EVERYDAY WITH PRACTICAL ELECTRONICS

FEBRUARY 1993

INCORPORATING ELECTRONICS MONTHLY

FULLY S.O.R. £1.80

BIOMET

PROBE THE RHYTHM OF LIFE WITH THIS PULSE RATE MONITOR

SIMPLE RADIO CONTROL SYSTEM

RECHARGEABLE HAND LAMP

METRONOME

02
9 770262 361034

MICROWAVE CONTROL PANEL. Mains operated, with touch switches. Complete with 4 digit display, digital clock, and 2 relay outputs one for power and one for pulsed power (programmable). Ideal for all sorts of precision timer applications etc. Now only £4.00 ref 4P151. Good experimenters board.

FIBRE OPTIC CABLE. Stranded optical fibres sheathed in black PVC. Five metre length £7.00 ref 7P29R or £2 a metre.

12V SOLAR CELL. 200mA output ideal for trickle charging etc. 300 mm square. Our price £15.00 ref 15P42R. Gives up to 15v.

PASSIVE INFRA-RED MOTION SENSOR. Complete with daylight sensor, adjustable lights on timer (8 secs -15 mins), 50' range with a 90 deg coverage. Manual overide facility. Complete with wallbrackets, bulb holders etc. Brand new and guaranteed. **Now only £19.00 ref 19P29**

Pack of two PAR38 bulbs for above unit £12.00 ref 12P43R

VIDEO SENDER UNIT Transmit both audio and video signals from either a video camera, video recorder or computer to any standard TV set within a 100' range! (tune TV to a spare channel) 12v DC op £15.00 ref 15P39R Suitable mains adaptor £5.00 ref 5P191R. Turn your camcorder into a cordless camera!

FM TRANSMITTER housed in a standard working 13A adapter (bug is mains driven). £26.00 ref 26P2R. Good range device.

MINATURE RADIO TRANSCEIVERS A pair of walkie talkies with a range of up to 2 kilometres. Units measure 22x52x155mm. Complete with cases and earpieces. £30.00 ref 30P12R

FM CORDLESS MICROPHONE. Small hand held unit with a 500' range! 2 transmit power levels. Reqs PP3 battery. Tuneable to any FM receiver. Our price £15 ref 15P42AR.

12 BAND COMMUNICATIONS RECEIVER. 9 short bands, FM, AM and LW DX/local switch, tuning 'eye' mains or battery. Complete with shoulder strap and mains lead. £19 ref 19P14R. Ideal for listening all over the world.

CAR STEREO AND FM RADIO Low cost stereo system giving 5 watts per channel. Signal to noise ratio better than 45db, wow and flutter less than .35%. Neg earth. £19.00 ref 19P30

LOW COST WALKIE TALKIES. Pair of battery operated units with a range of about 200'. Our price £8.00 a pair ref 8P50R. Ideal for garden use or as an educational toy.

7 CHANNEL GRAPHIC EQUALIZER plus a 60 watt power amp! 20-21KHZ 4-8R 12-14v DC negative earth. Cased. £25 ref 25P14R.

NICAD BATTERIES. Brand new top quality. 4 x AA's £4.00 ref 4P44R. 2 x C's £4.00 ref 4P73R, 4 x D's £9.00 ref 9P12R, 1 x PP3 £6.00 ref 6P35R Pack of 10 AAA,s £4.00 ref 4P92R.

TOWERS INTERNATIONAL TRANSISTOR SELECTOR GUIDE. The ultimate equivalents book. New ed. £20.00 ref 20P32R.

GEIGER COUNTER KIT. Complete with tube, PCB and all components to build a battery operated geiger counter. £39.00 ref 39P1R

FM BUG KIT. New design with PCB embedded coil. Transmits to any FM radio. 9v battery req'd. £5.00 ref 5P158R. 35mm square.

FM BUG Built and tested superior 9v operation £14.00 ref 14P3R

COMPOSITE VIDEO KITS. These convert composite video into separate H sync, V sync and video. 12v DC. £8.00 ref 8P39R.

SINCLAIR C5 MOTORS 12v 29A (full load) 3300 rpm 6"x4" 1/4" O/P shaft. New. £20.00 ref 20P22R. Limited stocks.

As above but with fitted 4 to 1 Inline reduction box (800rpm) and toothed nylon belt drive cog £40.00 ref 40P8R. 800 rpm.

ELECTRONIC SPEED CONTROL KIT for c5 motor. PCB and all components to build a speed controller (0-95% of speed). Uses pulse width modulation. £17.00 ref 17P3R. Potentiometer control.

SOLAR POWERED NICAD CHARGER. Charges 4 AA nicads in 8 hours. Brand new and cased £6.00 ref 6P3R. 2xC cell model £6.00.

ACORN DATA RECORDER ALF503 Made for BBC computer but suitable for others. Includes mains adapter, leads and book. £15.00 ref 15P43R

VIDEO TAPES. Three hour superior quality tapes made under licence from the famous JVC company. Pack of 10 tapes **New low price £15.00 ref J15P4**

PHILIPS LASER. 2MW HELIUM NEON LASER TUBE. BRAND NEW FULL SPEC £40.00 REF 40P10R. MAINS POWER SUPPLY KIT £20.00 REF 20P33R READY BUILT AND TESTED LASER IN ONE CASE £75.00 REF 75P4R.

12 TO 220V INVERTER KIT As supplied it will handle up to about 15 wat 220v but with a larger transformer it will handle 80 watts. Basic kit £12.00 ref 12P17R. Larger transformer £12.00 ref 12P41R.

VERO EASI WIRE PROTOTYPING SYSTEM Ideal for designing projects on etc. Complete with tools, wire and reusable board. **New low bargain price only £2.00 ref B2P1**

25 WATT STEREO AMPLIFIERIC. STK043. With the addition of a handful of components you can build a 25 watt amplifier. £4.00 ref 4P69R (Circuit dia included).

BARGAIN NICADS AAA SIZE 200MAH 1.2V PACK OF 10 £4.00 REF 4P92R, PACK OF 100 £30.00 REF 30P16R

FRESNEL MAGNIFYING LENS 83 x 52mm £1.00 ref BD827R.

12V 19A TRANSFORMER Ex equipment £20 but OK.

ULTRASONIC ALARM SYSTEM. Once again in stock these units consist of a detector that plugs into a 13A socket in the area to protect. The receiver plugs into a 13A socket anywhere else on the same supply. Ideal for protecting garages, sheds etc. Complete system now only £19 !!!

POWER SUPPLIES Made for the Spectrum plus 3 give +5 @ 2A, +12 @700mA & -12 @ 50mA. £8 ref O8P3

UNIVERSAL BATTERY CHARGER. Takes AA's, C's, D's and PP3 nicads. Holds up to 5 batteries at once. New and cased, mains operated. £6.00 ref 6P36R.

IN CAR POWER SUPPLY. Plugs into cigar socket and gives 3,4,5,6,7.5,9, and 12v outputs at 800mA. Complete with universal spider plug. £5.00 ref 5P167R.

RESISTOR PACK. 10 x 50 values (500 resistors) all 1/4 watt 2% metal film. £5.00 ref 5P170R.

QUICK CUPPA? 12v immersion heater with lead and cigar lighter plug £3.00 ref 3P92R. Ideal for tea on the move!

LED PACK. 50 red, 50 green, 50 yellow all 5mm £8.00 ref 8P52

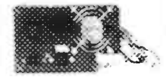
IBM PRINTER LEAD. (D25 to centronics plug) 2 metre parallel. £5.00 ref 5P186R. 3 metre version £6.00 ref 6P50.

COPPER CLAD STRIP BOARD 17" x 4" of .1" pitch "vero" board. £4.00 a sheet ref 4P62R or 2 sheets for £7.00 ref 7P22R.

STRIP BOARD CUTTING TOOL £2.00 ref 2P352R.

WINDUP SOLAR POWERED RADIO! FM/AM radio takes rechargeable batteries. Complete with hand charger & solar panel 14P200R. Set of 2 AA nicads £2 ref L2P9

PC STYLE POWER SUPPLY Made by AZTEC 110v or 240v input. +5 @ 15A, +12 @ 5A, -12 @ .5A, -5 @ .3A. Fully cased with fan, on/off switch, IEC inlet and standard PC flyleads. £15.00 ref F15P4



AMSTRAD MP3

UHF/VHF TV RECEIVER/CONVERTER

CONVERTS COLOUR MONITOR INTO A TV!

£9.00

TELEPHONE HANDSETS
10 brand new handsets with mic and speaker only £3.00 ref 3P146R

BENCH POWER SUPPLIES
Superbly made fully cased (metal) giving 12v at 2A plus a 6V supply. Fused and short circuit protected. For sale at less than the cost of the case! Our price is £4.00 ref 4P103R

SPEAKER WIRE
Brown twin core insulated cable 100 feet for £2.00 REF 2P79R

DISC DRIVES
Customer returned units mixed capacities (up to 1.44M) We have not sorted these so you just get the next one on the shelf. Price is only £7.00 ref 7P1R (worth it even as a stripper)

MICROSCOPE 1200X MAGNIFICATION
Brand new complete with shrimp hatchery, shrimps, prepared slides, light etc. £29.00 ref J29P4.

LIGHT ALARM SYSTEM
Small cased alarms that monitor a narrow beam area for sudden changes in light level. Complete with siren that sounds for a preset time when unit is triggered. £7.00 ref J7P1

JOYBALLS
Back in stock popular Commodore/Atari equiv (replace standard joystick) £5.00 ref J5P8

AMSTRAD 1640DD BASE UNITS

BRAND NEW AND CASED

TWO BUILT IN 5 1/4" DRIVES

MOTHER BOARD WITH 640K MEMORY

KEYBOARD, MOUSE & MANUAL

OUR PRICE JUST

£79!!!!

CAR BATTERY CHARGER
Brand new units complete with panel meter and leads. 6 or 12v output £7.00 ref J7P2.

CUSTOMER RETURNED SPECTRUM +2
Complete but sold as seen so may need attention £25.00 ref J25P1 or 2 for £40.00 ref J40P4

CUSTOMER RETURNED SPECTRUM +3
Complete but sold as seen so may need attention £25.00 ref J25P2 or 2 for £40.00 ref J40P5

SCART TO D TYPE LEADS
Standard Scart on one end, Hi density D type (standard VGA connector) on the other. Pack of ten leads only £7.00 ref 7P2R

OZONE FRIENDLY LATEX
250ml bottle of liquid rubber sets in 2 hours. Ideal for mounting PCB's fixing wires etc. £2.00 each ref 2P379R

VIEWDATA SYSTEMS
Brand new units made by TANDATA complete with 1200/75 built in modem Infra red remote controlled qwerty keyboard BT appproved Prestel compatible, Centronics printer port RGB colour and composite output (works with ordinary television) complete with power supply and fully cased. Our price is only £20.00 ref 20P1R

COMMODORE 64 COMPENDIUM Pack consisting of a Commodore 64 computer, power supply, data recorder and software. All for £69 ref Q69P1

PPC MODEM CARDS Made for the Amstrad PPC1640/1512 range these are plug in modules that operate at 2400 baud. No data £15 ref Q15P5.

AMSTRAD LQ3500 PRINTER ASSEMBLIES Entire mechanical assemblies including print head, platen, cables, stepper motors etc etc. infact everything bar the electronics and case! Our price just £10 ref Q10P3.

AMSTRAD DMP4000 PRINTER ASSEMBLIES Entire printer assemblies including print head, platen, cables, stepper motors etc. Everything bar the electronics and case. Our price just £20 ref Q20P2.

TOROIDAL TRANSFORMER 146VA with tappings at 8v, 10v and 32v will give 50v at 3A or 32 at 4A etc. Centre tapped primary. £9 ref Q9P2 Fixing kit is £2 ref Q2P1

AERIAL BRACKETS Wall plate 7.5" sq complete with rawl bolts, 10" stand off brackets with standard tube clamps. Will take up to 2" mask. Substantial bracket (would take body weight). £7 ref Q7P1.

TV SOUND RECEIVERS Popular units that with the addition of a speaker act as a tv sound receiver. Ideal as a stand alone unit or for connecting into HI FI!. £12 ref Q12P4

BULL ELECTRICAL

250 PORTLAND ROAD HOVE SUSSEX BN3 5QT TELEPHONE 0273 203500

MAIL ORDER TERMS: CASH PO OR CHEQUE WITH ORDER PLUS £3.00 POST PLUS VAT.

PLEASE ALLOW 7 - 10 DAYS FOR DELIVERY

FAX 0273 323077

SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK

CAMERAS Customer returned units. 3 for £10 ref L10P2.

STEAM ENGINE Standard Mamod 1332 engine complete with boiler piston etc £30 ref 30P200

TALKING CLOCK
LCD display, alarm, battery operated. Clock will announce the time at the push of a button and when the alarm is due. The alarm is switchable from voice to a cock crowing! £14.00 ref 14P200.R

HANDHELD TONE DIALLERS
Small units that are designed to hold over the mouth piece of a telephone to send MF dialling tones. Ideal for the remote control of answer machines. £5.00 ref 5P209R

AMAZING TALKING COINBOX!
Fully programmable talking, lockable coinbox BT approved, retail price is £79 ours is just £29! ref J29P2.

ANSWER PHONES £15
Customer returned units with 2 faults one we tell you how to fix the other you do your self! £18 ref J18P2 or 4 for £60 ref J60P3 BT approved (retail price £79.95!! each)

COMMODORE 64 MICRODRIVE SYSTEM
Complete cased brand new drives with cartridge and software 10 times faster than tape machines works with any Commodore 64 setup. The orginal price for these was £49.00 but we can offer them to you at only £25.00! Ref 25P1R

90 WATT MAINS MOTORS Ex equipment but ok. Good general pupose unit £9.00 ref F9P1

HI FI SPEAKER BARGAIN Originally made for TV sets they consist of a 4" 10 watt4R speaker and a 2" 140R tweeter. If you want two of each plus 2 of our crossovers you can have the lot for £5.00 ref F5P2

EMERGENCY LIGHTING SYSTEM
Fully cased complete with 2 adjustable flood lights. All you need is a standard 6v lead acid battery. Our price is just £10 ref J10P29

AMSTRAD 464 COMPUTERS
Customer returned units complete with a monitor for just £35! These units are sold as faulty and are not returnable.

WOLSEY DMAC DECODERS
Made for installation in hotels etc as the main sat receiver no data but fully cased quality unit. £20 ref K20P1. Suitable psu £8 ref K8P3.

SWITCHED MODE PSU
Fully cased unit 215mmx145mmx55mm giving +5, +12 and +20v well made case complete with mains lead. £8 ref K8P3.

REMOTE CONTROLS
Brand new infra red CONTROLS originally made for controlling WOLSEY satellite receivers. £2 ea ref K2P1 or 20 for £19 ref K19P1.

TELEPHONES
Modern 1 piece phones BT approved. Last no redial. £8 ref K8P1.

386 TOWER SYSTEMS
Tower case 52cmx40cmx20cm 2 fans, speaker, 275w psu, IEC I/L and O/L, 386 m/board with onboard disc controller, ethernet, display driver, parallel and serial ports. **There are several IC's missing from the m/board plus no data! £79 ref K79P1.**

DOS PACKS
Complete set of PC discs with MS DOS 3.2, Locomotive basic, gemdesktop and gem paint. No manuals, 5 1/4" discs. £10 ref K10P2

CORDLESS TIE CLIP MICROPHONE
transmits between 88-108MHZ FM. 5.2cm x 2cm, uses LR44 watch battery. Complete with wire aerial & battery. £16 ref K16P1.

CHASSIS MOUNT TRANSFORMERS
240v primary, 12v secondary 20VA £2 ref K2P2
240v primary, 16v secondary 10A (split winding). £10 ref L10P1

100 RED LED PACK (5MM) £5 REF K5P2

12V STEPPER MOTOR Ideal for models etc. 3" dia. £2 ref J2P14.

INFRA RED BEAM SWITCH 24v DC 5m range source & sensor housed in plastic case. £12 ref J12P1

CAPACITOR BARGAIN PACK 100 CERAMICS £2 REF J2P2.

SPECTRUM JOYSTICKS TWO FOR £5 REF J5P2.

AMSTRAD PC CASE, POWER SUPPLY AND 1.44MEG FLOPPY DRIVE ALL THIS FOR £44 REF L44P1

BUMPER PACK NO 1 10 of our popular £1 packs for just £5 our choice of contents.

BUMPER PACK NO 2 25 of our popular £1 packs for just £12. Our choice of contents.

LCD 1 X 32 DISPLAY Bargain price of just £3 complete with loads of data for a similar display. £3 ref L3P1.

USEFUL POWER SUPPLIES. 18v 900mA dc output (regulated) fully cased with mains cable and DC out cable. £6 ref K6P1

UNCASED PC POWER SUPPLIES. Standard PC psu without case, fan etc. Good for spare or low cost PC! £4 ref L4P6

RADAR DETECTORS. Detects X and K bands (ie speed traps). Not legal in the UK so only available if you intend to 'export' it. £59 ref J59P1.

100 WATT MOSFET PAIR. Same spec as 2Sk343 and 2SJ413 (8A,140v, 100w) 1 N channel and 1 P channel. £3 a pair ref J3P9.

LOW COST CAPS. 1,000 capacitors £3 (33uf,25v) ref J3P10.

VELCRO. 1 metre length 20mm wide, blue. £2 ref J2P16.

JUG KETTLE ELEMENTS. Good general purpose heating element just £3 ea ref £3P8 or 5 for £10 ref J10P3.

VERY BIG MOTOR. 200v induction 1.1kw 1410 rpm 10"x7" GEC 1" keyed shaft. Brand new. £95 ref J95P1

BIG MOTOR. 220-240v 1425rpm 2.8A 5/8th" keyed shaft GEC 6.5" x 8" complete with mounting plate. £38 ref J38P1.

SMALL MOTOR. Electrolux 160 watt 3,000 rpm, 220-240v 5/8" shaft precision built £18 ref J18P1.

EPROMS 27C64 PACK OF 10 £7 REF M7P1.

EPROMS 27C256 PACK OF 10 £9 REF M9P1.

EPROMS 27C512 PACK OF 10 £10 REF M10P1.

MODEMS FOR £1.25? These modems are suitable for stripping only hence they are only 4 for £5 ref J5P3.

SOLAR POWERED WOODEN MODELS. Complete with solar panel, motor and full instructions. £9 ref J9P2. 3 diff £20 ref J20P3.

TV SOUND RECEIVER Fully cased, mains powered, that need a speaker for stand alone use or could be wired into hifi. £12 ref 12P22.

SOUND OPERATED LIGHT. Clap your hands and light comes on. Turns after preset delay. (4 AA's req'd). £2 ref J2P3

FERGUSON SRB1 REMOTE CONTROLS. Brand new units ideal for a spare or have two remotes! £4 each.

IN SUSSEX? CALL IN AND SEE US!

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EVERYDAY WITH PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

The No. 1 Independent Magazine for Electronics, Technology and Computer Projects

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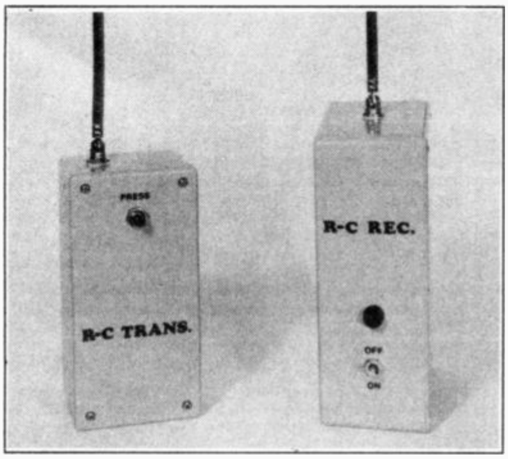
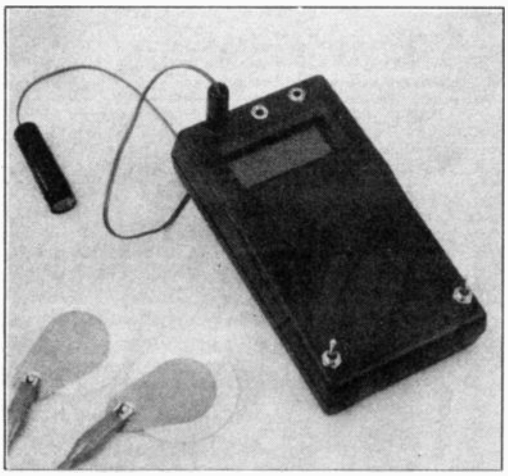
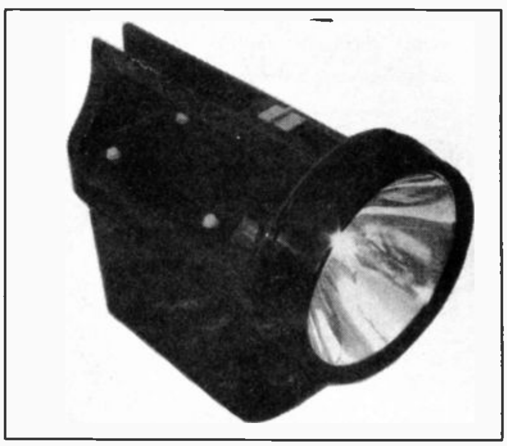
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .







Our March '93 issue will be published on Friday, 5 February 1993. See page 83 for details.

Projects

Series

Features

Surplus always wanted for cash!

THE *ORIGINAL* SURPLUS WONDERLAND!

Surplus always wanted for cash!

COMPUTER *SCOOPS*

PC-AT 386 20-DX FULLY LOADED FOR £449!

- 20 Mhz DX processor
- 2 megs RAM. Exp 10 meg
- 40 meg hard drive
- 1.2 meg 5-1/4" floppy
- 32K cache exp. 64K
- Installed VGA card
- Enhanced 102 key k/board
- Complete with MS-DOS 4.01
- 2 serial 1 parallel ports
- 8 free slots- 6 off 16 bit!

The MP386 quality made by Mitsubishi to last a lifetime! Brand new with all manuals and software plus Super PC-Quick Disk Accelerator for lightning disk access. Only.............. **£449** (F)

A COMPLETE IBM PC COMPAT SYSTEM FOR ONLY £99!!

Just plug in and go - fully expandable - the **Display PC-99!** System supplied complete with 12" mono monitor, 84 key keyboard, 360k 5-1/4" floppy disk drive, 256K RAM, 2 serial and 1 parallel port plus DOS with manual. Many other features include 7 slot backplane, all metal case, 150 watt PSU and US made mother-board. In very good used condition with 90 day guarantee. At the unique price of:

Optional FITTED extras: 640K RAM £39. 12" CGA colour monitor with card £89. 2nd 5-1/4" 360K floppy £29.95. 20 mbyte MFM hard drive £99. 31mbyte RLL hard drive £125.

£99 (E)

FLOPPY DISK DRIVES

5¼" from £22.95 - 3½" from £21.95!

Massive purchases of standard 5¼" and 3½" drives enables us to present prime product at industry beating low prices! All units (unless stated) are removed from often brand new equipment and are fully tested, aligned and shipped to you with a 90 day guarantee and operate from standard voltages and are of standard size. **All are IBM-PC compatible** (if 3½" supported).

3.5" **Panasonic** JU363/4 720K*	£21.95(B)
3.5" **Mitsubishi** MF355C-L. 1.4 Meg. Laptops only*	£29.95(B)
3.5" **Mitsubishi** MF355C-D. 1.4 Meg. Non laptop*	£29.95(B)
5.25" EXTRA SPECIAL BRAND NEW Mitsubishi MF501B 360K. Absolutely standard fits most computers	£22.95(B)

* **Data cable included in price.**

Shugart 800/801 SS refurbished & tested	£175.00(E)
Shugart 851 double sided refurbished & tested	£275.00(E)
Mitsubishi M2894-63 double sided switchable hard or soft sectors- BRAND NEW	£250.00(E)

Dual 8" drives with 2 mbyte capacity housed in a smart case with built in power supply! Ideal as exterior drives! **£499.00(F)**

End of line purchase scoop! Brand new **NEC D2246** 8" 85 megabyte of hard disk storage! Full CPU control and industry standard SMD Interface. Ultra hi speed transfer and access time leaves the good old ST506 interface standing. In mint condition and comes complete with manual. Only.........................**£299(E)**

THE *AMAZING* TELEBOX!

Converts your colour monitor into a QUALITY COLOUR TV!!

TV SOUND & VIDEO TUNER!

The TELEBOX consists of an attractive fully cased mains powered unit, containing all electronics ready to plug into a host of video monitors made by manufacturers such as MICROVITEC, ATARI, SANYO, SONY, COMMODORE, PHILIPS, TATUNG, AMSTRAD and many more. The composite video output will also plug directly into most video recorders, allowing reception of TV channels not normally receivable on most television receivers (TELEBOX MB). Push button controls on the front panel allow reception of 8 fully tuneable 'off air' UHF colour television or video channels. TELEBOX MB covers virtually all television frequencies VHF and UHF including the HYPERBAND as used by most cable TV operators. Composite and RGB video outputs are located on the rear panel for direct connection to most makes of monitor. For complete compatibility - even for monitors without sound - an integral 4 watt audio amplifier and low level Hi Fi audio output are provided as standard.

Telebox ST	for composite video input monitors	£32.95
Telebox STL	as ST but with integral speaker	£36.50
Telebox MB	as ST with Multiband tuner VHF-UHF-Cable. & hyperband For overseas PAL versions state 5.5 or 6mhz sound specification.	£69.95
Telebox RGB	for analogue RGB monitors (15khz)	£69.95

Shipping code on all Teleboxes is (B)

RGB Telebox also suitable for IBM multisync monitors with RGB analog and composite sync. Overseas versions VHF & UHF call. SECAM / NTSC not available.

No Break Uninterruptable PSU's

Brand new and boxed 230 volts uninterruptable power supplies from **Densei**. Model MUK 0565-AUAF is 0.5 kva and MUD 1085-AHBH is 1 kva. Both have sealed lead acid batteries. MUK are internal, MUD has them in a matching case. Times from interrupt are 5 and 15 minutes respectively. Complete with full operation manuals............MUK......£249 (F) MUD......£525 (G)

POWER SUPPLIES

Power One SPL200-5200P 200 watt (250 w peak). Semi open frame giving +5v 35a, -5v 1.5a, +12v 4a (8a peak), -12v 1.5a, +24v 4a (6a peak). All outputs fully regulated with over voltage protection on the +5v output. AC input selectable for 110/240 vac. Dims13" x 5" x 2.5". Fully guaranteed RFE.	£85.00 (B)
Power One SPL130. 130 watts. Selectable for 12v (4A) or 24 v (2A). 5v @ 20A. ± 12v @ 1.5A. Switch mode. New.	£59.95(B)
Astec AC-8151 40 watts. Switch mode. +5v @ 2.5a. +12v @ 2a. -12v @ 0.1a. 6-1/4" x 4" x 1-3/4".New	£22.95(B)
Greendale 19AB0E 60 watts switch mode.+5v @ 6a,±12v @ 1a,+15v @ 1a. RFE and fully tested.11 x 20 x5.5cms.	£24.95(C)
Conver AC130. 130 watt hi-grade VDE spec.Switch mode.+5v @ 15a,-5v @ 1a,±12v @ 6a.27 x 12.5 x 6.5cms.New.	£49.95(C)
Boshert 13090.Switch mode.Ideal for drives & system. +5v@ 6a, +12v @ 2.5a, -12v @ 0.5a, -5v @ 0.5a.	£29.95(B)
Farnell G6/40A. Switch mode. 5v @ 40a.Encased	£95.00(C)
Farnell G24/5S. As above but 24v @ 5a.	£65.00(C)

BBC Model B APM Board

WIN £100 CASH!

£100 CASH FOR THE MOST NOVEL DEMONSTRATABLE APPLICATION!

BBC Model B type computer on a board. A major purchase allows us to offer you the **PROFESSIONAL** version of the BBC computer at a parts only price. Used as a front end graphics system on large networked systems the architecture of the BBC board has so many similarities to the regular BBC model B that we are sure that with a bit of experimentation and ingenuity many useful applications will be found for this board!! It is supplied complete with a connector panel which brings all the I/O to 'D' and BNC type connectors - all you have to do is provide +5 and ± 12 v DC. The APM consists of a single PCB with most major ic's socketed. The ic's are too numerous to list but include a 6502, RAM and an SAA5050 teletext chip. Three 27128 EPROMS contain the custom operating system on which we have no data. On application of DC power the system boots and provides diagnostic information on the video output. On board DIP switches and jumpers select the ECONET address and enable the four extra EPROM sockets for user software. Appx. dims: main board 13" x 10". I/O board 14" x 3". Supplied tested with circuit diagram, data and competition entry form.

Only £29.95 or 2 for £53 (B)

SPECIAL INTEREST

Trio 0-18 vdc bench PSU. 30 amps. New	£ 470
Fujitsu M3041 600 LPM band printer	£2950
DEC LS/02 CPU board	£ 150
Rhode & Schwarz SBUF TV test transmitter 25-1000mhz. Complete with SBTF2 Modulator	£6500
Calcomp 1036 large drum 3 pen plotter	£ 650
Thurlby LA 160B logic analyser	£ 375
1.5kw 115v 60hz power source	£ 950
Anton Pillar 400 Hz 3 phase frequency converter 75Kw	POA
Newton Derby 400 Hz 70 Kw converter	POA
Haefely Impulse Testers P6T and PEMI 12; good cond.	POA
Sekonic SD 150H 18 channel Hybrid recorder	£2000
HP 7580A A1 8 pen high speed drum plotter	£1850
Kenwood DA-3501 CD tester, laser pickup simulator	£ 350

BRAND NEW PRINTERS

Microline 183. NLQ 17x17 dot matrix. Full width.	£139 (D)
Hyundai HDP-920. NLQ 24x18 dot matrix full width.	£149 (D)
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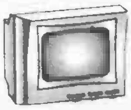

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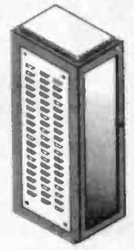

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NEXT MONTH

MICROPHONE COMPRESSOR

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The compressor levels off the signal variations thus avoiding overloading the amplifier input which results in distortion.

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148 PAGE CATALOGUE BANDED TO THE ISSUE

Full of components, test gear, tools, bargains etc

DIGITAL AUDIO BROADCASTING

We look ahead about 10 to 15 years to a digital audio broadcasting system that will match the quality we have come to expect from digital hifi systems. The article investigates the problems and looks at the solutions now being employed in test transmissions.

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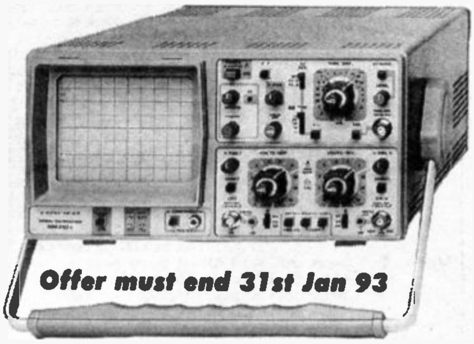

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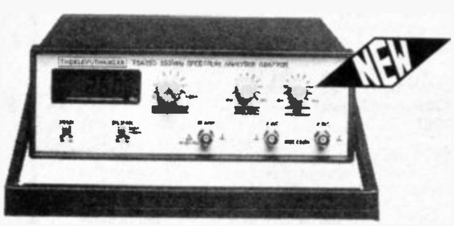

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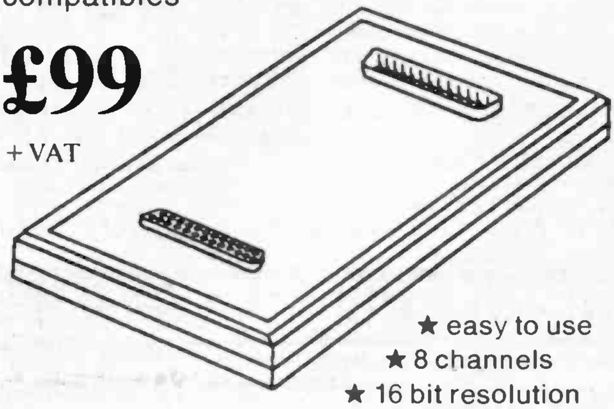

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TELEPHONE SOCKET TRANSMITTER TSTS Replace your telephone socket with this one within which a transmitter has been concealed.	14.74	-----	29.00
ROOM AND TELEPHONE TRANSMITTER RTT Operates as a room transmitter, then switches to telephone transmitter mode during telephone calls. Dimensions: 30 x 25mm	31.50	45.50	65.00
AUTOMATIC TELEPHONE RECORDER SWITCH TRS2 Record telephone conversations with this interface unit and your own tape recorder. Dimensions: 36 x 50mm	16.80	25.90	39.00
AUTOMATIC TELEPHONE RECORDER ATR1 Adapt the tape recorder included to record telephone calls automatically.	34.95	-----	59.00
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SHOTGUN MICROPHONE AMPLIFIER SMA Ideal for surveillance. The amplifier will pick up sounds from a long distance.	24.95	36.00	45.00
SIGNALLING TRANSMITTER SIGT Sends a continual audio pulse. Can be integrated into alarm, tracking or warning systems. Dimensions: 20 x 50mm	21.95	34.89	45.00
REMOTE SWITCHING SYSTEM RSS Transmitter/receiver set. Applications include car security and remote control of household appliances. Dimensions: Single channel transmitter; 45 x 35 x 12mm, Receiver; 50 x 60 x 25mm Double channel transmitter; 56 x 35 x 10mm, Receiver; 50 x 60 x 25mm	Single channel / Double channel		39.00 / 49.00
TELEPHONE AMPLIFIER TA5 Connected directly to the telephone, this unit will amplify both sides of a telephone call. Dimensions: 25 x 52mm	10.95	16.95	19.95
PROFESSIONAL SOUND TO LIGHT UNIT SK72 Custom built for disco or home use. Audio signal divided into bass, mid and treble bands, with internal microphone and spotlight option. Dimensions 210 x 45mm	21.95	32.49	44.95
1.5-12V POWER SUPPLY PSU Versatile low cost unit with variable or fixed voltage control (specify on ordering). Regulation better than 1%. Dimensions: 60 x 43mm	9.95	15.95	------
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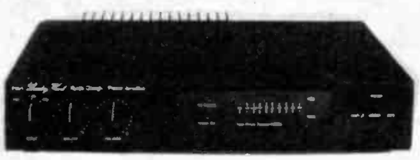
Our list will give you fuller details of all our Audio Kits, components and special offers.

AUDIO DESIGN 80 WATT POWER AMPLIFIER.



This fantastic John Linsley Hood designed amplifier is the flagship of our range, and the ideal powerhouse for your ultimate hifi system. This kit is your way to get £K performance for a few tenths of the cost!. Featured on the front cover of 'Electronics Today International' this complete stereo power amplifier offers World Class performance allied to the famous HART quality and ease of construction. John Linsley Hood's comments on seeing a complete unit were enthusiastic:- "The external view is that of a thoroughly professional piece of audio gear, neat elegant and functional. This impression is greatly reinforced by the internal appearance, which is redolent of quality, both in components and in layout." Options include a stereo LED power meter and a versatile passive front end giving switched inputs using ALPS precision, low-noise volume and balance controls. A new relay switched front end option also gives a tape input and output facility so that for use with tuners, tape and CD players, or indeed any other 'flat' inputs the power amplifier may be used on its own, without the need for any external signal handling stages. 'Slave' and 'monobloc' versions without the passive input stage and power meter are also available. All versions fit within our standard 420 x 260 x 75mm case to match our 400 Series Tuner range. ALL six power supply rails are fully stabilised, and the complete power supply, using a toroidal transformer, is contained within a heavy gauge aluminium chassis/heatsink fitted with IEC mains input and output sockets. All the circuitry is on professional grade printed circuit boards with roller tinned finish and green solder resist on the component ident side, the power amplifiers feature an advanced double sided layout for maximum performance. All wiring in this kit is pre-terminated, ready for instant use!
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Modern, ultimate sound systems are evolving towards built-in preamplifiers within or near the turntable unit. This keeps noise pickup and treble loss to a minimum. We now offer two units, both having the sonically preferred shunt feedback configuration to give an accurate and musical sound, and both having the ability to use both moving magnet and moving coil cartridges.
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Instructions only..........£2.80
Kit K1450 is a fully discrete component implementation of the shunt feedback concept and used with the right cartridge offers the discerning user the ultimate in sound quality from vinyl disks. Can be fitted inside our 1400 Preamp, used externally or as a standalone unit. It has a higher power requirement and needs to be powered from our 1400 Series preamplifier or its own dedicated power supply. K1450 Complete kit of board mounting parts for discrete component RIAA preamplifier..........£61.06
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K1565 Power Supply in matching case. Features shielded toroidal transformer and upgrade path to full preamp power supply..........£79.42

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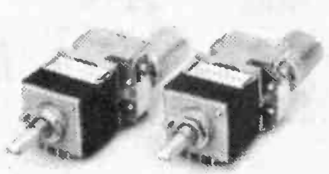

To fulfil the need for higher quality controls we are now importing an exciting new range of precision audio pots in values to cover most quality amplifier applications. All in 2-gang stereo format, with 20mm long 6mm dia. steel shafts. Now you can throw out those noisy ill-matched carbon pots and replace with the real hi-fi components only used selectively in the very top flight of World class amplifiers. The improvement in track accuracy and matching really is incredible giving better tonal balance between channels and rock solid image stability. Motorised versions have 5v DC Drive motor.
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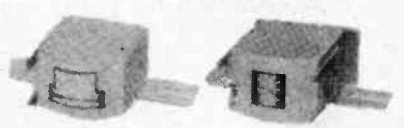

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A single board stand-alone stepping motor driver with built in oscillator and speed control circuits. A computer is not required with this board which will drive most unipolar 4 phase motors. Variable Acceleration, Speed, and Direction, may be controlled in **HALF STEP, FULL STEP**, and **ONE PHASE** modes. Up to 35V and 1.5A per phase. L.e.d. mimic display. Connector is provided for a computer port. The Kit includes our MD35 motor

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KIT 740..........................£19.98

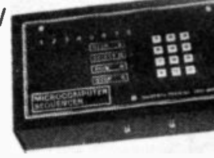
PEsT SCARER

Produces high power ultrasound pulses. L.e.d. flashes to indicate power output. Battery powered 9 - 12V, or mains adaptor £2.00 EXTRA.

KIT812..........................£14.81

KIT HIGHLIGHT

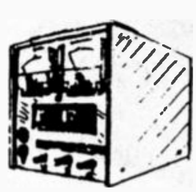
8 CHANNEL LIGHT SHOW PROGRAMMABLE SEQUENCER KIT 838



An advanced design using a pre-programmed microcontroller IC to generate over 100 light sequences. Additional battery backed RAM area to store your own sequences. Keypad control allows lamps to be controlled manually, sequences entered and selected, and sequence speed to be increased and decreased. ZERO VOLT SWITCHING. Programs include 3 and 4 channel versions so that existing lights can be used as well as 8 channel arrangements. Special output drive using a two winding transformer ensures foolproof operation with pin-spots and other difficult loads. This is a superbly finished kit with pre-drilled case and screen printed front panel. Full LED mimic. 2 P552 output sockets, 8 Amp isolated tab triacs with heatsink. Kit includes everything – down to the last nut and bolt. Tremendous Value.

KIT PRICE £64.89

MOSFET VARIABLE BENCH POWER SUPPLY 25V 2.5A



Our own high performance design. Variable output Voltage from 0 to 25V and Current limit from 0 to 2.5A. Capable of powering almost anything. Two panel meters indicate Voltage and Current. Fully protected against short-circuits. The variable Current limit control makes this supply ideal for constant current charging of NICAD cells and batteries. A Power MOSFET handles the output for exceptional ruggedness and reliability. Uses a toroidal mains transformer.

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DIGITAL CAPACITANCE METER

Provides clear readings of capacitance values from a few pF up to thousands of µF. Ideal for beginners. It allows obscurely marked components to be identified quickly and easily. Quartz controlled accuracy of 1%, and large clear 5 digit display. Kit is now supplied with a punched and printed front panel, case, all components and top quality printed circuit board. New low price.

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BAT DETECTOR

An excellent circuit which reduces ultrasound frequencies between 20 and 100 kHz to the normal (human) audible range. Operating rather like a radio receiver the circuit allows the listner to tune-in to the ultrasonic frequencies of interest. Listening to Bats is fascinating, and it is possible to identify various different types using this project. Other uses have been found in industry for vibration monitoring etc.

KIT 814..£21.44

QUICK CAPACITANCE TESTER

A low cost hand-held audio/visual unit which can identify short, open and working capacitors quickly and with a minimum of fuss. Also gives indication of leakage current . An ideal kit for beginners, built on a single printed circuit board which has large copper areas used as test pads. Only a minimum of wiring is needed. 2 l.e.d.s and a piezo transducer provide the output indication.

KIT 834..£10.34

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This alarm is useful where ordinary 'passive' (pir) detectors are not suitable. It works by detecting disturbances to its own short wave infra-red beam. Output is via mains rated relay contacts. Built in timer, and mains transformer.

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Our own widely acclaimed design. This sensitive Pulse Induction metal detector picks up coins and rings etc up to 20cm deep. Negligible 'ground effect' means that the detector can even be used with the head immersed in sea water. Easy to use, circuit requires only a minimum of setting up as a Quartz crystal provides all of the critical timing. Kit includes search-head, handle, case, PCB and all components.

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INSULATION TESTER

A reliable and neat electronic tester which checks insulation resistance of wiring and appliances etc., at 500 Volts. The unit is battery powered, simple and safe to operate. Leakage resistance of up to 100 Megohms can be read easily. A very popular college project.

KIT 444..........................£22.37

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Digital lock with 12 key keypad. Entering a four digit code operates a 250V 16A relay. A special anti-tamper circuit permits the relay board to be mounted remotely. Ideal car immobiliser, operates from 12V. Drilled case, brushed aluminium keypad.

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A powerful 23kHz ultrasound generator in a compact hand-held case. MOSFET output drives a special sealed transducer with intense pulses via a special tuned transformer. Sweeping frequency output is designed to give maximum output without any special setting up.

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KIT 559..........................£15.58

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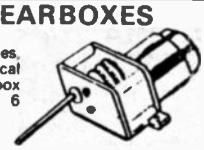

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4002	£0.17
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4010	£0.23
4011	£0.16
4012	£0.16
4013	£0.17
4014	£0.30
4015	£0.31
4016	£0.18
4017	£0.25
4018	£0.27
4019	£0.19
4020	£0.31
4021	£0.31
4022	£0.32
4023	£0.16
4024	£0.21
4025	£0.15
4026	£0.40
4027	£0.18
4028	£0.22
4029	£0.27
4030	£0.17
4031	£0.70
4033	£0.56
4034	£1.24
4035	£0.31
4040	£0.29
4041	£0.31
4042	£0.22
4043	£0.28
4044	£0.31
4046	£0.31
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4048	£0.31
4049	£0.20
4050	£0.20
4051	£0.25
4052	£0.25
4053	£0.25
4054	£0.56
4055	£0.30
4060	£0.31
4063	£0.29
4066	£0.18
4067	£1.91
4068	£0.16
4069	£0.20
4070	£0.17
4071	£0.20
4072	£0.17
4073	£0.17
4075	£0.17
4076	£0.30
4077	£0.17
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4082	£0.17
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4086	£0.26
4089	£0.65
4093	£0.15
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BC143	£0.34
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BC159	£0.12
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1.0	–	–	£0.05	£0.06	£0.15
2.2	–	–	£0.05	£0.06	£0.18
4.7	–	–	£0.05	£0.08	£0.30
10	£0.05	£0.05	£0.06	£0.08	£0.48
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

uF	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	£0.12	£0.48
22	–	£0.09	£0.13	£0.17	£1.06
47	£0.10	£0.11	£0.16	£0.20	£1.33
100	£0.10	£0.13	£0.21	–	£2.46
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	–	–	–
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TAKEN FOR GRANTED

It is easy to take things for granted when you have been involved in electronics for a number of years and sometimes, although we try to think about everything very carefully, we do not perhaps explain some points as well as readers would wish. Of course there are also occasions when we give a somewhat simplistic explanation to avoid getting bogged down in a lot of physics or maths or both.

If you find you don't understand something or possibly you don't agree with what has been said in one of our articles we will always try to sort things out. I hesitate to say it, because our postbag has been so full recently that we seem to be working flat out to keep up with the mail, but just drop us a line and put your point.

Since the merger of PE and EE our post and that going to Mike Tooley about *Circuit Surgery* has increased by about 50 per cent, so please bear with us if we take a few days to reply. Sometimes the production of the next issue must come first and letters have to be put to one side for a while. There are a dozen or so waiting for replies while I write this, but if I answered them you would have a blank page – possibly better than this rubbish you might think!

READOUT

Sometimes your letters give us the odd headache but we do like to keep in touch with readers and of course many of the comments are most encouraging or stimulating. We also try to provide a selection in *Readout* each month and presently we simply do not have enough space to fit in as many as we would like. As you can see from this month's letters we do get to a vast range of companies around the world and it is pleasing to know that EPE is avidly read by many professionals from Britain to Bulgaria to Bangkok.

READ IT

Can I just ask one thing, before you contact us, please make sure you have read the article and, if it's a component buying problem, also read *Shop Talk*. I can't tell you how many enquiries we get about where to buy components when full information has been given in the magazine. I know we are not fool proof and sometimes such questions arise that are not covered, but on occasions you could save yourself and us some time and effort.

Mike Kenward

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BACK ISSUES

Certain back issues of EVERYDAY ELECTRONICS and PRACTICAL ELECTRONICS are available price £2.00 (£2.50 overseas surface mail) inclusive of postage and packing per copy – **£ sterling only please**, Visa and Access (MasterCard) accepted, minimum credit card order £5. Enquiries with remittance, made payable to Everyday with Practical Electronics, should be sent to Post Sales Department, Everyday with Practical Electronics, 6 Church Street, Wimborne, Dorset BH21 1JH Tel: 0202 881749. In the event of non-availability one article can be photostatted for the same price. *Normally sent within seven days but please allow 28 days for delivery.* **We have sold out of Jan, Feb, Mar, Apr, June, Oct, & Dec. 88, Mar & May 89 & Mar 90 Everyday Electronics and can only supply back issues from Jan 92 to Oct 92 of Practical Electronics.**

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All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot however guarantee it and we cannot accept legal responsibility for it.

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers.

We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

We regret that **we cannot provide data or answer queries on projects that are more than five years old.**

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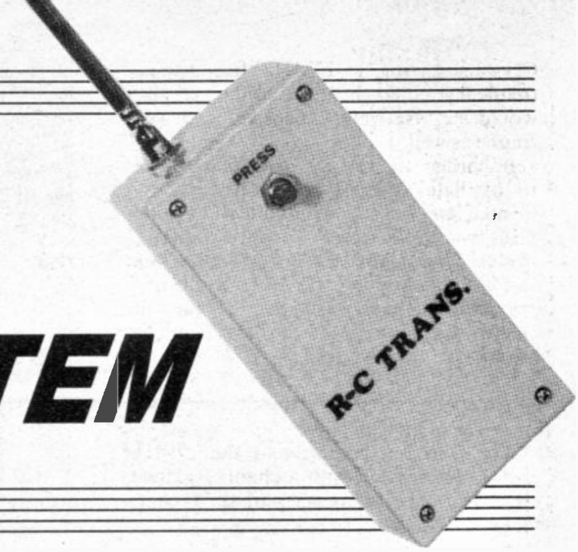
The Publishers regret that under no circumstances will the magazine accept liability for non-receipt of goods ordered, or for late delivery, or for faults in manufacture. Legal remedies are available in respect of some of these circumstances, and readers who have complaints should first address them to the advertiser.

TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

We would like to advise readers that certain items of radio transmitting and telephone equipment which may be advertised in our pages cannot be legally used in the UK. Readers should check the law before using any transmitting or telephone equipment as a fine, confiscation of equipment and/or imprisonment can result from illegal use. The laws vary from country to country; overseas readers should check local laws.

Constructional Project



SIMPLE RADIO CONTROL SYSTEM

ROBERT PENFOLD

Low cost, short range, crystal controlled transmitter and receiver with many possible applications. Operates on the 27MHz model control frequency.

THIS extremely simple radio control system operates on the 27MHz band, and provides short range operation (up to about six metres). It provides simple on/off operation, with a relay in the receiver switching in sympathy with a pushbutton switch on the transmitter.

This equipment is suitable for the control of model cars, etc. used indoors (or outdoors provided the limited range is borne in mind), or an application such as the remote control of a camera which has an electric release socket. A future article will describe a more sophisticated superhet Receiver that will give much greater range.

SYSTEM OPERATION

The block diagram of Fig.1 helps to explain the way in which this system functions. Sophisticated radio control systems operate by having a complex form of modulation on the basic 27MHz carrier wave.

However, the system described here is designed to be as simple as possible and consequently it does not use any form of audio or pulse coded modulation. It operates on the basis of the relay at the receiver being activated when the carrier wave is switched on, and switched off when the carrier wave is absent. The transmitter is manually keyed on and off via a pushbutton switch.

The transmitter is very simple indeed, and it just consists of an oscillator which generates the basic 27MHz radio signal, and an r.f. amplifier which boosts the output slightly and "cleans-up" the output signal. This amplifier drives the aerial, which is a short telescopic type. As the boost provided by the r.f. amplifier is very small, and the output power is quite low, there is little risk of the unit causing interference to other radio users, even if the transmitter is less than perfectly aligned.

