile unit which could be used for a wide range of tasks. Some suggestions as to what the Ramp Generator can be used for are covered later; just to whet your appetite: oscilloscope calibrator, plotter timebase, curve tracer, spectrum analyser, etc.

OVERVIEW

Let us begin by looking at the system block diagram, shown in Fig. 1. The heart of the Ramp Generator is a precision master crystal oscillator module whose output is 16·384MHz, within ±0·01%; this level of precision is easily attainable from off-the-shelf crystal modules.

The next stage is a presettable divider. This divides the master frequency (16·384MHz) by four to get 4·096MHz, and then sixteen further division stages of one, two, five and their decades to produce the clock signal for the rest of the Ramp Generator.

The Gate and Trigger block, together with External Trigger Input and Output, provides the main ramp controls. The main function of this block is to gate the clock signal to the next stage. Control functions include glitch-free pause and single sweep triggering – both requiring devious circuit design!

The 12-bit counter and digital-to-analogue converter (DAC) are responsible for converting the stream of digital pulses into a smooth ramping analogue waveform. The gated clock signal increments, or decrements, the counter, with the resulting 12-bit binary value being converted to an analogue voltage by the DAC. Being 12-bit there are 4096 steps for one complete cycle, so the required clock frequency for a ramp of 1ms duration is 4·096MHz.

Following the DAC are the Level, Offset and Output Buffering circuits. The summing junction is an op.amp, combining a proportion of the converter output signal with a variable constant d.c. offset voltage. The buffer amplifier provides plenty of signal for the ramp generator to drive a standard 50 ohm load.

Finally, running the whole show is the Power Supply Unit (PSU), transforming 240V a.c. to clean, regulated +5V and ±15V d.c.

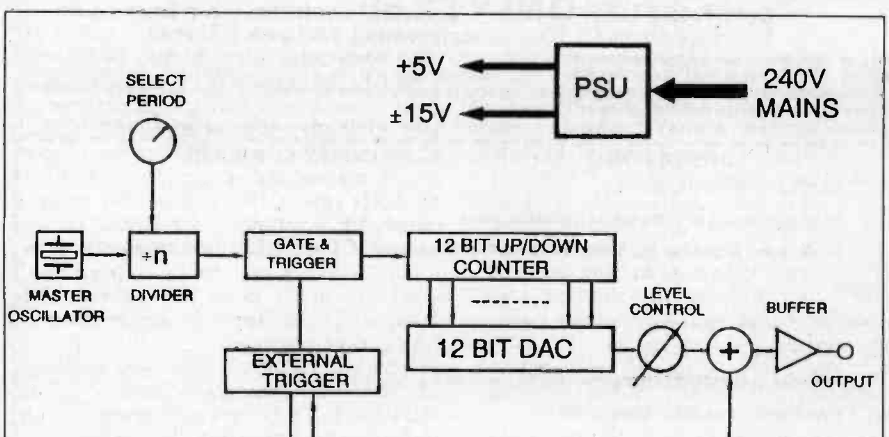


Fig. 1. System block diagram for the Ramp Generator.

CIRCUIT DESCRIPTION

Having taken a broad look at the Ramp Generator let's take a deeper look inside those blocks.

The Ramp Generator circuits are split into four main sections: Clock and Divider, Gate/Trigger and Counter, Converter and Buffer, and PSU.

The circuit diagram for the Clock and Divider is shown in Fig. 2. It follows a clockwise path starting at the top left with IC32, a readily-available crystal oscillator module. It is worth noting here the merits of these modules: they offer crystal controlled TTL-compatible clock signals in a sealed metal package with a standard 14-pin d.i.l. layout.

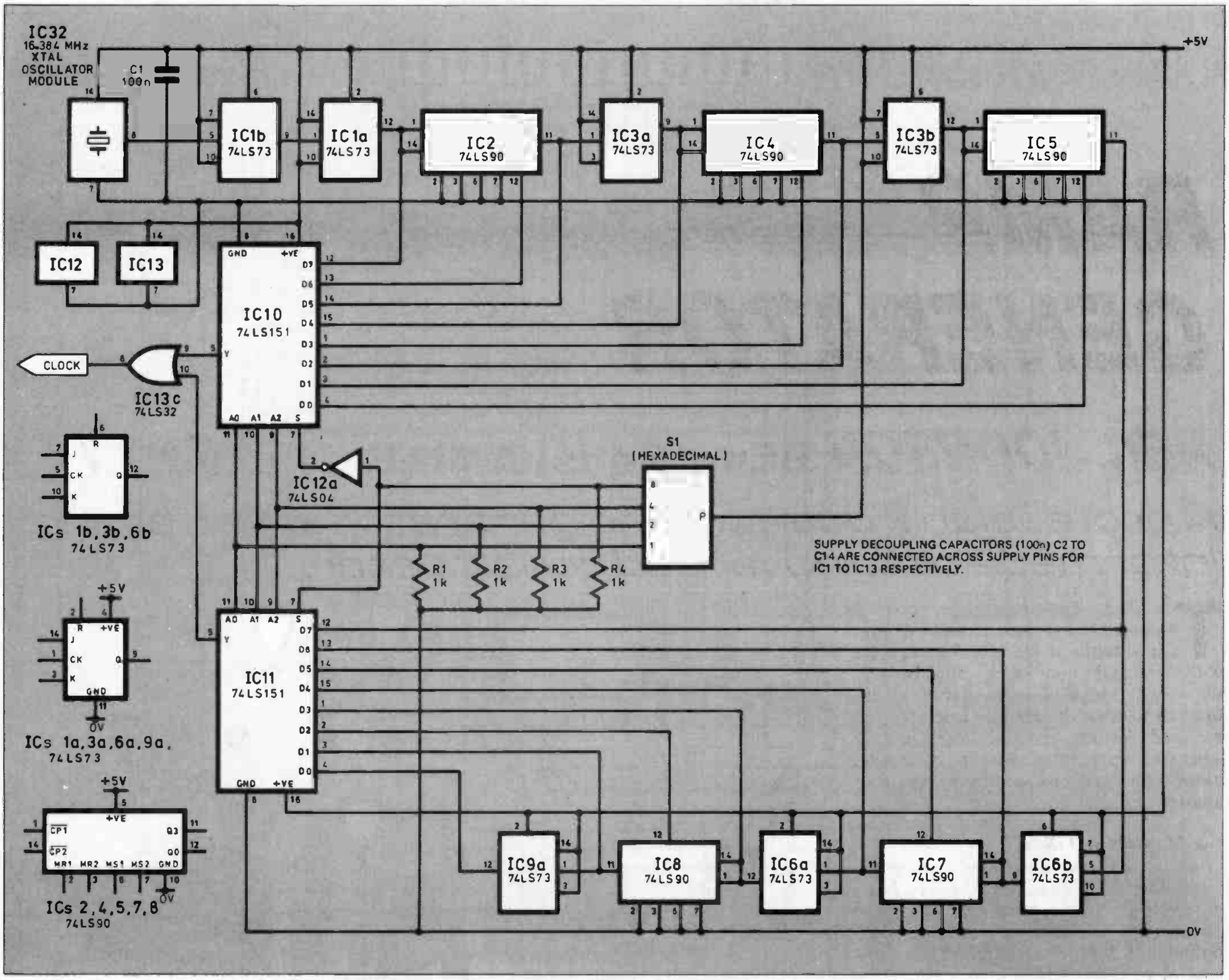


Fig. 2. Circuit diagram for the Clock and Divider sub-section of the Ramp Generator.

Some of you may be thinking "Cheat" – but consider: this module saves board space, around twenty holes, several other components and considerable design time, compared to building a crystal oscillator from individual components. Surely a better engineering solution?

The output of IC32 is divided by IC1b and IC1a down to 4·096MHz, the first clock frequency. This feeds the start of the main divider chain, IC2 to IC9a, to provide the other 15 clock frequencies listed in Table 1.

Frequency selection is made by the 8-input multiplexers IC10 and IC11. These are controlled by hexadecimal switch S1 via inverter IC12a, with IC10 selecting the first eight frequencies and IC11 the remainder. This double-selection system – rotary switch and multiplexers – may seem a bit extravagant (instead of a simple rotary switch alone) but it has at least two advantages: IC10 and IC11 can be placed on the circuit board where appropriate, and, more importantly, critical signals are kept to relatively short circuit paths, well away from the front panel.

The outputs of the two multiplexers are combined by OR gate IC13c before sending on to the next stage.

TABLE 1

Clock Frequency	Ramp Period
4·096MHz	1ms
2·048MHz	2ms
819·2kHz	5ms
409·6kHz	10ms
204·8kHz	20ms
81·92kHz	50ms
40·96kHz	100ms
20·48kHz	200ms
8·192kHz	500ms
4·096kHz	1s
2·048kHz	2s
819·2Hz	5s
409·6Hz	10s
204·8Hz	20s
81·92Hz	50s
40·96Hz	100s

GATE/TRIGGER AND COUNTER

Looking at the Gate/Trigger and Counter circuit diagram in Fig. 3, the clock signal first passes through AND gate IC19b, the Pause gate. This gate is controlled by switch S2, flip-flop IC9b and friends. A J-K flip-flop is used here for three reasons: being clocked from the input to the gate prevents any spurious runt pulses getting through; it provides a simple debounce circuit for switch S2 at no extra cost; and offers an extra output pin to operate an indicator circuit, based around transistor TR1 and l.e.d. D1.

The second AND gate, IC19a, is the main control gate. It is operated by the trigger circuitry, or can be held permanently open by switch S5 – with S5 open, IC19d pin 13 is pulled low through resistor R10 and, via inverter IC12b, resulting in IC19a pin 1 being set high.

The trigger circuitry is based around an SR flip-flop (AND gates IC15b and IC15c). In the reset state, IC19d pin 12 is set high and, together with switch S5 being closed, opens the clock gate and clears the counters (more on this later). The reset input is connected to the output of a rising-edge detector based on inverters IC14a, IC14b, IC14c and NAND gate IC15d.

This edge detector works on the finite propagation delay of the inverters, as shown by the timing diagram in Fig. 4. The input to the detector is a combination of the Reset push-switch S3 and the output of the zero-detector (yet to be described).

Setting the flip-flop is a bit more complicated. This time a falling-edge detector is used, consisting of inverters IC14d, IC14e, IC14f and OR gate IC13d. The two trigger inputs, manual and external, are combined by AND gate IC19c. The manual trigger, switch S4, is properly debounced by inverters IC12d, IC12e, and resistor R16, in order to avoid any spurious triggering, especially on the faster sweep times. The External Trigger Input is derived from a later part in the circuit.

Next along is the 12-bit counter, made up of three 4-bit counters in series – IC20, IC21 and IC22. Direction of count – up or down – is controlled by switch S6, the Ramp Mode control. For optimum performance the counters are operated synchronously from the common clock signal, to ensure that all 12 data bits

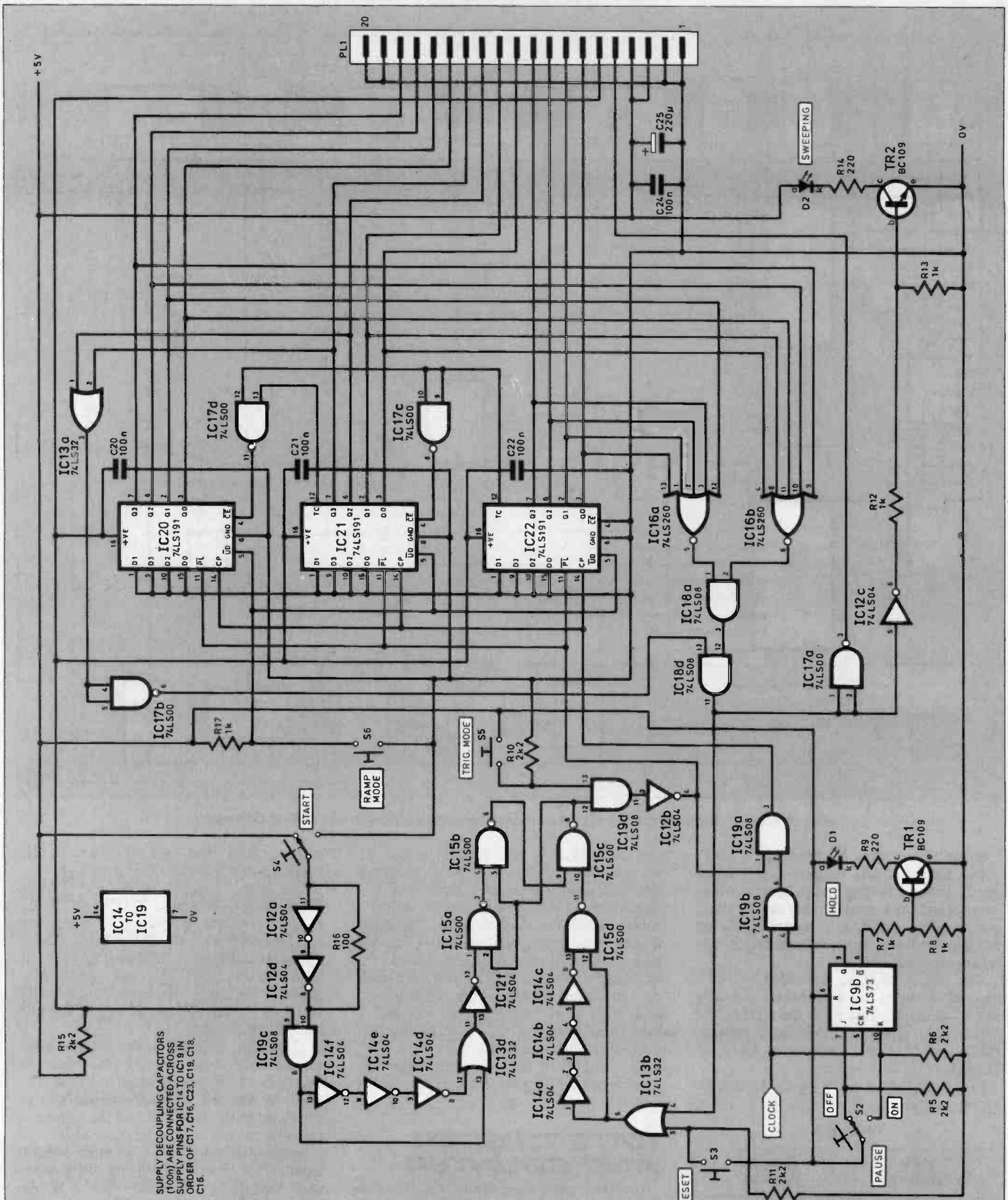


Fig. 3. Gate/Trigger and Counter circuit diagram details.

change at the same time. The three counters are linked together by NAND gates IC17c and IC17d.

Resetting all the counters to zero is accomplished with the Parallel Load function, loading a value of zero into all three counters at the same time. The 12-bit output of the complete counter passes on to a zero detector, based on NOR gates IC16a, IC16b, OR gate IC13a, NAND gate IC17b, and AND gates IC18a and IC18d. This circuit detects when all the counter outputs are zeroes, setting its own output, at IC18d pin 11, high during this condition.

The "zero" signal is used for three purposes: to reset the trigger flip-flop via the path commencing with OR gate IC13b; to operate the Sweeping l.e.d. D2 via inverter IC12c and transistor TR2; and to provide the control signal for the External Trigger Output stage, accessed via inverter IC17a and connector PL1.

Moving on to the next circuit section we jump via the 20-way IDC connector PL1 to the analogue circuit, whose details are shown in Fig. 5.

CONVERTER AND BUFFER

The first port of call in Fig. 5, is the DAC. This takes the 12-bit digital data and converts it into an analogue output voltage, which can be calculated from the following equation:

$$V_{out} = -V_{ref} \times D/4096$$

where V_{out} = output voltage
V_{ref} = reference voltage
D = digital input code, 0 to 4095

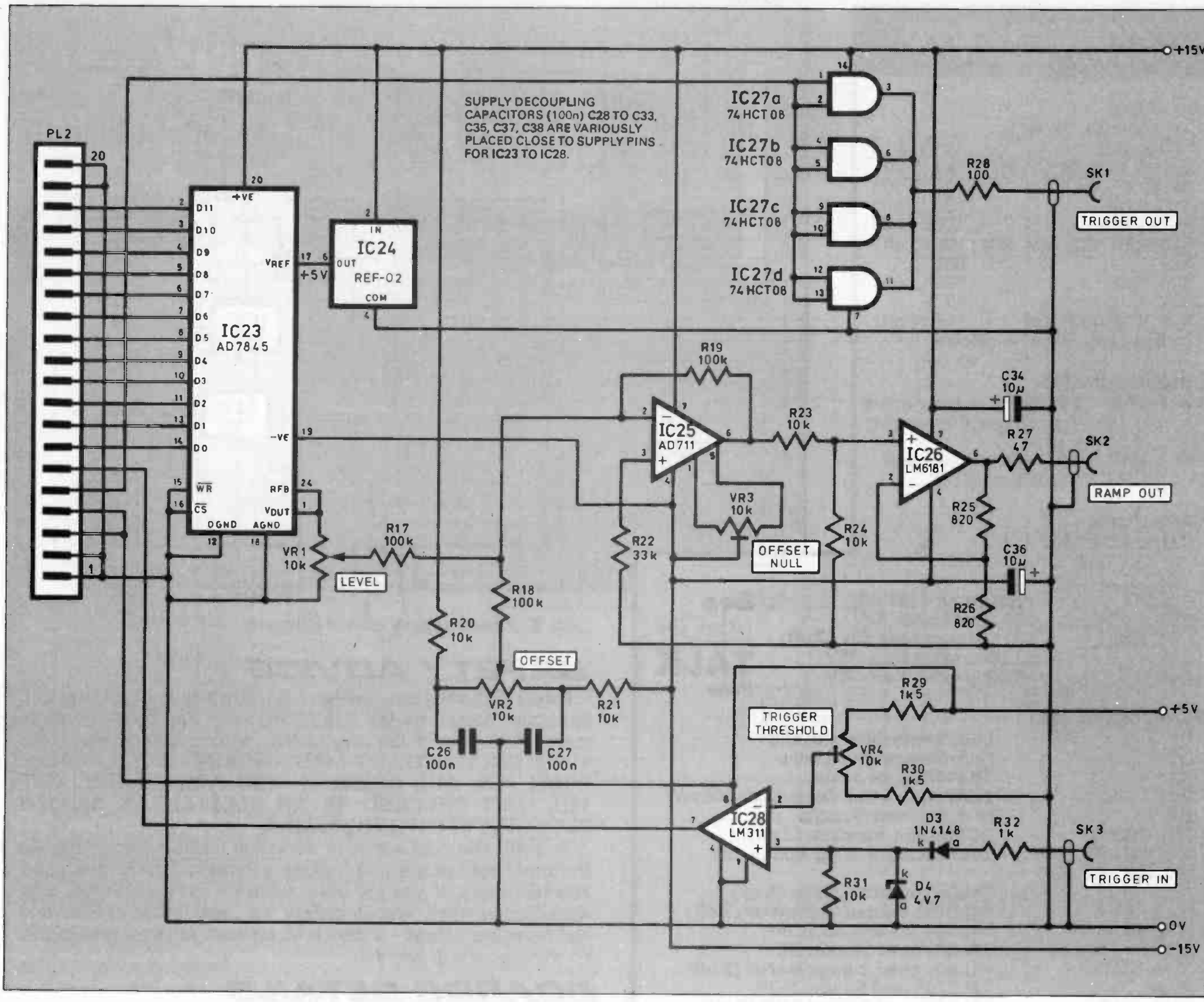


Fig. 5. Circuit diagram for the Analogue portion of the Ramp Generator.