The receiver is slightly more complex than the transmitter. A short telescopic or simple wire aerial feeds into an r.f. amplifier. This includes a tuned circuit which selects the signal from the transmitter, but attenuates signals at other frequencies.

The basic gain of the r.f. amplifier is not very high, and neither is the selectivity. The selectivity of a receiver is its ability to respond to the correct signal while ignoring signals on nearby frequencies.

REGENERATION

Regeneration is used in order to improve both the selectivity and sensitivity of the receiver. Regeneration is a form of feedback, and it entails sending an in-phase signal from the output of the amplifier back to the input.

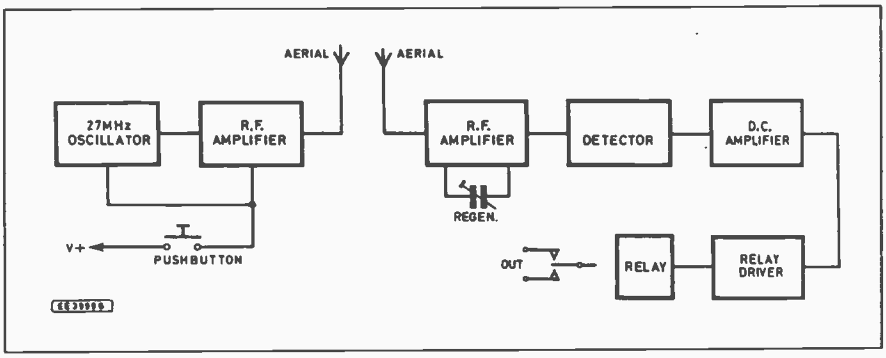


Fig.1. Block diagram for the Simple Radio Control System.

This feedback signal adds to and effectively boosts the input signal, giving a much stronger output signal. The feedback is greatest in the centre of the receiver's passband, and it consequently improves the selectivity.

There is a limit to the amount of feedback that can usefully be applied to the circuit. Excessive feedback results in the r.f. amplifier breaking into oscillation, and the receiver being held in the "on" state. For optimum results the regeneration level must be adjusted to a point just fractionally below that at which the amplifier breaks into oscillation.

A conventional diode detector circuit provides a d.c. output signal that is roughly proportional to the input signal level. The actual voltage produced is quite low even at very short ranges, and is unlikely to ever be more than a fraction of a volt.

A high gain d.c. amplifier is therefore used to boost this signal to a level that can reliably operate the next stage. This is a simple relay driver which activates the relay if the output from the detector stage is large enough.

Of course, with the transmitter switched off there will be no output from the detector, and the relay will not be activated. Provided the system is used within its maximum operating range, the relay will therefore switch on and off in sympathy with operations of the pushbutton at the transmitter.

There is a drawback to this ultra-simple system in that it is very vulnerable to interference from any nearby radio control transmitters operating on the same channel. With the transmitter switched off, any strong signal on the same channel will hold the receiver in the "on" state.

In practice this is not a major problem since the receiver is not very sensitive, and only radio control transmitters in fairly close proximity to the receiver could block operation of the system. However, it would obviously be advisable not to use the unit where there is a likelihood of interference from other radio control systems.

TRANSMITTER CIRCUIT

The transmitter circuit diagram appears in Fig.2. To ensure that the transmitter operates on the right frequency it must be crystal controlled. Quartz crystals enable accurate frequencies to be produced without the need for any adjustments.

Radio control crystals are invariably overtone types, and in most cases they are third overtone types. This simply means that their true resonant frequency is at about 9MHz, but in a suitable circuit they can be excited into oscillation at three times the fundamental frequency so that they provide a signal at around 27MHz.

Crystals having a 27MHz fundamental frequency could be produced, but they would be relatively expensive, and very fragile as well.

In order to get an overtone crystal to oscillate at its overtone frequency it is necessary to use a circuit which contains a conventional *L-C* tuned circuit at this frequency. This circuit uses a conventional overtone oscillator based on transistor TR1, and having capacitor C2 plus the main winding of r.f. transformer T1 as the tuned circuit. The adjustable core of T1 must be given a suitable setting in order to produce the correct resonant frequency, and oscillation from TR1.

There are six channels in the 27MHz radio control band with a channel spacing of 50kHz. The frequencies of these channels are as follows:

Channel 1	26·995MHz
Channel 2	27·045MHz
Channel 3	27·095MHz
Channel 4	27·145MHz
Channel 5	27·195MHz
Channel 6	27·245MHz

The prototype transmitter is fitted with a channel 6 crystal, but both the transmitter and the receiver can be adjusted to operate properly on any channel.

The secondary winding on T1 couples the output of the oscillator, via capacitor C3, to the input of a simple r.f. amplifier stage. This has a tuned load which is provided by the main winding of T2 and C6. There is a coupling winding on T2 which could be used to couple the output signal to the aerial, but a capacitive coupling via C5 from the collector of TR2 seems to provide a much stronger output signal.

Incidentally, the BC549 used for TR1 and TR2 is an audio transistor and not a radio frequency type. However, on trying various transistors in this circuit, BC549s and similar devices were found to work rather better than the more likely choices, some of which gave very little output at all.

The BC549 does actually have quite a high f_T figure of 300MHz, more than ten times higher than the frequency involved here. A definite advantage of BC549s is that they are much cheaper than most radio frequency transistors.

As the transmitter has only a modest output power it does not have a particularly high current consumption. In fact the typical current drain is only about 17mA.

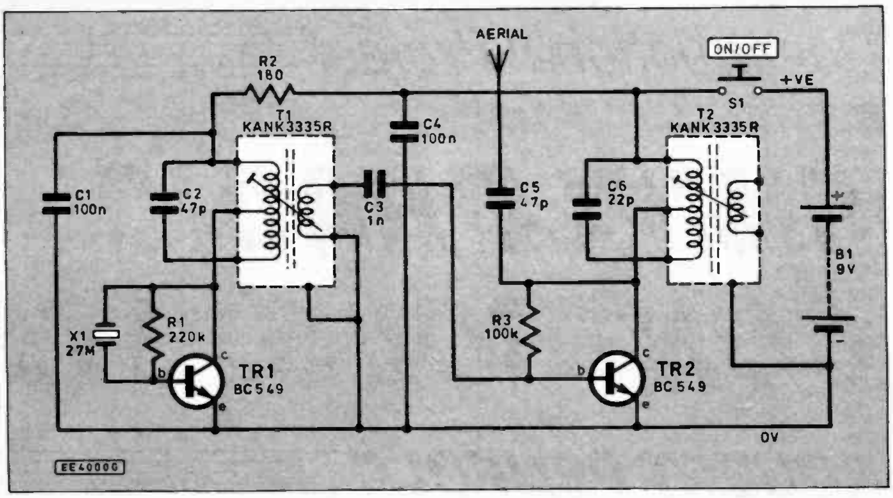


Fig.2. Circuit diagram for the handheld Transmitter. Transistor TR1 acts as the oscillator and TR2 is the r.f. amplifier. Notice the "grounding" of the transformer screening cases (cans) to the common 0V line.

Assuming the transmitter will only be activated briefly and intermittently, a small (PP3) size battery is adequate. If it will be switched on for longer periods of time a higher capacity battery (such as six HP7 size cells in a plastic holder) represent a more economic power source.

RECEIVER CIRCUIT

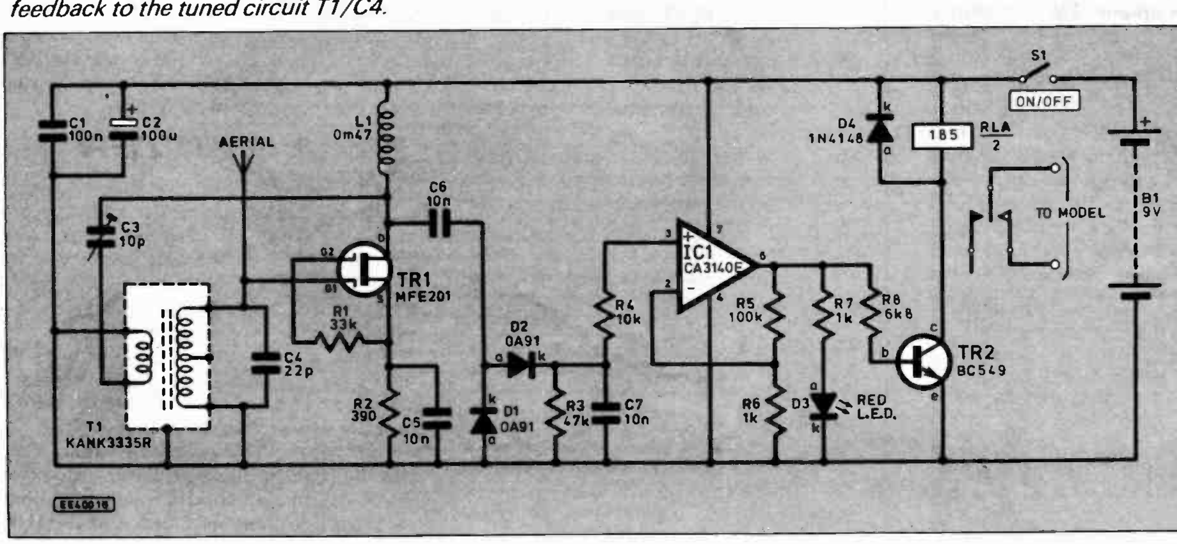
A dual gate MOSFET (TR1) is used as the r.f. amplifier in the receiver circuit (Fig.3). A dual gate MOSFET is used due to the relatively high performance it offers at 27MHz. The tuned circuit is comprised of capacitor C4 and the main winding of T1.

A MOSFET device has a very high input impedance, and it is therefore acceptable to directly couple the tuned circuit to the gate 1 terminal of TR1. The aerial can also be direct coupled to the tuned circuit as it will only be a short telescopic or wire type. There is no risk of this producing any major loading problems on the tuned circuit.

The gate 2 terminal of TR1 is not of major importance in this application, and it is simply given a suitable bias voltage from the source terminal via resistor R1. The r.f. choke coil L1 forms the drain load for TR1, and the trimmer capacitor C3 controls the regeneration.

This feedback from C3 is applied by way of a small winding on T1 to the tuned

Fig.3. Complete circuit diagram for the Receiver. The preset trimmer capacitor C3 controls the regeneration or feedback to the tuned circuit T1/C4.



circuit. This winding is connected with the right phasing for the required positive feedback.

Capacitor C6 couples the output from TR1 to a conventional diode detector circuit (D1, D2). IC1 is an operational amplifier which is used here as a non-inverting amplifier. The CA3140E used for IC1 is a type which can operate as a d.c. amplifier without the need for a negative supply. Note that other operational amplifiers are unlikely to operate properly in this circuit. Resistors R5 and R6 are the negative feedback circuit, and these set the closed loop voltage gain of IC1 at approximately one hundred times.

The output of IC1 (pin 6) drives an l.e.d. indicator D3 via current limiting resistor R7. This will not be of much help in normal use in most applications, but it is useful as a tuning indicator when initially getting everything set up correctly. In order to save battery drain, D3 can be disconnected once the receiver is set up properly and working well.

Transistor TR2 is the relay driver, and this is a simple common emitter switch which is turned on when the output of IC1 goes more than about one volt positive. It then activates the relay coil, which in turn activates the relay contacts and the controlled equipment. D4 is the usual protection diode which suppresses the reverse voltage spike that is generated when the relay coil is de-energised.

The current consumption of the Receiver circuit is only about five to six milliamps under standby conditions, but it will rise to around 40 milliamps when the relay is activated. A fairly high capacity 9V battery is therefore needed, such as six HP7 size cells in a plastic holder.

In some cases it might be possible to power the unit from the battery supply which is used for the controlled equipment. However, this can easily lead to problems due to noise modulated onto the supply of the model (or whatever) which is being controlled. The safest option is to give the unit its own battery supply, which is guaranteed to be fully noise-free.

CONSTRUCTION -TRANSMITTER

The transmitter circuit is built on a piece of stripboard and the component layout and details of breaks required in the copper tracks are are shown in Fig.4. The board has 25 holes by 19 strips, and this must be cut from one of the standard sizes in which the board is sold.

Stripboard is easily cut using a hacksaw, but as it is made from a fairly brittle material it needs to be worked quite carefully. The two mounting holes are 3·3 millimetres in diameter, and they will accept metric M3 or 6BA screws.

There are three components which are slightly awkward to fit onto the board. These are the transformers T1, T2, and crystal X1. With all these components it is not possible to fit them to the board directly because they have the wrong pin spacing and (or) pins that are too large to fit the holes in the board.

Fortunately there is an easy solution, and this is to first fit solder pins to the board at the positions indicated in Fig.4. If the tops of the pins and the pins of the components are then generously tinned with solder, there should be no difficulty in soldering the components onto the pins. Be careful not to overheat the components when soldering, be as quick as possible. Make quite sure that each pair of pins are properly connected together.

COMPONENTS

TRANSMITTER

Resistors

R1	220k
R2	180
R3	100k

All 0·25W 5% carbon film.

See SHOP TALK Page

Capacitors

C1,C4	100n ceramic (2 off)
C2,C5	47p polystyrene or ceramic plate (2 off)
C3	1n Mylar
C6	22p polystyrene or ceramic plate

Semiconductors

TR1,TR2	BC549 *npn* silicon (2 off)

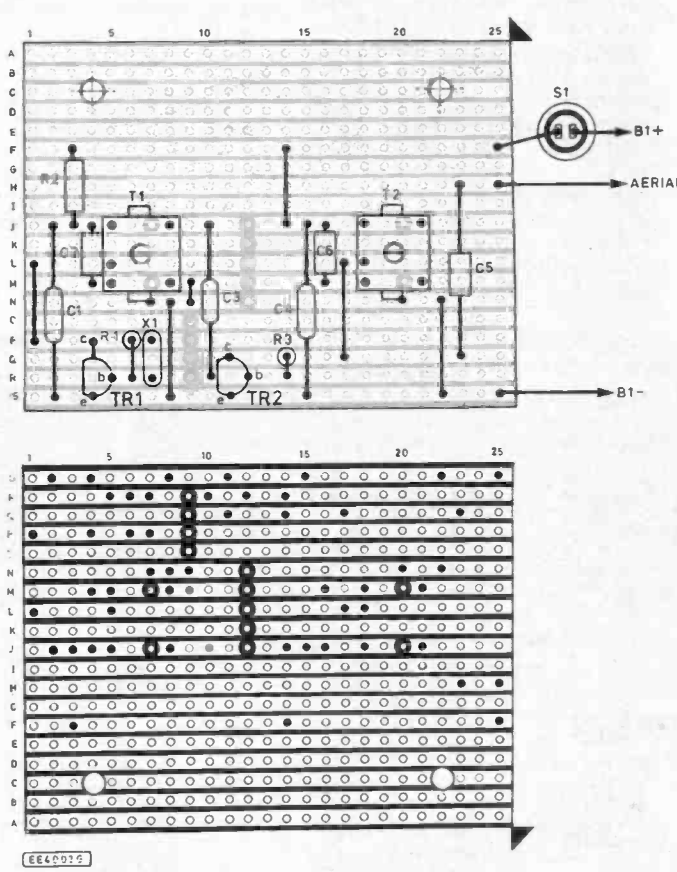
Miscellaneous

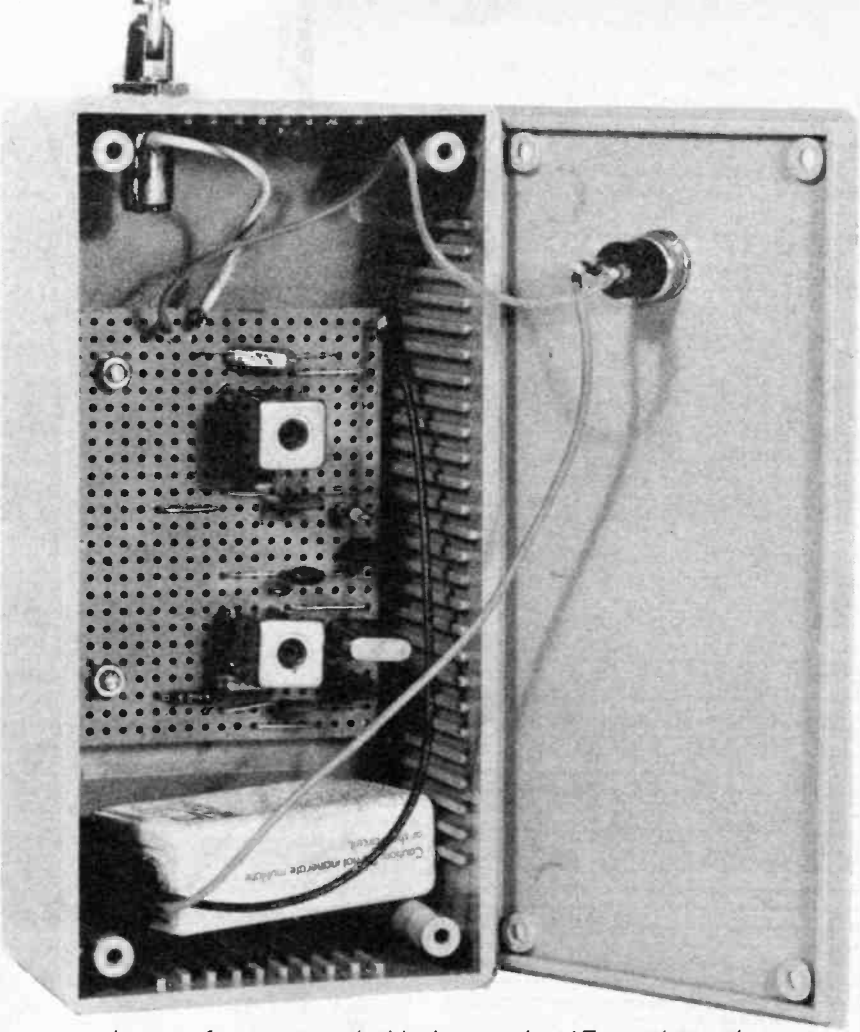
T1,T2	r.f. transformer, type Toko KANK3335R (pink) (2 off)
X1	27MHz radio control crystal
B1	9V battery (PP3 size)
S1	Pushbutton switch; push-to-make, release-to-break

Plastic case, size approx. 128mm x 65mm x 44mm; 0·1 inch matrix stripboard panel, size 25 holes by 19 copper strips; telescopic aerial; battery connector; solder pins; connecting wire; solder, etc.

Approx cost guidance only **£14**

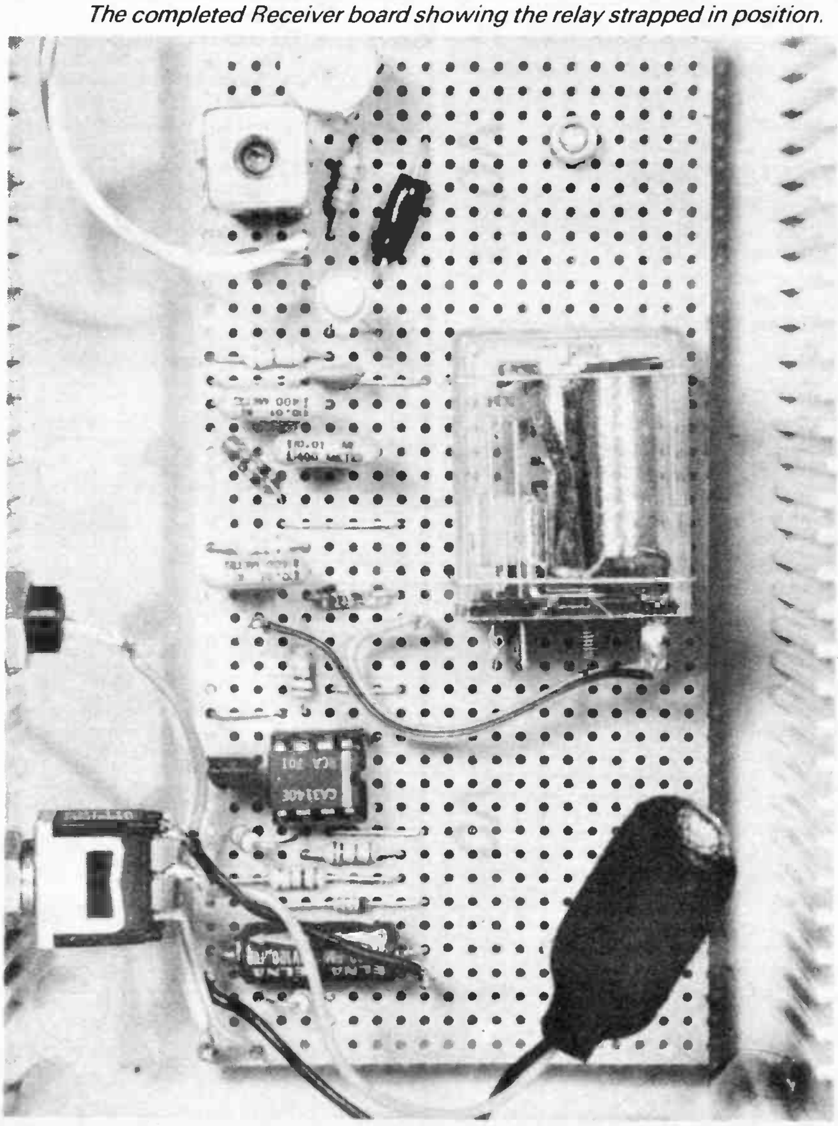
Fig.4. Transmitter stripboard component layout, wiring and details of breaks required in the underside copper tracks.





Layout of components inside the completed Transmitter unit.

The completed Receiver board showing the relay strapped in position.



It is possible the crystal X1 will be a wire-ended type which can be mounted directly onto the board. This is unlikely though, since most radio control crystals are of the plug-in variety so that the equipment can easily be changed to a different channel.

It would probably be possible to obtain a suitable crystal from a specialist crystal supplier, but this might prove to be expensive. It is almost certain to be cheaper if a pair of "off-the-shelf" radio control crystals are obtained from a general component supplier.

This may seem wasteful, since the receiver crystal is not needed for the receiver featured here. However, these pairs of crystals are quite cheap, and the receiver crystal will be there if you should build a superhet radio control receiver at some later date.

A small plastic case will comfortably accommodate everything, although a medium size case will be needed if the unit is powered from six HP7 cells. Also, if you use a telescopic aerial which fits inside the case or retracts into it, a larger case will be needed in order to accommodate it.

The general layout of the unit is not critical, but mount the circuit board in a position that will provide easy access to the cores of T1 and T2. Only a very small amount of hard wiring is needed, and this is included in Fig.4.

RECEIVER

The topside component layout and underside details of the receiver circuit board is shown in Fig.5. This is based on a stripboard which has 43 holes by 21 copper strips. The receiver is constructed in much the same way as the transmitter unit, and we will therefore concentrate here on some additional points which need to be borne in mind when constructing the receiver unit.

The first point to note is that TR1 and IC1 are both MOS devices, and that they therefore require the usual anti-static handling precautions. In the case of IC1 this means that it should be fitted in a holder, and that it should not be fitted into place until the unit is in all other respects finished. Handle this component as little as possible once it has been removed from the anti-static packaging.

Transistor TR1 must be soldered directly to the board, but this must be done using a soldering iron having an "earthed" bit. It should not be fitted on the board until the other components (except IC1) have been fitted. Like IC1, it should be handled as little as reasonably possible once it has been removed from the anti-static packaging.

The trimmer capacitor C3 and transformer T1 will not fit direct onto the board, but are easily fitted via solder pins (like T1, T2, and X1 in the transmitter). The relay must be a type that will operate reliably from about 7 volts, have a coil resistance of about 180 ohms or more, and have suitable contacts of adequate rating.

Unfortunately, most of the relays currently on offer that will operate reliably from a 7V coil voltage seem to have quite low coil resistances. Using one of these would give the unit a rather high current consumption, and could result in TR2 being destroyed by an excessive current flow.

Probably the best choice is a "continental" style relay having a 12V, 185 ohm coil, and

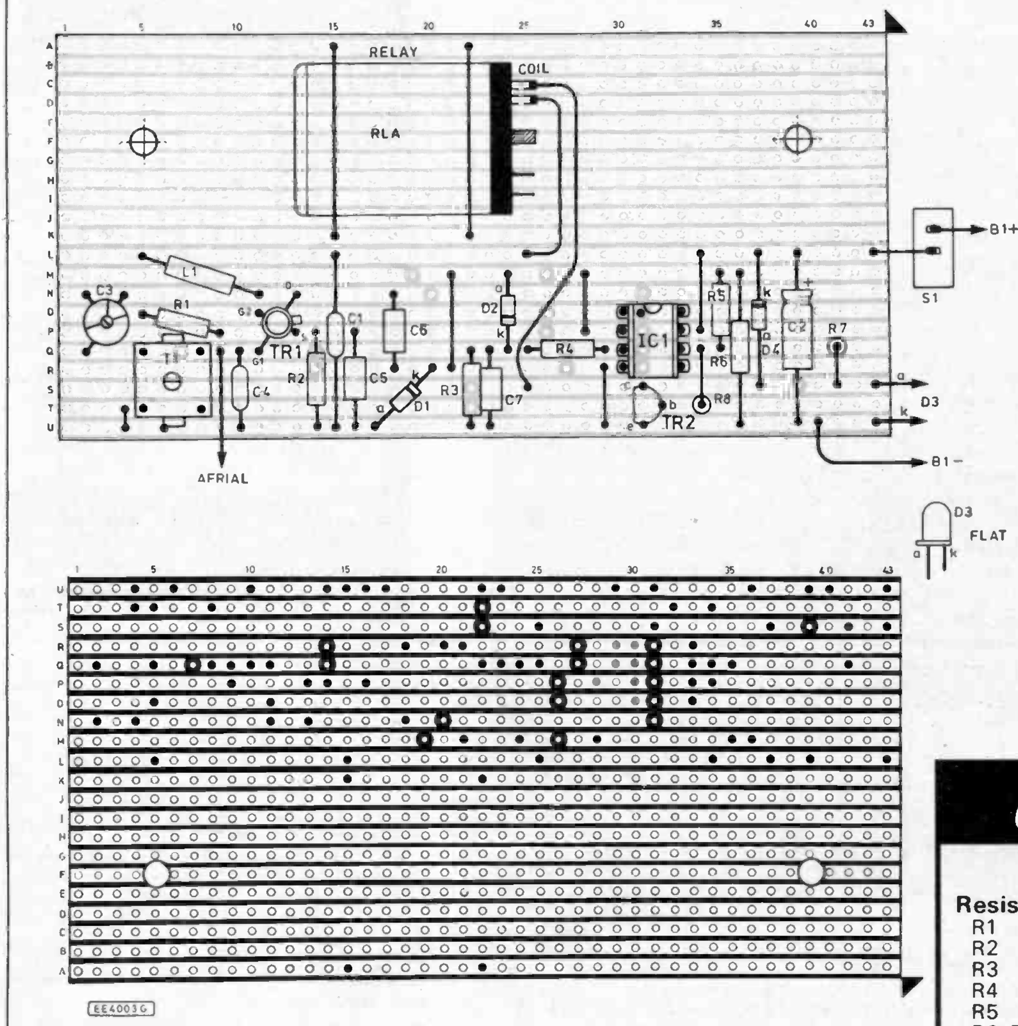


Fig.5. Stripboard component layout, details of underside breaks in the copper tracks and off-board wiring for the Receiver. The relay RLA is held on the board by wire "straps" and the contacts wired to the board with insulated connecting wire.

twin changeover contacts. Although the coil has a nominal voltage rating of 12V, it will actually operate reliably on voltages as low as 5·5 volts, making it perfectly suitable for use in this circuit.

This relay does not have a base that is compatible with 0·1 inch pitch stripboard. One way of reliably fixing it to the board is to glue it in place, and to also secure it with a couple of wire "straps" soldered to the board. Once mounted on the board, the relay is hard wired to the circuit board and the controlled equipment.

If the receiver is to be used in an application such as a remote camera trigger, it can be mounted in a plastic case in the usual way, complete with a telescopic aerial. Connection to the relay can then be via a (say) a 2·5mm jack socket fitted on the case, plus a suitable lead to connect this socket to the camera.

If the receiver is to be fitted in a model it might be better not to bother with the case. It would just add to the cost of the system, add weight to the model, and probably serve no real purpose.

Where feasible it is best to use a telescopic aerial about a metre long, but it might be necessary to improvise a suitable aerial. Ideally the aerial should be about 0·6 to 1·2 metres long, and it can be made using anything from thin wire to thick metal rods or tubes. *It is important that the aerial is not in electrical contact with anything other than the receiver circuit.*

ADJUSTMENT

Alignment of the system starts with the Transmitter. Use a proper trimming tool when adjusting the cores of any of the r.f. transformers. Small screwdrivers can produce detuning effects when they are removed from a core, and their wedge shape can also cause damage to the brittle ferrite cores.

The core of T1 must be given a suitable setting or the oscillator with fail to operate. In practice a wide range of settings should give satisfactory results.

Use a multimeter to measure the current consumption of the transmitter circuit. It should be something under 20 milliamps if the oscillator is functioning, or around 35 to 40 milliamps if it is not. If a high reading is obtained, adjust the core of T1 until a suitably low reading is obtained.

Next the core of T2 must be adjusted for maximum output. Again using a multimeter to monitor the current consumption of the transmitter, adjust T2 for minimum current consumption.

There will probably be a wide range of settings that give very much the same level of current consumption, but at some point there should be a definite (although probably quite small) dip in the current reading. It is in this dip that maximum output is obtained.

With the aid of a suitable field strength meter, or a shortwave receiver fitted with a tuning or S-meter, it might be possible to

COMPONENTS

RECEIVER

See SHOP TALK Page

Resistors

R1	33k
R2	390
R3	47k
R4	10k
R5	100k
R6, R7	1k (2 off)
R8	6k8

All 0·25W 5% carbon film

Capacitors

C1	100n ceramic
C2	100µ axial elect., 10V
C3	10p min. film dielectric trimmer
C4	22p polyester or ceramic plate
C5, C6, C7	10n polyester (3 off)

Semiconductors

D1, D2	OA91 germanium signal diode (2 off)
D3	red panel l.e.d.
D4	1N4148 silicon signal diode
TR1	MFE201 dual gate MOSFET
TR2	BC549 *npn* silicon
IC1	CA3140E MOS input op.amp

Miscellaneous

T1	r.f. transformer, type Toko KANK3335R (pink)
RLA1	relay 185 ohm 6V coil, with 2-pole changeover contacts
L1	0·47mH r.f. choke
B1	9V battery pack (6 x HP7 size cells)
S1	s.p.s.t. sub-min toggle

Plastic case about 150mm x 90mm x 52mm; 0·1 inch stripboard, size 43 holes by 21 strips; battery connector; plastic battery holder for 6 x HP7 size cells; telescopic aerial; 8-pin d.i.l. i.c. holder; solder pins; connecting wire; solder, etc.

Approx cost guidance only **£16**

adjust the cores of T1 and T2 for slightly higher output. In particular, adjusting the core of T1 to maximise the output of the oscillator might give a boost in output power.

Note though, that the setting of T1's core will probably have to be backed-off somewhat from the setting that provides peak output. Otherwise the oscillator will almost certainly show a reluctance to start-up properly. Apparently this is quite normal for crystal oscillators. You may even find it necessary to detune T2 very slightly in order to obtain reliable keying of the transmitter.

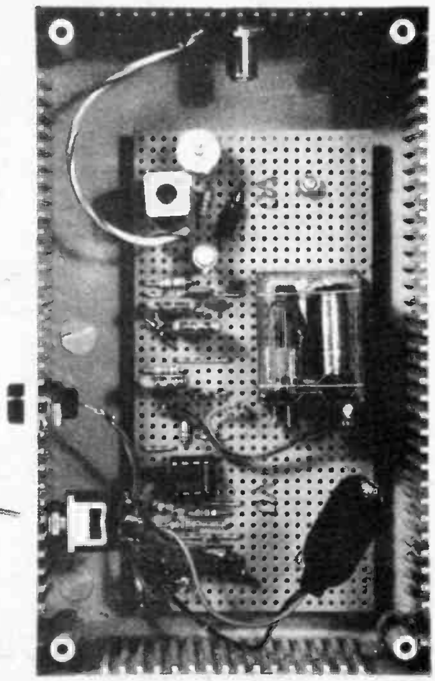
Moving on to the Receiver, initially trimming capacitor C3 should be set near to minimum value (i.e. with the two sets of metal plates only slightly meshed together). With the transmitter and receiver circuits switched on, and close together, it should be possible to get the relay to operate by adjusting the core of T1.

There should also be an indication from l.e.d. D3. Adjust the core of T1 for maximum brightness from D3.

By advancing C3 and readjusting the core of T1 it should be possible to obtain improved sensitivity. As higher sensitivities are achieved, it is advisable to move the transmitter further away from the receiver. Otherwise D3 will be switched fully on at a small range of settings, preventing an accurate peak indication from being obtained.

The receiver will be held in the "on" state if C3 is advanced too far, and the signal from the transmitter will then have no effect on the receiver. Optimum sensitivity is obtained just below this point. It can be a bit tricky getting this type of circuit accurately setup, but with some persistent and very careful "tweaking" it should be possible to get the system operating reliably over a distance of around 6 metres or more.

It is only fair to point out that results can be slightly erratic when a system of this type is operated indoors. Reflected signals can produce standing waves which give strong signals well away from the transmitter, or "blind" spots quite close to it. If problems with "blind" spots should occur, simply moving the transmitter slightly will often effect a cure. □



SHOP TALK

with David Barrington

Mini Lab (Teach-In '93)

This month the space reserved on our *Mini Lab* printed circuit board (p.c.b.) is for a useful piece of "test equipment" called a Signal Generator. This circuit produces sine, square and triangle waveforms and is centred around the ICL8038 waveform generator i.c.

The waveform generator i.c. may prove difficult to source locally but it is currently listed by **Cricklewood** (☎ *081 452 0161*), **Viewcom** (☎ *081 471 9338*) and **Electromail** (☎ *0536 204555*) code 305-844. Provided you make sure to specify the *plastic* 14-pin d.i.l. ICL8038CC version (not the more expensive ceramic BC type) it should work out to about £4 to £5.

The heatsink for Darlington transistor is one of the cheap TO-220 19°C/W "drop-in" type which should be available generally. The RS 401-863 (Electromail) and **Farnell** (☎ *0532 636311*) 170-070 are suitable TO220types and will fit the board directly (check for minimum order charges). Don't forget the transistor mounting kit.

If the loudspeaker is to fit directly on the p.c.b., the 50mm square "polyester" cone type should be ordered. The 'speaker was purchased from Electromail, code 250-277 (8 ohm), and is the flanged type. Other types of 8 ohm speakers can be used, but some form of mounting may need to be improvised.

A selection of kits for the *Mini Lab* has been put together by **Magenta Electronics** (☎ *0283 65435*), including the single Eurobreadboard which replaces the two discontinued plug-in Veroblocs. The large printed circuit board is available from the *EPE PCB Service*, code Mini Lab.

Simple Radio Control System

Some of the items called up for the *Simple Radio Control System* may prove a little difficult to locate locally.

The MFE201 dual gate MOSFET transistor seems to be only listed by **Cirkit** (☎ *0992 444111*) and carries the stock code of 06-04201. As the same company are main stockists of Toko coils, the KANK3335R(pink) r.f. transformers can be ordered from the same source.

Looking around for the 4·7mH r.f. choke proved quite a task, expecting to find a range of chokes available it was surprising to find that most values were stocked *except* the 4·7mH range. However, **Maplin** list one with the correct value and the stock code is UK80B. The miniature trimming capacitor used in the receiver was also purchased from Maplin, code WL69A.

The radio control crystals are normally sold in pairs and should be stocked by most of our component suppliers. Although only one is required it works out cheaper to purchase the pair. If you do experience any difficulty they are available from Maplin, code HX30H.

Turning to the telescopic aerials. Most of our components advertisers list a fairly wide range of aerials in their catalogues and it should be possible to select one to suit this application. The ones on the models are Maplin code YT20W.

The relay used in the receiver is a "continental" plug-in type rated at 12V and has a coil resistance of 185 ohms. This relay is claimed to work down to 5·5V, making it ideally suited to this circuit. This relay is available from Electromail, code 348-908.

Other relays will, of course, work in this circuit but most of those that will operate from about 7V seem to have a coil resistance less than that specified. Using one of these will increase the current consumption and could, in some cases, cause damage to transistor TR2.

Biomet Pulse Monitor

Items like the 3½ digit LCD, the light dependent resistor, some of the semiconductors and more general components needed to build the *Biomet Pulse Monitor* should be stocked by most component suppliers. The more specialised devices all seem to be only available from **Electromail**.

The following items, including their code numbers, are all available from the above mentioned source. The MF10 filter, code 302-407; H11AA1 opto-isolator, code 585-258; LM2917-8N tachometer, code 302-047; TSC7126 display driver, code 303-652; and finally the 3½ digit liquid crystal display, code 589-250.

The CA3306CE 6-bit flash ADC is available from **Maplin**, code CR23A. The printed circuit boards are obtainable from the *EPE PCB Service*, codes 817 (Sensor) and 818 (Display) – see page 156.

Automatic Plant Watering System

All the "electronic" components for the *Automatic Plant Watering System* should be readily available from most of our component advertisers and not cause any problems. However, the TIP121 power Darlington transistor may be in short supply and it is suggested, by some stockists, that the TIP122 be used instead. This device has not been tried in the model.

You will have to take a trip down to your local car breakers yard or visit a local car accessory shop for the water pump. The one used in the model is a 12V car windscreen washer pump purchased from a Halford's store at a reasonable price. You may find your local garden centre can compete on price for a small pond pump.

Please note that this project MUST only be **battery powered** and don't forget to make provision for an "overflow" system in case of malfunction.

Rechargeable Handlamp

The power hand lantern used in the *Rechargeable Handlamp* is the Ever Ready R690 lamp. It should be stocked by most large electrical stores.

The 2V 2·5Ah Cyclon rechargeable sealed lead-acid cell (battery) appears to be special to RS Components and only available from a *bona-fide* RS stockist or their mail order outlet, Electromail. When ordering quote stock number 591-461.

You will require a multimeter for setting this circuit up. If you do not have one, there are some very good offers around from our advertisers at the moment.

Simple Metronome

All the components required to build the *Simple Metronome* are standard "off-the-shelf" items and should be available from most of our advertisers. Note that the polyester capacitor should be a printed circuit board mounting type having a 10mm (0·4in.) lead spacing.

Please Note

Last month we carried a new advertisement (supplied by them) from **Marco Trading** for their new components catalogue. Unfortnately, all those readers who wanted a copy of this useful catalogue were disappointed – it did not include an address of where to send for copies.

Copies can be obtained from **Marco Trading, Dept EPE, The Maltings, High Street, Wem, Shropshire, SY4 5EN.**

Also last month in *Shoptalk*, we gave an incorrect code number for the p.c.b. mounting co-axial socket used in the *TV/UHF Aerial Amplifier*. The correct **Cirkit** code is: **10-01200**. We understand that they are out of stock at the moment but new supplies will arrive shortly.

We apologise for this slip and we will make every effort to ensure it does not happen again. This is, to our knowledge, the first time we have got an order code wrong, but it does show how important it is to send off for catalogues as soon as they are issued.

Innovations

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

OFFICE OF THE FUTURE

Addressing the problem of the office of tomorrow, Prof. Peter Cochrane, Kim Fisher and Rob Taylor-Hendry from BT's research laboratories at Martlesham Heath, Suffolk, gave an intriguing insight to BT's future plans when they presented a paper entitled "The Office You Wish You Had".

THE EVOLUTION of technology during the past 60 years has now outstripped the rate of our biological evolution to cope with change. Moreover, our interface with technology has generally been designed for the convenience of the technology and is not intuitive or biologically matched to our abilities. If we are to change the office and the working environment significantly in the future, then these issues have to be addressed.

Computer and communications technologies now look ripe to introduce some radical and long overdue change. All the technology and know-how is available (in abundance) to revolutionise the office, the home and the place of work far beyond what we currently enjoy. In many respects we might now consider the modern office to be an unnatural and even hostile environment for most humans, they are not convenient, user friendly, or conducive to efficient and pleasant operation.

So here is a proposal for a method of breaking down these barriers in the office environment centred around the realisation of a "future desk". In Fig. 1 the desk is realised with currently available technology integrated to satisfy all of our known and well defined requirements, but with the inclusion of a set of human orientated interfaces.

Specific features of the desk include: optical communication that is cordless and large bandwidth; built-in equipment and an active surface for document display, manipulation and cordless/active peripherals; multi-standard input and output devices; intelligent non-intrusive interfaces; software filing, summarising, and correlating; intuitive and ergonomic control systems; built-in recognisers for 'hot desking', with a secure data environment; teleconferencing with human scale interactive images; hi-fi acoustics; voice I/O and command. Let us look at some of these features in detail in the sections that follow.

OFFICE WIRING

One of the major limitations of present day office design and realisation is the necessity for hard wired desks. Even with the exciting optical fibre technology developments there still remains an underlying problem with the cabled office: getting fibre or cable to where you want it.

Optical wireless affords an important means of short-range, diffuse and line-of-sight fixed and mobile communication for inside the office without the regulatory or frequency restrictions of radio alternatives. Furthermore the bandwidth of the channel is potentially as broad as cable based optical fibre systems, thereby allowing broadband multi-channel services. The principle is directly analogous to radio. Data can be omnidirectional radiated from a ceiling, desk or body mounted antenna and transceiver (Fig. 3).

So with optical wireless the office can have an omnipresent optical ether so that people and their desks can be mobile and still have broadband communication. People and equipment are thus free to roam within a building with no more data, printer, fax or telephone cables – only power is required.

The optical ether also enables the use of a lightweight headset with microphone and earpiece to provide cordless communication. Furthermore, voice recognition software allows direct voice I/O with computer and communications systems.

With intelligence built into the cellular optical wireless system the headset can be tracked and automatic location and activity systems can be used to produce "who, where and when" activity databases.

Combining voice recognition and the location facility provides a secure method of "hot desk" operation anywhere in an office. Talk to any desk and it can check your identity and configure to your own personal definition using the broadband optical communication to access your virtual desk's facilities.

THE DESK

Today desks are passive objects on which we stack, and in which we store, things. Technology has made them a mass of wires, equipment boxes, keyboards, mice and phones; none of which easily work with each other and all with their own proprietary interfaces. The wiring alone causes configuration nightmares whilst the integration of diverse software and hardware is rapidly approaching the impossible.

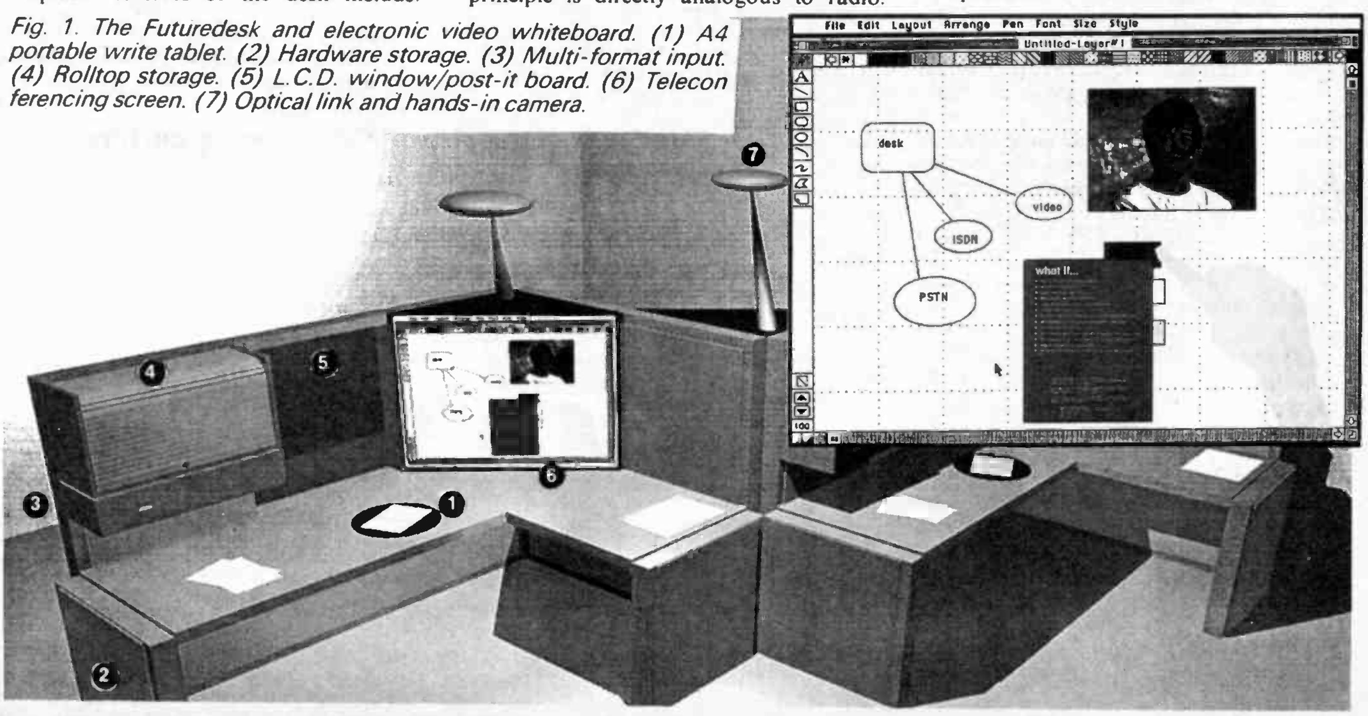


Fig. 1. The Futuredesk and electronic video whiteboard. (1) A4 portable write tablet. (2) Hardware storage. (3) Multi-format input. (4) Rolltop storage. (5) L.C.D. window/post-it board. (6) Teleconferencing screen. (7) Optical link and hands-in camera.

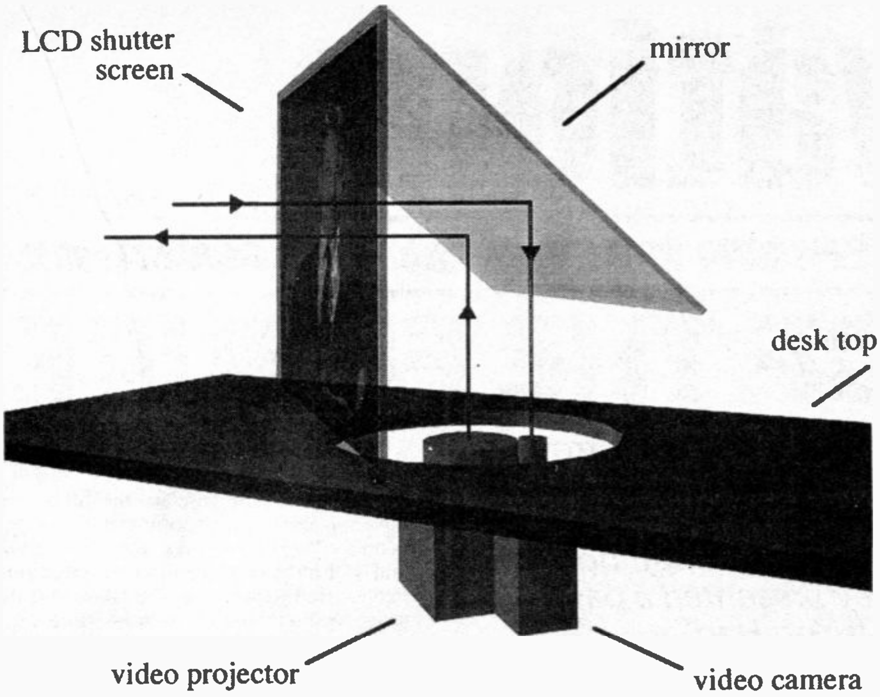


Fig. 2. HDTV video back-projection schematic.

One solution to this is an activity desk with: a built-in optical backplane; a partitioned structure used to house equipment; an inductive working surface to provide battery charging and communication to cordless peripherals; ergonomically built-in multiuse displays and input devices; radically new user interface such as "hands in the screen and eye plus voice tracking".

If optical wireless is used in the office, then cordless objects could be used instead of wired mice and keyboards. Inductive loops printed below the surface of the desk (like a car's heated rear window) would charge anything placed on its surface. A laptop or active organiser placed on the desk would be trickle charged at the same time as communicating with the desk allowing the full processing power of the desk to be instantly available without any physical connections.

VIDEO CONFERENCING

Video conferencing has the ability to radically reduce the need for people to travel. With the addition of telepresence hardware, a person can literally "be in two places at once". The constrained bandwidth available today for this human interface currently produces visual anomalies in the perception of the images and is detrimental to realising its full potential. To improve and humanise the limiting aspects of videoconferencing a different type of interface is proposed.

A large rear projected HDTV monitor can be ergonomically placed (Fig. 2) in the desk. This produces high definition life-size images in front of the user (in a natural face-to-face mode). By the use of an LCD shutter as the screen material a video camera can be aligned to be looking directly at the user through the screen. This enables a human sized image of your conversant with eye to eye contact and gaze awareness. Because of the large size of display the peripheral vision would be partially filled and create a feeling of "being there" rather than watching a picture.

As this display is High Definition, then it can also be used as a computer monitor and in many applications allows the mixing of videoconferencing and computer generated data.

By using an infra red emitting pen the screen can also be turned into an electronic whiteboard via infrared sensing in the camera driving the cursor controls of the computer. This allows multiple videoconferencing participants to work together in the same electronic media space in real time.

HANDS IN THE SCREEN

The addition of an overhead camera, scanning the desk's surface, and producing a positional image of the user's hand ("or finger worn" 3D RF positioning sensors) allows the realisation of an economic "hands-in-the-screen" interface. This direct hand control and manipulation of objects is linked to the function of the computer and peripheral equipment. No keyboard or mouse control is necessary; just speak the text and then "grab it" and put it where you want it.

ELECTRONIC POST-IT

To ensure that the main working display is not crowded with buttons, icons and electronic messages, another simple display with a touch sensitive surface and voice activation can be appropriately positioned. This can be used for telephone directory listings, "post it" pads and soft keys for all desk controls. For example this enables an up to date electronic directory to be displayed and a telephone call established whilst still being part of a video team working session.

PAPER

The user interface to electronic mail system can be radically improved if our human-oriented user interface is applied with a few minor enhancements. For example; the scanning of bar coded documents allows automatic logging, filing, abstraction and tracking. For example, the document arrived at 9:15am on 27th October. Rob and Phil were with you plus a visitor. The text correlator reads the central file copy and the key words are "Information Exchange" and "publication date". This related information, when automatically appended, enables single location filing and retrieval via sparse descriptors. This falls precisely in line with our abilities. As humans, we can vaguely remember the scenario: "Rob was with a visitor and it was in the morning". All the documents in this category, complete with a video snap of the visitor, can thus be recalled.

As we move to a multimedia environment then the ability to add colour, moving images, sound and interaction to documents will lead to paper being a less powerful medium. Electronic mail will then include video sequences, active directories and databases in a form that match your desk's personal 'sifter' and organiser.

MEMORY AND COMMUNICATION

In order to reduce the memory required, a process of (Hebbian) data decay is being investigated. Documents are reduced in data content with time as their perceived importance diminishes. Thus a document with full colour and voice annotation decays with time through to a monochrome document with low quality audio. Finally it is compressed with only contextual and retrieval information easily accessible. Regularly used or vitally important documents can remain uncompressed and complete.

FINAL REMARKS

All of the technology described is either available or currently under development. A decade from now could see it generally available in the work place.

Optical wireless in the office...ceiling satellite

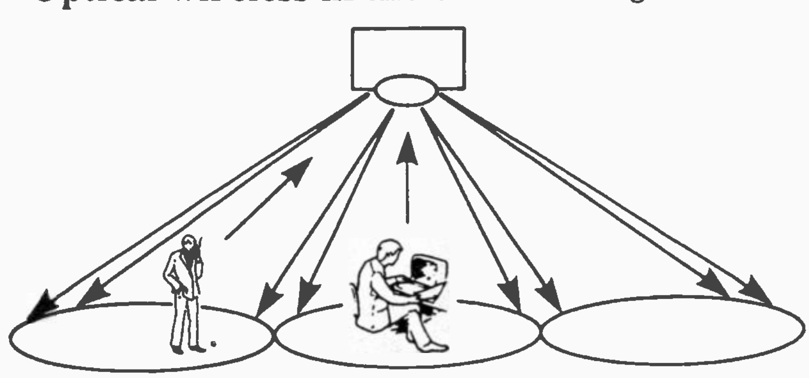


Fig. 3. Mobile communications using diffused infra-red light.

New Technology Update

Ian Poole reports on improved power MOSFETs, six-channel surround sound and Doppler disc checks.

A NEW development in i.c. technology now enables high power MOSFETs to be placed on the same chip as its low power controlling circuitry. This development by Harris Semiconductors uses a poly-silicon thin film transistor process.

So far only experimental models have been made but they have been capable of switching currents of up to 1A and voltages of 100V. Even so the process is capable of being extended further with no difficulty and it should be possible to control voltages up to 1000V and currents of 50A.

Isolated Power

The technique uses a thick oxide layer between the bulk silicon used for the basic i.c. and the high power thin film transistors. By having complete isolation in this way there is no compromise in the performance of either section. Currently the oxide layer gives an isolation of 500V although it is expected that this figure could be raised to 1000V or 1500V with little difficulty.

During manufacture the power FETs are fabricated after most of the basic i.c. is complete. The first step is to deposit the poly-silicon onto the layer of oxide and then a thin layer of oxide is grown onto the channel. When this process has been completed another layer of poly-silicon is deposited as shown in Fig. 1 to act as the gate for the devices.

In view of the large currents on the chip special care has to be taken to ensure the chip can withstand the heat generated. The manufacturers state that the chip can operate with a case temperature of up to 200°C. Beyond this there is an on-board circuit to shut the i.c. down before it is destroyed.

Whilst this chip may not find many uses within the amateur sphere of electronics, there are likely to be a number of spin-offs. These could be very useful because there are comparatively few high power i.c.s.

Sound Improvements

Today there are a tremendous number of developments taking place in the hi-fi and audio market place. CDs have long established their place and brought about the demise of the vinyl disc. Digital audio tapes or DATs are being used increasingly, albeit at the top end of the market. Digital compact cassettes are starting to appear and mini-discs are close on their heels.

All these new technologies use digital techniques, and give a far superior sound quality than the older analogue ones. However, very few changes have taken place to the basic hi-fi systems. Stereo is used in virtually all systems. Whilst quadraphonic systems did appear for a while in the 1970s they never really caught on.

Now Dolby Laboratories (inventors of the Dolby noise reduction system used on most analogue cassette recorders these days) has teamed up with a company called Zoran Corporation to produce a new digital six-channel surround sound system. Operating at a data rate of 320K bits/second, it is stated that this new system gives tremendous clarity and spatial realism whilst not requiring excessive amounts of storage space. Aimed initially at the professional market the system should soon be incorporated in domestic systems.

Within the partnership Dolby has devised the basic system and a new coding algorithm. Essentially, this compresses the data so that it can be transmitted and stored relatively easily and without taking up too much space. The other partner, Zoran will develop a single chip decoder in place of the five digital signal processors which are currently needed.

Initially the cost of these chips will be high, limiting their use to the top end of the market. Later developments are expected to be much cheaper and they should eventually cost around £15 to £20.

This means that they will be suitable for use in a much wider range of consumer hi-fi products. In fact it is hoped that the system could be applied to a wide range of products including compact discs, digital compact cassettes, mini-discs and video recorders.

Doppler Shift Improves Discs

Today's computer disc drives are very high precision pieces of equipment. They need to be designed and manufactured to exceedingly tight tolerances to be able to achieve the performances required of them.

Data transfer rates are very high as indeed are the storage capacities. To achieve these levels of performance the heads used for reading and writing the data have to "fly" just above the surface of the disc without actually touching it. In fact it is the aerodynamics of the head which keeps a thin layer of air between them whilst the disc is rotating.

With the minute distances between the disc and the head it is absolutely critical that the surface of the disc is flat, and that there is a minimal amount of movement in the level of the surface of the disc. Whilst there will always be a small amount in any system, too much will cause the head to crash into the surface of the disc. This results in a very annoying loss of data and damage to the disc.

As a result of this manufacturers need to be able to determine any movement in the disc itself very accurately, and with the disc in situ. This is not very easy, particularly when the disc is rotating. However, an ingenious solution has been found by using the well known Doppler principle.

The system is built around a laser. This fires a minute spot of light, 10µm in diameter, at the disc. Reflections from this spot are detected by sensors. The results are then digitised and fed into a high speed PC where they are processed using digital signal processing techniques.

In the first instance, the data from the doppler shift gives information about the velocity of the disc relative to the laser sensing head. However, from a knowledge of the time and the velocity it is possible to calculate the movement or run-out of the disc.

Further information about the surface of the disc itself can also be obtained and this is very useful. Normally both sides of a disc can be measured and the results obtained in less than 15 seconds.

It is hoped that this new technique will greatly advance the development and test of disc systems. It will particularly help in locating problems with disc clamping as well as flatness.

By identifying these problems it should enable heads to be run even closer to the discs whilst increasing reliability. This should bring even higher storage densities and faster access speeds in the future.

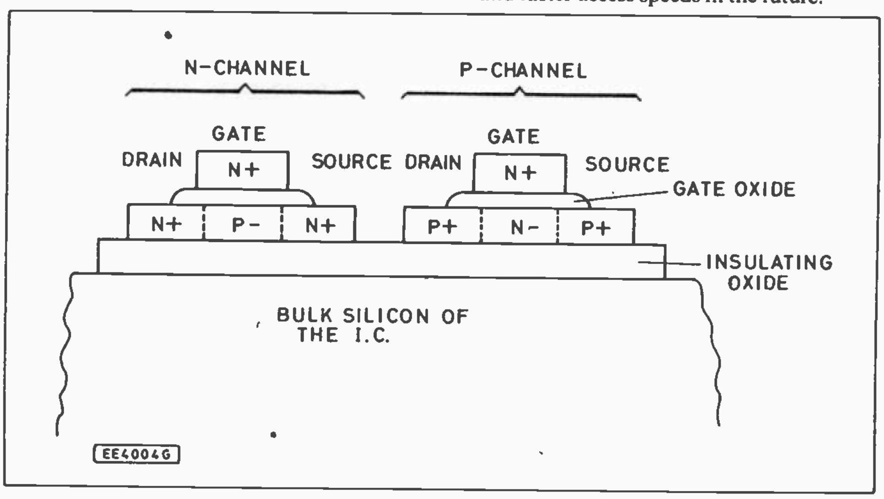


Fig. 1. Structure of the power MOSFET i.c.

AUTOMATIC PLANT WATERING SYSTEM

T. R. de VAUX-BALBIRNIE

Houseplant care while you are away from home

THIS battery-powered automatic watering system was designed for the care of indoor plants. It operates on demand – water being delivered whenever probes in the compost sense a fall in the level of dampness. Water is then pumped from a container through narrow-bore tubing to the plants.

The pump used in the prototype unit was a 12V car windscreen washer pump. These may be bought from car accessory shops such as Halford's quite cheaply and have been proved effective and reliable over a test period.

The current requirement is quite high – up to 1A – but since the periods of operation are relatively short, the life of the battery pack will be several months in normal use. The standby current requirement is 15µA approximately which may be regarded as negligible.

The moisture-sensing probes are connected to the unit using a standard power-in type socket on the side of the unit. Note that the Automatic Plant Watering System is designed as a ***battery-powered*** circuit and on NO ACCOUNT should it be used with a *mains*-operated power supply.

CIRCUIT DESCRIPTION

The complete circuit diagram for the Automatic Plant Watering System is shown in Fig. 1. This works on the principle of water conducting electricity. Thus, probes *A* and *B* placed in the compost will have a certain resistance between them which depends on the water content. This resistance will be typically a few hundred kilohms or several megohms when almost dry and less than 100 kilohms when damp.

The power-in plug and socket PL1/SK1 connect the probes to the main unit. IC1 is a micro-power operational amplifier connected as a voltage comparator. Thus, if the voltage at the non-inverting (+) input, pin 3, exceeds that at the inverting (–) one, pin 2, the device is on with the output, pin 6, high (positive supply voltage). In other cases it is off with the output low.

The resistance between *A* and *B*, together with fixed resistor R2, form the top section of a potential divider. The lower part consists of resistor, R3. With on-off switch S1 on, a certain voltage will therefore exist at IC1 inverting input. The value of this voltage will depend on the degree of dampness as sensed by the probes – the damper the compost, the higher it will be.

Preset potentiometer, VR1 in conjunction with fixed resistor, R1, form a further potential divider connected across the supply. This imposes a certain voltage on IC1 non-inverting input, pin 3 – the value of which depends on the adjustment of VR1.

With VR1 correctly adjusted and with damp compost, the voltage at IC1 inverting input, pin 2, will exceed that at the non-inverting one, pin 3. The op.amp is then off with the output, pin 6, low. Under these conditions nothing further happens.

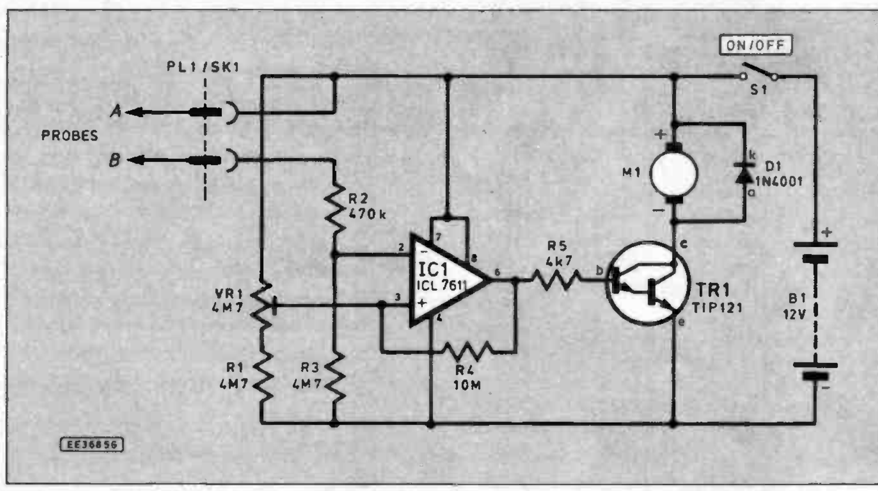


*Fig. 1. Complete circuit diagram for the Automatic Plant Watering System. On no account must the system be run from a **mains** operated supply.*

When the compost is dry, the resistance between the probes rises and the voltage at pin 2 consequently falls. At a certain point, this voltage falls below that at pin 3 and the op.amp switches on with pin 6 going high.

This allows current to flow into the base of transistor TR1 through current-limiting resistor, R5. Collector current then flows through motor, M1, which turns and operates the pump. This delivers water to the compost, the resistance between the probes now falls and the op.amp, TR1 and the pump switch off. This will happen every time the dampness falls below the predetermined level set by VR1.

MOISTURE CONTROL

It is necessary to provide an adjustment of the operating point since the level of dampness required is a matter of personal preference. Also, it depends on such factors as the quality of the water and compost and the length and separation of the probes. VR1 will be adjusted at the end of construction to take account of these factors.

The resistors in the potential divider section have a very high value. This minimises the continuous current which flows through them from the battery.

Transistor, TR1 is really a Darlington device – it consists of two transistors in one package. This provides an exceptionally high current gain so that the small current flowing from IC1 pin 6 through resistor R5 into its base is amplified sufficiently to operate any pump. Note that TR1 does not need a heatsink in this application. IC1 is a CMOS op.amp which has been specially chosen for its exceptionally small quiescent current requirement. Diode D1 by-passes the reverse high-voltage pulse which may occur when the motor switches off – without this, semiconductor components could be destroyed.

POWER SUPPLY

A stabilised power supply is not needed for this circuit. This is because, as the battery ages and the supply voltage falls, the inputs to both op.amp inverting and non-inverting inputs will fall in like manner. The switching point will therefore remain unchanged.

A 12V battery supply capable of delivering at least 1A is needed to power this project. In the prototype unit, eight 1·5V "AA" size alkaline cells were used in an appropriate holder. This was mounted inside the case. An alternative idea would be to use three type 1289 4·5V batteries connected in series but a larger case would be needed.

There would be no problem using a nominal 13·5V supply here. For heavy-duty use where, perhaps, several large plants are to be watered two PJ996 6V batteries connected in series or a 12V PP1 battery (of the type often used for burglar alarm systems) mounted externally would provide excellent service.

FEEDBACK

Fixed resistor, R4, applies some positive feedback from IC1 output, pin 6, to the non-inverting input, pin 3. This provides a Schmitt trigger action and prevents excessive on-off switching of the motor near the critical point. Thus, when the level of dampness sensed by the probes is sufficient to switch the motor on, the pump then overruns to deliver rather more water than would otherwise be needed to switch it off again.

The value of R4 could be the subject of experiment later but the specified value gave good results in the prototype unit. This point will be mentioned again later.

CONSTRUCTION

Construction of the Automatic Plant Watering System is based on a circuit panel made from a piece of 0·1in. matrix stripboard, size 10 strips x 21 holes. Fig. 2 shows the topside component layout and details of breaks required in the underside copper tracks.

Begin by cutting the material to size and drilling the two mounting holes. Make the track breaks and inter-strip links then follow with the on-board components taking care over the polarity of diode D1. Leave preset VR1 adjusted to approximately mid-track position.

Solder 10cm pieces of stranded connecting wire to strip 1*A* and 1*C* on the left-hand side and to strip 21*H* on the right-hand side of the circuit panel as indicated. Connect the negative wire of the battery clip (or as appropriate to the battery being used) to strip 21*I*.

Prepare the case by drilling holes for on-off switch, S1 and for the power-in socket SK1 used for connecting the probes. Drill holes in base of the box to align with those already made in the circuit panel (see photographs). Secure the battery pack to the case or provide wires for an external battery.

In the prototype unit, the pump was mounted inside the box in the position shown (see photograph) and this provides a convenient self-contained unit. Some readers will wish to mount the pump externally.

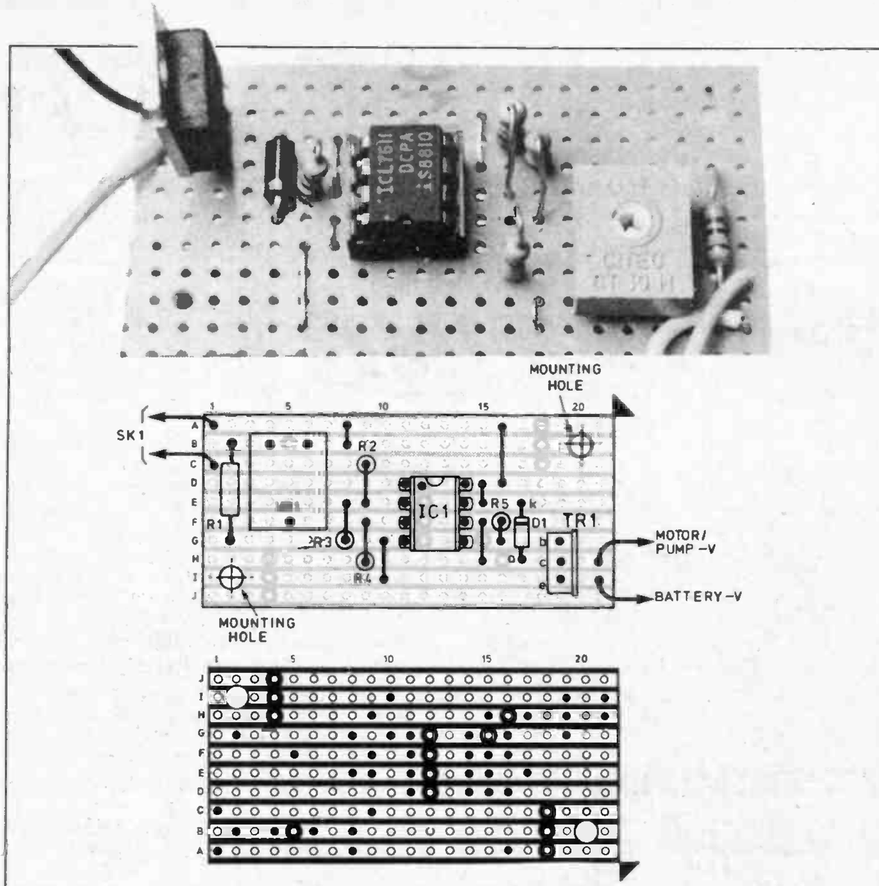


Fig. 2. Stripboard component layout and details of breaks required in the underside copper tracks. The completed board is also shown above.

COMPONENTS

Resistors
R1, R3 4M7 (2 off)
R2 470k
R4 10M
R5 4k7
All 0.25W 5% carbon

See SHOP TALK Page

Potentiometer
VR1 4M7 min. enclosed preset, horizontal

Semiconductors
IC1 ICL7611 CMOS op.amp
TR1 TIP 121 *npn* Darlington power transistor
D1 1N4001 1A 50V rect. diode

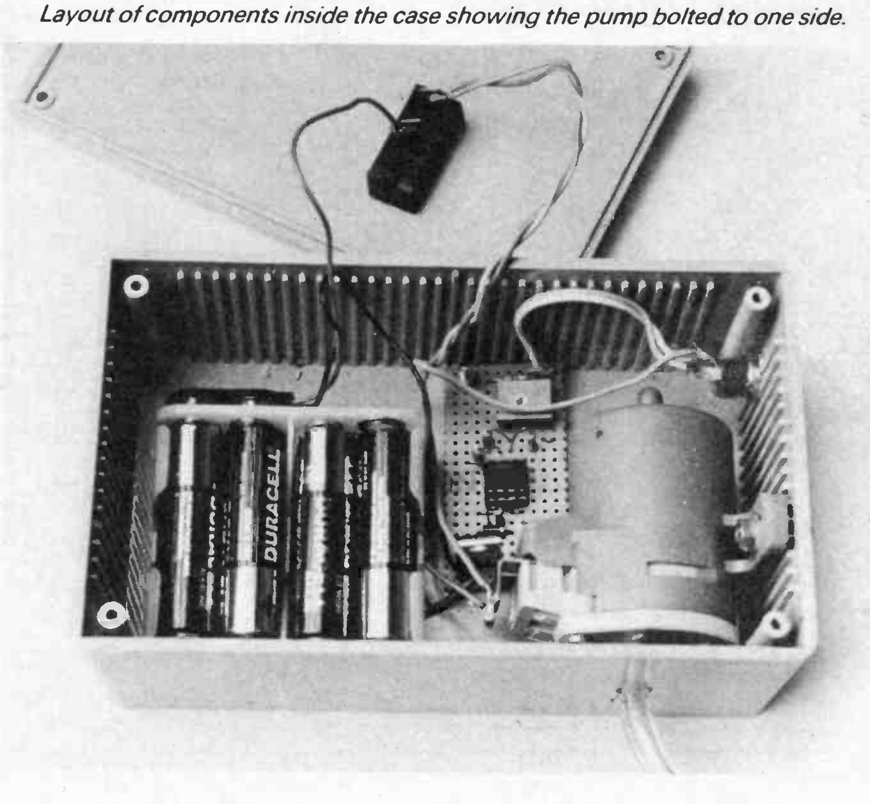
Miscellaneous
S1 1A s.p.s.t. toggle or rocker switch
M1 12V windscreen washer pump (see text)
B1 12V battery pack, batteries and connector (see text)
PL1/SK1 2·1mm power-in plug and matching socket

Stripboard 0·1in. matrix, size 10 strips x 21 holes; plastic case, size 149·5mm x 90mm x 52·5mm external; 8-pin d.i.l. socket; material for probes (see text); stranded connecting wire; small fixings; solder etc.

Windscreen washer type plastic tubing, jets, T-pieces and connectors as required for the "watering system".

Approx cost guidance only **£7**
plus pump, tube and batt s

Layout of components inside the case showing the pump bolted to one side.



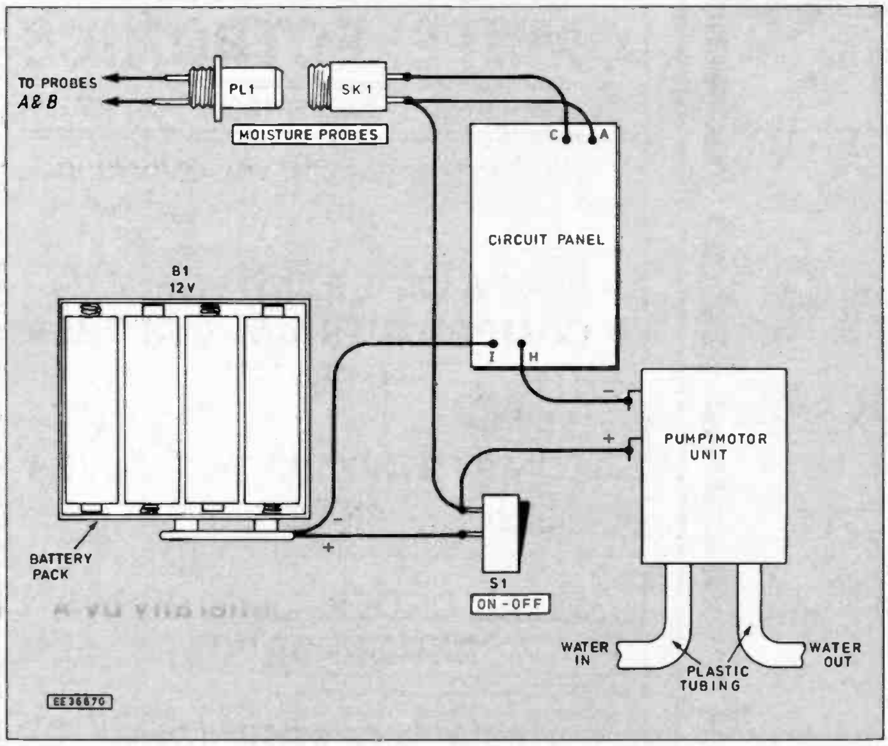


Fig. 3. Interwiring from the circuit panel to all off-board components. Make sure that the connections to the pump motor terminals are correct.

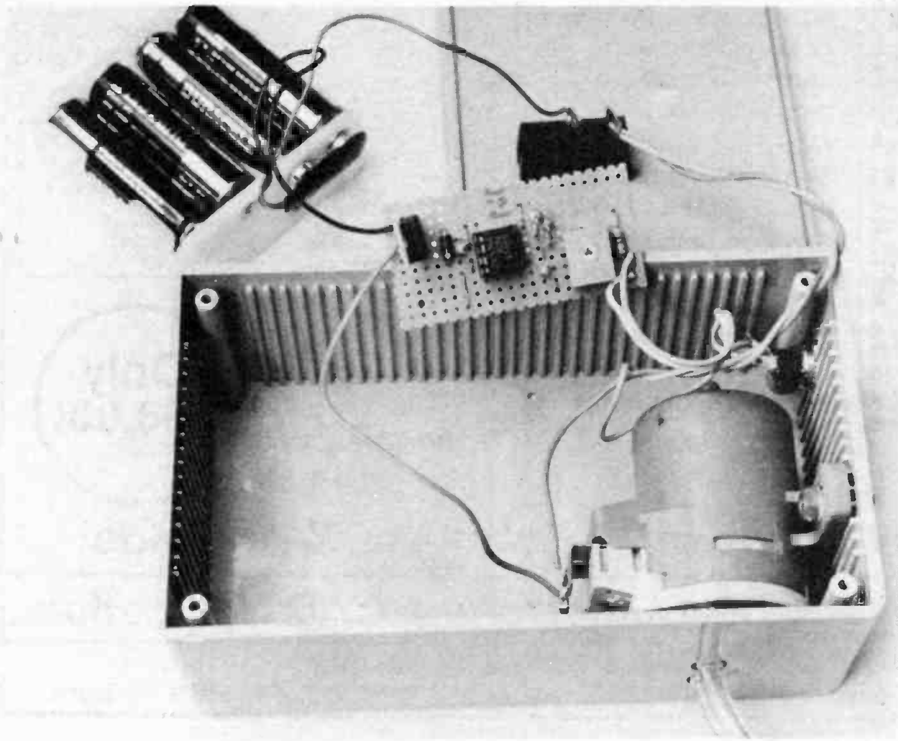
If mounting it inside the box, holes need to be drilled to secure the unit itself and also for the plastic tubing forming the water inlet and outlet. In the prototype, one of the pump plastic lugs having a mounting hole drilled in it had to be cut off to allow clearance for the lid of the box to be fitted. However, one fixing proved perfectly adequate to hold it securely in position. The exact arrangement will depend on the pump being used.

Referring to Fig. 3, complete the internal wiring using light-duty stranded connecting wire and mount the remaining components. Make the pump electrical connections using push-on "spade" connectors or solder the wires directly in place. Note that the polarity of the motor should be observed. Switch S1 off and insert the batteries into their holder.

PROBES

In the prototype, the probes consisted of meter test prods with 1mm plugs on the end. These plugs were cut off and the wires connected to the power-in plug. This arrangement gave a good appearance to the finished unit and worked well.

The battery-pack, circuit board and lid removed from the case to show positions of the water pump and water feed tubes.



An alternative idea – perhaps more suited to long-term use – is to use gold plated contact wire of the type used for keyboard instruments. A piece of screw terminal block connector could then be used to make the connections.

Connect the probes to the unit and switch on S1 – the motor should be heard to operate. Touch the probes together – the motor should stop. If this basic test works correctly, the circuit is likely to be sound and only needs adjusting.

ADJUSTMENT

Water a plant "correctly" and push the probes into the compost. If using thin wires for the probes, make sure they do not touch. Adjust preset VR1 using a small screwdriver so that the motor is just off. This will give a basic setting.

You will find that VR1 has a little "backlash" where the "on" position is not quite the same as the "off" one. This is due to the feedback action of resistor R4.

Make up the plastic tubing of the required length(s) using T-pieces as necessary to make branches. Soften the tubing by holding the ends in hot water before pushing them into position. The tubes may terminate in single or double jets – all these parts are available as windscreen washer accessories. The inlet tube should dip into a water container of sufficient size for the job.

The exact way in which the plastic tubing and jets are arranged is left to the user but it will be found that a slow rate of flow generally gives good results. Sometimes best results are obtained simply by pushing the plain ends of the tubing lightly into the compost.

Check that the tubing makes watertight connections at the pump especially if this is sited inside the box. Any trace of water on the circuit panel caused by leaks could cause false triggering and possible damaging "short circuits" across copper tracks.

If several plants are to be watered, the probes should be placed in an "average" one. Over a trial period of several days, preset VR1 should be adjusted for best results.

If, after adjusting VR1, the pump overruns more than it should so that the compost becomes too wet, resistor R4 should be increased in value. If the motor switches on and off excessively, it should be reduced. Since R4 already has the largest easily-obtained value (10MΩ), higher values are obtained by connecting more than one of these resistors in series.

It is advised that the plant pots be placed in such a position that should ever a catastrophic failure of the system occur, causing the pump to run continuously, it will not cause a problem with flooding – especially where a large water reservoir is used. □

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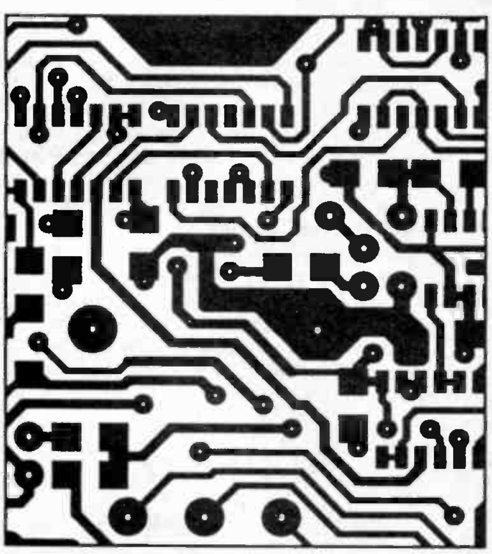

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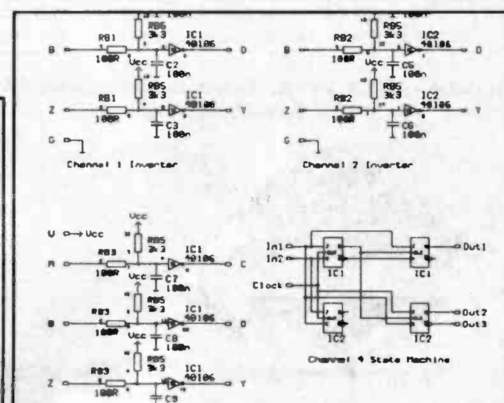

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BIOMET PULSE MONITOR

JOHN BECKER

Part One

Probe the rhythm of life with this mini heart monitor. Can be used on its own, with a liquid crystal display, or linked to a personal computer.

THE Biomet is a heart and pulse rate monitor which can be used on its own or in conjunction with a computer. The computer screen displays heart rhythm waveforms and pulse rates. Pulse rates are also shown on the Biomet's liquid crystal display screen.

The block diagram for the complete system is shown in Fig. 1. Alternative shorter versions may be built. Two types of monitoring probe are described, one simple, the other more sophisticated.

BOARD GROUPING

Three printed circuit boards are used in the complete Biomet Pulse Monitor. Throughout this article they are referred to as the *Sensor, Display* and *ADC* (analogue-to-digital converter) boards.

The Sensor board holds the high gain amplifier, 50Hz filter and test-waveform generator circuits, plus an opto-isolator which couples the sensor system to the ADC board. The Display board holds a pulse-rate analyser and liquid crystal display (l.c.d.) circuits.

Both these boards are housed in a small handheld case. In this form, the system can be battery powered as a completely self-contained pulse rate monitor.

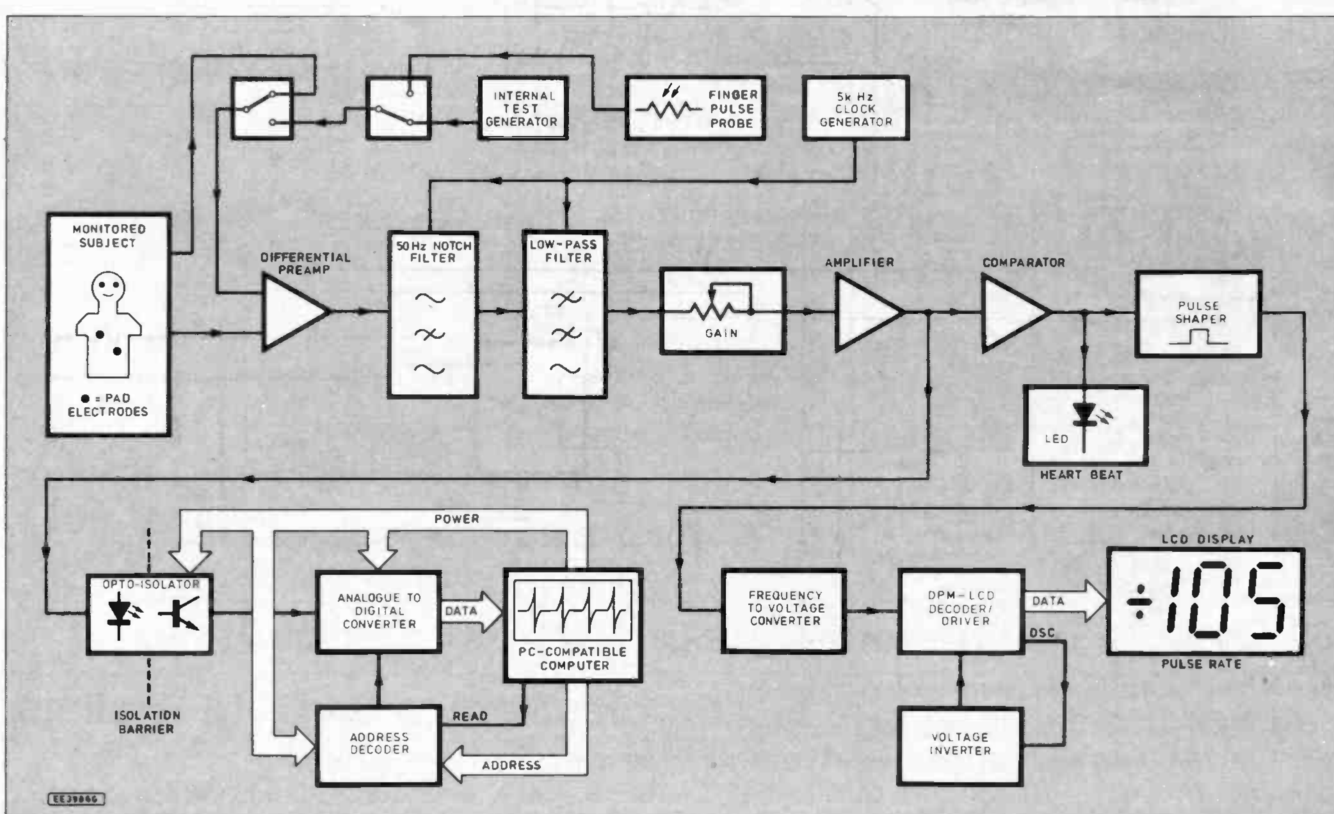
The ADC board is an interface which allows heart waveform signals from the Sensor board to be accessed and displayed by any computer which has a suitable parallel data input/output port. It includes an address decoding circuit for use with a PC-compatible computer. A PC-compatible software listing appears next month.

If the Biomet is to be used only with a computer, the Display board may be omitted.

MONITORING PROBES

Two forms of monitoring are available. With the first, the electrical impulses generated by the heart are sensed by

Fig. 1. Block diagram of complete Biomet Pulse Monitor system.



two monitoring electrodes attached to the chest. Conventionally, one probe is attached to the upper part of the right chest, and the other to the lower lefthand side of the rib cage.

In the second, less precise, method a finger or thumb is placed across a probe containing a light dependent resistor (LDR). The LDR detects small light level changes as the finger or thumb slightly swells and contracts in response to the blood pulsing through it.

PROBE AMPLIFIER

The circuit diagram for the probe amplifier, 50Hz filter, and computer isolation interface are shown in Fig. 2. The heart's very low amplitude electrical signals detected by the probes are fed into the differential amplifier formed around IC1a, IC1b and IC1d.

The circuit has the dual function of amplifying the heart signals, while inhibiting noise jointly picked up by both probes. Such noise includes 50Hz mains hum and higher frequency interference from other electrical equipment, for example, radiated signals from nearby computer screens.

The two signal paths combine at IC1d and are balanced by adjustment of the preset VR1. Bias voltage for the amplifier and other parts of the Sensor board is supplied by the circuit around IC1c.

FILTER AND VARIABLE GAIN

From IC1d, the preamplified signal is passed to the dual switched-capacitor filter IC2. The first half of IC2 is configured as a notch filter which attenuates signals having a central frequency of about 50Hz. Other frequencies are amplified by about 10 times.

From IC2 pin 3, the notched signal is passed to the second half of IC2. This is configured as a low-pass filter, allowing through only those signals which have a frequency below 50Hz.

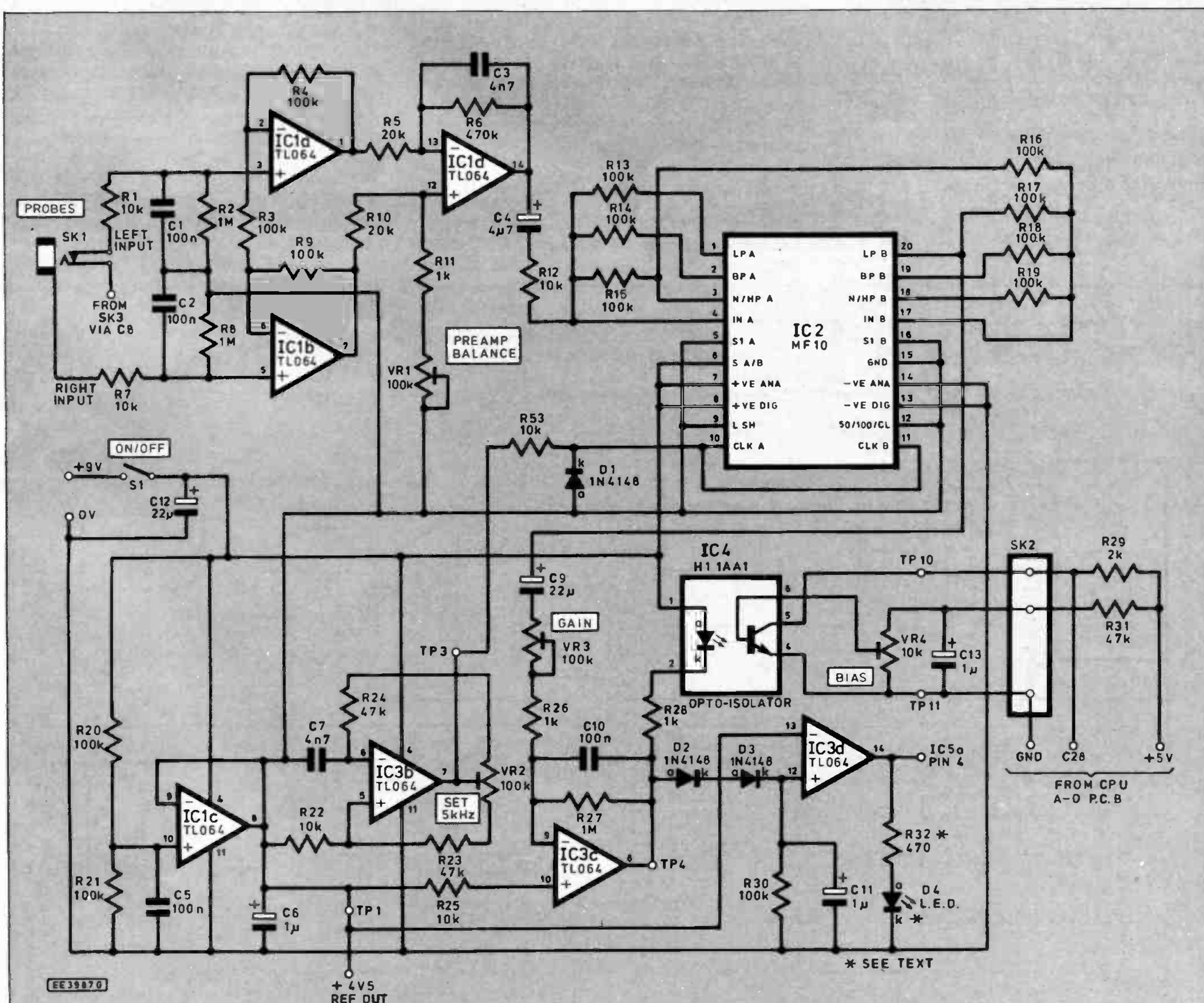
The clock generator which controls IC2 is formed around IC3b and has its output frequency fine-tuned by preset VR2. In this application a clock frequency of 5kHz is required to set the filter's signal frequency modes for 50Hz operation.

Following IC2 is a variable-gain stage formed around IC3c. The gain is controlled by VR3 and can be varied between x10 and x1000. Capacitor C10 filters out the residual 5kHz clocking frequency.

COMPUTER ISOLATION

At this point in the circuit, the signal is split into two directions. The first direction takes it to the opto-isolator IC4 which provides a safety interface between the Biomet and the ADC circuit connected to a

Fig. 2. Circuit diagram of the probe amplifier, 50Hz filter, test waveform generator and ADC isolation interface.



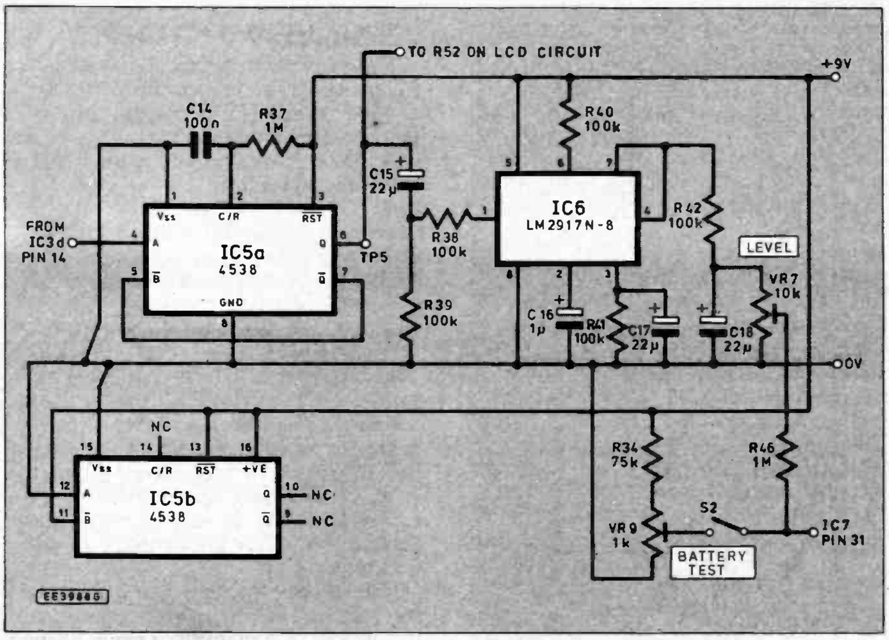


Fig. 3. Beats per minute converter and battery test circuit.

mains powered computer. Preset potentiometer VR4 sets the base bias of the isolator's output transistor.

The H11AA1 device used for IC4 has an isolation rating of 7500V a.c.

PULSE SHAPER

With the second route from IC3c, the signal is rectified across diodes D2, D3 and capacitor C11 and fed to the comparator circuit around IC3d. The use of two diodes raises the trigger threshold to about one volt above the reference voltage on IC3d pin 13. Adequately amplified heart beat signals cause the comparator output to be triggered high.

Optionally, the comparator output can be monitored by l.e.d. D4 in series with resistor R32, the l.e.d. flashing synchronously with detected heart beats. However, since the l.c.d. also displays heart beats, the l.e.d. can be omitted if preferred.

The positive-going output of IC3d is the trigger source which controls the beats-per-minute converter circuit IC5 – see Fig. 3.

Individual pulse lengths can vary irregularly from subject to subject and with the rates at which any subject's heart beats. Consequently, monostable IC5a is included as a pulse length standardiser.

When IC5a pin 4 is triggered by the positive-going pulse from IC3d, the Q output at IC5a pin 6 goes high for the duration set by R37 and C14. The feedback action between IC5a pins 5 and 7 inhibits the monostable from being re-triggered until after the timed period has ended.

PULSE RATE DISPLAY

Output Q of IC5a controls two functions, the first of which is to control the flashing of the pulse-beat monitoring symbol on the l.c.d., as will be seen shortly.

Secondly, it controls the tachometer chip IC8 (see Fig. 4). This converts input pulse rates into an equivalent output d.c. voltage which is fed via Level control VR7 and R46 to the next stage, the l.c.d. driver circuit shown in Fig.4.

Digital panel meter (DPM) chip IC7 decodes the voltage from resistor R46 (Fig. 3) into an equivalent digital output format suitable for driving a 3·5 digit l.c.d. The data voltage is compared against a reference voltage set by VR8 to around one volt, resulting in a display increment of one digit for each millivolt increase in the sampled voltage.

Within IC7 is a clock generator which has its frequency sub-divided by internal counters to control the signal sampling rate and the l.c.d. backplane frequency. The clock frequency is set by resistor R43 and capacitor C19 to produce a sampling rate of about one sample every two or three seconds.

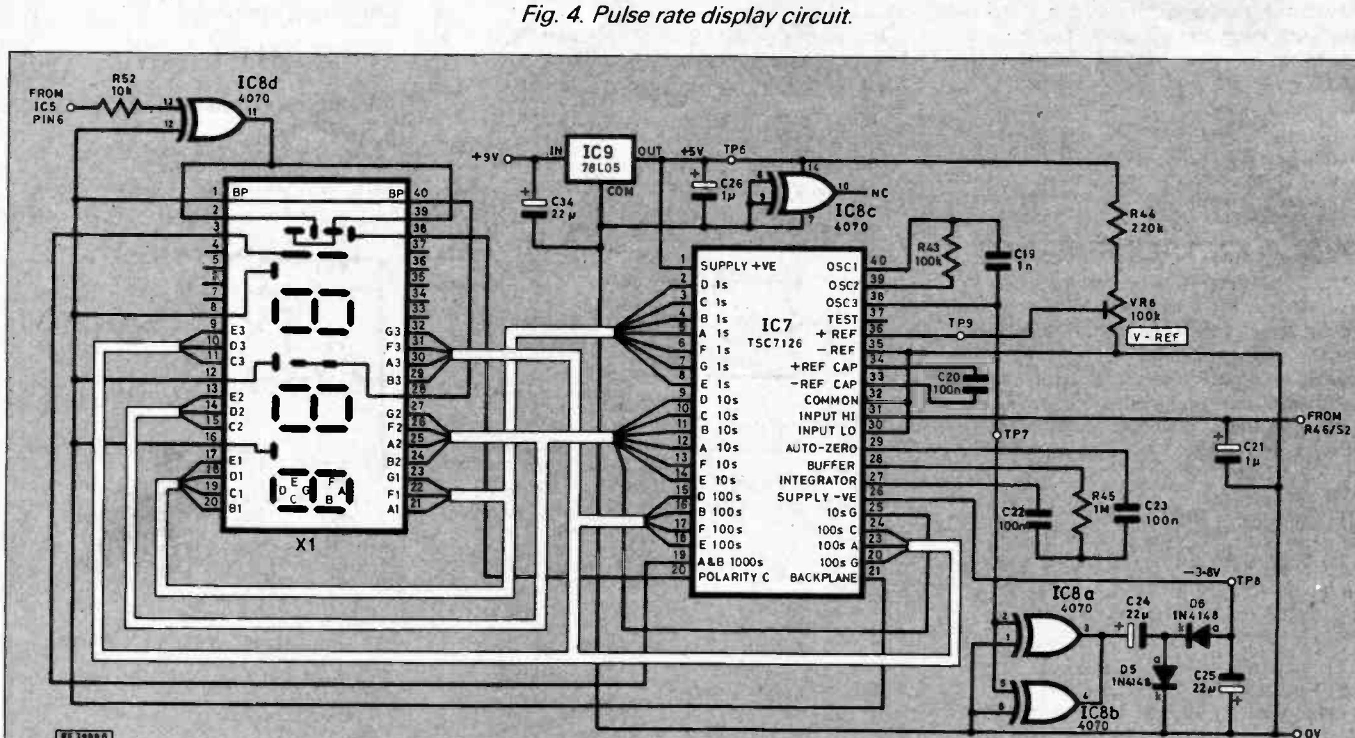
The positive power supply rail for IC7 is stabilised at +5V by the voltage regulator IC9. The negative supply, of about −3·8V, is generated from IC7's clock output at pin 38. The latter is buffered by the parallel gates IC8a and IC8b to provide sufficient current to drive the inverted rectifier circuit consisting of C24, D5, D6 and C25.