The reference voltage is provided by a precision +5V reference device, IC24. Potentiometer VR1, the Level control, feeds a portion of the converter's output signal to the inverting input, pin 2, of the summing amplifier based around op.amp IC25. A further signal to this input is provided by VR2, the Offset control. Resistors R20 and R21 set the maximum and minimum settings, while capacitors C26 and C27 filter out any unwanted noise. The Offset Null adjustment preset VR5 is provided should you decide not to include VR2.

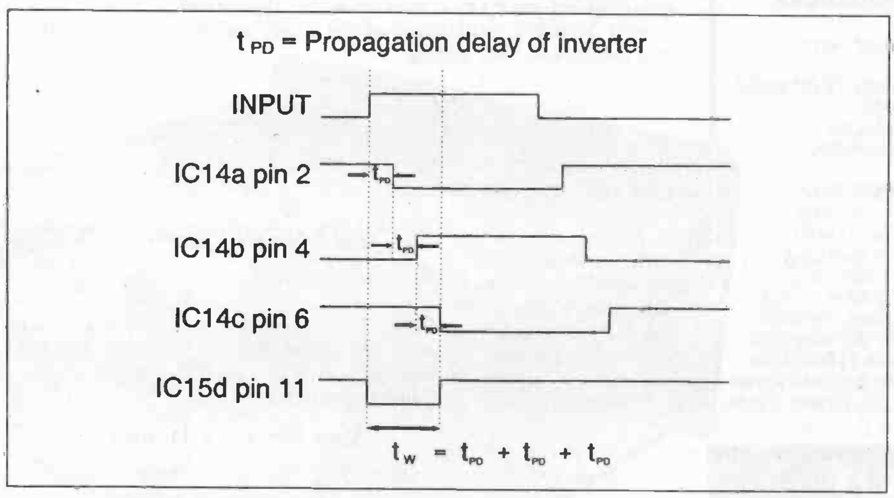


Fig. 4. Rising edge detector timing diagram.

The last stage of the main signal path is the output buffer. This is built around op.amp IC26, National Semiconductor's LM6181. This device is able to directly drive a 50 ohm terminated load up to 10V peak without complaining, with a bandwidth extending up to 100MHz. The buffered ramp waveform then reaches the outside world via connector SK2.

The External Trigger Output signal from the zero detector is buffered by IC27, all four AND gate sections being wired in parallel. The buffer output is protected from short circuits by resistor R28 and is brought to the front panel via socket SK1.

The External Trigger Input circuit based around comparator IC28 is accessed via socket SK3, resistor R32 and diode D3. Zener diode D4 is the input limiter which starts to work above 5V and handles input voltages up to 30V – exceed this and resistor R32 will turn into a little black'n'crispy ex-resistor!

POWER SUPPLY UNIT

The Power Supply is a fairly simple transformer-rectifier-regulator linear unit. Its circuit diagram is shown in Fig. 6. Transformer T1 reduces the mains voltage down to about 30V a.c., rectified by bridge rectifier REC1 to produce ±20V d.c. This is smoothed by capacitors C39 and C40 before being regulated at +15V, −15V and +5V by IC29, IC30 and IC31, respectively. The positive supply smoothing capacitor, C39, has a larger capacity than C40 to provide smooth current for both +15V and +5V regulators. Power-on indication is provided by l.e.d. D5.

Supply decoupling is performed at a local level to each chip. Details are given in the respective circuit diagrams. In all cases the decoupling capacitors are physically located as close to the devices as possible.

COMPONENTS

Resistors

R1 to R4, R7, R8, R12, R13, R32	1k (9 off)
R5, R6, R10, R11, R15	2k2 (5 off)
R9, R14	220 (2 off)
R16, R28	100 (2 off)
R17 to R19	100k (3 off)
R20, R21, R23, R24, R31	10k (5 off)
R22	33k
R25, R26	820 (2 off)
R27	47
R29, R30, R33, R34	1k5 (4 off)

All 0.5W 5% carbon/metal film

Potentiometers

VR1, VR2	10k rotary lin. conductive plastic, p.c.b. mounting (2 off)
VR3, VR4	10k horiz cermet preset multiturn (2 off)

Capacitors

C21 to C24, C26 to C33, C35, C37, C38, C41 to C47	100n ceramic (21 off)
C25	220µ radial elect. 63V
C34, C36	10µ tantalum bead 35V (2 off)
C39	22,000µ radial elect. 35V
C40	10,000µ radial elect. 35V

See SHOP TALK Page

Semiconductors

D1	l.e.d. 5mm yellow plus clip
D2	l.e.d. 5mm green plus clip
D3	1N4148 signal diode
D4	BZX79C4V7 4V7 Zener diode 500mW
D5	l.e.d. 5mm red plus clip
TR1, TR2	BC109 *npn* transistor (2 off)
IC1, IC3, IC6, IC9	74LS73 dual J-K flip-flop (4 off)
IC2, IC4, IC5, IC7, IC9	74LS90 decade counter (5 off)
IC10, IC11	74LS151 8-input multiplexer (2 off)
IC12, IC14	74LS04 hex inverter (2 off)
IC13	74LS32 quad 2-input OR
IC15, IC17	74LS00 quad 2-input NAND (2 off)
IC16	74LS260 dual 5-input NOR
IC18, IC19	74LS08 quad 2-input AND (2 off)
IC20 to IC22	74LS191 binary up/down counter (3 off)
IC23	AD7845 12-bit digital to analogue converter
IC24	REF-02 +5V precision voltage reference
IC25	AD711 single high speed op.amp
IC26	LM6181 single 100kHz op.amp
IC27	74HCT08 quad 2-input AND
IC28	LM311 voltage comparator op.amp
IC29	7815 +15V 1A regulator
IC30	7915 −15V 1A regulator
IC31	7805 +5V 1A regulator
IC32	16·384MHz crystal oscillator module
REC1	W005 50V 1A bridge rectifier

Miscellaneous

S1	hexdecimal rotary switch, with mounting bracket
S2 to S6	2-pole changeover interlocking push-switch (5 off)
S7	s.p.s.t. 4A mains-rated latching push-switch, with mounting bracket
PL1, PL2	d.i.l. header plug and socket 20-way (2 off each)
SK1 to SK3	panel mounting BNC socket (3 off)
SK4	panel mounting mains input connector
T1	mains transformer, 2 x 15V 1A secondary windings, p.c.b. mounting

Printed circuit boards available from the *EPE PCB Service*, codes 944 (logic), 945 (analogue); 6-switch latching assembly bracket for S2 to S6; knob for S1 to S7 (7 off); knob for VR1, VR2 (2 off); s.p. push-make switch (optional – see text); 8-pin d.i.l. socket (4 off); 14-pin d.i.l. socket (18 off); 16-pin d.i.l. socket (5 off); 20-pin d.i.l. socket; mica hardware for IC29 to IC31 (3 sets) plus silicone heatsink grease; panel mounting clips for l.e.d.s. (3 off); 20-way IDC connector socket (2 off); 20-way IDC ribbon cable (15cm minimum); metal case 290mm x 150mm x 260mm (L x H x W) type RS 581-082; aluminium sheet 2mm x 74mm x 30mm; cable; connecting wire; solder, etc.

Approx cost guidance only **£150** *excl. case*

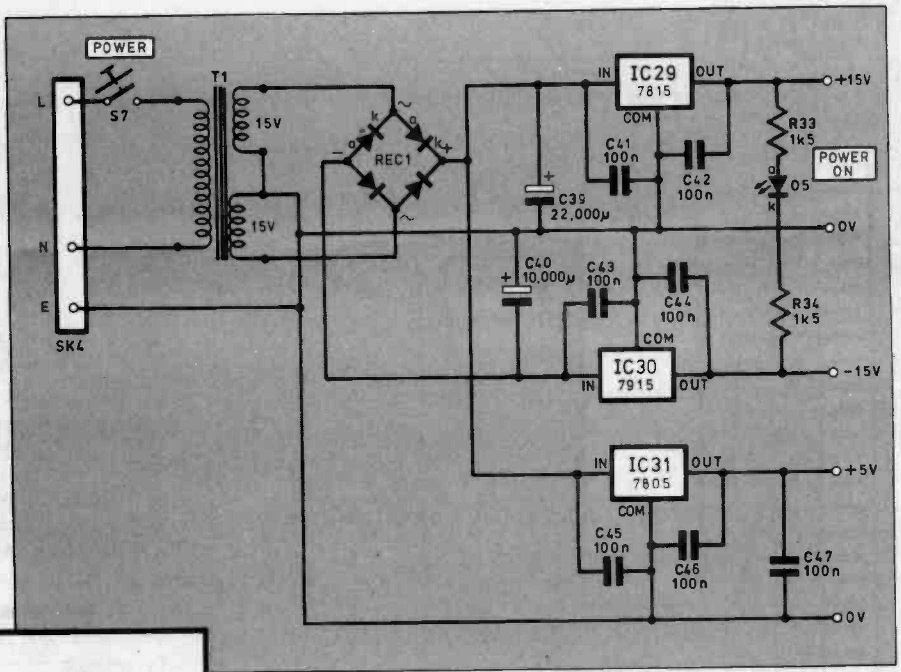


Fig. 6. Power supply circuit diagram.

SAFETY ADVICE

Before discussing construction it is worth mentioning a couple of important points. As the Ramp Generator has its own built-in mains PSU, part of the construction process will involve mains wiring. ONLY ATTEMPT MAINS WIRING IF YOU KNOW WHAT YOU ARE DOING. IF YOU ARE UNSURE, GET THE UNIT CHECKED BY AN ELECTRICIAN BEFORE PLUGGING IT INTO THE MAINS.

You will also need access to workshop facilities for drilling the front and rear panels and making a bracket for the two panel potentiometers. If you are using someone else's workshop, or a workshop at work, school, college, etc., ask for permission first and never work alone – if there is an accident you may need to rely on someone else to help you.

BOARDS DETAILS

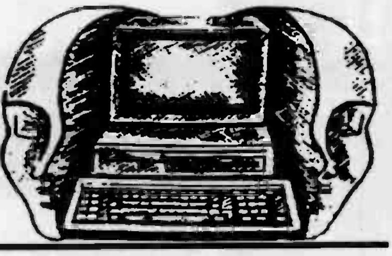
The printed circuit board (p.c.b.) for the Ramp Generator Logic circuit is a double-sided board with plated-through-holes (PTH). The Analogue board is single-sided p.c.b. These boards are available from the *EPE PCB Service*, as a pair, code 944/945.

However, the full-size copper foil track layouts for the boards are too large to publish. Full-size photocopies of the layouts, though, and full size legend details for the recommended case, can be obtained FREE from the Editorial Office address.

Readers who use the ready-made Logic board, which is PTH, do not need to use additional through-board link pins. Readers making their own board, though, will need to insert and solder link pins at the points where tracks are taken from one side of the board to the other. There are 78 of these points. With non-PTH boards, it is essential that component leads are soldered on both sides of the board in order to link tracks where appropriate. The use of turned-pin d.i.l. i.c. sockets in this application is vital.

Next Month: Construction of the Logic and Analogue boards, case details and final testing.

INTERFACE



Robert Penfold

USING a personal computer as the basis for a weather monitoring system is quite fashionable amongst electronics and computer enthusiasts. It is possible to undertake most of the normal types of monitoring using a PC plus some home constructed sensors. In some cases the fully computerised method could be regarded as doing things the hard way. With something like rainfall measurement for example, using the traditional method of measurement and typing the data into the computer's data base is likely to be the simplest and most accurate method.

Measurements such as temperature and wind speed, where frequent readings are required and accurate electronic sensing is reasonably simple, are a different matter. The all-electronic method is a more attractive proposition. Temperature measurement using an LM35 sensor and an analogue-to-digital converter based on the ZN448E is quite easy, and has been covered in previous articles. For the amateur meteorologist the only problem is in obtaining a suitable temperature range for his or her purposes.

Scaling

The LM35CZ covers a range of 0 to 100 degrees Celcius, and the LM35DZ covers −40 to +110 degrees Celcius. Both devices have three terminals and a standard TO92 style plastic encapsulation. Leadout details are shown in Fig.1 (which is a base view).

For both devices the output voltage is a straightforward 10mV/°C, with no offset voltage to contend with. On the face of it, this matches up very well with the 10 millivolt resolution of the ZN448E.

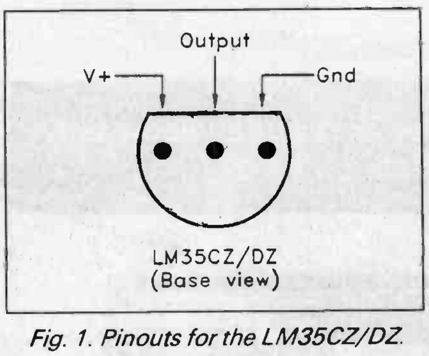


Fig. 1. Pinouts for the LM35CZ/DZ.

In practice this is not really the case, because the maximum output voltage of the LM35DZ is only 1·1 volts, which compares with a full scale value of 2·55 volts for the ZN448E. Directly interfacing these two devices does not even give full seven bit resolution. In the current context, temperatures of more than about 40 degrees are of no interest. Even with the rather erratic weather we get in the UK these days, it seems unlikely that a temperature of 40°C (104 degrees Fahrenheit) will be reached in the near future.

Amplifying the output from the LM35 gives a more restricted temperature coverage, but also provides much better resolution. Amplifying the output voltage by a factor of five gives a voltage change of 50mV/°C. When fed to the input of a ZN448E this gives a temperature range of 0 to 51°C, and a resolution of 0·2 degrees Centigrade. This compares to a resolution of 1°C if no amplification is used.

Temperature Interface

The circuit for a simple temperature interface that covers a range of 0 to 51°C is shown in Fig. 2. Dual balanced 12V supplies were used to power the prototype, but dual 5V supplies should just about suffice. IC1 is the temperature sensor. I used an LM35DZ, but over this range of temperatures the LM35CZ should work just as well.

The output from IC1 feeds into a non-inverting mode amplifier based on IC2. The closed loop voltage gain of the amplifier is set by resistors R1, R2, and preset VR1. The latter is adjusted to give a voltage gain of five times.

In practice, VR1 is given the correct setting by first subjecting the sensor to a temperature which is equal to about half to one hundred percent of the full scale value (i.e. about 20 to 51 degrees). In most cases the room temperature will be about 20 to 25 degrees Celcius, and this will suffice. An accurate thermometer is used to accurately measure the room temperature, and then VR1 is adjusted for the appropriate reading.

This interface can be used with the PC Analogue Input Port described in the April 1995 issue of *EPE* (Fig. 2 on page 317). Resistors R2, R3, R4, and VR1 are omitted from the analogue port, and the output of the temperature interface connects direct to pin 6 of IC1. The interface should work equally well with other analogue inputs that are based on a ZN448E series converter, or the earlier ZN427E, provided the output of the interface can be connected direct to the input pin of the converter chip.

Negative Thoughts

There is an obvious drawback to this temperature interface in that it does not handle negative temperatures. Even in the mild part of the UK where I live, the night-time air temperature occasionally dips below zero. Using an LM35DZ sensor it is possible to measure temperatures that go well below zero. However, negative temperatures produce negative output voltages from the LM35DZ, and the ZN488E cannot handle these.

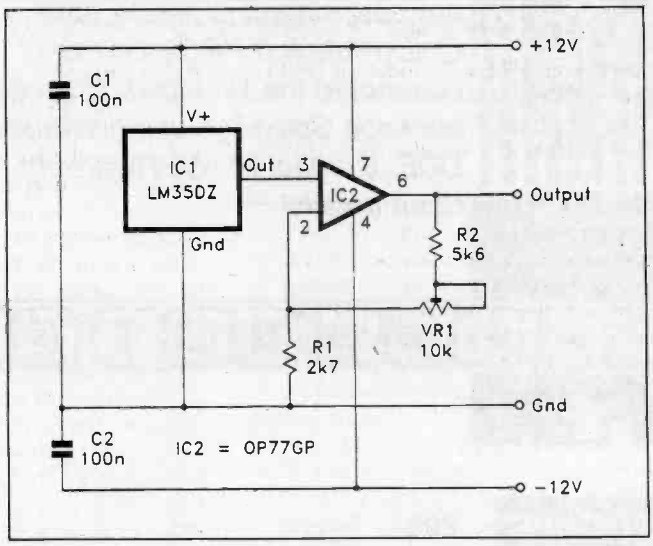


Fig. 2. A temperature interface which covers a range of 0 to 51 degrees Celcius.

The solution to the problem is to provide a positive offset voltage to the output signal of the LM35DZ, so that negative output voltages are brought within the input voltage range of the ZN448E. Fig. 3 shows the circuit for a modified version of the temperature interface that can provide this offset voltage.

This is basically the same as before, with IC2 being used to amplify the output of IC1 by a factor of five. The difference is that the lower end of R2 is not connected to the 0 volt rail, but is instead connected to the output of a variable voltage source. This uses VR2 and R4 to provide the variable voltage, and IC3 to act as a buffer stage so that R2 is fed from a low impedance source. This prevents the offset circuit from significantly affecting the closed loop voltage gain of IC2.

IC3 provides a small negative output voltage. The voltages at IC2's inputs are maintained at the same potential by the standard negative feedback action. With the lower end of R2 taken negative, the output of IC2 has to go more positive in order to maintain this balance. The positive offset at the output of IC2 is equal to the voltage set on VR1 multiplied by the closed loop voltage gain of IC2. For example, a negative potential of

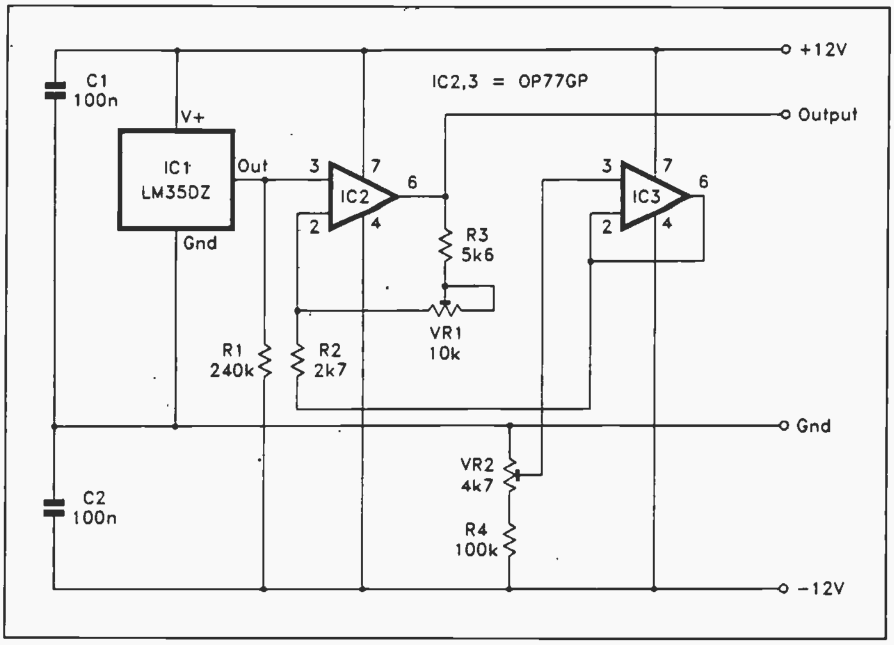


Fig. 3. An interface circuit which covers the range −11°C to +40°C.

100mV from VR2 will produce a positive offset of 500mV at the output of IC2.

The circuit can handle a wide range of offset voltages, but an offset of 110mV at IC2's output is a good choice. An output potential of −110mV from the sensor then gives zero volts at the output of IC2. This provides a temperature range of −11°C to +40°C. In colder parts of the country it might be better to use an offset of 160mV, which would give a temperature range of −16°C to +35°C.

Precision operational amplifiers are specified for IC2 and IC3, but as large voltage gains are not involved, most 741C compatible operational amplifiers will give good results in this circuit. The supply regulation is probably a more important factor, particularly the negative supply as this is used to provide the offset voltage. The circuit should work with dual 5V supplies if the value of R1 is reduced to 100k, and R4 is reduced to 39k. Ideally, VR1 and VR2 should both be multi-turn "trimpots".

Adjustment

Start with VR1 at a roughly middle setting, and then subject the sensor to a low and accurately known temperature. This can be zero degrees provided by some iced water. Note though, that the sensor's leadouts must be electrically insulated from the water, or the sensor must be held so that the leadout wires are just clear of the liquid. VR2 is then adjusted for a reading of zero.

Next the sensor is subjected to a higher and accurately known temperature. This can simply be the room temperature. Give the sensor plenty of time to adjust to the change in temperature. Then adjust VR1 for the correct reading. This whole process is repeated a few times until no further adjustment is required.

Software

The following GW BASIC or Q BASIC program reads the temperature sensor and prints the temperature on the screen:

```
10 REM GW BASIC TEMPERATURE
   PROGRAM
20 CLS
30 OUT &H37A,1
40 OUT &H37A,0
50 X = INP(&H379) AND 120
60 X = X/8
70 OUT &H37A,4
80 Y = INP(&H379) AND 120
90 Y = Y * 2
100 Z = X + Y
110 Z = Z/5
120 Z = Z − 11
130 PRINT Z " Degrees C."
140 FOR DELAY = 1 TO 20000
150 NEXT DELAY
160 A$ = INKEY$
170 IF LEN(A$) = 1 THEN END
180 CLS
190 GOTO 30
```

It is assumed that the temperature interface is used in conjunction with the printer port analogue interface circuit mentioned previously. Lines 30 to 100 read the port and place the returned value in variable Z. If the interface is used with a different analogue input port, these lines must be changed to suit the particular port used.

Line 110 divides the returned value by five, and line 120 then deducts 11 from this value. The 0 to 255 range of values from the converter is thus converted to the required range of −11 to +40. If a temperature range of −16 to +35 degrees is required, 16 must be deducted at line 120. The temperature is printed on the screen at line 130, and after a delay the program is looped back to line 30 where another reading is taken. Lines 160 and 170 enable the program to be broken out of the loop and halted by pressing any character key.

This program can also be used with the temperature interface of Fig. 2, but line 120 should be omitted. The software will then cover the same 0 to 51 degree range as the hardware.

RING BINDERS FOR EPE

This ring binder uses a special system to allow the issues to be easily removed and reinserted without any damage. A nylon strip slips over each issue and this passes over the four rings in the binder, thus holding the magazine in place (see photo).

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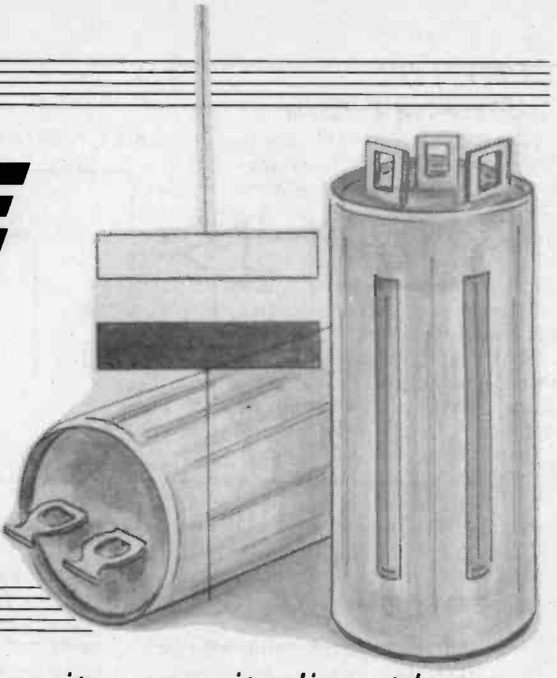
The price is £5.95 plus £3.50 post and packing. If you order more than one binder add £1 postage for each binder after the initial £3.50 postage charge, (for overseas readers the postage is £6.00 each to everywhere except Australia and Papua New Guinea which costs £10.50 each).

Send your payment in £'s sterling cheque or PO (Overseas readers send £ sterling bank draft, or cheque drawn on a UK bank or pay by credit card), to Everyday with Practical Electronics, Allen House, East Borough, Wimborne, Dorset BH21 1PF. Tel: 01202 881749. Fax: 01202 841692 (We cannot reply to overseas queries or confirm orders by fax due to the high costs).

We also accept credit card payments. Mastercard (Access) or Visa (minimum credit card order £5). Send your card number and card expiry date plus cardholders address (if different to the delivery address).

Constructional Project



HIGH VOLTAGE CAPACITOR REFORMER

PAUL STENNING

In the name of economy and antiquity, revitalise the capacitors of ancient radio sets.

WHEN not designing magazine projects, the author enjoys repairing and restoring valve radios. Often these sets will previously have been stored for a few years in somebody's loft. Electrolytic capacitors within sets of this age are prone to deterioration if they are not used for some time. This normally results in low capacitance and high leakage current. It is not unknown for one of these components to explode if a set is powered up after being left unused for years.

The easy approach could be taken and all the electrolytics replaced by modern components. However, from an antique-collector's point of view, this would be regarded as cheating. The correct way to go about antique restoration is to use as many of the original parts as possible. Additionally, even if antiquity is not a relevant factor, high voltage electrolytics are not cheap, so restoring the capacitors rather than replacing them has obvious cost benefits.

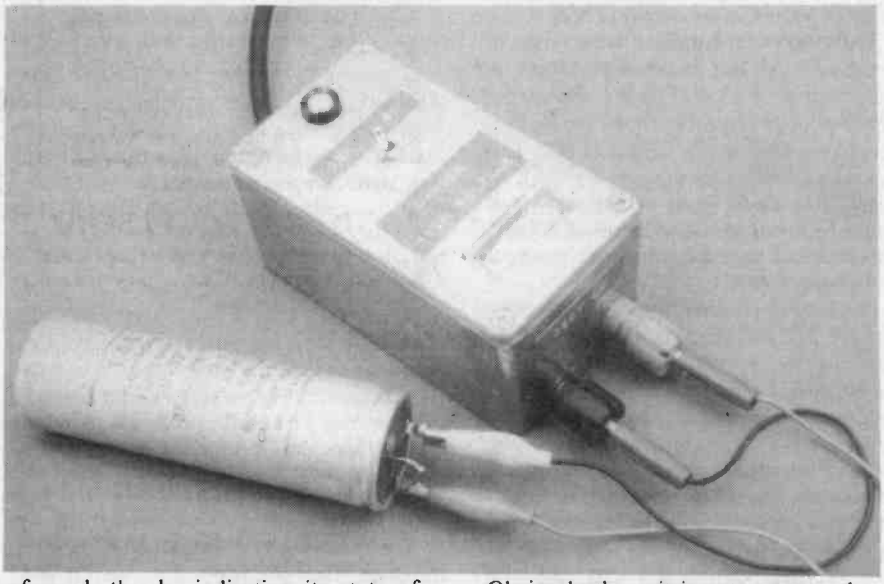
Be warned, though, that **this capacitor reformer is intended to be used in a workshop situation, by persons who know what they are doing.** Those who are familiar with working on valve equipment should be used to dealing with high voltages, and should therefore able to *treat this unit with due respect*.

This project is definitely not suitable for beginners.

DESIGN CONCEPT

This High Voltage Capacitor Reformer is designed for use with electrolytic capacitors rated at 350V d.c. or greater. It is possible, though, for components rated at lower voltages (275V or greater) to be handled with the addition of an external resistor or Zener diode, as described later.

The unit applies a high d.c. voltage (340V) via a current limiting resistor to the elderly capacitor. This causes the chemical composition of the component to reform – thereby gradually restoring normal operation. The limited current prevents the component from getting too hot (minimising the risk of explosion or leakage), and allows the reforming to take place gradually. A small meter shows the actual voltage across the capacitor being



reformed, thereby indicating its state of health.

The time taken to reform a capacitor depends on its initial state. In most cases an hour or two will be sufficient, but some components will need to be left connected to the unit overnight. If a capacitor is not reformed within about ten hours, it never will be.

Obviously the unit is not guaranteed to work in every case. Of ten capacitors reformed so far using the prototype, nine were successful. The tenth remained almost short-circuit, and would probably have exploded if the radio set had been powered up. Even though the unit didn't fix the tenth capacitor, it did prevent a most horrible mess!

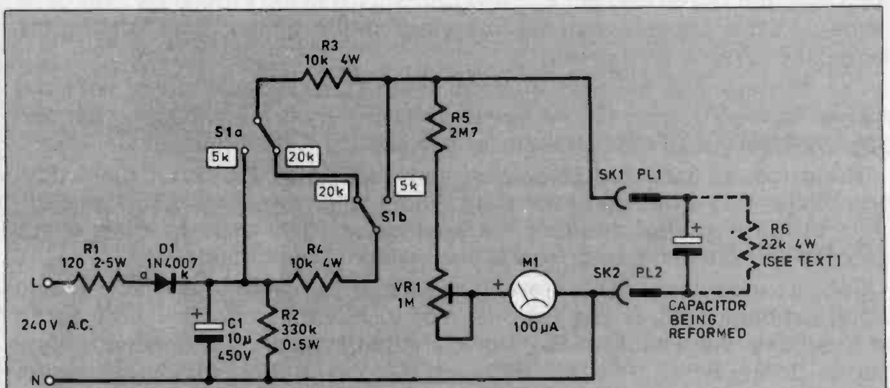


Fig. 1. Circuit diagram for the heart of the HV Capacitor Reformer.

CIRCUIT OPERATION

The circuit diagram for the heart of the Capacitor Reformer is shown in Fig.1. Diode D1 acts as a half-wave rectifier, allowing capacitor C1 to charge to the mains peak voltage (240V × 1·414 = 340V d.c.) with no load present. On load, there will be some ripple present as the current drawn increases, but this seems to help the reforming operation.

Resistor R1 limits the surge current at switch-on, when C1 is in a discharged condition. A wirewound resistor is used because carbon and metal film resistors are prone to failure when subjected to surges (as the author found out the hard way!).

A discharge path for C1 and the capacitor being reformed when the unit is switched off is provided by resistor R2. It should be rated at 0.5W or greater, and must be capable of operating at 350V d.c.

Resistors R3 and R4 limit the current through the capacitor being reformed. Switch S1 allows them to be connected either in series or parallel, giving a resistance of either 20 kilohms or 5 kilohms. These resistors should be rated at a minimum of 4W. They will get quite hot in the early stages of reforming when they have to drop a higher voltage.

The unit should be switched to the *20k* setting initially, and then switched over to *5k* once the voltage has risen to about 80 per cent of maximum. As the voltage across the capacitor rises, so the voltage across the resistors reduces, as does the current through them. The *5k* setting is intended to compensate for this. The use of a constant current circuit in this application did not seem justified.

Meter M1 indicates the voltage across the capacitor being reformed. It is a small 100µA edge meter, resistor R5 and preset VR1 being arranged to give a full scale reading at about 350V. Alternatively, the normal workshop multimeter could be used instead of an integral meter.

The voltage across the reforming capacitor gives a fair indication of its state of health, since it will rise as the leakage current drops. The resistor values can be changed if a different integral meter is used. Suggested values for other common meter movements are given in Table 1.

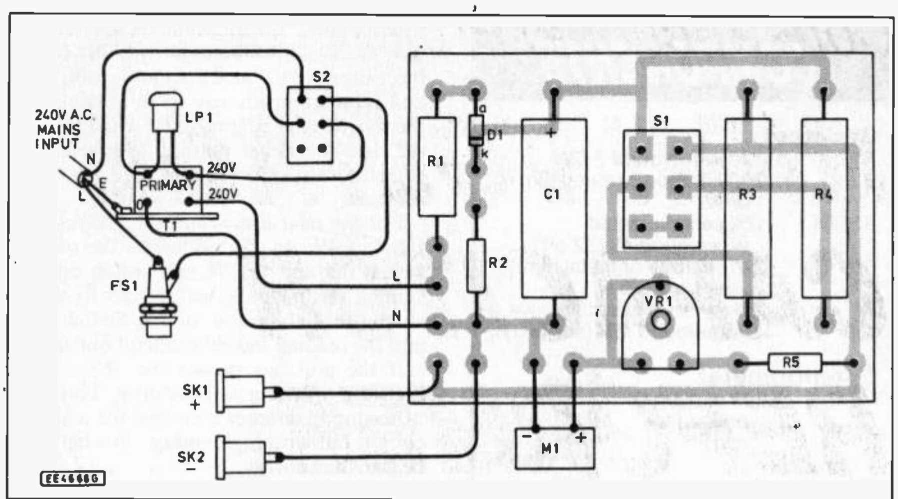
Table 1. Scaling component values for different meters.

Meter Current (F.S.D.)	R5	VR1
100µA	2M7	1M
200µA or 250µA	1M2	470k
500µA	470k	220k
1mA	270k	100k

SAFETY INTERFACE

With his own unit, the author chose not to isolate the circuit from the mains since he felt that it inherently **produces dangerous high voltages.** It is strongly recommended, however, that the circuit should be connected to the mains via the circuit shown in Fig.2.

The circuit of Fig.2 provides isolation from the mains by transformer T1. This has a 1:1 winding, so a 240V a.c. input will result in a 240V a.c. output. Since the current drawn by the reformer circuit is only small, a 25VA transformer, delivering a maximum of about 100mA, will probably suffice. (A small transformer may buzz when the unit is loaded, due to the half-wave rectification).



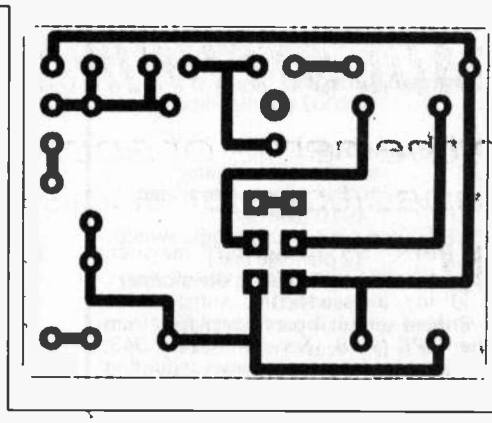


Fig. 3. Component layout and wiring diagram for the HV Capacitor Reformer complete with safety interface. The p.c.b. copper foil track master is shown full size.

If an isolation transformer is not used, the mains neutral **must** go to the circuit's negative (N) power rail as shown on Fig. 1.

It is also strongly recommended that an RCCB (Residual Current Circuit Breaker) device is also used between the mains supply and the unit.

CONSTRUCTION

Take great care with the construction of this unit. Mistakes on mains powered equipment can be potentially lethal.

The components of the main part of the unit are mounted on a small single-sided p.c.b. (printed circuit board), whose constructional and wiring details are shown in Fig.3. This board is available from the *EPE PCB Service*, code 943.

Stripboard is not a suitable substitute for the recommended p.c.b. since the gaps between the tracks on stripboard are too close to withstand high voltages.

Resistors R3 and R4 will get warm in use, and should be mounted about 4mm above the p.c.b. Drill out a hole below preset VR1 so that it can be adjusted from below the board. Switch S1 should be raised above the board by soldering short lengths of thick tinned copper wire to its pins. Do not solder this until you have positioned the board in the case.

BOXING UP

The prototype was fitted in a small diecast box. Such boxes are cheap and durable, making them ideal for this type of application. A plastic case *should not be used* because of the heat generated by resistors R3 and R4, and because it cannot be earthed. The required dimensions of the box will depend upon the size of the transformer selected. (The photograph of the interior of the author's prototype unit excludes a transformer.)

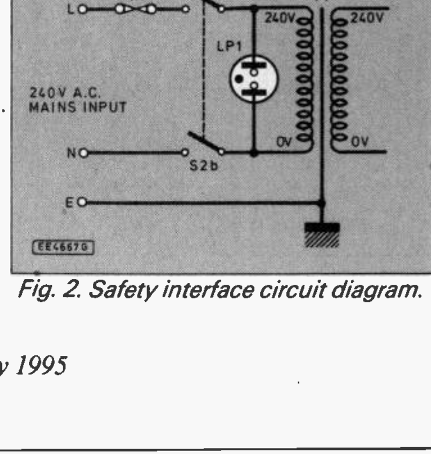


Fig. 2. Safety interface circuit diagram.

A rectangular hole is required at one end of the box lid for the meter. This may be cut by drilling a series of holes then breaking out the centre part and filing the edges smooth. Diecast aluminum is very easy to work with. The task can be done just using a simple hand drill and a small flat file. A vice or similar can be used to hold the case in position and make the job easier.

The p.c.b. is mounted in the box via the bush of switch S1. Once the switch is mounted, move the board by bending the switch wires so that the edges are at least 3mm from the case. Now solder the switch wires to the board and check that this holds the board fairly firmly.

Two 4mm sockets are used for the output connectors. These should be fitted towards the bottom of the box so that they do not foul on the meter. A hole at the other end is used for the mains input – again make sure this does not foul on anything. Use a cable clamp to prevent damage to the cable and to secure it in position. Drill a small hole near the mains input, and screw a solder tag to it for Earthing purposes.

Mark the positions of the toggle switch with "20k" and "5k" in the appropriate places. It is advisable to also mark the unit with "DANGER HIGH VOLTAGE" or something similar, in case it finds its way into the hands of someone who doesn't know what it is.

You will also need to make up two short test leads (about 300mm long) with 4mm plugs on one end and small *insulated* crocodile clips on the other end. To avoid polarity confusion, use red wire and connectors for one and black for the other.