PULSE MARKING DISPLAY

The subject's monitored pulse rate is numerically displayed on the l.c.d. in terms of beats per minute. Each pulse beat also triggers the + (plus) symbol of the l.c.d. on and off, allowing immediate monitoring of the subject's uniformity of heart rate.

The on/off state of the symbol is determined by the phase of a clock signal supplied to it by the Exclusive-OR gate IC8d. One input of the gate is fed by the l.c.d.'s backplane clock. The other input is controlled by the Q output of IC5a (Fig. 3), which when high inverts the output clock phase of IC8d with respect to the phase of the l.c.d.'s backplane clock, so turning on the symbol.

Fig. 4. Pulse rate display circuit.



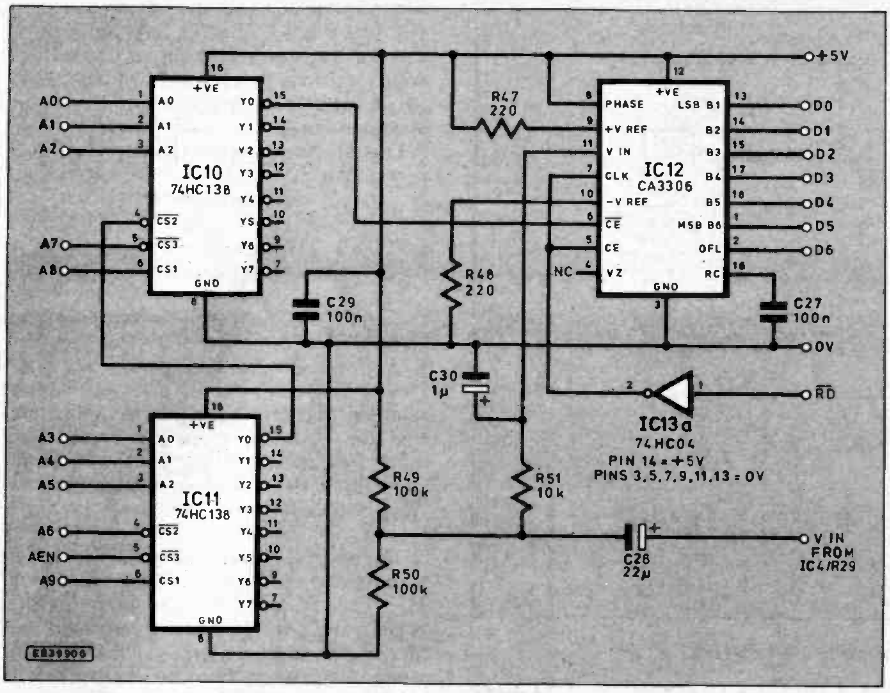


Fig. 5. PC-compatible ADC interface circuit.

ADC CIRCUIT

The analogue-to-digital converter (ADC) circuit diagram, which interfaces the Biomet to a suitable computer, is shown in Fig. 5. It consists principally of a 6-bit flash ADC chip, IC12, and two address decoding chips, IC10 and IC11. The latter allow the unit to be used with a PC-compatible computer.

Analogue data from the opto-isolator IC4 (Fig. 2) is brought to pin 11 of ADC IC12 via C28 and R51. Between them C30 and R51 filter out any high frequency noise which may be picked up in the connecting lead. Resistors R49 and R50 set the bias on IC4 pin 11 to approximately 2·5V.

Referring to IC12, when input CE is high, and $\overline{CE}$ is low, each positive-going clock pulse on pin 7 causes the chip to convert the analogue data on pin 11 to an equivalent 6-bit binary code. The conversion range is determined by the reference currents through R47 and R48. The binary code is transferred, via an internal register, to the output lines B1 to B6. If either CE is low, or $\overline{CE}$ is high, the output lines are set to a high impedance state and the conversion process is inhibited.

PC-ADDRESSING

Most PC-compatible computers usually have at least three expansion slots specifically intended for use with interface cards. The slots are connected to the computer's address and data buses and to a variety of other power and control lines. Cards housed in these slots are accessed from software by calling any address between decimal 768 and 799.

The wiring of the Y-outputs of IC10 and IC11 determines the address call to which the ADC board will respond. In ascending order from Y0 to Y7, the choice of output connections allows the required address call to be incremented by individual steps with IC10, and by steps of eight with IC11.

As shown in Fig.5, the $\overline{CE}$ input of IC12 is controlled by the Y0 output of IC10, which only goes low when a software call to address decimal 768 is made. Inputs CE and CLK are both controlled by the computer's $\overline{RD}$ (Read) line via inverter IC13a. At the moment that software makes a Read call to address 768, the ADC performs its conversion and allows data to be read from its outputs.

TEST CIRCUIT

A test circuit to assist in the checking out of the Biomet is shown in Fig.6. It is a slow-speed squarewave oscillator based around IC3a which produces an output pulse across C32. The pulse shape is not related to any known heart waveform.

The Rate preset VR5 can vary the frequency between about 30 and 300 pulses per minute. The pulse output is taken via the internal connections of socket SK3, through C33, Level control VR6 and C8 to SK1 in Fig.2.

In this mode, the signal is only amplified by the path through IC1a. The path through IC1b is held at the static reference level.

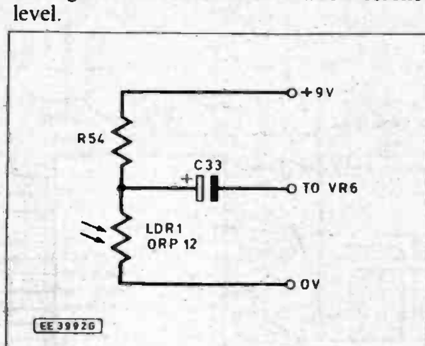


Fig. 7. Theoretical circuit of the finger probe.

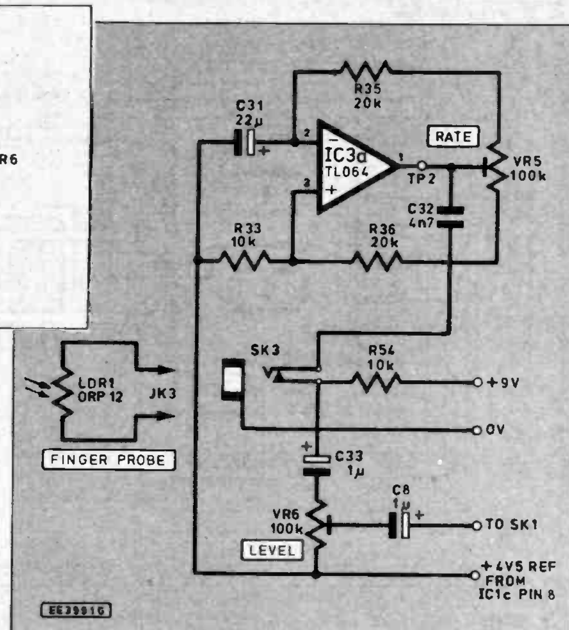


Fig. 6. Test oscillator and finger probe

FINGER PROBE

The finger probe circuit is shown fully in Fig.6 and in a simpler theoretical form in Fig.7. When JK3 is plugged into SK3, the test oscillator output is switched off and LDR1 is switched into series with R54 across the power lines.

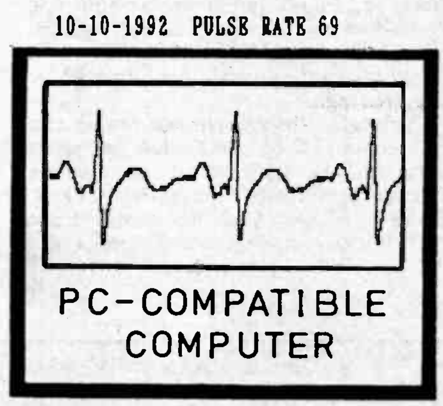
The LDR's resistance varies with changes in the amount of light falling on it, so varying the voltage at the junction with R54 and C33. As with the test circuit, VR6 presets the effective signal level.

POWER SUPPLY

The Biomet has been designed to run from a PP3-type 9V battery enclosed within the handheld case. This provides 9V to the Sensor board at about 15mA, and to the Display board at about 8mA. The ADC board and the opto-isolator is supplied by 5V, at an average of about 2mA, directly from the computer to which it is connected.

If the Biomet is to be put to frequent use, it is recommended that a rechargeable battery is used. Alternatively, a mains adapter capable of delivering at least 25mA at 9V d.c. may be used. ***However, it is essential to ensure that the mains adapter is totally safe and that under no circumstances can it allow mains voltage to be applied to Biomet and the subject to whom the monitoring probes are connected.***

A battery test circuit is shown in Fig.3. It consists of R34 and VR9 connected directly across the 9V battery power line. VR9 presets an output voltage which when switched into circuit by S2, causes the l.c.d. to display an equivalent output number.



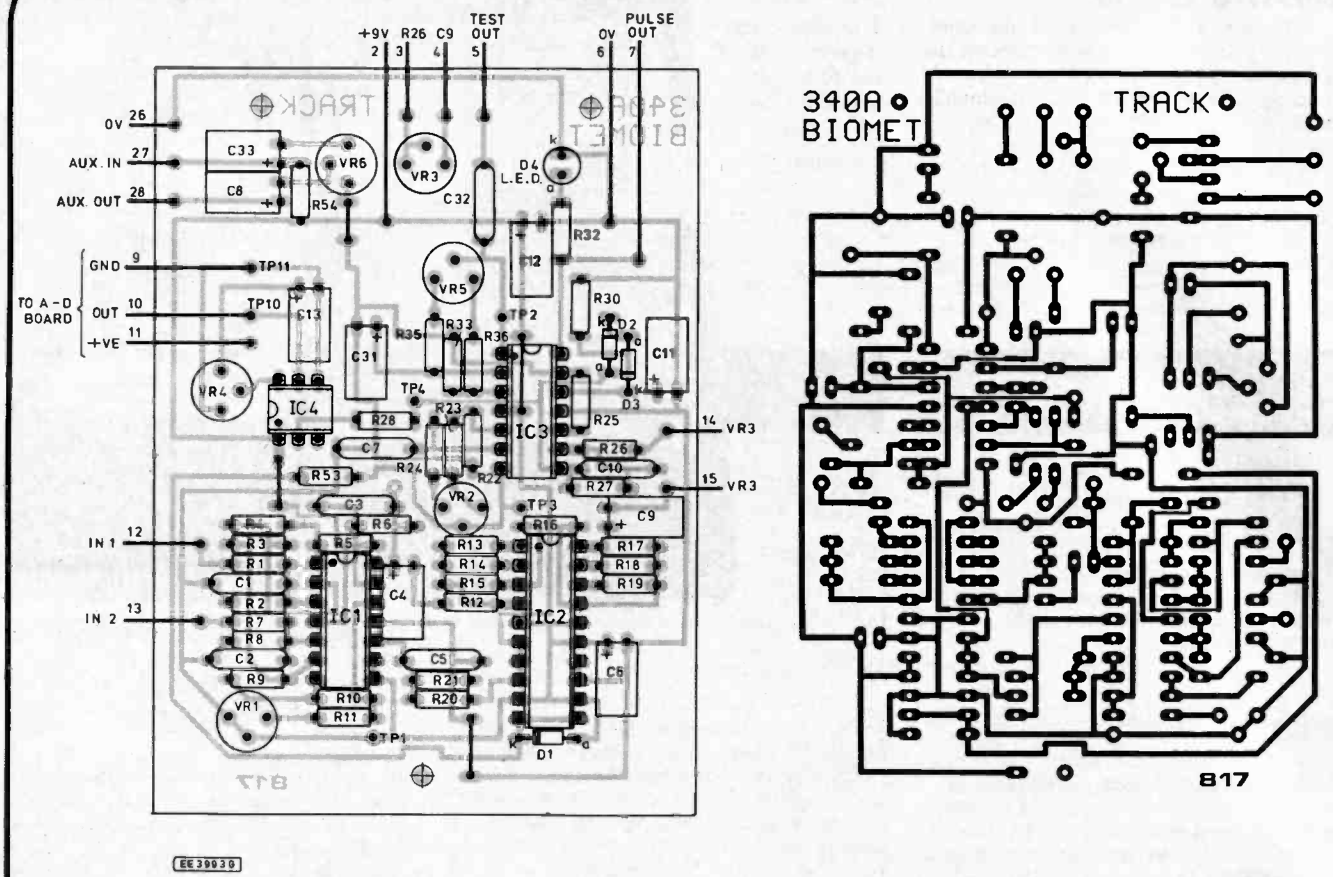


Fig. 8. Printed circuit board component layout and full size copper foil master pattern for the Sensor board. The l.e.d. and preset VR3 are only mounted on this p.c.b. if the LCD Display board is not used. All the radial electrolytic capacitors are mounted flat, see text. The 100n polyester (Philips type) are also mounted flat, some covering other components.

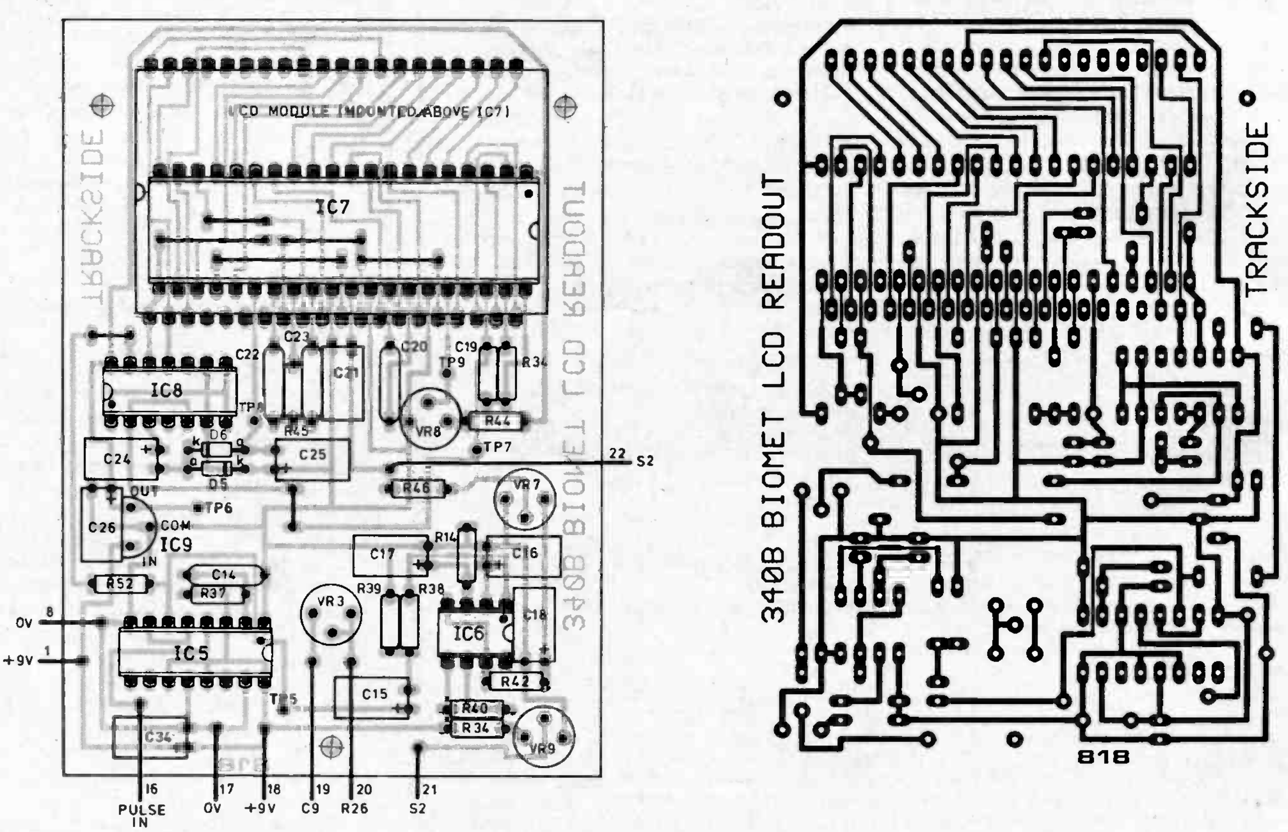


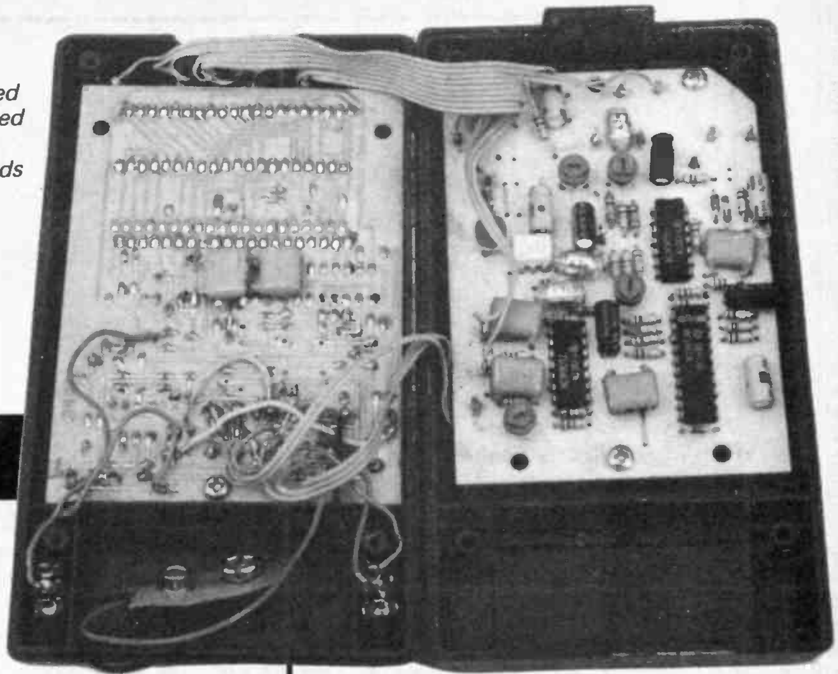
Fig. 9. Component layout and full size copper foil master pattern for the Display board. The radial electrolytics and the Philips type polyester capacitors are mounted flat on the board, some covering other components. On the prototype, capacitors C20 and C23 were soldered on the trackside.

CONSTRUCTION - MAIN UNIT

Achieving a low profile of the components is important when assembling the Sensor and Display printed circuit boards (p.c.b.s). These boards are obtainable, from the *EPE PCB Service*, codes 817 (Sensor). 818 (Display). Details of the ADC board will be covered next month.)

The component layouts and full size copper foil master patterns for these boards are shown in Fig.8 and Fig.9 respectively. They have been designed to fit into the upper and lower sections of a handheld case measuring 80mm x 145mm x 35mm and will do so comfortably providing that the following points are observed:

The completed Biomet opened out to show the two boards mounted in the case.



COMPONENTS

Resistors

R1, R7, R12, R22, R25, R33, R51 to R54	10k (10 off)
R2, R8, R27, R37, R45, R46	1M (6 off)
R3, R4, R9, R13 to R21, R30, R38 to R43, R49, R50	100k (21 off)
R5, R10, R35, R36	20k (4 off)
R6	470k
R11, R26, R28	1k (3 off)
R23, R24, R31	47k (3 off)
R29	2k
R32	470
R34	75k
R44	220k
R47, R48	220 (2 off)
LDR1	ORP12 light dependent resistor

All 0·25W 5% carbon film or better, except for LDR1

Potentiometers

VR1 to VR3, VR5, VR6, VR8	100k (6 off)
VR4, VR7	10k (2 off)
VR9	1k

All sub-min cermet presets, 7mm diameter

See SHOP TALK Page

Capacitors

C1, C2, C5, C10, C14, C20, C22, C23, C27, C29	100n polyester (10 off)
C3, C7, C32	4n7 polystyrene (3 off)
C4	4μ7 radial elect., 35V
C6,C8,C11,C13,C16,C21, C26, C30, C33	1μF radial elect., 63V (9 off)
C9,C12,C15,C17,C18,C24,C25, C28, C31, C34	22μF radial elect., 16V (10 off)
C19	1n polystyrene

Semiconductors

D1-D3	1N4148 signal diode (3 off)
D4	red l.e.d. (see text)
D5-D6	1N4148 signal diode (2 off)
IC1, IC3	TL064 quad low power f.e.t. op-amp (2 off)
IC2	MF10 dual switched-capacitor filter
IC4	H11AA1 opto-isolator
IC5	4538 dual monostable
IC6	LM2917-8N tachometer
IC7	TSC7126 l.c.d.-driving DPM
IC8	4070 quad exclusive-OR gate
IC9	78L05 5V 100mA regulator
IC10, IC11	74HC138 1-of-8 decoder/multiplexer (2 off)
IC12	CA3306CE 6-bit flash ADC
IC13	74HC04 hex inverter

Sockets

SK1, SK3	3·5mm mono jack socket (2 off)
SK2	3·5mm stereo jack socket

8-pin dil socket, 14-pin dil socket (2 off), 16-pin dil socket (3 off), 18-pin dil socket, 40-pin dil socket (see text)

Miscellaneous

S1, S2	sub-min s.p.d.t. toggle (2 off)
X1	3½ digit liquid crystal display (LCD)

Printed circuit boards available from *EPE PCB Service*, codes 817 (Sensor), 818 (Display); handheld plastic case, size 80mm x 145mm x 35mm, with l.c.d. viewing cutout; PP3 battery clip; 0·25 inch plastic jack plug (see text); 3.5mm plastic mono jack plug (2 off); 3·5mm plastic stereo jack plug; heart-monitoring electrode pads (see text – next month); miniature crocodile clips (2 off); terminal pins, connecting wire and cable; solder etc.

Approx cost guidance only **£70** *excluding electrodes*

First trim off the top corners of the Sensor board so that it avoids the internal pillars of the box. Solder in all resistors, diodes and polystyrene capacitors. Next solder in IC1, IC2, IC3, IC4, IC7 and IC9 but *do not* use i.c. sockets. You may use i.c. sockets for IC5, IC6 and IC8, which should be soldered in next.

A socket has to be used for the l.c.d. since it is mounted above IC7. As 40-pin sockets of l.c.d. width do not seem to be available, cut a normal 40-pin i.c. socket in half lengthwise to produce two 20-pin strips, and solder them into the board.

Using radial electrolytic capacitors (those which have both leads coming out of the same end), bend the connecting leads through ninety degrees so that the capacitors lie flat on the p.c.b.s, and solder them in place. Now solder in the sub-miniature preset potentiometers, which should have a diameter of about 7mm.

There is a choice of mounting position for the preamplifier Gain preset VR3. If you are building the Biomet just for use with a computer and do not want an l.c.d. readout facility, mount VR3 on the Sensor board. If you are using the l.c.d. facility, mount VR3 on the Display board.

The polyester capacitors are the familiar Philips miniature dipped case variety with a lead spacing of 10·16mm (0·4 inches). Straighten their crimped leads then bend the leads through ninety degrees so that the capacitors will lie flat when inserted into the board. Solder capacitors C20 and C23 to the back (trackside) of the Display board. The other polyester capacitors are mounted on the normal side of the board, but positioned so that they lie flat on top of any neighbouring resistors.

It is preferable to use terminal pins for the test (TP) and wiring points on the Sensor p.c.b. With the Display board, it is easier to solder connecting wires to their designated points on the track side of the board.

Thoroughly check your soldering with a close-up magnifying glass before proceeding further, paying special attention to soldered joints which have tracks running closely beside them. Make certain that the i.c.s, diodes and electrolytic capacitors are correctly orientated.

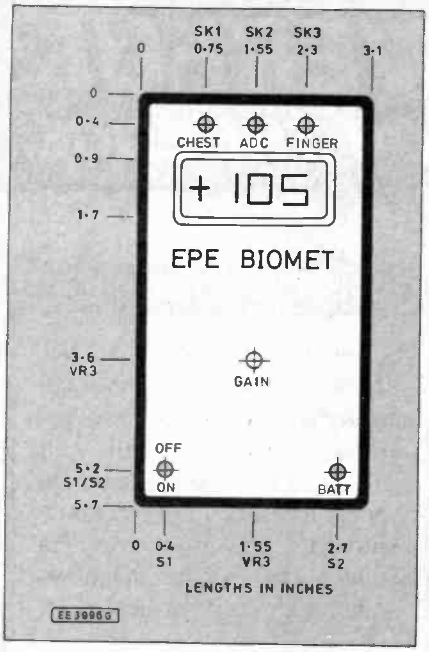


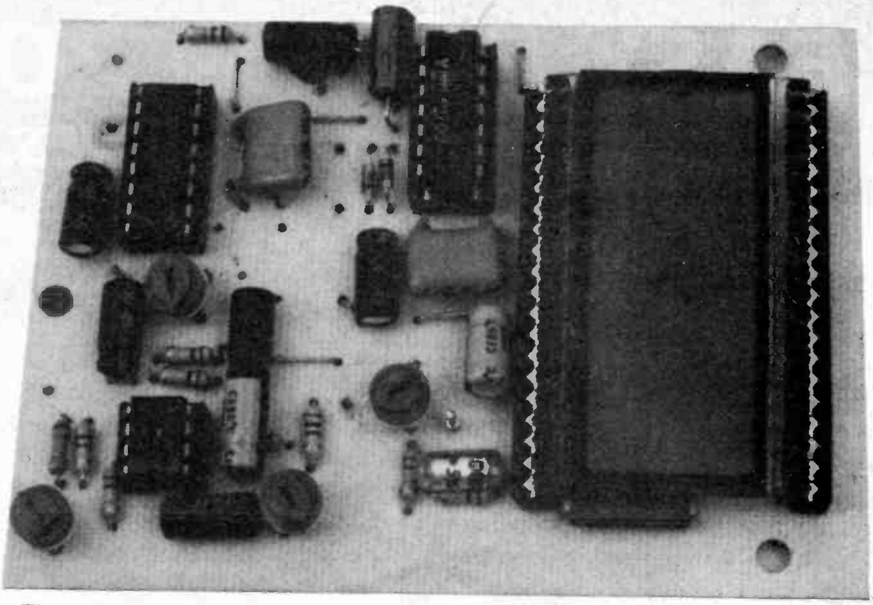
Fig. 10. Biomet case drilling details.

CASE AND INTERWIRING

Drill out holes in the case lid for the switches and sockets, plus the hole below which preset VR3 is mounted for access by a small screwdriver. Fig.10 shows the measurements as used on the prototype unit. Since case dimensions may differ slightly between manufacturers, check that the measurements suit your case before drilling.

Using the thinnest flexible connecting wire conveniently available, wire-up the boards, switches and sockets as shown schematically in Fig. 11. Keep the wiring neat so that the two halves of the case can be closed without difficulty.

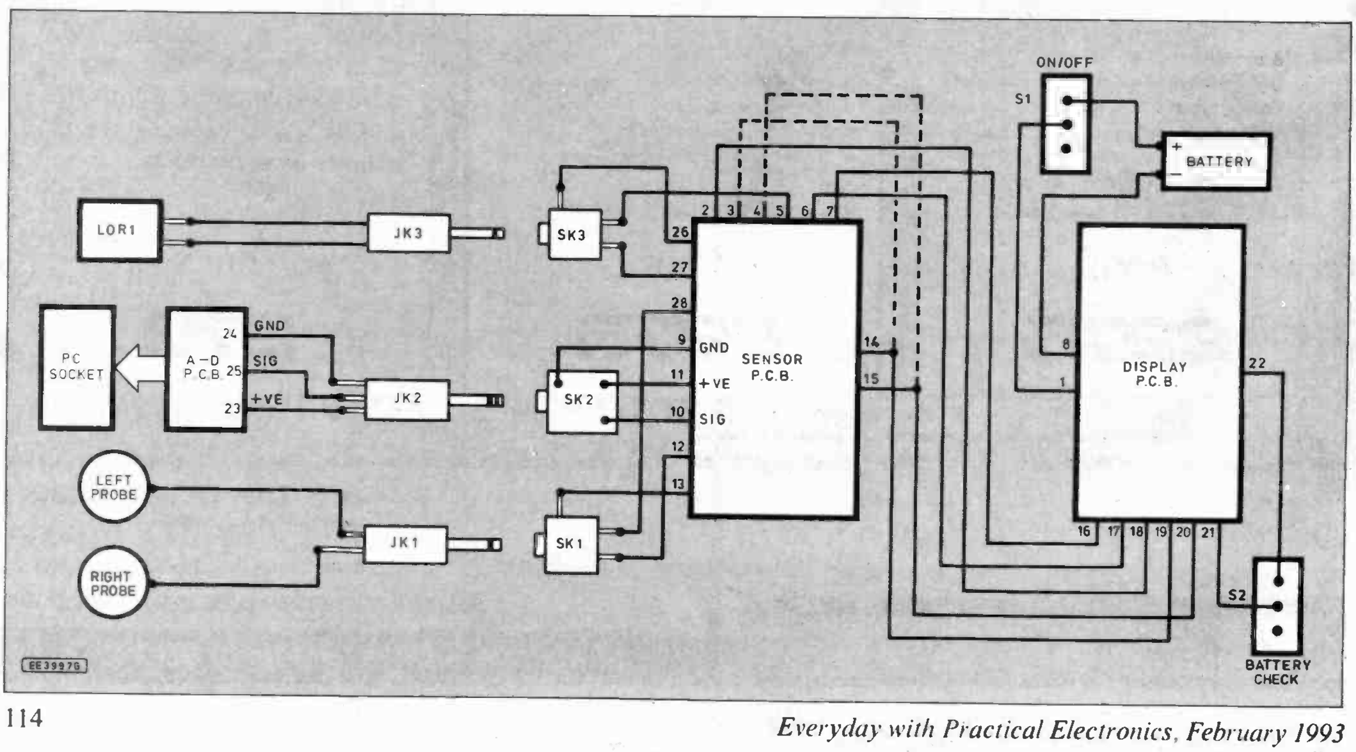
In the test model, the LDR of the finger probe was mounted across the end of the body of a plastic standard jack plug, with the rest of the plug discarded. Any other suitably sized plastic tube may be used. The connecting cable can be any reasonable length and does not need to be screened.



The completed display board. Note the display driver i.c. underneath the LCD.

Next Month: Details of the ADC computer interface board, setting-up and checking, software listing and using the Biomet Pulse Monitor.

Fig. 11. Schematic wiring details. Links 3/14 and 4/15 only used if Display p.c.b. is NOT used.



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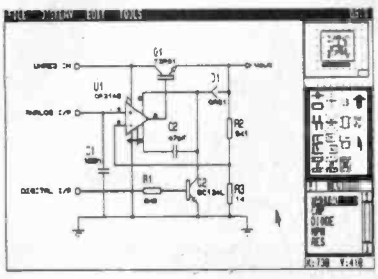

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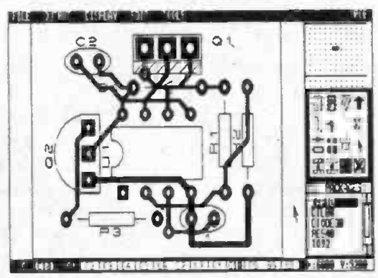

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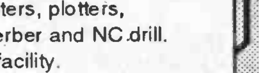

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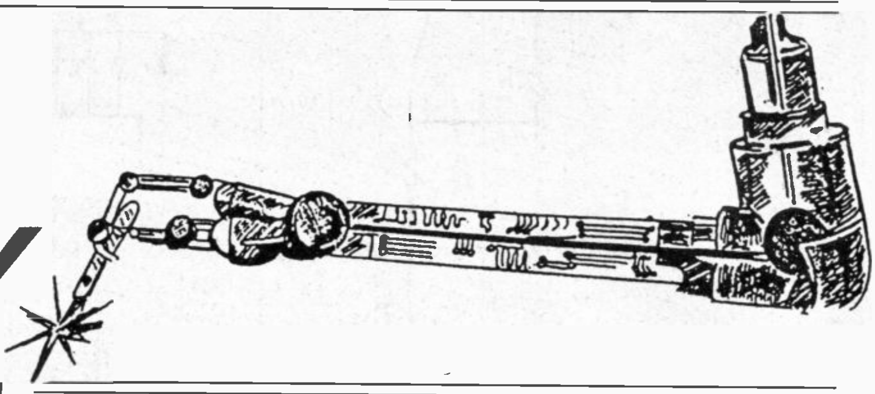
CIRCUIT SURGERY



MIKE TOOLEY B.A.

Once again, welcome to Circuit Surgery, our regular clinic which deals with readers' problems. In this month's Surgery we shall be describing a simple L.E.D. Bargraph Indicator which can be used to measure the current supplied to a car battery. We also describe some simple methods of indicating and detecting the presence of an a.c. mains supply.

L.E.D. Bargraph Ammeter

Bill Blake has written from South Africa with an interesting request for a modified version of the bargraph meter described in *Circuit Surgery* for September 1992. Bill writes:

"Here in the back of beyond EPE is available but components are another story and instruments cost a King's ransom. An add-on to the bargraph meter display that would enable auto-electricians to check the charging of alternators (0 to 90A) without disconnection would be a useful, interesting and educational article. Auto-electrics as a whole has a lot of scope not covered by any magazines that we see."

Thirteen years ago, a good friend of mine, David Whitfield, suggested that we should get together and design a range of solid-state car instruments based on a chip which had just become available, the LM3914 l.e.d. bargraph driver. The series was to include a battery condition indicator, tachometer (rev. counter), temperature gauge, dwell meter, and an ammeter.

This series gave us both a lot of fun and not a few headaches! The principal difficulty, in each case being involved with designing the circuitry and techniques used to sense the quantity being measured.

In the case of the ammeter, I decided to make use of the very small voltage drop

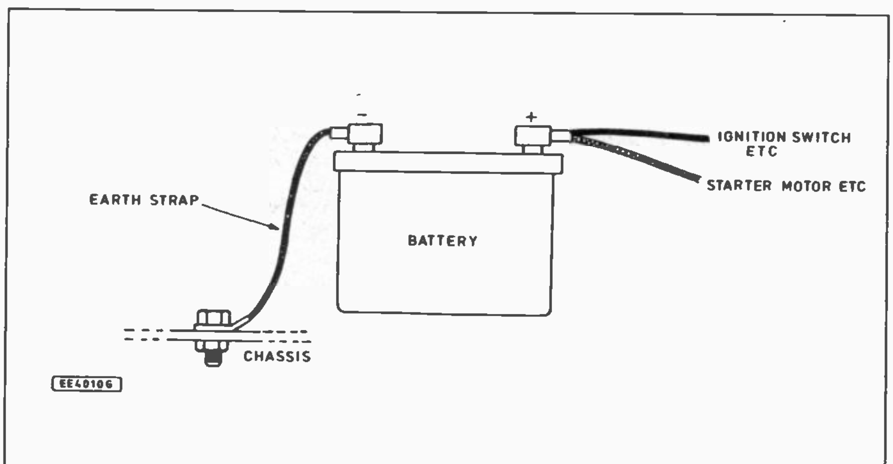


Fig. 1. Conventional car battery connections.

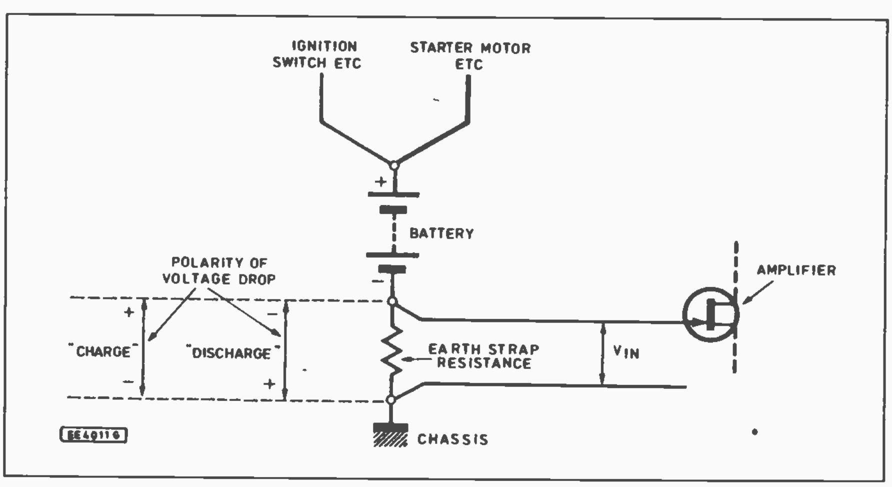


Fig. 2. Method of sensing the batery current.

COMPONENTS

Bargraph Ammeter

Resistors

R1	10k
R2	470k
R3, R4, R9	3k3 (3 off)
R5, R7	470 (2 off)
R6, R8	1k (2 off)
R10	2k2

All 0·25W 5% carbon

See SHOP TALK Page

Potentiometers

VR1	4k7 miniature skeleton preset
VR2	220k miniature skeleton preset

Capacitors

C1, C2, C3	10μ elect. 16V
C4	47μ elect. 16V

Semiconductors

D1, D2	1N4148 signal diode (2 off)
D3	BZY88 C9V1 Zener diode 9·1V 500mW
D4, D15	BZY88 C5V6 Zener diode 5·6V 500mW (2 off)
D5 to D14	10-segment l.e.d. bargraph display
TR1, TR2	2N3819 *n*-chanel field effect transistor
TR3	BFY50 *npn* silicon transistor
IC1	TL071 or TL081 operational amplifier
IC2	LM3914 linear bargraph driver

Miscellaneous

Small piece of 0·1in. matrix stripboard (size approx. 50mm x 70mm); plastic ABS case (to suit constructor's preference; 8-pin low-profile d.i.l. socket; 18-pin low-profile d.i.l. socket; solder/terminal pins (4 off); connecting wire; solder, etc.

Approx cost guidance only **£11** *excl. case*

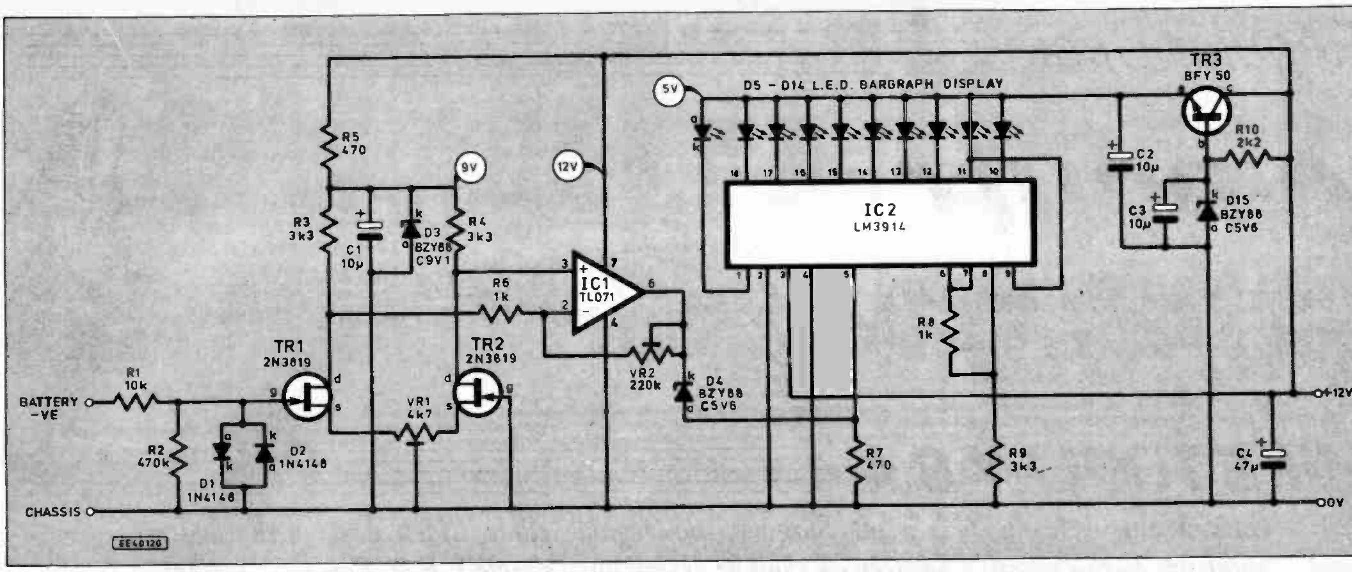


Fig. 3. Complete circuit of the L.E.D. Bargraph Ammeter.

which appears across the battery "earth strap". This connection (see Fig. 1) has a very low resistance (typically 0·002 ohm).

The voltage dropped across the earth strap resistance is directly proportional to the current flowing in it. Furthermore, the polarity of the voltage will depend upon the direction of current flow (as shown in Fig. 2). Hence it is possible to sense whether the battery is being charged or discharged.

The disadvantage of this technique is that the relatively small voltage dropped (typically 20mV for a current of 10A) will require amplification before it can be applied to the LM3914 which requires an input voltage in the range 0V to +5V.

The obvious solution is to make use of a high-gain operational amplifier. However, there is still a problem associated with the fact that the input voltage (developed across the earth strap) varies in polarity either side of 0V. This is overcome by means of a differential long-tailed pair based on two junction gate field effect transistors.

The complete circuit diagram of the L.E.D. Bargraph Ammeter is shown in Fig. 3. Diodes D1 and D2 provide input protection for the long-tailed pair formed by transistors TR1 and TR2. Preset VR1 provides a means of balancing the circuit and allows the display to be centre-zeroed.

The differential output from TR1 and TR2 is amplified by means of IC1. Preset VR2 allows the gain of this stage to be varied and this allows calibration of the ammeter. IC2 and associated components form a conventional bargraph driver arrangement.

When installed in the vehicle, VR1 should first be adjusted for a centre zero indication. Then VR2 should be adjusted for an appropriate indication as various electrical accessories are switched on. Calibration can be performed provided the power or current requirements of several items of electrical equipment are known.

If, for example, two headlights are illuminated, each rated at 60W, together with side and rear lights totalling a further 60W, the total load on the battery (engine not running) will be 120W and a current of 10A will be taken. Preset VR2 should then be adjusted to the corresponding position on the display, as required by the individual constructor.

L.E.D. mains indicator

D. Lee writes from Birkenhead:

"I would be grateful if you could advise me on how to calculate the value and component type to use so that an l.e.d. may be used as a 240V a.c. indicator."

Mr Lee has suggested the perfectly functional circuit shown in Fig. 4. It is possible to use either a capacitor or a resistor in this circuit but, in either case, the component ***must*** be appropriately rated.

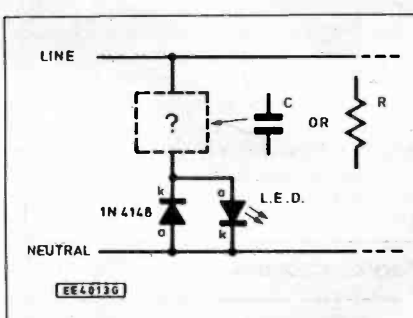


Fig. 4. Mr Lee's l.e.d. mains indicator circuit.

The l.e.d. will require an average current of around 7·5mA for a reasonably bright indication. This current can be achieved by means of a capacitor of 100nF or a 33 kilohm resistor when connected to a 240V 50Hz a.c. supply.

It is important to note that the capacitor should be rated for *continuous* mains operation (240V a.c.) whilst the resistor should be rated at 2W, or greater (note that a 2W resistor will run warm). To avoid the problems associated with heat dissipation, a capacitor is recommended in this circuit.

Mr Lee has also asked for some details of circuitry which can be used to sense the presence of a mains supply and provide a standard logic-compatible signal for a microcomputer. Fig. 5 shows a simple solution to this problem in which an opto-isolator is used to provide a very high degree of electrical isolation between the mains and the logic circuitry.

The output of the circuit is approximately 5V (logic 1) when the mains is off and 0V (logic 0) when the mains is on. Almost any opto-isolator can be used in this circuit.

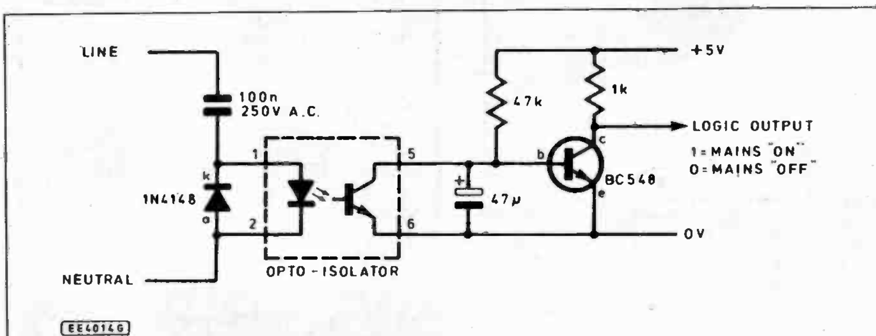


Fig. 5. Simple mains sensor based on an opto-isolator.

Thanks

Finally, my sincere thanks to *F. W. Yeates* for sending me a genuine "red spot" transistor. I had almost forgotten what these looked like!

Next month: We show how a standard 74LS00 quad NAND gate can be configured to produce all of the other logical functions. We also offer some advice concerning the selection and use of batteries. For good measure, we also hope to take a peek (pun intended) at the increasingly popular *All Formats Computer Fairs* which never fail to provide a host of bargains for would-be experimenters!

In the meantime, if you have any comments or suggestions for inclusion in *Circuit Surgery*, please drop me a line at: Faculty of Technology, Brooklands College, Heath Road, Weybridge, Surrey, KT13 8TT. Please note that I *cannot* undertake to reply to individual queries from readers however I will do my best to answer all questions from readers through the medium of this column.

Teach-In '93

with Alan Winstanley
and Keith Dye B.Eng(Tech)AMIEE

Part 4

Teach-In '93 continues a tradition of offering an interesting and thorough tutorial series aimed specifically at the novice or complete beginner in electronics. The series is designed to support those undertaking either GCSE Electronics or GCE Advanced Levels.

SO FAR, we have examined the operation of a number of electronic components which behave in a certain way, often having certain unique characteristics. An "active" component has a degree of "intelligence" – like a transistor or an op-amp, which we can control and use at the heart of a process to modify signals. Conversely a "passive" component – like a resistor or a capacitor – has characteristics which cannot change.

ELECTRONIC SYSTEMS

A very simple system is illustrated in the block diagram of Fig. 4.1. In fact you have already constructed several systems on your *Mini Lab* – like the simple Thyristor Burglar Alarm system detailed last month. The **input** could be an alarm signal from the normally-closed protection loop: the **process** consists of the thyristor which, when triggered by the input, "latches" in an alarm condition. The **output** device could be a light-emitting diode or the *Mini Lab* buzzer.

Similarly the *Mini Lab* L.E.D. Voltmeter you constructed in Part Two is a *voltage-measuring system* which can readily be divided into simple building blocks, summarised like this:

SYSTEM PURPOSE:
To enable a voltage level to be measured and displayed clearly.

BUILDING BLOCKS:	FUNCTION WITHIN THE SYSTEM:	SUB-SYSTEM CONTENTS:
Input	Monitors the input voltage level	Range selector & Potential Dividers
Process	Measures the input voltage	LM3914 integrated circuits
Output	Displays the measured voltage	20 light-emitting diode scale

It is useful when designing or interpreting electronic circuits to split them into simple building blocks or "black boxes" which perform certain tasks within the system. It is then often easier to think about a block or "sub-system" rather than a number of components inside it. The lines which you

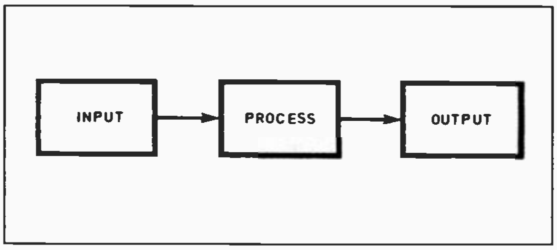


Fig. 4.1 Block diagram of a simple system. The lines connecting the blocks represent flows of information rather than electric current.

draw to interconnect the sub-systems of your Systems Diagram then represent a *transfer of information* rather than an actual current flowing through components. This is different to the lines we draw in circuit diagrams, which of course represent *conductors* connecting the circuit together.

Designing the system then becomes a matter of specifying the individual sub-systems, ensuring that the information which passes from one block to the next is in a suitable form which the subsequent sub-system can recognise. Ensuring that the information which is generated by one building block is compatible with the input requirements of the next, is called **interfacing**. We deal with other forms of interfaces in future topics.

TRANSDUCERS

A **transducer** is simply a device which converts one form of energy into another. An *input transducer* has a mechanical (i.e. non-electrical) input and is used to generate an *electrical output* which we can utilise as the input stage of a system. In other words, they convert physical forms such as heat, light, pressure or sound into an electrical signal. Input transducers often need additional electronic components to do this. Fig. 4.2 illustrates the appearance of some input transducers.

Looking at the other end of our system, an *output transducer* converts an electrical signal into a non-electrical form, such as light, sound or motion. You will recognise some output transducers shown in Fig. 4.3.