COMPONENTS

Resistors

R1	120 wirewound 2·5W
R2	330k carbon or metal film 0·5W
R3, R4	10k ceramic cased wirewound 4W (2 off)
R5	2M7 carbon or metal film (see text) 0·5W
R6	22k ceramic cased wirewound 4W (see text)

Potentiometer

VR1	1M min. horiz. preset (see text)

See SHOP TALK Page

Capacitor

C1	10µ axial elect. 450V minimum

Semiconductors

D1	1N4007 rectifier diode

Miscellaneous

LP1	mains neon indicator
M1	100µA edge meter scaled 0-10 (see text)
S1, S2	d.p.d.t. mains toggle switch (2 off – see text)
T1	mains isolating transformer (see text)

Printed circuit board, available from the *EPE PCB Service,* code 943; diecast box (see text); panel mounting fuseholder and 1A fuse; mains cable clamp; 4mm socket (2 off – red and black); 4mm plug (2 off – red and black); crocodile clip (2 off – red and black); connecting cables; wire; solder etc.

Approx cost guidance only **£20**
excl. transformer and case

TESTING

Screw the case together. Set a multimeter on its lowest resistance range and check for a direct connection between the mains plug Earth pin and the case.

Now switch to the highest resistance range and measure between the earth pin of the plug and the following points: mains plug live, mains plug neutral, positive output terminal, and negative output terminal. In all cases the meter should read open circuit.

Remove the case lid again. Set the multimeter to a suitable resistance range, and connect it between the positive end of capacitor C1 and the positive output terminal. Switch S1 between its two positions to produce readings of 20k and 5k. Check that the case markings are the right way round!

Set VR1 to the mid-way position. Set the multimeter to a high d.c. voltage range and connect it to the output terminals. Connect the unit to the mains via an RCCB as previously recommended, and switch on. The multimeter should read about 340V d.c. (depending on the actual value of the mains voltage), and meter M1 should indicate somewhere near full scale.

Adjust VR1 to give exactly full scale on meter M1. Ideally, you should switch the unit off and wait for capacitor C1 to discharge before making any adjustments. BE EXTREMELY CAREFUL if you (inadvisably!) choose to adjust VR1 with an insulated tool when the mains power supply is switched on.

Disconnect the multimeter. Switch the unit to *20k* and momentarily short circuit the output. The meter should read zero, and return immediately to full scale when the short circuit is removed. Switch the unit off, and the meter reading should slowly drop to zero. This should take about 15 seconds.

For the next test connect a 22k resistor, rated at 4W or greater, across the output, switch the unit to *20k* and switch on. Assuming the meter is scaled zero to ten, it should read about four or five. Switch to *5k* and the reading should rise to about eight.

If the unit has passed the above tests, then it is working satisfactorily. This level of testing may seem excessive for a simple circuit, but with high voltages it's better to be safe than sorry.

IN USE

Regardless of what the previous owner of an old set may have told you about its condition, ideally its capacitors should be removed and tested one at a time.

Make sure the capacitor is rated at 350V or higher. Connect the unit to the capacitor, making sure you have the polarity correct. If there is more than one capacitor in a single can, each should be tested individually. You will need to use a capacitor mounting clip, a metal Terry clip, Jubilee clip or something similar, to connect the unit to the case of the capacitor if this is the only negative terminal. Place the capacitor on an insulated surface, and do not allow it to come into contact with anything, including the case of the Reformer.

Set switch S1 to *20k* and switch on the unit. **DO NOT TOUCH THE CAPACITOR OR OUTPUT LEADS WHEN THE UNIT IS SWITCHED ON.** Observe the reading on the unit's meter. If the capacitor is good, the reading will steadily climb to full scale within about 30 seconds or so.

If the capacitor is not so healthy the meter will show a lower reading and climb very slowly. Check the reading about every 15 minutes. It should be a bit higher each time you look. If the reading is below about four, SWITCH OFF and feel the temperature of the capacitor. If it is warm, leave the unit switched off to let the capacitor cool down before continuing.

Once the reading has reached about seven or eight, switch S1 to *5k*. The reading will probably go up a bit immediately, and should then continue to rise slowly. With luck the unit should read full scale after a couple of hours, but leave it for up to about ten hours before giving up.

If the reading rises to about nine or higher and then stops, the capacitor may still be usable as long as it is not the main h.t. smoothing component (connected directly to the cathode of the rectifier valve). In this case, re-install the capacitor in its original piece of equipment, and feel its temperature after the equipment has been powered up for about 10 or 15 minutes. If it is significantly warmer than the chassis, it should not be used further.

When the capacitor has been reformed, **switch the unit off at the mains and wait for the capacitor to discharge and the meter to read zero.** This could take a minute or more, depending on the value of the capacitor.

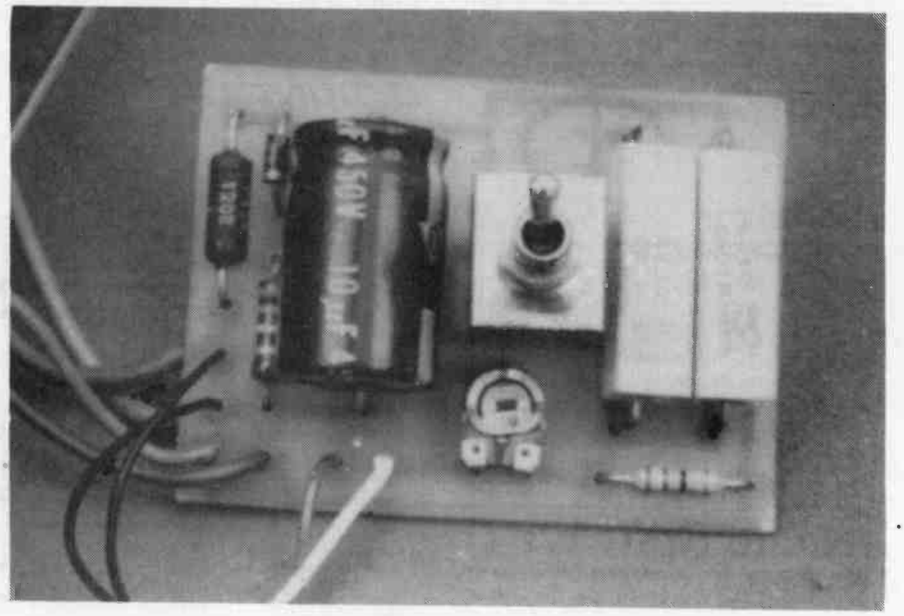
ALTERNATIVE TECHNIQUES

To reform a 275V capacitor, connect a 22k 4W resistor in parallel with it. With switch S1 on the *20k* setting, the meter will only read up to four or five. When this value is reached, switch to the *5k* setting. The maximum reading will now be eight. If a more elegant method is preferred, make up a chained series of Zener diodes that total about 260V to 270V (e.g. a 120V Zener in series with a 150V one). Connect this in place of the resistor.

A quick check can be made on the main h.t. capacitors in a set without going through the hassle of removing them first. With the set disconnected from the mains, connect the Reformer unit between the h.t. rail (cathode of rectifier valve) and chassis, switch S1 to *20k* and switch on. If the circuit diagram for the set is available, check for potential divider circuits across the supply rails – these will affect the readings and may be worth disconnecting.

Switch S1 to the *5k* setting once the reading is above about eight. If the unit's meter reads above nine on the *5k* setting within about ten minutes, it can be assumed that the capacitors are reasonably OK. If not, they will have to be removed and reformed individually.

If you have a dud capacitor that cannot be reformed, don't throw it away. The tidy (and "antique value") solution is to fit it back onto the chassis so that it looks



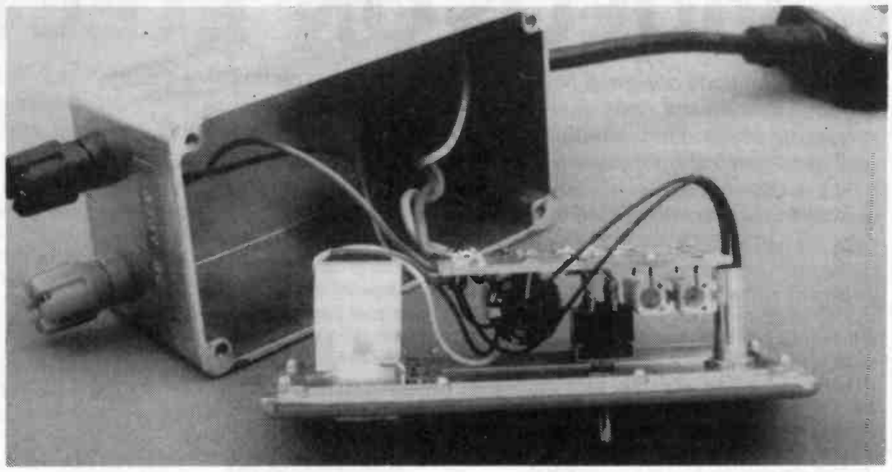
right, but don't connect it. Fit a modern electrolytic tidily below the chassis, and no-one will ever know! If you're really enthusiastic you could dig out the innards of the old capacitor and fit the modern replacement inside the can – if you have this much patience!

UNKNOWN SET TESTS

When initially testing an unknown receiver, it is often advised that the set should be powered from a lower than normal mains voltage via a variac (variable auto-transformer). This is intended to give a lower voltage h.t. supply which is also at a higher impedance due to the valve heaters being underrun. This will also show up leaky capacitors and many other problems without causing additional damage.

For those who do not have access to a variac (they are fairly expensive), the HV Capacitor Reformer will enable similar tests to be carried out. The unit is simply connected across the main h.t. smoothing capacitor (with the receiver disconnected from the mains) as described previously.

Any leaky low-value non-polarised decoupling capacitors (and other capacitors which have a high voltage across them in use) will show up after a few minutes by the wax bubbling at one end. If any resistors are getting warm, the reason should be investigated. In the majority of receivers there are no potential dividers or other resistive circuits across the h.t. supply, so the h.t. rail should reach about 350V. If anything is dragging this down, it should be investigated (remember that at this time valves have no power across their heaters and therefore will not be drawing current from the h.t. supply).



Measure the voltage at the grid of the output valve, relative to the chassis. If this is at all positive, the grid coupling capacitor is leaky and should be replaced. Also check the voltage at the anode of the output valve. If this is not at the full h.t. level (about 350V) the output transformer primary may be open circuit. If you have the service sheet for the receiver you can carry out a number of similar checks – all before the mains supply has been applied.

SAFETY ADVICE

To reiterate and expand on the warnings given earlier:

This unit produces potentially lethal voltages. Even though a mains isolating transformer is recommended, the unit should still be regarded as being connected directly to the a.c. mains. **Do not touch the output leads or anything connected to them while the unit is switched on. Wait for the meter to read zero after switching off.** Keep this unit out of the reach of children, pets and anyone who does not appreciate the danger.

When working on live equipment, always keep one hand in your pocket or behind your back – this will reduce the chances of current passing through your heart if you accidentally touch something electrically live.

The use of an RCCB (Residual Current Circuit Breaker) should be regarded as a "must", *but is no substitute for safe working practices.* **A large capacitor can give a fatal shock without the circuit breaker responding.**

Never work on live equipment alone – always make sure there is someone present who knows how to administer the appropriate first aid.

Electricity can kill – TAKE CARE. □

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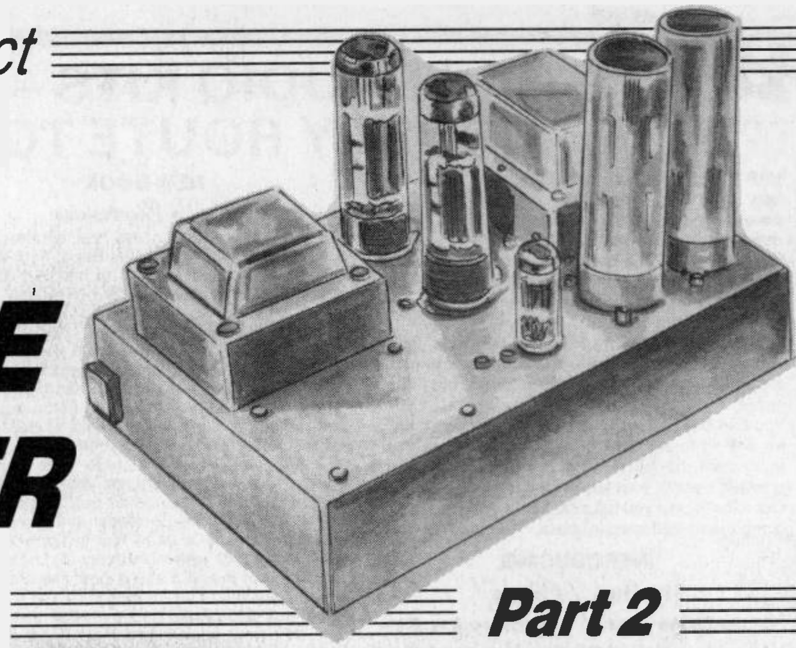

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• 30W r.m.s. into 8 ohms • 20Hz to 20kHz, ±0·2dB •
• Input Sens. 300mV for full output • less than 0·1% t.h.d. at 15W into 8 ohms • Hybrid design for minimum valve count • Monoblock design (two required for stereo) • Optimised for use with CD •

LAST month we looked at comparisions between valve and solid-state amplifiers and introduced circuits which combined both technologies. We also covered the p.c.b. construction of the single i.c. phase-splitter stage of the amplifier.

This month we conclude with the final wiring, testing and setting-up. We also offer some circuit ideas for possible further development.

HEATER WIRING

With all valve circuits wired in the traditional manner, the heater wiring is put down *first* so that it can be laid close to the chassis. It is also twisted and kept clear of the grid pins and by using these techniques hum pick-up from the heater a.c. power is minimised.

The heater, power wiring and other wiring that needs to be completed before the tag strips are dropped into place, on the underside of the chassis, is shown in Fig. 11. The phase-splitter (last month) printed circuit board should also be mounted in position at this intermediate stage.

TAG STRIPS

There are two tag strip assemblies in the design which can be conveniently constructed outside of the chassis before they are installed. Fig. 12 shows how the two tag strips should be cut from standard lengths before use. Note that some of the "earth" tags on the driver strip have been cut to increase the number of "floating" tags.

The component layout on the tag strip for the Driver stage is shown in Fig. 13. Note how the grid stopper resistors are positioned so as to slide straight through the grid tags on the valveholders.

Another point to watch is the possibility of shorts and these are prevented by use of silicone sleeving over component leads. Also, if uninsulated metal-cased capacitors are used for C15 and C17, mount them so that their case is connected to the grids otherwise they will be floating at 200V. Before bolting and soldering the tag strip into place make sure the output transformer wiring is in place.

The second, smaller, tag strip is for the cathode components for the power valves. The anti-surge resistor R39 is also mounted on the same tag strip and the whole assembly is shown in Fig. 14.

It is essential to use a hot thermostatically controlled soldering iron such as a Weller W60 for traditional hard wiring. That old 15W iron will not do!

The final complete interwiring of the chassis is shown in Fig. 15. Note that the connections to the p.c.b. are made by Molex connectors. These need a special crimp tool to do the job properly. Fig. 16 shows how to complete a Molex connector.

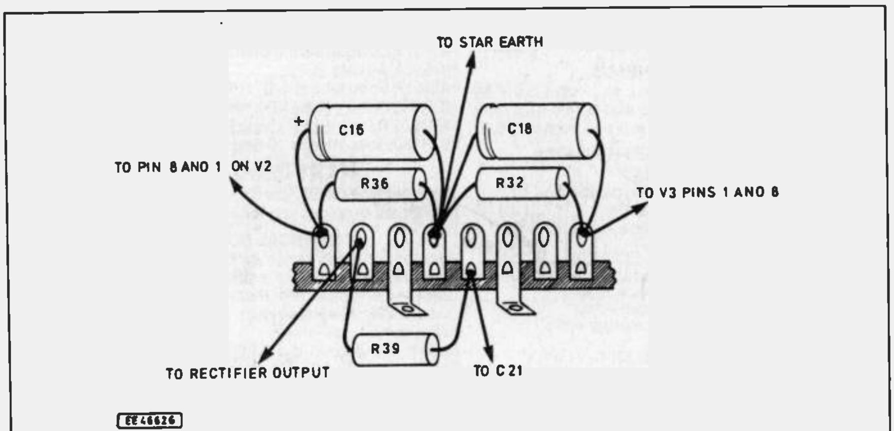


Fig. 14. Cathode tag strip assembly and wiring.

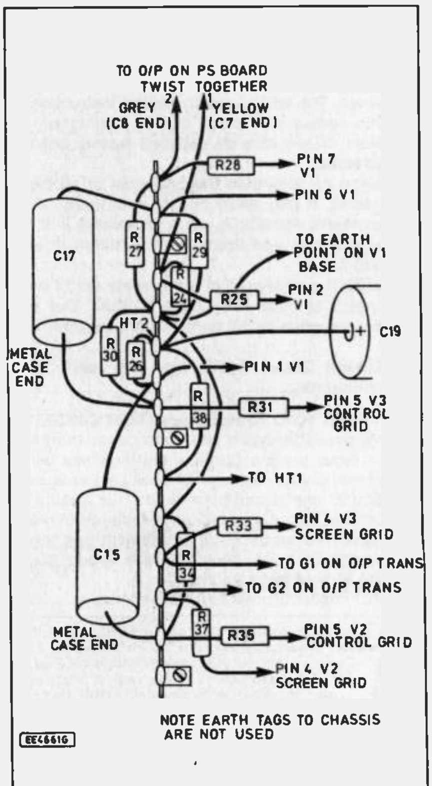


Fig. 13. Driver stage tag strip assembly.

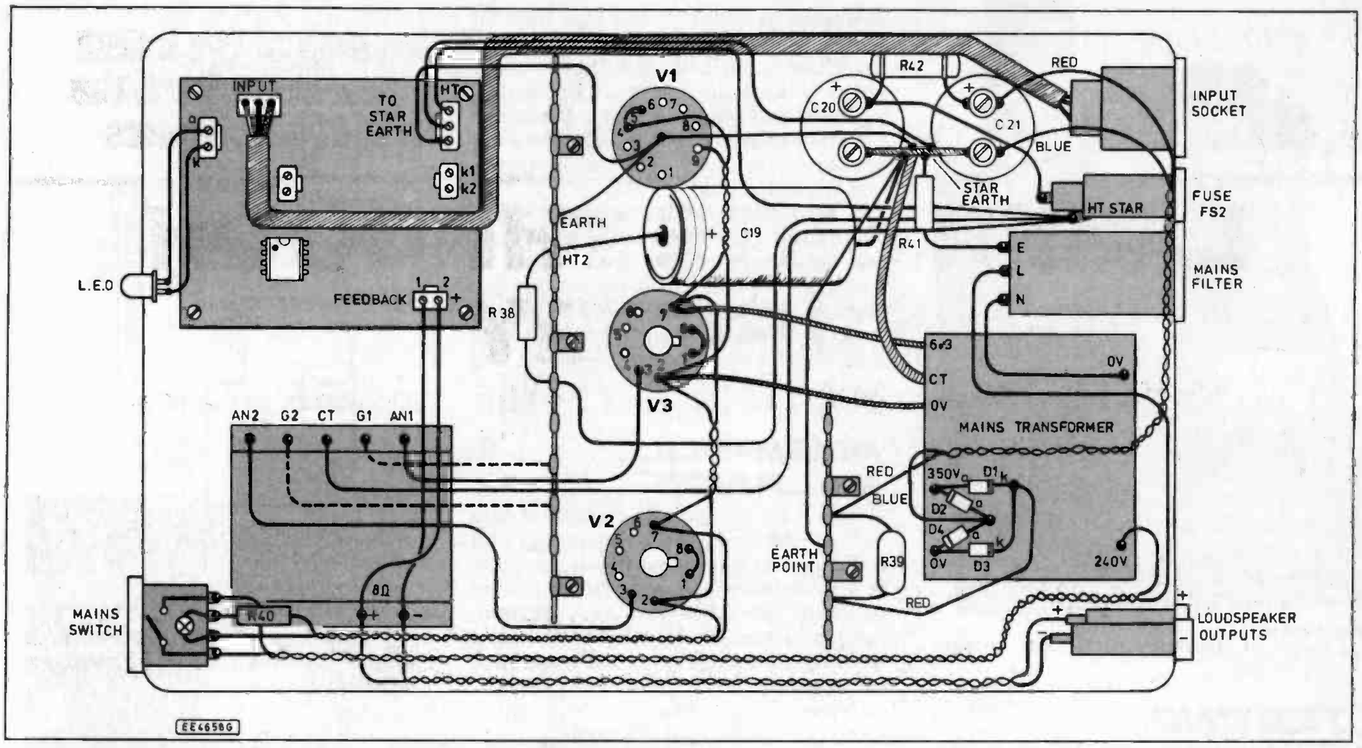


Fig. 11. First stage of the chassis "hard wiring," prior to dropping the tag strips in place. The heater wiring should be completed first and be kept away from the valve grid pins.

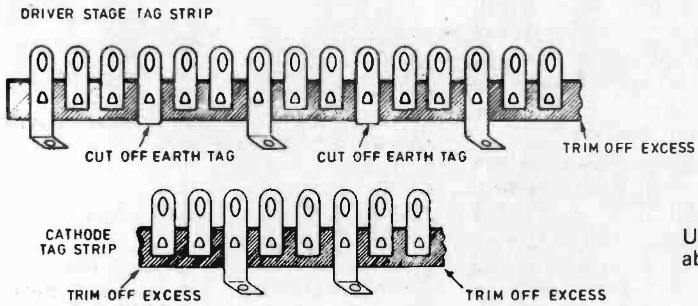


Fig. 12. Preparation of the two tag strips from standard lengths.

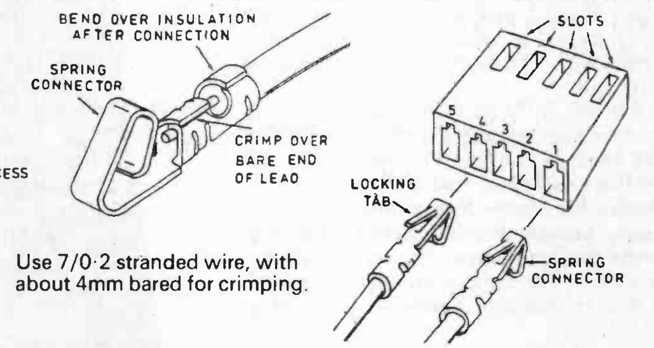


Fig. 16. Assembling the p.c.b. header connectors.

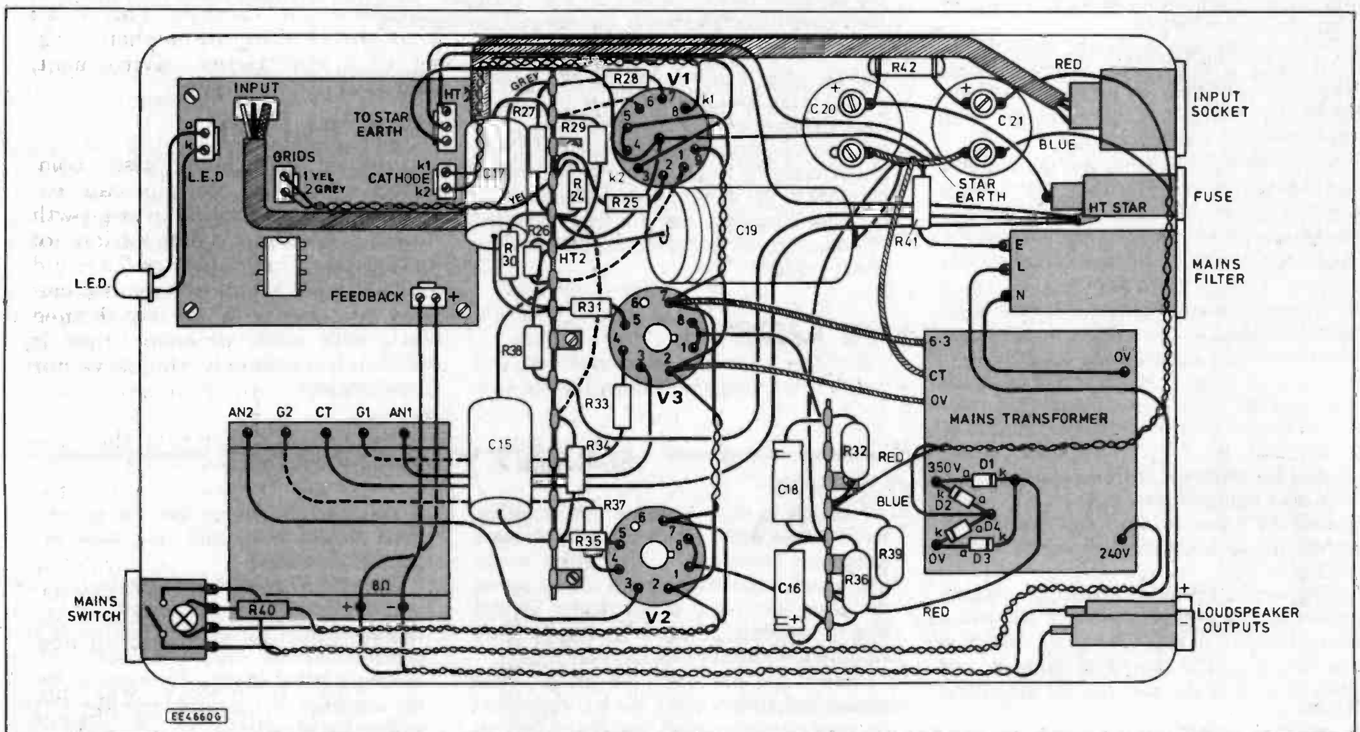
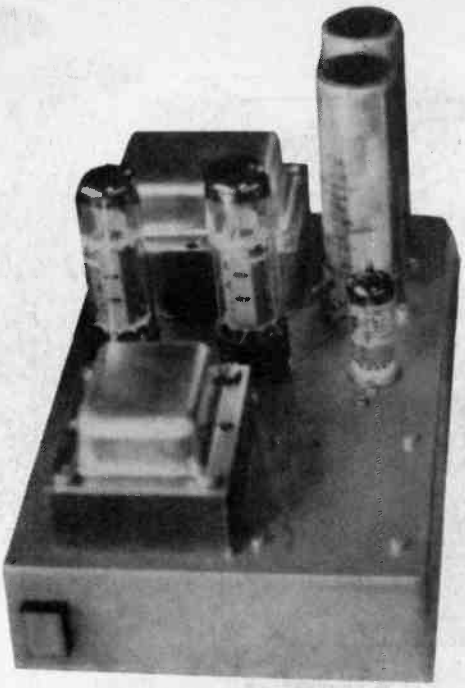


Fig. 15. Final complete chassis interwiring. Connections to the Phase-splitter p.c.b. are made using p.c.b. header connectors.



Layout of components on the topside of the chassis.

TESTING

This amplifier is quite difficult to test with the normal test gear set-up of signal generator and oscilloscope because of the balanced inputs and outputs. The balanced input is not a problem since it can easily be converted to unbalanced by the simple expedient of grounding one of the input terminals.

Putting a 'scope on the output is problematic because if either terminal of the floating output is grounded the feedback is unbalanced and the amp will operate incorrectly giving a greatly reduced output swing. The *unsafe* method of getting round this is to remove the mains earth on the 'scope. The safer recommended method is to use a differential probe or a balancing transformer.

As with all valve power-amps it is not happy without a load, since there may be damaging flashovers in the output valves due to high back e.m.f.s being generated by the output transformer.

Valve amps are generally much more tolerant of wiring errors than solid-state amps, because there are no ready paths for chains of destruction, as there are with direct-coupled semiconductors.

However, it is logical to test the unit in a sensible sequence rather than just firing it up. The first stage is to check the mains and heater wiring by powering-up with the h.t. fuse FS2 removed. All the valves should light up. Listen out for unusual noises such as stressed power transformer hum, but do not be alarmed by the tinkling noises valves normally make as they warm up.

The next stage is to power-up with the h.t. fuse in place, with the driver valve V1 removed (this reduces the chance of oscillation). An 8 ohm 25W load resistor should be connected at this stage. If the h.t. fuse does not blow, measure the h.t. (which should be around 430V) and the voltage across the cathode resistors which should be 29V to 34V.

The next stage is to check the op.amp power supply voltage at pin 8 of IC1 which should be 32V to 36V. The offset voltage at the outputs of IC1 should be measured and should be half the rail voltage at around 16·5V.

If all is well, plug in the driver valve V1. If the amplifier oscillates it will be generally be audible as a high pitched buzz from the output transformer. The normal cause of oscillation is the feedback being the wrong phase. If this is the case it can be cured by reversing the feedback Molex connector on the Phase-splitter board. Finally check the voltage on the driver valve anodes (pins 1 and 6) which should be 205V.

A final check should be made with a 1kHz sine wave applied to the input looking for distortion. The level should be increased to check for symmetrical clean clipping. The amplifier should be able to swing 40V peak-to-peak into the 8 ohm load resistor just before clipping. This equates to 24W r.m.s. (20V peak × 0·707 = 14V r.m.s. $P = V^2/R = 196/8 = 24{\cdot}5W$.

PUSH-PULL BALANCE

Here is an old dodge to check that each half of the amplifier is operating with equal gain so that the push-pull operation is fully balanced. Simply wire a pair of matched 100 kilohms, one per cent, resistors across the anodes of the output valves as shown in Fig. 17 and hook up to the 'scope.

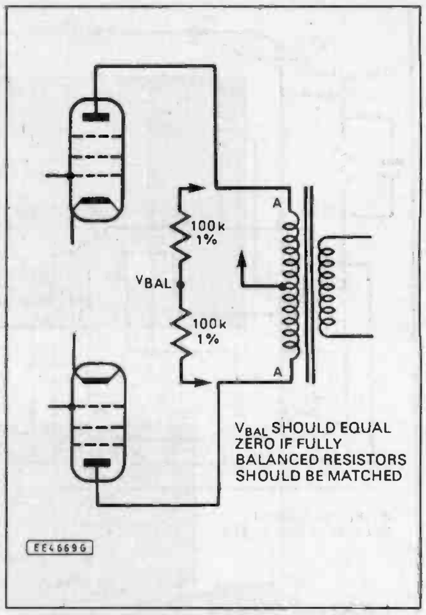
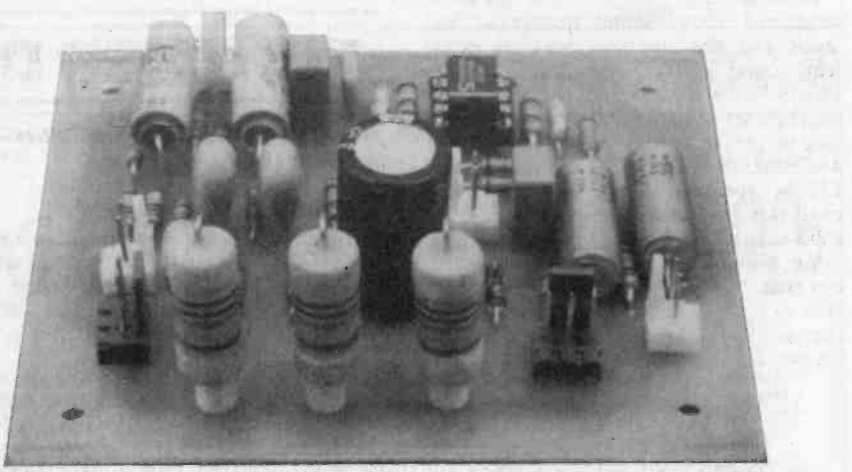


Fig. 17. Using two close tolerance, 100 kilohm resistors to check "push-pull" balance.



Layout of components on the completed Phase-splitter p.c.b. (last month). Notice the ceramic bead spacers on the "dropper" resistors (to help keep heat away from the board), and the p.c.b. header pin connectors.

If the amp is in balance the two signals should cancel out. It is worth trying this at a few different levels and frequencies.

If there is an imbalance in level it can be corrected by tweaking one of the anode resistors in the driver stage. Imbalances at the high frequency end are best corrected by adjusting the feedback capacitors in the phase-splitter.

IN USE

Since the amplifiers are monoblocks and have a low impedance balanced input, they can be placed near the loudspeakers, minimising the need for expensive loudspeaker cables.

With a 10k input impedance, the valve amplifier is only suitable for use with pre-amps that can drive low impedance loads. Usually the amp will be used with a passive pre-amp of the type shown in Fig. 18 with a CD player.

The output is only 24W but because of the soft clipping it will sound as loud as a 40W solid-state amp. To get high levels it is necessary to use high sensitivity loudspeakers.

SAFETY WARNING

Not only is there mains 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. Such shocks across the heart may result in ventricular fibrillation or breathing paralysis leading to death within a few minutes without resuscitation.

Always use well insulated probes when testing and always check the h.t. capacitors for residual charge when working on the unit if switched off. To prevent the across the chest shocks, work with "one hand in the pocket" if possible.

It should be pointed out that the l.e.d. D6 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.

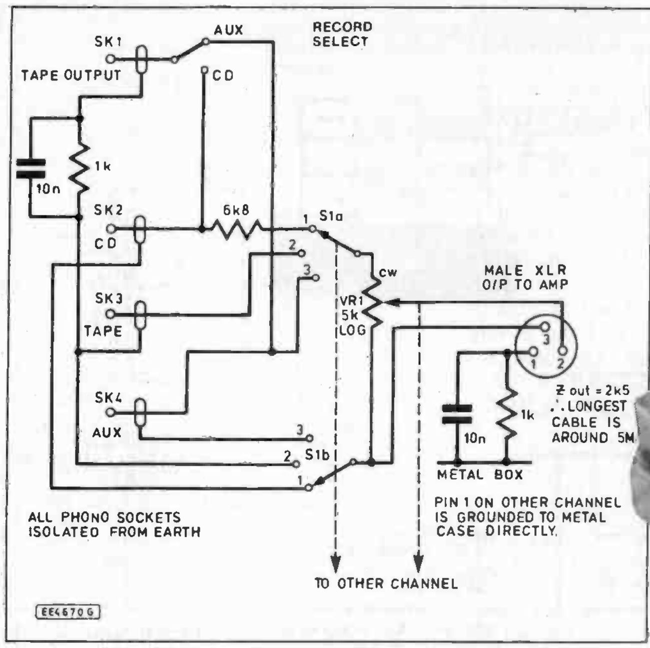
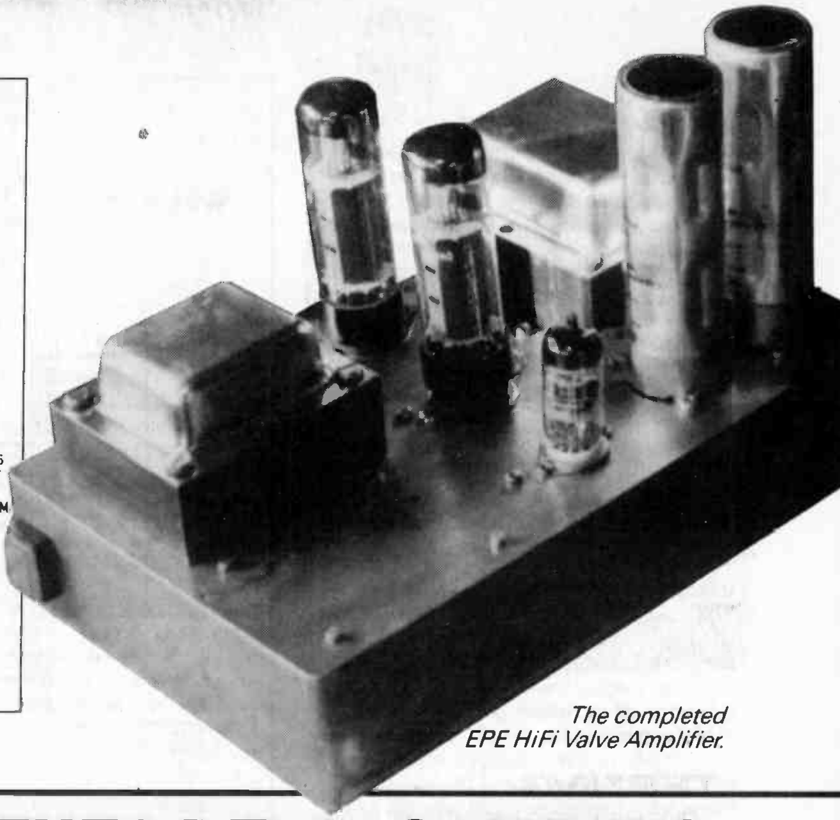


Fig. 18. Passive preamplifier for connection to CD.



The completed EPE HiFi Valve Amplifier.

However, most valve amp users are more concerned about sound quality at low levels and the amplifier provides excellent sound quality with the low sensitivity (81dB/W) LS3/5a type "bookshelf" speakers set at reasonable domestic levels. One way of increasing the maximum level and retain the quality, is to use valve driven LS3/5a speakers along with an active crossover driven sub-woofer powered by a solid-state amp.

Valve amps can get quite hot so it is essential the units get plenty of ventilation. It is not a good idea to put them in an enclosed box – use a perforated steel cage if they need to be cased.