A method of using an input transducer to measure light levels is shown in Fig. 4.4(a). R1 is a pull-up resistor (see Part One) and R2 is a **light-dependent resistor** (l.d.r.), sometimes called a photo-conductive cell. Do you recognise the circuit as a potential divider?

Obtain a suitable l.d.r. such as the popular ORP12 type and then assemble this simple circuit on your *Mini Lab* breadboard, connecting to the Power Supply section as shown in Fig. 4.4(b). Note how one of the filament bulbs is used as a light source, and the +12V voltage supply is the supply rail for the transducer circuit.

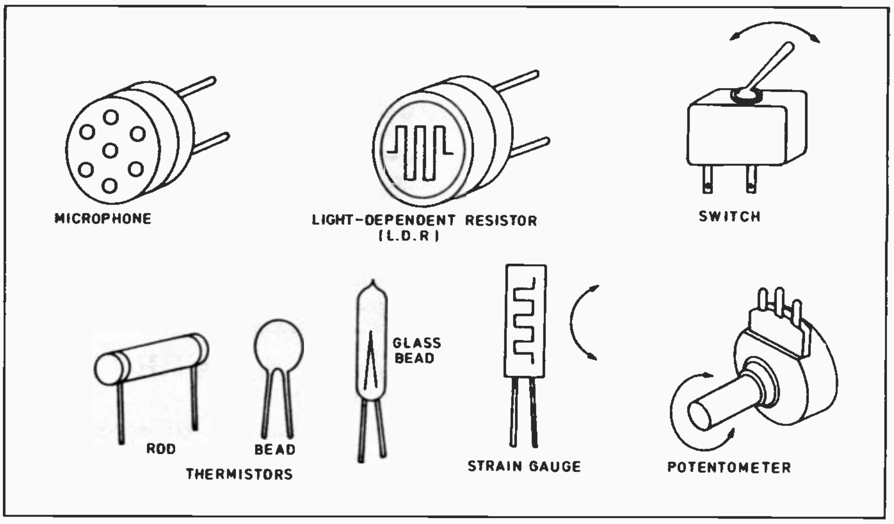


Fig. 4.2. Illustrating a selection of input transducers.

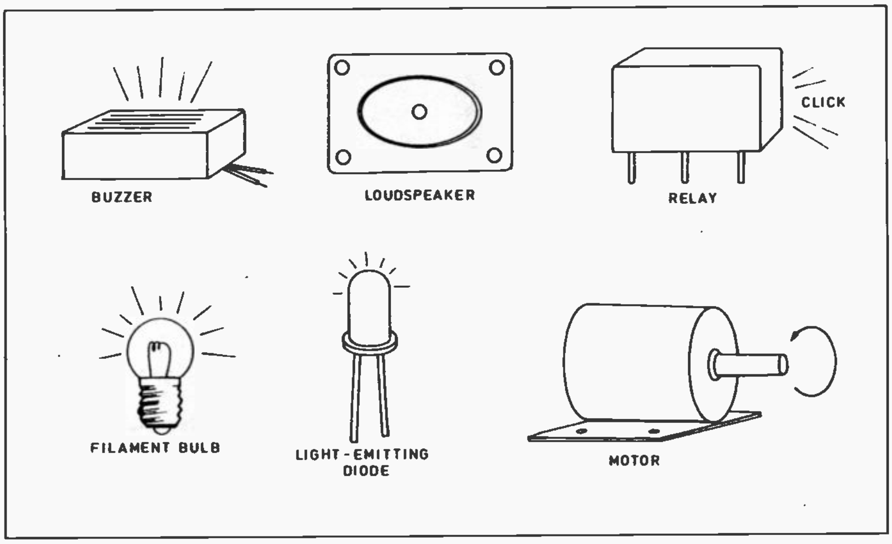


Fig. 4.3. A range of output transducers.

Position the l.d.r. so that it is pointing at the bulb. The L.E.D. Voltmeter is set for 5V f.s.d. and is connected to the junction of R1 and R2. (There's no need to hook up the 0V terminal of the voltmeter because this connection is always ready-made to 0V by the *Mini Lab* p.c.b.) Finally, switch on the Transformer Unit followed by the +5V and +12V rails. A small piece of cardboard is required next: place the cardboard in between the l.d.r. and the bulb – what happens to the voltmeter reading? Move the cardboard around and observe the l.e.d. scale, and record your readings below.

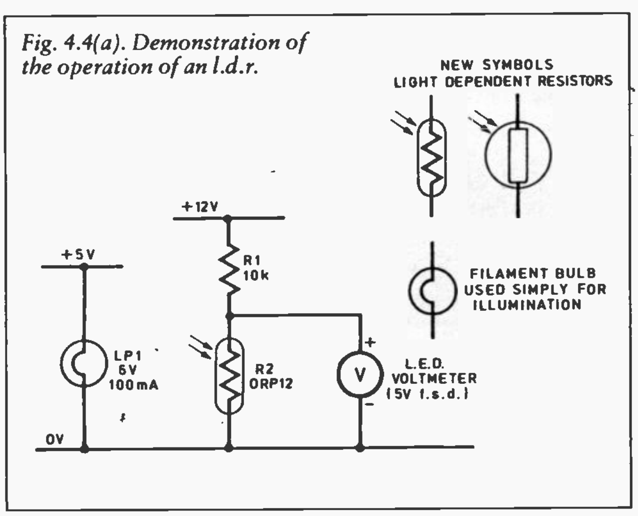


Fig. 4.4(a). Demonstration of the operation of an l.d.r.

Fig. 4.4(a)	L.E.D. VOLTMETER READING (VOLTS)
Cardboard in position (l.d.r. darkened)	
Cardboard removed (l.d.r. illuminated)	

Clearly, the voltage at the junction of R1 and R2 is *higher* when the l.d.r. is darkened, and when the card is removed, the l.d.r. is exposed to light and the measured voltage *reduces*. Can you work out what is happening to the resistance of the light-dependent resistor when the light level changes?

When the light falling on the l.d.r. *increases*, its resistance *decreases*. This causes the junction of R1 and R2 to be moved towards the 0V rail because of Potential Divider action, so the voltage is seen to fall. Conversely when the l.d.r. is obscured, its resistance will *rise*, pushing the measured voltage towards the +12V rail.

LIGHT SENSITIVE UNIT

This simple technique forms the basis of a *light-sensitive* unit which is capable of converting ambient light levels into information in the form of a varying voltage. The output of the unit is taken from the junction of R1 and R2 as shown in Fig. 4.4(c).

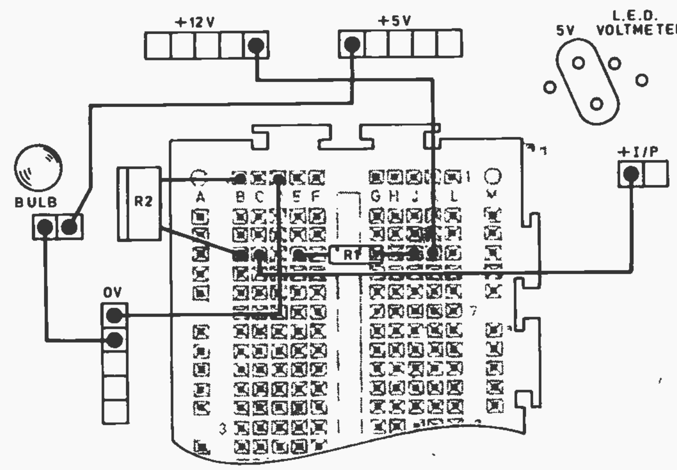


Fig. 4.4(b). Mini Lab connection for the l.d.r. demonstration. The 0V sockets near R2 are new: see constructional details.

If however we require a reverse effect, such that the output voltage *rises* when the light level increases, then the circuit of 4.4(d) could be used. The l.d.r. and resistor (now a "pull-down" resistor) are transposed. Build this on your *Mini Lab* and prove it.

A typical light-dependent resistor like the ORP12 may have a resistance of only 1 to 2k or less in bright light, possibly increasing to several megohms in total darkness (check it with the resistance range of your multimeter). Those who are mathematically inclined might thus be able to *calculate* the output voltages using the Potential Divider formula from Part One.

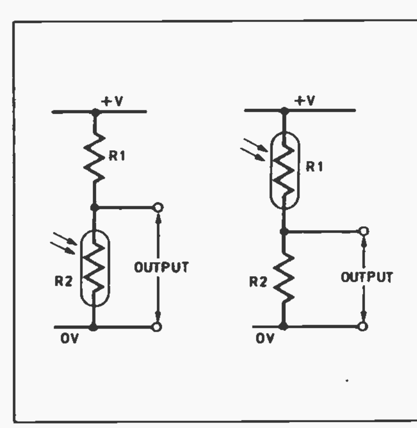


Fig. 4.4(c). (left) The output falls when the light level upon R2 rises. (d) (right) Output rises when the light level rises.

TEMPERATURE SENSOR

A **thermistor** is a temperature-sensitive resistor. Several different shapes and sizes are available including the relatively cheap and durable *rod* and *bead* types, as shown earlier in Fig. 4.2. In order to demonstrate their action, we recommend purchasing a budget-price bead or rod device, *not* a glass bead variety. Often, catalogues specify the resistance of the thermistor at 25 degrees C., so purchase one which is rated at roughly 5k at 25 degrees. Any general-purpose thermistor costing well under £1 will suffice.

The schematic symbol for a thermistor is detailed in Fig. 4.5(a). See if you can use the *Mini Lab* yourself to build this demonstration circuit in the same way as the light-sensitive unit described earlier. Simply connect the thermistor and fixed resistor across the +12V rail, mounting both devices on the breadboard. Don't forget to switch on the +5V supply for the L.E.D. Voltmeter.

Monitor the voltmeter reading and note down your reading below. Then hold the thermistor between finger and thumb in order to warm it up. What happens to the output voltage? The change won't be as dramatic as that of the l.d.r.!

Fig. 4.5(a)	L.E.D. VOLTMETER READING (VOLTS)
Thermistor at ambient room temperature	
Thermistor warmed up between finger & thumb	

We see how the output voltage *reduces* in this circuit when the temperature of the thermistor *increases*. This means that the thermistor's resistance falls when its

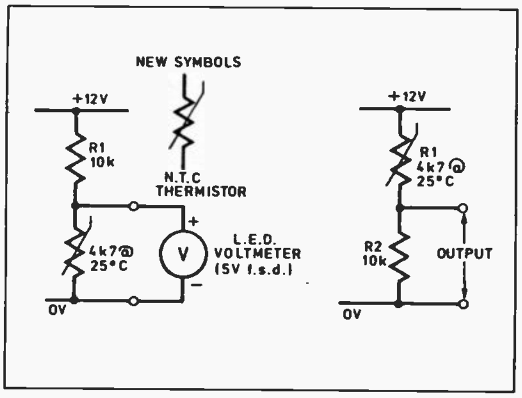


Fig. 4.5(a) (left) Thermistor demonstration circuit. (b) (right) Output rises when the thermistor temperature increases.

temperature rises – just like the l.d.r.'s resistance drops when the light level rises. The reverse effect will be observed if you assemble Fig. 4.5(b) on your *Mini Lab.*

The problem with these basic thermistors is that they can't respond instantly to temperature changes. You will have noticed that the reading on the L.E.D. Voltmeter doesn't really change much when the thermistor is warmed up, so the transducer is not particularly sensitive. Glass bead thermistors are more delicate than rod or bead types but respond much more quickly to temperature movements. And so they should – they cost ten times more!

Because the thermistor's resistance drops when the surrounding temperature rises, we say that it has a **negative temperature co-efficient**, abbreviated to *n.t.c. thermistor.* This characterises the most common types of thermistor, though positive temperature co-efficient (p.t.c.) thermistors are sometimes available too: they work in reverse.

TRANSISTOR SYSTEMS

We have now described two input units which utilise input transducers to respond to changes in ambient conditions: light levels and temperature. To make use of them, it's necessary to *interpret* the information they provide in the form of a varying voltage – i.e. an analogue signal – and process this information using a system, more of which shortly.

In 1948, three Americans (Bardeen, Brattain and – appropriately – Shockley) perfected a new component called a "transfer resistor" which was to totally change the face of electronics. It became known as the **Transistor.** It is a founder member of the class of semiconductors, and its purpose in life is extremely simple: when you feed it with a suitable small electrical signal, the transistor causes a larger "wiggle" to appear elsewhere in a higher voltage circuit. So in effect it *amplifies* small signals by making a larger voltage wiggle in sympathy.

In fact we will take a look at the amplifying characteristics of the transistor later on. Take a look at Fig. 4.6(a) which shows a transistor in a very simple circuit. TR1 is an *npn* **transistor**, type ZTX300 – a very cheap and common device which you can purchase from any electronics retailer. Buy some! Transistors come in two flavours – *npn* or *pnp.* Think of them as negative-positive-negative (*npn*) or vice-versa for *pnp* types. We'll be concentrating on the *npn* variety, because they're easier to understand and more popular.

As you can see from the circuit diagram, the transistor has three terminals: **emitter, base** and **collector.** Which one is which is clearly identified in the diagram, where we annotate each terminal with "e", "b" or "c" respectively. Firstly, you can see we have connected the emitter directly to 0V – that's O.K. because the arrowhead in the *npn* transistor symbol tells you that current can only **flow out** of the emitter (to 0V in this case), not into it. A bulb, LP1, is connected as a load between the collector terminal and the +5V supply.

remember that layout diagrams, where given, show an aerial (bird's eye) view of all components, including transistors. It is also common practice to show the underside view of transistor packages separately, so it is impossible (theoretically) to confuse the lead-outs. But we've all done it!

TRANSISTOR SWITCHES

In its simplest form, the transistor can be made to act as a *solid state switch* which, like a normal mechanical switch, is either on or off. When you are happy that everything is correctly and soundly constructed, switch on the 5V power supply – rotate VR1 to and fro – what happens to the bulb?

Your ZTX300 transistor is currently wired on the *Mini Lab* as a switch which can be made to drive a filament bulb. Now connect the +I/P terminal of the L.E.D. Voltmeter (2.5V f.s.d.) to the *base* terminal of TR1 on the breadboard. Rotate VR1 as before, watching the bulb dim or glow accordingly. What do you notice on the voltmeter?

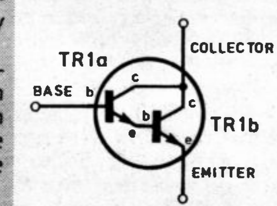
The bulb will *not* illuminate when the voltage at the base of the transistor is much less than roughly 0.7V. The *base-*

THE DARLINGTON TRANSISTOR

These semiconductor devices contain two transistors TR1a and TR1b in one package, interconnected as represented by their schematic symbol, see below. Thus TR1a provides the base current for TR1b. If the gain of each transistor is say 100, then the base current for TR1a is only 1/100th of its collector current; however this same collector current also forms the base current for TR1b and is only 1/100th of TR1b collector current.

The effect is that the gain of the *overall package* is equal to the h_{FE} of TR1a multiplied by that of TR1b – so the h_{FE} of this *npn* Darlington transistor TR1 would be **10,000.** This is much higher than the transistors we have utilised so far. It would also be possible to construct an equivalent circuit using two individual transistors like the ZTX300, but the combined package is clearly more convenient.

The other major difference is that there are *two* base-emitter junctions within the Darlington transistor, which means that the base must be about **1.4V** more positive than the emitter for the Darlington to conduct. Have a look in the Transistor Data section of a good catalogue and compare the h_{FE} ratings yourself against other types.



Finally, VR1 is a 4k7 preset wired across the 5V supply, its wiper connected through resistor R1 to the base terminal of TR1. You should now assemble this circuit on your *Mini Lab* in accordance with Fig. 4.6(b). Follow this diagram closely to ensure that you connect your transistor the right way round. We also show the underside view of the ZTX300 transistor, to help you orientate the leads.

In our experience, the biggest source of disappointment when studying electronics arises through wrongly connected transistors. They will only *function* correctly when they are *connected* correctly. You should

emitter junction of the transistor actually behaves like a diode. Remember that a silicon diode has to be forward-biased by 0.7V before it conducts. Likewise an *npn* transistor requires the base terminal to be 0.7V more positive than the emitter before current will flow through the transistor.

Rotating VR1 varies the voltage at TR1 base terminal and when it finally reaches 0.7V, current is then able to flow from collector to emitter, completing the circuit to the bulb which illuminates. This might not appear to be of much use, especially when there are simple mechanical switches which do the same job. However the transistor

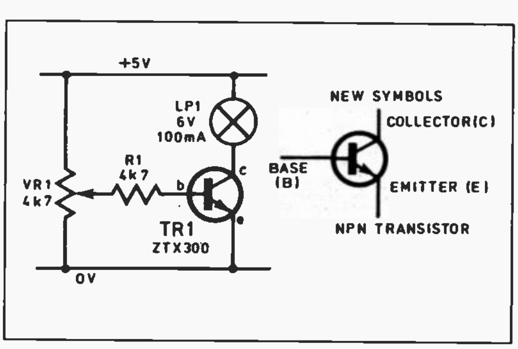


Fig. 4.6(a). Basic function of the npn transistor.

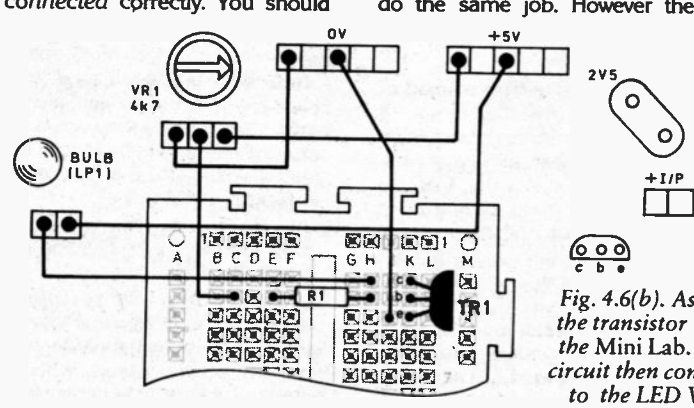


Fig. 4.6(b). Assembly of the transistor circuit on the Mini Lab. Build this circuit then connect TR1 to the LED Voltmeter.

has characteristics which enable them to *process information* provided by an input system, such as the light-sensing unit described earlier.

GAIN

For instance, transistors have an amplifying characteristic called *gain*. It is given the symbol h_{FE} and is determined by the formula:

$$h_{FE} = Ic/Ib$$

where Ic is the *collector current* and Ib is the *base current*.

In Fig. 4.6(a), the base current will be that flowing through the *base resistor* R1, whilst the collector current will be the current flowing through the bulb into TR1 collector terminal. Then both the base and the collector currents combine within the transistor and flow out of the emitter to become the *emitter current*. In fact, the base current is so small in comparison that we often ignore the fact that it's included with the much larger emitter current.

The h_{FE} parameter for our ZTX300 transistor is stated in the supplier's data to be about 150 when the collector current is 10mA. This means that if a collector current (Ic) of 10mA is flowing, then the base current (Ib) is only 150th of this – roughly 60 microamps. *So only a small current is needed to flow into the base terminal for a larger current (Ib × h_{FE}) to flow as collector current.* The simple transistor switch used in Fig. 4.6(a) is therefore a **current amplifier.**

Let's analyse this circuit a little more. By rotating VR1 we are controlling the voltage at TR1 base. R1 is included as a precaution so that when VR1 is moved round to the +5V rail, the base current is limited to a safe value to prevent damage. The collector current we require in our transistor switch is 100mA, so the base current required is about 150th of this – 0.7mA roughly. (It's not necessary to be precise.)

Transistor TR1 will only switch on when the base is at 0.7V with respect to the emitter (itself at 0V here). So to turn on TR1, the base resistance has to waste 5V – 0.7V = 4.3V. The required base current is 0.7mA, so we can easily work out the value of the base resistor using Ohm's Law:-

$$Rb = 4.3/0.7mA = 6.1k$$

In fact, h_{FE} is not really a reliable specification, because it can vary enormously between individual transistors. Manufacturers often quote a *spread* of h_{FE} such as 100-500, or specify an h_{FE} at a particular collector current. You might observe that the bulb can be made to glow *dimly* but is only fully on once the base is at 0.7V or so. When we use transistors as simple "on-off" switches, it's best to ensure that they do indeed turn the load hard on, by allowing more base current to flow than the calculation for Rb above might suggest.

SATURATION

Hence we used a 4.7k resistor instead of 6.1k for R1 which ensures that plenty of base current flows when VR1 is set at +5V (but not so much as to damage the transistor). This is a safe way of ensuring that the transistor is hard on. The term **saturation** is used to describe a transistor which is turned fully on and which can't turn on any more. Under these circumstances, the collector is almost at 0V and so the "saturation voltage" between emitter and collector is almost nil.

Some of the most popular transistor packages are shown in Fig. 4.7. There's an endless list of transistors available in both

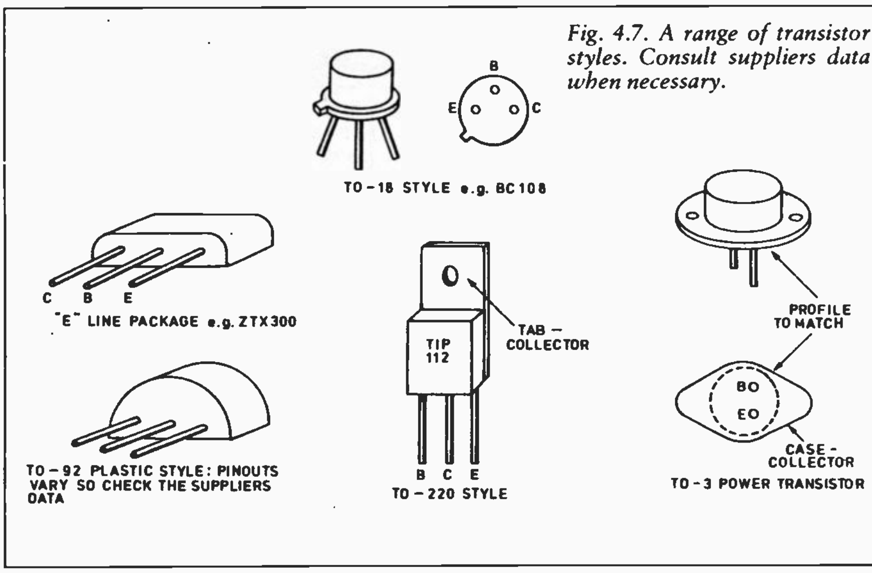
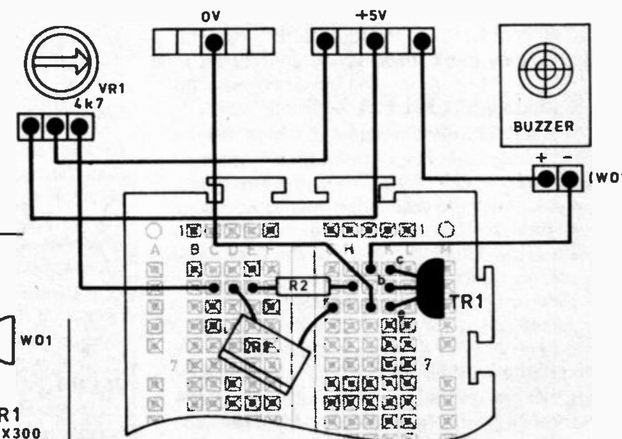


Fig. 4.7. A range of transistor styles. Consult suppliers data when necessary.



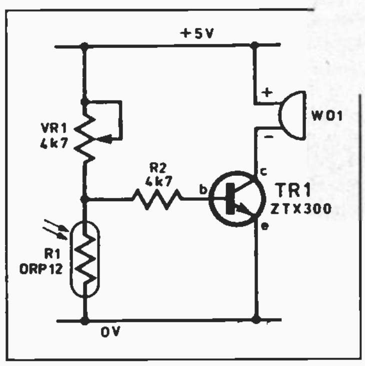


Fig. 4.8(a). (left). A light-sensitive switch using a single transistor.

Fig. 4.8(b). (above). Mini Lab *interwiring diagram for the light-sensitive switch.*

flavours; they all have individual and unique code numbers such as 2N3055, BC108, BD534 – or ZTX300. They are also made in a variety of sizes and shapes and although they might look different, or have different part numbers, you can often find a *substitute* for a particular transistor which will have the same characteristics and which will probably work successfully in your circuit.

ELECTRONIC SWITCH

You have now constructed your first *solid state switch* which can form the heart of a simple process capable of utilising any of the sensing units described earlier. Fig. 4.8 is the circuit diagram for a complete **light-sensitive switch** which uses an l.d.r. to detect ambient light and operate a buzzer at a certain level. Can you predict how the buzzer responds to bright light or to darkness?

Now assemble this circuit on the breadboard using the +5V rail, as shown in Fig. 4.8(b). The buzzer replaces the bulb in the collector circuit, and you should ensure that both the buzzer and the transistor are orientated correctly. Set VR1 to midway then switch on, and the buzzer may or may not sound. Illuminating the l.d.r. with a torch (or one of the *Mini Lab* bulbs) should silence it – experiment by adjusting VR1 as necessary.

How does it work? VR1 and R1 form a light-sensitive potential divider, the action of which we proved earlier. When R1 is subjected to a beam of light, its resistance falls dramatically and this prevents the base of TR1 from reaching 0.7V, so the buzzer is silenced. When R1 is darkened, its resistance increases which pushes the base towards the +5V rail – so when it reaches 0.7V, the transistor will switch on and drive the buzzer. Can you think of any applications – perhaps a light-beam burglar alarm, or a "People Counter" at a turnstile?

The diagram of Fig. 4.9 is a similar circuit except the light-sensing unit is reversed. Also, a relay is used instead of the buzzer. Note how a back-e.m.f. protection diode D1 is necessary across the relay coil – this prevents the relay from damaging the transistor when it switches *off* – see Part Two. The diode should now already be built into the *Mini Lab* so you must connect the relay coil the right way round: a reverse connection might damage the transistor and the diode.

To refresh your memory on relay operation, we added a bulb which is switched by the normally-open contacts RLA1. Now, when torchlight falls onto R1, its resistance reduces and this causes the base voltage to rise – when it reaches 0.7V, TR1 turns on which completes the circuit to the relay. The contacts RLA1 closes and the bulb lights.

Check out the operation of this circuit after building it yourself on the *Mini Lab*, adjusting VR1 as required: it functions in reverse to the circuit of Fig. 4.8. You will increasingly find that we will not always show a *Mini Lab* layout diagram – you should by

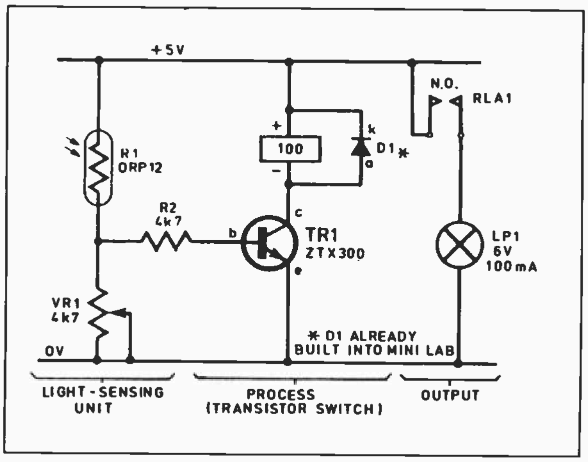


Fig. 4.9. Light-opeated switch system.

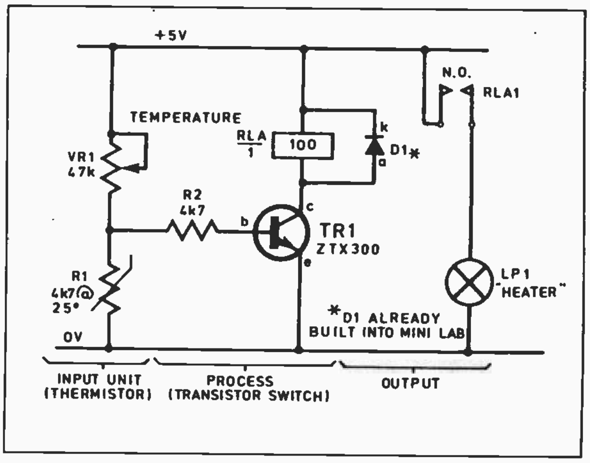


Fig. 4.10. An electronic thermostatic system.

now be able to work out the simple arrangements yourself, just referring to the circuit diagram. We will, of course, give you all the connection data you need to construct the circuit successfully.

THERMOSTAT

A very simple **thermostat** which uses a thermistor-based input unit with a 47k preset is shown in Fig. 4.10. When the thermistor cools down, its resistance increases which pushes the base towards +5V. TR1 will switch on when the base voltage reaches 0.7V. Imagine the bulb as a heater in the same room as the thermostat: it will turn on automatically when the thermistor has cooled down to a level determined by VR1. Then the "heater" will switch on and warm up the room and the thermistor, the resistance of which now lowers until eventually

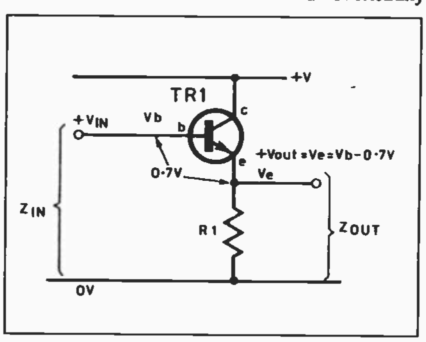


Fig. 4.11. Emitter follower transistor configuration. Also refer to the section on "Impedance".

TR1 and the "heater" turn off again. The circuit will cycle like this automatically, maintaining a temperature which can be controlled by adjusting VR1.

Go ahead and build this on the *Mini Lab* if you wish, but you will probably find that with the rod or bead thermistor used earlier, it is quite slow and insensitive in action. The only useful way of demonstrating its operation is to alternately spray the thermistor bead with a freezer aerosol, then warm it up between finger and thumb. The bulb switches on when R1 is cold, and switches off when it's warmed. You could reverse this action by transposing VR1 and R1, or by using the *normally-closed* contacts of RLA instead.

This automatic thermostat utilises the principle of **feedback**. The processing subsystem (TR1) demands information (feedback) so that it senses when the room is warm enough, in order that it can turn the heater off. Without this "knowledge", the heater would simply keep burning away uncontrollably. Feedback is an essential element in any control system such as this, where temperature is fed back to the thermistor input system, which is always "looking for" the desired temperature level at which point it will operate the heater accordingly. We investigate other forms of feedback in Part Five, when we look at analogue processing systems in greater depth.

This very basic circuit would require some further refinement to turn it into a truly practical thermostat. The main problems are the lack of sensitivity plus the slow transition times between the "on" and "off" states, which result in relay arcing and interference for several seconds when the relay switches. For best results, what's needed is a true "snap-action" circuit such as the *Schmitt Trigger* which we look at next month.

EMITTER FOLLOWER

Up to now, our simple transistor systems have used a transistor with the emitter grounded to 0V. Fig. 4.11 illustrates another useful configuration called the **emitter follower**. Here, the collector of TR1, an *npn* transistor, is connected to the positive supply whilst the emitter is now connected through an *emitter resistor* R1 to ground. As the emitter voltage is always 0.7V below the base voltage (Ve = Vb–0.7V) then the emitter will simply *follow the changes in the base voltage.*

The emitter follower circuit has a higher *input impedance* (refer to the separate section on Impedance) than the output impedance, so this type of circuit is often used to match a system which has a high *output impedance* to a *load which has a low input impedance.* Refer to Part One and the section on "Potential Dividers" and the "Ten Per Cent Rule" for an explanation of these loading effects. This impedance-matching necessity is often called **buffering a signal**. For example, an input transducer which has a high output impedance such as a crystal microphone (1M or more) cannot drive a load with a much lower impedance like a loudspeaker (e.g. 8 ohms), without a system to match the impedances which ensures that we optimise the signal transfer between the two devices.

In the emitter follower, the amount of buffering offered is determined by the transistor's h_{FE} specification or "parameter". Fig. 4.12 shows how the 10k impedance of an input transducer like a microphone needs an impedance converter (buffer) to drive a 1k load impedance which could perhaps be the input stage of a hi-fi amplifier. The *voltage* across this load (= Ve) is nearly the same as the source output (= Vb) which appears across the 10k source impedance. Given that Ve = Vb–0.7V, there's only a base-emitter drop of 0.7V difference between the source and load voltages.

However, a larger *current* flows in the emitter resistor R1 because it has a lower resistance than the source impedance. Thus, the voltage across the load is roughly equal to the voltage across the source, but a larger current is flowing. An emitter follower **amplifies current, not voltage.**

The formula

$Zin = (h_{FE} + 1).Re = h_{FE}.Re$ (approximately)

calculates the degree of buffering, and is the **input impedance of the emitter follower transistor.** A ZTX300 has an h_{FE} of roughly 150, so the input impedance of this stage would be 150k – so it won't load the source impedance of 10k. You can perhaps see how the impedance of the source is buffered so that it won't be shunted by the load: this helps to avoid any distortion or degeneration of the signal.

BIASING

The previous example of an emitter follower driven by a signal source will only work when the signal is positive with respect to ground. For a signal *below* 0.7V, the transistor will be turned off and so the output of the emitter follower will be at 0V, being pulled down by the emitter resistor.

A sine wave signal is shown in Fig. 4.13 where the input signal applied to an emitter

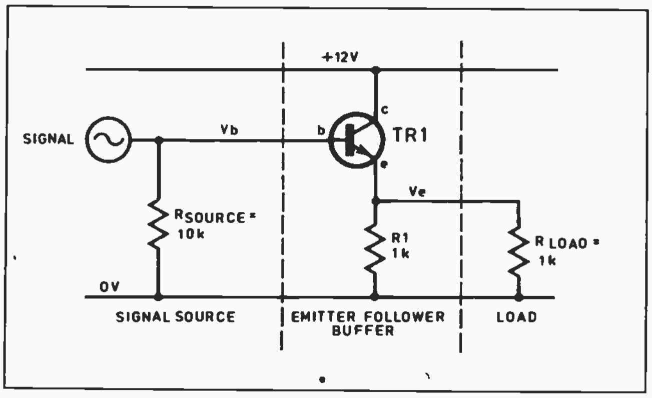


Fig. 4.12. Using an npn *transistor as a buffer to prevent excessive loading of a signal.*

follower is symmetrical around the 0V rail. The *output voltage seen at the emitter* will contain only the positive half of the sine wave, because the transistor cannot conduct when the base-emitter junction is reverse biased (i.e. when the emitter is more positive than the base). The output signal is said to have been **clipped**. (In fact transistors are damaged if the base-emitter junction is reverse biased by more than a few volts.)

To "see" the negative half of the sine wave signal at the emitter, we need to **bias** the input d.c. conditions to about halfway between the supply rails, as shown in the practical emitter follower of Fig. 4.14. The a.c. input signal is now **level-shifted** and can be seen at the buffer output (TR1 emitter) in its **full** glory! Let's examine this important circuit more closely.

If R1 equals R2 in value, then the voltage at TR1 base must be held firmly at +6V. The emitter will therefore be 0.7V less than this, i.e. 5.3V. Now there is room for both positive and *negative voltage* changes to be seen across the emitter resistor R3 and the output voltage can now swing from a centre value of 5.3V. In fact the sine wave could be up to 10.6V **peak-to-peak** before clipping occurred. Work out why.

The values of R1 and R2 have to be chosen to hold the base at the required voltage whilst enabling the input to pull the base voltage up and down. If the resistors are too low in value then they will load the signal source undesirably – a case of mismatched impedances again. A rule of thumb is to set the impedance of the two resistors *in parallel*, to 1/10th the input impedance of the emitter follower stage. Using the formula $Zin = h_{FE}.Re$ (see earlier), the input impedance is about 560k assuming an h_{FE} of 100. So the impedance of R1 *in parallel* with R2 should be about 1/10th of this or 56k.

Capacitor C1 performs an important **function**: it *couples* the a.c. sine wave signal from the signal source to the emitter follower without upsetting the d.c. bias network of R1 and R2. The capacitor blocks d.c. voltages but allows a.c. signals to pass through. The effectiveness of such a circuit is demonstrated in the next experiment.

The next section requires the use of the Mini Lab 8038 Signal Generator which is described in the constructional section of this issue. Access to an oscilloscope is also helpful for part of the demonstration.

EMITTER FOLLOWER EXERCISE

As an exercise, construct the simple emitter follower circuit of Fig. 4.14 utilising a general-purpose *npn* transistor such as the ZTX300. Try to work out the simple layout yourself, referring to the ZTX300 pin-outs given earlier. Use the +12V power supply, and also connect the Signal Generator Sine output to C1 on the breadboard with a link wire. PLEASE NOTE: the Signal Generator could be damaged if the Sine or Triangle outputs are accidentally shorted to 0V for any length of time. Remember that all the 0V rails of the *Mini Lab* modules are interconnected, so strictly speaking all you need is one 0V connection to the circuit built on the breadboard.

Your oscilloscope should be set on a **d.c.** range, with its 0V input being connected with a test lead to the 0V rail of the *Mini Lab*. Switch on the +12V rail to power the circuit and Signal Generator, and use the C.R.O. to monitor the *sine wave output of*

TEACH-IN GCSE QUESTIONS

A question from a past paper to test candidates' understanding of simple transistor systems, and offering more welcome mock-exam practice.

QUESTION © THE WELSH JOINT EDUCATION COMMITTEE

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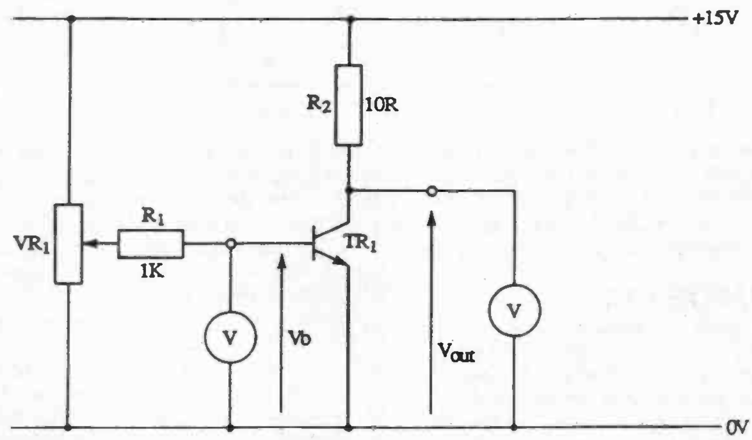
The test circuit shown below was set up to investigate how a transistor behaves.



Complete the following sentences by filling in the gaps.

When a small current flows into the base of the transistor, the voltage at the base will be

.... volts. A much larger .... will then flow into the

.... terminal. All the current flows .... of the third

terminal which is called the.....................................

With no base current flowing, the transistor will be switched .... and the

output voltage V_{out} will be .... A large base current causes the transistor circuit

to be .... which means that the transistor is fully...................................... .

The output voltage would then be almost ....

The base current and collector current were measured. The base current was 50 mA and the collector current was 1 A. This gives us a h_{FE} value of....................................... for the transistor.

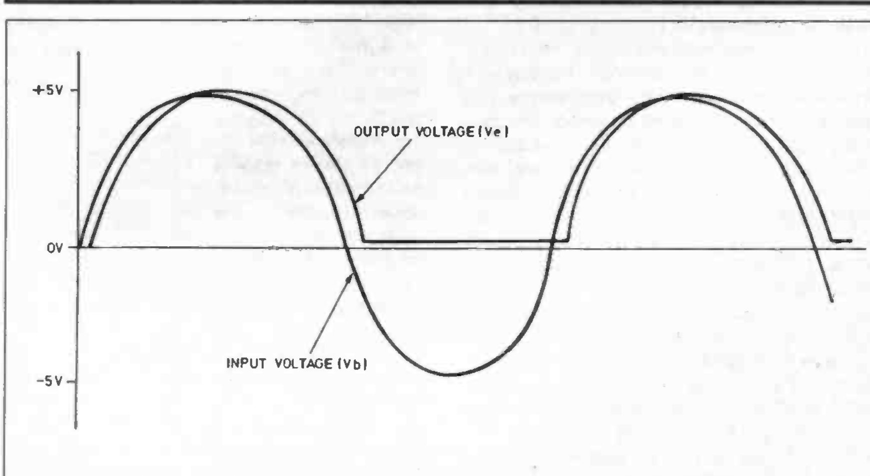


Fig. 4.13. How a signal may suffer clipping because of insufficient biasing.

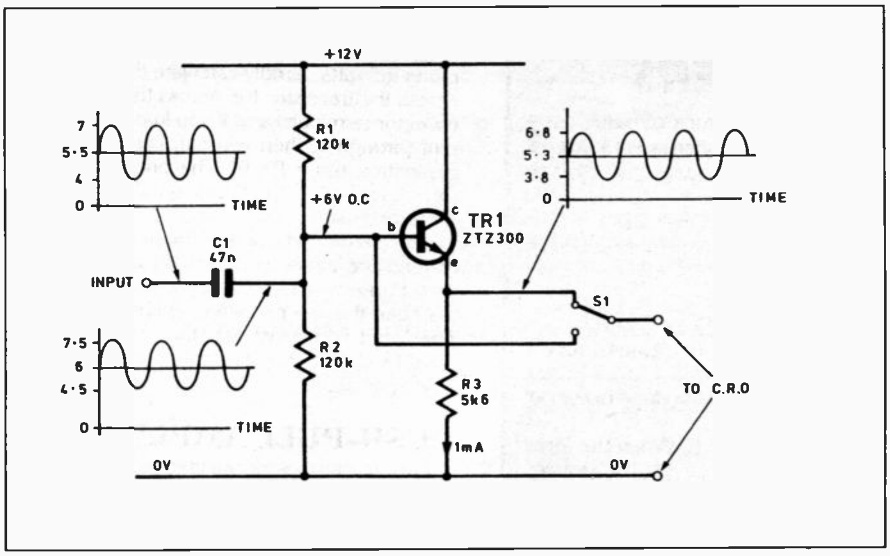


Fig. 4.14. A practical emitter follower transistor, with base biasing provided by R1 and R2, the waveforms shown are observed with an oscilloscope on a d.c. setting.

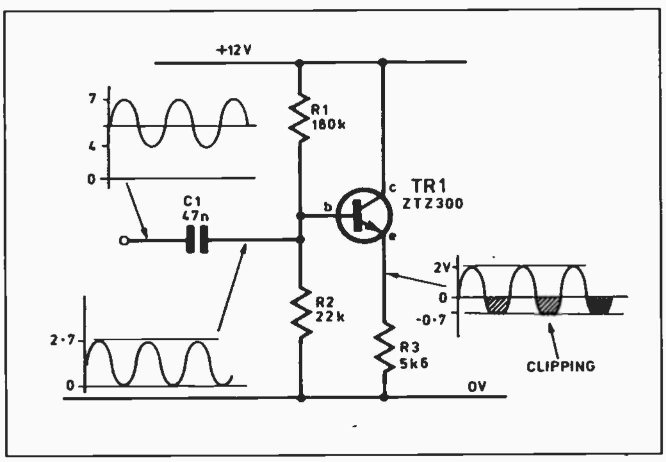


Fig. 4.15. The base is biased at too low a voltage, resulting in signal clipping.

GCSE QUESTION (see previous page) ANSWERS

When a small current flows into the base of the transistor, the voltage at the base will be **0·7** volts. A much larger **current** will then flow into the **collector** terminal. All the current flows **out** of the third terminal which is called the **emitter**.

With no base current flowing, the transistor will be switched **off** and the output voltage V_{out} will be **+15V**. A large base current causes the transistor **circuit to be saturated which means** that the transistor is fully **switched on.** The output voltage would then be almost **0V**.

The base current and collector current were measured. The base current was 50mA and the collector current was 1A. This gives us an h_{FE} value of **20** for the transistor.

the 8038. Select the 5kHz frequency range and adjust the Duty Cycle and the Distortion to roughly mid-way in order to generate a reasonably uniform sine wave.

You will observe how the 8038 output swings between roughly +4V and +7V, so it is a 3V peak-to-peak sine wave superimposed on approximately a 5.5V d.c. level. The coupling capacitor C1 removes this d.c. bias and superimposes the sine wave onto the bias network of R1 and R2, so C1 allows the 8038 output to be level-shifted to the transistor base voltage.

Using one of the handy s.p.d.t. toggle switches as shown in the circuit diagram enables you to switch the waveform displayed on your C.R.O. between the base signal and the output of the emitter follower. It's the next best thing to a *dual beam* oscilloscope! Notice how the emitter signal is the same as the base signal, but roughly 0.7V less, as depicted in the oscillographs.

Now try changing the base bias network by altering R1 to 180k and R2 to 22k, which biases the base at about 1.3V, see Fig. 4.15. It is now not possible for the emitter follower to conduct the negative portion of the sine wave, which will now be clipped as shown. This demonstrates how important it is to bias the base sufficiently so that clipping can be avoided.

COMMON EMITTER AMPLIFIER

All the previous circuits have exhibited *current gains* where the *current* in the collector/ emitter circuit is much higher than the *current* into the base. A **common emitter amplifier** is shown in Fig. 4.16 which resembles the emitter follower, but now a **collector resistor** R3 is included. Also, we have taken the output from the **collector**, not the emitter. What difference does this make?

The base is biased at 1.7V using R1 and R2, so the emitter "follows" this voltage minus the 0.7V base-emitter voltage drop, so under "stationary" or quiescent conditions the emitter voltage Ve is +1.0V. Using Ohm's Law, the **emitter current** is therefore Ve/ R4 = 1mA.

In effect, this current also flows through the **collector** resistor R3 and thus the voltage drop across R3 is 5k6 × 1mA = 5.6 volts. This means that the voltage at TR1 collector is 12–5.6 = 6.4V with respect to 0V. Also, note that 5.4V appears across the transistor between collector and emitter. These again are the *quiescent* operating conditions.

Now imagine a rising signal applied through a coupling capacitor C1 which increases TR1 base voltage. The emitter voltage will rise as described earlier, which increases the current through R4. This same increase in **current** also flows through R3: but R3 is about five times larger than R4, so a much larger **voltage drop** has to be produced across R3 than will be produced across R4. The ratio of the resistors R3/R4 holds the key to the **voltage gain** of the common emitter amplifier, which can be proved by putting in some values.

If the base signal increases by 0.5V to 2.2V, the emitter voltage also rises to 1.5V due to emitter follower action. The current in R4 now increases to 1.5mA which also flows through R3. The voltage drop across R3 (previously 5.6V) is now 8.4 volts. The output voltage at the **collector** therefore has to lower from 6.4V to 3.6V.

The result is easily seen. An **increase** in base voltage of 0.5V will **reduce** the output voltage by 2.8 volts. The input signal has been **inverted** by the common emitter amplifier: a rise of input voltage **reduces** the output when it's taken from the collector, which is forced downwards towards 0V. In this circuit, gain is expressed as:

Gain = –Vout/Vinput

and the negative symbol shows that the signal has been inverted. For this amplifier,

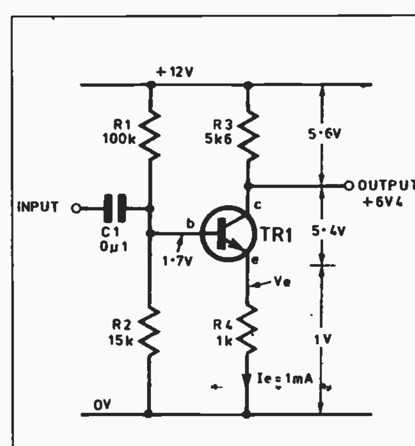


Fig. 4.16. Common emitter amplifier.

the voltage gain is –2.8/0.5 = –5.6. We actually stated earlier that the ratio R3/R4 determines the voltage gain. It just so happens that 5k6/1k = 5.6! This will work for both positive and negative swings, allowing a.c. signals to be voltage-amplified. You might also see simpler circuits with no emitter resistor (R4) at all – but they would still be classed as common emitter amplifiers.

POWER RATING

Note however that now the transistor is operating as an amplifier rather than just a simple saturated switch. A voltage now appears across the transistor, which means

ADVANCED LEVEL IMPEDANCE AND FILTERS

Impedance, symbol **Z**, is the term mainly used to describe the resistance of either components or complete circuits to a.c. signals. Circuits which have alternating currents flowing in them often contain capacitors and inductors (coils), the impedances of which *vary* with the frequency of the a.c. waveform – refer to Part Two. The more specific term **Reactance** means the "resistance of a capacitor or inductor" at a given frequency.

For a capacitor C (Farads) operating at a frequency **f (Hertz)**, the capacitive reactance (Zc) in ohms is:–

$$Z_C = 1/(2\pi f.C)$$

which means that as the applied frequency increases, the reactance decreases. Prove it by calculating the reactance of a 100µF capacitor at 1Hz and 500Hz (1.6k and 3.2 ohms). It's a useful property which enables us to make a frequency-dependent voltage divider or **filter**.

Fig. 4.21(a) shows a resistor load *R* connected to a series capacitor *C*. When the input voltage rises, the capacitor will charge with the current passing through the resistor, and is seen as a rising output voltage. Conversely when the input voltage drops, the capacitor starts to discharge and the voltage across the resistor falls. Provided that the input changes before the capacitor has fully charged or discharged, the input signal will be seen at the output.