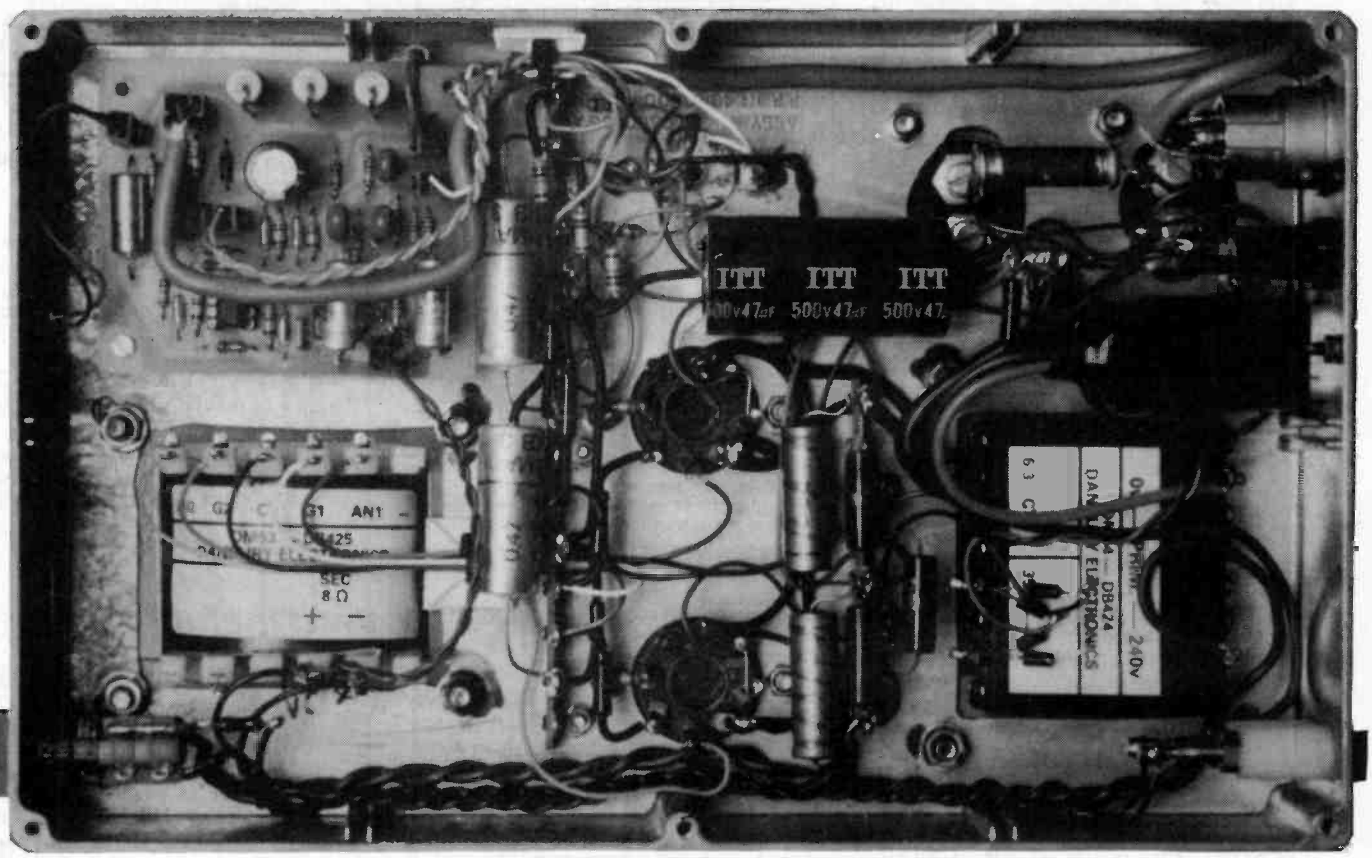
FURTHER DEVELOPMENTS

Here are some suggested possible circuit improvements that should be of interest to experimenters.

Standby Switch

If the amp is to be left running for a long time, such as in a studio, it is worth putting a switch in the h.t. line. This enables the heaters to be left running without the h.t. When the amp is needed it can be switched on instantly with the Standby switch.

A Standby switch also prolongs the life of the valves since it is the electron emission that fails long before the heaters. Cathode stripping is also eliminated if the standby switch is turned on after the valves have warmed up.



The compact chassis underside component layout and interwiring of the completed EPE HiFi Valve Amplifier. The twisted heater winding leads run along the bottom and the screened signal lead across the top (as seen).

Output Transformers

The output transformers are the heart of any valve power-amplifier and they basically determine the low frequency performance of the amplifier. The recommended transformers are perfectly functional and at around £26 are one of the cheapest. It is possible to get better transformers which give more bass power below 40Hz from companies like Sowter's and Audio Note, but expect to pay at least double.

The reason for the high cost of valve output transformers is that the windings are much more complex than a power transformer. They have to be, to minimise distributed capacitance and leakage inductance which are the main factors in obtaining a flat frequency response.

The winding configuration used in the specified transformer is shown in Fig. 19. This configuration is called a five-section winding, where the primary is divided into three layers and the secondary into two.

Cheap output transformers use a three-section winding which generally results in a resonance in the 25kHz area, whereas the one above has a damped resonance of around 80kHz, well out of the audio band. Some very expensive types use up to ten sections, but after five sections the onset of diminishing returns is very rapid.

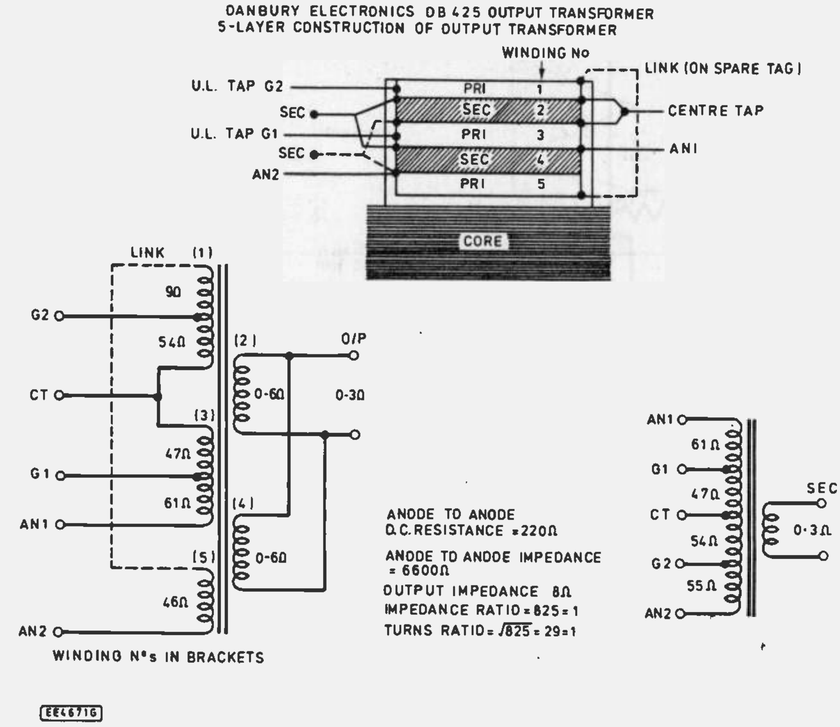


Fig. 19. Five-section output transformer construction and d.c. resistances.

Choke Smoothing

To reduce the hum further, a choke filter could be tried since a 10 Henry valve smoothing choke is now available from Maplin (order code ST28F). It is only officially rated at 100mA but this is not a thermal rating and on this basis, the choke can handle the full 140mA current of the valve amplifier.

The problem is that the core saturates reducing the inductance to some extent. The remaining inductance still seems to offer much improved smoothing however. The circuit for installing the choke is shown in Fig. 20.

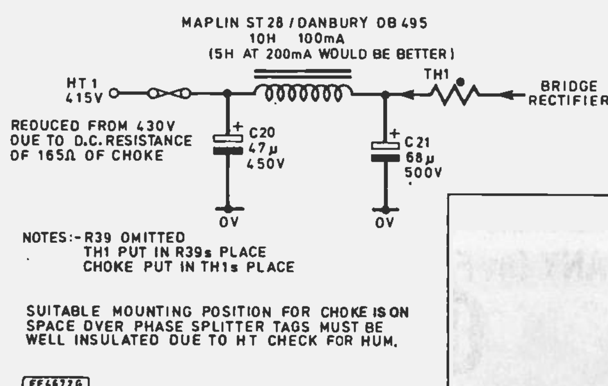


Fig. 20 (left). Using a choke smoothed power supply.

Cathode Current Regulation

The anode currents of both output valves must be equal to ensure complete cancellation of hum and residual magnetic field in the output transformer. Of course, the signal voltages do not cancel since they are out of phase, while the steady-state anode current does, because it flows through the valves in the same direction.

If the currents are unequal the result is 100Hz hum. This can be trimmed out by tweaking the cathode resistors, although there should not normally be a problem since valve tolerances are generally very good.

The currents can be accurately set and held constant over the life of the valves, by replacing the cathode resistors with constant current sinks. These can be built around simple voltage regulators chips.

By making the voltage adjustable, the currents can be accurately trimmed and any hum nulled out. A suitable circuit is given in Fig. 21. It should be noted that if a valve shorts out it will destroy the semiconductors. The regulators are protected from over voltage by Zener diodes.

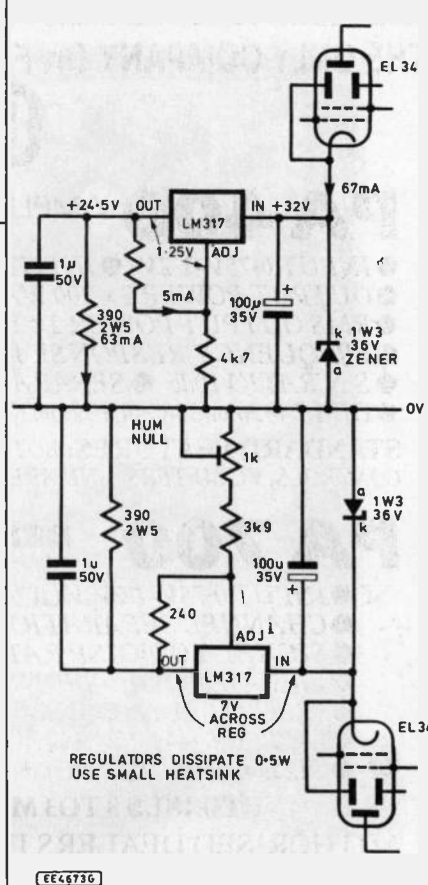


Fig. 21. Constant current cathode biasing.

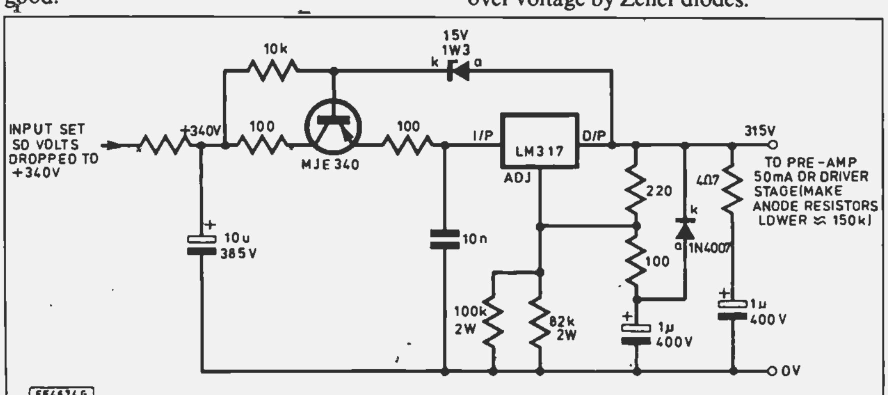


Fig. 22. Suggested circuit for a solid-state h.t. regulator.

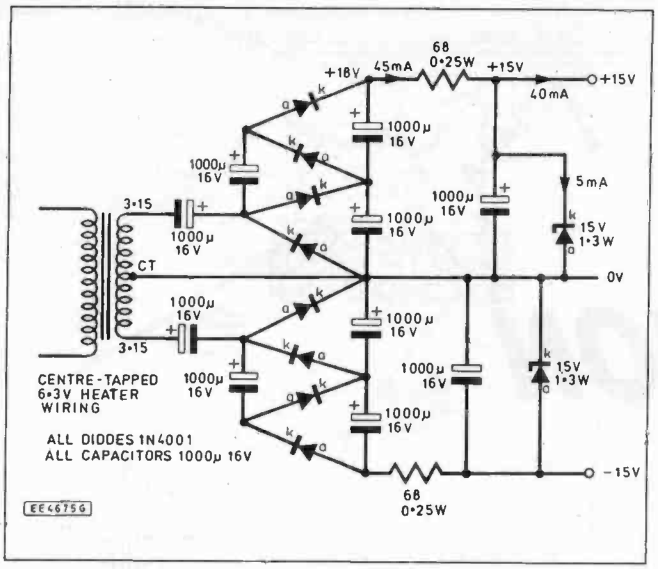
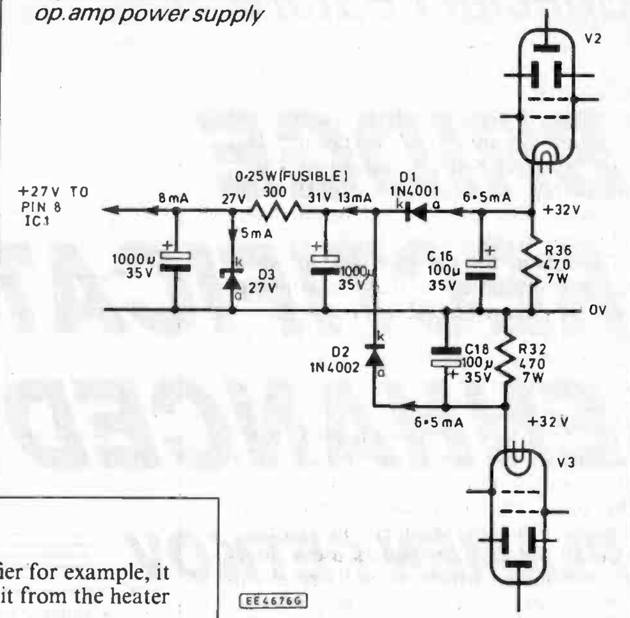


Fig. 24. Heater derived dual-rail op.amp power supply.

Fig. 25. Cathode derived op.amp power supply



Solid-state Ripple Suppression

To obtain the lowest supply ripple, a solid-state regulator could be used. However, semiconductors are not very reliable in such high voltage conditions and the circuit given in Fig. 22 is unlikely to be short circuit proof. However a regulated h.t. rail will make an improvement for valve pre-amps.

Heater-derived Op.amp P.S.U.

The simple Zener supply in the amplifier is only suitable for powering a couple of op.amps in single rail mode. If extra power is needed, for a preamplifier for example, it would be better to derive it from the heater supply.

A voltage tripler circuit such as that shown in Fig. 23 which provides dual rails, could be used.

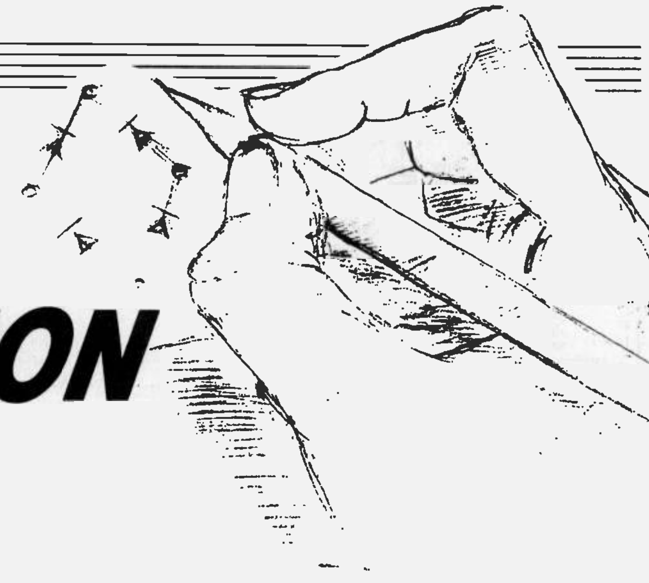
Cathode-derived Op.amp PSU

If it is desired to remove the dissipation of the dropper resistors it should be possible to derive op.amp power from the cathode resistors as shown in Fig. 24. The maximum voltage available is limited but there is sufficient gain in the driver stage to make up for any lost headroom. □

Further reading

Reviving the Valve Sound by Jake Rothman EPE Feb 1994
Circuits for Audio Amplifiers Mullard 1959*
The Williamson Amplifier Wireless World*
Glass Audio magazine (USA)*
An Approach to Audio Amplifier Design GEC*
Radio Designer's Handbook F. Langford-Smith 1963 (this is the valve designers bible!)
*All available from Falcon Acoustics (☎ 01508 578272).

Special Feature



BRIDGE RECTIFICATION ENHANCED

PLAMEN PETKOV

Ancient and modern rectifying techniques are combined to facilitate multi-voltage supply line derivation.

THE CLASSICAL bridge rectifier circuit, as shown in Fig. 1, is one of the most widely used types of a.c. to d.c. rectifying circuit. Conventionally, it is powered from a single secondary winding of a mains transformer.

When additional voltage supply lines are required from the same transformer, this secondary winding is either centre tapped, or additional secondary windings are employed, each having its own rectifying circuit.

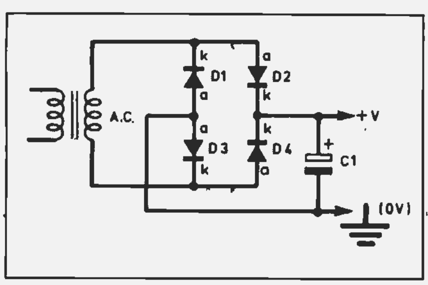


Fig. 1. Classical bridge rectifier circuit.

COST FACTORS

In many commercial manufacturing situations, it may be cost-effective to have transformers specially wound to meet the voltage requirements of new equipment designs. In other cases, though, cost demands may make it preferable to use an off-the-shelf transformer rather than a custom designed one. Regrettably, however, the available transformers may not have the number of windings needed to supply the required variety of voltage levels.

Also, the need sometimes arises for additional voltage levels to be supplied to existing equipment if it is being upgraded. For example, the addition of op.amps, where previously none had been used, may require a negative voltage line to be added. It could even be the case that voltages higher than those already existing might need to be added.

Rather than use an additional transformer to supply the extra voltage levels, it is possible in a variety of instances to derive the voltages from an existing secondary winding of a transformer, by using conventional voltage multiplying, inverting or regulating circuits.

BRIDGE PROBLEMS

However, not all situations can be catered for in this manner because of an inherent problem with bridge rectifier circuits, caused by their lack of a common connection between the input and the output.

Although it may be tempting to try using an additional rectifying circuit connected between one of the a.c. leads and the ground line, for example the voltage inverter/doubler circuit shown in Fig. 2a, the attempt will be likely to fail due to the uni-directional conductivity of the voltage source. Unfortunately, the input connections to this circuit require both charge and discharge current paths.

The reason for this is that the transformer secondary winding, grounded via the diodes of the bridge rectifier, provides only a charge path. A discharge path does not exist, as will be seen in the equivalent circuit in Fig. 2b.

In other words, the problem is that the diodes conduct only in one direction, which is, of course, an essential feature for the correct operation of the classical bridge rectifier circuit.

SYNCHRONOUS RECTIFIER

What is needed in this situation is a switching component which is capable of conducting during the appropriate half-wave period of the a.c. supply, irrespective of its polarity.

Historically, such a switching circuit was invented long before valves or semiconductor diodes became available. It was known as the synchronous rectifier and was based on a polarised relay circuit, schematically shown in Fig. 2c.

It is possible to upgrade this concept for modern applications by using semiconductor devices. Indeed, the functionally equivalent circuit shown in Fig. 3a offers vast opportunities for multi-voltage supply requirements.

The idea of the circuit illustrated in Fig. 3a is to complement the "grounding diodes" of the bridge rectifier with bypassing transistors, switched *on* simultaneously with the corresponding diode during the appropriate a.c. half wave.

The operation of this modified bridge rectifier is similar to the historical synchronous rectifier configuration due to the fact that the respective transistors are *on* or *off* simultaneously with their diodes. The only difference from the historical circuit is the ability of this modern equivalent to provide a discharge path through transistors in addition to a charge path through diodes.

It should be noted that the transistors are protected from "wrong polarity" by the diodes, which inhibit the "reverse voltage".

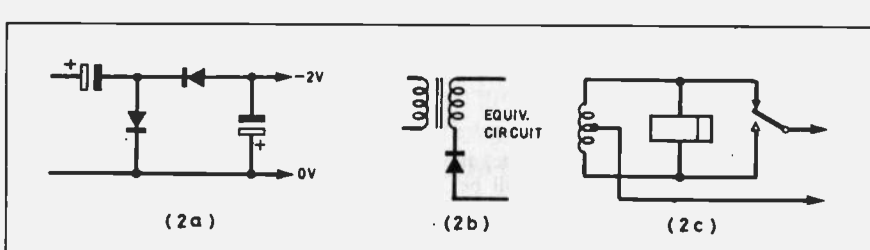


Fig. 2(a) Voltage inverter, (b) and its equivalent circuit; (c) relay-driven synchronous rectifier.

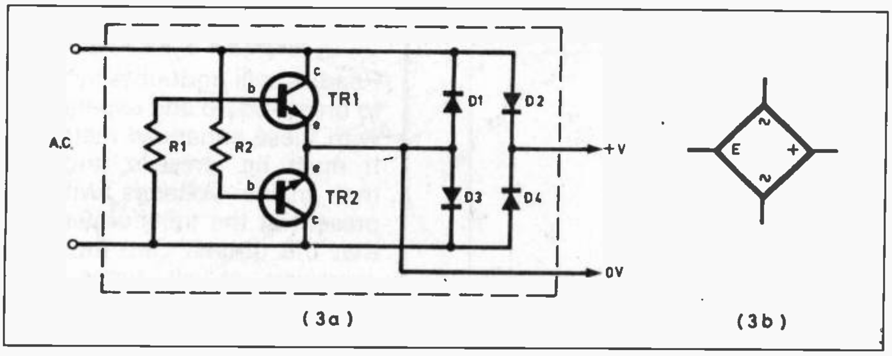


Fig. 3(a) Modified bridge rectifier circuit and (b) its symbol.

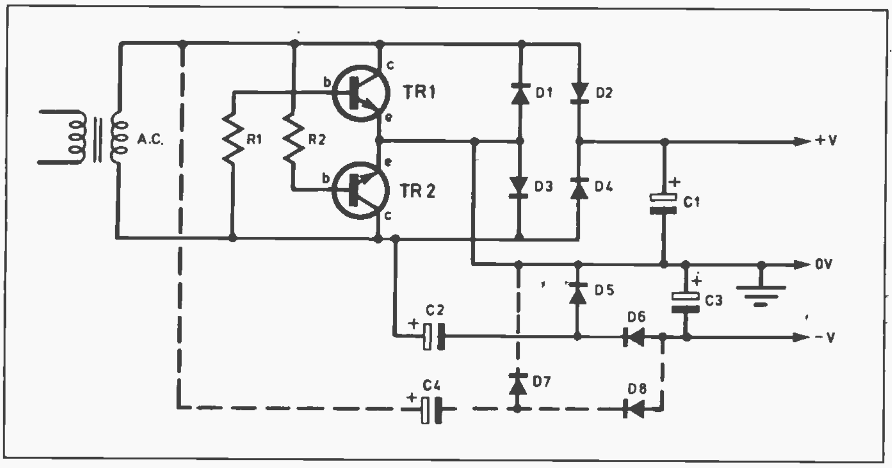


Fig. 4. Bipolar rectifier, full-wave addition indicated by dotted line.

The inclusion of the resistors ensures that the transistors are controlled by "safe" voltages and currents.

For the sake of illustrative convenience in later circuit diagrams, the circuit of Fig.3a has been given the schematic symbol shown in Fig.3b. The letter "E" denotes the common emitter (0V) point.

CIRCUIT EXAMPLES

The circuits shown in Fig. 4 to Fig. 9 illustrate how the circuit of Fig. 3a can be used in conjunction with other rectifying circuits to produce a variety of "integer" and "non-integer" conversion ratios of the output voltage levels, both positive and negative, with respect to the input voltage level.

The circuit diagram in Fig. 4, for example, illustrates how an additional negative voltage can be derived from a transformer secondary winding which is already engaged in bridge-rectifying a positive voltage. As will be seen in the upper section of the circuit diagram, the positive voltage is produced by a circuit identical to that shown in Fig. 3a.

The circuit configured around diodes D5 and D6, and capacitors C2 and C3, forms a standard half-wave voltage-inverting rectifier. Full-wave voltage-inverting rectification is achieved when the circuit configured around capacitor C4 and diodes D7 and D8 is included as well (shown as dotted line connections).

Nominally, the negative voltage is equal to the positive voltage. For example, if "+V" equals +12V, then "−V" will be −12V. Note, though, that the exact voltage relationship may be different due to component tolerances and the actual currents drawn. In this context, note that there is a voltage drop of about 0·7V across the series diodes, and that the value of the series capacitors must be sufficiently great to provide current charge transfer to the output, in other words, to pass the amount of a.c. current required. The value of the parallel (output) capacitors should be chosen to provide acceptable ripple levels. This proviso applies to all the nominal voltage relationships quoted in the ensuing circuit diagrams.

SCALING VOLTAGES

The circuits of Fig. 5 and Fig. 6 demonstrate an additional refinement, respectively dividing the nominal output negative voltage by two and by three.

A negative voltage which is nominally half that of the equivalent positive voltage can be produced by the circuit shown in Fig. 5. That is, if "+V" = +12V then "−V/2" = −6V.

Similarly, a negative voltage nominally one third that of the equivalent positive voltage can be produced by the circuit shown in Fig. 6. Thus, if "+V" = +12V then "−V/3" = −4V. Obviously, further voltage division in a similar fashion to less than one third is theoretically possible, but is rarely practical.

The idea of these circuits, which the author calls "scaling inverting rectifiers", is to alternately charge a number of serially connected capacitors, and to discharge them to the load in parallel connection. Accordingly, each capacitor is "equipped" with a charge diode and

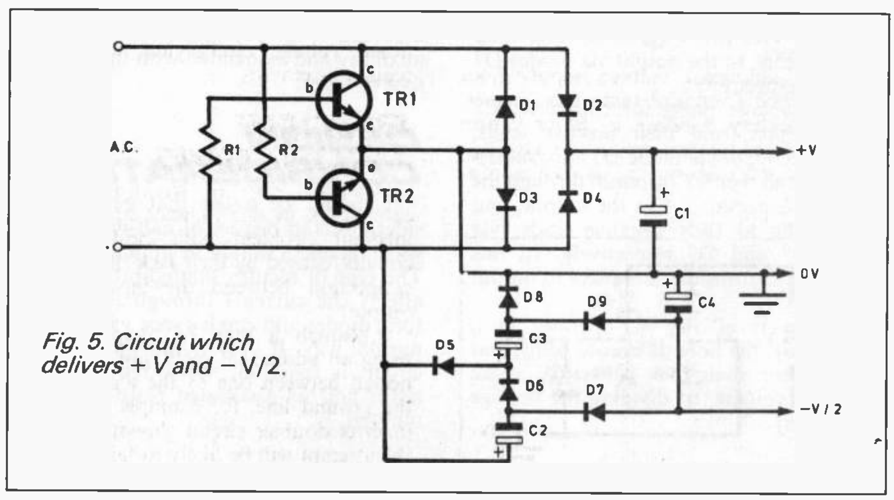


Fig. 5. Circuit which delivers + V and − V/2.

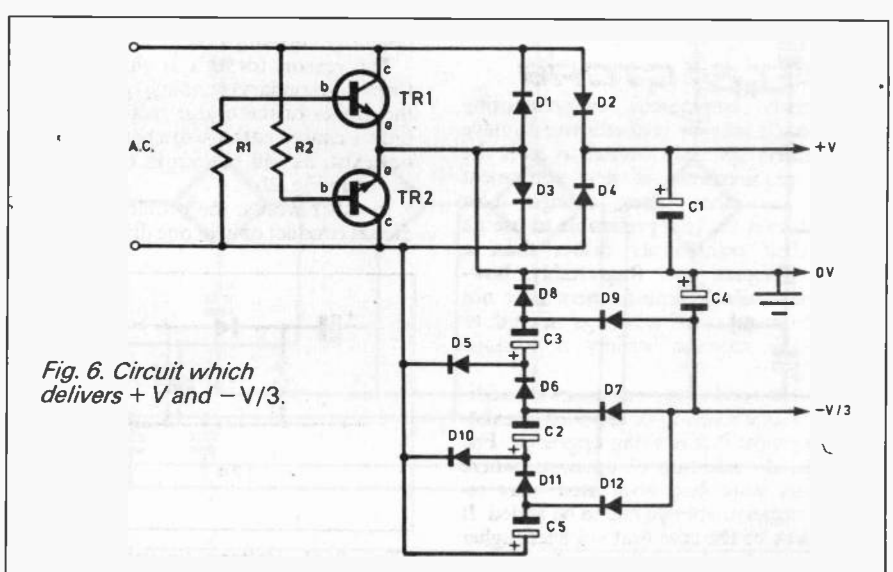


Fig. 6. Circuit which delivers + V and − V/3.

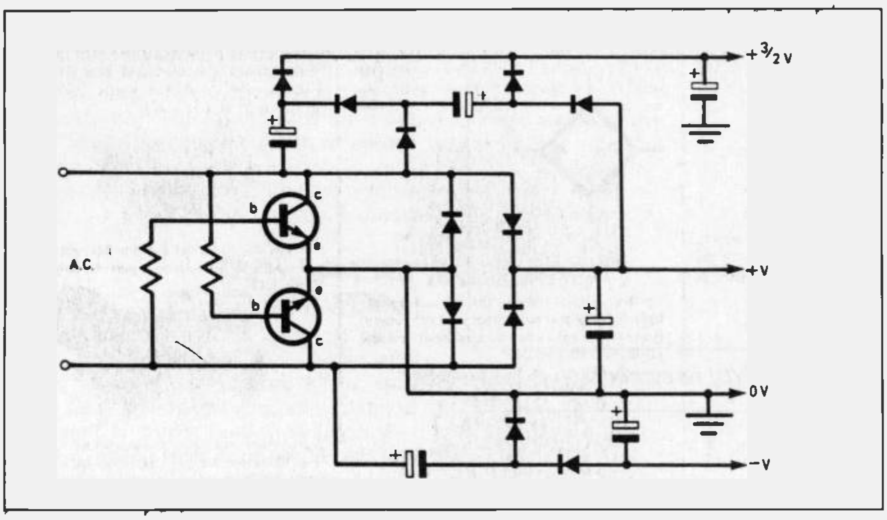


Fig. 7. This circuit delivers + V, + 3/2 V and − V.

a pair of discharge diodes. The first capacitor, from the input, has only one discharge diode to the output.

Referring to Fig. 5, these capacitors (C2 and C3) are charged during the positive half-wave along the path: lower a.c. connection, capacitor C2, diode D6, capacitor C3, diode D8, 0V (ground), diode D1, upper a.c. connection. Given that capacitors C2 and C3 are of equal capacitance, they charge to approximately half of the input voltage level.

During the "zero" half-wave, capacitors C2 and C3 are connected in parallel to the output: their positively charged leads (C3 via diode D5, and C2 directly) through transistor TR2 to 0V (ground), and their negative leads to the output via diodes D7 and D9, respectively.

The discharge paths for capacitors C2 and C3 start from their positive leads, either directly, or via diode D5 and transistor TR2, and then 0V (ground) through the load and capacitor C4 to the output, and then finally to their negative leads, via diodes D7 and D9 respectively. In this stage, charge transfer takes place to output capacitor C4.

The circuit of Fig. 6. operates in a similar way, the only difference being that three, rather than two, capacitors share the input voltage, so dividing the voltage accordingly.

The "scaled" voltages can be made positive and added to the main positive voltage in order to produce "non-integer" multiplying. For example, the circuit in Fig.7 illustrates a "+3/2V" multiplier in addition to "+V" and "−V" supply lines.

Indeed, there is practically no limit to the number of rectifying circuits that can be driven in association with the modified bridge circuit of Fig. 3a. A further example is shown in Fig. 8. This circuit illustrates how full-wave "+2V, +V, −V and −V/2" voltage supply lines can be derived from a single winding of a transformer.

It should be noted that in Fig. 8 only one of the bridge rectifiers is the modified (Fig. 3a) type. The others are auxiliary and associated with their respective voltages.

DESIGN CONSIDERATIONS

It should be noted that general considerations in respect of half-wave or full wave rectifiers should be applied as usual. The type of rectifier configuration chosen affects the currents through the transistors, diodes and capacitance values in the normal way. If only a half-wave rectifier circuit is required, the unrequired transistor and its associated resistor may be omitted.

CAUTION

Readers will undoubtedly wish to bread-board and experiment with these enhanced rectifiers. It must be stressed, though, that mains voltages will be present at the transformer and that the utmost care must be exercised at all times. Experimentation with the circuits is not recommended for electronics beginners.

When choosing which component types and values to use, the following parameters should be considered:

Transistor Maximum Collector Current: average current to match the output current; peak current at least three times higher to take into account the capacitive load.

Transistor Maximum Collector Voltage: to match the peak value of the input voltage (1.41 times nominal input voltage), plus some safety margin, i.e. at least twice the input voltage.

Transistor Base Resistance: less than Vin × h_{fe}/I_{out}, where V_{in} is the input voltage, h_{fe} is the transistor's minimal current gain (common emitter), and I_{out} is the output current. A resistance value lower than this is required to provide saturation when in the *on* state. A resistance value of about one fifth of that calculated would be a good choice. Too low a value, though, may jeopardise the self protection against short circuits, resulting from the current limitation of the transistor's base (and therefore collector current).

Output Filter Capacitors: these are required to reduce ripple voltages, consequently the optimum capacitance value is both load current and ripple voltage dependent. A rough rule is 2μF/mA.

Charge Pump Capacitors: these transfer the charge to the output. Insufficient capacitance leads to a voltage drop when the load increases. A general rule is again 2μF/mA. When dividing circuits are used, the capacitance can be reduced proportionally to the division ratio.

POTENTIAL BENEFITS

The example circuits shown in this article actually deal with two independent matters, the modified bridge rectifier circuit, and various diode/capacitor rectifier circuits. There are instances, of course, where the latter may be used independently in other circuits without the modified bridge circuit.

Any one or more of the circuits could be of benefit where several voltage levels need to be supplied from a single transformer winding, provided that the output current requirements are not too great to be readily supplied via capacitive coupling.

It is acknowledged, though, that in some instances conventional voltage derivation techniques may provide better power line stabilisation. However, when next considering how best to derive several different supply line voltages from a single transformer winding, give thought to the versatility offered by the examples shown here. □

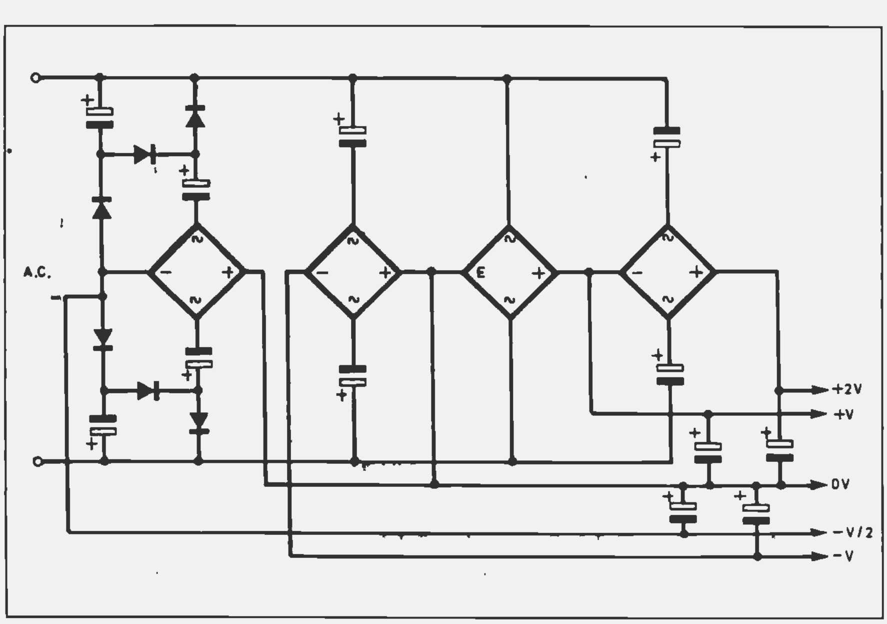
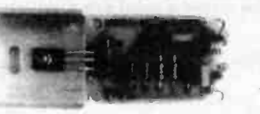


Fig. 8. Four voltage levels are output from this circuit: + V, + 2V, − V, and − V/2.

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.

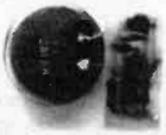


Electronic siren kit with an impressive 5 watt power output. Ideal for car/bike alarms etc. 6-12vdc, max current 1A, tone frequency 1.2khz. £7.05 Kit no 1003.

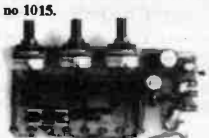
3-30v Power supply, variable, stabilized power supply for laboratory use. Shortcircuit protected, suitable for professional or amateur applications. 24v 3A transformer is also needed to complete the kit. £16.45 Kit no 1007.

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.



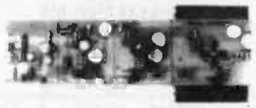
Mosquito repeller, modern way to keep midges at bay! Runs for about a month on a 1.5v battery. £8.22 Kit no 1015.



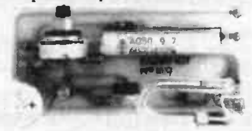
3 channel wireless sound to light system, mains operated, separate sensitivity adjustment for each channel, 1,200 watt power handling. Microphone included. £16.45 Kit no 1014.

Motorbike/cycle trembler alarm, adjustable sensitivity, preset alarm time, auto reset. Could be connected to bikes horn etc. £14.10 Kit no 1011

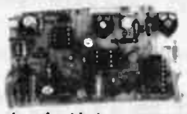
0-5 minute timer, adjustable from 0 to 5 mins, will switch up to 2A mains. Perfect for alarms, photographic laboratories etc. 12vdc. £8.22 Kit no 1020.



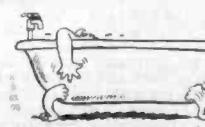
4 watt FM transmitter, small but powerful transmitter, 3 RF stages, microphone and an audio preamp include in kit. £23.50 Kit no 1028.