Hence slowly changing input signals (low frequencies) are *attenuated* at the output, but fast signals pass through almost unchanged, as though the *RC* network doesn't have time to catch up. This arrangement forms a **high pass filter**, producing a **frequency response curve** like that in the graph. You could characterise it by comparing the ratio V_{out}/V_{in} to applied frequency. At lower frequencies, Vout/Vin is lower, so the high pass filter attenuates low frequencies. This makes sense if you recall that a capacitor blocks d.c. (zero frequency) altogether.

A **low pass filter** is shown in Fig 4.21(b) where the RC network has been reversed. Now the capacitor is in parallel with the output, where it attenuates higher frequencies; at d.c., C has no effect and so no attenuation takes place. For *both* filters, the filter frequency response curve is characterised by the frequency *f* when the gain is 0.7. This frequency equates to $1/(2\pi RC)$.

Finally, GCE "A" Level Physics candidates might already know that a capacitor actually "resists" frequencies without producing any heating effect – a sort of "Watt-less" resistance, unlike a resistor which of course is subject to I^2R heating.

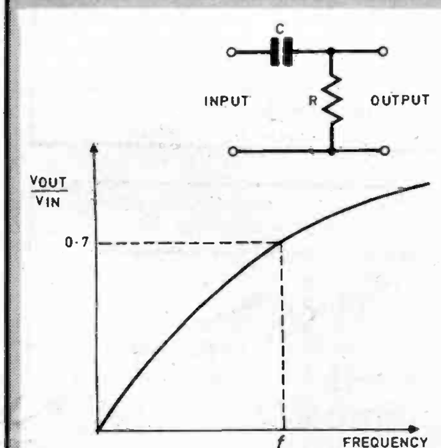


Fig. 4.21(a). A High pass filter attenuates lower frequencies but allows higher frequencies to pass through.

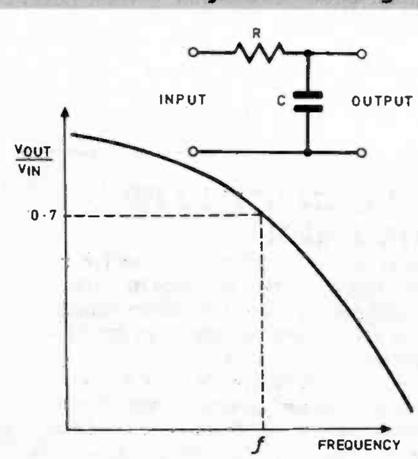


Fig. 4.21(b). A Low pass filter lets lower frequencies pass through whilst attenuating higher frequency bands.

that TR1 will dissipate power. The designation *Pt* is often seen in transistor data sheets to describe the device's maximum power rating in Watts. Simply calculate the voltage across the transistor (i.e. across the emitter/collector terminals) and if you know the current through it, then you can calculate the dissipation using P = IV. The price you will pay for exceeding the *Pt* rating will be that of a new transistor!

There are other considerations which are beyond the scope of *Teach In* which concern transistor design, and it should be emphasised that the preceding circuits are very basic and somewhat less than high-fidelity amplifiers! But they are still useful, as we shall soon see.

PUSH-PULL AMPLIFIER

Two transistors connected as a *push-pull amplifier* are shown in Fig. 4.17. Notice that this uses a *pnp* transistor in conjunction with an *npn* transistor, and that a split or dual voltage supply is used. A *pnp* transistor operates in a fashion similar to the *npn* type demonstrated so far, but it has different biasing requirements: for our purposes, all you need to know is that its base needs to be 0.7V **less than** the emitter in order to conduct, and that current flows into the emitter, as depicted by the arrowhead symbol. We don't need to investigate the *pnp* transistor in any more depth here – besides, the *npn* device is easier to understand!

The push-pull amplifier overcomes any power dissipation problems which exist with the single-transistor emitter follower. The positive half of the signal is amplified by TR1 and the negative half by TR2 where current flows from 0V and through TR2 to the –V rail. There is no steady current flowing through the load so no energy is wasted.

One problem is that small input signals cannot overcome the 0.7V base-emitter drop of both transistors, which could result in a condition called *cross-over distortion* where neither transistor conducts at times. This is illustrated by the sine wave shown in Fig. 4.18 and can be overcome with extra design effort in the bias circuit.

SIMPLE AMPLIFIER

The following section requires the Mini Lab loudspeaker and the Power Transistor – refer to the constructional section elsewhere in this issue for details.

It's now possible to use our basic knowledge of transistor amplifiers to construct a simple audio amplifier which

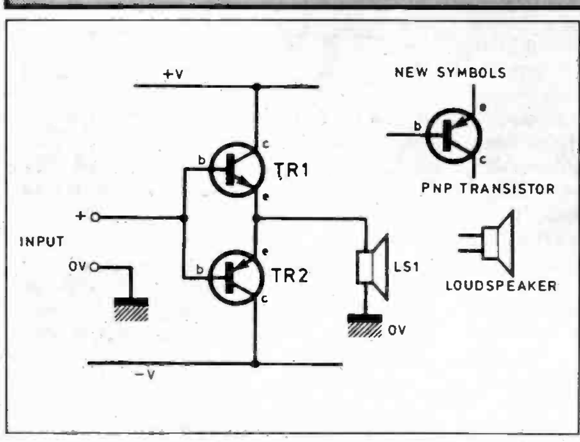


Fig. 4.17. A Push-Pull output stage using both an npn *and* pnp *transistor – a "complementary pair". Note the use of split supply rails.*

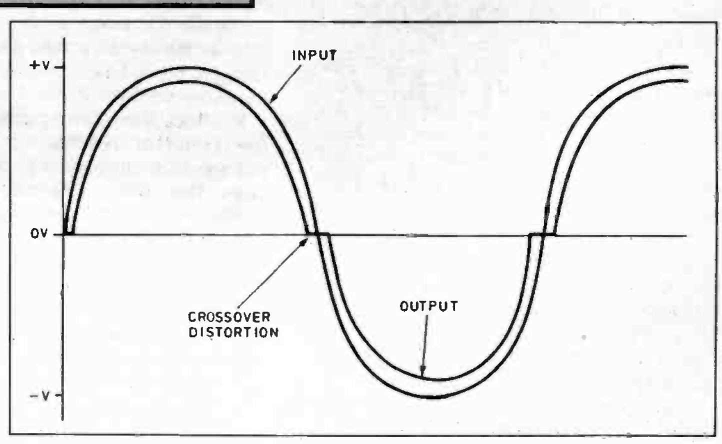


Fig. 4.18. Crossover distortion arising through the non-conduction of the transistors in the push-pull output stage.

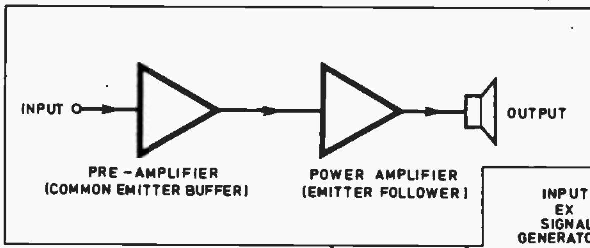


Fig. 19(a). Block diagram of an amplification system.

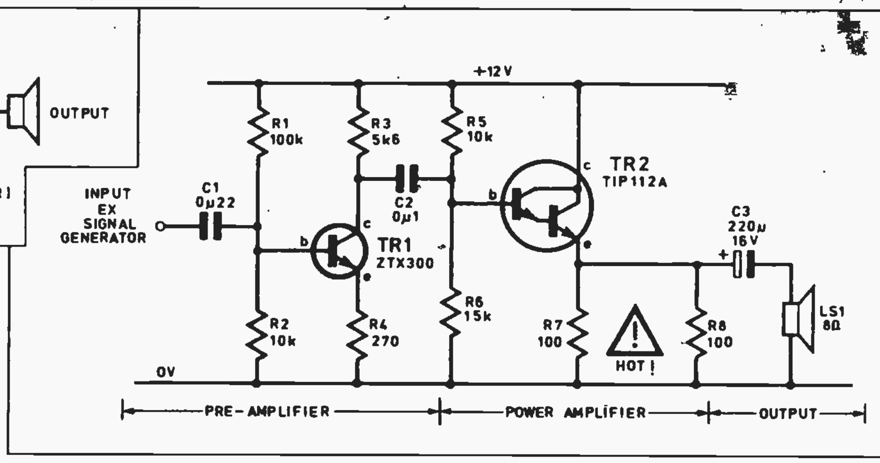


Fig. 4.19(b). (right). Complete circuit diagram of an audio amplifier to monitor the 8038 Signal Generator. Use ½W types for resistors R7 and R8.

firstly will be used to actually listen to the output of the Signal Generator. The 8038 is a low power device which is certainly not capable of driving a loudspeaker directly. It needs a simple amplification system such as that shown in block form in Fig. 4.19(a). A simple *pre-amplifier* provides a degree of voltage gain before the signal can be fed into a *power amplifier* which provides *current amplification* to drive a loudspeaker.

The circuit of Fig. 4.19(b) uses TR1 as a common emitter amplifier to provide voltage gain. The input signal passes through C1 which removes the d.c. content of the signal and ensures that the input bias conditions set by R1 and R2 are not adversely affected. The output of the common emitter amplifier is itself coupled through C2, which again permits the a.c. signal to flow straight through whilst not affecting any d.c. bias voltage set this time by R5 and R6. The voltage-amplified signal thus passes to the base of TR2, a Darlington Power Transistor (see the separate section on the Darlington) which acts as an emitter follower buffer or current amplifier to enable it to drive a loudspeaker LS1.

Transistor TR2 has much higher ratings (h_{FE} and collector current) than the smaller ZTX300 transistor we have employed so far, which enables it to handle the high currents flowing in the output stage of our simple amplifier. Note that the 'speaker is itself coupled by C3, a polarised electrolytic capacitor which prevents any direct current flowing whilst allowing the a.c. *signal* to pass through LS1 unhindered; this improves current consumption and decreases power dissipation in TR2.

"A" LEVEL EXERCISE

As an exercise we would now like GCE "A" Level candidates to source (locate) the parts shown and construct this unaided on the *Mini Lab* (but there's nothing to stop GCSE followers assembling it too!), making full use of the breadboard, and connecting to the +12V and 0V rails, loudspeaker and Power Transistor. Your earlier experience with a ZTX300 transistor switch will help, and the practice will help you to realise circuit diagrams in three dimensions. You should be grateful!

Give yourself plenty of room, ensure that both transistors are correctly connected and that no adjacent wires are shorting together. The terminations for the Darlington Transistor are clearly marked on the *Mini Lab* board. Do take your time and assemble the circuit neatly and methodically to avoid disappointment, using long-nose pliers to help insert wires if necessary. It should work first time. PLEASE NOTE: the Signal Generator could be damaged if the Sine or Triangle outputs are shorted to 0V for any length of time.

With assembly complete, use the Signal Generator controls to listen to the varying frequency ranges of your 8038 generator. Be warned that some frequencies are ear-piercing and may cause discomfort at close range: please consider other people. (We don't think that the Editor ever recovered after we demonstrated this to him (*Pardon? – Ed.*).) The power transistor may become warm, which is why a heatsink is used. Expect R7 and R8 to become *hot* in normal operation.

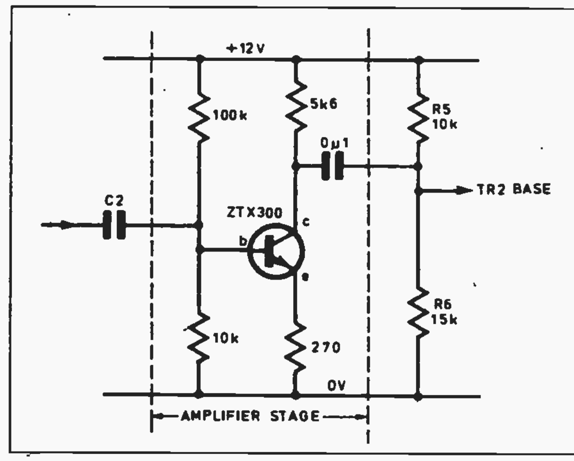


Fig. 4.20. Use this extra amplifier stage with the audio amplifier, to provide extra gain for the microphone.

MICROPHONE AMPLIFIER

A microphone is another *input transducer* and it converts sound pressure waves into an electrical signal. Different types exist, some being more sensitive than others. A *crystal* microphone has a very high impedance – 1M or more and has poor sensitivity; they rely on the *piezoelectric effect* where mechanical pressure applied to a crystal causes a tiny voltage to be generated.

A *dynamic ("moving coil") microphone* is more sensitive and, usefully, has a much lower impedance – say a few hundred ohms. The final experiment this month utilises such a microphone; you might possess an old cassette-recorder microphone or perhaps you can borrow one: otherwise purchase one (target price £2.50) for the following experiment. (You can use it in Part Five next month, too.)

These types of microphone are mostly terminated with two audio jack plugs. The smaller-diameter jack plug, where fitted, should be ignored. Improvise with a pair of test leads and connect the two terminals of the microphone jack plug both to the amplifier input (C1) and also 0V, in place of the Signal Generator. The results depend on the quality of your microphone, but the loudspeaker should at least reproduce any tapping sound which you make on the microphone. However, speech reproduction will probably be extremely poor. Quite a handicap for a microphone amplifier!

The problem is simple: as it stands the amplifier has insufficient gain. This can be overcome by adding another identical transistor stage based around the ZTX300, the circuit diagram of which is given in Fig. 4.20. Simply build this extra stage separately on the breadboard and splice it into the amplifier as shown by the circuit schematic, remembering to switch off before making any modifications.

Even we were pleasantly surprised what a difference the extra amplifier stage made. Using just an old dynamic cassette-recorder microphone, speech was greatly amplified and quite clearly reproduced on the loudspeaker. The microphone amplified ticking watches and other barely audible sounds remarkably well.

FEEDBACK

Now try holding the microphone near to the loudspeaker: you will hopefully hear every pop musician's nightmare called "howlround" or feedback (not that it's different to the rest of the racket they make! – *You're showing your age – Ed.*), where sound from the speaker is picked up by the microphone, amplified and then reproduced over the speaker – which is picked up by the microphone and amplified . . . and so it goes round. Experiment further using the microphone to amplify the sound from a personal stereo earpiece – the audio signal should be reasonably discernible on the *Mini Lab* loudspeaker.

We hope you have enjoyed this introduction to transistor systems. Next month, we delve deeper into modern electronics, introducing integrated circuit operational amplifiers, accompanied as usual by plenty of interesting demonstrations for your *Teach-In Mini Lab*. We also build an "awesome amplifier" for your microphone which brilliantly demonstrates the *Mini Lab* Audio Amplifier. Silicon chips with everything!

Home Base

Jottings of an electronics hobbyist – Terry Pinnell

Fuse Tester

The frequency with which we blow fuses around here ensures that one of my oldest and simplest projects gets plenty of practical use.

One of the first gadgets I ever constructed, probably about 15 years ago, was the Fuse Tester circuit shown in Fig. 1. Although its electronics is about as basic as you can get, it is a pleasure to use. You just grasp the tester in one hand, hold one end of the fuse with your other hand and touch the other end of the fuse to the tester's probe, made out of a washer bolted to the plastic cap. If the l.e.d. does not come on, then your fuse has gone the way of John Cleese's parrot. In practice, I always touch my bare finger to the probe, to check that the circuit is working OK and because it's fun to see such a basic demonstration of small current electronics.

The two transistors (TR1, TR2) are connected in Darlington configuration and therefore constitute a current amplifier with very high gain. Any resistance of under about 15 Megohms passes sufficient base current to activate the l.e.d. So it can also be used as a general purpose continuity tester, although 15 Megohms is not my usual idea of "continuity".

While drafting this, I became curious to confirm my suspicion that the batteries had never been changed in those 15 years. I should have left well alone.

It proved difficult extracting the small piece of stripboard to get at them, and I suppose I must have shorted something, because suddenly I became aware how warm the case was getting. It was only about another five seconds before I cut everything in sight and isolated the batteries, but the case was distinctly hot by then, so the discharge through those four tiny Mallory Duracell 1·5V AAA cells must have been substantial.

Anyway, they were indeed the originals: a pretty good shelf-life I reckon. Even after the abuse I'd given them, my battery tester gave all four the OK and on a multimeter their combined unloaded voltage was 5·8V. So maybe I can get another 15 years use out of them, if fuses don't go out of fashion in that time.

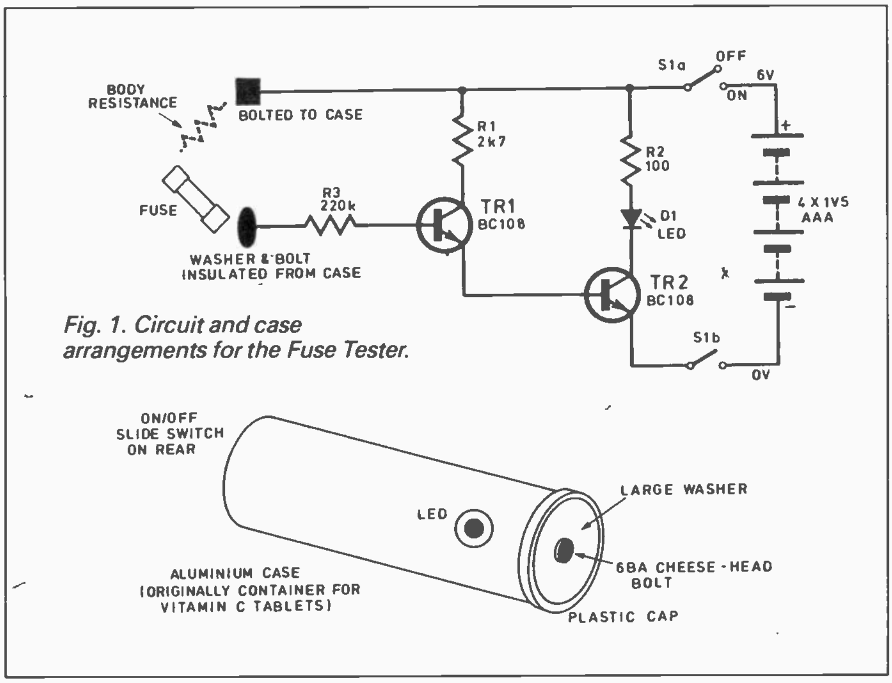


Fig. 1. Circuit and case arrangements for the Fuse Tester.

Battery Assault

The current from those alkalines was impressively high, but NiCads take some beating for sheer power. In fact, with careless handling they can be downright dangerous, as I discovered the other day.

I was using my home made charger, set to about 120mA to charge four HP2 (D-type) NiCads, which I'd loaded a few hours earlier into an ordinary plastic holder. Working nearby, I suddenly noticed smoke curling up.

My instinctive reaction was to pull the mains plug out, but I was bemused to see the smoke continue unabated! I then saw that one of the thin metal strips connecting the battery compartment was glowing bright red. This was burning the plastic and giving off the smoke. Snatching the crocodile clip connectors from the battery holder terminals restored normality.

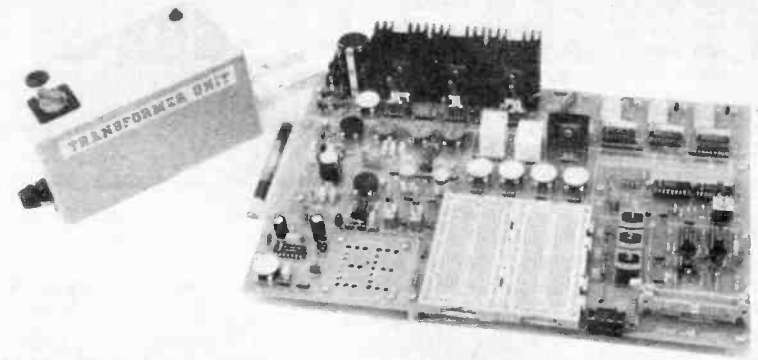
Either I had not secured the croc' clips to the holder terminals firmly enough, or they had been knocked, because one had slipped and made firm contact with the other. A nice short circuit for a set of heavy duty NiCads.

The connecting strip was clearly the point of highest resistance in this circuit. I'd guess the current could have been about 30A. So if the strip had a resistance of say a tenth of an ohm, then the power being dissipated in it was $P = I^2R$, which comes to 90W. A light bulb's worth of heat concentrated in a tiny area, so the dramatic consequences were hardly surprising.

According to the label on the batteries, their capacity was 1·2A for one hour. So if they had been say 80 per cent charged to start with, they could have sustained a 30A discharge rate for about two minutes. Plenty long enough to start a nasty little fire!

Teach-In Project

MINI LAB



Alan Winstanley & Keith Dye B.Eng(Tech)AMIEE

The Everyday with Practical Electronics Mini Lab has been created to accompany Teach-In '93, and enables the reader to assemble demonstration circuits by following the clear instructions and diagrams contained in the main text, with every chance of it working first time.

THIS month a compact Signal Generator is assembled to fill one of the areas reserved on the *Mini Lab* p.c.b. The circuit diagram is shown in Fig. 1, and the impressively simple circuit is centred around a long-established signal generator chip IC1. This is an ICL8038 i.c. which is capable of offering sine, square and triangle waves from three separate outputs.

CIRCUIT OPERATION

A constant-current source provides a charging current for an external capacitor, the value of which (C2 to C5) is selected by an on-board selector plug. Because a *constant-current* source is used, the capacitor charges in a useful *linear* fashion rather than in an exponential curve (see *Teach-In* Part Two). This produces a linear ramp voltage which is utilised by the 8038 to create a triangle or square wave. Further internal circuitry converts the triangle wave into a reasonable sine wave, generated separately. The frequency range spans the low tens of Hertz to roughly 50kHz.

Note that the square wave has a **pull up resistor** R4, which means that the square wave is biased to +5V, either being at +5V or 0V. This waveform is utilised in digital circuits which are introduced in Part Six. Also, the sine wave consists of a 3V peak-to-peak sine superimposed on roughly a 6V d.c. level. It's often necessary to use a *coupling capacitor* to level-shift the sine wave to a circuit which is biased at a different voltage. You need to remember that the sine wave does *not* revolve around the 0V axis.

Potentiometer VR1 controls the frequency (the range of which is determined by the choice of timing capacitor), and VR2 adjusts the duty cycle (the percentage of time for which the square wave is "high" during the total time period). VR3 is useful for adjusting the symmetry of the sine wave, in order to produce a reasonable sine wave.

Finally, the circuit operates from the +12V rail of the *Mini Lab* Power Supply, so remember to switch this supply on when you wish to utilise the Signal Generator. Also switch on the +5V supply if you require the square wave.

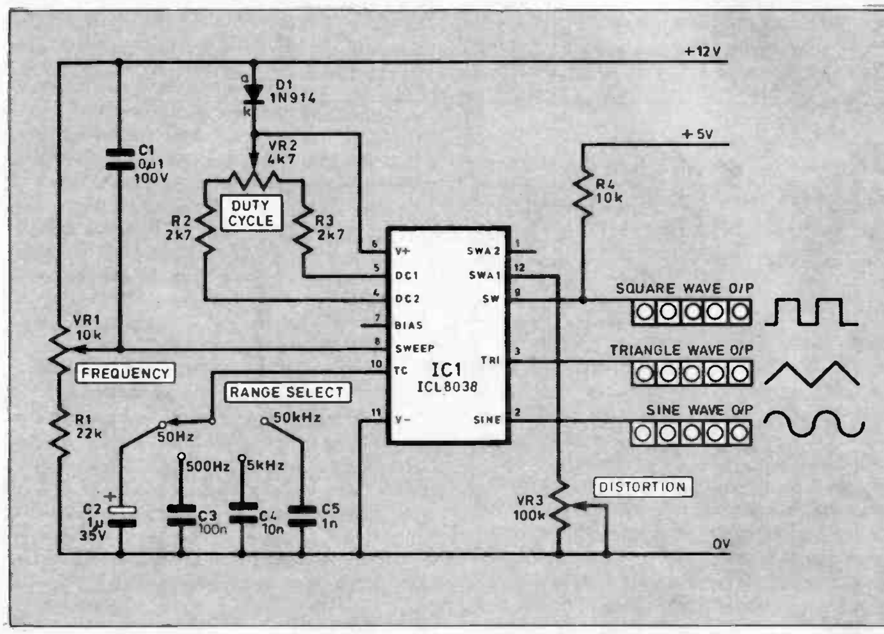


Fig. 1. Circuit diagram of the Mini Lab *Signal Generator.*

CONSTRUCTION

The complete circuit is constructed on the clearly identified Signal Generator section of the *Mini Lab* p.c.b., and will be seen to take up comparatively little space. Assembly is very straightforward, see Fig. 2 which illustrates the component layout. Once again, silk-screen printing on the board aids component location.

Start by inserting and soldering into position the five p.c.b. jack sockets, the turned pin s.i.l. sockets and the link wires. Do not overlook the link near the +12V socket strip between VR2 and VR3 – this connects the supply rail to the 8038 circuit. Also, it is strongly recommended that an i.c. socket is used to carry IC1, so that thermal damage will be avoided during soldering. Take great care not to apply excessive solder or you may short out adjacent pins. The green solder-resist coating of the *Mini Lab* will help in this respect. As always, do not overheat the solder pads of the p.c.b. or you may damage the board irreparably. It should take only 1·5 – 2 seconds to solder a perfect joint.

If possible, utilise preset potentiometers which have snap-on thumbwheels which enable adjustments to be made very easily without the use of screwdrivers. Complete the rest of the construction in accordance with Fig. 2, observing the correct polarity of D1 and C2. Again, do not overheat D1 which, being a semiconductor, is sensitive to thermal damage when soldering.

INTEGRATED CIRCUIT

The main component IC1 is housed in a *dual-in-line* (d.i.l.) package. It is absolutely *essential* that you insert it **the right way** round into the d.i.l. socket, or damage may result. The device is not cheap, so take care to orientate the package correctly: one end has a distinct notch which identifies pin 1 as shown in the layout diagram.

Align the pins carefully with the d.i.l. socket and, because they tend to be splayed out when received, gently press one side of the i.c. down on a flat surface to bend the pins inwards a little so that each pin is aligned in its individual socket.

CHECKING

When the Signal Generator is completed, double check the polarity and location of all components, plug in and switch on the Transformer Unit, then switch on the +12V supply. It would be invaluable to monitor the output waveforms on an oscilloscope if one is available: connect the 0V terminal of the C.R.O. to any of the 0V locations on the *Mini Lab* and check the waveforms of each output in turn using the 'scope probe. If you set the oscilloscope to the *d.c. input* function then you will clearly see the sine wave superimposed on a d.c. level.

Also check out the variable controls to see what effect they have on the waveforms. Normally the duty cycle and distortion controls can be set to mid-way. Alternatively monitor the output waveforms with the L.E.D. Voltmeter using the following interesting technique:

Select the 10V range and "DOT" mode on the voltmeter for best effect, and choose the 50Hz range on the Signal Generator, setting all controls to their mid-way positions. Connect the "SINE WAVE" output to the "+I/P" of the Voltmeter, then switch on the +5V and +12V rails. The *middle* five or six l.e.d.'s should be alight!

This illustrates the 3V peak-to-peak a.c. which is imposed on a 6V d.c. voltage. Reduce the frequency of the sine wave by turning the Signal Generator control anticlockwise. You will now clearly see the l.e.d. display move sideways in sympathy with the rising and falling of the sine wave voltage. Slow it right down and see how the distortion and duty cycle controls affect the *symmetry* of the sine wave. Do the same with the triangle waveform.

Now try this for fun: set all the 8038 controls back to *mid-way* and hold the *Mini Lab* firmly so that the l.e.d. display is *vertical* – then move it from side to side, focussing your eyes *past* the *Mini Lab*. What do you see? A triangle wave in front of your very eyes! Try the sine wave again and convert your L.E.D. Voltmeter into a simple oscilloscope, using your arms as the timebase!

Finally, when using the Signal Generator take care that you *don't* short the sine wave or triangular waveform outputs to 0V, or damage to the 8038 may result.

POWER TRANSISTOR

The power transistor is installed on the *Mini Lab* as shown in Fig. 3. Firstly solder in three s.i.l. sockets for the base, collector and emitter connections. The Darlington transistor is bolted to a lightweight drop-in heatsink, using a TO-220 mounting kit (see last month). Use the recommended heatsink which is very economical and will fit the p.c.b. directly. However, *do not* try to solder the aluminium heatsink mounting lugs. The transistor will easily support the heatsink without further assistance.

LOUDSPEAKER

The *Mini Lab* accommodates an 8 ohm one Watt square-style loudspeaker with polyester cone, in the position shown on the p.c.b. where the "EE" logo acts as a grille, see Fig. 4. Use only the specified speaker to ensure a perfect fit, employing 4BA or M3 nuts and bolts. Two solder pins are pushed through from the topside at the locations marked "SP1" and the loudspeaker terminals are linked to these underneath using two short lengths of interconnecting wire. Ensure that you also solder the pins securely to the p.c.b. tracks.

Solder into place six s.i.l. sockets as shown, and then the speaker is ready for use. Note that two s.i.l. sockets are assigned to each loudspeaker terminal. Finally, at the same time we recommend adding two rows of five s.i.l. sockets which are handy 0V terminals positioned to the right of the loudspeaker. You will find these helpful in assembling this month's and future demonstration circuits.

Next Month: Audio Amplifier.

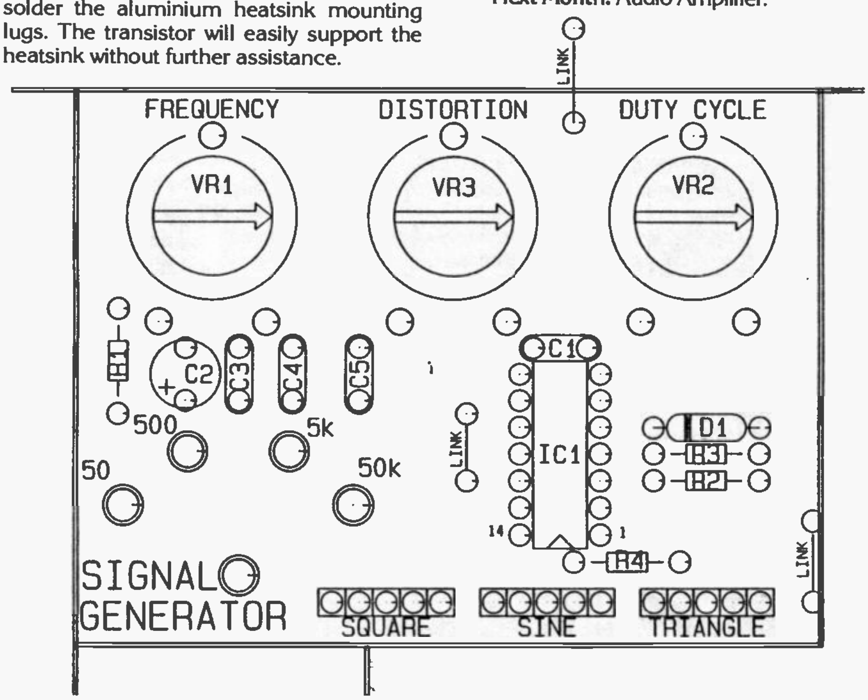


Fig. 2. Arrangement of components on the Mini Lab *p.c.b.*

MINI LAB COMPONENTS

Resistors

R1	22k
R2, R3	2k7 (2 off)
R4	10k

All ¼W 5% carbon film

See SHOP TALK Page

Potentiometers

VR1	10k
VR2	4k7
VR3	100k

All 0.25W presets & thumbwheel

Capacitors

C1	100n polyester
C2	1µ tantalum bead 35V
C3	100n polyester
C4	10n polyester
C5	1n polyester

Semiconductors

IC1	ICL8038CCPD signal generator i.c., 14-pin plastic package
D1	1N914 or 1N4148 silicon diode

Miscellaneous

14-pin d.i.l. socket; s.i.l. turned pin sockets (15 off); p.c.b. mounting "jacks" (5 off); 0.5in. insulated shorting link.

POWER TRANSISTOR

TR1	TIP112 *npn* Darlington transistor

Drop-in TO-220 heatsink; TO-220 mounting kit; s.i.l. turned pin sockets (3 off).

LOUDSPEAKER

LS1	8 ohm 1W 50mm square Polyester cone–RS250-277

S.I.L. turned pin sockets (6 off); M3 or 4BA nuts & bolts; solder pins; wire, etc.

Price £15 Approx

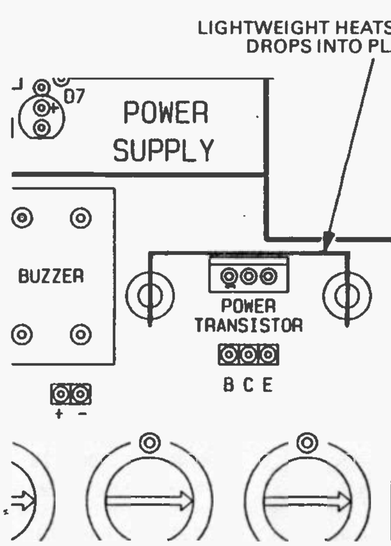


Fig. 3. Power Transistor location. The device supports a lightweight heatsink which is NOT soldered to the p.c.b.

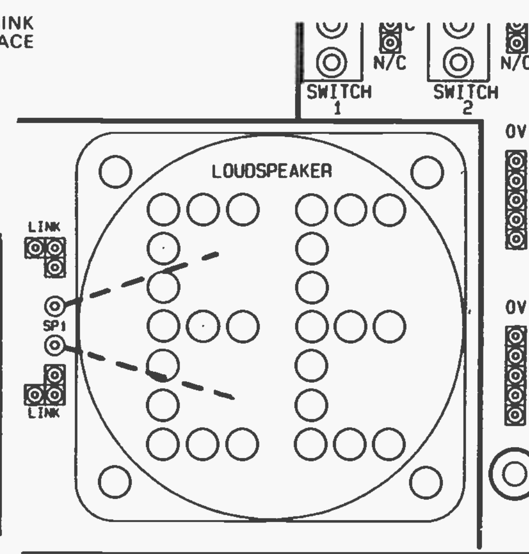
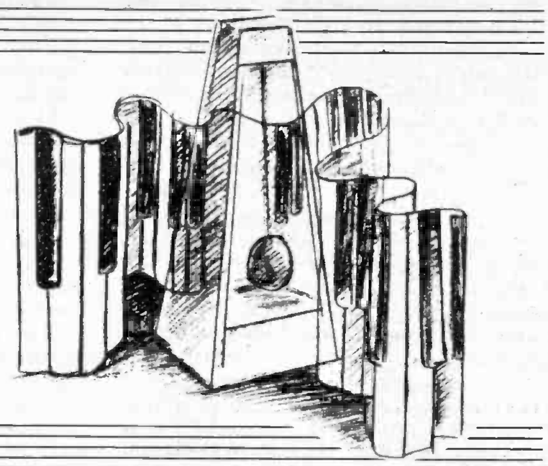


Fig. 4. Position and connection of the Mini Lab *loudspeaker.*



SIMPLE METRONOME

ROBERT PENFOLD

Set the tempo and improve your timing with this low-cost timer.

A TRADITIONAL metronome (Maelzel's metronome) is a purely mechanical device which gives a "click" sound at regular intervals. The beat rate can be adjusted via a calibrated control.

Some composers mark their scores with beat rates to accurately indicate the initial playing speed, plus any subsequent changes in tempo. A metronome can then be used to show the correct playing speeds.

Probably a more common use is where a music student has to learn to play a piece at a certain tempo. The metronome is set to the correct rate and the student then does his or her best to keep up!

These days metronomes are mostly electronic devices which mimic the sound of a traditional mechanical metronome. This very simple electronic metronome produces a reasonably loud "click" sound that can be adjusted to any rate between about 30 and 300 beats-per-minute.

CRICUIT DESCRIPTION

In order to obtain the required "click" sounds the loudspeaker must be fed with a series of pulses. Long pulses produce a sort of "thud" sound – very short pulses give a "thin" and high pitched "click" sound. The ideal pulse duration for a good metronome sound seems to be roughly in the middle of these extremes, which equates to an actual pulse length of about 0·2ms to 0·5ms.

The full circuit diagram for the Simple Metronome is shown in Fig. 1. This is based on a 555 timer integrated circuit which is operated here in the standard astable (oscillator) mode. The 555 is a good choice for this application as it can provide the required pulsed output waveform, and it can also provide high enough output currents to drive a loudspeaker at good volume.

The basic action of the circuit is for timing capacitor C2 to first charge up to two thirds of the supply voltage, via the series resistance of potentiometer VR1 and resistors R1, R2. It then discharges to one third of the supply potential via resistor R2 and an internal transistor of IC1. C2 is repeatedly charged and discharged in this way, giving a form of continuous oscillation.

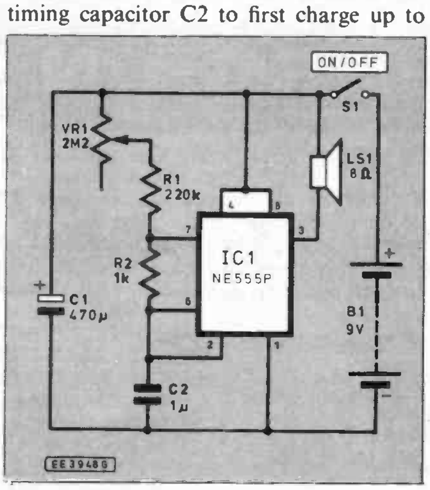


Fig. 1. Simple Metronome circuit diagram. IC1 drives the speaker with a series of brief pulses.

Potentiometer VR1 is used to control the rate at which capacitor C2 charges, and it acts as the beat rate control. It provides an operating frequency of about 0·5Hz at maximum resistance, rising to 5Hz at minimum resistance. In terms of beats-per-minute this corresponds to the 30 to 300 beats per minute range mentioned previously.

In most applications, including the present one, it is not the signal in the timing circuit that is of interest. Pin 3 of IC2 provides a signal that goes high while C1 is charging, and low while it is discharging.

Since C2 discharges through the relatively low resistance of R2 and the insignificant resistance of IC1's internal switching transistor, the time for which pin 3 of IC1 goes low is comparatively short. In fact it goes low for roughly 0·5ms, which is at the high end of the acceptable duration range. A slightly lower value for resistor R2 might actually

COMPONENTS

Resistors
R1 220k
R2 1k
All 0·25W 5% carbon film

See SHOP TALK Page

Potentiometer
VR1 2M2 rotary carbon, linear

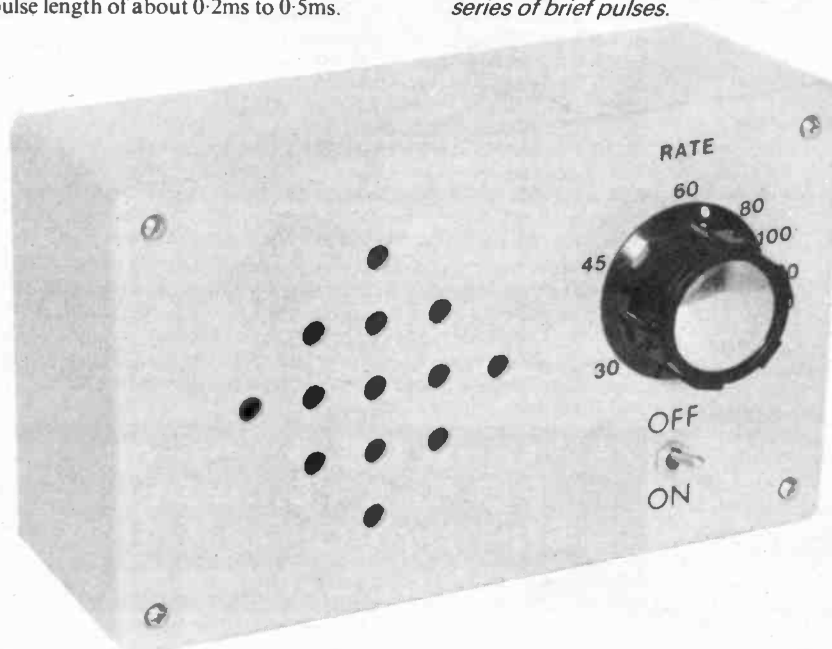
Capacitors
C1 470µ radial elect., 10V
C2 1µ polyester layer

Semiconductor
IC1 NE555P bipolar timer

Miscellaneous
S1 s.p.s.t. min. toggle switch
LS1 8 ohm, 76mm diameter loudspeaker
B1 9V (PP3 size) battery, with connector clips

Medium size plastic case; stripboard, 0·1in. matrix, size 21 holes by 14 strips; control knob; 8-pin d.i.l. i.c. holder; solder pins; connecting wire; solder; etc.

Approx cost guidance only **£10.50**



give a better sound, but it might also reduce the volume to an inadequate level.

By connecting loudspeaker LS1 between the output of IC1 and the positive supply rail, it is driven with a large pulse of current each time the output (pin 3) of IC1 goes low. This gives the required "click" sounds.

The loudspeaker LS1 ***must not*** be connected between IC1's output and the negative supply rail. This would result in the loudspeaker being fed with a high current most of the time, with brief pauses each time IC1's output pulsed low. This would generate the "click" sounds, but would result in IC1 quickly overheating and being destroyed.

The large supply decoupling capacitor (C1) ensures that the large pulses of current can be supplied even when the battery is nearing exhaustion. The current consumption of the circuit is approximately 8mA. A PP3 battery is adequate as the power source, but a larger battery (such as a PP9 or six HP7 size cells in a holder) would be more practical if the unit will receive a lot of use.

The current consumption could be greatly reduced by using a low power version of the NE555P for IC1. However, it is not recommended as most low power versions of the 555 do not seem to drive low impedance loads very well. At best the volume would probably be very low, and at worst the unit would fail to work at all.

CONSTRUCTION

The Simple Metronome is built on a small piece of 0·1in matrix stripboard, size 21 holes by 14 copper strips. The topside component layout is shown in Fig. 2. Four breaks are required in the underside copper tracks between IC1 pins.

Start construction by cutting out a board of the appropriate size using a hacksaw, and then file the sawn edges to a smooth finish using a small flat file. Next drill the two 3·3mm diameter mounting holes and make the four breaks in the copper strips.

The board is now ready for the components, link wires, and solder pins to be added. Note that IC1 has the opposite orientation to normal (i.e. pin 1 is towards the bottom edge of the board). Be careful to fit the electrolytic capacitor C1 the right way round as well. Its polarity will be marked by "+" and (or) "−" signs on the body of the component. Getting either of these components the wrong way round could result in a large current flow and the component being ruined.

Capacitor C2 has quite a high value, but it must be a *non*-electrolytic type. The tolerances and leakage levels of electrolytics are too high to guarantee good results in a timing application of this type. In order to fit easily into this layout C2 must be a printed circuit mounting type having 10mm (0·4 inch) lead spacing.

CASE

Quite a small plastic box could be used as the case for this project provided a loudspeaker having a diameter of about 50mm or less is used for LS1. Trying to miniaturise the unit is not recommended though, as this seems to result in quite a low volume level. Much better volume seems to be obtained using a loudspeaker of around 76mm in diameter, together with a suitably large case.

The component board is mounted on the rear panel (base) of the case using 6BA or metric M3 fixings. Switch S1, loudspeaker LS1, and rotary control VR1 are mounted on the front panel (lid), and it is advisable to fit VR1 with a fairly large control knob. It can then be calibrated with a large and reasonably accurate dial.

A grille is needed for the loudspeaker. Probably the easiest way of handling this is to drill a pattern of holes, about 5mm or so in diameter, in the case front panel.

This needs to be done carefully, since quite small errors in the positioning of the holes can produce some decidedly scrappy looking results. The best approach is to first drill some small guide holes as accurately as possible. These are then enlarged to about 3·5mm in diameter, and then to the final size of 5mm.

It is very unusual for small loudspeakers to have any provision for fixing screws. This means that the loudspeaker will almost certainly have to be glued in place behind the grille. Any good quality general purpose adhesive should be suitable. Apply a small amount of adhesive to the front rim of the loudspeaker, being careful not to smear any adhesive over the diaphragm.

To complete the unit the point-to-point wiring is added. This is shown in Fig. 3, which should be used in conjunction with Fig. 2. Use ordinary multi-strand p.v.c. insulated hook-up wire for these connections.

CALIBRATION

The finished Metronome will not be of much practical value unless the "Beat" control knob of VR1 is calibrated with a beats-per-minute scale. This can be done quite easily using rub-on transfers. Some trial and error is needed in order to find the calibration points, and this is likely to be quite time consuming if the unit is to be calibrated really accurately.

A worthwhile saving in time can be achieved by counting the number of beats in a fifteen second period and multiplying by four, rather than counting the number of beats in a one minute period. Provided this is done carefully it should give quite accurate results. □

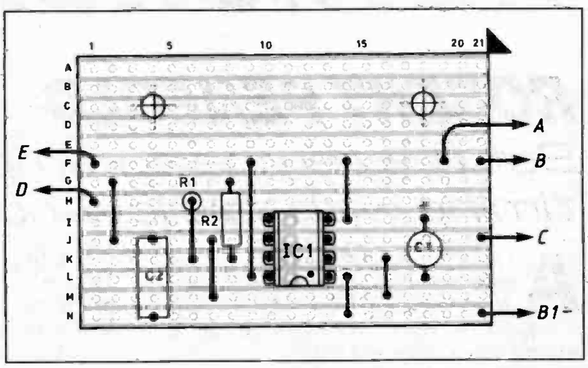


Fig. 2. Stripboard component layout. Note that four breaks are required in the copper tracks between the two rows of i.c. pins.

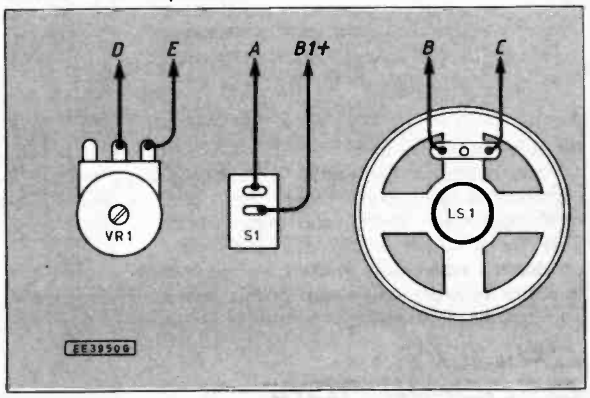
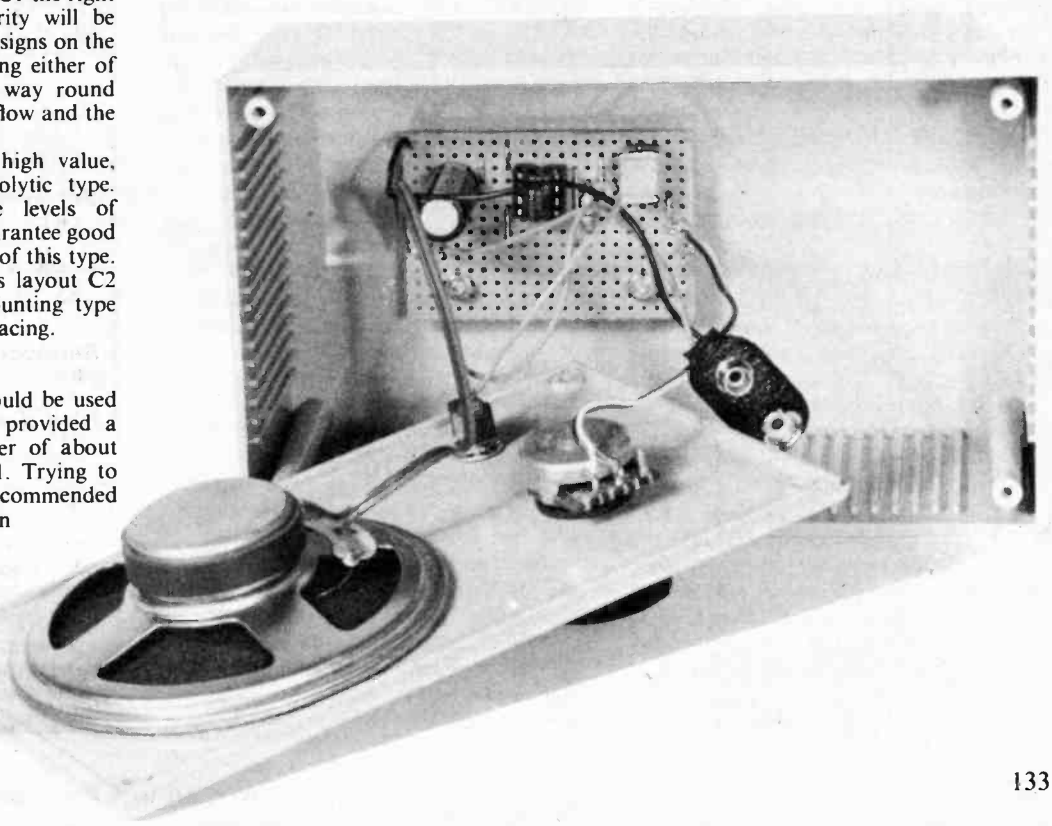


Fig. 3. Details of the wiring from the lid-mounted components to the circuit board. Use this diagram in conjunction with Fig. 2 above.



INTERFACE

Robert Penfold

A SPARE printer port offers what is potentially a very easy means of controlling relays, motors, l.e.d.s, etc. from a computer. A parallel printer port has eight main data outputs, plus two or three inputs/outputs for handshaking purposes, plus what can be as many as half a dozen other input and output lines which normally carry various error and status signals.

In practice many computers only have a single printer port, which is usually needed for a printer and is not free for connection to user add-ons. This problem can be overcome using a two-way printer switch-box so that the computer's output can be switched between the printer and the add-on circuits, but the cost of the switch-box and cables might be deemed too high for this to be worthwhile.

The situation is different with IBM compatibles, since many of these have two printer ports in the standard configuration. Even if only one port is fitted as standard, a very inexpensive printer card is all that is needed in order to add the second port.

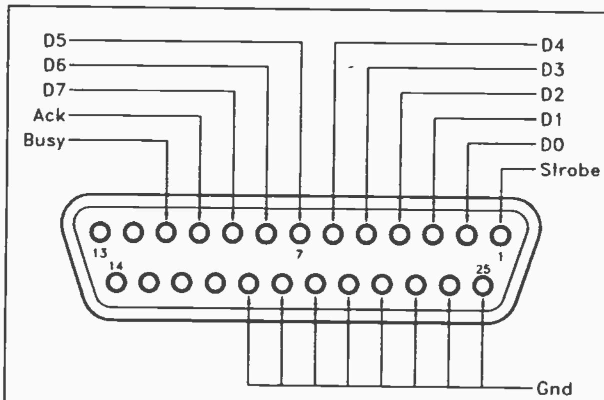


Fig. 1. Basic connection details for a PC compatible printer port.

Latching Data

A PC printer port connects to the outside world via a female 25-way DIN connector. Fig.1 provides basic connection details for a PC printer port. Only the data, ground, and handshake lines are included in Fig.1, and for the time being we will ignore lines that handle error signals and status information.

In normal use a byte of data is placed on the data outputs (D0 to D7) and the normally high "strobe" output is then pulsed low. There is normally an eight bit data latch at a printer's parallel input port, and the strobe signal returning to the high state latches fresh bytes of data into this circuit. The strobe pulse also indicates to the printer's control circuits that a new byte of data is available and must be processed.

The "Ack" (acknowledge) and "Busy" lines are handshake inputs at the computer end of the system. If necessary, these can be used to provide a hold-off so that the flow of data can be temporarily halted. This prevents the computer from sending large amounts of data at such a high rate that the printer's data buffer becomes overloaded. Remember that even the most simple of parallel ports can send data at quite high rates. Rates of about one megabyte per second are quite possible, but bear in mind that the recommended cable length is only about two or three metres.

Busy

The "Busy" handshake line is the more simple of the two. The printer simply takes this line high when it is unable to accept more characters, and sets it low again when it is ready to receive more data. The "Ack" handshake line is normally high, and it is pulsed low by the printer to indicate a byte of data has been received and processed, and that the next byte can be sent.

On he face of it, in order to use a printer port as a simple eight bit output port it is merely necessary to have a latch circuit added on the eight data outputs. A 74LS273 octal D type flip/flop could be used to latch the data, with the strobe output providing the latching pulse to its "clock" input. In practicep this does not seem to be necessary, and virtually all computer printer ports have latching outputs. You can therefore use the data outputs themselves as latching outputs to directly operate relay drivers and the like.

Properly Addressed

From the software point of view there are two basic ways of accessing the printer port. One route is to use the support provided for the printer port by whatever programming language you are using. In BASIC this will be in the form of an LPRINT command, or an equivalent. This indirect route might be the best method of control if large amounts of data will be sent to the port, and handshaking must be used. In many cases though, handshaking will not be needed, and direct access to the hardware of the printer port then represents a more simple and straightforward approach.

The PC's printer ports are placed in the input/output maps at addresses from &H378 to &H37F (port 1) and &H278 to &H27F (port 2). The data latches are at the base addresses, and in order to write data to printer port 1 it is therefore sent to address &H378 (address 888 in decimal). Data for printer port 2 is sent to address &H278 (address 632 in decimal). The data outputs are straightforward TTL compatible latching types, with no added inverters or other surprises.

Using GWBASIC or a compatible PC BASIC language, data can be written to a printer port using the OUT command. For example, the command:–

OUT 888,15

would send a value of 15 to printer port 1. It would set D0 to D3 high, and D4 to D7 low. As one would expect, this direct method of accessing the printer ports does not generate a strobe pulse, but for many purposes a strobe pulse is unnecessary.

Obviously a basic 8-bit latching output port has its limitations. However, using a spare PC printer port in this way represents a very simple and inexpensive method of controlling motors, l.e.d.s, etc. Using the method described in previous *Interface* articles, you could have seven outputs to provide speed control of a model train, and the eighth bit to provide direction control. Even if your PC is already equipped with something like an 8255 PIO card, an extra eight outputs provided by a printer port could be more than a little useful.

Circuit Analysis

I have mention the "PSPICE" and "ACIRAN" circuit analysis programs in previous *Interface* articles. "PSPICE" is the industry standard program of this type, and it is, to say the least, a very complex piece of software. The full commercial package is also quite expensive.

The educational "PSPICE" program (which can be obtained from some shareware vendors) is a slightly cut down version, but it retains most of the facilities available on the full program. It cannot handle complex circuits, but it is adequate for most educational and hobbyist requirements. Its big attraction is that apart from the initial cost of the shareware disks, it is completely free.

The latest educational version is supplied on two high density disks, and it has been steadily updated from the original "free" version. The "PROBE" graphics printing program (which requires a maths co-processor) now supports more output devices, the library of component models includes some additions such as Motorola power MOSFETs, and some super VGA cards are now supported. It is nice to see that the educational version of the program is being kept up to date with the "real thing".

It is only fair to point out that "PSPICE" is a complex program which you will not learn to use in a few minutes. It is a powerful and interesting program though, and one that probably justifies the effort needed in order to master it.

"ACIRAN" has also been steadily improved over the years. Enhancements include support for HP Laserjet and compatible printers, and for Postscript printers, plus better frequency scaling when using a logarithmic sweep. In common with many graphics programs which can accommodate logarithmic scaling, early versions of the program tended to give some extremely odd scale divisions which made it difficult to interpret results. The current version seems to automatically provide more sensible major scale divisions (Fig.2).

Windows

For Windows enthusiasts there is now a Windows version of "ACIRAN". It provides the same basic functions as the standard DOS version, and the menu structure is very similar. However, it is a proper Windows conversion, with graphs, etc. popping up in their own windows, plenty of dialogue boxes, etc. The data display has the usual scroll bars so that you can scroll up and down through the data.

The program will work with any Windows supported screens, printers, pointing devices, etc. The graph printouts (as in the example of Fig.3) are a bit basic compared with the on-screen graphs, but as this is a Windows program the screen graphs can be "pasted" into other graphics programs for enhancement and printing out.

Of the various circuit analyser programs I have tried, "ACIRAN" has always seemed to be the most straightforward

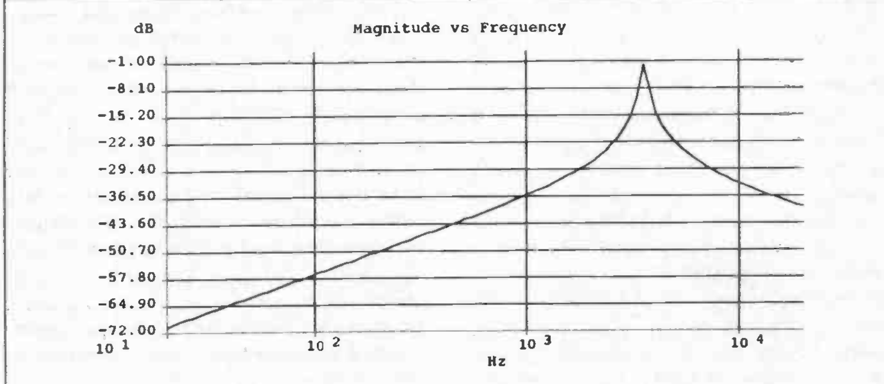


Fig. 3. A frequency response plot from ACIRAN for Windows.

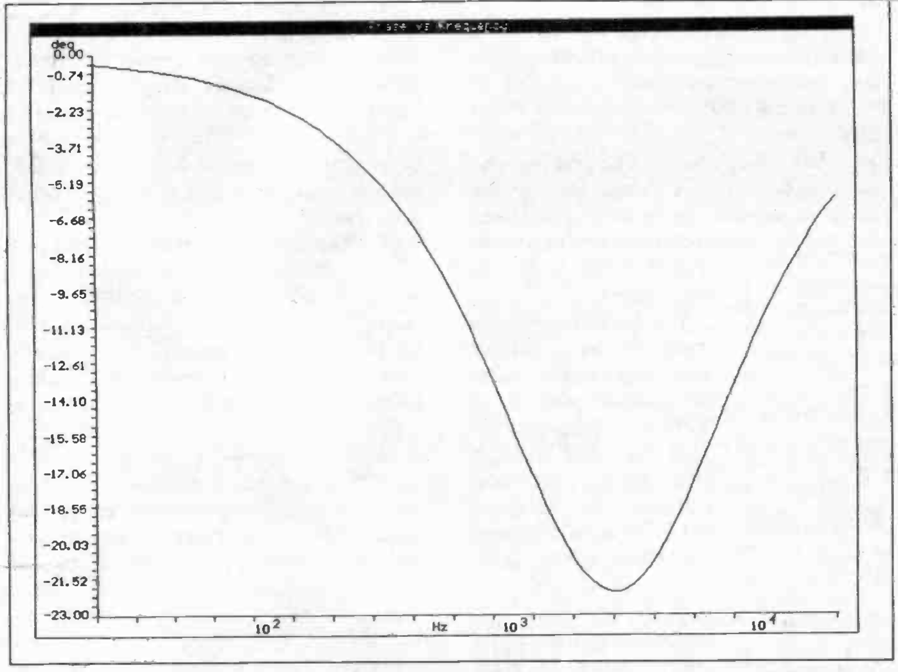


Fig. 2. An ACIRAN phase response graph.

to use. The Windows version has a proper "Install" program, which means that it can be loaded onto the hard disk and run within a few minutes. For anyone who is familiar with Windows programs it should then take no more than a few minutes to get the program working on the demonstration circuit files. Both versions of "ACIRAN" are shareware, but the registration fee of £65-00 is very reasonable indeed for circuit analyser software of this quality.

If you have a PC it is well worthwhile giving "ACIRAN" and "PSPICE" a try. These programs are available from The PDSL, Winscombe House, Dept EPE, Beacon Road, Crowborough, Sussex, TN6 1UL (Tel: 0892 663298). "PSPICE", "ACIRAN", and "ACIRAN" for Windows are on disks H035A/B, 3286, and 3511 (H035A/B are two high density disks). They are probably available from other PC shareware sources, but they will be under different catalogue numbers, and might not be the latest versions.

DOWN TO EARTH

George Hylton

Readers will no doubt be familiar with the use of an ohmmeter to make quick tests on bipolar (*npn* or *pnp*) transistors. Measurements can indicate internal short-circuits, open-circuits and excessive leakage.

It is also possible to treat the transistor as a pair of diodes with the base as a common terminal. The base-emitter junction should read low resistance one way and high with the meter leads reversed, and the same for the base-collector junction.

PNP OR *NPN*?

This test can also show whether a transistor is *npn* or *pnp*, but caution is necessary. When an ordinary analogue multimeter is used on an ohms range the "positive" lead actually goes to the negative terminal of the internal battery, and vice versa.

The polarity of the voltage applied to the junctions is therefore the reverse of the polarity of the meter terminals. When an *npn* device is tested, conduction occurs when the "negative" meter lead goes to the base (Fig. 1) and the reverse for *pnp*.

With most digital meters (and a very few analogue ones) the positive lead is really positive on ohms ranges, so the junctions behave as expected.

GAIN MEASUREMENT

While these tests are quick and useful for fault-finding they don't give any indication of how good a transistor is as a current amplifier. Some multimeters do incorporate special facilities for measuring the current amplification factor h_{FE}. But not many, and not mine.

When my proper transistor tester packed up I remembered reading somewhere that a general-purpose analogue multimeter can be adapted to transistor testing. Some pencil and paper work plus bench tests showed that, if you are stuck with an old-fashioned analogue multimeter with no h_{FE} measurement facility, you can still get a useful idea of transistor gain, provided that you have a suitable variable resistance, preferably calibrated. (The method probably won't work with digital multimeters.)

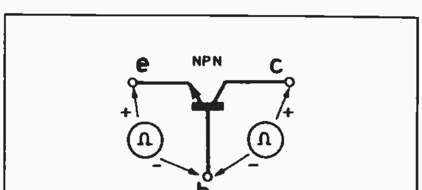


Fig. 1. Checking the base-emitter and base-collector junctions. With the meter leads as shown the junctions conduct when the transistor is npn.

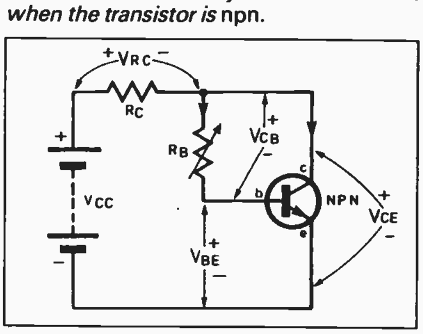


Fig. 2. When $V_{CB} = VR_C$ the h_{FE} of the transistor is very nearly R_B/R_C.

TEST CIRCUIT

The transistor circuit which lends itself to multimeter tests (Fig. 2) is the much used "auto bias" arrangement. Here the d.c. base current flows between collector and base, via a resistance R_B. The other resistance (R_C) is the d.c. collector load.

A certain voltage (VR_C) is dropped in R_C while another voltage (V_{CB}) appears across R_B. If R_B is adjusted so that $VR_C = V_{CB}$ then $R_B/R_C = h_{FE}+1$. Since practical values of h_{FE} are quite high, the "+1" can be ignored and we can say that $h_{FE} = R_B/R_C$.

To make this h_{FE} measurement, all you need is a battery, a fixed resistor (R_C), a variable resistor R_B and some means of showing when $VR_C = V_{CB}$. An analogue multimeter with ohms ranges contains R_C (the range setting resistance), a battery, and a micro-ammeter (Fig. 3, left hand).

All that's now needed is a variable R_B and some system for making the pointer tell you when $VR_C = V_{CB}$. A simple calculation then gives h_{FE}.

RANGE RESISTANCE

If the base-emitter voltage of the transistor (V_{BE}) were zero there would be no problem. Having first zeroed the meter on an ohms range (pointer deflection full scale) the test leads would be applied (with the appropriate polarity) to the transistor and R_B adjusted to obtain a half-scale deflection, using any *linear* scale as an indicator. In this condition half the battery voltage is lost in R_C, so $VR_C = V_{CB}$. Then $h_{FE} = R_B/R_C$. Of course, R_C is the internal resistance of the ohmmeter, and you don't know it. But you can easily find it.

Again taking any convenient *linear* scale (volts, amps) find the half-scale point. Now note what value of resistance appears opposite this point on the *Ohms* scale. This value is R_C.

Naturally, you may have to multiply it by a scaling factor. If the mid-scale value is 40 ohms on the "Ohms ×1" range it must be 4000 ohms on the "Ohms ×100" range.

This value also gives another useful piece of information, the full-scale current. If, on a particular ohms range, the half-scale current resistance mark is 5k (kilohms), and the internal battery is 1·5 then the full-scale current is $1{\cdot}5/5k = 300\mu A$.

Knowing this enables you to estimate the collector current at which you are measuring h_{FE}. Since h_{FE} varies with this current it's sometimes necessary to allow for the variation when comparing your measurement with the maker's data for the type of transistor under test.

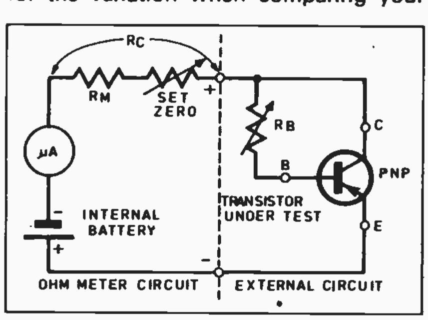


Fig. 3. A calibrated variable resistance R_B enables h_{FE} tests to be made with an ohmmeter.

Data sheets often specify a collector current at which h_{FE} peaks. At higher or lower currents h_{FE} is reduced.

The internal resistance changes as you switch from one resistance range to another so the test current also changes. This opens the possibility of selecting a collector current appropriate to the transistor type.

BASE-EMITTER VOLTAGE

However, I'm running ahead of the subject. With real transistors V_{BE} is not zero. It's likely, in this sort of test, to be round about 0·7V (for a silicon transistor). With an internal battery of only 1·5V this, in effect, reduces the test voltage to around 0·8V.

Clearly, this will produce large errors unless a correction can be made. Having zeroed the ohmmeter, connect to the transistor test circuit and set R_B to zero. This shorts collector to base and turns the transistor into a diode whose forward voltage is approximately V_{BE}. The position of the pointer now indicates a revised "zero": not the ohms zero, which is at full scale, but the maximum deflection obtained when the battery voltage is reduced by V_{BE}.

Estimate the mid-point of the segment of the scale between the pointer position and zero on any d.c. voltage or current scale. In other words find (and note) the reading (Fig. 4) where $x = y$. Adjust R_B to move the pointer to this reading. Then $h_{FE} = R_B/R_C$.

For germanium transistors, V_{BE} is quite low (0·1V to 0·3V) so the pointer deflection when $R_B = 0$ is closer to full scale than for silicon transistors. For all transistors, the $R_B = 0$ deflection varies from one resistance range to another.

There are several sources of error in the test circuit but the measurements I obtained are not wildly different from those of a commercial tester when differing collector currents are allowed for. If all you want is to match transistors or sort high-gain specimens from low-gain the error is unimportant.

Given a plug-in component board the test circuit can be quickly assembled whenever needed. Since h_{FE} is likely to be in the range 10-1000 the variable R_B should be 10-1000 times the mid-scale resistance (R_C).

NO RESISTANCE BOX

If no calibrated resistance is available for R_B use an uncalibrated one. Having set the pointer to the correct reading short base to emitter and take a resistance reading using an ohms scale. This gives R_B.

Erratic readings may be the result of high-frequency oscillation. This is quite likely when the current is high (i.e. a low resistance range is being used). Connecting a low-inductance capacitor between base and emitter often helps. Try 0·1μF.

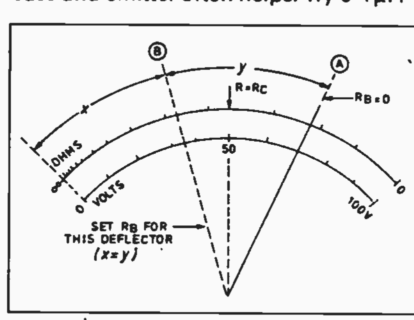
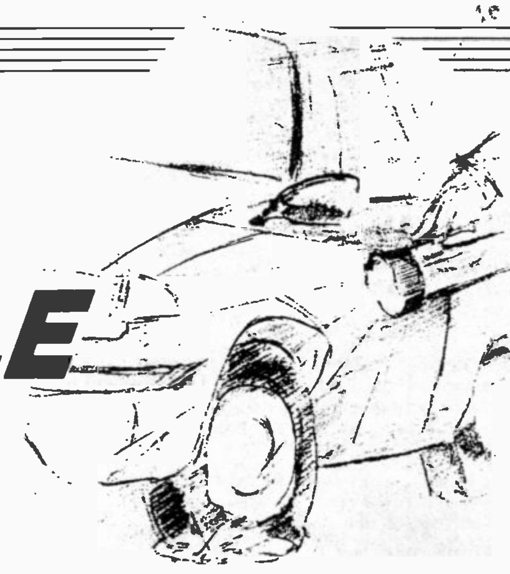


Fig. 4. Meter readings during transistor testing. A with $R_B = 0$: B when $x = y$ R_B is set for h_{FE} calculation.



HEAVY-DUTY RECHARGEABLE HANDLAMP

BRIAN CORDINGLEY

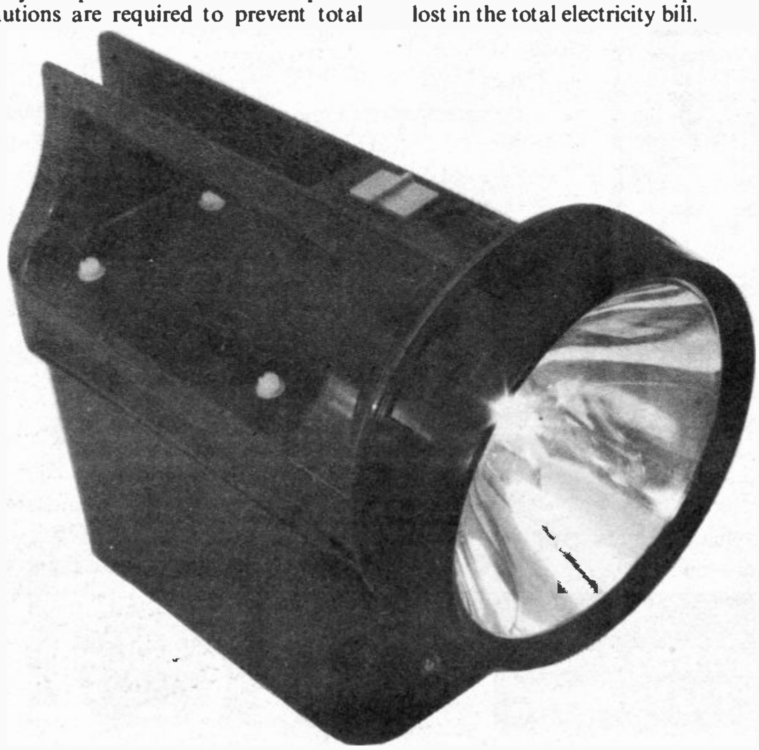
Will provide a bright light for over four hours of continuous operation and retain its charge over a long period of storage.

THE Ever Ready R690 handlamp has proved popular over the years with those who required something superior to a standard torch. The handlamp in its original form is designed to take two PJ996 batteries. In this article details are given on how to convert this unit to run with sealed, maintenance-free, rechargeable lead-acid batteries.

The attractiveness of rechargeable torches has been recognised for some time. Many models are available from retail outlets, though nearly all of these will employ nickel-cadmium cells (NiCads).

Nickel-cadmium cells are offered to the consumer market as they can be charged by very simple circuits and no special precautions are required to prevent total discharge of the cells. Their major drawback is their rapid rate of self discharge – it makes NiCads suitable only for applications where they are either left permanently connected to a charger or are used within a few weeks of being charged. They are not very practical, for example, for keeping in the car for emergencies as they are likely to have lost the major part of their charge before they are required for use.

Where NiCads are left permanently on charge the benefit of economy of rechargeable batteries is likely to be lost. The cost of maintaining the mains supply to a torch left on stand-by charge approaches that of replacing the batteries once a year – of course this cost is not conspicuous as it is lost in the total electricity bill.



LONG LIFE

The rechargeable lamp described in this article employs a sealed lead-acid rechargeable battery. The significant advantage of using lead-acid technology over that of nickel-cadmium for this application follows from the much lower rate of self discharge of the lead-acid battery. The cells specified for use in this project will still contain a useful charge a year after charging.

Lead-acid batteries require more complex charging circuits than do NiCads and also protection is required to prevent accidental total discharge of the cells. Nevertheless, given that these factors are borne in mind when specifying the circuitry, lead-acid batteries will give very good service over a period of many years.

LOW STATE OF CHARGE WARNING

If you have used a nickel-cadmium torch you may well have been irritated by the fact that, when the lamp approaches the end of its stored charge, the bulb dims to extinction rapidly with little warning. In this project, the circuit designed to restrict depth of discharge is also used to give some warning that the lead-acid battery is nearly discharged – the bulb dims gradually as the discharged condition is approached.

EMERGENCY OPERATION

If the lamp is left on for an extended period the current to the bulb will be too low to provide any light. Some charge remains in the battery under these circumstances and provision is made to provide some further periods of light for emergency use.

PORTABILITY

The portability of the handlamp is facilitated by building the charger into the body of the unit. Portability is further enhanced by selecting a mains socket for the project of a type commonly available on domestic equipment. If this is done it will not be necessary to provide a dedicated lead for charging.

PRIMARY CONSIDERATIONS

Before proceeding with the details of construction for this project, it is helpful to recall the relative properties of some battery systems that could be employed in handlamps. For comparisons of operating times, it is assumed that the lamp is fitted with a 0·5A 6V bulb.

Primary Batteries (non-rechargeable)

The primary batteries most often used in torches are founded on zinc-carbon or zinc-chloride systems. These cells have a nominal voltage of 1·5V and, for a given size, have a higher amp-hour capacity than nickel-cadmium or lead-acid rechargeable batteries.

For example, two PJ996 batteries (each battery consisting of four series-connected cells) of six volts and parallel-connected could be expected to operate the R690 lamp for about 24 hours. During the latter part of their life these batteries would be operating at reduced voltage and their performance would be degraded.

These primary batteries have a long shelf life and could be expected to perform satisfactorily for two or three years if used infrequently. The total cost of two PJ996 batteries is currently about £7.

Secondary Batteries (rechargeable)

The most widely available maintenance-free secondary batteries are based on nickel-cadmium or lead-acid technology.

NiCads

Nickel cadmium cells have a nominal voltage of 1·2V and, were they to be used for this project, it would be reasonable to connect five industrial C-size cells in series. The battery formed would have a capacity of 2Ah and cost a total of about £19. It would be capable of keeping a 0·5A bulb glowing brightly for about four hours and could be recharged many hundred times.

Manufacturers claim a life of from five to seven years where, say, a couple of hundred charge and discharge cycles are employed. High-capacity NiCads, such as C-size cells, employ a sintered-plate construction and their ability to retain charge is poor. It is likely that little useful charge would be retained after about two months' storage.

NiCads have an advantage in that they can be charged by simple techniques and it is not essential to provide protection against deep discharge. The metal case of a sintered-plate NiCad is connected electrically to the negative electrode.

Lead-Acid

The nominal voltage of a lead-acid cell is 2V. The cells specified for this project are "Cyclon" cells of 2·5Ah capacity. Three series-connected cells are required to provide a 6V supply and they can be expected to cost a total of about £12. These lead-acid cells have good charge retention and can store a useful charge for more than a year.

The life of lead-acid cells depends on the charging cycle and is strongly dependent on the depth of discharge. As a consequence more complex charging techniques need to be employed than is the case with NiCads and also it is necessary to employ protection against deep discharge. Given these facilities, several hundred charge-discharge cycles can be expected with an overall battery life of up to ten years.

The Cyclon cells employ a separate negative electrode, the case being electrically neutral.

Common Features

The capacities of cells are not identical. When cells are charged and discharged in series there is a likelihood that the cell with the lowest capacity will become increasingly undercharged as cycling proceeds. An occasional sustained period of charging (sometimes called an equalising charge) counteracts this tendency both in lead-acid and NiCad rechargeable batteries.

It is a common feature of NiCads and lead-acid cells that the voltage remains fairly constant over the whole discharge period before dropping suddenly as stored charge approaches zero. This characteristic leads to an efficient use of the stored energy during the main discharge period but necessitates the provision of detection circuitry if advance warning of failure is to be provided.

CIRCUIT DESCRIPTION

The combined charge and discharge circuit diagram for the Heavy-Duty Rechargeable Handlamp is shown in Fig. 1. Charging is accomplished by employing what is essentially a two-step constant-current source.

The mains transformer T1 should have a 12V secondary rated at 300mA or greater. In transformers containing more than one secondary winding rated at 12V, the design of the transformer will often permit parallel connection of these windings to achieve the required total current capability. Use, if possible, a transformer which employs a split-bobbin construction which is suitable for domestic appliances.

When the battery is in a low state of charge, IC1 limits the charging current to a maximum of about 200 milliamps. The voltage drop across resistor R2 resulting from the flow of this current is sufficient to forward bias the emitter-base junction of TR1 and cause this transistor to turn on.

The red l.e.d. (D5) is, as a consequence, illumninated and serves to indicate that charging current is flowing. A current of about 5mA to 10mA bypasses IC1 and flows in the circuit R1-D6-D7 and illuminates D6, the green l.e.d.

The state of charge of the battery is monitored at pin 4 on IC1. Preset VR1 is set so that the main charging current falls rapidly as battery voltage rises through 7·35V. The red l.e.d. extinguishes when the main charging current has been reduced to about 50 milliamps.

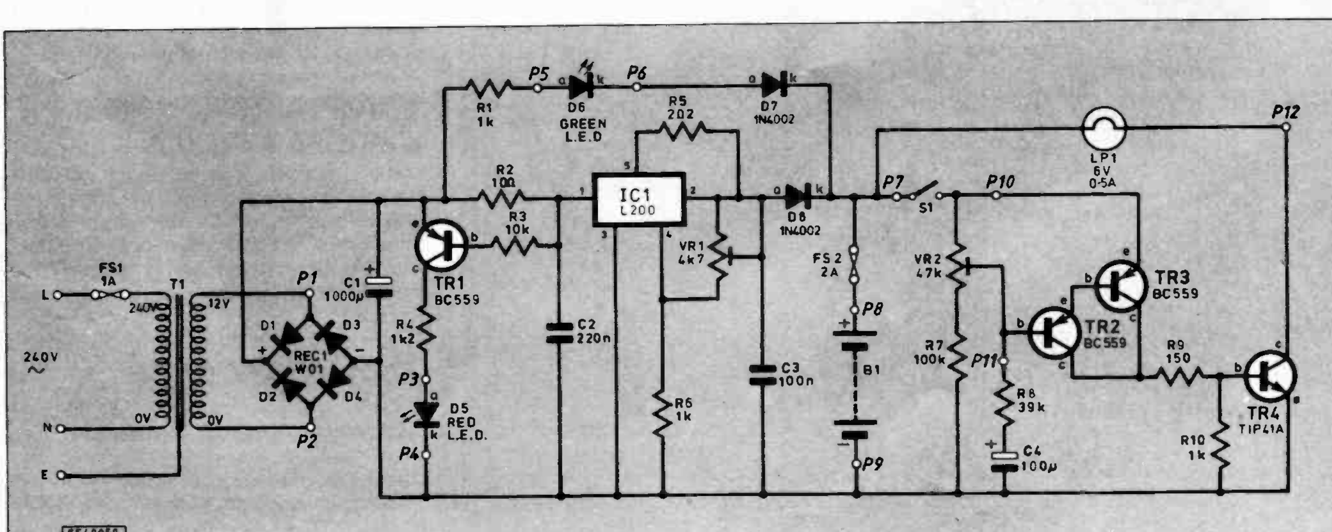
Further increase in battery voltage causes the main current flow to approach zero, though a trickle of charging current continues to flow through the green l.e.d. The purpose of this trickle charge is to provide equalisation of charge on the individual cells of the battery.

Split-rate constant current charging is accepted as one of the best methods of charging sealed lead-acid batteries. When the battery is in a low state of charge, charging is at a high rate. When the battery is nearly fully charged, charging is switched to a safe low rate.

The net benefit is that when the battery is discharged it may be recharged rapidly without the risk of damage through overcharging if it is left on charge for an extended period. A cut-off voltage of 7·35V is selected to provide excellent life combined with good energy storage.

It will be noticed from Fig. 1. that the charging circuit is permanently connected to the battery B1. The diodes D7 and D8

Fig. 1. Complete circuit diagram showing both charging circuit and discharge-protection circuit.

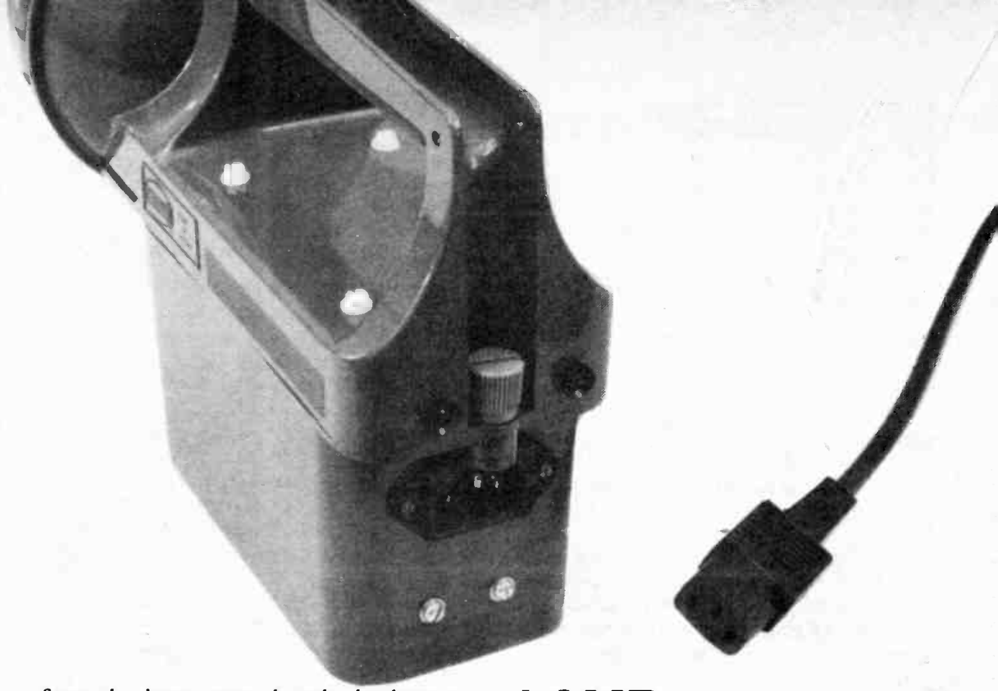


prevent the battery discharging through the charging circuit when the mains supply is disconnected.

The connection of the mains to the charger is accomplished via a socket incorporated into the body of the torch. In the prototype, a socket compatible with that found on an electric kettle was employed so ensuring that charging facilities were readily available.

The reader may prefer to select a socket which is compatible with some other item of domestic equipment, say one designed for use with a cassette player or radio. If no earth connection is provided on the socket then it will be necessary to use plastic or nylon nuts and bolts so that NO METAL PARTS will be exposed on the finished lamp.

A 2A fuse should be fitted in the mains plug if a lead dedicated to the lamp is employed. The fuse attached to the socket (FS1) provides protection when a lead containing a high-current mains fuse is used (for example, one designed to supply an electric kettle).



DISCHARGE CIRCUIT

Lead-acid rechargeable cells have a very low internal resistance and consequently a high fault current will flow on short circuit. The use of the 2A fuse, FS2, in the discharge circuit is to prevent damage in the case of a short circuit in the discharge path.

The bulb LP1 is permanently connected to the battery and is switched on with transistor TR4. This switching technique is employed as it avoids the flow of significant current through the lamp's switch S1 and the consequential voltage drop across this component.

Transistor TR4 may appear at first sight to be overrated for this duty. However, a relatively high surge current flows in the bulb circuit when the lamp is first switched on and TR4 must be capable of withstanding this current.

The use of a high-current transistor for TR4 also results in a very low on-state voltage drop which improves circuit efficiency. With a 0·5A bulb the voltage drop across TR4 is typically less than 0·2V when this transistor is fully on.

The battery voltage is sensed by the forward biased base-emitter junction of transistor TR2. The potentiometer, VR2, controls the current entering the base of TR2.

When the base-emitter junction of this transistor is near its threshold level current increases rapidly with battery voltage. This current is amplified by the Darlington-connected transistors, TR2-TR3, and if it is high enough, it drives TR4 into saturation and transfers the battery voltage across the load.

When the voltage across the battery approaches a level which corresponds to a low state of charge, the current flowing in the base of TR4 is reduced and the transistor starts to come out of saturation. The overall effect is that the collector-emitter voltage of TR4 rises and the bulb dims.

The circuit is adjusted so that the bulb starts to dim when the battery voltage is about 5·4V and gets dimmer as battery voltage falls. Eventually, with further fall of battery voltage, the voltage across TR4 exactly opposes that of the battery and current flow effectively ceases.

Under some circumstances, it may prove desirable to have a few seconds of light from the lamp even though the battery is nearly exhausted. The inclusion of capacitor C4 and resistor R8 provides a boost of current to TR2 at first switch on and will cause TR4 to turn on for a few seconds as C4 charges. This "current boosting" will function even when the battery voltage is too low to maintain a continuous light output. Switching off for a few further seconds allows C4 to discharge so that the process may be repeated.

When the battery voltage has fallen to 5·4V virtually all the energy stored within the battery has been used. Restricting the depth of discharge ensures that the cells give long and trouble-free operation.

CONSTRUCTION

Before starting work, remove the bulb housing and cover the whole of the external surface of the lamp with masking tape. The body is plastic and is easily scratched during construction. Before mounting components on the control circuit board, some modifications need to be made to the handlamp itself.

LAMP MODIFICATION

The transformer, fuse FS1, and three cells together with the mains socket are contained within the battery compartment of the lamp. The transformer and cells are mounted on a strip of mild steel or aluminium cut to fit into the battery compartment with the transformer at the rear end.

After cutting, bend the metal so that it approximates the shape illustrated in Fig. 2. Mark the chassis so that front and rear-facing ends can be easily identified. Grooves are filed into the sides of the metal so that it fits neatly into the base of the lamp.

Drill four holes in the turned-up lips of the metal to take the 4BA fixing bolts. Place the stick-on feet at the base of the battery compartment but do not stick these to the chassis at this stage. Mark the positions of the fixing holes and drill four corresponding holes in the case.

Bind the three D-type cells together with

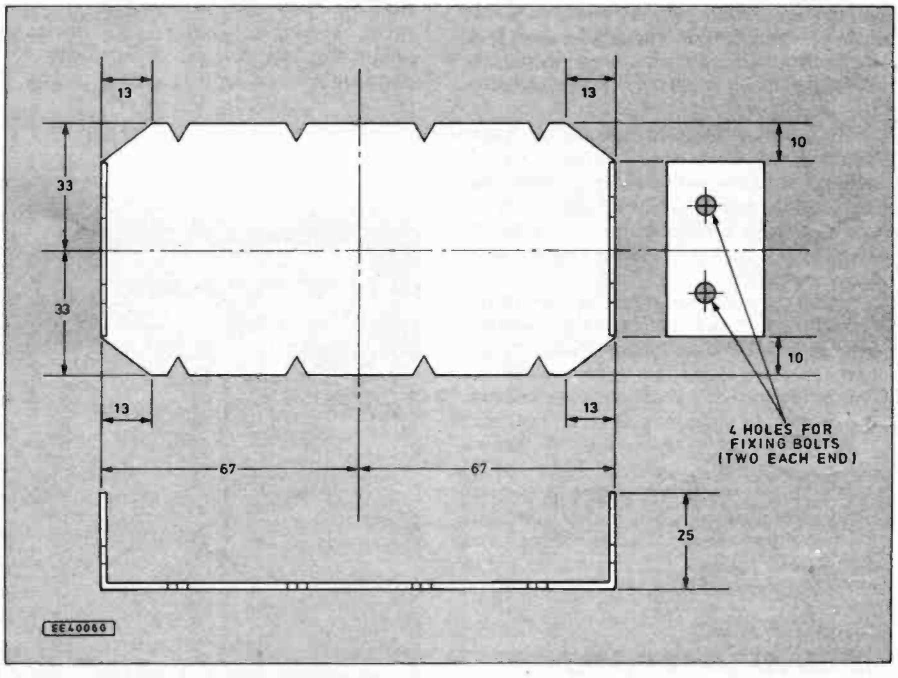


Fig. 2. Approximate shape of metal chassis which should be cut and drilled to fit into the battery compartment. Dimensions are in millimetres.

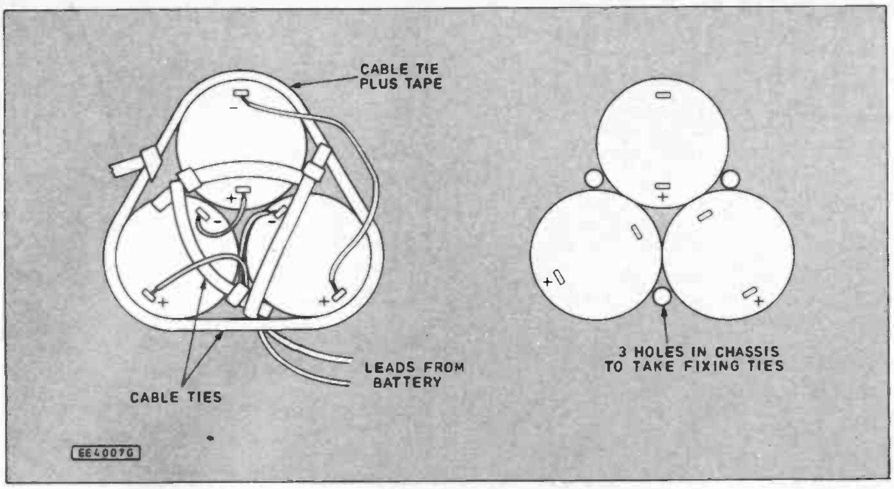


Fig. 3. Method of fixing cells. A cable tie and tape are used to bind the cells together and three cable ties are used to hold the battery to the chassis. Solder the wires to the cells before attaching to chassis, finally cover terminals with insulating tape.

sticky tape so that one terminal on each cell is as near as possible to the centre of the arrangement (see Fig. 3). Place a cable tie around the cells to reinforce the tape.

Remove the chassis plate and determine suitable positions for the transformer and cells, remembering to allow clearance for the mains socket and the attachment of the fixing nuts. The exact layout will depend on the size of the transformer and mains socket employed. The photograph opposite shows the layout used in the prototype. Mark the site of the fixing holes for the transformer.

BATTERY PACK

The D-cells are held in position by cable ties so mark three holes for these ties as illustrated in Fig. 3. Solder wires to connect the cells in *series* leaving the two free ends insulated. The wires should be soldered as near the body of the cells as possible and the excess terminal length removed with wire cutters. Note that the cells are supplied with significant charge and care must be taken to avoid shorting the terminals during construction.

Bolt the transformer, and solder tag for "earthing", to the chassis and attach the cells with cable ties. The ties should be adjusted so that the locking end fits neatly at the side of the cells rather than on top of them (see Fig. 3).

Cut holes in the lamp case for the mains input socket and its fixing bolts. Check that its position will not cause it to foul the transformer. It may be necessary to bend the extended leads on the socket to avoid the danger of possible contact with the transformer.

Solder connecting wires to the transformer and mains socket, Earth connections (if available) and fuse. Stick three or four feet to the chassis at convenient points. Remove the masking tape from the battery compartment and bolt the chassis in position. Next bolt the mains socket and fuse holder for FS1 in place.

If no earth connection is to be provided, it is ***essential*** to use *plastic* or *nylon* bolts for this duty. If *metal* bolts are employed they *MUST* be Earthed, use solder tags to provide points for the earth connections.

UPPER COMPARTMENT

Identify the brass connectors which are intended to connect to the outermost contacts of the disposable batteries. Remove these after first disconnecting the terminal that joins them to the switch. Cut off this terminal and leave as long a length of wire as possible attached to the switch. Leave in position the brass strip that was designed to connect with the centre terminal of the dry cells and provides the connection to the centre terminal of the bulb.

Drill two holes in the rear of the upper compartment of the lamp to take the l.e.d.s. The positioning of components in the upper compartment is shown in the photographs.

Cut the component stripboard to size. This is most easily done by cutting along a row of holes with a hacksaw and filing down to the correct size. When working on the stripboard, remember that it is fairly brittle and do not subject it to too much stress.

The circuit board is held in position by four insulating bolts of about 4BA size. Drill the four holes for the fixing bolts. Mark the positions of four corresponding holes in the upper surface of the lid and drill these.

Check the alignment of the bolt holes with the corresponding holes in the lid of the lamp. If necessary, enlarge the fixing holes in the stripboard with a round file.

Clean part of the two brass contacts which connect with the bulb and solder in position two flexible lengths of wire (Fig. 4). Do this soldering operation as rapidly as possible to avoid conducted heat melting the plastic body of the lamp.

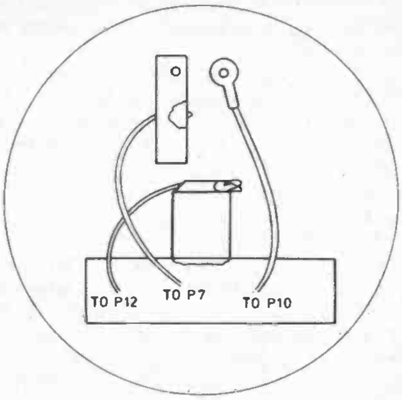


Fig. 4. Connections within bulb compartment.

CIRCUIT BOARD

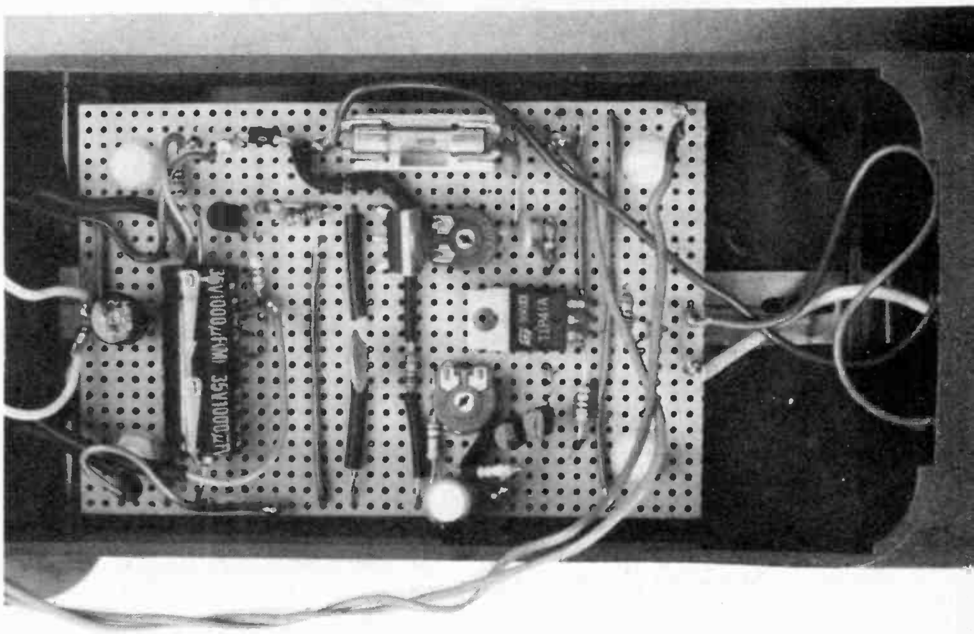
The lamp can now be put aside while we turn our attention to the charging/discharing control board. Commence construction of the board by cutting the breaks in the underside stripboard tracks. The positions of these cuts together with the topside component layout are shown in Fig. 5.

Fit the solder pins; designated as *P*-numbers. These may need pushing with a hot soldering iron to seat properly. Also, using insulated wire, add the wire links.

Fit the remainder of the components taking the usual care to ensure that the i.c., transistors, diodes and polarised capacitors are fitted with the correct orientation. Do not connect resistor R8 to pin *P11* at this stage. Trim the wires and solder to the board.

Remove the masking tape from the lid. Loosely position the circuit board in the lid and confirm that the electronic components do not foul the mains socket or the cells. There should be enough room to use a nut as a spacer in the lid to ensure that the remaining brass strip in the lid does not connect with the underside of the board.

Check that the bulb switch is in the Off position and join the wires to the appropriate pins (except *P11*) observing correct polarity for the l.e.d.s. Replace the bulb and lamp compartment. The circuit is now ready for testing.