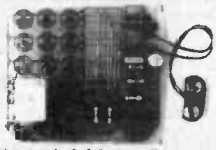
25 watt FM transmitter 4 RF stages, preamp required (our kit 1068 is suitable). Due to the complexity of the transmitter it is supplied in built up form only. £92.82 Kit no 1031.



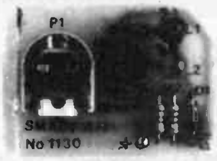
Strobe light, adjustable frequency from 1- to 60 Hz (a lot faster than conventional strobes) mains operated. £18.80 Kit no 1037.



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.

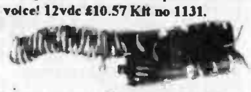


Liquid level detector useful for detecting fluid levels in tanks, fishponds, baths or as a rain or leak alarm. Will switch 2A mains. £5.87 Kit no 1081.



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.

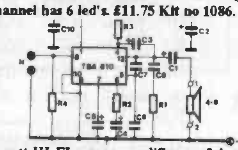
Telephone bug, small bug powered by the telephone line, starts transmitting as soon as the handset is picked up! £9.40 Kit no 1135.

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.

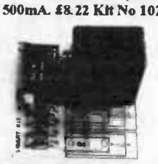
3 Channel light chaser, 800 watts per channel, speed and direction controls supplied with 12 leds and mains triacs, so you can use mains light bulbs if you want. 9-15vdc £19.97 Kit no 1026.

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.

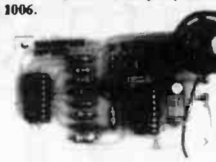
Lead acid charger, two automatic charging rates, visual indication of battery state, ideal for alarm systems, emergency lighting etc. 100mA 12vdc. £14.10 Kit no 1095.

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.

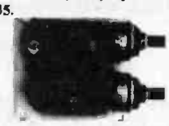
Portable alarm system, based on a mercury switch. The alarm continues to sound until the unit is disabled by the owner. Buzzer included. £12.92 Kit no 1150.

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.

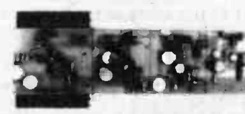
Mini metal detector, suitable for locating pipes in walls etc, range 15-20 cm, complete with case. 9v operation. £9.40 Kit no 1022.



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.

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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.

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All sizes are in millimetres

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Brand New – P.I.R. Intrusion Detector
Attractive, two tone beige.
Measures 10 x 7 x 2.75 cm. Wall mounted.
44' Detection area. 6-14V DC at 12 to 28mA.
Normaly closed relay contact output.
Sealed optical system – prevents false alarms from insects. Tamper circuit.
Very neat attractive unit.........**Only £7.95**

MICRO SWITCH roller arm operation spdt 40p each

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spdt	60p each	spdt 3 position c/off	70p each
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9 pin	30p	30p	35p
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In white
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50 x 70 x 25mm
60p each 10 for £5.00

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5mm rnd red/yellow/green/amber	10p each 12 for £1.00 any mix
5mm rnd high brightness red/green	20p each 6 for £1.00 any mix
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5mm rnd bi-colour	35p each, tri-colour 45p each
LED mounted in chrome bezel red, yellow or green	30p each, 4 for £1
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High quality probe precision temperature sensor. Mounted in a plastic covered probe with a 1 meter coiled lead. Temp. range −40 to 150°C. Resistance at: 150°C 188.3 ohms; 25°C 10.0 kohm and at −40°C 336.5 kohm. The original price of these probes was over £24.00. **OUR PRICE £3.76** with data

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10 or 20 minute bell cut off +ve or −ve trigger' timed relay contacts. £4.96

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Single zone alarm control unit built into a domestic light switch box. Ideal for home, caravan, boat, garage, shed etc.
Facilities: – Normally closed loop for pir sensors, door/window contacts etc. Normally open loop for pressure mats. 24-hour loop for personal attack button Visual indication that the system is operational. Automatic entry/exit delay. Automatic system reset. Alarm output cmos logic level.

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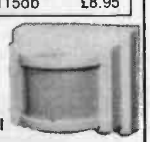
Brand new passive infra-red sensor, measures only 33mmW x 24mmH x 29mmD. Logic level output. Full data and application notes supplied.



EX INSTALLATION PASSIVE INFRA-RED SENSORS TESTED WORKING.!
Type 1. Measures 130 x 70 x 50mm with walk test led, relay output and tamper protection. 12 volt dc supply required £6.50 each
Type 2. As above but a smaller unit 90 x 75 x 50mm £8.50 each
Type 3. Ceiling mounting passive, infra red sensor 360° detection, 12V d.c. supply relay output, tamper circuit and pulse count option. Data supplied. £11.75 each

Please note: There may be variations in the size of the above passive infra red sensors depending on stock at the time of ordering. But the unit will certainly be within the stated sizes.

DOOR/WINDOW CONTACTS
Surface or flush mounting, white £1.10 each
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white 6 way 60p

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Suitable low insertion force socket 28 pin 40p each 3 for £1.00
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BO1 S.P. on 4 for £1.00
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BO3 3 x D.P. 3 pos, centre off
BOO4 **DIL SWITCHES** 4-way S.P. on 3 for £1.00
BOO5 **DIL SWITCHES** 8-way S.P. on 2 for £1.00
BOO6 **DIL SWITCHES** 12-way 90° sp on 2 for £1.00
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BO12 **4 x 28-WAY TURNED PIN DIL SOCKET**
BO13 **15 x 12 VOLT WIRE-ENDED LAMPS**
BO14 **8 x 2 PIN DIN PLUGS** screw terminal connection
BO15 **2 x LIGHT DEPENDENT RESISTOR** Less than 200 ohms in daylight, greater than 10 megohms in darkness
BO16 **1 x KEYPAD** 20-key in 5 x 4 matrix bubble type switch contacts
BO17 **2 x PIEZO BUZZERS** approx 3 to 20 volt d.c.
BO18 **5 x 78M12 VOLTAGE REGULATORS** positive 12V 500mA
BO19 **4 x TL082CP** bi-fet op-amps
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BO22 **4 x CONSTANT CURRENT LED** 5mm round, red 2-18V d.c. or a.c. nominal 14mA
BO23 **50 x IN4148** diode
BO24 **2 x INFRA-RED TRANSISTOR FPT5133**
BO25 **5 x DIACS**
BO26 **3 BDX33C** 10 amp 100V npn transistor
BO27 **12 x 2N3702** Transistor
BO28 **12 x 2N3904** Transistor
BO29 **12 x BC337** Transistor
BO31 **2 x MAN6610** 2 digit 0.6" 7 segment display Com anode, amber
BO32 **3 x PHONO TO PHONO LEAD** 63cm long
BO33 **15 x RECTANGULAR RED LEDs** 6 x 6 x 2mm stackable
BO34 **1 x PHOTO SENSITIVE SCR** mounted on a PCB, data sheet supplied
BO35 **4 x IEC Panel Mounting Mains Plug** Snap fix
BO36 **5 x ASSORTED PIEZO TRANSDUCERS**
BO37 **5 LENGTHS OF HEATSHRINK SLEEVING** 8mm dia. 400mm long
BO38 **25 x CERAMIC DISC CAPACITORS** 0.1 mfd 63V
BO39 **15 x MONOLITHIC CERAMIC CAPACITORS** 0.1 mfd 63V, in a dil package
BO40 **25 x ASSORTED ELECTROLYTIC CAPACITORS** PCB mounting useful values
BO41 **25 ASSORTED PRE-SET RESISTORS**
BO42 **6 x 3·5mm LINE JACK SOCKETS** (mono)
BO43 **6 x 3·5mm JACK PLUG** (mono)
BO44 **8 x 3·5mm CHASSIS SOCKET** (mono)
BO45 **2 x TRIACS** 800 volt 8 amp
BO46 **12 x BC213L** Transistor
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PROJECT CONSTRUCTION

POPULAR ELECTRONIC PROJECTS
R. A. Penfold
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DESIGN YOUR OWN CIRCUITS
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TESTING, THEORY, DATA AND REFERENCE

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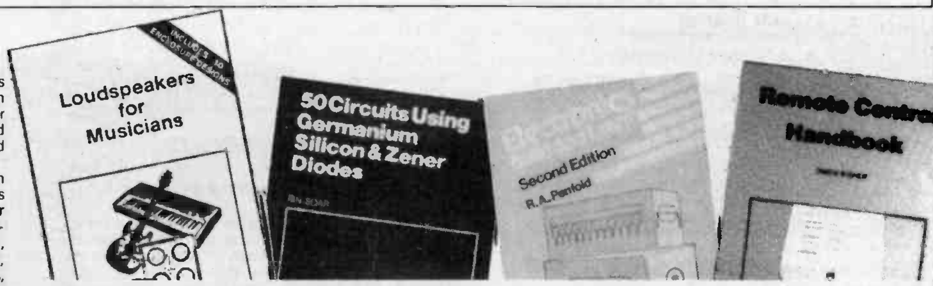

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REPORTING AMATEUR RADIO

Tony Smith G4FAI

SATELLITES LOST

Two amateur radio satellites were lost when their launch vehicle, a Russian START rocket, exploded on March 28. Two Russian satellites (for studying meteorite particles) were also lost.

One of the amateur satellites was the *GURWIN-1 Techsat*, built at the Technion-Israel Institute of Technology in Haifa. The other was the *UNAMSAT*, assembled by students at the Universidad Nacional Autonoma de Mexico (UNAM) in Mexico City. Both were designed for packet radio repeater use and *UNAMSAT* also carried a unique "meteor radar" experiment.

The START rocket is based on the SS-25 inter-continental ballistic missile and the launch was to have demonstrated that refurbished military rockets could be used for civilian purposes.

In November 1993, the first test launch of a converted SS-25 was successful, but with a lighter load. As a result, radio amateurs, particularly in Europe, had hoped that the Russian rockets could provide an inexpensive way to launch amateur radio satellites.

The loss is a very great disappointment, not only to those who worked so hard to design and construct the spacecraft but to all radio amateurs around the world who participate in satellite operation.

The Israelis will, apparently, rebuild and could have another unit ready in a matter of months, but it is not known if the Mexicans are able to do this. There was no insurance. (Information from *W5YI Report*).

FIRST RADIO AMATEUR

The International Amateur Radio Union has designated the third Saturday in September as *World Amateur Radio Day*. This, it says, will be an opportunity to focus public attention on the benefits derived from Amateur Radio; and the theme for 1995 will be "100 Years of Radio".

This year is of course being celebrated as the 100th anniversary of the invention of wireless by Guglielmo Marconi in 1895. Marconi's name has been so well-known since that time that it is hard to realise how ill-equipped he was when he began the experiments which gave him his place in history. In later years he was described as "the first radio amateur".

He was not particularly well educated, although an aptitude for physics was encouraged by a neighbour, Prof. Augusto Righi, who arranged library facilities for him at Bologna University. He obtained no qualifications, and spent much of his time at home undertaking minor scientific experiments.

In 1894, he read a commemorative article by Righi about Heinrich Hertz' work with radio waves. Fired with enthusiasm he repeated Hertz' experiments, quite indifferent to the fact that previously only experienced scientists had sought to repeat, and improve on, the great man's work.

Hertz had found that waves radiated from an electric spark induced another, feebler, spark in a receiving circuit a few metres away. Marconi experimented with a coherer (detector), discovered by Edouard Branly and already used by others, including Oliver Lodge, in similar experiments. By trial and error Marconi produced an improved version, enabling his signals to be detected outside the house.

In 1895, he connected sheet iron to each side of his transmitter spark gap to obtain a longer wavelength. By chance he held one sheet in the air whilst the other lay on the ground. This primitive antenna radiated a much stronger signal. He modified the receiver in the same way and increased the range to about a kilometre.

FIRST INTERNATIONAL CONTACT

The receiver was carried further into the surrounding countryside by Marconi's brother, helped by his father's employees. A handkerchief waved on a stick acknowledged reception of a signal, and a rifle shot told Marconi that his waves had successfully reached over two kilometres, with a hill between transmitter and receiver.

He now tried to interest the Italian authorities in his work, but without success. In February 1896 he went to London where, on June 2, he applied for the first ever wireless patent. He was introduced to William Preece, Engineer-in-Chief of the Post Office who, impressed by Marconi's equipment, arranged demonstrations before Post Office and military observers.

At a public demonstration, Preece lectured whilst Marconi, moving among the audience, carried a receiver which rang a bell every time Preece pressed a switch on the platform. Marconi, the amateur experimenter from Italy, was now a 22 year-old celebrity.

Only eighteen months after leaving home, he returned by official invitation and was presented to the King and Queen of Italy. In a demonstration for the Italian navy he established contact with a ship below the horizon.

On 27 March 1899 he achieved the first international radio contact, between England and France, a distance of some 50km. Later that year the range was increased to about 130km.

The earliest transmitters were untuned and during demonstrations for the US navy Marconi was unable to communicate between two warships whilst a shore-based station was operating. In 1901, however, he patented a system enabling a transmitter to radiate on a particular radio frequency and a receiver to be tuned to that frequency.

In that year he carried out his famous transatlantic tests. High-powered spark transmitters were installed at Poldhu in Cornwall. After various mishaps, with the vast antennas specially erected for the purpose blown down by gales, one-way contact was finally established from Cornwall to Newfoundland, where Marconi used a 183 metres long kite antenna coupled to an untuned receiver.

TRANSATLANTIC SUCCESS

Poldhu sent the Morse letter "S" for three hours a day. At 12.30 on December 12, Marconi passed the earphone to his assistant, asking, "Can you hear anything Mr Kemp?" The prearranged signal was there, and was heard three times that day.

A company was formed in 1900 to provide communications with ships at sea carrying Marconi apparatus. Seventy ships were equipped by the end of 1902, and there were twenty-five shore stations, including several in America.

He died on July 20, 1937. The next day radio transmitters round the world shut down for two minutes in tribute to him. For that brief period the ether was as quiet as it had been in 1894.

From modest beginnings had grown a great commercial empire but Marconi was always aware of the value of the amateur approach. In 1919, when there was pressure on the British government to re-introduce amateur radio after WW1, he wrote:

"In my opinion it would be a mistake to introduce legislation to prevent amateurs experimenting with wireless telegraphy. Had it not been for amateurs, wireless telegraphy as a great world-fact might not have existed at all. A great deal of the development and progress of wireless telegraphy is due to the efforts of amateurs."

SUMMER BROADCAST GUIDE

The International Short Wave League's summer issue of their *"Guide to English Language Short Wave Broadcasts to Europe"* is now available.

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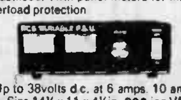

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Published on approximately the first Friday of each month by Wimborne Publishing Ltd., Allen House, East Borough, Wimborne, Dorset BH21 1PF. Printed in England by Benham & Co. Ltd. Colchester, Essex. Distributed by Seymour, Windsor House, 1270 London Road, Norbury, London SW16 4DH. Sole Agents for Australia and New Zealand–Gordon & Gotch (Asia) Ltd., South Africa–Central News Agency Ltd. Subscriptions INLAND £24 and OVERSEAS £30 (£47.50 airmail) payable to "Everyday with Practical Electronics" Subs Dept, Allen House, East Borough, Wimborne, Dorset BH21 1PF.

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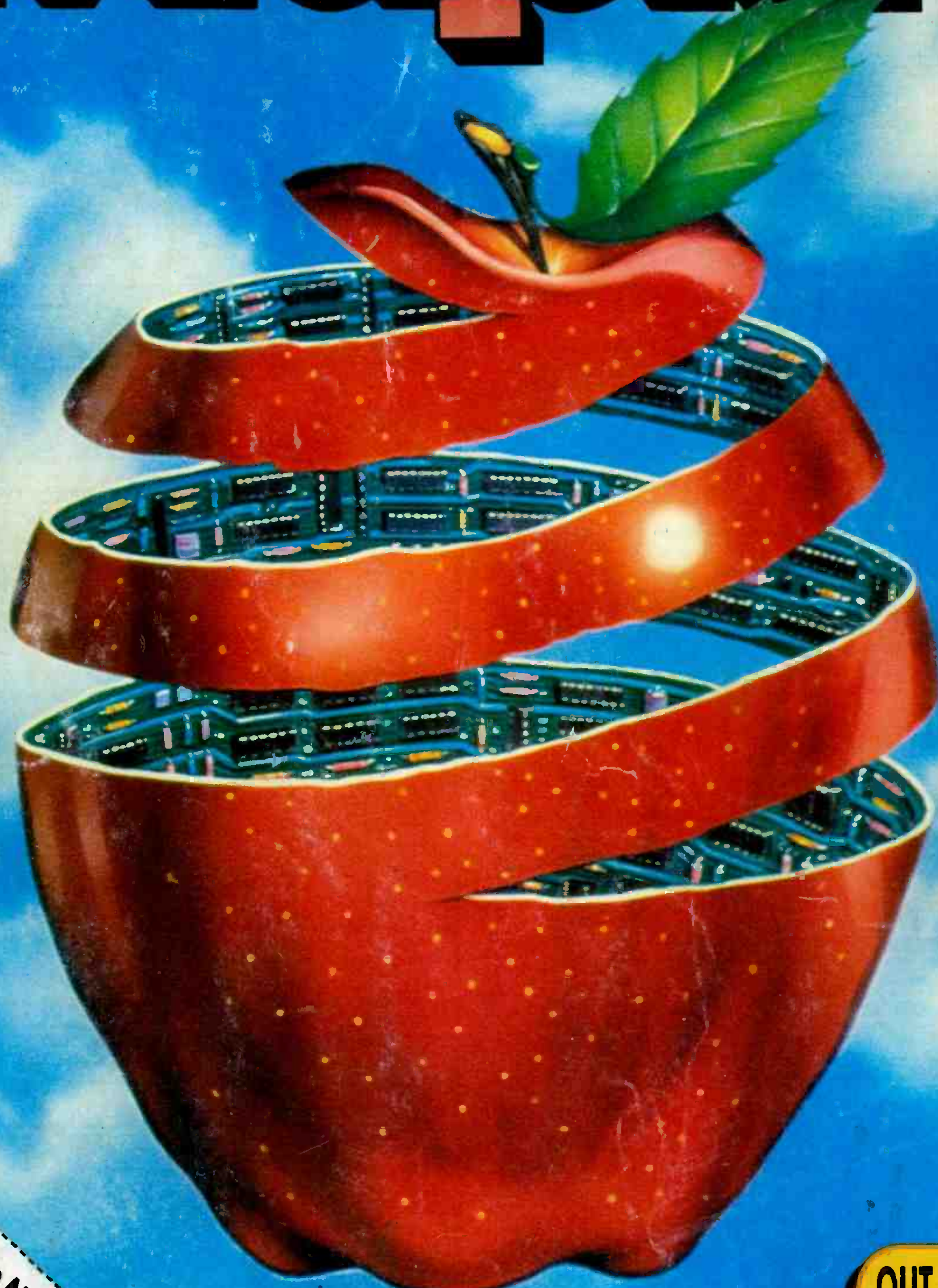

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