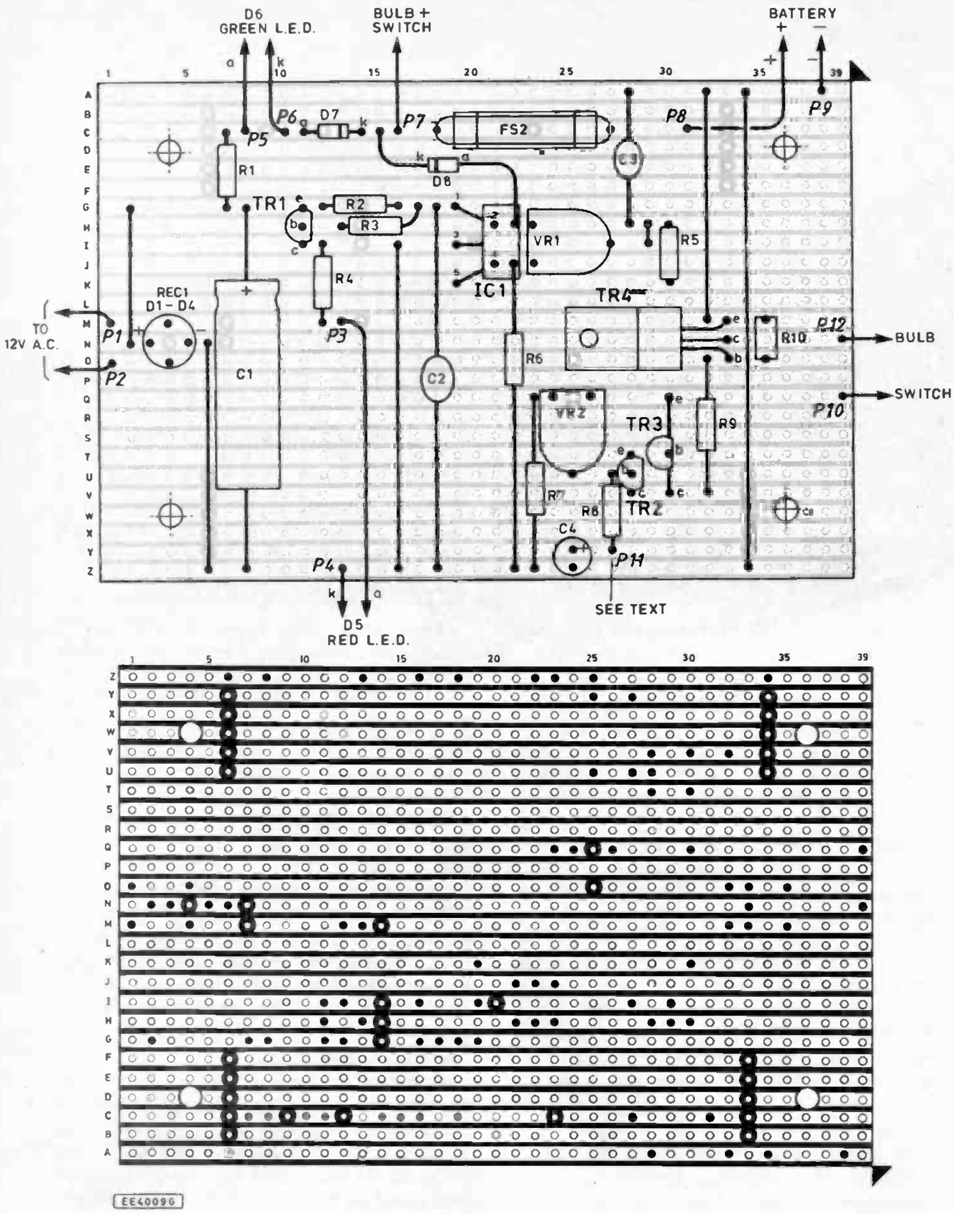


Fig. 5. Strip board component layout and details of breaks required in the underside copper tracks. The "P" numbers indicate the positions of the test pins and the points at which connections are made to other circuits.

COMPONENTS

Resistors

R1, R6, R10	1k	
R2	10, 0·5W	
R3	10k	
R4	1k2	
R5	2Ω2	
R7	100k	
R8	39k	
R9	150	

See SHOP TALK Page

All 0·25W carbon film, unless specified.
In addition a 150 ohm 1W resistor will be required for calibration.

Potentiometers

VR1	4k7 preset, linear
VR2	47k preset, linear

Capacitors

C1	1000µ axial elect., 35V
C2	220n ceramic
C3	100n ceramic
C4	100µ radial elect., 25V

Semiconductors

REC1	W01 bridge rectifier
D5	5mm red l.e.d.
D6	5mm green l.e.d.
D7, D8	1N4002 1A 100V rect. diode (2 off)
TR1 to TR3	BC559 *pnp* silicon transistor (3 off)
TR4	TIP41A *npn* 6A silicon power transistor
IC1	L200 voltage and current regulator

Miscellaneous

LP1	Ever Ready R690 R-series heavy-duty handlamp
T1	Mains transformer, 300mA (4VA or greater): mains primary; 12V secondary.
FS1	1A fuse 20mm
FS2	2A fuse 20mm
B1	2V, 2·5Ah Cyclon sealed lead-acid cell (3 off)

Two 20mm fuse holders one p.c.b. mounting, one panel mounting; strip-board 0·1in matrix, size 39 holes by 26 strips; twelve single-ended 1mm p.c.b. solder pins; 4BA insulating mounting nuts, bolts and washers; metal strip, approximately 184mm x 66mm; mounting feet; four cable ties 280mm long, approx. 4.8mm wide; connecting wire; mains socket and plug.

Approx cost guidance only **£35**

INITIAL TESTS

Before beginning the calibration procedure check that the circuit is functioning correctly. If the circuit fails to operate as specified below then look for mistakes in construction or for faulty components.

Turn presets VR1 and VR2 fully anticlockwise. Ensure that the bulb supplied with the lamp has a current capability of 0·6A or less or, alternatively, its power rating is less than 3·6W. The voltage of the bulb should be between 5V and 6·5V.

CHARGE CIRCUIT

Warning: Due to mains voltages being present, extreme care should be exercised when carrying out work on the unit.

Connect the circuit to the mains and test that both red and green l.e.d.s illuminate. These indicate respectively that both main and trickle charging currents are flowing in the battery circuit. Adjust VR1, the red l.e.d. should go from on to off as the preset "wiper" is rotated clockwise.

Switch off the mains supply and examine the battery voltage. It if is below 6V turn VR1 fully anticlockwise again, reconnect the mains and leave the battery to charge for a few hours before proceeding further.

DISCHARGE CIRCUIT

Switch on the lamp, and – with the mains supply disconnected – adjust VR2. As this preset is rotated clockwise the bulb should go from off to on with a narrow intermediate range where the bulb appears dimly lit.

It is important that no circuit fault causes the battery to discharge when the lamp is switched off. To examine the level of leakage, switch off the lamp and remove the fuse FS2.

Use a multimeter as an ammeter and connect it between pins *P7* and *P8*. It should record negligible leakage current (significantly less than 20µA and probably zero on most meters). Replace fuse FS2.

CHARGE/ DISCHARGE ADJUSTMENT

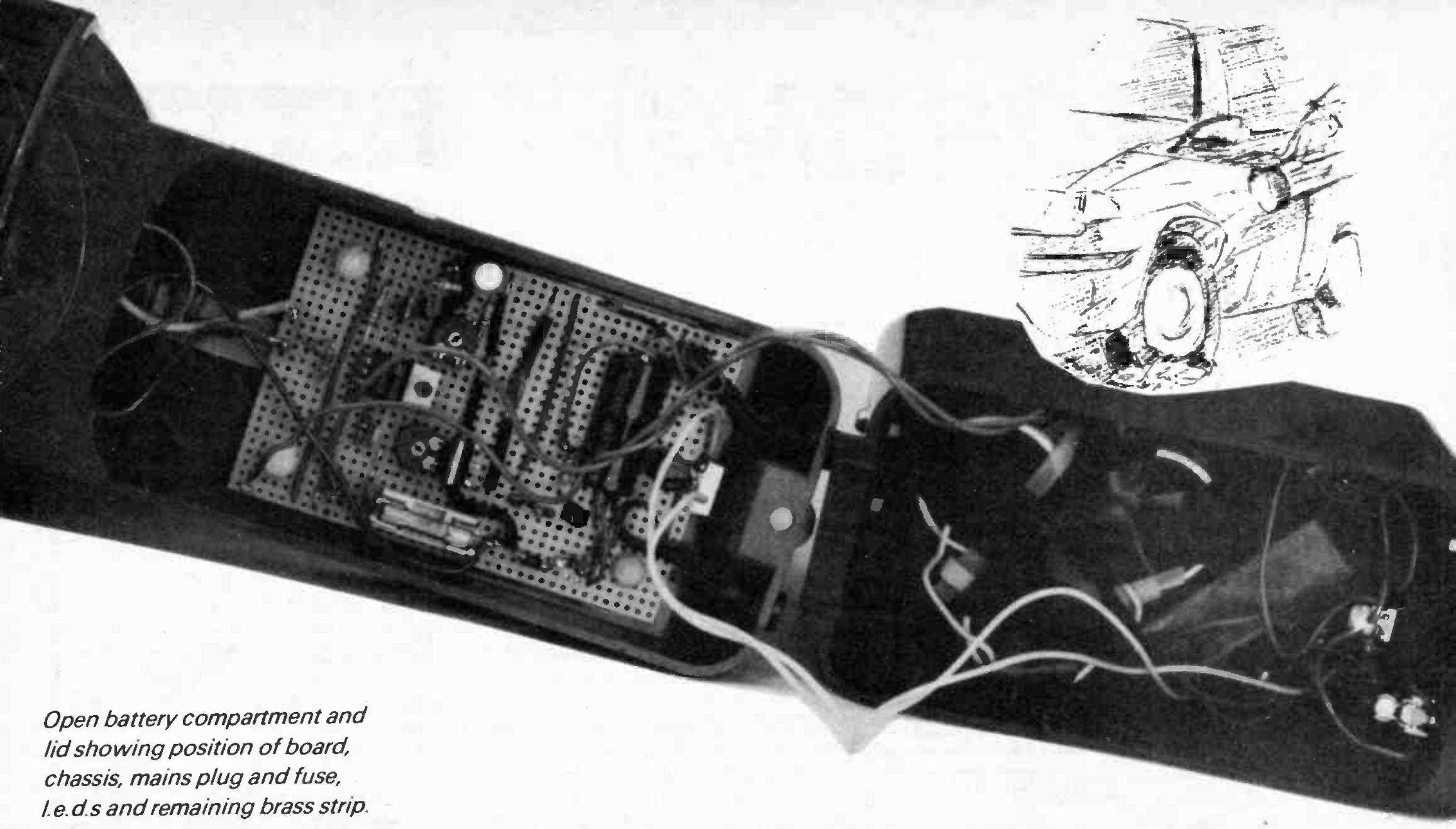
It was mentioned earlier in the text that for maximum battery life it is necessary to control both *charge* and *discharge* processes fairly closely. A 150 ohm one watt "test" resistor is used to facilitate the adjustment of both presets VR1 and VR2.

The charge and discharge circuits are set under specific operating conditions, the characteristics of the circuits are then relied upon to ensure adequate performance under other conditions of operation.

Charging Circuit

Calibration of the charging circuit is achieved by replacing the battery with the resistor. Disconnect the battery and check that the lamp switch is in the off position. Connect the "test" resistor across pins *P8* and *P9*.

Ensure that the multimeter is set to read up to 10V and connect this also across *P8* and *P9*. Switch on the mains supply and adjust VR1 so that the voltage recorded is 7·35V.



Open battery compartment and lid showing position of board, chassis, mains plug and fuse, l.e.d.s and remaining brass strip.

After this adjustment the charging circuit will provide a charging current of the order of 200mA at battery voltages below 7·2V and a trickle charge of about 10mA at voltages greater than 7·5 volts. There is no need to test that the conditions in this paragraph are met.

Discharge Circuit

Switch off the mains, remove the fuse FS2 and move the 150 ohm resistor so that it is connected between solder pins *P7* and *P8*. Connect the negative terminal of the voltmeter to pin *P9* and the positive to pin *P7*. Reconnect the battery and switch on the lamp, the bulb will not glow under these conditions.

Adjust VR2 until the voltage recorded is 5·0V. Remove the resistor and voltmeter and replace FS2. The bulb should glow brightly. Switch off the lamp.

After conducting the above procedure, with the lamp switched on, the collector-emitter voltage across transistor TR4 should be less than 0·3V when the battery voltage is greater than 6V. If accidentally the torch is left switched on for an extended period the drain on the battery should be less than 2mA when its voltage is 4·8V.

This current drain will reduce further if the battery voltage continues to fall. Again there is no need to check these performances. The gain of the discharge circuit is affected by ambient temperature, the cut-off voltage increasing as temperature falls. The adjustment described above should be carried out at room temperature, that is between 20 degrees C and 25 degrees C, this circuit will then perform satisfatorily down to temperatures somewhat below freezing point.

After the outlined adjustments have been made, solder resistor R8 to *P11*. This part of the circuit is left disconnected during the calibration procedure as the time constant of R8-C4 makes the work of calibrating the discharge circuit difficult.

The circuit board may now be bolted into position. Insulating tape is placed over the individual cell terminals and the lamp reassembled. After a charge of about 20 hours the lamp will be ready for use.

A few notes on the effects of bulb specification may be of interest here.

BULB SELECTION AND LIGHT OUPUT

The bulb supplied with the lamp is likely to be rated at about 5V and 0·5A. The manufacturer will have specified it to give a good performance when used in conjunction with a disposable battery which will spend much of its life yielding its power at somewhat less than six volts. The contact resistance of the switch in the original configuration is also likely to give a reduced voltage across the bulb.

The lead-acid battery used in this project will release most of its energy at a fairly constant voltage of 6V; further, the voltage drop across TR4 is likely to be less than that across the switch when it is required to conduct the full lamp current. In this circuit the mechanical switch only carries a few milliamps. The net result is that the bulb will be operated at a higher average voltage than if the lamp were to be used with disposable batteries.

The use of a 5V, 0·5A bulb with the converted lamp will give a bright light output but the life of the bulb will be relatively short. If you require a longer bulb life but not such a bright light then replace this bulb with one rated at 6V, 0·5A. A six volt halogen bulb rated at 3W or 0·5A is available and may be used if you feel that the extra light output justifies the greater cost of this bulb.

With a 0·5A bulb fitted, conventional or halogen, the fully-charged lamp will give a bright light for about four hours. If a longer period of illumination is required, albeit at reduced light output, then a bulb of lower current and power rating should be substituted.

The duration of full light output under continuous operation is approximately $2/I$ where I is the current rating of the bulb at 6V. The discharge circuit is designed and calibrated for bulbs rated at 0·5A or lower. It will not work well with bulbs of a significantly higher current rating.

OPERATION AND MAINTENANCE

When the lamp is first placed on charge both red and green l.e.d.s will illuminate. As the battery approaches its fully-charged state the red l.e.d. goes out though the green l.e.d. continues to glow, indicating that a trickle charge is flowing. This trickle charge flows the whole time the lamp is connected to the mains.

The Cyclon cells specified for this project are very robust, nevertheless, it is beneficial to avoid their being allowed to remain in a low state of charge for an extended period. If the lamp becomes discharged then it should be recharged as soon as possible. Recharging the lamp when it is already partially charged will cause no harm.

Charging from the discharged state takes somewhat less then 20 hours. The lamp should occasionally be left on charge for an extended period to equalise the charge in the cells. For example, leave on charge for a few days after every ten cycles or once a year if the lamp is used infrequently.

When the lamp is used it will give a bright light for a major part of its operating period. As the battery becomes discharged the bulb will gradually dim. However, even when the bulb is extinguished a bright light may be obtained for brief periods by occasionally switching the lamp off and on.

FLOAT CHARGING

The ability of lead-acid cells to retain charge for long periods makes float charging unnecessary for many applications. If the lamp is to be left permanently on charge, then for optimum battery life, the main charging current should be interrupted at a battery voltage lower than that specified for periodic charging.

Preset VR1 should be adjusted to give 6·9V rather than 7·35V when calibrating the charging circuit with the 150 ohm resistor in place of the battery. The trickle charge rate should also be reduced to below 5mA by increasing resistor R1 from 1 kilohm to 2·2 kilohm. □

REPORTING AMATEUR RADIO

Tony Smith G4FAI

RAE RESULTS

In the June 1992 City & Guilds of London examinations, 369 candidates sat the *Novice Radio Amateurs Examination* (NRAE) and 271 were successful, a pass rate of 73·4 per cent. In the May Radio Amateurs Examination (RAE), 1653 candidates were successful, a pass rate of 81·2 per cent. In the period of just over one year following the introduction of the Novice licence, 962 candidates have now passed the NRAE.

Each year several thousand new licences are issued but almost the same number lapse resulting in a marginal growth in the amateur population. One wonders why this is. Has amateur radio reached its natural level in the UK?

Are the attractions of other hobbies and activities that much greater? Is it seen to be too expensive? Is the need to study for an examination before being able to actually go on the air the main deterrent?

I would be interested to hear from any readers who have considered taking up amateur radio but for some reason decided against it. Within the hobby there is much discussion on why it is not continuing to grow as previously, but a view of the problem from within may be quite different to how it is seen from the outside. Write to me c/o the editor and let me know your views!

U5MIR FOR SHUTTLE

I previously told the story of how cosmonauts in the (ex) Soviet space station *Mir* took up amateur radio to help counteract the monotony and boredom associated with long spells in space.

According to a recent *W5YI Report*, two cosmonauts have been selected to fly on the US space shuttle next year. One of them, Sergei Krikalev, has the amateur call U5MIR, dating from his time on *Mir*, and will be first choice for the flight, with his colleague as a back-up. At the time of the report (October) it was not known, however, if U5MIR would be operating *SAREX* (Shuttle Amateur Radio Experiment) equipment during the flight.

The latest news on *SAREX* is that three space shuttle missions scheduled for Spring 1993 will have amateur radio operators aboard. STS-55, planned for February, will operate 2-meter f.m. voice and packet radio. STS-56 in March will operate slow and fast-scan TV in addition to voice and packet, and STS-57, in late April will also be a *SAREX* mission.

AN AMATEUR STARTED CB!

Without wishing to debate pros and cons, I think that in many ways Citizens Band radio is a good idea. It has given many thousands of people an interest in radio communications without the hassle of study and exams, and has led many of them subsequently into amateur radio with its wider horizons and more serious approach to the subject.

I have sometimes wondered who started CB, and now I know. It was a radio amateur! The *W5YI Report* recently ran an interview with Al Gross, W8PAL, who was about to be honoured by the prestigious Radio Club of America for his technical contributions to two-way radio.

Al is best known as the inventor of the handheld radio and surface mount technology, ie, the printed circuit, and for his miniaturisation techniques. As early as 1939, he designed and built some very small handhelds and after publicity in an amateur magazine in 1942 was asked by the OSS to design and build a two-way system for aircraft-to-ground communications.

FROM CLANDESTINE RADIO

By 1944 his "Joan-Eleanor" equipment, which looked something like CB radio, and contained surface mount technology, was working on 250MHz, having a wire recorder attached to the transceiver installed in the aircraft. The code-name for the equipment on the ground was "Eleanor", and that in the aircraft was "Joan". These enabled OSS agents behind enemy lines to communicate directly with operators flying 30,000 feet above them, with a highly directional line-of-sight vertical cone-shaped signal making interception unlikely.

Towards the end of the war Al demonstrated his walkie-talkie to the Federal Communications Commission and discussed the possible uses of such a device for personal two-way radio after the war. At that time radio licences could only be granted to citizens of the United States aged 18 or over, so it was decided to call the proposed new service the Citizens Radiocommunication Service.

One of the FCC Commissioners was so impressed by Al Gross's equipment that he wrote an article "PHONE ME BY AIR" in the *Saturday Evening Post*, July 28, 1945. He described how American citizens, firms, groups and communities might, after the war, be able to transmit and receive short-range messages by radio; and he gave full credit to Al Gross for his work in developing the technology which would make this possible.

INTERNATIONAL AGREEMENT

After the war, the FCC allocated 460MHz to 470MHz for the new service, with the aim of using the band's line-of-sight propagation characteristics to restrict distances covered.

In 1947, Al demonstrated the forthcoming citizens radio at the World Administrative Radio Conference in Atlantic City, and it was internationally agreed that 460MHz-470MHz would be a worldwide allocation for personal two-way radio.

In 1948 Al formed a company called the Citizens Radio Corporation to manufacture type approved two-way radios. According to him, his patented circuitry and technology for 460MHz caused difficulties for other manufacturers who also wanted to build low-cost two-way radios. To meet this problem, the FCC eventually (in 1958), allocated 27MHz for a new Citizens Radio Service.

FORECAST PROBLEMS

Not surprisingly, this was objected to by ARRL, America's national amateur radio organisation, since the new service took over the American 11-metre (26·960MHz to 27·230MHz) amateur band. According to Al, he was then blamed by ARRL for the loss and expelled from membership.

He says that he warned the FCC about the danger of opening up 27MHz to CB radio. He forecast that it would be used illegally, that "skip" would permit operation over distances far greater than was intended, and that the service would be misused in various ways. Much of what he predicted has happened and after the great CB boom in America of the 1970's it is now in decline, as it is in this country.

Al has been involved in a lot more than the original development of CB. He patented radio-paging and suggested spread spectrum techniques to the military. During the '60s he did highly classified work on the ICBM for the Defense Department.

Today, at 74, he continues to be ahead of his time. He is Senior Staff Engineer with Orbital Sciences Corporation in Arizona, heavily involved in aerospace physics. Among other things, he is working on the *OrbComm* project which is somewhat similar to personal two-way radio, using low Earth orbiting (LEO) satellites to retransmit v.h.f. radio messages back to ground.

He credits amateur radio with getting him started in his career. He is still an active amateur operator and gives talks to amateur clubs.

After his interview was published, ARRL dug down in their archives but were unable to find any record of his membership being formally terminated as he claimed. They suggest that whatever happened might have arisen from a disagreement between individuals. In a subsequent letter sent to Al, they say *"regardless of what may have happened at the time . . . today you're welcome as a member, and we would value your support"*.

Techniques

ACTUALLY DOING IT!

by Robert Penfold

IF YOU ask someone who remembers electronic project building in the 1960s about the biggest changes to the hobby over the years, they will probably tell you about the impact of semiconductors, and integrated circuits in particular. While I would not deny that integrated circuits are responsible for major changes in this hobby, I would suggest that there have been other equally major, if less spectacular changes.

CASE FOR CHANGE

One of these major changes is the switch from home-made to ready-made cases. In the past both metal bending and woodworking were essential parts of building many projects. Ready-made cases were available, but the choice was quite limited, and the prices were quite high.

In fact prices in general were fairly high, and you get some staggering results if you convert some sixties prices into their modern "real terms" equivalents. Who would buy BC109s at £5 each these days?

Things have changed, and if you consult any large component catalogue there are likely to be dozens of boxes and cases listed. Prices are low in comparison to those of the sixties, although case prices seem to have risen relatively fast over the past few years.

Some of the higher quality enclosures are starting to become quite expensive compared to the electronics they house. On a recent trip to my local electronics shop I spent about £11 on a small instrument case, which was nearly twice the cost of all the components (including the battery and circuit board) that went inside it!

Despite the comparatively high cost of good quality cases I would be surprised if there was any large return to "do-it-yourself" case construction. Most constructors seem to be far more interested in the electronics than in the "nuts and bolts" side of things.

Probably the most popular solution is to simply settle for a low cost ready-made case, particularly for projects where the electronic components only cost a few pounds. Unfortunately, with project cases as with most things in life, you get what you pay for. Inexpensive cases do not usually have a standard of finish to rival expensive models, and in some cases they are very much of the "rough and ready" variety.

UP TO SCRATCH

Many inexpensive cases are made from aluminium, and as supplied they have a natural finish. Aluminium is a soft metal which marks and scratches easily. This is reflected in a fair number of marks and scratches on virtually all of these low cost aluminium boxes. Some of these marks seem to be an inevitable part of the manufacturing process, and are present on all cases of certain types.

Minor scratches and surface marks can be polished out using practically any metal polish. However, with anything like this always read the instructions first to see if there are any "banned substances".

Polishing aluminium will produce an attractive mirror-like finish. In some cases simply rubbing the aluminium panels quite hard using a piece of kitchen paper will bring the panel to a good shiny finish.

The problem with a high-gloss natural aluminium finish is that it tends to tarnish quite rapidly. The case is likely to tarnish especially quickly anywhere you have touched it, which will eventually result in very obvious finger-marks all over the it.

A hot and humid atmosphere (such as in a kitchen) will also produce a very rapid deterioration in the finish of the case. A very bright and shiny case can look a real eyesore after a few weeks.

Spraying an aluminium case with a clear coating such as Scotch Sprayfix or Rowney Perfix will retain a good natural finish, and should totally avoid any discolouration even over a period of a few years. The sprayed panels will not have quite the same mirror finish as "raw" aluminium panels, but they will be far more practical and should still look good.

Any panel legends produced using rub-on transfers should be added to the panel before it is sprayed. If you try to add the labels after the panel has been sprayed it is more than likely that the lettering sheets will tend to stick to the panel.

This generally results in about ten letters randomly stuck to the panel for each letter you manage to get in the right place. After the panel legends have been added the panel should be carefully given a final polished before it is sprayed.

MELT DOWN

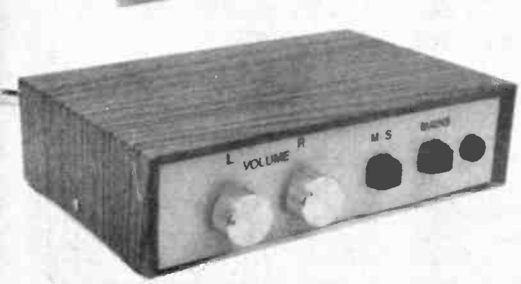
At one time I sprayed all cases with a clear lacquer after the panel legends had been added. This gives the transfers a useful degree of protection against abrasion and general wear and tear.

However, the lacquers seem to dissolve some plastics. Using them on a plastic case can sometimes have disastrous consequences.

Before using any paint or lacquer on a plastic case it is a good idea to try putting a small amount of it *inside* the case. If it should attack the plastic, the damage should be very minor and where it will not be seen anyway. If not, you can go ahead and spray the whole case with a minimal risk of any problems arising. No modern spray-on lacquers should give any problems with aluminium or other metal cases.

(Left) Rub-down lettering applied directly on the front panel, prior to final mounting of components. Gas Alarm *(Aug '92)*.

(Below) Black rub-down lettering applied directly on the aluminium box and covered with protective, clear varnish – Soft Distortion Unit *(Jan '93 issue)*.



(Above left) Using white and black lettering on a painted surface enhances the final appearance – Capacitance Meter *(Oct '92)*.

(Left) The metal front panel was badly marked so a piece of "aluminium laminated veneer" has been glued over the marks and finished with rub-down lettering. – Personal Stereo Amp *(Nov '92)*.

SKIN DEEP

As a simple alternative to spraying a panel you can cover it with a transparent self-adhesive material. This material is available in rolls from most stationers, etc., and it provides very good protective "skin" for the panel.

The thicker grades are probably best for the present purpose, but they seem to be difficult to obtain these days. The thin grades are quite good, but it can sometimes be difficult to avoid leaving the odd air bubble here and there when fitting this material. However, if a pin is used to burst the bubbles they should then press down into place without any difficulty.

If you add the transparent veneer after the legends have been marked on the panel the veneer will give really good protection to the transfers. This method will give a really professional finish.

Unfortunately, there is a slight snag in that it is essential to get it right first time when fitting the veneer. If you peel some of it back so that it can be relayed, some of the transfers will almost certainly come away on the veneer. If this happens you may well have to clean off the panel, redo most of the transfers, and fit a new piece of veneer.

MAKING YOUR MARK

With anything more than very minor scratches something beyond simple polishing will be required. An old ploy, but one which is still well worth trying, is to use a coarse grade of wire-wool to give a sort of brushed aluminium "hi-fi" effect. If you have problems obtaining wire-wool, a scouring pad (Brillo, etc.) will do the job quite well.

All you have to do is repeatedly run the pad of wire-wool along the full length of the panel, producing thousands of fine scratches. It is important to get the scratches running reasonably parallel to one another, or a rather scrappy looking effect might be produced. It is a good idea to practice first using a piece of scrap aluminium, or the reverse side of the panel.

Some very attractive finishes can be obtained by using various criss-cross and swirl patterns, but it requires a fair amount of skill to get this type of thing to look really neat. With fancy patterns you will certainly need a lot of practice before trying your hand at finishing a real front panel.

Once a panel has been given the brushed aluminium effect it should be polished using a soft cloth or a piece of kitchen paper. This will remove the aluminium dust generated by the "brushing" process, and will leave an attractive finish. However, the panel will probably not look its best until it has been sprayed with clear lacquer.

PAINT JOB

Another method of hiding slight scratches is to paint the case. Few paints will stick well to aluminium (or other metals) even if they have a clean and grease-free finish. If you simply slap on a couple of coats of paint it will soon start to rub off again.

A useful first step is to give the panel the brushed aluminium effect just described, but do not bother about making it neat. This gives a mechanical key for the paint to adhere to.

After cleaning the panel it should be given a coat of metal primer. This primer should be one that is compatible with the paint you are using, or it could do more harm than good. The panel should then be given at least two coats of a tough, high quality paint, carefully following the manufacturers application instructions.

When painting anything you should take your time, and be meticulous about every stage of the process. Otherwise the finish of the paint-work is likely to be poor, and the paint may soon blister and start to peel off.

When painting plastic cases it is not normally necessary to use a primer. It is a good idea to use wire-wool or very fine sandpaper to produce the mechanical key for the paint, and the case should be clean and free from grease.

Bear in mind the warning given previously about paints, etc. attacking some plastics. Spray paints will usually give better results than the brush-on variety, but they must be used in accordance with the manufacturers recommendations.

I would advise against using spray paints indoors, because despite your best efforts the paint is likely to find its way into all the wrong places. It is best to wait for a calm day and do the job outdoors. Follow the manufacturers instructions precisely, and you should get good, even, and bubble-free results.

It is best not to attempt to paint cases that are made from p.v.c. or a similar semi-soft plastic. Most of these plastics are virtually paint-proof. In attempting to paint a case which is constructed from a semi-soft plastic you run a real risk of ruining it.

COVER UP

For really bad scratches there is no alternative to covering the panel with some sort of veneer. There are numerous self-adhesive plastic veneers available, but most of these are too fancy to be of much use in the current context. However, if you can find a plain veneer of this type it will probably represent the quickest and easiest method of covering up the scratches.

With very bad scratches it is a good idea to go over them using some very fine sandpaper, which should flatten out any raised edges. Otherwise there is a definite risk of the scratches showing through a thin plastic veneer.

The best veneer I have come across is a self-adhesive aluminium laminate. It might be available elsewhere, but I have only seen it advertised in the Maplin catalogue.

This is much thicker than the usual self-adhesive materials, and it is very tough indeed. It has a superb "blushed" aluminium type finish. The only drawback of this veneer is that it is relatively expensive, although it still costs well under a pound to cover the average front panel with this material.

Probably the most simple method of using ordinary self-adhesive veneers is to first cut out and fit a slightly over-sized piece. This is then trimmed to a neat fit using scissors or a modelling knife.

Being a fairly thick and tough material this method does not work too well with the aluminium laminate, which tends to be a bit difficult to trim to size. It seems to be better to cut a piece precisely to size, and then fit it in position as accurately as possible.

It can be cut to size using a very sharp modelling knife, a steel rule, and a lot of care. The adhesive is very powerful, but if you should happen to get the veneer and panel slightly out of alignment it is possible to slowly peel off the veneer and try again.

IN THE WOODS

There are plenty of real wood veneers available, and these are well suited to something like the outer casing of a hi-fi amplifier. These veneers are not well suited for use on front panels. They can be glued in place using any general purpose adhesive, and being real wood, the surface is then treated as such.

In the present context it is probably best to first gently sandpaper the surface to a very smooth finish using a *very* fine grade of paper, and to then give it a couple of coats of a good quality polyurethane varnish. If done carefully this can give quite a tough and extremely attractive finish. Unfortunately, the cost of real wood veneers is such that this is unlikely to be a particularly cheap way of enhancing an inexpensive case.

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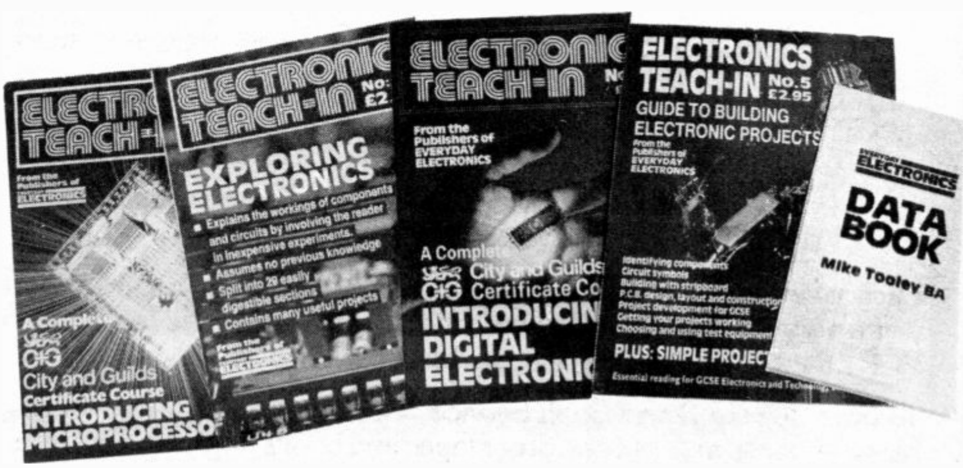

Computers and Computing

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Published by *Everyday Electronics*

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The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ. Project descriptions include circuit diagrams, explanations of their operation, and detailed instructions for building them. A number of the projects are suitable to the beginner while others will be of interest to the more advanced constructor.
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One hundred and forty useful alarm circuits, of a variety of types, are shown in this volume. The operating principle of each one is explained in concise but comprehensive terms, and brief construction notes are given where necessary.
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124 pages Temporarily out of print

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This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning. This is not a constructor's book in the sense of presenting circuits to build and use, it is for the user who wants to design and troubleshoot digital circuitry with considerably more understanding of principles.
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Ian R. Sinclair
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E. A. Parr
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R. A. Penfold
Both books include practical circuits together with details of the circuit operation and useful background information. Any special constructional points are covered but p.c.b. layouts and other detailed constructional information are not included.
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The topics covered in this book include: The broadcast bands and their characteristics; The amateur bands and their characteristics; The propagation of radio signals; Simple aerials; Making an earth connection; Short wave crystal set; Simple t.r.f. receivers; Single sideband reception; Direct conversion receiver.
Contains everything you need to know in order to get started in this absorbing hobby.
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F. A. Wilson
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For the professional engineer, electronics enthusiast, student or others with technical backgrounds, there are numerous appendices backing up the main text with additional technical and scientific detail formulae, calculations, tables etc. There is also plenty for the DIY enthusiast with practical advice on choosing and installing the most problematic part of the system – the dish antenna.
104 pages Temporarily out of print

AN INTRODUCTION TO AMATEUR COMMUNICATIONS SATELLITES
A. Pickford
Communications and broadcast satellites are normally inaccessible to individuals unless they are actively involved in their technicalities by working for organisations such as British Telecom, the various space agencies or military bodies. even those who possess a satellite television receiver system do not participate in the technical aspects of these highly technological systems.
There are a large number of amateur communications satellites in orbit around the world, traversing the globe continuously and they can be tracked and their signals received with relatively inexpensive equipment. This equipment can be connected to a home computer such as the BBC Micro or IBM compatible PCs, for the decoding of received signals.
This book describes several currently available systems, their connection to an appropriate computer and how they can be operated with suitable software.
102 pages Order code BP290 £3.95

AERIAL PROJECTS
R. A. Penfold
The subject of aerials is vast but in this book the author has considered practical aerial designs, including active, loop and ferrite aerials which give good performances and are relatively simple and inexpensive to build. The complex theory and mathematics of aerial design have been avoided.
Also included are constructional details of a number of aerial accessories including a pre-selector, attenuator, filters and tuning unit.
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P. Shore
Provides the casual listener, amateur radio DXer and the professional radio monitor with an essential reference work designed to guide him or her around the ever more complex radio bands. This new edition has been completely revised and rewritten and incorporates much more information which is divided into the following sections:
Listening to Short Wave Radio; Choosing a Short Wave Radio Receiver; How to Use the IRSG; Abbreviations; Country Codes; Worldwide Short Wave Radio Stations; European, Middle Eastern and African Long Wave Radio Stations; European, Near and Middle Eastern and African Medium Wave Radio Stations; Canadian Medium Wave Radio Stations; USA Medium Wave Radio Stations; Broadcasts in English; Programmes for DXers and Short Wave Listeners; UK FM Radio Stations; Time Differences From GMT; Wavelength/Frequency Conversion.
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FOX REPORT

by Barry Fox

FUNNY OLD STUFF

Funny old stuff, this magnetism. You cannot see it, hear it, feel it or smell it. But its effects are very obvious. Just try putting two magnets together and feel the forces.

Over the years people have turned this to advantage. TDK used to sell magnetic pendants for people to hang round their necks, to improve health. There have been magnetic bracelets too, which are somehow supposed to be beneficial to the wearer. Hifi buffs buy "flux dumpers" which are said to soak up stray magnetic flux around an audio system, and improve its sound.

People selling these gadgets are often trading on auto-suggestion. Anyone who pays good money for a gadget which produces unmeasurable benefits will feel sure those benefits are real. To admit otherwise means admitting that it was a mistake to spend the money in the first place. And what better way to prove that the money was well spent than to persuade friends and neighbours to buy the gadgets too, and then hear them confirm the same benefits?

This is why the hifi world buys green felt pens with which to mark the edges of CDs. Who can say for sure that they don't improve the sound? That would need controlled scientific tests, with a "blind" listening panel and enough results to be statistically significant. Why spend the money on tests when sceptics can be written off as cloth-eared, or boring old closed minds.

Bear all this in mind when next a friend, or neighbour, or man you meet in the pub, offers to sell you a device, that costs £60, and is claimed to make your car run better, cut pollution from the exhaust and do more miles to the gallon.

Over the last year or so there have been several gadgets which made these claims. All rely on magnetism and none that I have seen yet comes with clear, independent documentary evidence of any real benefit, other than auto-suggested confidence.

MORE MAGNETIC M.P.G.

The latest device, called Posivlow, is made by McKeown Industries in Northern Ireland. Posivlow clamps four small bar magnets round the car's fuel pipe. This is claimed to give up to 20 per cent more miles per gallon and "up to 50 per cent less exhaust gas emission", while making a car "sharper or nippier".

McKeown's "Go Green and Save" press release says baldly that "the unit is also guaranteed to improve a car's performance".

Says Norman McKeown, Company Chairman, "Posivlow excites fuel into flowing at a more positive rate". Perhaps it does. But so far the company has failed to offer any convincing explanation of why this should happen, or any independent proof that it does.

The gadget, like many products these days, is being sold by network or multilevel marketing. Would-be salesmen and women pay a registration fee of £25, for which they get a promotional video and printed sales literature. They then buy Posivlow devices from McKeown and sell them on at a profit to anyone, anywhere, they can.

McKeown has been running business opportunities meetings round the UK, with one "extravaganza" at the Hyde Park Hotel in London, hosted by a TV celebrity. "Stormin' Norman rallies the troops", says the official newsletter of Norman McKeown's company.

NOT ACCEPTED

Norman McKeown argues that Posivlow is different from all the previous devices, and said at a London press conference that its claims had been "accepted" by the Advertising Standards Authority. But the ASA confirmed that it was already investigating two complaints against Posivlow, even before its official launch, and that it had not accepted anything about Posivlow.

Although it is always hard to control what individual salesmen say, the ASA can investigate a company's sales literature. This explains that "Posivlow's unique co-axially aligned, powerful magnetic field acts on the molecular structure of fuel, altering it in such a way that, when mixed with air in your vehicle's engine, the fuel will burn more efficiently".

"Designed, made, tried and tested in the UK, Posivlow can save you up to 20 per cent of your annual fuel costs" promises the colour leaflet. "You'll also ... see an improvement in your vehicle's performance".

Ronald Gorman, inventor of Posivlow, says "The technology is on the edges of technology and science". But the company's technical data sheet tells that "the science used in the development of Posivlow is known as Magnetohydrodynamics" and that Posivlow "brings about a change in the hydrogen molecules which causes the fuel, when atomised within the cylinder chamber and mixed with air, to form into a more explosive or easily burnt mixture".

"A unique arrangement of very special ceramic magnets (is) formulated in a special way ... a co-axially focussed uni-polar assembly whose focal centre is the midle of the fuel line to which the Posivlow is clamped. As the fuel flows through the highly concentrated magnetic field the hydrogen molecules are subjected to what is regarded to be molecular spin alignment and thus take on what is loosely termed a 'positive charge'"

The device comes as two bent metal bars, each with two small bar magets on its surface, encapsualted in green plastics.

SENSITIVE NORTH

Gorman says that the South Pole of the ring of magnets is in the inside but the location of the North Pole is "commercially sensitive". He can offer no explantion as to why non-magnetic fluid fuel which has passed through the North pole of a magnetic field should burn better than identical fuel which has not.

However McKeown's data sheet also claims that "additional and ongoing testing confirms that applying the very powerful uni-polar magnetic field to fuel immediately before burning in an internal combustion engine does improve combustion efficiency ... Extensive trials with Posivlow, used in normal road conditions, confirm that fuel saving results – irrespective of whether the car runs on petrol or diesel; whether it runs on regular or un-leaded petrol or whether it is a new or old car. Every test was successful; the worst result producing a 15.16 per cent fuel saving, the best an outstanding 37 per cent fuel saving".

Chairman Norman McKeown is even more bullish. He talks of "an average of 20 per cent fuel saving, an average pollution reduction of 50 per cent and upgraded performace". McKeown's promotional video has drivers talking of "feeling the difference".

But neither McKeown nor Gorman could cite any scientific evidence to back these very specific claims. They say they have commissioned independent tests but will not say who is doing them, only that they began in April/May 1992 and will be ready in April or May 1993.

MONEY BACK

In defence of marketing a device without either a scientific explanation of why it should work or independent tests to prove that it does work, McKeown says that after a "pre-launch" in Northern Ireland earlier this year the company sold 25,000 devices worldwide and only 98 people claimed on the money-back guarantee. But McKeown's literature warns that there is a "running-in" or "stabilisation" period of up to 90 days and the guarantee promises money back only after the device has been fitted for three months (with up to 28 days more allowed for repayment).

McKeown confirms that the fact that the UK launch of Posivlow was held at the Society of Motor Manufacturers and Traders plush premises in London should not be taken as official blessing of the device by by the SMMT. As the Society's own publicity material makes clear, the premises are available for hire.

The Advertising Standards Authority says it will not be satisfied by the user testimonials which McKeown is distributing. The ASA wants to see detailed documentary evidence involving on-the-road tests with UK vehicles. The ASA will then ask its own independent consultants to vet the evidence. This is likely to take many months.

Until then my mind remains open and my wallet closed.

READOUT

SPOT ON

Dear Ed.,

Mike Tooley's query in the December issue about remembering the "red spot" transistors of the 1950's, was nostalgic and coincidental.

Some time ago, in one of the occasional clearouts of the spares boxes, and piles of technical articles, I firstly discovered quite a few "red spot" transistors of the OC type.

A little later I came across an article from *Everyday Electronics* of March 1972, on the construction of a Signal Injector, employing a couple of OC44's with a 1·5V battery, and a few other components, all housed in a "Steradent" tube.

The temptation was toó much to resist, and the project was soon completed. Testing confirmed that the injector produced a "square" wave of basic frequency 11kHz.

A fun exercise, but useful even so.

T. W. Cawte
Worthing

OFFENDED

Dear Ed.,

We feel very much offended by your author Mr Robert Penfold in your November '92 issue.

This because he dares to compare the Layo1 freeware apparently without having used it. He comes to all kinds of conclusions which are exactly the opposite of reality. He may be right that the 250 page manual may contain language errors, but that is all.

Even the other program (PADS) he did not use really, writing only about the demo inside of it.

Please ask your readers about the technical aspects of Layo1 and let them compare. They will confirm that this is the only usable professional PCB and router freeware in the entire world, permitting the creation of boards of some importance and allowing double-sided autorouting but also single-sided autorouting which is very important for your hobbyist.

In France we have over 30,000 users of this freeware and 6,000 users of extensions, Telecom, Philips, Motorola, Ti, Cerne-Geneva, all three armies, nuclear industries, and all universities, etc.

During the last two years over 20 full pages of editorial comments appeared (we can send you that on request) in five different magazines on electronics with no single line of critcism.

Comparision:

PADS Shareware: Maximum number of IC's to load, 30; Maximum number of connections, 30; Next upgrade for usable version, £1,200; Next upgrade including all options from the shareware like place, plot, £1,500.

LAYO1 Freeware: Maximum number of components to load, about 250; Maximum number of connections, about 300; Upgrade for version 4 x bigger, £140; Upgrade for version 10 x bigger, £290; Upgrade for version 20 x bigger, £470. Changing from one level to the next one you only pay the difference. No special options at costs.

Gerald J. Nefkens
Layo France SARL
Hyères, France

It might be as well to start with the "PADS-PCB" program. I ran the two demonstration programs, and although I am not normally a great fan of running demos, I found these very useful. They gave a very good idea of what the program can and cannot do, and the general way in which it is used. I then tried running the main programs, going through the various stages of board production, but not actually producing a "real" board. When I ran into the inevitable problems they were quickly sorted out by referring to the excellent on-disk documentation.

It could well be the case that the freeware "LAYO1" is more powerful than the freeware "PADS-PCB" but note that the maximum number of connections for PADS-PCB is around 300, and not the 30 as quoted by Mr Nefkens). Also, I accept that the commercial versions of "PADS-PCB" may well be too expensive for many potential users, although I have not checked the current UK prices. However, for most hobbyists and many educational users the free version of "PADS-PCB" will be perfectly adequate. Bear in mind that you can freely copy this program and use it as much as you like with no registration fee at all being required.

Having used "PADS-PCB" as much as the available time allowed, I moved on to "LAYO1" and tried to repeat the test process. The general impression I obtained was that "LAYO1" was a very powerful and stable program. I am quite willing to believe that it is as good as Mr Nefkens claims, and a good single-sided auto-router would certainly be more than a little useful for the hobbyist. However, after spending a substantial amount of time on this program I made very little progress.

When I ran into difficulties it was often difficult to find a solution in the manual. It seems to be less well organised than the "PADS-PCB" manual, and contains numerous errors. This is not just a matter of odd syntax problems here and there. In many cases totally the wrong words seem to have been used, making it difficult to take the thing seriously. A well written manual is important with any software, but particularly with complex programs. I would certainly recommend that anyone interested in p.c.b. design programs for the PCs should try out both programs, which will hardly "break the bank". I still feel that many potential users of "LAYO1" will simply give up due to the inadequacies of the English manual. – Robert Penfold.

We understand a new manual is being produced. – Ed.

DOESN'T ADD UP

Dear Ed.,

For decades musicians have been telling electronics engineers that sounds do not add up properly in electronic organs both in the case of two notes pressed at the same time and in the case of two stops drawn at the same time and for decades electronics engineers have been trying to fathom out why this is. All kinds of way out explanations have been given.

In the case of octavely related notes in divider organs where the signals are in phase the real simple reason is that if the voltage applied to a loudspeaker is doubled the current through it is also doubled and the power is increased four times, that is the power from a loudspeaker is proportional to the voltage squared. For example sound A = 1 unit of C1 plus 1 unit of C2, sound B = 1 unit of C2 plus 1 unit of C3. Feed each to a separate loudspeaker and you get 1 unit of C1, 1 unit of C3 and 2 units of C2 which is correct. Mix these two signals electrically and feed the result to one loudspeaker and you get 1 unit of C1, 1 unit of C3 and 4 units of C2. The C2 signal is twice what it should be. Not only is the volume wrong but the ratio of C2 to C1 is wrong, that is the tone is also wrong.

By feeding signals to separate loudspeakers and comparing the sound with that from electrical mixing and feeding to one loudspeaker the truth of this explanation can be demonstrated.

J. H. Asbery
Wembley

PCB SERVICE

Printed circuit boards for certain EPE constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remittances should be sent to **The PCB Service, *Everyday with Practical Electronics*, 6 Church Street, Wimborne, Dorset BH21 1JH.** Cheques should be crossed and made payable to *Everyday with Practical Electronics* (**Payment in £ sterling only**).

NOTE: While 95% of our boards are now held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

Please check price and availability in the latest issue.

Boards can only be supplied on a payment with order basis.

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Digital Experimenter's Unit – Pulse Generator		682	£4.46
Power Supply		683	£3.66
Enlarger Timer		684	£4.28
Weather Stn: Rainfall/Sunlight Display		685	£4.27
Rainfall Sen and Sunlight Sen		686/687	£4.16
Amstrad Speech Synthesiser	MAY'90	689	£4.68
80 Metre Direct Conversion Radio	JUN'90	691	£4.95
Mains Appliance Remote Control	JUL'90		
Encoder Board A		694	£6.61
Encoder Board B		695	£4.78
The Tester		696	£4.15
Mains Appliance Remote Control	AUG'90		
Mains ON/OFF Decoder		697	£4.55
(5 or more 697's ordered *together* £3.25 each)			
Simple Metronome		698	£3.94
Hand Tally: Main Bd and Display Bd	SEP'90	699, 700	£10.95
Alarm Bell Time-Out		701	£4.10
Mains Appliance Remote Control			
Temperature Controller (p.c.b. only)		702	£5.20
Ghost Waker	OCT'90	703	£4.32
Frequency Meter		704	£5.25
Freq. Meter/Tachometer	NOV'90	705	£3.98
EE Musketeer (TV/Video/Audio)		706	£5.78
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Versatile Bench Power Supply Unit		710	£4.24
Teach-In '91, Part 1 – L200 Module		711	£3.93
Dual Output Module		712	£4.13
LM723 Module		713	£4.21
Spatial Power Display	JAN'91	714	£5.33
Amstrad PCW Sound Generator		715	£5.03
Teach-In '91, Part 2 – G.P. Transistor Amp		717	£3.77
Dual Op.Amp Module		718	£3.83
Intercom (Teach-In '91 Project 2)		719	£4.41
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		all 3 together	£8.16
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Teach-In '91 Part 8–Light Sensitive Switch		761	£4.74
Opto-Link (Teach-In '91 Project 9) – Transmitter		762	£4.85
Receiver		763	£4.88
Portable PEsT Scarer		764	£3.77
Capacitance Meter	SEP'91	751	£5.17
Modular Disco Lights – Dimmer Interface		765	£8.17
Mod. Disco Lights	OCT'91		
VU Sound Module (Double-sided)		767	£8.68
UV Exposure Unit		768	£4.63
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